Angeles Link Q1 2024 Quarterly Report Appendices (Phase 1)

For the Period January 1, 2024, through March 31, 2024

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APPENDIX 1 –
Q1 DRAFT REPORTS AND PRELIMINARY FINDINGS

January 2024

ANGELES LINK DEMAND REPORT

DRAFT

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SoCalGas

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Pilot Flying J
Port of LA
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Burbank Water & Power
Vista Metals Corporation
World Energy

Disclaimer: The analysis and conclusions set forth in this report do not represent the views of any one particular organization but take into account the inputs from interviews and peer reviews as interpreted by SoCalGas.

List of Acronyms

ACF – Advanced Clean Fleets
ACT – Advanced Clean Trucks
Ag – Agricultural (Equipment)
ANL – Argonne National Laboratories
ARCHES – Alliance for Renewable Clean Hydrogen Energy Systems
BEV – Battery Electric Vehicle
CARB – California Air Resources Board
CapEx – Capital Expenditure
CCUS – Carbon Capture, Utilization and Storage
CHC – Commercial Harbor Craft
CHE – Cargo Handling Equipment
CPUC – California Public Utilities Commission
C&M – Construction and Mining
GHG – Greenhouse Gas
DOE – U.S. Department of Energy
EO – Executive Order
FCEB – Fuel Cell Electric Bus
FCEV – Fuel Cell Electric Vehicle
GSE – Ground Support Equipment
HDV – Heavy-Duty Vehicle
LADWP – Los Angeles Department of Water and Power
LAWA – Los Angeles World Airports
LDV – Light-Duty Vehicle
MDV – Medium-Duty Vehicle
NREL – National Renewable Energy Laboratory
OEM – Original Equipment Manufacturer
OGV – Ocean-Going Vessels
OpEx– Operating Expenditure
R&D – Research and Development
SAF – Sustainable Aviation Fuel
SB – Senate Bill
SoCalGas – Southern California Gas Company
TPY – Tonnes per Year
ZEV – Zero-emission Vehicle

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Executive Summary

Demand Study Overview

On December 15, 2022, the California Public Utilities Commission (CPUC) adopted Decision 22-12-055 (Decision), which authorized Southern California Gas Company (SoCalGas) to establish the Angeles Link Memorandum Account to record the costs of performing Angeles Link Project Phase One feasibility studies. The Demand Study is one of the sixteen Phase One feasibility studies being performed which analyzes total potential demand for clean renewable hydrogen in SoCalGas' service territory through 2045 across three sectors: mobility, power generation, and industrial. Consistent with the Decision, Angeles Link is intended as a project to transport only 100% clean renewable hydrogen to these sectors. This report sets forth the scope, methodology, and results of this study.

Summary Results

The Demand Study projects demand for clean renewable hydrogen across the mobility, power generation, and industrial sectors in SoCalGas' service territory through 2045. Three scenarios were modelled over the time period of 2025-2045 with the results indicating 1.9 Million (M) tonnes per year (TPY) of hydrogen by 2045 in its conservative scenario, 3.2M TPY in the moderate scenario, and 5.9M TPY in the ambitious scenario. Demand comes primarily from the Mobility sector in the conservative scenario, driven by heavy-duty vehicles (HDVs). In the moderate and ambitious scenarios, the Power and Industrial sectors play an increasingly large role with Power becoming the largest sector by demand volume. Figure 1 below defines the scenarios that were evaluated, and the sectors included in each scenario.

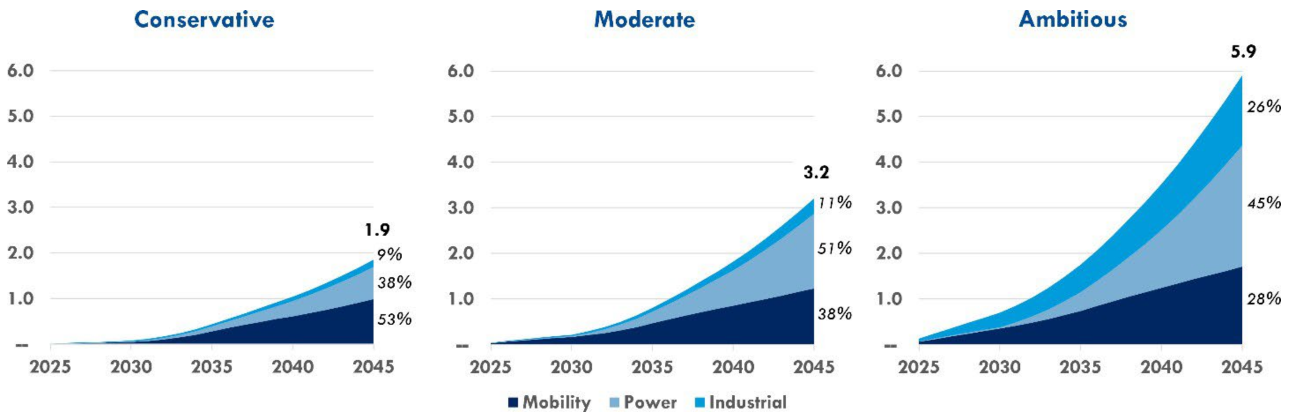
Figure 1: Demand Model Scenario Definition and Subsectors Included

Conservative	Scenario assumes lower adoption rates for hydrogen across a limited set of use-cases within prioritized sectors and sub-sectors, primarily driven by existing legislation. **Mobility:** Heavy Duty Vehicles, Medium Duty Vehicles, Cargo Handling Equipment, Ground Support Equipment, Agricultural Equipment, Construction & Mining Vehicles, Commercial Harbor Craft, Ocean Going Vessels* **Power:** Peaker, Baseload **Industrials:** Cogeneration, Food & Beverage, Metals, Stone, Glass, and Cement, Paper, Chemicals, Aerospace and Defense
Moderate	Scenario assumes increased hydrogen adoption across an expanded set of use-cases within prioritized sectors and sub-sectors, driven by existing legislation. **Mobility:** Heavy Duty Vehicles, Medium Duty Vehicles, Cargo Handling Equipment, Ground Support Equipment, Agricultural Equipment, Construction & Mining Vehicles, Commercial Harbor Craft, Ocean Going Vessels* **Power:** Peaker, Baseload **Industrials:** Cogeneration, Food & Beverage, Metals, Stone, Glass, and Cement, Paper, Chemicals, Aerospace and Defense
Ambitious	Scenario assumes more ambitious policies are put in place and businesses are incentivized to support widespread hydrogen adoption within prioritized sectors and sub-sectors. **Mobility:** Heavy Duty Vehicles, Medium Duty Vehicles, Cargo Handling Equipment, Ground Support Equipment, Agricultural Equipment, Construction & Mining Vehicles, Commercial Harbor Craft, Ocean Going Vessels*, Aviation **Power:** Peaker, Baseload **Industrials:** Refineries, Cogeneration, Food & Beverage, Metals, Stone, Glass, and Cement, Paper, Chemicals, Aerospace and Defense

**OGV vessel demand modeling reflects hydrogen for diesel fuel replacement only (does not include bunker fuel replacement)*

Figure 2 below shows the total hydrogen demand across the conservative, moderate, and ambitious scenarios through 2045, as well as the breakdown of demand across the three sectors. SoCalGas' service territory-wide hydrogen demand is anticipated to scale up starting around 2030 across all three sectors.

Figure 2: Clean Renewable Hydrogen Demand Forecast in SoCalGas' Service Territory, by Scenario
(2025-2045, values in Million TPY)



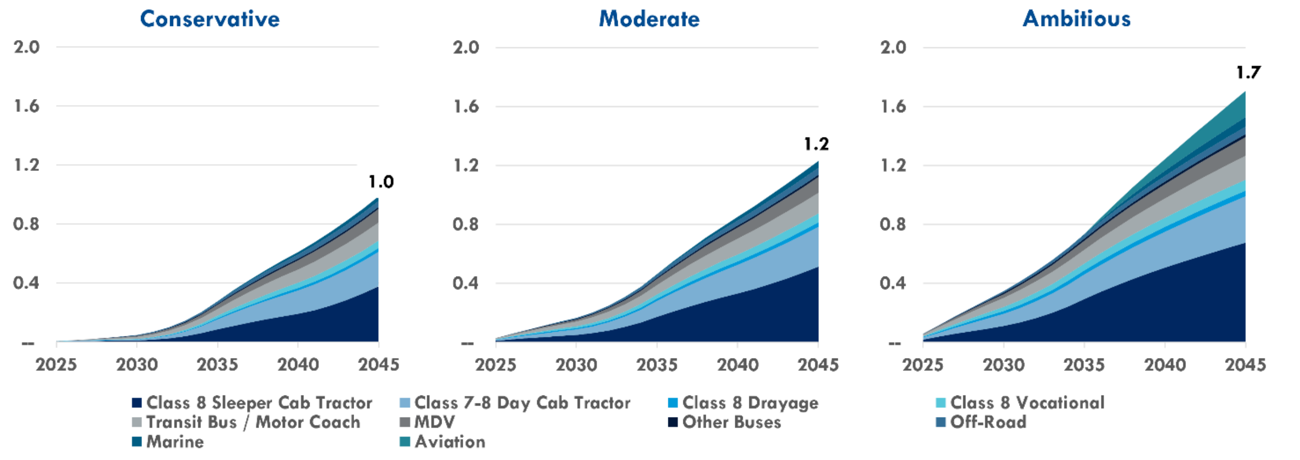
The findings point to potentially widespread demand across these sectors and the significance of hydrogen in decarbonizing California's mobility, power generation, and industrial sectors should these levels be achieved.

Mobility

Clean renewable hydrogen demand in the mobility sector is projected to reach between 1.0 and 1.7M TPY by 2045. The principal driver of mobility sector demand is the Advanced Clean Fleets (ACF) regulation, which requires zero-emission vehicles (ZEV) sales starting in 2024 for drayage trucks and "high-priority" (large private) fleets; and ZEV sales for all fleets by 2035. Therefore, across all the study's scenarios, HDVs—including Class 7-8 sleeper cabs, day cabs, drayage trucks, vocational vehicles—as well as transit buses, represent the majority of the mobility sector's demand by 2045. Many of these HDVs currently refuel along key transit corridors, a pattern that is expected to continue regardless of their conversion to fuel cell electric vehicles (FCEV) or battery electric vehicles (BEV).

In addition, operational characteristics such as long-range requirements, heavy load requirements, long duty-cycles, and fast fueling requirements lead to heavy duty applications—Class 8 sleeper cabs, day cabs, and drayage trucks, as well as transit buses—being prime candidates for hydrogen adoption over alternative low-carbon technologies. These HDV applications comprise roughly 80% of total 2045 mobility sector demand across scenarios. Outside of this, clean hydrogen demand for off-road applications is expected to remain moderate in SoCalGas' service territory, largely due to relatively small fleet sizes, small daily fuel consumption rates, or the competitive value propositions of alternative fuels, namely battery electric. For marine and aviation applications, hydrogen derivatives such as ammonia and methanol and synthetic fuels such as sustainable aviation fuel (SAF) are expected to play a significant role in decarbonization, though hydrogen fuel cell technology may achieve significant enough penetration to constitute notable demand for clean renewable hydrogen. Figure 3 shows the breakdown of clean renewable hydrogen demand in the mobility subsectors.

Figure 3: Total Expected Clean Renewable Hydrogen Demand in the Mobility Sector
(2025-2045, values in Million TPY)



Early hydrogen demand ramp-up (pre-2035) will be largely dependent on Original Equipment Manufacturer (OEM) production rate and on announced programs such as Port of Los Angeles and Port of Long Beach's Clean Air Action Plan, which sets targets for terminal operators to achieve 100% ZEV cargo handling equipment (CHE) by 2030. After 2035, many significant regulations such as ACF will come into full effect, requiring 100% of new truck sales to be ZEV. As such, modelled hydrogen demand is expected to noticeably increase when this takes effect. Additionally, in September 2023, CARB proposed 2023 LCFS amendments which would increase the stringency of carbon intensity reduction targets through 2030 and extend targets through 2045. The proposed amendments would also create incentives for clean fuel production and refueling infrastructure, which could further accelerate ZEV adoption and hydrogen demand.[1]

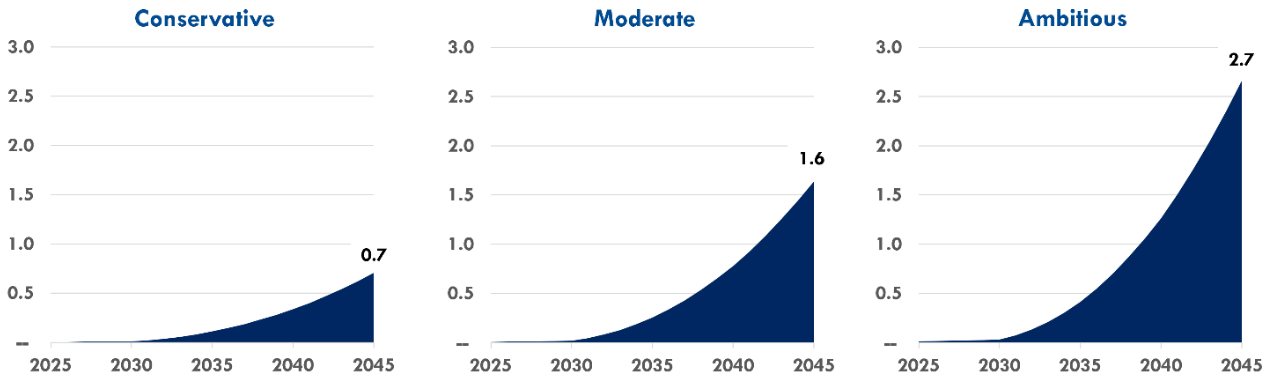
Power Generation

Clean renewable hydrogen demand in the power generation sector is expected to range between 0.7M and 2.7M TPY by 2045. Policy is a key driver for the sector, including Senate Bill (SB) 100[2]—requiring California's power generation system to be 100% carbon-free by 2045, and SB1020[3] which accelerates the SB100 mandate requiring 90% of all retail sales of electricity be from renewable energy resources by 2035. California Air Resources Board (CARB) forecasts that roughly 9 GW of incremental hydrogen capacity will be needed as an electricity resource in California by 2045 in their 2022 Scoping Plan for

[1] California Air Resources Board. "Low Carbon Fuel Standard 2023 Amendments". https://ww2.arb.ca.gov/sites/default/files/2023-09/lcfs_sria_2023_0.pdf
[2] California Legislative Information. "Senate Bill No. 100". https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB100
[3] California Legislative Information. "Senate Bill No. 1020". https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB1020

Achieving Carbon Neutrality[4]. Additionally, Los Angeles Department of Water and Power's (LADWP) target of supplying 100% renewable energy by 2035 will likely be a major contributing factor in the adoption of hydrogen in the region.[5]

Figure 4: Total Expected Clean Renewable Hydrogen Demand in the Power Sector
(2025-2045, values in Million TPY)



Firm dispatchable power, up to 45GW, is estimated to be needed in California's future[6], and hydrogen can be one of those resources. Hydrogen provides value as firm dispatchable and flexible power generation, helping power producers manage the anticipated daily to seasonal fluctuations in the production of renewable energy and to help ensure continuous, reliable electricity service—particularly during heat waves and other extreme weather events that extend beyond the duration of current battery storage. As the amount of solar and other intermittent renewable energy resources on the electric grid increases, and as traditional dispatchable generating resources change, clean renewable hydrogen can play a key role and be called upon when needed. The specific utilization and capacity factors of each power plant will have a significant influence on potential hydrogen demand. Figure 4 reflects these trends.

There are a variety of technological and operational considerations that will impact the level of hydrogen demand in the power sector. This demand study focused on hydrogen combustion turbines only, with OEMs generally targeting 2030 for 100% hydrogen capable combustion technologies based on public announcements and interviews[7,8,9]. As combustion technologies mature over time, hydrogen uptake is expected to grow as well. It is worth noting that interviews and analysis in this sector found

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[4] California Air Resources Board. "2022 Scoping Plan for Achieving Carbon Neutrality". Figure 4-5. (December 2022). https://ww2.arb.ca.gov/sites/default/files/2023-04/2022-sp.pdf
[5] Los Angeles 100% Renewable Energy Study (LA100). https://maps.nrel.gov/la100/la100-study/report
[6] EDF. "California needs clean firm power, and so does the rest of the world". https://www.edf.org/sites/default/files/documents/SB100%20clean%20firm%20power%20report%20plus%20SI.pdf
[7] Euractiv. "GE eyes 100% hydrogen-fueled power plants by 2030". (May 2021). https://www.euractiv.com/section/energy/news/ge-eyes-100-hydrogen-fuelled-power-plants-by-2030/
[8] U.S. Environmental Protection Agency. "Hydrogen in Combustion Turbine Electric Generating Units: Technical Support Document". (May 2023). https://www.epa.gov/system/files/documents/2023-05/TSD%20-%20Hydrogen%20in%20Combustion%20Turbine%20EGUs.pdf
[9] Siemens Energy. "Zero Emission Hydrogen Turbine Center". https://www.siemens-energy.com/global/en/home/products-services/solutions-usecase/hydrogen/zehtc.html#:~:text=H%E2%82%82%20capabilities%20of%20our%20medium,to%20reach%20100%25%20by%202030.

that many existing natural gas combustion turbines in SoCalGas' service territory are capable of utilizing blended fuels of up to 30% hydrogen by volume with certain retrofits[10,11]. Modifications to fuel delivery systems would be required, and doing so could provide a near-term pathway for hydrogen adoption for existing gas combustion turbines.

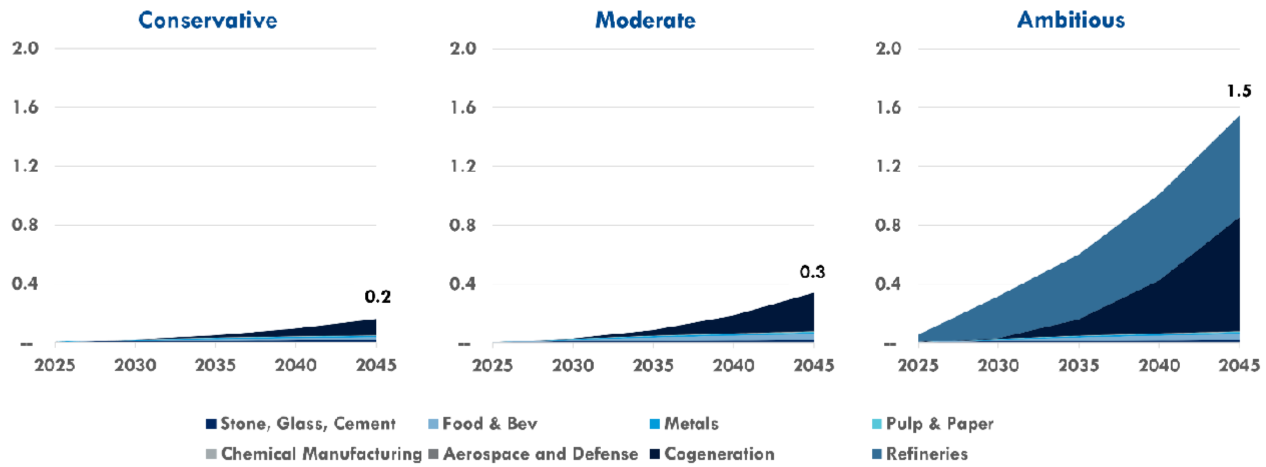
Industrial Sector

Demand volume in the industrial sector is expected to range between 0.2M and 1.5M TPY by 2045. California has a large industrial base, and its size and diversity of end users creates significant potential for long-term hydrogen demand in a wide range of industrial applications. This study focused on quantifying demand in the industrials subsectors of metals, food & beverage, stone, glass, & cement, aerospace & defense, and refineries, and included evaluation of on-site power cogeneration.

Many industrial end users across subsectors are interested in the potential of clean renewable hydrogen, however a lack of legislative mandates and large capital requirements for equipment upgrades suggest that additional industrial-specific incentives may be needed to accelerate hydrogen demand. One subsector that may see higher policy and market drivers like what is seen in the Power sector is cogeneration at industrial facilities. However, there remains significant uncertainty around the future of cogeneration in California, with the CARB Scoping Plan projecting all cogeneration to be retired by 2045.[12] Outside of cogeneration, the most significant source of industrials-sector potential hydrogen demand is refineries. Refineries use significant amounts of fossil-fuel derived (gray) hydrogen today, namely for applications such as hydrocracking and removing sulfur from petroleum. However, as demand for carbon-based traditional fuels (such as diesel, gasoline, or jet fuel) decreases, the amount of hydrogen demand for refining and developing these products may decrease. In response to these expected declines in traditional fuel demand, refineries are considering conversions to producing synthetic fuels such as renewable diesel which would use significant amounts of clean hydrogen as hydrotreatment of renewable feedstocks requires considerably more hydrogen than desulfurization of diesel[13]. Given the uncertainties of this conversion, refineries are included in the ambitious scenario only, accounting for the large uptick in industrials demand between moderate and ambitious scenarios. Outside of cogeneration and refining, demand from other industrials subsectors is largely a result of fuel switching, and while relatively small, will likely be a steady and therefore important source of demand.

[10] U.S. Environmental Protection Agency. "Hydrogen in Combustion Turbine Electric Generating Units: Technical Support Document". (May 2023). https://www.epa.gov/system/files/documents/2023-05/TSD%20-%20Hydrogen%20in%20Combustion%20Turbine%20EGUs.pdf
[11] S&P Global. "Hydrogen-capable natural gas turbines gain traction in power sector". (March 2022). https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/natural-gas/031622-hydrogen-capable-natural-gas-turbines-gain-traction-in-power-sector
[12] California Air Resources Board. "2022 Scoping Plan". https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2022-scoping-plan-documents
[13] U.S. Energy Information Administration. "Biofuels Explained". https://www.eia.gov/energyexplained/biofuels/biodiesel-rd-other-basics.php

Figure 5: Total Expected Clean Renewable Hydrogen Demand in the Industrial Sector
(2025-2045, values in Million TPY)



Future demand in the industrial sector will depend on the pace of technological advancements for key use cases. Progress is being made in this area, with several 100% hydrogen-compatible burners and furnaces being piloted in Europe as an example. The speed at which industrial equipment currently in operation may be replaced will also be a key driver of hydrogen adoption timelines in the industrial sector.[14]

Conclusion

The Demand Study findings indicate potential for significant demand—1.9M TPY to 5.9M TPY—for clean renewable hydrogen across the mobility, power and industrials sectors by 2045 in SoCalGas' service territory. Further research will be required in future phases of the Angeles Link to assess economic feasibility as well as further refinement of potential pipeline configurations to bring together supply and demand of clean renewable hydrogen. The demand study findings will be updated in future phases once approved by the CPUC. Phase One findings from other Angeles Link studies may also be incorporated.

[14] Heat Treat Today. "Global Steel Manufacturer Develops Historic Hydrogen Heat Treat." (May 25, 2020). https://www.heattreattoday.com/industries/manufacturing-heat-treat/global-steel-manufacturer-develops-historic-hydrogen-heat-treat/#:~:text=For%20the%20first%20time%20ever%2C%20heat%20treaters%20have,furnace%20at%20the%20Hofors%20rolling%20mill%20in%20Sweden.

Introduction

Background and Context

Hydrogen is an essential component of economy-wide decarbonization, particularly in sectors with few other decarbonization alternatives. In the Decision, the CPUC limits any future hydrogen transported in Angeles Link to clean renewable hydrogen, which is defined as hydrogen that does not exceed a standard of four kilograms of carbon dioxide-equivalent produced on a lifecycle basis per kilogram of hydrogen produced and does not use any fossil fuel in its production process.[15] Clean renewable hydrogen is a zero-emission fuel solution for hard-to-electrify sectors. For example, it provides faster refueling times and reduced weight for FCEVs relative to BEVs, reducing operational and cargo capacity impacts. Hydrogen is a low carbon energy carrier capable of being transported across long distances and stored for extended periods of time.

According to the U.S. Department of Energy's (DOE) "Pathways to Commercial Liftoff: Clean Hydrogen", hydrogen has a strong potential to support the decarbonization of long-haul trucking, maritime fuels, aviation fuels, chemicals, iron and steel, and refining, which collectively make up 10-25% of global energy-related carbon emissions.[16] Hydrogen can also contribute to the decarbonization of buses and short-haul trucks, other transportation, firm dispatchable power generation, cement, and other industries, which collectively accounts for an additional 25-40% of global energy-related carbon emissions. The report predicts that by 2050, clean renewable hydrogen could reduce overall U.S. carbon dioxide emissions by 10% compared to 2005 baseline levels.

State and federal interest in building out a hydrogen economy has risen in recent years, beginning with the passage of up to $7B of Clean Hydrogen Hub funding to support the development of 6-10 hydrogen hubs across the United States as part of the Biden Administration's Infrastructure Investment and Jobs Act[17] and the subsequent selection of the California Hydrogen Hub[18] to begin award negotiations. In addition, a notice of intent for $1B of funding to support demand-side initiatives was released in July 2023 to promote investment in hydrogen hubs, accelerate the hydrogen economy, and encourage private sector participation.[19] The recent Inflation Reduction Act also provides new incentives for hydrogen, with the 45V tax credit created to incentivize hydrogen production. The 45V tax credit awards up to $3/kg of hydrogen produced to projects with a lifecycle greenhouse gas (GHG) emissions intensity of less than 0.45 kilograms per kilogram of hydrogen.[20]

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[15] California Public Utility Commission. "Decision Approving the Angeles Link Memorandum Account to Record Phase One Costs." (December 15, 2022). https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M500/K167/500167327.PDF

[16] Department of Energy, "Pathways to Commercial Liftoff: Clean Hydrogen" (March 2023). https://liftoff.energy.gov/wp-content/uploads/2023/05/20230523-Pathways-to-Commercial-Liftoff-Clean-Hydrogen.pdf

[17] Department of Energy, "Bipartisan Infrastructure Law: Additional Clean Hydrogen Programs (Section 40314): Regional Clean Hydrogen Hubs Funding Opportunity Announcement" (September 22, 2022). https://oced-exchange.energy.gov/Default.aspx#FoaId4dbbd966-7524-4830-b883-450933661811

[18] Office of Clean Energy Demonstrations. "Regional Clean Hydrogen Hubs Selections for Award Negotiations". https://www.energy.gov/oced/regional-clean-hydrogen-hubs-selections-award-negotiations

[19] Department of Energy, "Notice of Intent: H2Hubs Demand-side Support" (July 25, 2023). https://oced-exchange.energy.gov/FileContent.aspx?FileID=9a1e375b-218e-4ae7-8fd0-c9a529a404ec

[20] Center for Strategic & International Studies. "How the 45V Tax Credit Definition Could Make or Break the Clean Hydrogen Economy". How the 45V Tax Credit Definition Could Make or Break the Clean Hydrogen Economy (csis.org)

In November 2022, California created the world's first plan to achieve net-zero carbon pollution by 2045.[21] As the world's fifth largest economy, the state is taking ambitious measures to reduce pollution and increase deployment of renewable energy and other low-carbon technologies. Achieving this goal requires a combination of innovative solutions to bring decarbonization alternatives of best-fit to each market subsector.

In 2022 California established the Alliance for Renewable Clean Hydrogen Energy Systems (ARCHES). ARCHES is a public-private hydrogen hub consortium of over 150 industry partners of hydrogen suppliers and end users across the state, including SoCalGas, in partnership with the Governor's Office of Business and Economic Development (GO-Biz).[22] ARCHES's focus is on creating clusters of hydrogen production, transport, storage, and use to support the development of a statewide hydrogen economy.[23] ARCHES submitted an application to the U.S. Department of Energy (DOE) for the Regional Clean Hydrogen Hubs Funding Opportunity and aims to utilize local renewable resources to produce hydrogen and fully decarbonize the regional economy. After a rigorous application and review process, ARCHES was one of 7 hubs selected for up to $1.2 billion in federal funding[24]. The application details are still confidential, and ARCHES will need to go through a negotiation stage with the DOE in order to secure funding and start building out the hub. DOE/ARCHES negotiations initiate on November 1, 2023. This new development supports California's clean energy and climate goals with a strong commitment on community benefits and is a central focus of SoCalGas. Key priorities of ARCHES' efforts include environmental justice, equity, economic leadership, and workforce development. In addition to existing state-wide zero-emission legislation and goals, the State has allocated funds towards key elements of the hydrogen value chain, including $20M in grant funds to support the development of 100 publicly available hydrogen refueling stations across the state with California Assembly Bill 126.[25]

Purpose and Objectives

Ordering Paragraph 6 of the Decision requires SoCalGas to provide the following findings (among others) from its Phase One feasibility studies:

- "Identification of the demand and end uses for the Project" (Ordering Paragraph 6.a)
- "Identification of the ratepayers who would be end-users, including current natural gas customers and future customers" (Ordering Paragraph 6.c)

[21] State of California, "California Releases World's First Plan to Achieve Net Zero Carbon Pollution" (November 16, 2022). https://www.gov.ca.gov/2022/11/16/california-releases-worlds-first-plan-to-achieve-net-zero-carbon-pollution/

[22] Alliance for Renewable Clean Hydrogen Energy Systems. https://archesh2.org/

[23] ARCHES, "Alliance for Renewable Clean Hydrogen Energy Systems" (2023). https://archesh2.org/

[24] ARCHES, "California wins up to $1.2 billion from feds for hydrogen" (October 20, 2023). https://archesh2.org/california-wins-up-to-1-2-billion-from-feds-for-hydrogen/

[25] State of California, "AB-126 Vehicular air pollution: Clean Transportation Program: vehicle registration and identification plate service fees: smog abatement fee: extension." (October 9, 2023). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202320240AB126

The Demand Study has identified both existing and future SoCalGas ratepayers who would be end-users of Angeles Link. Existing ratepayers include power generation facilities, industrial customers such as metal fabrication shops, food and beverage manufacturing/processing facilities, stone/glass/cement facilities, pulp and paper, chemicals, mobility customers such as bus fleet operators and other heavy-duty vehicle operators that take service from SoCalGas CNG stations, and refineries, among others. Future potential ratepayers, who are not currently served by SoCalGas and could benefit from Angeles Link, include non-utility served heavy-duty vehicle operators, commercial harbor craft operators, ocean-going vessel operators, and locomotive operators. This study is limited to identification of certain but not all potential end uses that may drive potential demand for clean renewable hydrogen and does not attempt to evaluate the rate treatment of Angeles Link's construction and operation and maintenance costs, which is expected to occur in future phases. Continued analysis in future phases of Angeles Link will further identify and refine potential customers and beneficiaries of Angeles Link.

Scope

The aim of the Demand Study is to provide a comprehensive and market-validated outlook for clean renewable hydrogen demand in the mobility, power generation, and hard-to-electrify industrial sectors from present day to 2045. The main objectives include:

1. Identifying and validating demand, major end uses, and representative end users from present to 2045 across the Mobility, Power Generation, and Industrials sectors. Sectors, subsectors, and scenarios included in the analysis can be seen in figure below.

2. Consolidating results into a final report, consisting of timeline, demand map, and a list of representative adopters and non-adopters

3. Supporting integration of demand results into other Phase One studies, including technical and engineering studies, and project economics.

Figure 6: Demand Model Scenario Definition and Subsectors Included

Conservative	Scenario assumes lower adoption rates for hydrogen across a limited set of use-cases within prioritized sectors and sub-sectors, primarily driven by existing legislation. **Mobility:** Heavy Duty Vehicles, Medium Duty Vehicles, Cargo Handling Equipment, Ground Support Equipment, Agricultural Equipment, Construction & Mining Vehicles, Commercial Harbor Craft, Ocean Going Vessels* **Power:** Peaker, Baseload **Industrials:** Cogeneration, Food & Beverage, Metals, Stone, Glass, and Cement, Paper, Chemicals, Aerospace and Defense
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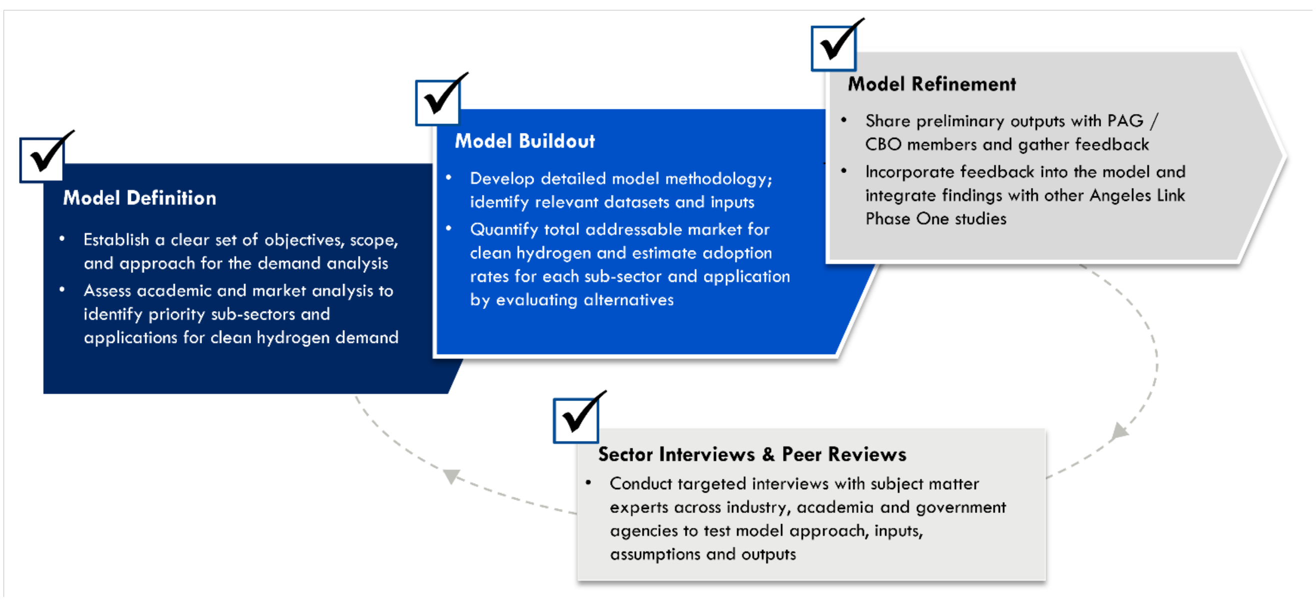
** OGV vessel demand modeling reflects hydrogen for diesel fuel replacement only (does not include bunker fuel replacement)*

Methodology

Demand Analysis Approach

The Demand Study followed three main steps designed to embed rigor and third-party review throughout the full analysis process. These steps are described in the figure below:

Figure 7: Demand Analysis Approach



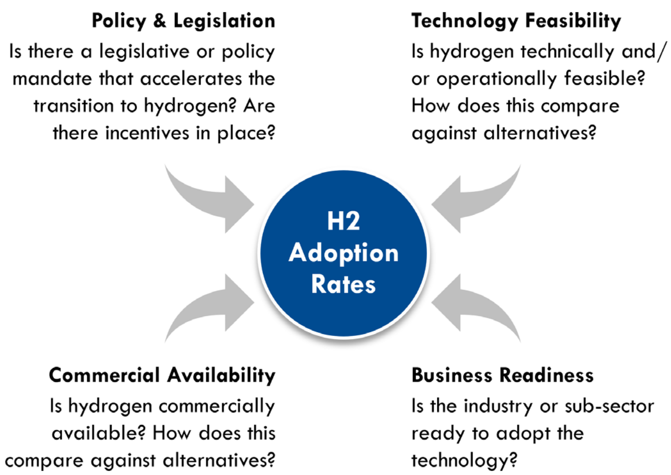
At the onset of the Demand Study, subsectors were prioritized for quantitative analysis based on current emissions, current natural gas usage, and a qualitative evaluation of potential for hydrogen in the subsector. The hydrogen demand for prioritized subsectors has been analyzed, with quantitative demand results outlined in this report. Subsectors not prioritized for quantitative analysis were not modelled, but potential opportunities for additional demand in these subsectors has been noted in this report. Throughout the analysis process, targeted interviews were conducted with subject matter experts across industry, academia and government agencies to test these adoption inputs and assumptions, the model approach, and model outputs.

Adoption Factors

Four primary factors were used to determine future hydrogen adoption across sectors: policy & legislation[26], technology feasibility, commercial availability, and business readiness. These factors reflect whether hydrogen is likely to be adopted in a specific subsector and to what extent hydrogen will be adopted versus alternatives.

Adoption factors have been quantified and inputted into the demand model where possible, with the different levels of adoption in 2045 and curves of the adoption rate from 2025-2045 reflecting the substantial variations in adoption factors between subsectors. Sector-specific treatment and considerations are described in the following findings by sector sections.

Figure 8: Hydrogen Adoption Factors



Simplifying Assumptions

The Demand Study has various simplifying assumptions for the purpose of meeting the study objectives in a timely manner. Simplifying assumptions and plans to address them are outlined below:

[26] Throughout the report, the word "legislation" is used to refer to law, rules, and regulations, whether passed/adopted on at the federal, state, regional, or local level.

- **Price of Hydrogen:** The forecasted cost of clean renewable hydrogen was not factored into the potential demand analysis in order to understand the total potential of hydrogen as a fuel in the Los Angeles Basin and SoCalGas territory. In addition, the key drivers for hydrogen use in many cases in this Demand Study are policy mandates such as SB100, Advanced Clean Trucks (ACT), and ACF, as well as technical feasibility. The forecasted cost of clean renewable hydrogen is an important factor in projecting adoption and will need to be assessed in future phases of the Angeles Link project. Although analysis and forecasts of delivered levelized cost of hydrogen (LCOH) were outside the scope of this Demand Study, the LCOH analysis will be evaluated in other Phase One studies and further refined in future Angeles Link phases. Specifically, SoCalGas intends to study LCOH in the High-Level Economics and Cost Effectiveness Study. SoCalGas will also utilize forecasts of clean renewable hydrogen costs to refine demand volumes in future phases.

    - **Mobility:** The CapEx and OpEx of hydrogen FCEVs were evaluated against alternatives, with fuel prices omitted.

    - **Power:** The CapEx of retrofitted hydrogen combustion equipment versus CCUS and battery alternatives were considered, and the price of hydrogen was assumed equivalent to the price of natural gas.

    - **Industrials:** The CapEx of retrofitted hydrogen combustion equipment versus CCUS and battery alternatives were considered, and the price of hydrogen was assumed equivalent to the price of natural gas.

  Demand analysis refinements may be considered in the future as economic projections are updated.

- **Power System Reliability & Capacity Factors:** This study has not conducted a grid level system reliability analysis to understand how hydrogen capacity can support California's electric reliability standards as renewable penetration increases; therefore, the current analysis does not attempt to model the full power system or forecast future electric grid demand. Additional future assessments will be needed to more thoroughly understand reliability, particularly in the context of increased electric demand and its potential impact on hydrogen capacity and capacity factors.

- **Readily Available Hydrogen:** The demand study assumed that hydrogen will be readily available so as not to constrain the analysis with supply side limitations. This assumption may require future refinement to incorporate findings from other Angeles Link studies and industry updates.

Recommendations for Future Analysis

Throughout the study, a variety of simplifying assumptions were used to develop a reasonable range for hydrogen demand within the Angeles Link Phase One timeline. Areas where simplifying assumptions have been used provide an opportunity for more detailed analysis in the future to improve the granularity and confidence level of demand projections. The specific components that should be assessed in future phases of Angeles Link include:

1. Full power system modeling, including load growth and electric sector reliability modeling, to inform the extent to which hydrogen is needed and can be used to fulfill future reliability requirements.
2. Economic modeling to understand future declines in the cost of hydrogen, future increases in the cost of current fuels (due to carbon pricing programs), demand elasticity, and the associated impact to demand volumes.
3. Geographic demand analysis with a focus on mobility to better understand at a granular level how demand will be distributed across SoCalGas' service territory.

Other assumptions may also be refined in future Angeles Link work, and other areas for recommended further analysis are identified throughout the report where applicable.

Key Findings

The Angeles Link demand study found that potential clean renewable hydrogen demand across SoCalGas' service territory could range between 1.9M and 6.0M TPY by 2045. Demand is projected to be highest in the mobility sector in the conservative scenario, followed by the power generation and industrials sectors, respectively. In the moderate and ambitious scenarios, the power sector accounts for the largest portion of hydrogen demand, followed by the mobility sector and then the industrials sector.

Mobility

- **Mobility can drive early adoption and scale.** 1.0M to 1.7M TPY of hydrogen demand is expected from the Mobility sector, accounting for 53% in the conservative scenario and 28% in the ambitious scenario. Since hydrogen fuel cell vehicles and associated transportation infrastructure is already being rolled out in SoCalGas' service territory, mobility applications may be the largest source of near-term clean hydrogen demand.

- **The operational characteristics required for on-road HDV applications lend favorably towards hydrogen adoption over alternatives.** Characteristics such as range requirements, load requirements, duty-cycle requirements, and fueling requirements all lend themselves positively towards adopting hydrogen over battery electric alternatives. Importantly, these characteristics should be considered in unison—as opposed to looking at any one of these characteristics in isolation. When doing so and evaluating FCEVs vs. BEVs, maximizing tonne-mile potential of a vehicle lends favorably to FCEVs over BEVs. If a fleet operator is looking to maximize freight transported over time, they would look more favorably on FCEVs.

- **Mobility demand is likely to be concentrated along transit corridors**, largely reflecting current diesel consumption today. Large fleet operators, particularly those moving freight, are unlikely to want their operations to change. Warehouse locations, refueling locations, and associated infrastructure have developed where they are now and have been optimized. So, to minimize any future investment required or changes in operations, we expect that fleet operators will look for diesel replacements that can operate as similarly as possible to diesel trucks today (short refueling times, long range, and a distributed fueling network). In SoCalGas service territory, there are currently over 50 truck stops, nearly 100 cardlock facilities, and over 4,000 gas stations publicly listed by the CEC.[27] Their scale and locations reflect breadth of current refueling infrastructure.

- **FCEV OEMs need to achieve economies of scale to achieve vehicle price reductions and mass adoption.** ZEVs can still be 2-6x more expensive than ICE vehicles (particularly for the

[27] California Energy Commission. https://hub.arcgis.com/datasets/ec575b2693f64199866bc18744d232fe/explore

heaviest-duty vehicles), though prices are steadily dropping.[28] Meanwhile 60 OEMs have announced planned sales of electric medium-duty vehicles (MDV), HDVs, or buses by 2024, whereas only 10 OEMs have done so for the equivalent hydrogen vehicles (According to CALSTART's ZETI tool, as of September 2023).[29] While the number of OEMs announcing production is not necessarily correlated to the amount of vehicles produced, these figures highlight the challenges faced for FCEV mass adoption. That said, many of these OEM announcements are for MDVs, which generally have lower operational requirements (range, load, etc) and therefore favor conversion to BEV or FCEV.

- **A secondary market for ZEVs may reduce adoption barriers.** Secondary markets create liquidity, encourage price transparency, and enable lower prices. While a secondary market is not necessarily a requirement for mass-adoption of ZEVs, there are many fleet operators today—importantly, drayage fleet operators—who tend to procure ICE vehicles on the secondary market due to affordability concerns. So, with ZEV prices still significantly above ICE vehicle prices, these operators may face substantial costs to purchase new ZEVs and to comply with state requirements. There are very few heavy-duty ZEVs in use today beyond those in pilot programs, and few incentive mechanisms in place to support primary and secondary ZEV markets, so, more affluent fleet operators may be hesitant to assume the financial risks associated with being first movers; the less affluent fleet operators may be even more hesitant to adopt ZEVs until affordability issues are resolved. The creation of ZEV resale credits to provide financial assurances for early adopters and to create affordability for purchasers on the secondary market could enable wider adoption of ZEVs.

- **Marine and aviation applications could have significant demand for clean hydrogen.** Long-haul and regional aircraft, as well as cargo ships, consume substantial amounts of fuel. The inherent long replacement cycle (often 30+ year asset lifetimes), high duty-cycles, and the inter-state and international aspect of these applications mean that adoption of a new standard fuel could take many years.

Power Generation

- **Power could become the anchor hydrogen infrastructure driver** if capacity factors reach scenarios assessed in this demand study**.** Power represents between 0.7M and 2.7M TPY of hydrogen demand by 2045, accounting for 38% of total demand in the conservative scenario and 51% in the ambitious scenario. These results reflect the important and complementary role clean renewable hydrogen could play to renewable energy as a dispatchable resource that can be ramped up or down in response to changes in solar and wind generation and can provide long-duration storage. This phase one Demand Study does not attempt to forecast future

[28] Argonne National Labs. "Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains". (April 2021). https://publications.anl.gov/anlpubs/2021/05/167399.pdf
[29] CALSTART ZETI. https://globaldrivetozero.org/tools/zeti/. Accessed 9/26/2023.

electric load growth; however, CARB has projected in their 2022 Scoping Plan[30] that hydrogen will play a larger role in serving future load growth and be part of the resource mix that helps California meet its SB100 retail sales target. CARB projects 9 GW of incremental hydrogen capacity on top of 33 GW of gas generation that will be needed to meet SB100 targets by 2045, and the Demand Study estimates 10-13 GW of hydrogen capacity adoption within today's existing power capacity levels (in other words assuming conversion from only existing gas-fired plants in operation today, not incremental capacity). The relatively high hydrogen demand projected in the power sector positions power generation as a key source of the demand volume needed to kickstart infrastructure development.

- **Future hydrogen capacity factors remain uncertain.** Capacity factors will be dependent on the makeup of the overall power system, the future demand of the electric grid, and the cost and availability of hydrogen fueled power generation relative to other forms of generation. The cost of hydrogen as a fuel source will be a critical factor. Timing of supply and demand will also impact capacity factors for hydrogen fueled power generation. Even at very low annual capacity factors, the hourly flow rates needed to support power generation during peak demand periods could be significant, making cost-effective and reliable delivery of hydrogen to power plants a key consideration and serving as a determining factor for pipe sizing. In addition, achieving sufficient local reliability will be an important element that impacts future capacity factors and the need for firm dispatchable power.

- **Legislation is a key enabler.** SB100 and SB1020 are key pieces of legislation driving power-sector decarbonization in California. The legislation accelerates the state's Renewable Portfolio Standard (RPS) program to 90% renewable by 2035 with 100% renewable and zero-carbon electricity by 2045. Additional legislation making hydrogen in gas turbines eligible for SB100 compliance could specifically drive the adoption of clean renewable hydrogen in this sector, as the combustion of hydrogen is not RPS compliant nor is zero-carbon resources defined to include hydrogen.[31,32] For example, while this report does not advocate for any particular policy outcomes, it is noted that if hydrogen was included in the CPUC's Integrated Resource Plan and was eligible for SB100, that could increase hydrogen demand. LADWP's target of supplying 100% renewable energy by 2035 is a key driver of early renewables adoption as well.

- **The transition to hydrogen will be gradual.** In the near term, as utilities prepare for SB100 and SB1020 requirements, analysis suggests that existing natural gas combustion turbines within SoCalGas' service territory can be modified to burn blended volumes of up to 30% hydrogen and that technologies capable of utilizing 100% volumes of hydrogen can be available

[30] California Air Resources Board. "2022 Scoping Plan for Achieving Carbon Neutrality". Figure 4-5. (December 2022). https://ww2.arb.ca.gov/sites/default/files/2023-04/2022-sp.pdf

[31] California Energy Commission. "Renewable Portfolio Standard Eligibility Guidebook". Renewables Portfolio Standard - RPS | California Energy Commission

[32] Hydrogen produced without fossil fuels and used in a fuel cell is an eligible RPS resource per the CEC RPS Guidebook

by 2030.[33,34,35] Despite the gradual nature of a hydrogen transition in the power sector, power purchase agreements between renewables companies and hydrogen producers or hydrogen-based power producers and utilities can be used to provide certainty for hydrogen power projects, making them more attractive to investors and helping establish a stable market for hydrogen-generated electricity. Public acceptance will also be crucial for enabling this hydrogen transition.

Industrials

- **Hydrogen has been recognized as a clean fuel alternative for hard-to-electrify industries.** The breadth of industries in California presents a plethora of potential hydrogen use cases, with industries such as metals, food and beverages, stone, glass, and cement, chemicals, and aerospace facing difficulties decarbonizing through electrification. For example, part of CARB's actions in their 2022 Scoping Plan include hydrogen fueling 25% of process heat by 2035 and 100% by 2045 for the chemicals, pulp and paper sector, and include dedicated hydrogen pipelines in the 2030s to serve industrial clusters.[36] However, this breadth of industries presents challenges given the fragmented nature of the market.

- **Power cogeneration and refinery chemical usage represent the largest industrials demand centers for clean hydrogen in Southern California.** Within SoCalGas' service territory, model results indicate potential hydrogen demand of 0.2M to 1.5M TPY by 2045. In the conservative and moderate scenarios, industrials accounts for 9-26% of total demand. Demand outside of refining and cogeneration applications is primarily from fuel switching applications (often heating), where direct electrification is competitive.

- **Technology Research and Development (R&D) continues to be needed to accelerate commercialization across other sectors, which means ramp up may take some time.** Customers will likely want to see clear demonstrations of the value of conversion to hydrogen before interrupting their existing capabilities and systems that are optimized for operational efficiency. In the food and beverage industry, gas catalytic-style hydrogen-capable burners can be used for baking, drying and space conditioning, but these are under development and are 5-10 years away from commercialization. In the metals industry, infrared emitting hydrogen-capable burners are also under development. Purpose-built 100% hydrogen furnaces, ovens and boiler systems are being modeled and will be in demonstration in the coming years that can provide metals industry customers with more efficient by-design hydrogen fueled process heating alternatives. For example, companies in Europe are expecting to produce green steel by as early as 2025 using clean hydrogen.[37]

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[33] Mitsubishi Power. "Hydrogen Gas Turbine". https://solutions.mhi.com/power/decarbonization-technology/hydrogen-gas-turbine/
[34] GE Gas Power. "Hydrogen fueled gas turbines". https://www.ge.com/gas-power/future-of-energy/hydrogen-fueled-gas-turbines
[35] Siemens Energy. "Zero Emission Hydrogen Turbine Center". https://www.siemens-energy.com/global/en/home/products-services/solutions-usecase/hydrogen/zehtc.html
[36] California Air Resources Board. "2022 Scoping Plan for Achieving Carbon Neutrality". Table 2-1. (December 2022). https://ww2.arb.ca.gov/sites/default/files/2023-04/2022-sp.pdf
[37] European Commission. "The HYBRIT story: unlocking the secret of green steel production". (June 20, 2023). https://climate.ec.europa.eu/news-your-voice/news/hybrit-story-unlocking-secret-green-steel-production-2023-06-20_en

- **Legislation/Regulation will be important to accelerate the timeframe and scale of hydrogen's impact.** Decarbonization of industrial sectors is difficult and costly given the typically long lifetime of equipment, the potential need for facility-wide retrofits, and the currently integrated natural gas usage. Where companies are not willing to take on these costs and challenges, legislative and regulatory targets and incentives can serve as drivers of hydrogen demand and growth. For example, if CARB created programs similar to LCFS for stationary sources, this would authorize those companies to participate in a carbon reduction program while receiving incentives to pay for the more expensive fuel and equipment. Cement is one early example where we see legislation taking place and where we expect hydrogen demand for fuel switching to take shape first, with existing legislation through SB 596 that mandates a reduction in emissions from cement producers by 40% of 1990 levels by 2030 and net-zero by 2045. In addition, part of CARB's actions for their Scoping Plan scenario in the

Cross-Sector Takeaways

- **There exists a wide breadth of use cases for hydrogen in SoCalGas' service territory, providing a stable source of demand under any scenario**. Multiple hard-to-electrify subsectors have been evaluated across mobility, power generation, and industrials, with many subsectors showing positive potential for hydrogen. This study reveals that hydrogen is a feasible decarbonization alternative that can fit into and strengthen the broader state decarbonization portfolio. Subsector diversification will drive economies of scale across hydrogen production, transportation and distribution, and consumption, ultimately leading to a growing hydrogen market in the future.

- **Legislation and regulation can have a significant impact to accelerate hydrogen adoption.** As demonstrated by the rapid displacement of traditional fuels by alternative fuels driven by the CARB LCFS Program—in Q1 2023, CARB announced that 50% of California diesel fuel was replaced by clean fuels[38]--market dynamics can shift based on legislation and regulation. For example, the recent demand-side funding mechanism released by the DOE could help spur significant demand from a diverse set of off-takers. If additional funding, tax incentives, and regulations to incentivize end-users to adopt clean renewable hydrogen solutions were established, those programs would also be expected to accelerate and increase adoption across all market sectors. Future legislation and policy, plus increased stringency of existing carbon regulatory programs, have the potential to impact the industrials sector in particular, where there have been minimal targeted legislative targets and policy incentives to date. In the mobility and power sectors, California has already been leading proactively on the policy front, with aggressive targets for clean power through SB100 and for the mobility through the Advanced Clean Cars II, ACT and ACF regulations. Similarly, if clean renewable hydrogen is included in the list of approved fuels for the SB100[39] and SB1440 programs in the future, it is

[38] California Air Resources Board. "For first time 50% of California diesel fuel is replaced by clean fuels". (August 2023). https://ww2.arb.ca.gov/news/first-time-50-california-diesel-fuel-replaced-clean-fuels
[39] Clean hydrogen is eligible in SB100, however in the first SB100 report, the CEC decided not to model hydrogen in any of the scenarios.

expected that would have the effect of driving down costs for clean renewable hydrogen, similarly to how the RPS program reduced the cost of solar and wind.

- **Public-private partnerships are an attractive arrangement that can lower the cost of hydrogen adoption and scale up technological and commercial availability of hydrogen-related technology.** According to the DOEs Commercial Liftoff Report for Hydrogen, scaling clean renewable hydrogen will require a 4-10x scale-up of capital by 2030.[40] This includes the investment of both public and private sector capital. Federal investment can enable the financing of innovative projects and scale deployment rapidly. The development of contracting mechanisms to de-risk hydrogen projects, with the support of public entities, could incentivize additional investment across the private sector. Policy and market-based solutions to increase capital availability in the hydrogen economy will help mitigate cost and technical challenges for clean renewable hydrogen adoption across all sectors. In California, ARCHES was established to establish a federally co-funded clean renewable hydrogen hub in the state and to create an economically sustainable and expanding renewable hydrogen market in California and beyond.

- **Technology cost is a key limiting factor to hydrogen adoption in the short-term.** Today, converting to hydrogen technology poses significant capital expenditures and debt servicing across the mobility, power, and industrials sectors that may inhibit financial feasibility in the short- to medium-term. For mobility, the costs of hydrogen refueling infrastructure for FCEVs will be high in early years, as there will be fewer users per station until there is greater adoption across the market. For power generation, there will be cost to retrofit existing combustion turbines to be 100% hydrogen capable—today, existing power plants that can burn more than a trace amount of hydrogen are rare, although 30% blends by volume are possible in the near future with retrofits to delivery systems. For industrials, the cost of retrofit and replacement of existing equipment could be significant and any change to existing processes could impact efficiency and for certain processes, product quality. Beyond technology costs alone, the DOE has set targets of achieving $1 per kilogram hydrogen by 2030 with their Hydrogen Shot initiative.[41]

- **Readily available hydrogen supply through connective infrastructure will be critical to supporting long-term adoption.** Whether available at refueling stations or through common carrier access pipelines, both public and private users of clean hydrogen will rely on connective infrastructure. The demand study assumed that hydrogen will be readily available so as not to constrain the analysis with supply side limitations. But, fulfilling the demand for clean renewable hydrogen presupposes that sufficient and stable supply of hydrogen, as well as the connective infrastructure that will bridge supply and demand, exist. Hydrogen pipelines such as the Angeles Link project proposed by SoCalGas would be able to serve as this bridge. The DOE's Hydrogen Strategy Report highlights the importance of hydrogen infrastructure in scaling and

[40] Department of Energy. "Pathways to Commercial Liftoff: Clean Hydrogen". (March 2023). https://liftoff.energy.gov/wp-content/uploads/2023/03/20230320-Liftoff-Clean-H2-vPUB.pdf
[41] Department of Energy. "Hydrogen Shot". (2021). https://www.energy.gov/eere/fuelcells/hydrogen-shot

commercialization, noting that "If regional networks prioritize shared, open-access infrastructure they can help to reduce the delivered cost of hydrogen"[42]

- **Community engagement and support is critical.** There is a broad range of stakeholders interested in the development and study of Angeles Link, including potential end users, potential suppliers, environmental and environmental justice community groups, ratepayer advocacy groups, union organizations, state agencies, and others. SoCalGas has invited these stakeholders to join a Planning Advisory Group and public webinars, townhalls, and workshops to gather feedback and technical advice and collaboration on Project design and development.[43] While these types of stakeholder engagements are important for the design and development of Angeles Link, they are also a key component in ensuring that the use of clean renewable hydrogen reach the projected levels of demand projected in the demand study. By gaining public trust and approval through close community engagement, end users can more easily adopt hydrogen given favorable policy, technical, and commercial conditions.

[42] "U.S. National Clean Hydrogen Strategy and Roadmap." https://www.powermag.com/wp-content/uploads/2023/06/us-national-clean-hydrogen-strategy-roadmap.pdf

[43] California Public Utility Commission. "Decision Approving the Angeles Link Memorandum Account to Record Phase One Costs." (November 7, 2022). https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M498/K339/498339407.PDF

Findings by Sector

Mobility

Introduction

California's mobility sector accounts for 37% of the state's GHG emissions, nearly 80% of nitrogen oxide pollution, and 90% of diesel particulate matter pollution.[44] California has set targets to achieve net zero emissions by 2045 across all sectors, and decarbonizing the mobility sector will be key to reaching these goals.[45] In the push to decarbonize the mobility sector, both hydrogen fuel cell and battery electric technologies have shown promise for many applications. This study shows the potential for hydrogen, with particular focus on the use cases best fit for this fuel type. The mobility sectors modelled include four primary subsectors: on-road vehicles, off-road vehicles, marine, and aviation.

Mobility Landscape

California State Policy and Legislative Initiatives for a Zero-Emission Mobility Sector

California is a clear leader in ambitious decarbonization initiatives, from establishing new policies and mandates to supporting the adoption of renewable technologies. In line with the State's goal to achieve carbon neutrality by 2045, the State and many entities within it have passed legislation or submitted plans to significantly decarbonize the mobility sector, including but not limited to:

- **Executive Order (EO) N-79-20** – Issued by Governor Gavin Newsom in 2020, setting targets for achieving net zero in the mobility sector by 2045.[46]
- **ACF** – Regulation adopted by CARB and the State of California in 2023 requiring 100% of new truck purchases by fleets be ZEV by 2035, and as early as 2024 for some vehicles.[47]
- **ACT** – Regulation adopted by CARB and the State of California requiring ZEV sales to achieve certain milestones from 2024 to 2035 and beyond.[48]
- **Innovative Clean Transit (ICT)** – Requires each transit agency to submit a complete Zero-Emission Bus Rollout Plan (Rollout Plan).[49]

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[44] California Air Resources Board. "California Greenhouse Gas Emissions for 2000 to 2020". (October 26, 2022). https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/2000-2020_ghg_inventory_trends.pdf

[45] California Air Resources Board. "California releases final proposal for world-leading climate action plan that drastically reduces fossil fuel dependence, slashes pollution." (November 16, 2022). https://ww2.arb.ca.gov/news/california-releases-final-2022-climate-scoping-plan-proposal

[46] State of California. "Executive Order N-79-20". (September 23, 2020). https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf

[47] California Air Resources Board, "Advanced Clean Fleets Regulation Summary" (May 17, 2023). https://ww2.arb.ca.gov/resources/fact-sheets/advanced-clean-fleets-regulation-summary

[48] California Air Resources Board, "Advanced Clean Trucks" (2019). https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2019/act2019/fro2.pdf

[49] California Air Resources Board. "ICT-Rollout Plans". (2023). https://ww2.arb.ca.gov/our-work/programs/innovative-clean-transit/ict-rollout-plans

- **Advanced Clean Cars II (ACCII)** – Regulation adopted by CARB and the State of California requiring 35% of new car sales to be ZEV starting in 2026, ramping up to 100% of sales by 2035.[50]

- **Clean Air Action Plan (CAAP)** – Strategy set forth by the Port of Los Angeles and Port of Long Beach (together known as the San Pedro Bay Ports) to reduce emissions in the port area by requiring 100% of CHE to ZEV by 2030.[51]

- **Clean Shipping Act of 2023** – Bill passed in 2023 requiring commercial vessels to operate with 100% zero emission fuel by 2040.[52]

- **Low Carbon Fuel Standard (LCFS)** – Covered under the AB 32 Scoping Plan (Assembly Bill 32 (AB 32)) which is an emissions trading rule designed to reduce the average carbon intensity of transportation fuels.[53]

- **SCAQMD Warehouse Indirect Source Rule (ISR)** – approved in 2021 requires warehouses greater than 100,000 square feet to directly reduce nitrogen oxide (NOx) and diesel particulate matter (PM) emissions, or to otherwise reduce emissions and exposure of these pollutants in nearby communities.[54]

- **Cap-and-Trade** – California's cap-and-trade program sets annual reductions in the cap or amount of permissible emissions.[55]

The significant volume of legislation and zero-emissions guidelines in California are key driving factors for the adoption of hydrogen and battery technologies in the mobility sector.

Hydrogen in the Mobility Sector

There are over twelve thousand FCEVs, mainly passenger cars, on the road today in California.[56] These light-duty vehicles (LDV) have been some of the earliest proofs of concept for fuel cell technology. Meanwhile the early adopters of fuel cell technologies for heavy-duty applications has come from California's Transit agencies, with announced plans to purchase over 2,100 fuel cell electric buses (FCEB) across the state.[57] There are currently over 12,000 transit buses (of all types) in operation across the state.[58] Local transit operators are some of the earliest adopters of FCEBs, recognizing clean renewable hydrogen as an attractive solution for decarbonization of their fleets, given

[50] California Air Resources Board. "Advanced Clean Cars II Regulations: All New Passenger Vehicles Sold in California to be Zero Emissions by 2035." https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii
[51] The Port of Los Angeles. "Clean Air Action Plan." (2023). https://cleanairactionplan.org/
[52] 118th Congress, "Clean Shipping Act of 2023" (April 6, 2023). https://robertgarcia.house.gov/sites/evo-subsites/robertgarcia.house.gov/files/evo-media-document/garcro_029_xml.pdf
[53] California Air Resources Board. "Low Carbon Fuel Standard". https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard/about
[54] South Coast AQMD. "South Coast AQMD Governing Board Adopts Warehouse Indirect Source Rule. (May 2021). http://www.aqmd.gov/home/research/pubs-docs-reports/newsletters/august-september-2021/indirect-source-rule
[55] California Air Resources Board. "Cap-and-Trade Program". https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program/about
[56] California Energy Commission. "Zero Emission Vehicle and Infrastructure Statistics". (2023). https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics
[57] California Air Resources Board. "Fuel Cell Electric Bus Deployment in California". (2023). https://ww2.arb.ca.gov/sites/default/files/2022-10/FCEB-Deployment-Map.pdf
[58] California Air Resources Board. "California transitioning to all-electric public bus fleet by 2040". https://ww2.arb.ca.gov/news/california-transitioning-all-electric-public-bus-fleet-2040

hydrogen's ability to support multiple shifts each day with fast refueling times. Several manufacturers are currently developing fuel cell trucks for on-road heavy-duty applications as well, including Toyota, Hyundai, and Nikola, who are developing fuel cell Class 8 semi-trucks with reported ranges of up to 500 miles when fully loaded.[59, 60, 61] With refueling in as little as 20 minutes today, Nikola has demonstrated that their fuel cell electric semi-truck can travel as much as 900 miles in a single day [62]

California is also leading in hydrogen refueling infrastructure and commitments with 57 out of 58 on-road, public refueling stations nationwide being in California (as of July 2023).[63] In its 2022 Annual Evaluation of FCEV Deployment, CARB projected 176 open stations by 2026 and 2027 in the state, 35 of which are being planned in Los Angeles County.[64] Additionally, the CEC, as part of the Clean Transportation Program, is providing funds to support the development of 100 public fueling stations across California.[65] Additionally, many transit agencies are developing private cardlock hydrogen fueling stations for their FCEB fleets as well. These stations could support fast fueling: in 2019 the DOE released updated targets to achieve 8 kg H2/min fueling flow rates by 2030 and 10 kg H2/min by 2050.[66] Infrastructure readiness is a critical factor influencing business readiness to adopt hydrogen or electric technologies.

While current hydrogen fueling stations are generally being built for LDVs or FCEBs, these investments are critical to promoting shared infrastructure and the viability of hydrogen technology that can be leveraged by HDV applications in the future. There are currently no final standards or example stations tailored for HDV applications, resulting in considerable uncertainty surrounding commercial costs. However, as the hydrogen ecosystem develops around LDVs, FCEBs, and fuel cell HDVs, the technologies developed to support certain applications can be leveraged to help grow hydrogen usage for other applications. In 2018, the California Fuel Cell Partnership published its vision for 2030, reflecting the input and consensus of more than 40 partners; according to this vision, the Partnership will pursue a network of 1,000 hydrogen refueling stations and one million FCEVs in California by 2030.[67]

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[59] Green Car Reports. "Hyundai will test 500-mile hydrogen fuel-cell semis in California". (July 27, 2021). https://www.greencarreports.com/news/1133014_hyundai-will-test-500-mile-hydrogen-fuel-cell-semis-in-california

[60] Toyota. "Toyota, Kenworth Prove Fuel Cell Electric Truck Capabilities with Successful Completion of Truck Operations for ZANZEFF Project". (September 2022). https://pressroom.toyota.com/toyota-kenworth-prove-fuel-cell-electric-truck-capabilities-with-successful-completion-of-truck-operations-for-zanzeff-project/

[61] Nikola. "Nikola Celebrates the Commercial Launch of Hydrogen Fuel Cell Electric Truck in Coolidge, Arizona". (September 2023). https://www.nikolamotor.com/press_releases/nikola-celebrates-the-commercial-launch-of-hydrogen-fuel-cell-electric-truck-in-coolidge-arizona/#:~:text=Nikola's%20ground%2Dbreaking%20hydrogen%20fuel,as%20low%20as%2020%20minutes.

[62] Securities Exchange Commission. "Nikola President & CEO Steve Girsky Chat Transcript". (September 13, 2023). https://www.sec.gov/Archives/edgar/data/1731289/000173128923000252/exhibit991firesidechat91323.htm

[63] US DOE Alternative Fuels Data Center. "Alternative Fueling Station Counts by State." https://afdc.energy.gov/stations/states

[64] CARB. "2022 Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development" https://ww2.arb.ca.gov/sites/default/files/2022-09/AB-8-Report-2022-Final.pdf

[65] State of California, "AB-126 Vehicular air pollution: Clean Transportation Program: vehicle registration and identification plate service fees: smog abatement fee: extension." (October 9, 2023). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202320240AB126

[66] Department of Energy. "DOE Advanced Truck Technologies Subsection of the Electrified Powertrain Roadmap Technical Targets for Hydrogen-Fueled Long-Haul Tractor-Trailer Trucks" (October 31, 2019). https://www.hydrogen.energy.gov/pdfs/19006_hydrogen_class8_long_haul_truck_targets.pdf

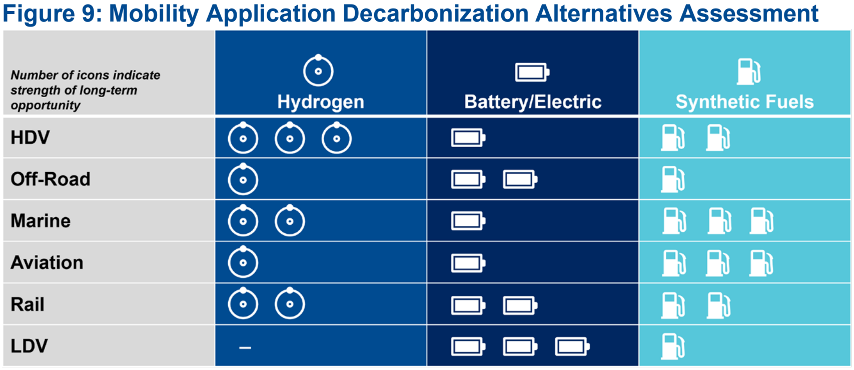
[67] California Fuel Cell Partnership. "The California Fuel Cell Revolution". (August 28, 2018). https://h2fcp.org/sites/default/files/CAFCR-Presentation-2030.pdf

For hydrogen fuel cell technologies to become commercially available and affordable, fuel cell production needs to be ramped up to achieve the cost reductions and operational efficiencies of economy of scale. While cell type and stack composition may change and be optimized by application, fuel cells can generally be used across applications, meaning that the fuel cells manufactured for LDVs or HDVs could be used in off-road vehicles. To facilitate mass-production of fuel cells, DOE has set targets of $60 per kilowatt (kW) for fuel cell stacks by 2050.[68] Additionally, the federal government has announced several funding opportunities to provide funding to accelerate fuel cell development, such as $750 million as a part of IIJA to research Fuel Cell Membrane Electrode Assembly and Stack Manufacturing and Automation, Fuel Cell Supply Chain Development, and more.[69]

Decarbonization Pathways and Alternatives

There are typically three types of low-carbon alternatives to traditional fuels in the mobility sector: electric (either direct electrification or battery), hydrogen (used in fuel cells or combusted), or synthetic fuels (such as renewable diesel or SAF). Each of these alternatives and their associated technologies has their own benefits and challenges over current fossil fuel technologies, and the future cost, performance, and development trajectories of each technology is uncertain.

Figure 9: Mobility Application Decarbonization Alternatives Assessment



The DOE's U.S. National Blueprint for Transportation Decarbonization outlines the plausibility of various decarbonization fuel alternatives across some of the mobility subsectors.[70]

Battery Electric

CARB states in their 2022 Scoping Plan that the primary ZEV technologies available today are battery electric and hydrogen fuel cell electric vehicles, and that both types of vehicles are rapidly growing in performance, affordability, and popularity.[71] Today, battery technologies are prevalent among LDV applications, building upon the momentum of the hybrid electric technologies before them. However, for

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[68] Department of Energy. " DOE Advanced Truck Technologies Subsection of the Electrified Powertrain Roadmap Technical Targets for Hydrogen-Fueled Long-Haul Tractor-Trailer Trucks." (October 31, 2019). https://www.hydrogen.energy.gov/pdfs/19006_hydrogen_class8_long_haul_truck_targets.pdf

[69] Department of Energy. "EERE Funding Opportunity Announcements, DE-FOA-0002922: BIPARTISAN INFRASTRUCTURE LAW: CLEAN HYDROGEN ELECTROLYSIS, MANUFACTURING, AND RECYCLING, Area of Interest 2, Topic 4." https://eere-exchange.energy.gov/Default.aspx#Foalda9a89bda-618a-4f13-83f4-9b9b418c04dc

[70] US DOE. "The U.S. National Blueprint for Transportation Decarbonization". https://www.energy.gov/sites/default/files/2023-01/the-us-national-blueprint-for-transportation-decarbonization.pdf

[71] California Air Resources Board. "2022 Scoping Plan for Achieving Carbon Neutrality". (December 2022). https://ww2.arb.ca.gov/sites/default/files/2023-04/2022-sp.pdf

marine, aviation, and heavy-duty applications, both technologies are still in relatively nascent stages. There are several companies working on BEVs in the heavy-duty sector today, particularly for on-road applications. While achieving sufficient range for long-haul BEVs may be technically possible, high battery costs, reduced cargo capacity, and relatively long charging times could limit the economic and operational feasibility of electric semi-trucks for long haul applications compared to those operating on regional and urban routes. Additionally, charging technology for heavy-duty trucks will require much higher power than for LDVs. For example, analysis by Argonne National Labs (ANL) on the SAE J3271 fast charging system states that a long-haul trucker driving a Class 8 tractor would require a 1.6-MW charge to recover 400 miles of charge within a 30-minute break.[72] 1.6 MW can be enough to power 1,600 homes. So, achieving a charging rate appropriate for heavy-duty trucks would mean significant electric infrastructure upgrades, posing challenges for grid management due to steep load peaks.

The battery electric market for off-road mobility is well-developed for many applications. For example, airport ground support equipment (GSE) can be particularly well-suited for electrification because of its low-end torque, frequent starts and stops, long downtime, and short-range requirements.[73] Electric technologies for other mobility subsectors are still emerging.

Synthetic Fuels

Hydrogen produced from electricity can be combined with byproduct or captured CO2 to produce a wide variety of synthetic fuels (also known as eFuels). Synthetic fuels are typically hydrocarbon-based fuels (except for synthetic ammonia) making them similar in composition to the traditional fuels they are meant to replace. They are a good fit for applications that have fuel system energy density requirements higher than what electric and hydrogen technologies can offer. Because many synthetic fuels can be used as a "drop-in" replacement for existing fossil fuels (i.e., in traditional combustion engines, jet engines, and other existing technologies), they also present an attractive value proposition for applications where capital costs are prohibitively high for electrification or hydrogen technologies.

Synthetic renewable diesel is a prime example of a synthetic drop-in liquid fuel. Other types of synthetic fuels include synthetic versions of SAF, methanol, ammonia, and dimethyl ether. By 2021, California was consuming over 28 million barrels of renewable diesel annually. Perhaps the largest consideration for synthetic fuels is that while they may present a path to reduced emissions (since they offer a utilization option for CO_2 that may have otherwise been emitted at the source), they contain carbon and therefore have direct GHG emissions. As such, the full emissions lifecycle of captured CO_2 and emitted CO_2 (and other pollutants) needs to be considered for synthetic fuels to become the long-term solution to decarbonization.

[72] Argonne National Labs. "Charging for Heavy-Duty Electric Trucks". (March 2023). https://www.anl.gov/sites/www/files/2023-03/MCS_FAQs_Final_3-13-23.pdf.
[73] NREL. "Electric Ground Support Equipment at Airports". (Dec. 12, 2017). https://afdc.energy.gov/files/u/publication/egse_airports.pdf

Model Scope and Key Assumptions

Model Scope

The mobility sector analysis focused on vehicles operating in SoCalGas' service territory, based on the total vehicles in eleven counties: Imperial, Kern, Kings, Los Angeles, Orange, Riverside, San Bernardino, San Luis Obispo, Santa Barbara, Tulare, and Ventura. Analysis was conducted for applications that would use hydrogen fuel cells only (hydrogen combustion technologies and synthetic fuels were excluded[74]). The specific scope and assumptions utilized in the model are summarized below.

Table 1: Scenario Definitions for Mobility: Subsectors Modelled

<table>
<tr><th colspan="2">Scenario Definition Characteristic</th><th>Conservative</th><th>Moderate</th><th>Ambitious</th></tr>
<tr><td rowspan="4">Subsector</td><td>On-Road</td><td colspan="3">• Heavy Duty Vehicles
• Medium Duty Vehicles</td></tr>
<tr><td>Off-Road</td><td colspan="3">• Cargo Handling Equipment
• Ground Support Equipment
• Agricultural Equipment
• Construction & Mining Equipment</td></tr>
<tr><td>Marine</td><td colspan="3">• Commercial Harbor Craft
• Ocean-Going Vessels (OGV)*
Note: OGV demand modeling reflects hydrogen for diesel fuel replacement only (does not include bunker fuel replacement)</td></tr>
<tr><td>Aviation</td><td>• n/a</td><td>• n/a</td><td>• Aircraft</td></tr>
</table>

Note: The demand study quantifies clean renewable hydrogen demand for vehicle classes 2b-8, given the viability of hydrogen for these vehicle classes and the current state of the market for other decarbonization alternatives. LDVs are excluded from the scenarios due to the general market push towards electrification of this vehicle class. However, given the considerable number of FCEVs currently on the road (over 13 million passenger cars in SoCalGas' service territory), potential hydrogen demand may be significant, even at low market penetration.

Key Assumptions and Adoption Levers

The key levers influencing Demand Study outputs by scenario are the hydrogen adoption rates. These adoption rates are determined for each scenario and modelled by application category by assessing the four factors of legislation, technology feasibility, commercial availability, and business readiness. Hydrogen FCEV adoption rates may vary across each scenario based on each of the legislation,

[74] Note: any potential clean renewable hydrogen demand for the development of synthetic fuels is accounted for in the Industrials sector portion of the Demand Study as the synthetic fuel production facilities, not the vehicles, would represent the locations and facilities of clean renewable hydrogen demand.

commercial availability, and business readiness assumptions; technology feasibility evaluations remain constant across the scenarios.

Total demand was calculated at the vehicle application level across the three modeling scenarios, with scenarios defined as follows:

Table 2: Scenario Definitions for Mobility: Hydrogen Adoption Rate Factor Definition

Scenario Definition Characteristic		Conservative	Moderate	Ambitious
Adoption Factors	**Policy & Legislation**	Consideration of existing policy & legislation		Consideration of existing policy and legislation, and additional legislation beginning in 2025
	Commercial Readiness	Conservative timeline to achieve cost parity with decarbonization alternatives	Moderate timeline to achieve cost parity with decarbonization alternatives	Ambitious timeline to achieve cost parity with decarbonization alternatives
	Technical Feasibility	Evaluated per vehicle application group but held constant across scenarios		
	Business Readiness	Conservative assessment of market readiness to adopt hydrogen vehicles	Moderate assessment of market readiness to adopt hydrogen vehicles	Ambitious assessment of market readiness to adopt hydrogen vehicles

Policy & Legislation

To model the transition from ICE to ZEV technologies, legislation as defined by mobility subsector was reflected. This legislation generally impacts the sale or purchase of new vehicles needing to be ZEVs and assumes that vehicles will not be forced to retire early). As such, vehicle and application retirement rates were also modelled, using CARB estimates and industry research to determine when vehicles would naturally retire.

For on-road applications, legislation may be the most influential driver of hydrogen adoption. The ACF regulation,[75] passed April 28, 2023, lays out decarbonization timelines and requirements for high priority medium- and heavy-duty fleets, government-owned fleets, and drayage fleets to convert to ZEVs. Some of ACF's highlights include:

- 100% of truck sales starting 2035 will be ZEV for all fleets.
- 100% of truck sales starting 2024 will be ZEV for ACF priority fleets.

[75] California Air Resources Board. " Advanced Clean Fleets Regulation Summary." (2023). https://ww2.arb.ca.gov/resources/fact-sheets/advanced-clean-fleets-regulation-summary

- 100% of new drayage trucks registered with CARB need to be ZEV starting 2024, and 100% of drayage trucks need to be ZEV starting 2035 to be allowed to enter the ports and modal railyards.

ACF complements the previously adopted ACT regulation, which requires manufacturers to sell ZE trucks and school buses, as well as the issued 2020 EO N-79-20, which set goals for the State to achieve 100% ZEV sales for new trucks by 2035 and for MDV and HDV by 2045. This comprehensive approach encompasses both the supply and demand sides of the market, which will transition a significant amount of the MDV and HDV subsectors to cleaner transportation options.

For non-on-road applications, legislation is sparser. But similar adoption principles to those outlined in ACF are utilized. Vehicle lifespans vary significantly by application, so retirement and replacement rates vary.

Technology Feasibility

The feasibility of adopting hydrogen-powered vehicles is driven by the vehicle operational characteristics, such as range, load, or duty-cycle requirements. Operational characteristics are assessed to determine if hydrogen fuel cell solutions are a fit for each application, versus other decarbonization alternatives (such as BEVs). A series of factors was defined for each mobility subsector, and each vehicle application category was evaluated across these factors to determine the likelihood of adopting hydrogen over decarbonization alternatives.

Commercial Availability

Commercial availability assesses the availability and cost-competitiveness of hydrogen FCEVs compared to other zero-emission alternatives (namely, BEVs) and traditional diesel and gasoline vehicles (until new diesel/gasoline vehicles are no longer allowed to be sold in California). CapEx and OpEx (excluding fuel cost) analysis were conducted to determine if and when FCEV and BEV technologies would achieve relative cost parity with each other and with traditional vehicles.

Business Readiness

Business readiness is a factor included in determining hydrogen adoption rates to reflect the relative readiness of fleet operators to adopt hydrogen technology. For example, companies such as Walmart, AB InBev, and many others who operate or who contract large on-road fleets for distribution of their products have set targets to achieve Net Zero by 2040.[76] With such commitment, some companies and certain industries will lead the adoption of ZEVs and FCEVs as early adopters, and some others will be fast followers. Targets such as these may lead to an acceleration in FCEV or BEV adoption beyond what would otherwise be legislatively required. CARB affirms that promoting private investment in the transition to ZEV technology is one of their strategies for achieving success in their scoping plan.[77] Business readiness could be caused by either faster infrastructure availability to support hydrogen

[76] Walmart. "Climate Change." (2023). https://corporate.walmart.com/esgreport/environmental/climate-change ; Anheuser-Busch InBev. "Our Ambition to Achieve Net Zero". https://www.ab-inbev.com/assets/pdfs/Net%20Zero%20Executive%20Summary_FINAL%2012pm.pdf
[77] California Air Resources Board. "2022 Scoping Plan for Achieving Carbon Neutrality". (December 2022). https://ww2.arb.ca.gov/sites/default/files/2023-04/2022-sp.pdf

vehicles, or the early retirement of ICE vehicles and associated earlier adoption of FCEVs.

Mobility Demand Study Results

Overview

The mobility sector analysis shows potential demand in SoCalGas' service territory ranging from 1.0M TPY in the conservative scenario to 1.7M TPY in the ambitious scenario by 2045, as depicted in the figure below. The on-road subsector accounts for 83% to 93% of potential mobility sector hydrogen demand in 2045 across scenarios, driven primarily by heavy-duty Class 8 vehicle applications and transit buses; off-road, marine, and aviation applications make up the remainder.

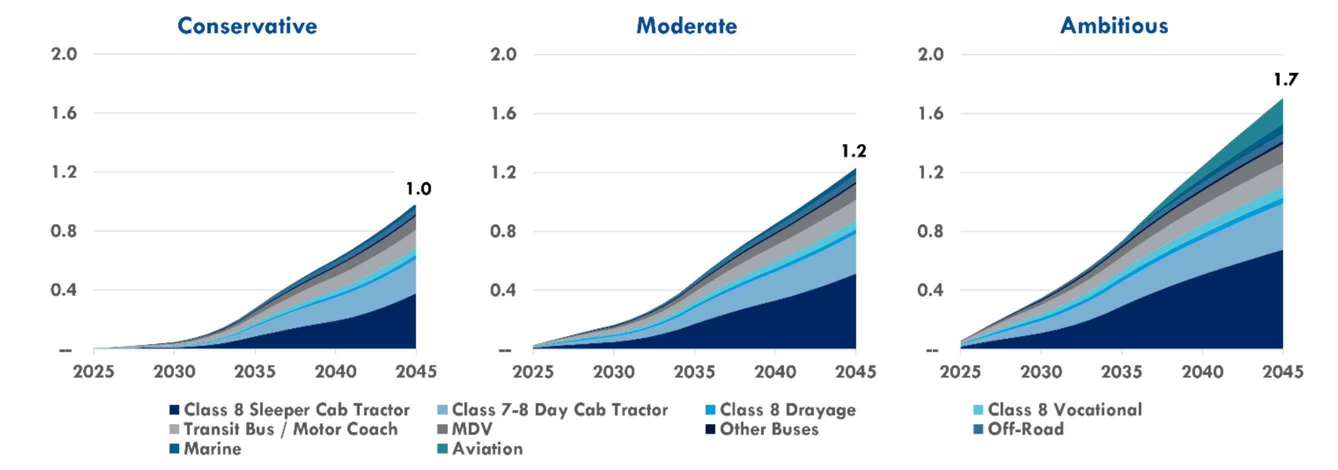
Forecasted potential hydrogen demand for the mobility sector takes a noticeable uptick in 2035 onwards across all scenarios, largely due to the regulations for on-road vehicles that have been passed which effectively require 100% ZEV sales starting in 2035. This would imply that as today's vehicles retire in the 2030s, they will largely be replaced by ZEVs, of which many could be FCEVs (pending application). The distribution of demand across subsectors remains relatively similar across scenarios.

While the proportion of demand for the off-road subsector may be relatively low, these applications have an important role to play in supporting the early adoption of hydrogen. For example, the San Pedro Bay Ports are pursuing adoption of various FCEV technologies today in support of their Clean Air Action Plan goals of having 100% of their CHE being ZEV by 2030. This early net zero target strongly supports the State's decarbonization goals (non-road applications account for 10% of emissions in California).

The marine and aviation subsectors account for 3% to 14% of mobility sector hydrogen demand in 2045 across scenarios. This large spread is a reflection that there is a large degree of uncertainty regarding clean hydrogen's role for these applications: the development of synthetic fuel alternatives such as SAF or clean ammonia or methane for shipping may win out in these applications over hydrogen for use in fuel cells. To reflect these uncertainties, only the ambitious scenario only includes potential clean hydrogen demand for fuel cell aircraft; for marine applications only hydrogen for diesel replacement is considered (in all scenarios).

Figure 10: Total Expected Mobility Sector Clean Renewable Hydrogen Demand by Subsector

2025-2045, values in Million TPY



Adoption beyond the conservative case will be dependent on the hydrogen adoption rates across legislative, commercial availability, technical feasibility, and business readiness factors as described above. Additional incentives enticing early retirement of vehicles or supporting early adoption of hydrogen vehicles would be valuable to accelerate the adoption curve and the creation of a second-hand vehicle market.[78]

Figure 11: Total Expected Mobility Sector Hydrogen Demand by Scenario and Application Group (2045, in Thousands TPY)

Sub-Sector	Conservative	Moderate	Ambitious
Heavy Duty Vehicles	691	879	1,109
Medium Duty Vehicles	91	105	124
Buses	135	153	178
Off-Road	41	47	52
Marine	31	46	65
Aircraft	--	--	178
Total	**988**	**1,230**	**1,707**

[78] U.S. Department of Energy. “Biden-Harris Administration to Jumpstart Clean Hydrogen Economy with New Initiative to Provide Market Certainty and Unlock Private Investment”. (July 5, 2023). https://www.energy.gov/articles/biden-harris-administration-jumpstart-clean-hydrogen-economy-new-initiative-provide-market

Subsector Results

On-Road Vehicles

Overview

Most of the mobility sector demand is driven by on-road applications: 93% in the conservative scenario and 83% in the ambitious scenario. There can be several explanations for this high concentration, including:

- SoCalGas' service territory includes a very dense population center around Los Angeles, with roughly 50% of the state's population. This means that demand for on-road vehicle fuel is high, and demand for agricultural or mining related off-road applications is minimal versus what may be the case in more rural areas.[59]
- The San Pedro Bay Ports account for 29% of all containerized international waterborne trade in the U.S., and 75% of all containerized cargo destined for the West Coast.[79] This volume and value of goods means that many trucks—not just drayage trucks—are accessing fuel in SoCalGas' service territory.
- Legislation for zero-emission on-road vehicle applications has been established and continues to be refined and added to, whereas specific legislation for non-on-road applications has been slower to develop.

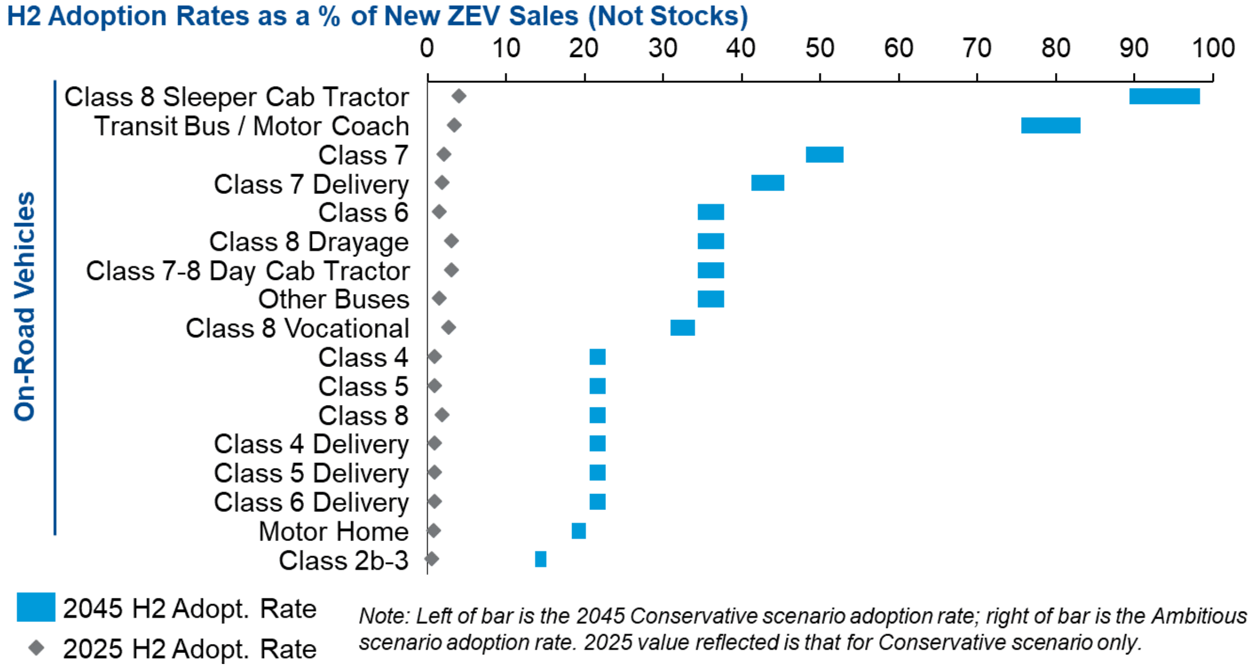
The top 5 vehicle on-road applications assessed—Class 8 Sleeper Cab Tractors, Class 7-8 Day Cab Tractors, Class 8 Vocational Trucks, Class 8 Drayage Trucks, and Transit Buses—together account for 88% of projected on-road hydrogen demand and 82% of projected mobility sector hydrogen demand by 2045 in the conservative scenario. These vehicles have several things in common, leading to their high hydrogen usage—relatively large fleet sizes, high fuel consumption rates, high duty cycles, and high load requirements. As described above, these characteristics can lend themselves towards a higher likelihood of hydrogen technologies for many applications.

Hydrogen Adoption Rate Evaluation

New ICE vehicles effectively cannot be sold in California after 2035, which makes BEV or FCEV technologies the two leading options for decarbonizing on-road transportation. Accordingly, these two alternatives were evaluated for each modelled vehicle application group to determine the adoption rates. Long-term FCEV 2045 adoption rates across the conservative to ambitious scenarios by application group can be seen below in the figure below. BEV adoption rates would be the inverse of the FCEV adoption rates.

[79] The Port of Los Angeles. "Facts and Figures". (2023). https://www.portoflosangeles.org/business/statistics/facts-and-figures

Figure 12: Hydrogen FCEV Adoption Rates of New Sales of On-Road ZEVs



Hydrogen (FCEV) adoption rates vary significantly by application. For 2025, hydrogen adoption rates are as low as 1% in the conservative scenario (meaning that BEVs or other non-hydrogen ZEV technologies would be the dominant technology). Some of the key factors influencing adoption rates are the expected fit of the FCEV technology to the application, and the expected advancements in price reduction and vehicle availability. The following characteristics were considered for evaluating the fit of FCEV technology to on-road vehicle applications:

- **Range Requirements.** Trucks that must travel long distances are generally evaluated to favor FCEV adoption over BEV adoption. This can be due to a series of factors which may vary by application but include considerations such as faster refueling times and longer ranges.

- **Load Requirements.** Fuel cells are generally lighter-weight relative to batteries, meaning BEVs generally face a higher penalty in terms of cargo capacity reduction relative to FCEVs due to federal and state vehicle weight restrictions. This is especially true for vehicles that need to travel long distances which would require significantly more battery capacity. So, vehicle applications with higher payloads—at least some of the time—were assessed to have a higher likelihood of adopting hydrogen. This includes vehicles such as Class 8 Sleeper Cab Tractors, Day Cab Tractors, Heavy-Duty Vocational Vehicles (such as garbage or cement trucks) and Drayage Trucks. FCEV semis have much lower mass sensitivity to range, so they can achieve long haul operation without as much cargo loss.

- **Duty Cycle Requirements.** Many vehicles may be operated by different drivers throughout the day. For example, some drayage truck fleets accessing the San Pedro Bay Ports will operate in three 8-hour shifts and will operate 24/7. Transit buses often operate in two 8-hour shifts per day as well. When multiple, extended shifts per day are required, this is evaluated as having a high duty cycle, and driving favorability of FCEV technology over BEV technology. Particularly in cases where vehicles are expected to operate nearly 24-hours per day, there is little downtime time for refueling, so leveraging hydrogen refueling—in a matter of minutes, as opposed to battery recharging which may take hours—is operationally advantageous.

- **Fueling Infrastructure Requirements**. Charging or refueling infrastructure is a critical factor influencing FCEV vs BEV adoption. Some vehicles operate with back-to-base operations, meaning that they typically refuel or recharge at the same location every day. Other vehicles operate with distributed fueling operations, meaning they refuel in various locations every day. Based on the type of fueling operations and the ease or difficulty of establishing refueling or recharging infrastructure, certain vehicle applications may be more or less likely to convert to BEV or to FCEV technology. For example, vehicles such as transit buses or vocational trucks, generally operate in back-to-base operations. Depending on the size and location of these operations, developing hydrogen fueling infrastructure may be easier than developing charging infrastructure, such as where significant additional grid capacity would need to be developed to support centralized, high-power charging operations. Meanwhile delivery vehicles, which operate back-to-base but don't travel such long distances with high duty cycles would require less new infrastructure build to support charging, making BEV technology more feasible.

While fit for application is critical, fleet operators cannot or will not buy FCEV or BEV technologies if they are not available to purchase or if they are cost prohibitive. As such hydrogen adoption rates were modelled to take the CapEx and OpEx for each vehicle class into account using ANL's BEAN Model[80] to assess when FCEVs might achieve relative cost parity versus alternatives.

Off-Road Vehicles

Cargo-Handling Equipment (CHE)

There are around 4,000 pieces of CHE operating today at the San Pedro Bay Ports, and the role of CHE within the overall mobility sector is relatively small. Accordingly, CHE accounts for 2.3% of mobility-sector demand in the conservative scenario and 1.7% in the ambitious scenario (23-29k TPY) by 2045. Despite the small percentages of total hydrogen demand, CHE may play a pivotal role in the hydrogen mobility market. As an early adopter, it may serve as an example of successful hydrogen rollout that can be replicated by other sectors.

While there is no CHE-specific legislation in California driving adoption, the Clean Air Action Plan sets more aggressive targets than those otherwise defined in EO-N-79-20, which states "a goal of the State

[80] Argonne National Laboratory. "BEAN". https://vms.taps.anl.gov/tools/bean/

to transition to 100 percent zero-emission off-road vehicles and equipment by 2035 where feasible;"[81] the CAAP sets targets for terminal operators to achieve 100% zero-emission CHE by 2030.[82]

Assessment of the technology feasibility of hydrogen-based solutions for CHE was conducted across five key factors: load factor, duty cycle, the relative maturity of electric vehicle alternatives, the space required for refueling, and infrastructure challenges for electrification. Some vehicle applications such as ship-to-shore cranes are almost entirely electrified at Port of Los Angeles and Port of Long Beach today, indicating minimal likelihood of hydrogen adoption in coming years. These cranes are stationary and can be connected to the grid directly. Meanwhile, several pieces of container handling equipment are already running pilot projects with both hydrogen and battery technologies. Mobile, heavier-duty CHE types have significant power requirements and little downtime to charge, so transitioning them to BEVs is expected to decrease equipment productivity, require increased equipment count to compensate, and require significant electric infrastructure upgrades to support high-power charging during shift breaks.

With the above in mind, port container handling equipment and terminal tractors (also known as yard tractors) are assessed to have the highest adoption rates across the CHE applications. Together these two applications account for over 90% of hydrogen demand from the CHE subsector by 2045 across all scenarios. There are over 2,000 terminal tractors operating today, which are assessed to consume an average of 8.7 kg of hydrogen per day; there are over 550 pieces of container handling equipment assessed to consume an average of 62.2 kg H2 per day. These pieces of equipment are identified by the CAAP Feasibility Assessment for CHE[83] as having a relatively high fit for hydrogen technology adoption.

Airport Ground-Support Equipment (GSE)

GSEs make up <1% of overall mobility-sector clean renewable hydrogen demand with just 1.5-1.9k TPY expected by 2045. This demand is largely modelled to come from the Los Angeles World Airports (LAWA) Ground Service Equipment Emissions (GSE) with emission reduction goals of 75% by 2030.[84]

The operational characteristics of GSE tend to align best with battery electric decarbonization alternatives. GSE is characterized by having relatively low duty cycles, centralized fueling operations, and minimal challenges for establishing charging infrastructure. LAWA itself has already established

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[81] State of California Executive Department. "Executive Order N-79-20". (September 23, 2020). https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf
[82] Port of Los Angeles. "San Pedro Bay Ports Release Final 2021 Cargo-Handling Equipment Assessment." (August 25, 2022). https://cleanairactionplan.org/2022/08/25/san-pedro-bay-ports-release-final-cargo-handling-equipment-assessment/
[83] San Pedro Bay Ports. "Clean Air Action Plan 2018 Feasibility Assessment for Cargo Handling Equipment". (September 2019). https://kentico.portoflosangeles.org/getmedia/8bbb559a-0270-415b-a79a-3265fa3bbb59/final-cargo-handling-equipment-che-feasibility-assessment
[84] Los Angeles World Airports. "Sustainability Action Plan for Los Angeles World Airports". (2019). https://cloud1lawa.app.box.com/s/63i2teszgnld5aws68xbou6yc0inl5rp

the LAX Electric Ground Support Equipment Incentive Program—a clear nod of existing preference towards BEV technologies[85]—and has over 30% of its GSE fleet today operating fully electric.[86]

While the immediate hydrogen potential for GSE at LAWA and other airports in SoCalGas' service territory may not be high in the near-term without changes in policy, potential upside may come if there is legislation passed to support hydrogen powered zero emission aircraft. If this were to happen, hydrogen fuel availability and fueling infrastructure on-site at airports could lower barriers to FCEV GSE conversion and increase demand above that estimated in this model.

Agriculture, Mining, and Construction Equipment (Other Off-Road Equipment)

Other off-road equipment is projected to account for 17-21k TPY of hydrogen demand by 2045 (1.3% of mobility-sector demand in the ambitious scenario; 1.7% of mobility-sector demand in the conservative scenario). As described above, there are many reasons why hydrogen demand by non-on-road equipment may be relatively low in SoCalGas' service territory. While there are over 160,000 pieces of other off-road equipment modelled, only two types of equipment are expected to consume more than 5 kg of hydrogen per day on average: heavy agricultural equipment (25.3 kg/day) and off-highway trucks (18.5 kg/day), and there are just over 400 and 1,300 of these vehicle types in the covered geography, respectively.

Non-road vehicles and equipment used in the agriculture, construction, and mining industries account for significant energy (primarily diesel) demand. Vehicles used by these industries, such as tractors and haul trucks, are similar in some respects (e.g., weight and power versus energy requirements) to on-road MDVs and HDVs, but they are potentially more difficult to electrify. This is due in part to infrastructure challenges that make charging more difficult and expensive, as these equipment types are often located in more temporary or remote locations. For this reason, decarbonizing these segments will in general more likely rely on hydrogen fuel cell vehicles to a greater extent than in on-road transportation.

Meanwhile there is little mining equipment in SoCalGas' service territory, but a relatively large amount of specialty construction equipment such as pavers or equipment working in (often) urban construction sites. While these pieces of equipment may operate with relatively high duty cycles when in use, they may also see longer periods without use. Access to recharging or refueling infrastructure may be sparse depending on the specific project site where equipment is operated.

Finally, there is no current specific legislative requirements for these off-road vehicles to convert to zero-emission alternatives other than State's goal to achieve 100% emission reduction of off-road vehicles *"where feasible"* by 2035, as indicated in EO N-79-20.

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[85] Los Angeles World Airports. "LAX Electric Ground Support Equipment Incentive Program". (June 2023). https://www.lawa.org/-/media/lawa-web/environment/files/gse-emissions-reduction-program/lax-egse-incentive-program.ashx

[86] Los Angeles World Airports. "Striving for Zero: LAX Ground Support Equipment Emissions Reduction Program" (March 3, 2020). https://anesymposium.aqrc.ucdavis.edu/sites/g/files/dgvnsk3916/files/inline-files/LAX%20GSE%20Presentation_030220.pdf

Marine Vessels

Commercial Harbor Craft (CHC)

CHCs are projected to account for just 9-13k TPY of hydrogen demand by 2045 as there are relatively few vessels in this category (<3,000). These vessels can have multiple engines (typically a main engine for propulsion and an auxiliary engine for powering on-board systems, though this varies by vessel type). Depending on the specific vessel and engine type, decarbonization solutions may include hydrogen, battery, or synthetic fuels such as methanol or ammonia.

Through mid-2023, zero-emission regulation for CHC focused on requiring upgrade to cleaner more modern engines, requiring widespread adoption by 2034, but fell short of requiring zero-carbon fuels. However, the Clean Shipping Act of 2023 expands upon this and requires 100% emissions reduction by 2040 for most vessels.[87]

For some niche applications, short-run ferries traveling less than three nautical miles over a single run and new excursion vessels (whale watching or dinner cruises), more ambitious legislation has already been passed, requiring new vehicle purchases of these vessel types to be ZEV starting 2024.[88] There are already some pilot projects in California demonstrating hydrogen technologies-such as the Sea Change ferry in San Francisco, the first hydrogen fuel cell passenger ferry in the United States.[89] While these demonstration projects show promise for some CHC applications, tugboats stand out as possible high adopters of fuel cell technology given their operational characteristics and sometimes 24/7 shifts.

OGVs

OGVs are modelled to account for 22-52k TPY of potential mobility sector hydrogen demand by 2045, representing 2.2-3.1% of mobility-sector demand. This value, however, has a large potential upside as it only reflects hydrogen demand from replacement of diesel fuel consumption. CARB recognizes the importance of hydrogen fueled OGVs with their 2022 Scoping Plan including the need for 25% of OGVs to utilize hydrogen fuel cell technology by 2045 as part of their action plans[90].

The recent introduction of the Clean Shipping Act of 2023—requiring almost all vessels to be fully ZEV by 2040—could significantly increase the amount of hydrogen demand by OGVs. However, the adoption of synthetic fuels such as synthetic methanol or ammonia represent the most likely alternatives that the industry is considering due to their increased energy density (lower volume of storage required relative to hydrogen). According to IEA analysis "*Ammonia and hydrogen are the main low-carbon fuels for shipping adopted over the next three decades in the IEA Net Zero Emissions by*

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[87] Alex Padilla U.S. Senator for California. "Padilla, Whitehouse Introduce Bills to Reduce Ocean Shipping Emissions". Padilla, Whitehouse Introduce Bills to Reduce Ocean Shipping Emissions - Senator Alex Padilla (senate.gov)
[88] California Air Resources Board. "Final Regulation Order Commercial Harbor Craft Regulation". https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2021/chc2021/chcfro.pdf, page 67
[89] California Air Resources Board. "LCTI: Zero-Emission Hydrogen Ferry Demonstration Project". LCTI: Zero-Emission Hydrogen Ferry Demonstration Project | California Air Resources Board
[90] California Air Resources Board. "2022 Scoping Plan for Achieving Carbon Neutrality". Table 2-1. (December 2022). https://ww2.arb.ca.gov/sites/default/files/2023-04/2022-sp.pdf

2050 Scenario, their combined share of total energy consumption in shipping reaching around 60% in 2050.”[91, 92]

The adoption of such clean fuels by OGVs may require significant international collaboration and the establishment of green shipping corridors that require the usage of clean fuels among trade partners. While California can influence local emissions requirements near its shores, CARB and others support that US EPA has primary authority to control emissions from marine vessels.[93] Locally in California meanwhile, regulations require emissions regulation while at berth using shore power or while near shore.[94]

Aviation

Clean renewable hydrogen demand for fuel cells in the aviation sector is only considered in the ambitious scenario of the study, as synthetic fuels (namely SAF) are widely considered to be the most dominant decarbonization pathway for the aviation sector. Hydrogen demand for SAF is represented in the industrials sector. Making the case for a role for hydrogen fuel cell solutions, CARB in their 2022 Scoping Plan Scenario lays out that by 2045, 20% of aviation fuel demand may be satisfied by hydrogen or battery alternatives (implying that the remaining 80% would be satisfied by SAF)[95]. Many third- party studies cite hydrogen or battery powered aircraft as being single-digit percentages of overall sustainable aviation demand, so this demand study models the scenario of 25% of CARB’s non-SAF portion (e.g., 5% of total aviation energy demand) would be hydrogen.[96] With this consideration, aviation accounts for roughly 10% of anticipated mobility sector clean renewable hydrogen demand in the ambitious case scenario at 178k TPY by 2045.

Potential Opportunities for Demand Upside

Light-Duty Vehicles

There are nearly 30 million cars in California today—over half of which are registered in SoCalGas service territory[97]—and nearly a quarter of all new car sales in California are ZEVs.[98] While most of these new vehicle sales are battery electric, the amount of hydrogen FCEVs is increasing exponentially. Even if FCEVs have relatively low adoption rates compared to BEVs, the sheer number of vehicles may lead to

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[91] IEA. “Maritime shipping to fall short of net zero emissions target”. (May 20, 2021). https://www.reuters.com/business/energy/maritime-shipping-fall-short-net-zero-emissions-target-iea-2021-05-20/#:~:text=%22Ammonia%20and%20hydrogen%20are%20the,2050%2C%22%20said%20the%20IEA

[92] IEA. “Net Zero by 2050: A Roadmap for the Global Energy Sector (2021)”. https://www.energy.gov/sites/default/files/2021-12/IEA%2C%20Net%20Zero%20by%202050.pdf

[93] California Air Resources Board. “2022 State Strategy for the State Implementation Plan”. https://ww2.arb.ca.gov/sites/default/files/2022-08/2022_State_SIP_Strategy.pdf

[94] California Air Resources Board. “Zero-Emission Off-Road Strategies”. https://ww2.arb.ca.gov/sites/default/files/2020-11/ZEV_EO_Off-Road_Fact_Sheet_111820.pdf

[95] California Air Resources Board. “2022 Scoping Plan for Achieving Carbon Neutrality”. Table 2-1. (December 2022). https://ww2.arb.ca.gov/sites/default/files/2023-04/2022-sp.pdf

[96] Mission Possible Partnership. “Making Net Zero Aviation Possible”. https://missionpossiblepartnership.org/wp-content/uploads/2023/01/Making-Net-Zero-Aviation-possible.pdf

[97] California Energy Commission. “Light-Duty Vehicle Population in California” https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/light-duty-vehicle

[98] California Energy Commission. “New ZEV Sales in California” https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/new-zev-sales

significant hydrogen demand. Specifically, as traditional ICE vehicles retire, and as new legislative requirements for new LDV sales come into effect—namely, Advanced Clean Cars II, requiring 100% of LDV sales to be ZEV by 2035[99]—there may be significant hydrogen demand from the LDV sector. Potential hydrogen demand by these vehicles may require a broader geographic distribution of fueling infrastructure (similar to how gas stations are more spread out than truck stops), however if each passenger car consumes an average 0.5 kg of fuel per day, the overall demand can be significant. In particular, with over 16,000 light-duty FCEVs having been sold to date in California,[100] these passenger cars may play a pivotal role in facilitating the early market for clean hydrogen and in piloting some of the technologies that may later be used in the heavy-duty and other subsectors.

Rail

Today, most of California's 11,000-line haul and 500 switcher locomotives run on diesel (~378M gal/year in CA), producing over 640 TPY of PM2.5 and over 29,000 TPY of NOx emissions.[101] To mitigate these emissions, regulations such as the In-Use Locomotive Regulation, approved by CARB on April 27, 2023, will set emissions reduction requirements for Tier 4 engines or higher by 2035.[102] These regulations set the stage for a transition to zero-emission rail operations. The regulation is set to take effect in 2024 and should increase the use of zero-emission technology. As part of this transition, various projects are underway across the state such as VeRail Technologies' collaboration with the Port of Los Angeles to develop a zero-emission switcher locomotive.[103] Also, part of CARB's 2022 Scoping Plan is that line haul and passenger rail rely primarily on hydrogen fuel cell technology.[104]

Ocean Going Vessels

The model for OGVs only includes hydrogen as a potential substitute current diesel fuel consumption. However, the main source of fuel demand from OGVs is typically bunker fuel (sometimes referred to as heavy fuel). This fuel is traditionally relatively inexpensive and can have significant emissions, and it is used to power main engines when operating in international waters where there is little regulation on emissions. If bunker fuel usage were to be replaced with hydrogen or hydrogen-based alternatives, it could represent an immense potential upside for clean renewable hydrogen at the San Pedro Bay Ports (or for the production site of such hydrogen-based alternatives). This scenario is plausible if green shipping corridors are to be developed with the U.S. wherein ships transiting to and from the port have emissions restrictions. Particularly, since the San Pedro Bay Ports are some of the busiest ports in the world, they could represent a highly concentrated demand center for hydrogen powered ships. The San Pedro Bay Ports have been described as "critical gateways to the U.S. economy," and are responsible

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[99] California Air Resources Board. "Advanced Clean Cars II". https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii
[100] California Energy Commission. "New ZEV Sales in California" https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/new-zev-sales
[101] California Air Resources Board, "The In-Use Locomotive Regulation was approved by the Board on April 27, 2023". https://ww2.arb.ca.gov/our-work/programs/reducing-rail-emissions-california/locomotive-fact-sheets
[102] California Air Resources Board, "The In-Use Locomotive Regulation was approved by the Board on April 27, 2023". https://ww2.arb.ca.gov/our-work/programs/reducing-rail-emissions-california/locomotive-fact-sheets
[103] Port of Los Angeles / Port of Long Beach
[104] California Air Resources Board. "2022 Scoping Plan for Achieving Carbon Neutrality". Table 2-1. (December 2022). https://ww2.arb.ca.gov/sites/default/files/2023-04/2022-sp.pdf

for approximately 70% all U.S.-international trade by tonnage, 40% of all containerized cargo, and about 30% of all containerized exports.[105] With such legislation such as California's Clean Shipping Act of 2023 requiring a 100% reduction in carbon intensity by 2040,[106] and the International Marine Organizations (IMO) 2020 implementation of the MARPOL treaty—which limits the allowable sulfur content of marine fuels used by GOVS in international waters to 0.5% by weight[107]—there are many forces which may increase hydrogen demand by OGVs.

Power Generation

Introduction

The power sector, which encompasses baseload and peaker plants currently operational in SoCalGas' service territory, is the second sector considered. California is a leader in power sector decarbonization, and its GHG emissions have consistently fallen over the past decade. Currently, in-state emissions from the power sector in California contribute to 11% of the state's overall GHG emissions footprint.[108]

Aggressive targets have been set to reduce the power sector's consumption of fossil fuels, with SB100 requiring net-zero electric retail sales by 2045.[109] In tandem, there has been a significant increase in renewables such as wind and solar on the California grid, with future growth expected as electrification in mobility, residential, commercial, and industrial sectors continues to increase.[110] However, renewables are not able to fully replace the role of natural gas generation in the energy system due to their inherent intermittency. These growing variable renewable resources do not provide the consistent, dispatchable, and firm generation needed to balance supply and demand on the grid at both the daily level – when the sun sets at night – and at the seasonal level – when sunlight decreases during wintertime. Dispatchable, firm generation, currently obtained through the combustion of natural gas, plays a critical role in balancing the grid when demand outstrips renewable supply and in providing power when variable renewable resources are not available or when needed during extreme weather events, ultimately providing for overall system reliability.

As this renewable transition continues and grows, clean renewable hydrogen will play a significant role in providing a zero-carbon alternative to natural gas while maintaining necessary grid reliability. Hydrogen can be used for power generation regardless of the season or time of day, as hydrogen produced by electrolysis can be stored during times of high renewable supply and dispatched in the

[105] Port of Los Angeles. "San Pedro Bay Ports Announce New Measures to Speed Cargo Throughput". (September 2021). https://www.portoflosangeles.org/references/news_091721_speedcargo#:~:text=Ports%20are%20critical%20gateways%20to,30%25%20of%20all%20containerized%20exports.
[106] Congress. "H.R. 4024 – Clean Shipping Act of 2023". (June 2023). https://www.congress.gov/bill/118th-congress/house-bill/4024/text?s=1&r=4#:~:text=Introduced%20in%20House%20(06%2F12%2F2023)&text=To%20amend%20the%20Clean%20Air,vessels%2C%20and%20for%20other%20purposes.
[107] International Maritime Organization. "IMO 2020 sulfur limit implementation-carriage ban enters into force". (March 2020). https://www.imo.org/en/MediaCentre/PressBriefings/pages/03-1-March-carriage-ban-.aspx
[108] California Air Resources Board. "California Greenhouse Gas Emissions for 2000 to 2020 Trends of Emissions and Other Indicators". (October 26, 2022). https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/2000-2020_ghg_inventory_trends.pdf
[109] California Energy Commission. "SB 100 Joint Agency Report". (September 3, 2021). https://www.energy.ca.gov/publications/2021/2021-sb-100-joint-agency-report-achieving-100-percent-clean-electricity
[110] California Energy Commission. "New Data Shows Growth in California's Clean Electricity Portfolio and Battery Storage Capacity". (May 25, 2023). https://www.energy.ca.gov/news/2023-05/new-data-shows-growth-californias-clean-electricity-portfolio-and-battery

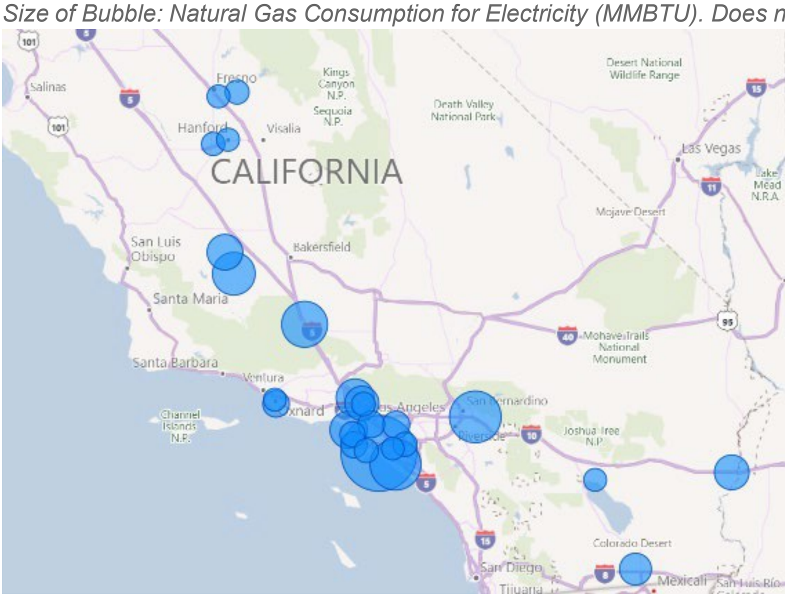
hours or seasons when demand overtakes supply. With modifications to fuel delivery systems, many existing combustion turbines are already capable of blending hydrogen at low percentages, and technical feasibility of fully hydrogen capable combustion technologies is projected to be complete within the next decade[111, 112,113]. It should be noted that consistent with the Decision, Angeles Link is intended as a project to transport only 100% clean renewable hydrogen in the pipeline, and any analysis of hydrogen blending refers strictly to "behind-the-meter" operations, not within SoCalGas control. As power plant owners and operators are looking to eliminate emissions while maintaining the dispatchable generation that natural gas provides, hydrogen is emerging as a priority dispatchable power solution for California.

Power Landscape

California State Policy and Legislative Initiatives

Figure 13: Current Natural Gas Consumption by Power Plants in SoCalGas' Service Territory by Zip Code

Size of Bubble: Natural Gas Consumption for Electricity (MMBTU). Does not include power generation in San Diego.[114]



- **SB100:** A consequential piece of legislation for hydrogen adoption in the power sector is the CA SB100 legislation, which accelerates the state's Renewable Portfolio Standard (RPS) program and requires 100% of retail sales to be supplied by renewable and zero-carbon energy by 2045, with RPS milestones of 50% by 2025 and 60% by 2030.

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[111] Siemens Energy. "H2 capabilities of our medium-sized gas turbines". https://www.siemens-energy.com/global/en/home/products-services/solutions-usecase/hydrogen/zehtc.html#:~:text=H%E2%82%82%20capabilities%20of%20our%20medium,to%20reach%20100%25%20by%202030.

[112] Euractiv. "GE eyes 100% hydrogen-fueled power plants by 2030". (May 2021). https://www.euractiv.com/section/energy/news/ge-eyes-100-hydrogen-fuelled-power-plants-by-2030/

[113] Fuel cells for the power sector were not included in analysis.

[114] U.S. Energy Information Administration. "Form EIA-923 detailed data with previous form data (EIA-906/920)". https://www.eia.gov/electricity/data/eia923/

- **LA100:** Another key policy is the LA100 plan, which set a target for LADWP to achieve 100% carbon-free generation by 2035.[115]

- **EPA 111 Ruling**: The proposed US EPA rule to set GHG standards for new and existing power plants seeks to reduce nationwide power plant emissions. The proposed rule would require that new power plants with capacity factors of 20% or higher and existing plants with capacity factors of 50% or higher to either blend increasingly higher percentages of low-GHG hydrogen with natural gas or utilize CCUS. Under EPA's 111(d) rules, existing plants are regulated by state plans that meet EPA's standards and are approved by the EPA. CARB has stated that California's suite of programs will deliver more reductions than implementing EPA's existing power plant standards and thus will likely submit a state plan which utilizes SB100, RPS, and the Cap-and-Trade program as equivalent.[116, 117]

  Most existing natural gas power plants in SoCalGas' service territory (and in CA) are expected to run for reliability only and thus are unlikely to have capacity factors greater than 50% when the blending requirements begin. However, many stakeholders have urged the EPA to lower the existing plant capacity factor threshold, which would increase the number of power plants potentially subject to the EPA rules and California's EPA-approved State Plan.[118]

- **CARB's 2022 Scoping Plan for Achieving Carbon Neutrality:** This scoping plan includes the need for 9 GW of hydrogen combustion turbines as an incremental electricity resource by 2045[119] to meet the state's carbon neutrality goals. CARB assumes hydrogen production via electrolysis which falls within Angeles Link's definition of clean renewable hydrogen consistent with D.22-12-055. Whether considering hydrogen conversion of a portion of today's existing power generation capacity or new incremental hydrogen capacity, both the Demand Study's analysis and CARB's analysis point towards the eventual need for hydrogen fueled thermal power generation capacity to provide clean firm dispatchable power in the state of California.

Hydrogen in the Power Sector

Hydrogen's application in the power generation sector will likely be in situations when intermittent renewable energy resources like wind and solar cannot supply the load necessary to support grid reliability. Unlike conventional power plants (such as natural gas-fired plants, nuclear, etc.), solar and wind resources cannot be fully dispatched, at will, to help meet demand, and in these instances,

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[115] National Renewable Energy Laboratory. "LA100: The Los Angeles 100% Renewable Energy Study". https://www.nrel.gov/analysis/los-angeles-100-percent-renewable-study.html
[116] Environmental Protection Agency. "CARB's comment letter to EPA Aug 8, 2023". https://www.regulations.gov/docket/EPA-HQ-OAR-2023-0072/comments?pageNumber=4&sortBy=postedDate&sortDirection=desc
[117] Environmental Protection Agency. "Greenhouse Gas Standards and Guidelines for Fossil Fuel-Fired Power Plants". (June 2023). https://www.epa.gov/system/files/documents/2023-06/111%20Power%20Plants%20Stakeholder%20Presentation_Webinar%20June%202023.pdf
[118] Environmental Protection Agency. https://www.regulations.gov/docket/EPA-HQ-OAR-2023-0072/comments?pageNumber=4&sortBy=postedDate&sortDirection=desc
[119] California Air Resources Board. "2022 Scoping Plan for Achieving Carbon Neutrality". Figure 4-5. (December 2022). https://ww2.arb.ca.gov/sites/default/files/2023-04/2022-sp.pdf

hydrogen supply will need to ramp up quickly, almost mirroring the drop-off of renewable energy. Initially hydrogen may be used in less significant amounts during times of the day when intermittent renewable energy is abundantly available and less expensive than clean renewable hydrogen. However, less dispatchable electricity makes it more difficult for grid managers to balance electricity supply and demand in a system with wide swings in net electricity demand. Hydrogen also has the capability of being stored for long durations, providing power during seasonal swings or extreme weather events.

On February 8, 2023, the Los Angeles City Council voted to convert LADWP's Scattergood Generating Station Units 1 and 2 from methane gas plants to hydrogen-ready plants, with an in-service date of December 30, 2029. LADWP has identified this project as a crucial step for the city to meet its goal of being 100% carbon-free by 2035.[120] LADWP plans to eventually implement conversions in other gas plants like the Harbor and Haynes and Valley Generating Station.[121] Using the LADWP's plans to convert the 830 MW Scattergood plant to 100% clean renewable hydrogen as an example, it is expected that hydrogen will be highly prioritized as an alternative fuel in the power sector.

Figure 14: Major Hydrogen Projects in the Power Sector

California Hydrogen Projects

Scattergood Repowering Project

LADWP is repowering their Scattergood plant with turbines capable of burning significant quantities of hydrogen, with ~400MW of H2 capacity buildout at Scattergood by 2038

400MW Net generation output by 2038

Intermountain Power Project

Project is retiring the existing coal-fueled units at the Utah IPP site, installing new natural gas-fueled electricity generating units capable of utilizing hydrogen

840MW Net generation output

Lodi Hydrogen Power Plant

PG&E has successfully installed a Siemens turbine at the Lodi Energy Center that can blend 45% hydrogen with natural gas, greatly reducing emissions

225MW Net generation output as of 2022

United States and Worldwide Hydrogen Projects

Hillabee Generating Station (Alabama)

Constellation will significantly lower greenhouse gas emissions by blending high concentrations of hydrogen with natural gas, reaching 38% without major modifications to the plant

753MW Net generation output as of 2023

Blueprint for Real Zero Proposal (Florida)

NextEra Energy envisions converting all of its Florida natural gas firing facilities to hydrogen. Collectively these plants will produce 16GW from green hydrogen.

16GW Net generation output by 2040

Low Carbon Energy Hub (Europe)

RWE and Equinor are building gas turbines in Germany served by a hydrogen pipeline between Germany and Norway, moving ~4M tons hydrogen/year with a target of 2030 for pipeline construction

3GW H2 power plant capacity, with a pipeline equivalent capacity of 18GW

Sources: 122 123 124 125 126 127

[120] Kevin Clark. "L.A. authorizes conversion of largest gas plant to hydrogen" Power Engineering. (Feb. 9, 2023). https://www.power-eng.com/hydrogen/l-a-authorizes-conversion-of-largest-gas-plant-to-green-hydrogen/#gref
[121] Kevin Clark. "L.A. authorizes conversion of largest gas plant to hydrogen" Power Engineering. (Feb. 9, 2023). https://www.power-eng.com/hydrogen/l-a-authorizes-conversion-of-largest-gas-plant-to-green-hydrogen/#gref
[122] Intermountain Power Agency. "IPP Renewed". https://www.ipautah.com/ipp-renewed/
[123] Hydrogen Insight. "Los Angeles moves forward with $800m plan to convert 830MW gas-fired power plant to run on green hydrogen". https://www.hydrogeninsight.com/power/los-angeles-moves-forward-with-800m-plan-to-convert-830mw-gas-fired-power-plant-to-run-on-green-hydrogen/2-1-1401866
[124] Lodi News. "Lodi to be base for hydrogen pilot program providing power to NorCal". (June 2022). https://www.lodinews.com/news/article_a18bc96e-e788-11ec-80fa-7730df49a97e.html
[125] Utility Drive. "Constellation sets hydrogen-gas plant blending record, but more advances needed for utility-scale use: experts". (June 2023). https://www.utilitydive.com/news/constellation-energy-hydrogen-blending-test-hillabee-power-plant/652000/
[126] NextEra Energy. "A Plan for Real Zero". https://www.nexteraenergy.com/real-zero.html
[127] Equinor. "Equinor and RWE cooperating on energy security and the energy transition". https://www.equinor.com/energy/equinor-rwe-cooperation

Decarbonization Pathways and Alternatives

CCUS

CCUS in thermal power generation separates CO_2 emissions from a power plant's flue gas or syngas stream to prevent its release into the atmosphere. The captured CO_2 is sequestered or converted to a long-lived product, resulting in an overall reduction in CO_2 emissions. CCUS can serve as an alternate and potentially complementary pathway along with hydrogen in supporting the future power system with clean firm power[128]. The CARB scoping plan projects CCUS as a pathway to meet decarbonization goals, with carbon removal targets of ~25 MMT CO2 for carbon capture and storage and ~64.4 MMT CO2 for direct air capture[129]. Although the economic case for CCUS in the power sector can be challenging at times, with costs potentially exceeding revenues for combined cycle gas turbines[130], there exists strong policy support at the federal level with tax credits and incentives[131]. Furthermore, CCUS faces some of the similar early-stage challenges as hydrogen in terms of infrastructure availability and requires a significant ramp up of pipelines and transportation systems to be a feasible solution for power plants. A combination of factors such as CO2 capture capacity, utilization, distance to storage, existing equipment, and infrastructure availability at the plant level will determine whether CCUS is implemented at a specific plant[132].

Battery Storage

Instead of generating electricity with peaker plants during times of high electricity and fuel prices, batteries and energy storage can be used to either 1) store renewable energy; or 2) "peak shift" by using lower cost energy stored during off-peak periods to meet the demand. However, current battery storage does not provide the duration necessary to fully replace power plants and carry a significant price tag compared to alternatives. Research performed by ANL and Massachusetts Institute of Technology found that supplementing renewable plants with battery storage is a "weak substitute" for the natural gas plants currently in place[133]. In California, where renewables experience sharp declines in the fall and winter, hydrogen has the potential to be a more feasible solution for long-duration energy storage. Hydrogen's long duration storage capabilities can prevent curtailment of excess renewables and when paired with adequate storage reserves, enable the use of that energy in seasons of higher demand. Spatial and cost considerations will serve as constraints for battery storage, with a Clean Air Task Force analysis of CAISO data suggesting power system costs rise exponentially as renewable penetration with battery storage climbs.[134] Although there are limitations to using energy storage in

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[128] EDF. "California needs clean firm power, and so does the rest of the world". https://www.edf.org/sites/default/files/documents/SB100%20clean%20firm%20power%20report%20plus%20SI.pdf

[129] California Air Resources Board. "2022 Scoping Plan Documents". https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2022-scoping-plan-documents

[130] US Department of Energy. "Pathways to Commercial Liftoff: Carbon Management". (April 2023). https://liftoff.energy.gov/wp-content/uploads/2023/04/20230424-Liftoff-Carbon-Management-vPUB_update.pdf

[131] Congressional Research Service. "The Section 45Q Tax Credit for Carbon Sequestration" (August 2023). https://sgp.fas.org/crs/misc/IF11455.pdf

[132] US Department of Energy. "Pathways to Commercial Liftoff: Carbon Management". (April 2023). https://liftoff.energy.gov/wp-content/uploads/2023/04/20230424-Liftoff-Carbon-Management-vPUB_update.pdf

[133] Applied Energy Volume 175. De Sisternes, Fernando J.; Jenkins, Jesse D.; Botterud, Audun. "The value of energy storage in decarbonizing the electricity sector." (August 2016). https://www.sciencedirect.com/science/article/abs/pii/S0306261916305967

[134] Clean Air Task Force, EDF. "Growing the Grid: A Plan to Accelerate California's Energy Transition". (October 2022). https://www.catf.us/2022/10/report-outlines-roadmap-accelerating-californias-clean-energy-transition/

large quantities, as discussed above, there is value in leveraging both hydrogen and battery storage in parallel to build a clean energy system in California.

Model Scope and Key Assumptions

Model Scope

The power sector demand projected encompasses all peaker and baseload plants in SoCalGas' service territory with capacity greater than 1 MW[135]. Plant-level retirement plans or published projected hydrogen demand is incorporated into the model where available.

The model assumes all future hydrogen consumption in the power sector will come from fuel switching of currently operating power plants. New power plant builds were not factored in this assessment, although as mentioned previously, CARB's 2022 Scoping Plan forecasts 9 GW of incremental hydrogen capacity. The analysis models future hydrogen-fired power plants and does not include hydrogen fuel cells for the power sector. The near-term path utilizes hydrogen blending with transition to full hydrogen firing over time. Blending hydrogen requires modification to fuel delivery systems. As the content of hydrogen in the fuel blend increases, retrofits are required that upgrade combustion hardware with components capable of burning higher blends of hydrogen, up to 100% in the future. Although grid load is expected to increase in the future as electrification increases, this study did not attempt to forecast future grid load.

Table 3: Power Subsector Definitions and Opportunity Profiles

Power Subsector	End Use Application	Definition	Clean Hydrogen Opportunity
Baseload	Grid reliability, resource adequacy	The minimum amount of power required over a 24-hour period to meet base load.	Support grid stability while reducing emissions
Peaker	Grid reliability, resource adequacy	Power supplied to meet peaks in demand over a 24-hour period and can include simple and combined cycle gas turbines	Increasingly volatile demand will require clean resources like H2 to support grid reliability.

The study focused mainly on baseload and peak load opportunities for hydrogen, given the impending technological feasibility of incorporating hydrogen into natural gas plant fuel mixtures.

Key Assumptions and Adoption Levers

The four adoption factors of policy and legislation, commercial availability, technical feasibility, and business readiness are the primary drivers of adoption rates in the power sector, with these adoption

[135] Although we expect the majority of demand to come from plants >1MW, potential future analysis may consider additional demand from plants <1MW.

factors influencing the quantity of current natural gas capacity transitioned to hydrogen, the utilization of this hydrogen capacity, and the timeline of adoption.

Commercial availability and technical feasibility drive the switch of current natural gas capacity to hydrogen, with capacity adoption based primarily on the technology costs and revenue opportunities of conversion to hydrogen compared to other forms of owned capacity against power purchases. Informed "what-if" analysis scenarios were used for the utilization of capacity, measured by the capacity factor for hydrogen combustion turbines.

Policy & Legislation

Recent SB100 and LA 100 policies are the primary drivers for increasing amounts of renewable energy on the electric grid. Due to its statewide applicability, the major policy that has impacts on the rate of hydrogen transition is California's SB100, which accelerates the states Renewable Portfolio Standard program to 100% clean, zero carbon, and renewable energy by 2045. Clean renewable hydrogen can play a supporting role in reaching these targets, by providing dispatchable generation when it is needed to complement renewable energy generation.

California's Cap-and-Trade program will also be a key driver of decarbonization in the power sector. As one of the largest multi-sectoral emissions trading systems in the world, covering around 450 businesses including electric power plants that meet the 25,000-metric tonne CO_2 emission threshold[136]. As we approach 2045, the cap will get progressively lower with minimal allocation of free allowances to electric utilities, causing a switch to clean, renewable fuels[137].

Technology Feasibility

The feasibility of hydrogen blending at low percentages in the short term and 100% hydrogen capable combustion turbines in the mid and long-term impacts the timeline of hydrogen adoption as well as the level of hydrogen that can be adopted in the power sector. Technology feasibility for blending in the short term has been evaluated at the plant level based on current combustion turbine configurations, where data is available. Input from OEMs has been used to determine current blending percentages at a market level, as well as timelines for 100% hydrogen capabilities feasibility.

The study found that the combustion systems of many current natural gas units have hydrogen capabilities up to a maximum of 30% by volume, providing a near-term pathway for hydrogen adoption. However, while current combustion systems are technically capable of blending up to 30% by volume, few units can burn any more than a trace amount of hydrogen today without modifications because of current limitations in fuel delivery systems. Utilizing the near-term pathway for blending that is available within current combustion systems will require additional piping, blending skid, control system, safety, and code requirements.

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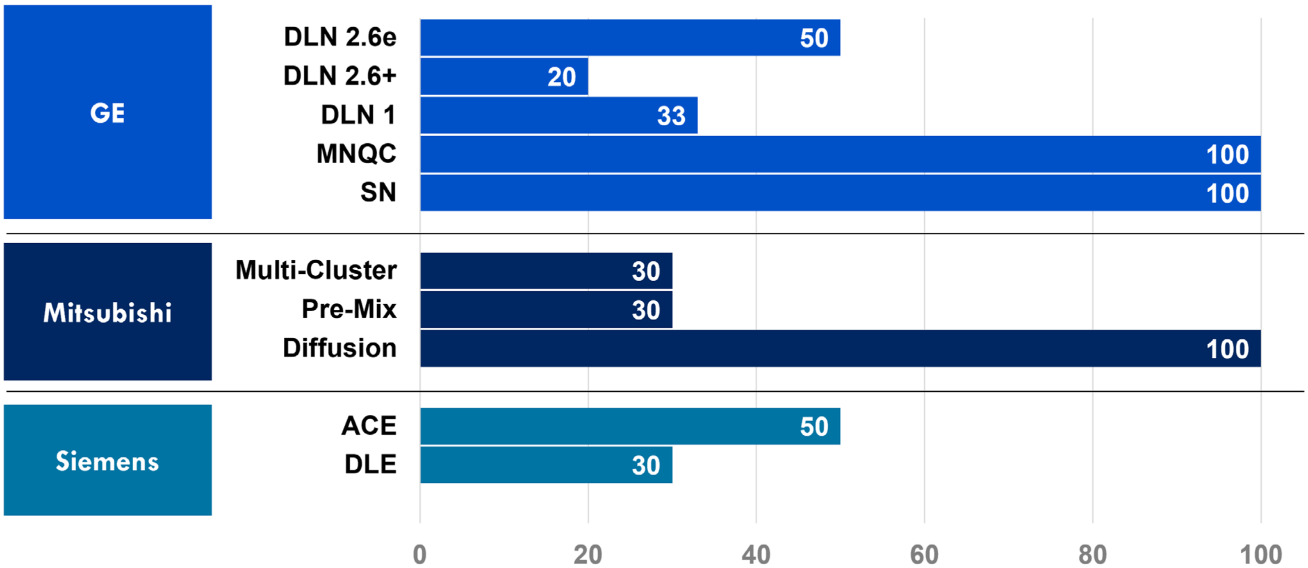
136 Center for Climate and Energy Solutions. "California Cap and Trade". https://www.c2es.org/content/california-cap-and-trade/
137 California Air Resources Board. "Cap-and-Trade Program: Allowance Distribution Factsheet." https://ww2.arb.ca.gov/resources/documents/cap-and-trade-program-allowance-distribution-factsheet

As hydrogen fuel delivery systems and combustion technologies improve over time, hydrogen fueling capability is expected to grow as OEMs supply systems with inherent hydrogen capability. Although gas turbines with combustion systems capable of burning 100% hydrogen are not available at this time, interviews with major manufacturers confirmed that technical feasibility for 100% hydrogen capable combustion systems is targeted by 2030 and is in fact a goal of many of those same manufacturers.

Figure 15: Current H2 Capability across Major Power Manufacturer Models (% by Volume)
Source: EPRI Analysis [138,139,140]



Both retrofits and complete replacements are available for OEMs that develop this technology. There has been focus by the OEMs to develop retrofit solutions for an already installed fleet. However, when these programs are complete, they would likely be offered if plants were to do a complete replacement as well. Most OEMs offer their highest hydrogen capability technology as standard on their new gas turbines.

It is not yet clear, however, whether 100% hydrogen capability will be realistic for all assets, or if the expected feasibility timeline will hold true. If reaching technological feasibility takes longer than expected, hydrogen adoption could follow a different curve than what is described in this study. Additionally, the implementation of 4-hour battery storage may impact the adoption rates of hydrogen as a fuel source as that amount of battery storage could provide much of the peak demand needed to augment intermittent renewable energy sources.

[138] GE Gas Power. “Hydrogen Fueled Gas Turbines”. https://www.ge.com/gas-power/future-of-energy/hydrogen-fueled-gas-turbines
[139] Siemens Energy. “Zero Emission Hydrogen Turbine Center”. https://www.siemens-energy.com/global/en/priorities/future-technologies/hydrogen/zehtc.html
[140] Mitsubishi Heavy Industries Group. “Decarbonizing Power Generation with Minimal Modifications”. https://iea.blob.core.windows.net/assets/64c27e00-c6cb-48f1-a8f0-082054e3ece6/Renewables2022.pdf

Despite uncertainties in exact H2 percentages and timelines, it is feasible that manufacturers and third parties will be able to provide technologies that can reach high blending levels of over 90% by volume by 2030.

Commercial Availability

Commercial availability assesses the commercial availability of hydrogen technologies as well as the cost competitiveness of them against alternatives including 4-hour batteries and CCUS, all relative to the cost of power purchases. Estimated cost equivalence between natural gas and hydrogen fuel at an MMBTU level is a driving assumption.

Business Readiness

Interviews with power plant operators suggest that multiple years may be needed to put in place the necessary processes, permits, and engineering plans for hydrogen upgrades. Although this can take place in parallel with pipeline operator and OEM timelines, the announcement and finalization of construction plans for hydrogen transport infrastructure as well as go to market timelines for turbine technologies will enable business decisions, permitting, and engineering studies to begin. This has been reflected in the Demand Study through a progressive increase in 100% hydrogen turbine adoption starting at 2030, with a small number of early adopters beginning to move to hydrogen in 2030 as technology becomes available. As 2045 approaches, adoption progressively increases, reflecting the expected gradual increase in business readiness.

Additional assumptions

- Hydrogen for power generation is likely used in peak situations that will require high flow rates of hydrogen to the units to fill the need for generation when wind and solar cannot generate. Subsequently, hydrogen will need to ramp quickly to make up for power lost as wind and solar go offline. This demand will be most significant when events such as extreme weather or net load ramps are widespread across SoCalGas' service territory and beyond.[141] Even when events are not widespread, the demand of ramping individual units on and offline will be a major draw on demand.
- Equipment cost assumptions have been made across hydrogen, batteries, and CCUS to determine the likelihood for plants to convert to hydrogen. CapEx costs have been estimated for both blending as well as full conversion to hydrogen based on turbine size and current hydrogen capability.
- To understand the total potential of hydrogen, the cost of hydrogen has been set equal to the incumbent fuel.

Scenario Definition

As with all three sectors, three scenarios were modeled for the demand study. A range of "what-if" capacity factor scenarios were evaluated to determine the total power generation from hydrogen in 2045. Capacity factors were not modelled and were instead input directly to understand what the

[141] IEA. "Renewables 2022: Analysis and Forecast to 2027". https://iea.blob.core.windows.net/assets/64c27e00-c6cb-48f1-a8f0-082054e3ece6/Renewables2022.pdf

potential demand could be across a range of different capacity factors. Interviews with OEMs and operators suggest that hydrogen capacity factors could reach 8-10% by 2045, driving the conservative case. The 30% capacity factor in the ambitious case is based on historical EIA natural gas capacity factor data in California which has fluctuated between roughly 25% - 35% over the past 10 years[142]. These EIA natural gas capacity factors are based on an average of aging once through cooling power plants and peakers which generally have very low capacity factors and combined cycle pants, which have much higher capacity factors. A 20% capacity factor scenario is used in the moderate case to reflect a midpoint between the conservative and ambitious cases. The probability of each capacity factor was not evaluated. Modeling the anticipated electric load increase and grid reliability requirements in future phases may help to determine which capacity factor is most likely, since capacity factors may be influenced by several factors such as electric demand, electricity imports, costs of energy sources, reliability and ramping needs among others. Details of the scenarios for the power sector are included in the table below.

Table 4: Scenario Definitions for the Power Sector

Scenario	Description
Conservative	10% system-wide capacity factor for H2 turbines in 2045
Moderate	20% system-wide capacity factor for H2 turbines in 2045
Ambitious	30% system-wide capacity factor for H2 turbines in 2045

Projected capacity factors as well as commercial viability will be additional key factors in driving demand. SB100 legislation assumptions and technology feasibility regarding timelines for current blending capabilities and timelines for 100% H2 turbines remain consistent across the conservative, moderate, and ambitious scenarios.

There will be a ramp up of this capacity from the near zero level of today to the level reached in 2045. Midpoint time ranges are based off a ramp which uses the same assumptions.

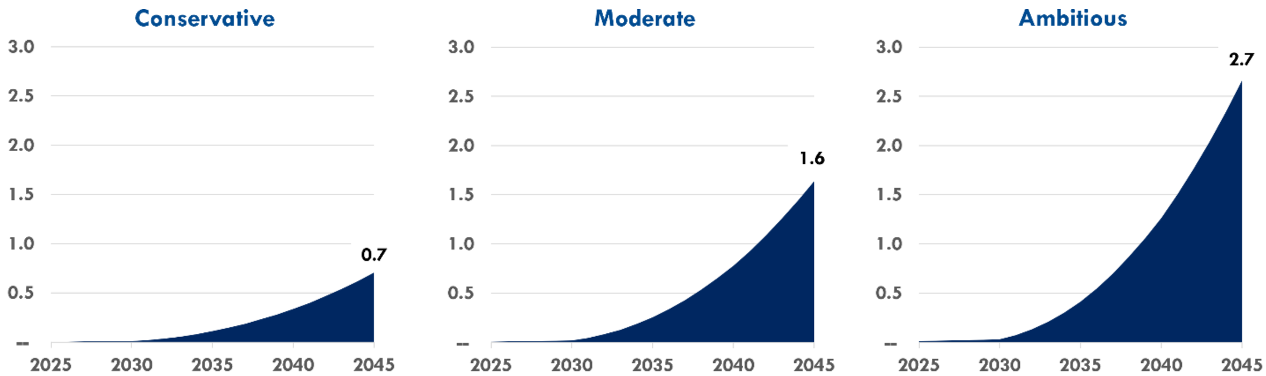
Power Demand Study Results

Overview

The analysis modeled potential hydrogen demand in the baseload and peaker subsectors by 2045 in three scenarios. The results suggest that, next to mobility, power generation represents another important source of demand, at between 0.7M – 2.7M TPY by 2045. This demand is projected to rapidly expand starting in 2030 due to technological readiness and key legislation, namely SB100. As electrification grows across mobility and other end-use energy sectors, clean renewable hydrogen will play a vital role in providing a low-carbon alternative to natural gas and in supporting grid reliability as more intermittent renewable energy sources come online.

[142] EIA. "State Electricity Profiles". https://www.eia.gov/electricity/state/california/state_tables.php

Figure 16: Total Expected Clean Renewable Hydrogen Demand in the Power Sector
2025-2045, values in Million TPY



As hydrogen ramps up or down in response to changes in solar and wind energy, demand for hydrogen in power generation is expected to occur during periods of peak demand and will be most necessary during extended and extreme events. While the modeled annual capacity factors for power generation using hydrogen are lower in the conservative and moderate scenarios than current rates for natural gas, the hourly flow rates needed to support power generation during peak demand periods could be significant, making cost-effective and reliable delivery of hydrogen to power plants a necessity. More detailed analysis of the electric grid and the effect of increasing penetration of intermittent renewable energy could uncover a need for additional reliance on hydrogen combustion turbines in certain locations with infrastructure delays or for system reliability.

"The H2 demand will be present as power plants can eat through supply as needed. Turbines can take oversupply off with no problem" -Turbine OEM

Subsector Results

<u>Peaker and Baseload</u>

As California's energy landscape changes, we expect to see a notable change in the way plants operate, and these changes are reflected in projected hydrogen demand. Although capacity factor assumptions in conservative and moderate scenarios are lower than the current system wide natural gas capacity factors that we see from natural gas today in California, we do not expect to see total dispatchable capacity requirements decline significantly from the capacity in place today in SoCalGas' service territory. In addition, if California is not able to rely as heavily on imports as it competes with other states that attempt to decarbonize their electric grid[143], demand for clean fuels like hydrogen for power generation may further increase. Therefore, projected hydrogen power generation capacity in

[143] CAISO has flagged long term electric resource diversity and potential capacity shortfall concerns in California resource planning proceedings. CAISO. "Comments of the California Independent System Operator Corporation, Order Instituting Rulemaking to Continue Electric Integrated Resource Planning and Related Procurement Processes, R-20-05-003". http://www.caiso.com/Documents/Oct23-2020_Comments-on-Integrated-Resource-Planning-R20-05-003.pdf

2045 may increase, with estimates of 10 to 13 GW across scenarios. This projection is directionally aligned with CARB's Scoping Plan[144] in showing the significant need for hydrogen fueled thermal power generation capacity by 2045. CARB's Scoping Plan also projects through 2045 a consistent need for 33 GW of firm gas generation, which will require some type of solution to achieve SB100's emissions targets, such as the use of carbon capture or conversion to a zero-carbon fuel. The decision will likely be made at the individual plant level, but if some choose to use hydrogen as an alternative to fossil fuels, that could potentially increase hydrogen capacity numbers beyond this study's estimates.

The hydrogen capacity in the future has been estimated based on analysis of the hydrogen upgrade probability by plant. This analysis is based on the costs and predicted revenues of electricity produced from hydrogen in combustion turbines, as well as those from natural gas with CCUS and battery, with all three compared against the cost of purchased power. What we see is that given a fuel price parity assumption to natural gas, hydrogen makes a strong economic case against alternatives, with hydrogen upgrade probabilities over 50% across scenarios. This is due to the low CapEx costs of retrofitting existing combustion turbines to utilize hydrogen compared to CCUS and battery costs for equivalent capacity.

These high capacities contrasted against declining capacity factors paint the picture of the future of hydrogen as a fuel source for combustion turbines: there will be a significant capacity in place when needed, during the highest peak days, while at the yearly level utilization may seem comparatively lower. This behavior shows that it is important that hydrogen can come online quickly, driving the importance of a hydrogen infrastructure that mimics the behavior of today's natural gas infrastructure.

Potential Opportunities for Demand Upside

Microgrids and Backup Power Generation

Microgrids are electric power grids that can function independently from the larger grid system, with increasing potential in remote areas and for critical facilities such as hospitals. Clean hydrogen can be introduced into microgrids to enhance community energy resilience by leveraging distributed renewable energy production, storage, and use. Local electricity generation reduces strain and supports the electric grid and is able to supply critical and emergency energy with zero GHG emissions during power outages. Furthermore, adding hydrogen to microgrids enables seasonal and long-term storage that cannot be provided by batteries. SoCalGas is already testing the potential of hydrogen for microgrids through the H2 Innovation Experience clean-powered microgrid and home.[145] Additional projects are taking place across California, with PG&E undertaking a hydrogen microgrid project at their California Resiliency Center substation, enabling islanding from the larger grid during public safety power shutoff

[144] California Air Resources Board. "2022 Scoping Plan for Achieving Carbon Neutrality". Figure 4-5. (December 2022). https://ww2.arb.ca.gov/sites/default/files/2023-04/2022-sp.pdf
[145] SoCalGas. "[H2] Innovation Experience. https://www.socalgas.com/sustainability/h2home

events.[146] Although hydrogen demand for microgrid applications was not analyzed, this application could serve as a potential upside to hydrogen demand projected in this demand study.

Industrials

Introduction

As the largest manufacturing state in the country, California has roughly 25,000 industrial enterprises. There is significant concentration of industrial activity within Southern California, contributing ~23% of the state's overall GHG emissions[147]. Within the industrials sector, there is a strong diversity of subsectors, seen in the figure below. Much of this natural gas used is in currently hard-to-electrify subsectors that rely on high temperature processes.

While there are currently few state policy and regulatory drivers to abate GHG emissions in this sector, hydrogen technology in the industrials sector has seen significant growth in maturity and adoption in industrial facilities globally, largely due to emissions mandates in Europe. As hydrogen technology becomes more proven and commercially available, industrial end users in California are expected to adopt technology at a similar pace. Certain high-natural gas use end-customers such as refineries and cogeneration facilities are likely to drive demand volumes, but hydrogen adoption is projected to be broader across many different subsectors in the region.

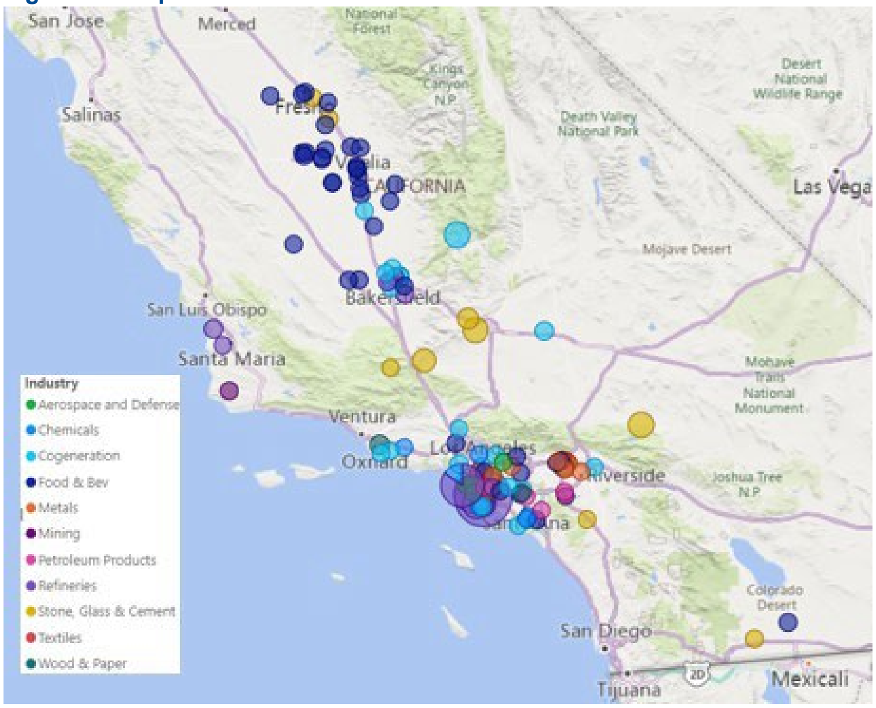
Industrials Landscape

There is a wide variety of industries located in Southern California, with a significant concentration in the LA Basin area.

[146] Microgrid Knowledge. "Utilities Eye Hydrogen Microgrids for Decarbonization, Resilience". (May 2023). https://www.microgridknowledge.com/utility-microgrids/article/33005764/utilities-eye-hydrogen-microgrids-to-meet-decarbonization-goals-provide-resilience

[147] California Air Resources Board. "Current California GHG Emission Inventory Data". (2022). https://ww2.arb.ca.gov/ghg-inventory-data

Figure 17: Map of Industrial Sites in Southern California



Source: CARB Industrial Facilities, SME Input

Hydrogen in the Industrials Sector

California's industrials sector consists of a diverse range of subsectors. Considering their total emissions, natural gas consumption, and number of facilities, this analysis primarily focuses on quantifying the demand from:

- Fuel switching in the food and beverage, metals, stone, glass, and cement industries as well minor demand from secondary subsectors for the three scenarios,
- Refineries in the ambitious case.
- Demand from all cogeneration plants, which are primarily located on industrial facilities.

Table 5: Hydrogen in the Industrials Sector

	Opportunities	Drawbacks	Use Cases
Hydrogen	• Decarbonization of high temperature energy intensive processes (>400ºF)	• Technology readiness is still in early stages. • Steady supply of H2 is required	• Furnaces • Kilns

Decarbonization Pathways and Alternatives

Electrification and CCUS are expected to be significant alternatives to hydrogen adoption. Electrification will be a strong deterrent to natural gas usage in lower-temperature processes across subsectors. CCUS is primarily a viable alternative in larger facilities, particularly in the cement industry. Since over 60% of emissions in this sector comes from the production of the raw material in cement, as opposed to fuel combustion, CCUS provides an alternative to capture larger amounts of carbon emissions.[148]

Table 6: Electrification and CCUS in the Industrials Sector

	Opportunities	Drawbacks	Use Cases
Electrification	• Decarbonization of low or medium heat processes (<400ºF) • Few process changes with new equipment	• Not easily viable for use in high temperature processes (e.g., furnaces) • Electricity prices may be cost prohibitive. • Large volumes of heat required may be challenging	• Refrigeration • Pressurization • Sterilization
CCUS	• Reduction of emissions at the source • Potential monetization of CO_2 for fuel production • Federal incentives and benefits including 45Q tax credit[149]	• Practical mainly for larger facilities with significant emissions, making CCUS more difficult in smaller distributed industries such as food & beverage. • Industries with lower-purity CO_2 streams show difficult project economics for CCUS[150]	• Large industrial plants (e.g., cement, refineries)

Model Scope and Key Assumptions

Model Scope

For each subsector, the development of each adoption lever was evaluated over the analysis period of 2025 – 2045. The following section details the subsectors analyzed as well as the trends amongst the four key adoption levers over time.

Table 7: Industrial Subsector Definitions and Opportunity Profiles

Industrial Subsector	Scenarios Included	Subsector Overview	Clean Hydrogen Opportunity
Metals	All	• Primarily concentrated in the Los Angeles Basin. • Large presence of fabricated metal facilities with some high emissions usage primary metals. • No production of raw steel in SoCalGas' service territory.	• Fuel switching from natural gas for high temperature equipment such as boilers and furnaces. • Hydrogen-based direct reduction of iron (DRI) used in raw steel processing (No presence in SoCal).

[148] Applied Energy Volume 317. Nhuchhen, Daya R.; Sit, Song P.; Layzell, David B. "Decarbonization of cement production in a hydrogen economy". (July 2022). https://www.sciencedirect.com/science/article/pii/S0306261922005529

[149] Congressional Research Service. "The Section 45Q Tax Credit for Carbon Sequestration" (August 2023). https://sgp.fas.org/crs/misc/IF11455.pdf

[150] US Department of Energy. "Pathways to Commercial Liftoff: Carbon Management". (April 2023). https://liftoff.energy.gov/wp-content/uploads/2023/04/20230424-Liftoff-Carbon-Management-vPUB_update.pdfgy.gov)

Food & Beverage	All	• Large number of facilities, primarily concentrated in Central California, near Bakersfield. • Wide variety of food and beverage industries (e.g., dairies, breweries).	• Fuel switching from natural gas for industrial equipment such as heating, cooling, and refrigeration.
Stone, Glass, Cement	All	• Major cement facilities located in Kern County, with smaller glass and cement facilities distributed in the LA Basin. • SB 596: 100% net zero GHG target in cement by 2045.	• Short- and medium-term opportunities are for fuel switching for high temperature equipment (e.g., kilns). • Potential long-term opportunity for synthetic methanol, not currently quantified.
Pulp & Paper	All	• Few facilities, concentrated in the LA Basin. • Significant cogeneration operations at paper plants and are captured in cogeneration section.	• Fuel switching from natural gas for high-temperature industrial equipment such as boilers and kilns.
Chemicals	All	• Few mid-sized chemical facilities, concentrated in LA Basin. • Primary chemicals presence in SoCal is in H2 production, which is not in scope.	• Fuel switching from natural gas for industrial equipment such as boilers. • Use as feedstock in chemical processing.
Aerospace & Defense	All	• Large number of businesses in Los Angeles, however, few have sizeable onsite manufacturing. • Many aerospace parts are manufactured in metal fabrication shops, captured in metals category.	• Fuel switching from natural gas for industrial equipment such as boilers. • Could serve as an early adopter given the strategic importance of the defense sector.
Cogeneration	All	• Largest presence is on oil fields in Kern County and refineries near the Port of Los Angeles. • Locations on additional commercial and industrial facilities.	• Fuel switching from natural gas to hydrogen blending and hydrogen turbines.
Refining	Ambitious Only	• Highly concentrated near the Port of Los Angeles and in San Joaquin Valley. • At present, hydrogen used in refineries is produced mainly from natural gas by SMR.	• Clean fuel switching from natural gas, and transitioning from grey to clean, renewable hydrogen for refinery direct processes and production of renewable diesel and SAF.

Key Assumptions and Adoption Levers

Policy and Legislation

Currently there is little industry-specific legislation that drives a transition to hydrogen in the industrials sector, either in California or nation-wide. California's SB596 states that the cement industry must decrease 1990 levels of emissions by 40% by 2030 and reach net-zero emissions by 2045. However, given the strong presence of alternatives in the industry, namely CCUS, this is not assumed to be a major demand driver. California's cap-and-trade program will also serve as a driver for decarbonization in the industrials sector, although the extent to which this program drives decarbonization may vary by facility.

Technology Feasibility

For most industrial facilities within SoCalGas' service territory, the primary opportunity for hydrogen will be fuel switching for process heat, switching from natural gas-based combustion to hydrogen-based combustion technology, as well as cogeneration. This fuel switching opportunity is most prevalent in high temperature equipment (e.g., furnaces, kilns) that are considered hard-to-electrify. In most industrial facilities, low concentration of hydrogen blending is possible without significant modifications to existing technology. However, 100% hydrogen-based technologies are required to achieve significant emissions reduction. Most hydrogen technology in this space has been in emerging stages; further technological development is expected as more facilities continue to conduct pilot programs and guide hydrogen technology manufacturers based on lessons learned. Hydrogen adoption for industrial and commercial sited cogeneration turbines is expected to follow the same levels of technical feasibility growth as the other turbines described in the Power sector section of this report.

However, among the different subsectors in the industrials portion of the study, there have been variances in the type of hydrogen-based technology that is being piloted and the processes that are required to implement these technologies.

Commercial Availability

Commercial availability of hydrogen technologies is increasing; however, most commercialized technologies remain focused on a narrow subset of use cases. Burners and combustion technologies remain in focus. Some burner models are in demonstration today and may be ready for product launch in the next three to five years. Developments and demonstrations in high temperature alloys and refractories use cases are more uncertain, with longer timelines to commercialization. Flame management and advanced combustion controls systems are projected to be ready for commercialization in the 5–10-year timeframe.

Business Readiness

Business readiness will be particularly important for hydrogen adoption in the industrials sector given the relative lack of legislative incentives. Even as hydrogen combustion technology becomes more technically feasible and commercially available, there are several facility-specific characteristics that impact when facilities adopt a technology, particularly in the case of fuel switching.

- **Equipment lifetimes:** Industrial technologies are very long-lived, with equipment such as furnaces lasting over 20 – 30+ years prior to retirement. It is difficult for facilities to switch to hydrogen equipment before current retirement timelines.

- **Retrofits vs. new equipment:** Industrial end-users are often risk averse (particularly with technologies that directly impact the final product), which would lead to technologies being repaired and their useful life being extended rather than switching to new hydrogen equipment.

- **Workforce Training**: Additional training is required for employees on proper procedures.

- **Lack of Facility Downtime:** Many facilities run 24/7 with minimal idle time apart from maintenance and repairs. The difficulty in stopping production limits facilities' abilities to pilot hydrogen technology.

Given these factors, facilities are more likely to wait until asset end of life prior to investing in hydrogen-based technologies in absence of legislative mandates or internal ESG goals. This consideration has been incorporated into the model methodology through the addition of a lag parameter that adjusts adoption growth based on the equipment lifetimes.

Early adopters will likely be companies that have multiple facilities. At these companies, hydrogen technology can be piloted at one location and then more easily deployed at remaining facilities using learnings and best practices gained from the initial pilot.

Scenario Definition

As with all three sectors, three scenarios were modeled for the demand study. Details of the scenarios for the industrials sector are included in the table below.

Table 8: Scenario Definitions for Industrials

Scenario	Description
Conservative	Assumes that there is no growth in the industrials sector and that no new legislation mandating a shift to low-carbon alternatives is introduced. For cogeneration, 10% system-wide capacity factor for H2 turbines in 2045 is assumed.
Moderate	Assumes that there is growth of hydrogen demand in the industrials sector, but that there is no new legislation. For cogeneration, 20% system-wide capacity factor for H2 turbines in 2045 is assumed.
Ambitious	Assumes that there are market or legislative drivers that promote industrial decarbonization and therefore includes demand for hydrogen from refineries. For cogeneration, 30% system-wide capacity factor for H2 turbines in 2045 is assumed.

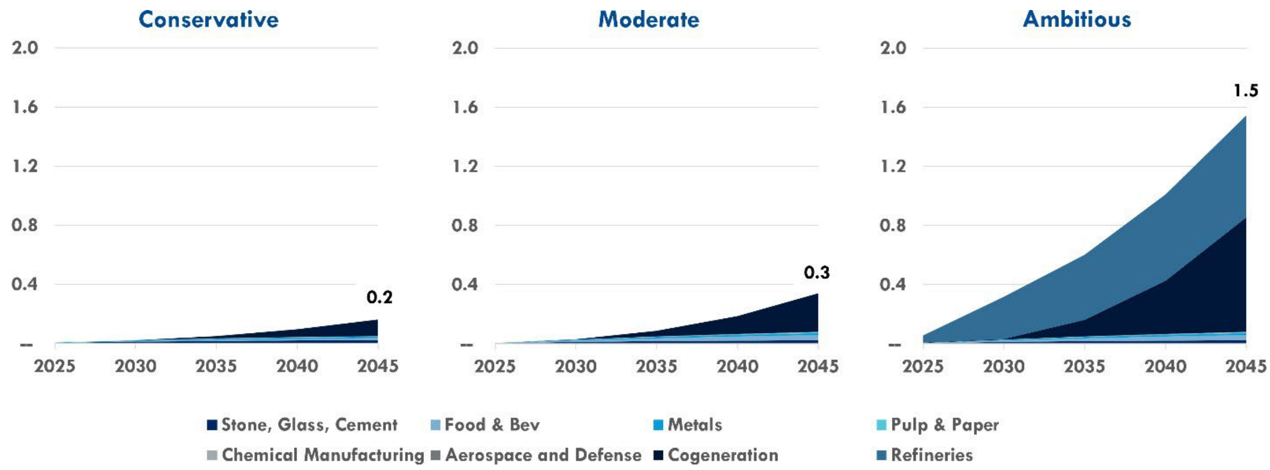
Industrials Demand Study Results

Overview

Potential hydrogen demand from the industrials sector within SoCalGas' service territory is expected to range from 0.2M to 1.5M TPY by 2045.

The demand scenario outcome will be heavily influenced by changes in the cost of capital requirements to transition to hydrogen and whether refineries make this switch. These two factors, in turn, can be largely determined by the enactment of legislation mandating emissions reductions in the industrials sector, as well as strategic decisions made by asset owners.

Figure 18: Total Expected Clean Renewable Hydrogen Demand in the Industrials Sector
2025-2045, values in Million TPY



The conservative scenario projects 0.2M TPY of demand by 2045 primarily from the food and beverage, metals, stone, glass, & cement industries, and cogeneration. In the moderate scenario, larger market-driven growth in hydrogen demand is assumed and the outlook increases to 0.3M TPY by 2045. In the ambitious scenario, refineries transition from current grey hydrogen to clean renewable hydrogen and capacity factors at cogeneration sites increase, driving demand to 1.5M TPY by 2045.

In the conservative and moderate cases, non-refinery industrial cogeneration facilities are expected to comprise most of the demand. This is largely due to increased technological developments and commercial availability in this sector compared to other industrials sectors. However, in the ambitious scenario, refineries are expected to be a significant portion of hydrogen in the industrials sector.

Currently, industrial entities in California are in the process of learning about and piloting hydrogen at large facilities. Consistent growth in technology readiness and commercial availability will be needed to reach projected demand. As more entities worldwide continue to pilot and integrate hydrogen-based technology, they will be able to serve as models for industrial companies in California.

In addition to increased education for stakeholders, targeted legislation that establishes a clear pathway to reduce emissions and incentives that reduce upfront capital costs and other adoption costs will be valuable in supporting a clean hydrogen transition. Legislation and mandates modeled after industrial emissions reduction standards seen in Europe or the mandates in the California mobility sector, such as the ACF regulation, can lead to increased and accelerated hydrogen adoption in the industrials sector. Sector-specific credit programs like the Low Carbon Fuel Standard (LCFS) are already contributing to hydrogen's cost-competitiveness, and the extent of this contribution is expected to increase in the near future[151].

Subsector Results

Metals

The hydrogen demand in the metals sector, comprising of primary and fabricated metals, is forecasted to range from 8.1K TPY in the conservative scenario to 12.3K TPY in the ambitious scenario. Like most industrials subsectors, there are no policy and legislation considerations for this subsector.

In the metal industry, technology is still emerging. Hydrogen-capable valve trains and piping are available today, but hydrogen-capable burners and furnaces for direct process heating and steam production are under development. For example, infrared-emitting hydrogen-capable burners that avoid flashback and mitigate concerns over thermal NOx formation, as well as fuel-agnostic burner designs are under development. These types of burners can decrease the risk of migration from hydrogen blends to full hydrogen adoption. 100% hydrogen furnace, oven and boiler systems will be in demonstration over the next three to five years, providing a potential pathway to broader commercial deployment. These systems have the potential to provide the metal manufacturers with more efficient by-design hydrogen-fueled process heating alternatives. Flame management and advanced combustion controls systems are less certain.

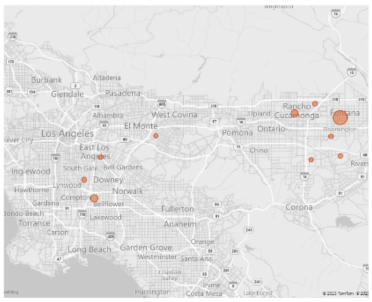
One aspect of commercial availability in this sector is that individual companies are bringing technological innovations to different components of the metals process. For example, there have been different approaches for switching from natural gas to hydrogen in the development of steel pipes and the heating of the raw steel itself. It illustrates that innovation in this sector can be championed by varied entities and that solutions for vertically integrated hydrogen across metals facilities will need further development.

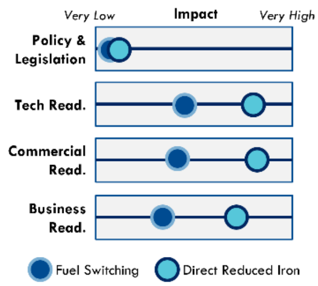
Given the lack of metals-specific policy drivers, adoption will largely be driven by business readiness and carbon pricing. Long equipment lifetime, facility wide retrofits, and integrated natural gas usage will slow initial growth until technology adoption processes and cost-benefit assessments have been better proven in the market.

[151] California Air Resources Board. "LCFS Electricity and Hydrogen Provisions". https://ww2.arb.ca.gov/resources/documents/lcfs-electricity-and-hydrogen-provisions

Figure 19: Hydrogen Adoption in the Metals Subsector

Major Southern California Facilities





Primary and Fabricated Metals

H2 Demand Forecast

8.1k – 12.3k

TPY by 2045

Statistics

Estimated Annual NG Usage: 6.8 BCF

Policy & Regulation Considerations

There are no policy mandates regarding the reduction of greenhouse gases. Notable regulations affecting H2 demand are the NOX limits set forth by the SQAMD. New "Buy America" provisions in recent federal infrastructure acts stipulate preferences for domestically manufactured steel, potentially increasing demand

Industry Characteristics

Metals industry serves a wide variety of critical industries in California (e.g., construction, automotives, aerospace & defense)

Southern California metals industry does not consist of raw iron manufacturing, which is the largest potential adopter of hydrogen in the industry through the use of Direct Reduced Iron (DRI).

While decarbonization of the metals industry has been progressing slowly in the US, there have been significant efforts in Europe. The European steel industry has set goals to cut carbon emissions by 55% by 2030 and reach climate neutrality by 2050.

Case Study: Cleveland-Cliffs

Cleveland-Cliffs completed a hydrogen injection trial at its Middletown Works blast furnace in Cleveland, OH during May 2023. This trial was the first H2 injection trial in North America. The hydrogen was delivered via existing pipeline infrastructure in place for the facility's other hydrogen uses, including for its annealing furnaces. Notable quote from Cleveland-Cliffs CEO states ""This achievement proves our ability to use green hydrogen throughout our footprint when it becomes readily and economically available…"

Key Takeaways

Hydrogen technology has made some inroads in the U.S. metals industry; however, without policy drivers, green hydrogen adoption in the industry will need to be cost-competitive before large scale adoption can be realized

Operational Characteristics

Primary metal facilities often run 24/7, with few idle periods apart from needed maintenance, whereas fabricated metal facilities can have more downtime between operations depending on the end products

Furnaces and other key equipment have long lifetimes, lasting 30+ years in operation

Data and insights based on interviews, market research, and Accenture calculations from EPA's Facility Level GHG Emissions and CARB Pollution Map databases.

Food and Beverage

The hydrogen demand in the food and beverage sector is forecasted to range from 13.8k TPY in the low scenario to 36k TPY in the ambitious scenario. Like most industrials subsectors, there are no policy and legislation considerations for this subsector.

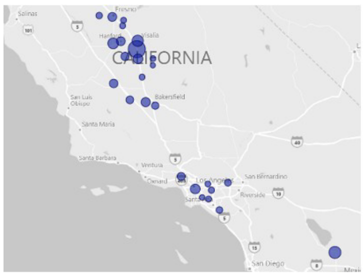
In the food and beverage industry, hydrogen use in process heating is technically feasible up to about 30% blending. However, increased blending ratios require many adjustments in fuel delivery process (e.g., BTU value, piping size, controls, burner sizes, and configurations.). In Southern California, there is a remarkably diverse set of food and beverage entities. While many hydrogen-based combustion equipment will be applicable to different entities, some equipment will need to be purpose built for specific industries (e.g., dairy).

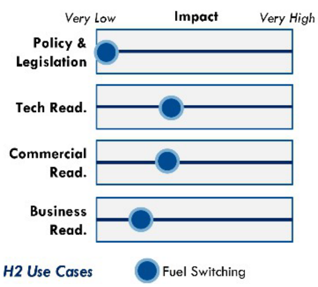
There are currently only a handful of hydrogen equipment manufacturers in the food and beverage industry, such as AMF Bakery Systems and RBS Oven Systems,[152] whose ovens can use hydrogen to bake a wide range of food products. These types of products can serve as replacements for aging, natural gas equipment but significant retrofits in other portions of the facility will be required. One benefit of this need for retrofits is that facilities may be willing to adopt multiple hydrogen-based equipment at once to avoid repeat retrofits and facility shutdowns.

[152] Reading Bakery Systems. "RBS Oven Systems: Baking for a Better Tomorrow". https://www.readingbakery.com/oven-systems.html

Figure 20: Hydrogen Adoption in the Food & Beverage Subsector

Major Southern California Facilities





Food & Beverage

H2 Demand Forecast

14k – 36k

TPY by 2045

Statistics

Estimated Annual NG Usage: 18.9 BCF

Policy & Regulation Considerations

There are no policy mandates regarding the reduction of greenhouse gases. Notable regulations affecting H2 demand are the NOX limits set forth by the SQAMD.

Industry Characteristics

There are a wide variety of food and beverage industries in Southern California (e.g. dairies, breweries). Decarbonization pathways related to hydrogen adoption are expected to be similar across industries.

Many food & beverage plants are in more remote locations compared to other industries, which makes the availability of energy infrastructure a challenge for any shifts to alternative energy sources

The predominant sources of carbon emissions in this sector are due to heating, cooling, and refrigeration.

Case Study: Budweiser Brewing Group UK&I

Budweiser Brewing Group UK&I collaborates with green energy firm Protium, introducing a large-scale hydrogen generation system in their South Wales brewery, eliminating 15,500 tons of CO2 annually. This pioneering move is driven by AB InBev's global commitment to source 100% renewable electricity by 2025. "Hydrogen... could play a crucial role in supporting the transition to a decarbonized global economy," stated the company. (Source)

Key Takeaways

Budweiser's UK initiative could inspire overseas hydrogen adoption by demonstrating its feasibility and environmental impact, including other AB InBev facilities located in California. Regulatory incentives and cost reductions in green hydrogen could drive utilities companies to invest in hydrogen infrastructure, viewing this case as a successful blueprint for carbon-neutral operations.

Operational Characteristics

Food & beverage processing facilities often run 24/7, with few idle periods apart from needed maintenance. Some types of food processing plants will have potential longer idle periods (e.g., tomato processing) due to seasonal agricultural trends

Key equipment (e.g., dryers) can have long lifetimes, lasting 20+ years

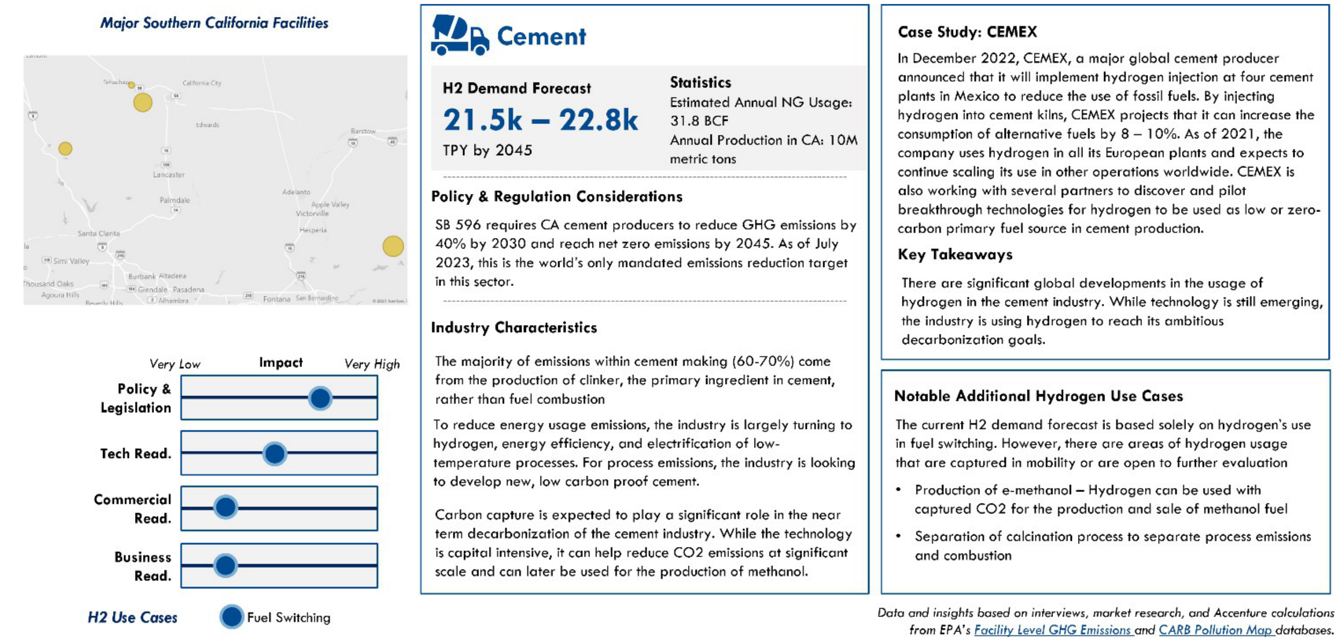
Stone, Glass, and Cement

The hydrogen demand in the stone, glass, and cement sector is forecasted to range from 21.5k TPY in the conservative scenario to 22.8k TPY in the ambitious scenario. Unlike most industrials sectors, there are decarbonization policy targets within the cement portion of this sector. SB 596 mandates that cement producers must reduce emissions by 40% of 1990 levels by 2030 and reach a goal of net-zero emissions by 2045.

In the cement industry, hydrogen may be blended with traditional fuels or used for specific process steps, but 100% hydrogen use as a fuel source currently has low technical feasibility due to the process changes that are required to implement the necessary technology. Hydrogen has a lower energy density compared to fossil fuels, which means much larger volumes of hydrogen are required to generate the same amount of heat. This could result in substantial modifications to cement kilns and downstream calciner processes that integrate kiln combustion gasses to recuperate waste heat.

Interviews with cement manufacturers affirm concerns about new hydrogen technologies disrupting process equipment, which is typically heavily integrated. A second emergent theme is the use of hydrogen for fuels production from captured cement carbon emissions. While there is industry interest on the potential increase in business, this use case described as more than 10 years out based on industry interviews and research on technology readiness. Greater technological feasibility and reduced cost of adoption would help establish a runway for increased clean renewable hydrogen demand.

Figure 21: Hydrogen Adoption in the Cement Subsector



<u>Secondary Subsectors (Paper, Chemical, Aerospace, Other)</u>

Additional industrials subsectors have been less engaged with hydrogen-based technology since they primarily deal with lower temperature processes that are more likely to switch to electrification as a decarbonization pathway. However, demand has been modeled for the limited high-process opportunities that are available in other sectors that have a presence in SoCalGas' service territory (e.g., paper, chemicals). The hydrogen demand in the pulp & paper sector is forecasted to range from 3.6k TPY in the conservative scenario to 5.1k TPY in the ambitious scenario. The hydrogen demand in the chemicals sector is forecasted to range from 1.7k TPY in the conservative scenario to 3.4k TPY in the ambitious scenario.

There will also be some potential for hydrogen in other subsectors in Southern California (e.g., textiles) that may have comparatively lower use of natural gas but may be inclined to adopt hydrogen technology to meet decarbonization targets. While these additional subsectors have not been modeled as part of this study, there may be an opportunity to capture demand from these sectors in further studies to better understand the needs of potential industrial off takers of hydrogen along pipeline routes.

Technology and commercial readiness for hydrogen in secondary subsectors will follow similar adoption growth as the other primary industrials sectors. Once technologies such as 100% hydrogen – based boilers become more proven, they can be leveraged in these secondary subsectors and replace natural gas fueled equipment. However, given the relatively low natural gas usage in secondary subsectors, there will be low business readiness to adopt major equipment changes.

Refineries

The hydrogen demand in the refinery sector, for non-cogeneration hydrogen use cases, is forecasted to range from zero TPY in the conservative scenario to 690k TPY in the ambitious scenario. The technical feasibility of hydrogen use is most advanced in the refining industry, where it is currently used as a feedstock in hydroprocessing operations to upgrade heavy oils, improve process conversion and yields, and remove impurities such as sulfur and nitrogen. Refineries and renewable diesel plants are already the largest industrial consumers of hydrogen, but hydrogen is primarily produced as a coproduct of naphtha reforming, a core process utilized in the production of gasoline, and via steam methane reforming (SMR) at refinery owned or third party dedicated hydrogen plants. The ready availability of hydrogen is one of key drivers for why clean, renewable hydrogen is not included in the conservative and moderate scenarios for Refineries. In contrast to carbon-free hydrogen produced by electrolysis powered by renewables, hydrogen produced via these incumbent refinery processes is considered to be very high in lifecycle carbon intensity. Clean renewable hydrogen is directly fungible with SMR produced hydrogen, however scale and ratability of renewable hydrogen production and delivery may be of concern to refiners.

Secondary to feedstocks, the refining industry can also be source of demand for clean renewable hydrogen for natural gas blending and/or switching for fired heaters and boilers. Hydrogen uptake as fuel is expected to follow broader industry trends with one caveat. Unlike general industrial processes, refineries can and do produce their own fuel gas as a byproduct of the refining process. Because of this, refineries have the ability to manage fuel gas heating value internally, through LPG blending, and at times can be constrained operationally by their ability to balance indigenous fuel gas production.

External market forces such as adoption of alternative fuel-based vehicles (e.g., hydrogen based, electric), will also directionally reduce aggregate hydrogen demand among conventional petroleum refineries. However, some of this hydrogen demand attrition in petroleum refining is expected to be offset, albeit not one-for-one, by increased production of renewable diesel and SAF, both of which require hydrogen in the production process.

Business readiness to adopt clean, renewable hydrogen as feedstock will largely be driven by the availability of steady supply at the volumes necessary for refinery operations. However, readiness for fuel-switching will be slower and dependent on the ability of refineries to deal with facility wide retrofits that can adjust current natural gas and hydrogen supply processes.

Cogeneration

The hydrogen demand in the cogeneration sector, including refinery-sited cogeneration is forecasted to range from 115k TPY in the conservative scenario to 799k TPY in the ambitious scenario. However, there remains significant uncertainty around the future of cogeneration in California, with the CARB Scoping Plan[153] and SB100[154] scenarios projecting all cogeneration to be retired by 2045. It is possible that cogeneration does not drive any hydrogen demand if cogeneration plants are retired by 2045. If

[153] California Air Resources Board. "AB 32 GHG Inventory Sectors Modeling Data Spreadsheet". https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2022-scoping-plan-documents
[154] California Energy Commission. "2021 SB100 Joint Agency Report". https://www.energy.ca.gov/sb100

cogeneration does remain past 2045, the Demand Study projection may be conservative as the capacity factors used in the modeling are relatively low for industrial cogeneration.

Cogeneration is included in the Industrials sector as the vast majority of cogeneration facilities are located on industrial sites (e.g., refineries, oil fields). Technology and commercial readiness for hydrogen in cogeneration plants is expected to follow the same adoption rates as the peaker and baseload plants, detailed previously in the power subsector results section. Adoption of hydrogen turbines at industrial sited cogeneration plants may help drive adoption of hydrogen in other industrial processes since any hydrogen supply network used at cogeneration plants could be used to supply hydrogen to the core industrial processes.

Potential Opportunities for Demand Upside

Agriculture

The industrial sector is diverse in sub-sectors and potential users for clean renewable hydrogen. While many of the most prominent sectors are formally modelled in the Demand Study, the future of California's industrial landscape may evolve. Along with this evolution, there are many industrial processes that could switch to hydrogen in the future as market scale, commercialization, and technology is tested and improves. One of the largest potential areas for this is fertilizer production. California is a global leader in farming, and a large consumer of fertilizer, however the State imports all fertilizer used. The world currently produces 175 million tons of ammonia per year, mostly for fertilizer, accounting for 1-2% of global carbon emissions.[155] If clean, renewable hydrogen were to be used to produce ammonia for fertilizer in State, then this could represent a huge upside for its demand and could help reduce global emissions significantly. Additionally, clean ammonia is being considered as potential shipping fuel for OGVs. However, there are safety and environmental concerns associated with the production and use of ammonia, so the future of ammonia remains uncertain in California.

Outside of ammonia and fertilizer production, there are many other potential avenues for hydrogen in agriculture: Hydrogen fuel cells may be used to power irrigation systems, many of which run on fossil fuels,[156] hydrogen could be used for agricultural drying (a high-heat processes to treat crops such as grains, nuts, etc, which may be difficult to electrify),[157]or hydrogen could be used to power greenhouses where a specific and constant energy supply is required to control the environment. These and many other potential use cases for hydrogen in the agriculture industry and beyond were not evaluated due to the diverse nature of the applications and their uncertainty in California's future.

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[155] Yale Environment 360. "From Fertilizer to Fuel: Can 'Green' Ammonia Be a Climate Fix?". (January 2022). https://e360.yale.edu/features/from-fertilizer-to-fuel-can-green-ammonia-be-a-climate-fix

[156] Penn State Extension. "Exploring the Potential of Hydrogen in Agriculture: Farming with a Green Future". (June 2023). https://extension.psu.edu/exploring-the-potential-of-hydrogen-in-agriculture-farming-with-a-green-future#:~:text=Currently%2C%20hydrogen%20is%20used%20in,of%20heat%20for%20these%20purposes.

[157] Iowa State University. "LP Gas Drying Estimate". (September 2004). https://crops.extension.iastate.edu/encyclopedia/lp-gas-drying-estimate#:~:text=LP%20gas%20requirements%20for%20high,0.025%20gal%2Fbu%2Fpt

Prepared By

In support of Angeles Link, Accenture and EPRI performed a demand analysis to quantify the potential clean, renewable hydrogen demand in SoCalGas' service territory and prepared this demand study report to share analysis outputs. Any policy recommendations included in this report are those of SoCalGas and do not reflect the opinions or views of Accenture or EPRI.

Technical Appendix

Angeles Link Phase 1 Demand Study

January 2024

DRAFT FOR REVIEW | CONFIDENTIAL

Contents

APPENDIX A: Methodology and Key Assumptions

Angeles Link Phase 1 Demand Study

Appendix A: Methodology and Key Assumptions

Overall Methodology

Methodology Approach

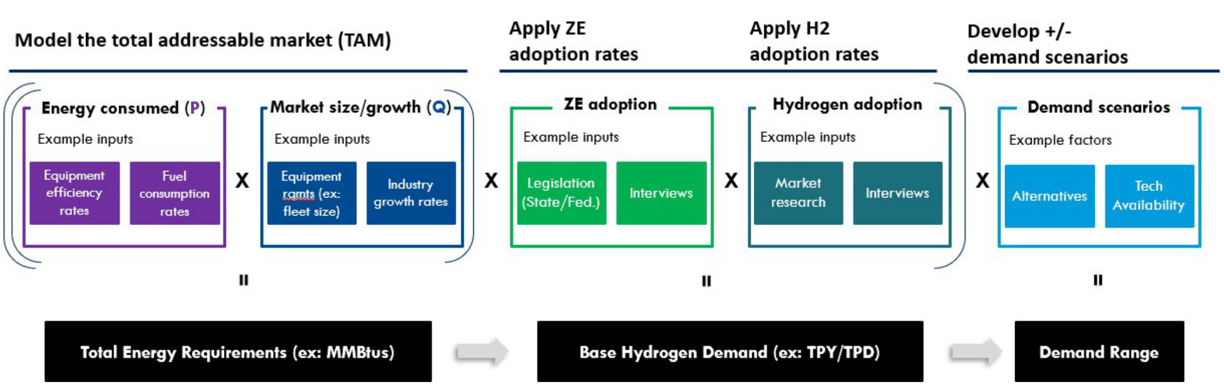
This section talks about calculations, equations, and effectively the flow diagrams of calculations used throughout the model. It explains the logic behind (1) what was modelled (2) how it was modelled.

At the onset of the demand study, subsectors were prioritized for quantitative analysis based on current emissions, current fuel usage, and a qualitative evaluation of potential for hydrogen in the subsector. The hydrogen demand for prioritized subsectors has been analyzed, with quantitative demand results outlined in this report. Subsectors not prioritized for quantitative analysis were not modelled, but potential opportunities for additional demand in these subsectors has been noted in this report.

Once subsectors were prioritized, the hydrogen demand was developed by modelling both the total addressable market for hydrogen as well as the adoption rates. This general methodology is outlined below, although specifics vary by sector and subsector:

1. Model Total Addressable Market (TAM) using current fuel usage.
    a. Determine industry growth rates.
    b. Define industry-specific characteristics (type of equipment used, efficiency rates and fuel consumption)
2. Apply Zero-Emission (ZE) adoption rates to TAM.
    a. Forecast transition to net-zero using current legislation and, when absent, align to State agency forecasts.
3. Apply hydrogen adoption rates to the ZE TAM
    a. Assess technical feasibility of each subsectors ability to convert, considering current industry equipment characteristics.
4. Develop demand scenarios.
    a. Define adoption scenarios through qualitative assessment of decarbonization alternatives, technology commercialization, and cost to adopt hydrogen.

Figure 1: Hydrogen Demand Methodology - Illustrative



Throughout the analysis process, targeted interviews were conducted with subject matter experts across industry, academia and government agencies to test these adoption inputs and assumptions, the model approach, and model outputs. Interviews were also held with end-users to inform model assumptions and overall results.

Adoption Factors

Four primary factors were used to determine future hydrogen adoption across sectors: policy & legislation, technology feasibility, commercial availability, and business readiness. These factors reflect whether hydrogen is likely to be adopted in a specific subsector and to what extent hydrogen will be adopted versus alternatives.

Adoption factors have been quantified and inputted into the demand model where possible, with the different levels of adoption in 2045 and curves of the adoption rate from 2025-2045 reflecting the substantial variations in adoption factors between subsectors.

Table 1: Hydrogen Adoption Rate Driving Factors

Driving Factor	Description
Policy and Legislation	Policy and regulatory mandates, where they exist, compel a transition to zero-carbon technologies, while financial incentives reduce the cost of transitioning to hydrogen.
Technology Feasibility	Hydrogen adoption is conditional on its technical and operational feasibility in end-use applications.
Commercial Availability	Hydrogen demand volume depends on commercial availability and cost of hydrogen technologies compared with other available technologies.
Business Readiness	Equipment lifespan, retrofit and upgrade schedules, and other operational factors can impact a business's readiness to adopt a new technology.

Notable References

Several data sets and reports were referenced in the creation of the Demand Study analysis. Several interviews and peer reviews were conducted as well to further understand existing data sets and reports, as well as to validate preliminary findings from the Demand Study. Some of the key data sets and documents referenced for the Demand Study were as follows:

- **CARB EMFAC Database** – Used to determine current and forecasted vehicle fleet sizes in SoCalGas service territory, by application, from 2025-2045, including vehicle miles traveled (VMT) and fuel consumption rates. This database includes information that was used for 54 on-road vehicle applications, 107 off-road vehicle applications, 31 commercial harbor craft applications, and dozens of maritime vessels.[1]

- **CARB 2022 Scoping Plan** – Containing several assumptions on vehicle characteristics, lifespans, and the future of hydrogen and battery technologies across sub-sectors.[2]
- **U.S. National Clean Hydrogen Strategy and Roadmap report –** Contained useful information on timing and size of adoption[3]
- **U.S. Department of Energy Clean Hydrogen Pathways for Commercial Liftoff report –** Provided various pathways to clean hydrogen adoption in U.S., covering various opportunities and incentive programs[4]
- **EIA Power and Industrials Data –** Database contains various datasets on current natural gas consumption across power and industrial sectors used as base for analysis[5]
- **California Energy Commission Fueling Station GIS** – Leveraged to determine current fueling station locations and to forecast possible hydrogen fueling station locations in the future.[6]
- **UC Davis Analysis** – Including interviews and analysis such as California Hydrogen Analysis Project: The Future Role of Hydrogen in a Carbon-Neutral California.[7]
- **UC Irvine Analysis** – Including interviews and analysis such as Roadmap for the Deployment and Buildout of Renewable Hydrogen Production Plants in California.[8]
- **NREL Analysis** – Including interviews and analysis such as The Technical and Economic Potential of the H2@Scale Concept within the United States.[9]
- **Argonne National Labs Models** – Has several reports and models which were leveraged to determine TCO for various on-road vehicle types. Models include the BEAN and Autonomie Vehicle System Simulation Tool.
- **Air Emissions Inventory Reports** – From the Port of Los Angeles, Port of Long Beach, and Los Angeles World Airports, containing some information on vehicle fleet sizes, plans for achieving zero emissions vehicles, vehicle retirement rates, and usage characteristics.[10, 11, 12]

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[1] California Air Resources Board. "Emissions Inventory". https://arb.ca.gov/emfac/emissions-inventory/

[2] California Air Resources Board. "2022 Scoping Plan Documents." https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2022-scoping-plan-documents

[3] U.S. Department of Energy. "U.S. National Clean Hydrogen Strategy and Roadmap." (June 2023). https://www.hydrogen.energy.gov/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf

[4] U.S. Department of Energy. "The Pathway to Clean Hydrogen Commercial Liftoff". (March 2023). https://liftoff.energy.gov/clean-hydrogen/

[5] Homepage - U.S. Energy Information Administration (EIA)

[6]CalOES GIS Data Management. "CA Energy Commission - Gas Stations" CA Governor's Office of Emergency Services. (July 2, 2019). https://hub.arcgis.com/datasets/ec575b2693f64199866bc18744d232fe/explore

[7] UC Davis Institute of Transportation Studies. "California Hydrogen Analysis Project: The Future Role of Hydrogen in a Carbon-Neutral California Final Synthesis Modeling Report". (April 19, 2023). https://escholarship.org/uc/item/27m7g841

[8] UC Irvine Advanced Power and Energy Program. " Roadmap for the Deployment and Buildout of Renewable Hydrogen Production Plants in California". (June 2020). https://www.apep.uci.edu/PDF_White_Papers/Roadmap_Renewable_Hydrogen_Production-UCI_APEP-CEC.pdf

[9] Ruth, Mark F., et al. "The Technical and Economic Potential of the H2@Scale Concept within the United States". National Renewable Energy Laboratories. (October 2020). https://www.nrel.gov/docs/fy21osti/77610.pdf

[10] Starcrest Consulting Group, LLC. "Inventory of Air Emissions for Calendar Year 2021". (September 2022). https://kentico.portoflosangeles.org/getmedia/f26839cd-54cd-4da9-92b7-a34094ee75a8/2021_air_emissions_inventory

[11] Port of Long Beach. "Emissions Inventory". (2023). https://polb.com/environment/air/#emissions-inventory

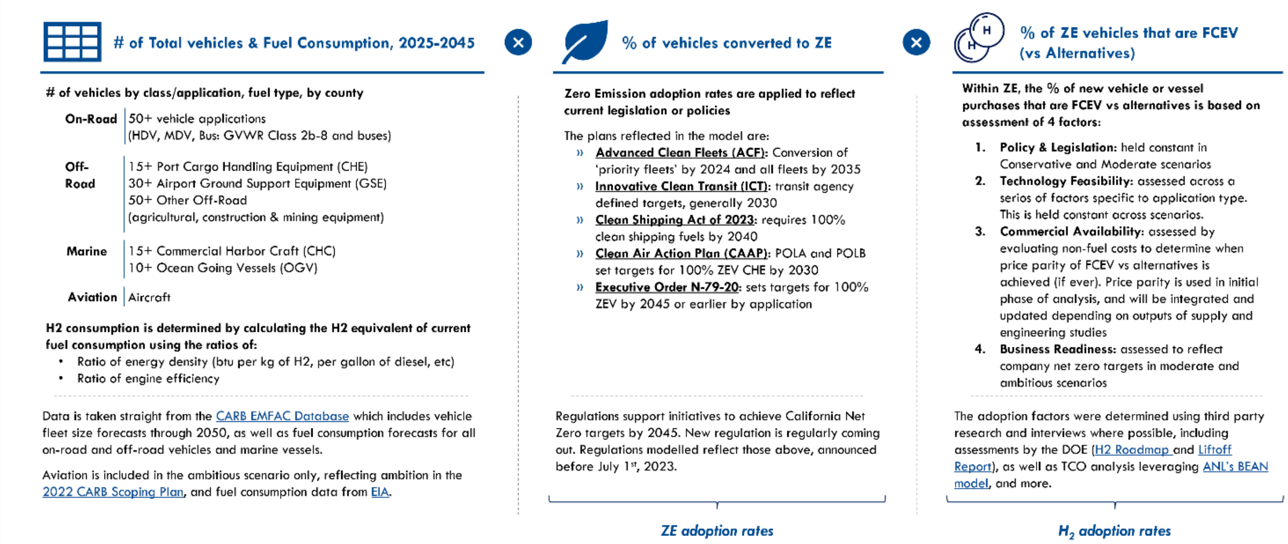
[12] Los Angeles World Airports. "LAX Air Quality & Source Apportionment Study". (June 2013). https://www.lawa.org/lawa-environment/lax/lax-air-quality-and-source-apportionment-study

Mobility

Methodology

Hydrogen demand for the mobility sector in SoCalGas service territory is modelled by multiplying critical factors together: total number of vehicles and fuel consumption (2025-2045), the percent of vehicles converted to ZEVs, and the % of ZE vehicles that are FCEV (vs alternatives). Each of these factors was either sourced from reference material or calculated using various assumptions as defined below.

Figure 2: Mobility Sector - High-Level Modelling Methodology



Total Addressable market

<u>Fleet Sizes and Forecasts</u>

CARB forecasts vehicle populations across the State of California through 2050 in their EMFAC Emissions Database.[13] This data is shown by county, by fuel type, as well as by application type for on-road and off-road vehicles (including for marine vessels as well, though the number of vessel engines rather than the # of vessels is usually reflected).

The vehicle (and vessel) forecasts listed by EMFAC were utilized in the Angeles Link Phase 1 Demand Study without modification in order to represent total vehicle population forecasts. While the database includes some vehicle forecasts by type (such as gasoline, diesel, or battery vehicles), these breakdowns were independently calculated. However, where ZEVs exist today (2025, the starting year of the model), these factors were taken into account as starting points for the ZEV vehicle populations.

EMFAC lists many vehicle applications and the following vehicle types were taken into account for the AL Phase 1 Demand Study. Additionally, some assumptions were made at an aggregate level, and some outputs were aggregated as well—the following table lists some categorizations for these groupings.

Table 2: List of Modelled Vehicles and Vessels

13 https://arb.ca.gov/emfac/emissions-inventory/

Sub-Sector	Type	H2 Adoption Rate Category	EMFAC202x Vehicle Class
On-Road	Bus	Other Buses	SBUS
On-Road	Bus	Other Buses	OBUS
On-Road	Bus	Other Buses	All Other Buses
On-Road	Bus	Transit Bus / Motor Coach	UBUS
On-Road	Bus	Transit Bus / Motor Coach	Motor Coach
On-Road	HDV	Class 7-8 Day Cab Tractor	T7 CAIRP Class 8
On-Road	HDV	Class 7-8 Day Cab Tractor	T7 NNOOS Class 8
On-Road	HDV	Class 7-8 Day Cab Tractor	T7 NOOS Class 8
On-Road	HDV	Class 7-8 Day Cab Tractor	T7 Tractor Class 8
On-Road	HDV	Class 8	T7 Public Class 8
On-Road	HDV	Class 8	T7 Utility Class 8
On-Road	HDV	Class 8	T7IS
On-Road	HDV	Class 8 Drayage	T7 Other Port Class 8
On-Road	HDV	Class 8 Drayage	T7 POAK Class 8
On-Road	HDV	Class 8 Drayage	T7 POLA Class 8
On-Road	HDV	Class 8 Sleeper Cab Tractor	T7 NNOOS Class 8
On-Road	HDV	Class 8 Sleeper Cab Tractor	T7 NOOS Class 8
On-Road	HDV	Class 8 Sleeper Cab Tractor	T7 Tractor Class 8
On-Road	HDV	Class 8 Vocational	T7 SWCV Class 8
On-Road	HDV	Class 8 Vocational	T7 Single Concrete/Transit Mix
On-Road	HDV	Class 8 Vocational	T7 Single Dump Class 8
On-Road	HDV	Class 8 Vocational	T7 Single Other Class 8
On-Road	LDV	Passenger	LDA
On-Road	LDV	Passenger	LDT1
On-Road	LDV	Passenger	LDT2
On-Road	LDV	Passenger	MDV
On-Road	MDV	Class 2b-3	LHD1
On-Road	MDV	Class 2b-3	LHD2
On-Road	MDV	Class 4	T6 Public Class 4
On-Road	MDV	Class 4	T6 CAIRP Class 4
On-Road	MDV	Class 4	T6 CAIRP Class 5
On-Road	MDV	Class 4	T6 Instate Other Class 4
On-Road	MDV	Class 4	T6 Instate Other Class 5
On-Road	MDV	Class 4	T6 OOS Class 4
On-Road	MDV	Class 4 Delivery	T6 Instate Delivery Class 4
On-Road	MDV	Class 5	T6 Public Class 5
On-Road	MDV	Class 5	T6 Utility Class 5
On-Road	MDV	Class 5	T6 OOS Class 5
On-Road	MDV	Class 5 Delivery	T6 Instate Delivery Class 5
On-Road	MDV	Class 6	T6 Public Class 6

On-Road	MDV	Class 6	T6 Utility Class 6
On-Road	MDV	Class 6	T6 CAIRP Class 6
On-Road	MDV	Class 6	T6 Instate Other Class 6
On-Road	MDV	Class 6	T6 Instate Tractor Class 6
On-Road	MDV	Class 6	T6 OOS Class 6
On-Road	MDV	Class 6	T6TS
On-Road	MDV	Class 6 Delivery	T6 Instate Delivery Class 6
On-Road	MDV	Class 7	T6 Public Class 7
On-Road	MDV	Class 7	T6 Utility Class 7
On-Road	MDV	Class 7	T6 Instate Other Class 7
On-Road	MDV	Class 7	T6 Instate Tractor Class 7
On-Road	MDV	Class 7 Delivery	T6 Instate Delivery Class 7
On-Road	MDV	Class 7-8 Day Cab Tractor	T6 CAIRP Class 7
On-Road	MDV	Class 7-8 Day Cab Tractor	T6 OOS Class 7
On-Road	MDV	Motor Home	MH
Off-Road	CHE	Container Handling Equipment	Cargo Handling Equipment - Port Container Handling Equipment
Off-Road	CHE	Excavator	Cargo Handling Equipment - Port Excavator
Off-Road	CHE	Forklift	Cargo Handling Equipment - Port Forklift
Off-Road	CHE	Port Crane	Cargo Handling Equipment - Port Crane
Off-Road	CHE	Port Crane	Cargo Handling Equipment - Port STS Crane
Off-Road	CHE	Port HDV	Cargo Handling Equipment - Port Rail Car Mover
Off-Road	CHE	Port HDV	Cargo Handling Equipment - Port Tractors/Loaders/Backhoes
Off-Road	CHE	Port MDV	Cargo Handling Equipment - Port Electric Pallet Jack
Off-Road	CHE	Port MDV	Cargo Handling Equipment - Port Lift
Off-Road	CHE	Port MDV	Cargo Handling Equipment - Port Other
Off-Road	CHE	Port MDV	Cargo Handling Equipment - Port Skid Steer Loaders
Off-Road	CHE	RTG Crane	Cargo Handling Equipment - Port RTG Crane
Off-Road	CHE	Terminal Tractor	Cargo Handling Equipment - Port AGV
Off-Road	CHE	Terminal Tractor	Cargo Handling Equipment - Port Tractor
Off-Road	CHE	Terminal Tractor	Cargo Handling Equipment - Port Truck
Off-Road	CHE	Terminal Tractor	Cargo Handling Equipment - Port Yard Truck
Off-Road	GSE	A/C Tug	Airport Ground Support - Misc - A/C Tug Wide Body
Off-Road	GSE	A/C Tug	Airport Ground Support - Misc - A/C Tug Narrow Body
Off-Road	GSE	A/C Tug	Airport Ground Support - A/C TugWide Body
Off-Road	GSE	A/C Tug	Airport Ground Support - A/C TugNarrow Body
Off-Road	GSE	Cart	Airport Ground Support - Misc - Air Start Unit
Off-Road	GSE	Cart	Airport Ground Support - Misc - Other
Off-Road	GSE	Cart	Airport Ground Support - Misc - Air Conditioner
Off-Road	GSE	Cart	Airport Ground Support - Misc - Cart
Off-Road	GSE	Cart	Airport Ground Support - Misc - Lav Cart
Off-Road	GSE	Generator	Airport Ground Support - Misc - Ground Power Unit

Off-Road	GSE	Generator	Airport Ground Support - Misc - Generator
Off-Road	GSE	HD Truck / Tractor	Airport Ground Support - Misc - Hydrant Truck
Off-Road	GSE	HD Truck / Tractor	Airport Ground Support - Misc - Catering Truck
Off-Road	GSE	HD Truck / Tractor	Airport Ground Support - Misc - Cargo Tractor
Off-Road	GSE	LD Truck / Tractor	Airport Ground Support - Misc - Sweeper
Off-Road	GSE	LD Truck / Tractor	Airport Ground Support - Misc - Water Truck
Off-Road	GSE	LD Truck / Tractor	Airport Ground Support - Baggage Tug
Off-Road	GSE	LD Truck / Tractor	Airport Ground Support - Cargo Tractor
Off-Road	GSE	LD Truck / Tractor	Airport Ground Support - Passenger Stand
Off-Road	GSE	LD Truck / Tractor	Airport Ground Support - Misc - Deicer
Off-Road	GSE	LD Truck / Tractor	Airport Ground Support - Misc - Fuel Truck
Off-Road	GSE	Loaders / Lifts	Airport Ground Support - Misc - Cargo Loader
Off-Road	GSE	Loaders / Lifts	Airport Ground Support - Misc - Belt Loader
Off-Road	GSE	Loaders / Lifts	Airport Ground Support - Misc - Lift
Off-Road	GSE	Loaders / Lifts	Airport Ground Support - Cargo Loader
Off-Road	GSE	Loaders / Lifts	Airport Ground Support - Other
Off-Road	GSE	Loaders / Lifts	Airport Ground Support - Misc - Passenger Stand
Off-Road	GSE	Loaders / Lifts	Airport Ground Support - Misc - Forklift
Off-Road	GSE	Loaders / Lifts	Airport Ground Support - Lift
Off-Road	GSE	Loaders / Lifts	Airport Ground Support - Forklift
Off-Road	GSE	Loaders / Lifts	Airport Ground Support - Belt Loader
Off-Road	GSE	MD Truck / Tractor	Airport Ground Support - Misc - Bobtail
Off-Road	GSE	MD Truck / Tractor	Airport Ground Support - Misc - Baggage Tug
Off-Road	GSE	MD Truck / Tractor	Airport Ground Support - Misc - Lav Truck
Off-Road	GSE	MD Truck / Tractor	Airport Ground Support - Bobtail
Off-Road	GSE	MD Truck / Tractor	Airport Ground Support - Misc - Service Truck
Off-Road	GSE	MD Truck / Tractor	Airport Ground Support - Misc - Maint. Truck
Off-Road	Other-Off Road	ATVs	Agricultural - ATVs
Off-Road	Other-Off Road	Digging	Construction and Mining - Trenchers
Off-Road	Other-Off Road	Digging	Construction and Mining - Misc - Trenchers
Off-Road	Other-Off Road	Digging	Construction and Mining - Misc - Excavators
Off-Road	Other-Off Road	Forklifts	Agricultural - Forklifts
Off-Road	Other-Off Road	Forklifts	Construction and Mining - Misc - Rough Terrain Forklifts
Off-Road	Other-Off Road	Forklifts	Construction and Mining - Rough Terrain Forklifts
Off-Road	Other-Off Road	Handheld	Construction and Mining - Misc - Concrete/Industrial Saws
Off-Road	Other-Off Road	Handheld	Construction and Mining - Misc - Plate Compactors
Off-Road	Other-Off Road	Handheld	Construction and Mining - Misc - Tampers/Rammers
Off-Road	Other-Off Road	Heavy Ag	Agricultural - Forage & Silage Harvesters
Off-Road	Other-Off Road	Heavy Ag	Agricultural - Combine Harvesters
Off-Road	Other-Off Road	Heavy Ag	Agricultural - Cotton Pickers
Off-Road	Other-Off Road	Heavy Mining & Construction	Construction and Mining - Rubber Tired Dozers

Off-Road	Other-Off Road	Heavy Mining & Construction	Construction and Mining - Scrapers
Off-Road	Other-Off Road	Heavy Mining & Construction	Construction and Mining - Off-Highway Tractors
Off-Road	Other-Off Road	Heavy Mining & Construction	Construction and Mining - Misc - Surfacing Equipment
Off-Road	Other-Off Road	Heavy Stationary Equipment	Construction and Mining - Bore/Drill Rigs
Off-Road	Other-Off Road	Heavy Stationary Equipment	Construction and Mining - Cranes
Off-Road	Other-Off Road	Heavy Stationary Equipment	Construction and Mining - Misc - Cranes
Off-Road	Other-Off Road	Heavy Stationary Equipment	Construction and Mining - Misc - Bore/Drill Rigs
Off-Road	Other-Off Road	Heavy Stationary Equipment	Construction and Mining - Misc - Crushing/Proc. Equipment
Off-Road	Other-Off Road	Light Ag	Agricultural - Bale Wagons (Self Propelled)
Off-Road	Other-Off Road	Light Ag	Agricultural - Hay Squeeze/Stack Retriever
Off-Road	Other-Off Road	Light Ag	Agricultural - Other Harvesters
Off-Road	Other-Off Road	Light Ag	Agricultural - Swathers/Windrowers/Hay Conditioners
Off-Road	Other-Off Road	Light Ag	Agricultural - Agricultural Tractors
Off-Road	Other-Off Road	Light Ag	Agricultural - Nut Harvester
Off-Road	Other-Off Road	Light Ag	Agricultural - Construction Equipment
Off-Road	Other-Off Road	Light Ag	Agricultural - Balers (Self Propelled)
Off-Road	Other-Off Road	Light Ag	Agricultural - Sprayers/Spray Rigs
Off-Road	Other-Off Road	Light Mining & Construction	Construction and Mining - Skid Steer Loaders
Off-Road	Other-Off Road	Light Mining & Construction	Construction and Mining - Misc - Skid Steer Loaders
Off-Road	Other-Off Road	Light Stationary Equipment	Construction and Mining - Misc - Signal Boards
Off-Road	Other-Off Road	Light Stationary Equipment	Construction and Mining - Misc - Cement And Mortar Mixers
Off-Road	Other-Off Road	Medium Mining & Construction	Construction and Mining - Rubber Tired Loaders
Off-Road	Other-Off Road	Medium Mining & Construction	Construction and Mining - Crawler Tractors
Off-Road	Other-Off Road	Medium Mining & Construction	Construction and Mining - Misc - Tractors/Loaders/Backhoes
Off-Road	Other-Off Road	Medium Mining & Construction	Construction and Mining - Excavators
Off-Road	Other-Off Road	Medium Mining & Construction	Construction and Mining - Misc - Rubber Tired Loaders
Off-Road	Other-Off Road	Medium Mining & Construction	Construction and Mining - Misc - Other
Off-Road	Other-Off Road	Medium Mining & Construction	Construction and Mining - Other
Off-Road	Other-Off Road	Medium Mining & Construction	Construction and Mining - Tractors/Loaders/Backhoes
Off-Road	Other-Off Road	Medium Mining & Construction	Construction and Mining - Misc - Dumpers/Tenders
Off-Road	Other-Off Road	Off Highway Trucks	Construction and Mining - Off-Highway Trucks
Off-Road	Other-Off Road	Paving	Construction and Mining - Surfacing Equipment
Off-Road	Other-Off Road	Paving	Construction and Mining - Paving Equipment
Off-Road	Other-Off Road	Paving	Construction and Mining - Pavers
Off-Road	Other-Off Road	Paving	Construction and Mining - Graders
Off-Road	Other-Off Road	Paving	Construction and Mining - Rollers
Off-Road	Other-Off Road	Paving	Construction and Mining - Misc - Asphalt Pavers
Off-Road	Other-Off Road	Paving	Construction and Mining - Misc - Rollers
Off-Road	Other-Off Road	Paving	Construction and Mining - Misc - Paving Equipment
Off-Road	Other-Off Road	Paving	Construction and Mining - Misc - Pavers
Marine	CHC	Barge / Dredge - AE	Commercial Harbor Craft - AE - Barge-Bunker

Marine	CHC	Barge / Dredge - AE	Commercial Harbor Craft - AE - Barge-Other
Marine	CHC	Barge / Dredge - AE	Commercial Harbor Craft - AE - Barge-Towed Petrochemical
Marine	CHC	Barge / Dredge - AE	Commercial Harbor Craft - AE - Dredge
Marine	CHC	Barge / Dredge - ME	Commercial Harbor Craft - ME - Dredge
Marine	CHC	Commercial Fishing - AE	Commercial Harbor Craft - AE - Commercial Fishing
Marine	CHC	Commercial Fishing - AE	Commercial Harbor Craft - AE - Commercial Passenger Fishing
Marine	CHC	Commercial Fishing - ME	Commercial Harbor Craft - ME - Commercial Fishing
Marine	CHC	Commercial Fishing - ME	Commercial Harbor Craft - ME - Commercial Passenger Fishing
Marine	CHC	Excursion - AE	Commercial Harbor Craft - AE - Excursion
Marine	CHC	Excursion - ME	Commercial Harbor Craft - ME - Excursion
Marine	CHC	Ferry - AE	Commercial Harbor Craft - AE - Ferry-Catamaran
Marine	CHC	Ferry - AE	Commercial Harbor Craft - AE - Ferry-Monohull
Marine	CHC	Ferry - AE	Commercial Harbor Craft - AE - Ferry-Short Run
Marine	CHC	Ferry - ME	Commercial Harbor Craft - ME - Ferry-Catamaran
Marine	CHC	Ferry - ME	Commercial Harbor Craft - ME - Ferry-Monohull
Marine	CHC	Ferry - ME	Commercial Harbor Craft - ME - Ferry-Short Run
Marine	CHC	Other - AE	Commercial Harbor Craft - AE - Crew/Supply
Marine	CHC	Other - AE	Commercial Harbor Craft - AE - Pilot Boat
Marine	CHC	Other - AE	Commercial Harbor Craft - AE - Research Boat
Marine	CHC	Other - AE	Commercial Harbor Craft - AE - Work Boat
Marine	CHC	Other - ME	Commercial Harbor Craft - ME - Crew/Supply
Marine	CHC	Other - ME	Commercial Harbor Craft - ME - Pilot Boat
Marine	CHC	Other - ME	Commercial Harbor Craft - ME - Research Boat
Marine	CHC	Other - ME	Commercial Harbor Craft - ME - Work Boat
Marine	CHC	Tugboat - AE	Commercial Harbor Craft - AE - Barge-ATB
Marine	CHC	Tugboat - AE	Commercial Harbor Craft - AE - Tugboat-ATB
Marine	CHC	Tugboat - AE	Commercial Harbor Craft - AE - Tugboat-Escort/Ship Assist
Marine	CHC	Tugboat - AE	Commercial Harbor Craft - AE - Tugboat-Push/Tow
Marine	CHC	Tugboat - ME	Commercial Harbor Craft - ME - Tugboat-ATB
Marine	CHC	Tugboat - ME	Commercial Harbor Craft - ME - Tugboat-Escort/Ship Assist
Marine	CHC	Tugboat - ME	Commercial Harbor Craft - ME - Tugboat-Push/Tow
Marine	OGV	Auto Carrier	Ocean Going Vessels - Auto Carrier
Marine	OGV	Bulk	Ocean Going Vessels - Bulk
Marine	OGV	Bulk	Ocean Going Vessels - Bulk - Heavy Load
Marine	OGV	Bulk	Ocean Going Vessels - Bulk - Self Discharging
Marine	OGV	Container	Ocean Going Vessels - Container - 1000
Marine	OGV	Container	Ocean Going Vessels - Container - 2000
Marine	OGV	Container	Ocean Going Vessels - Container - 3000
Marine	OGV	Container	Ocean Going Vessels - Container - 4000
Marine	OGV	Container	Ocean Going Vessels - Container - 5000
Marine	OGV	Container	Ocean Going Vessels - Container - 6000

Marine	OGV	Container	Ocean Going Vessels - Container - 7000
Marine	OGV	Container	Ocean Going Vessels - Container - 8000
Marine	OGV	Container	Ocean Going Vessels - Container - 9000
Marine	OGV	Container	Ocean Going Vessels - Container - 10000
Marine	OGV	Container	Ocean Going Vessels - Container - 11000
Marine	OGV	Container	Ocean Going Vessels - Container - 12000
Marine	OGV	Container	Ocean Going Vessels - Container - 13000
Marine	OGV	Container	Ocean Going Vessels - Container - 14000
Marine	OGV	Container	Ocean Going Vessels - Container - 15000
Marine	OGV	Container	Ocean Going Vessels - Container - 16000
Marine	OGV	Container	Ocean Going Vessels - Container - 17000
Marine	OGV	Container	Ocean Going Vessels - Container - 19000
Marine	OGV	Container	Ocean Going Vessels - Container - 20000
Marine	OGV	Container	Ocean Going Vessels - Container - 23000
Marine	OGV	Cruise	Ocean Going Vessels - Cruise
Marine	OGV	General Cargo	Ocean Going Vessels - General Cargo
Marine	OGV	Miscellaneous	Ocean Going Vessels - Miscellaneous
Marine	OGV	Reefer	Reefer
Marine	OGV	RoRo	Ocean Going Vessels - RoRo
Marine	OGV	Tanker	Ocean Going Vessels - Tanker - Aframax
Marine	OGV	Tanker	Ocean Going Vessels - Tanker - Chemical
Marine	OGV	Tanker	Ocean Going Vessels - Tanker - Handysize
Marine	OGV	Tanker	Ocean Going Vessels - Tanker - Panamax
Marine	OGV	Tanker	Ocean Going Vessels - Tanker - Suezmax
Marine	OGV	Tanker	Ocean Going Vessels - Tanker - VLCC

Note: H2 Adoption Rate Category reflects the application groupings that were utilized so that similar applications could be treated the same. The EMFAC202x Vehicle Class is the raw name of the vehicle application as defined by EMFAC. See EMFAC Vehicle Class Categorization.[14]

There are few modifications that were made to the list of EMFAC vehicle applications:

1. Motorcycles ("MCY") were omitted from analysis.
2. Power Take Off vehicles ("PTO") were omitted from analysis.
3. Class 8 Tractors were split out into Class 8 Day Cab Tractors and Class 8 Sleeper Cab Tractors in the ratios defined by CARB in their 2022 Scoping Plan Appendix.[15]
    a. Ratio of 1:9 in-state registered vehicles were considered Sleeper Cabs (vs Day Cabs)
    b. Ratio of 8:9 out-of-state registered vehicles were considered Sleeper Cabs (vs Day Cabs)

The data is available by county, so forecasts were taken by application for 2025-2045 for the 11 counties which generally reflect SoCalGas service territory.

[14] https://ww2.arb.ca.gov/sites/default/files/2021-03/emfac2021_volume_3_technical_document.pdf
[15] https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/appf.pdf

EMFAC does not forecast aircraft populations or jet fuel consumption, so these were modelled separately. Information on current jet fuel consumption (used as a proxy for what may be displaced by hydrogen fuel cell aircraft) was taken from EIA.[16] Additionally, data was filtered to reflect flight passenger traffic through the busiest airports in SoCalGas service territory: Los Angeles, Burbank, Long Beach, Ontario, and Orange County.[17]

Hydrogen Fuel Consumption Rates

Hydrogen fuel consumption rates were determined by modelling the hydrogen equivalent of current diesel or gasoline consumption. The EMFAC data set was also utilized to pull current average diesel or gasoline fuel consumption by vehicle application for the vehicles in SoCalGas service territory. For this, 2019 values were utilized (to reflect the most recent year without COVID impacts). For most applications—on-road, off-road, and marine—the vast majority of fuel consumption is diesel, so the hydrogen equivalent to diesel consumption was calculated. If a vehicle listed both diesel and gasoline consumption, generally the diesel equivalent figures were used.

To calculate potential hydrogen consumption rates, a conversion was calculated based on energy density ratios and typical engine efficiency ratios. While some of these figures, such as engine efficiency, may vary by application or individual vehicle, these broad industry averages were leveraged as representative of a typical vehicle.

Table 3: Fuel Efficiency Ratios

Metric	Units	Value
BTU per kg Hydrogen[18]	BTU / kg H2	134,510
BTU per gallon Gasoline[19]	BTU / gallon gasoline	117,500
BTU per gallon Diesel[20]	BTU / gallon diesel	137,500
Polymer Electrolyte Membrane Fuel Cell Efficiency[21]	%	50%
Diesel Engine Efficiency[22]	%	50%
Gasoline Engine Efficiency[23]	%	20%

Finally, to account for advances in fuel cell efficiency (i.e., that fuel cells fuel economy will improve), a conservative assumption of 0.5% efficiency improvement per year was modelled. The way this is modelled yields an important implicit assumption: that vehicle miles travelled (VMT) is assumed to be constant by vehicle application through 2045 (for all on-road vehicles).

[16] https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_fuel/html/fuel_jf.html&sid=CA
[17] https://industry.visitcalifornia.com/research/passenger-traffic?a1=LAX
[18] https://afdc.energy.gov/fuels/properties
[19] https://afdc.energy.gov/fuels/properties
[20] https://afdc.energy.gov/fuels/properties
[21] https://www.energy.gov/eere/fuelcells/articles/fuel-cells-fact-sheet
[22] https://www.hydrogen.energy.gov/pdfs/19006_hydrogen_class8_long_haul_truck_targets.pdf
[23] https://www.anl.gov/article/combining-gas-and-diesel-engines-could-yield-best-of-both-worlds

Assumptions (ZEV adoption Rates)

To determine the theoretical ceiling for the amount of hydrogen fuel cell vehicles and vessels, existing legislation was considered to identify how quickly ZEVs would replace their ICE counterparts. Legislation generally exists for the mobility sub-sectors modelled.

Importantly, it should be noted that legislation almost unanimously impacts the sales of new vehicles and generally does not force early retirement of vessels. Therefore, vehicle retirement rates are also a critical factor in determining the population forecasts of ZEVs in California. The following assumptions were made regarding vehicle retirement rates:

Table 4: On-Road Vehicle Retirement Rates

Vehicle Type	Retirement Rate
Heavy Duty Vehicles	17 years[24]
Medium Duty Vehicles	17 years[25]
Light Duty Vehicles	17 years[26]
Buses	12 years[27]

Table 5: Off-Road Vehicle Retirement Rates

Vehicle Type	Retirement Rate
Ground Support Equipment	15-19 years[28]
Cargo Handling Equipment	10-20 years[29]
Other Off-Road Equipment	5-20 years[30] [31]
Marine Vessels (Commercial Harbor Craft)	15 years[32]
Marine Vessels (Ocean Going Vessels)	n/a*

Note: For some vehicle applications generalizations of estimates were used given lack of readily available data.
** Ocean Going Vessels (OGV) were modelled slightly differently to other vehicle and vessel types. Since fleet size data, vessel lifespan or vessel engine lifespan data, and information on which vessels would often make port of calls to POLA and POLB, instead of the new vessel replacement rate being modelled, instead, a % of the total vessel population converting to ZEV was modelled.*

[24] CARB 2022 Scoping Plan Appendix H, Table H-1: https://ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp-appendix-h-ab-32-ghg-inventory-sector-modeling.pdf
[25] CARB 2022 Scoping Plan Appendix H, Table H-1: https://ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp-appendix-h-ab-32-ghg-inventory-sector-modeling.pdf
[26] CARB 2022 Scoping Plan Appendix H, Table H-1: https://ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp-appendix-h-ab-32-ghg-inventory-sector-modeling.pdf
[27] CARB 2022 Scoping Plan Appendix H, Table H-1: https://ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp-appendix-h-ab-32-ghg-inventory-sector-modeling.pdf
[28] https://www.aviationpros.com/gse/article/21256272/state-of-the-industry
[29] https://cleanairactionplan.org/download/239/cargo-handling-equipment/5192/2021-che-feasibility-assessment-report-final.pdf
[30] https://thompsontractor.com/blog/average-lifespan-of-common-construction-equipment/
[31] https://www.tractorhouse.com/listings/search?Category=1112&Manufacturer=JOHN%20DEERE&Hours=4000%2A&Year=1990%2A2015
[32] https://ww2.arb.ca.gov/sites/default/files/classic/msprog/tech/techreport/draft_chc_technology_assessment.pdf

Since legislative requirements are fixed reference points, their impacts are held constant across all modelled scenarios (i.e., the number of ZEVs do not change across the Conservative, Moderate, or Ambitious scenarios modelled, only the composition of the ZEVs—BEV, FCEV, or other—varies by modelled scenario).

The following pieces of legislation and related decarbonization strategies below were modelled.

Advanced Clean Fleets (ACF)

On April 28, 2023, California passed the Advanced Clean Fleets regulation to help achieve Governor Gavin Newsom's goal of transitioning trucks in California to using zero-emissions technology by 2045.[33, 34] The ACF regulation states:[35]

High priority and federal fleets must comply with the Model Year Schedule or may elect to use the optional ZEV Milestones Option to phase-in ZEVs into their fleets:

- *Model Year Schedule: Fleets must purchase only ZEVs beginning 2024 and, starting January 1, 2025, must remove internal combustion engine vehicles at the end of their useful life as specified in the regulation.*
- *ZEV Milestones Option (Optional): Instead of the Model Year Schedule, fleets may elect to meet ZEV targets as a percentage of the total fleet starting with vehicle types that are most suitable for electrification.*

Since the ZEV Milestones Option is listed as optional and would often require fleet operators to retire vehicles earlier than they normally would, Option 1 was modelled. This takes the more conservative view that vehicles would generally be replaced with ZEVs when they would organically retire. Specifically, the AL Phase One Demand Study model reflects:

- 100% of truck sales starting 2024 will be ZEV for ACF priority fleets.
- 100% of truck sales starting 2035 will be ZEV for all fleets.

Exponential adoption rates were modelled to ramp up to the 100% by 2035 requirement.

Since the ACF regulation applies differently to those subject to it (priority fleets) versus those not subject to ACF, the vehicle populations listed previously were split using assessment of the type of vehicle as well as CARB's estimates for how many vehicles may be subject to the regulation:

- 100% of drayage trucks
- 67% of Class 7-8 Tractors
- 52% of Class 4-8 Vocational
- 12% of Class 2b-3

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[33] https://ww2.arb.ca.gov/resources/fact-sheets/carb-fact-sheet-2023-advanced-clean-fleets-regulation-drayage-truck#:~:text=On%20April%2028%2C%202023%2C%20CARB,California's%20intermodal%20seaports%20and%20railyards.

[34] https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf

[35] https://ww2.arb.ca.gov/resources/fact-sheets/advanced-clean-fleets-regulation-summary

Finally, ACF states that ICE vehicles should retire after 18 years or 800,000 miles. However, most vehicles will retire organically before they would be flagged to retire according to ACF (see vehicle lifespan estimates above).

Advanced Clean Trucks (ACT)

The Advanced Clean Trucks regulation requires OEMs of medium- and heavy-duty vehicles to sell ZEVs at increasing rates through 2035 and beyond. In short, by 2035, OEMs must sell ZEVs as a portion of total sales:

- 55% of Class 2b-3 truck sales be ZEV by 2045
- 75% of class 4-8 straight truck sales be ZEV by 2045
- 40% of truck tractor sales be ZEV by 2045

Since the ACF regulation effectively requires 100% of truck sales to be ZEV by 2035, ACT's impacts are inherently considered in the AL Phase 1 Demand Study model through ACF's modelling.

Clean Air Action Plan (CAAP)

The Clean Air Action Plan is not a piece of legislation, but a strategy and proposal developed by the Port of Los Angeles and Port of Long Beach (together, the San Pedro Bay Ports). CAAP effectively states that terminal operators are expected to achieve 100% ZEV by 2030. While this is not strictly enforceable (it is not legislation), terminal operators have signed on and agreed to this, and so the AL Phase 1 Demand Study model considers these targets for all types of Cargo Handling Equipment (CHE) at the ports.

Innovative Clean Transit (ICT)

The ICT legislation requires transit agencies to achieve net zero by 2035. Though many transit agencies have already committed to and have begun purchasing 100% ZEVs, transit agencies are required to submit their plans to achieve 100% ZEV to CARB. These plans are regularly revised.[36]

Executive Order N-79-20

For vehicle types not already covered by current legislation, such as for agricultural or construction equipment, there is no specific legislation yet. For these sub-sectors, guidance from EO N-79-20 was considered.[37] This executive order passed in 2020 set some of the initial State targets "to achieve 100 percent zero-emission from off-road vehicles and equipment operations in the State by 2035."

As done for other sub-sectors, where current ZEV populations are 0 (or effectively 0) today, exponential rates were assumed for the new sale of vehicles to achieve 100% of vehicle sales being ZEV by 2035.

Maritime Vessels and Aircraft

The largest maritime legislation passed is the Clean Shipping Act of 2023, which requires 100% clean shipping fuels by 2040 for most vessels.[38] Having passed in mid-2023, it is still unclear how shipping operators plan to achieve this, but more regulation is coming in this space. In addition to the Clean Shipping Act of 2023, some more niche legislation has passed, such as the 2021 ZEAT Commercial

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[36] https://ww2.arb.ca.gov/our-work/programs/innovative-clean-transit/ict-rollout-plans

[37] https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf

[38] https://www.congress.gov/bill/118th-congress/house-bill/4024/text?s=1&r=4

Harbor Craft Regulation[39] requiring CHC to have cleaner engines and for short-run ferries and excursion vessels to be 100% ZEV sales starting 2025.

Beyond these pieces of legislation, the 2022 CARB Scoping Plan[40] cites in their scenario that "25% of OGVs [will] utilize hydrogen fuel cell electric technology by 2045." It also states that "20% of aviation fuel demand is met by electricity (batteries) or hydrogen (fuel cells) in 2045."

Given some of the uncertainties and continually developing legislation for marine vessels, legislation was accounted for in the following way:

- **Commercial Harbor Craft (CHC)**: the model assumes that new vessel engine sales will be 100% ZEV by 2035. This means that 100% of vessel engine sales will convert to hydrogen fuel cell, battery, or synthetic fuel technologies.
- **Ocean Going Vessels (OGVs)**: the model makes the conservative assumption that by 2045, 25% of OGVs will utilize non-synthetic fuel ZE solutions by 2045. The Hydrogen adoption rates reflect what percent of this 25% would utilize hydrogen fuel cell technology. As well, it's worth noting and reiterating that the model only accounts for replacing current diesel consumption by OGVs. Bunker fuel replacement (e.g., the main engine's typical fuel) is not considered.
- **Aircraft:** the model takes the 2022 CARB Scoping Plan assumption's estimate that 20% of aviation fuel demand would be non-SAF.

Hydrogen Adoption Rates

The scope of the AL Phase 1 Demand Study considered hydrogen fuel cell technology only as the driver for hydrogen demand (i.e., hydrogen combustion was not considered for Mobility applications). As such, hydrogen fuel cell technology was assessed and compared to various alternatives by application.

- On-Road (FCEVs) – the primary alternative considered was BEVs.
- Off-Road (FCEVs) – the primary alternative considered was BEVs.
- Marine (CHC) – the primary alternatives considered were both battery or hydrogen derivatives / synthetic fuels.
- Marine (OGV) – the primary alternative considered was hydrogen derivatives / synthetic fuels.
- Aircraft – the primary alternative considered was battery or sustainable aviation fuel*

**The model assumes that the majority (80%) of aviation fuel will convert so SAF, but that the remaining 20% should be a comparison between fuel cell and battery aircraft.*

Adoption Factors

To model how hydrogen fuel cell technology may stack up against these alternatives, and to determine the associated hydrogen adoption rates over time (as a % of ZEV), 4 primary factors were considered.

1. Technical Feasibility—a metric to assess the likelihood of adoption for hydrogen fuel cell technology against alternatives based on technical or operational factors such as range requirements, load requirements, duty cycle, etc. The factors vary across on-road, off-road, and other sub-sector applications.

[39] https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2021/chc2021/chcfro.pdf
[40] https://ww2.arb.ca.gov/sites/default/files/2023-04/2022-sp.pdf

2. Commercial Availability—a metric reflecting if and when FCEV technology is commercially available. This factor is quantified using TCO cost values—less fuel costs—based on Argonne National Lab's (ANL's) BEAN model.
3. Business Readiness—a metric that accelerates or decelerates adoption rates based on business factors. For example, an industry with companies setting near-term zero emissions targets may choose to accelerate adoption of ZEVs.
4. Policy & Regulation—a metric that accelerates or decelerates adoption rates based on potential changes in existing legislation. For example, as of the time of writing, the DOE's recently announced Demand-side Support Mechanism could be an accelerator for hydrogen FCEV adoption.[41]

Each of these factors constituted unique evaluation by vehicle application grouping. To model associated H2 adoption rates (as a % of ZEV adoption rates), variables for the 4 factors were multiplied:

$$RR(TT, CC, BB, PP) = TT * CC_{tt,ss} * BB_{tt,ss} * PP_{tt,ss}$$

RR = H2 Adoption Rate [0, 1]
TT = Technology Feasibility [0, 1]
CC_{tt} = Commercial Availability [0.05, 1.5]
BB_{tt} = Business Readiness [0.8, 1.2]
PP_{tt} = Policy & Regulation [0.8, 1.2]
tt = time value for evaluation: 2025, 2030, 2035, 2040, 2045 (e.g., each factor listed is evaluated at each time period indicated)
ss = scenario (low, medium, high)

The resultant hydrogen adoption rates, represented as values between 0% and 100%, were a proportion of zero emission technology. For example, if the hydrogen adoption fuel cell rate of 20% is calculated for a certain on-road vehicle type, then this would mean that 80% adoption is covered by battery electric vehicles.

The hydrogen adoption rate factors were generally evaluated as follows:

Table 6: High-Level definition of H2 Adoption Rate Factors (Mobility)

Factor	Conservative	Moderate	Ambitious
Policy & Legislation	Existing legislation considered only		Existing legislation +additional legislation 2025 onwards (↑10% H2 adoption)
Commercial Readiness	Conservative timeline to achieve cost parity with decarbonization alternatives	Moderate timeline to achieve cost parity with decarbonization alternatives	Ambitious timeline to achieve cost parity with decarbonization alternatives
	Assessed by modelling TCO (without fuel cost) for on-road using ANL's BEAN model, and market research for non-on-road applications.[42]		
Technical Feasibility	Evaluated per vehicle application group but held constant across scenarios.		

[41] https://oced-exchange.energy.gov/Default.aspx#FoaId8e15135b-a033-47ca-9c7a-ebf2e5771a41
[42] https://vms.taps.anl.gov/tools/bean/

Business Readiness	Conservative assessment of market readiness to adopt hydrogen vehicles	Moderate assessment of market readiness to adopt hydrogen vehicles (↑10% H2 adoption 2035-)	Ambitious assessment of market readiness to adopt hydrogen vehicles (↑20% H2 adoption in 2030; ↑10% in 2035-)

Technical Feasibility

Technology feasibility is evaluated on a series of factors ff. The list of factors varies by sub-sector (on-road, off-road, marine, aviation).

$$TT_{ff} = \frac{\sum_{1}^{nn} ff_{nn}}{nn}$$

Each factor is evaluated as Very Low (0%), Low (25%), Medium (50%), High (75%), or Very High (100%) to indicate likelihood of H2 adoption based on that factor alone. Values for each factor are averaged to determine the net likelihood of H2 adoption, TT_{ff}, based on Technical and Operational characteristics alone (n = number of factors).

The metrics evaluated were unique to each sub-sector group:

- On-Road applications were evaluated on the metrics of range requirement, load requirement, duty cycle requirement, and fueling requirements.
- Cargo Handling Equipment applications were evaluated on the metrics of load requirements, duty cycle requirements, proven viability of EV technologies, sufficient space & time for charging/fueling, and infrastructure challenges for electrification.
- Ground Support Equipment applications were evaluated on the metrics of load requirements, duty cycle requirements, centralization of fueling operations, and infrastructure challenges for electrification.
- Other off-road equipment applications were evaluated on the metrics of load requirements, infrastructure challenges for electrification, and duty cycle requirements.
- Commercial Harbor Craft applications were evaluated on the metrics of weight and size impact of H2 vs alternatives (if structural changes would be needed on ships), and operational shift requirements (how long vessels tend to be working and away from port).
- Ocean Going Vessel applications were evaluated on the metrics of weight and size impact of H2 vs alternatives (if structural changes would be needed on ships), and operational shift requirements (how long vessels tend to be working and away from port).
- Aircraft were evaluated on the metrics of weight and size impact of H2 vs alternatives (if airplane design changes would be needed), and operational shift requirements (how long aircraft would need to fly before refueling/recharging).

For Example, TT_{ff} for Class 8 Sleeper Cab Tractors is evaluated as:

ff_1 = RRRRnnRRRR RRRRRRRRRRRRRRRRRRnntt = VVRRRRVV HHRRRRh = 100%

ff_2 = LLLLRRLL RRRRRRRRRRRRRRRRRRnntt = HHRRRRh = 75%

ff_3 = DDRRttVV CCVVCCCCRR RRRRRRRRRRRRRRRRRRnntt = HHRRRRh = 75%

ff_4 = FFRRRRCCRRnnRR RRRRRRRRRRRRRRRRRRnnttss = HHRRRRh = 75%

$$TT_{ff,\ \text{CCCCCCssss 8 SSCCSSSSSSSSSS CCCCCC TTSSCCTTttTTSS}} = \frac{\sum_{1}^{nn} ff_{nn}}{nn} = 81\%$$

The evaluation of on-road vehicles considered some of the following research and analysis:

- **Range requirements** – Current diesel semis reportedly have a maximum range of approximately 2000 miles, which is well beyond the capabilities of all BEV and FCEV options except for FCEV trucks with liquid hydrogen fuel storage. This statistic will be a challenge for FCEVs and BEVs to address, however federal hours of service rules allow a driver to drive for a maximum of 8 hours before stopping for a break, which would equate to 600 miles of driving at a relatively fast 75 MPH.[43] The range of diesel semis would allow drivers to skip multiple fuel stops, but if sufficient infrastructure was available a much lower range could be acceptable.
- **Load requirements** – The expected mass impact for current battery technology was evaluated: Battery cells currently have a specific energy of approximately 250 Wh/kg. BEV trucks with this technology will have a cargo/mass tradeoff above approximately 450 miles of range relative to diesel trucks, while compressed hydrogen would have much lower sensitivity and liquid hydrogen would be superior to diesel for all vehicle ranges. However, if battery energy density improves to 400 Wh/kg, this tradeoff doesn't occur until approximately 750 miles of range relative to diesel. No current commercial battery achieves an energy density this high, but various battery companies have announced that they have achieved battery densities this high or higher in prototype cells.[44, 45, 46, 47] Although it will take considerable development efforts to bring these technologies to production, if these efforts were successful, they could make BEV semis as competitive as compressed hydrogen FCVs.
- **Duty cycle requirements** – Another challenge for zero emissions trucks is refueling time. This is most important for trucks that operate with high duty cycles (2 or 3 eight-hour shifts per day). Although standards for recharging and refueling heavy duty BEV and FCEV semis have not been developed yet, it is likely that fueling times for both compressed and liquid hydrogen FCEVs can be made comparable to diesel, given that this has been achieved for light-duty applications. This will be effectively impossible for BEV semis since this would require very high-power levels.
- **Fueling requirements** – There are 2 factors of fueling requirements considered to assess the viability of BEV vs FCEVs: centralization of fueling operations, and difficulty in building fueling/charging infrastructure. Some considerations are as follows:
  - Building ubiquitous retail fueling stations akin to gas or diesel stations today will be a challenge for both technologies (to maintain customer expectations). This issue would be less prevalent with MDV and HDF fleets which operate more often with back-to-base operations. The notable exception here is long-haul tractors which refuel in highly distributed locations. For long-haul, high-power charging would be needed (up to 4.5 MW per charger for long-haul), which would require significant upgrades to electrical capacity; the steep load peaks would be difficult to manage too.

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43 https://www.federalregister.gov/documents/2020/06/01/2020-11469/hours-of-service-of-drivers

44 https://cleantechnica.com/2020/08/25/tesla-air-elon-musk-hints-tesla-could-mass-produce-400-wh-kg-batteries-in-3-4-years/

45 https://cleantechnica.com/2022/07/24/svolt-energy-readies-solid-state-battery-with-400-wh-kg-energy-density-for-production/

46 https://www.electrive.com/2023/03/30/amprius-achieves-battery-energy-density-of-500-wh-kg/

47 https://www.batterytechonline.com/news/catls-aerospace-ready-battery-has-energy-density-500-whkg

- Hydrogen is primarily delivered to fueling stations today as a compressed gas (via tube trailers) for the LDV. Liquid hydrogen delivery being pursued for higher-volume/heavier-duty fueling stations (even for gaseous fueling) due to energy density advantages.[48]
- Electricity must be used in real time, coordinating the direct use of electricity with a desired generation source may be difficult. Energy storage solutions (like batteries) at charging stations can help to address this mismatch but would be expensive. Hydrogen meanwhile would not have this real-time electricity production/offtake mismatch issue.
- Compressed hydrogen fueling stations require significantly more space than conventional (diesel) stations for compressors and other equipment, and significant electric power capacity is required to run compressors.[49]

Evaluation for off-road vehicles, marine vessels, and aircraft was based on comparable logic and methodology. Where less information was available, high-level estimates were made based on industry reports and interviews.

Commercial Availability

On-Road

Data and Assumptions

Commercial availability, $CC_{tt,ss}$, is evaluated by application, by scenario ss over time, tt. Values for $CC_{tt,ss}$ were developed by leveraging TCO analysis done by Argonne National Labs' (ANL) BEAN model.[50] The defaulted values from BEAN were leveraged except for 3 exceptions:

Exception 1: Fuel Cell Costs

Fuel Cell costs were increased vs the default values in the ANL BEAN model as they were intentionally set by ANL to reflect price parity of diesel engines. For comparison, the DOE's target values are also shown.

Table 7: Fuel cell costs used in TCO analysis vs ANL defaults and DOE target.

Transit, Box Medium 6 ($/kw)	2025	2030	2050
ANL (High)	126	70	50
ANL (Mid)	126	90	65
ANL (Low)	126	110	80
DOE (MDV)	177	157	
Values Used (High)	231	128	92
Values Used (Low)	651	361	257

HDV/Day Cab Sleeper ($/kw)	2025	2030	2050
ANL (High)	130	80	60
ANL (Mid)	136	97	73
ANL (Low)	142	113	85
DOE (HDV)	145	107	60

[48] https://www.nrel.gov/docs/fy22osti/83036.pdf
[49] https://nacfe.org/wp-content/uploads/2023/04/H2-NACFE-2023-Report-FINAL.pdf
[50] ANL BEAN Model: https://vms.taps.anl.gov/tools/bean/

Values Used (High)	238	146	110
Values Used (Low)	671	412	309

Exception 2: H2 Storage Costs

Hydrogen storage tanks on vehicles are rapidly improving but carry significant cost vs diesel or gasoline alternatives. Cost estimates for these storage tanks were updated and modelled reflecting the below:

Table 8: Hydrogen storage costs used in TCO analysis vs ANL defaults (Variable)

Hydrogen storage variable costs $/kg	2025	2030	2050
ANL (High)	274	247	219
ANL (Mid)	289	260	233
ANL (Low)	301	274	247
Values Used (all scenarios)	495	424	377

Table 9: Hydrogen storage costs used in TCO analysis vs ANL defaults (Fixed)

Hydrogen storage fixed costs $/kg	2025	2030	2050
ANL (High)	3,366	3,029	2,693
ANL (Mid)	3,534	3,198	2,861
ANL (Low)	3,703	3,366	3,029
Values Used (all scenarios)	5,790	5,211	4,632

Exception 2: Battery Costs

Batteries are one of the main cost components in battery electric vehicles (BEVs), the primary foreseeable ZEV alternative for FCEV technology. Battery costs were updated as follows:

Table 10: Battery costs used in TCO analysis vs ANL defaults.

Battery costs ($/kWh)	2025	2030	2050
ANL (High)	95	75	60
ANL (Mid)	112	88	65
ANL (Low)	128	100	70
Values Used (all scenarios)	79	63	50

TCO Curve Development and Analysis

With the above changes, the BEAN model was leveraged to generate TCO cost curves for each on-road vehicle class. These cost curves were leveraged to determine how commercially viable certain technologies would be against alternatives.

First, the BEAN model was used to gather data across the following metrics:

- Years: 2025, 2030, 2035, and 2050
- Vehicle cost characteristics: Vehicle, Financing, Fuel, Insurance, Operation, Tax & Fees, M&R (repairs).

- Applications: LonghaulSleeper 8, RegionalDayCab 8, DrayageDayCab 8, TransitHeavy 8, BoxMedium 6, Small SUV
- Fuel Type: ICE, BEV, FCEV

Fuel costs were omitted from the model, but all other values were utilized to determine lifetime total costs of ownership (TCO). For where there are gaps in data, linear approximations were made: costs between data in years provided were calculated linearly; costs for vehicle classes were calculated linearly (e.g., Class 7 costs were an average of Class 8 and Class 6 costs). ANL's BEAN model only provides data for on-road applications.

Second, once annual costs were derived by vehicle application group, for ICE, BEVs, and FCEVs, the following definitions were adopted to determine values of $CC_{tt,ss}$:

- Far From Parity = when $TTCCTT_{FFCCFFFF}$ >20% more expensive than $TTCCTT_{AACCttSSSSnnCCttAAAASSss}$
- Close to Parity = when $TTCCTT_{FFCCFFFF}$ is between 10% and 20% more expensive than $TTCCTT_{AACCttSSSSnnCCttAAAASSss}$
- At Parity = when $TTCCTT_{FFCCFFFF}$ is within 10% of $TTCCTT_{AACCttSSSSnnCCttAAAASSss}$
- Cheaper = when $TTCCTT_{FFCCFFFF}$ is between 10% and 20% cheaper than $TTCCTT_{AACCttSSSSnnCCttAAAASSss}$
- Much Cheaper = when $TTCCTT_{FFCCFFFF}$ is >20% cheaper than $TTCCTT_{AACCttSSSSnnCCttAAAASSss}$

Note: FCEV alternatives for TCO comparison consist of ICE and BEVs through 2035 (FCEV is compared against whichever alternative is the lowest cost that year), but only BEVs after 2035 (due to ACF and associated legislation).

Since the cost curves are shown over time, values for $CC_{tt,ss}$ are determined at each time period tt (2025, 2030, 2035, 2040, 2045) across each scenario ss (Low, Mid, High), by application. One example, for the Class 8 Sleeper Cab Tractor application is listed below:

Table 11: Example TCO Outputs for Modelling (Class 8 Sleeper Cab Tractor)

Class 8 Sleeper Cab Tractor TCO Evaluation	2025	2030	2035	2040	2045
Low Scenario	Far from Parity	Far from Parity	Close to Parity	Close to Parity	At Parity
High Scenario	Close to Parity	At Parity	At Parity	At Parity	At Parity

Note: values for the Moderate scenario were taken as the mid-point between the Conservative and Ambitious scenarios.

Third, the adoption rate factors were applied at each time interval to determine the multiplier effect of the Commercial Availability $CC_{tt,ss}$ variable:

Table 12: Definition of Commercial Availability Values (TCO Parity Value Assumptions)

Evaluation	Value
Far from Parity	5%
Close to Parity	50%
At parity	100%
Cheaper	125%
Much Cheaper	150%

Note: no outputs from the ANL BEAN model showed FCEVs ever achieving >10% cost advantage over alternatives, so the "Cheaper" and "Much Cheaper" scenarios were never achieved.

Off-Road (including Marine and Aviation)

For non-on-road applications, fewer models exist, but there is a decent amount of 3rd party research which was leveraged to determine the denotation of far from parity, close to parity, or at parity for these applications. Where no data was available, best estimates were made, or cost assumptions were based on comparable on-road values where possible, generally with a 5+ year lag in evaluations. This assumption was made as a reflection of the number of OEMs announcing production of off-road fuel cell vehicles being generally behind that of on-road vehicles (similar to how legislation for off-road applications is lagging that of on-road applications). Also, many off-road applications may be more viable options for engine swaps, where the combustion engine in a vehicle may be swapped out with a fuel cell, but the rest of the vehicle remains unchanged. This could be a particularly attractive option for some applications where most of a vehicle's costs are not the engine (such as a large crane).

Select references for off-road TCO evaluations include those from the EPA,[51] DOE,[52] and ANL.[53]

<u>Business Readiness</u>

Business Readiness is a multiplying factor used to reflect the impact of companies or firms accelerating (or decelerating) their adoption of FCEV technology. For example, many global organizations have set Net Zero targets and will likely be early adopters of FCEV or BEV technology. If they adopt primarily FCEV technology, this will accelerate H2 adoption.

Table 13: Definition of Business Readiness Values

Evaluation	Value
Laggard	80%
Delayed	90%
Market Driven	100%
Fast Follower	110%
Early Adopter	120%

There are many companies with Net Zero Targets, and many have signed up and publicized these policies, such as with Net Zero Tracker.[54] Since assumptions were conducted at the vehicle application level, evaluations were not an explicit representation of individual company commitments, but rather a representation of how fleet operators may act.

In the Low scenario, all evaluations across all time periods across all applications were evaluated as Market Driven, meaning the multiplier would be 100% and that H2 adoption rates would not be impacted by business readiness. For Medium and High scenarios standard evaluation were used across most applications, reflecting:

Table 14: Standard Evaluations of Business Readiness Across Scenarios

Scenario	2025	2030	2035	2040	2045

[51] https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1015AQX.pdf
[52] https://www.hydrogen.energy.gov/pdfs/review23/ta065_ahluwalia_2023_o.pdf
[53] https://www.energy.gov/sites/default/files/2021-12/922-9-mission-innovation-ANL.pdf
[54] https://zerotracker.net/

Low Scenario	Market Driven	Market Driven	Market Driven	Market Driven	Market Driven
Medium	Market Driven	Fast Follower	Fast Follower	Fast Follower	Fast Follower
High Scenario	Market Driven	Early Adopter	Fast Follower	Fast Follower	Fast Follower

<u>Policy & Regulation</u>

While policy and regulation considerations are already factored into the model through the ZEV adoption rates and existing legislation (see Mobility - Assumptions section), an additional factor was added to consider potential changes in legislation. Similar to Business Readiness, the Policy & Regulation driver was defined as follows:

Table 15: Definition of Policy & Regulation Driver Values

Evaluation	Value
Significantly Delayed Legislation	80%
Delayed Legislation	90%
Existing Legislation	100%
Some H2 Legislation	110%
Significant H2 Legislation	120%

It's important to reiterate that this additional factor differs from existing legislation, in that existing legislation has already been taken into account in the model to inform the % of ZEV sales, and this additional factor affects the % of FCEV sales out of the ZEV sales.

In the Conservative and Moderate scenarios, this model driver effectively has no impact on H2 adoption rates as only existing legislation is reflected (the multiplier value is 100%). For the Ambitious scenario, the possible impact of potential additional legislation is reflected across the entire modeled time period.

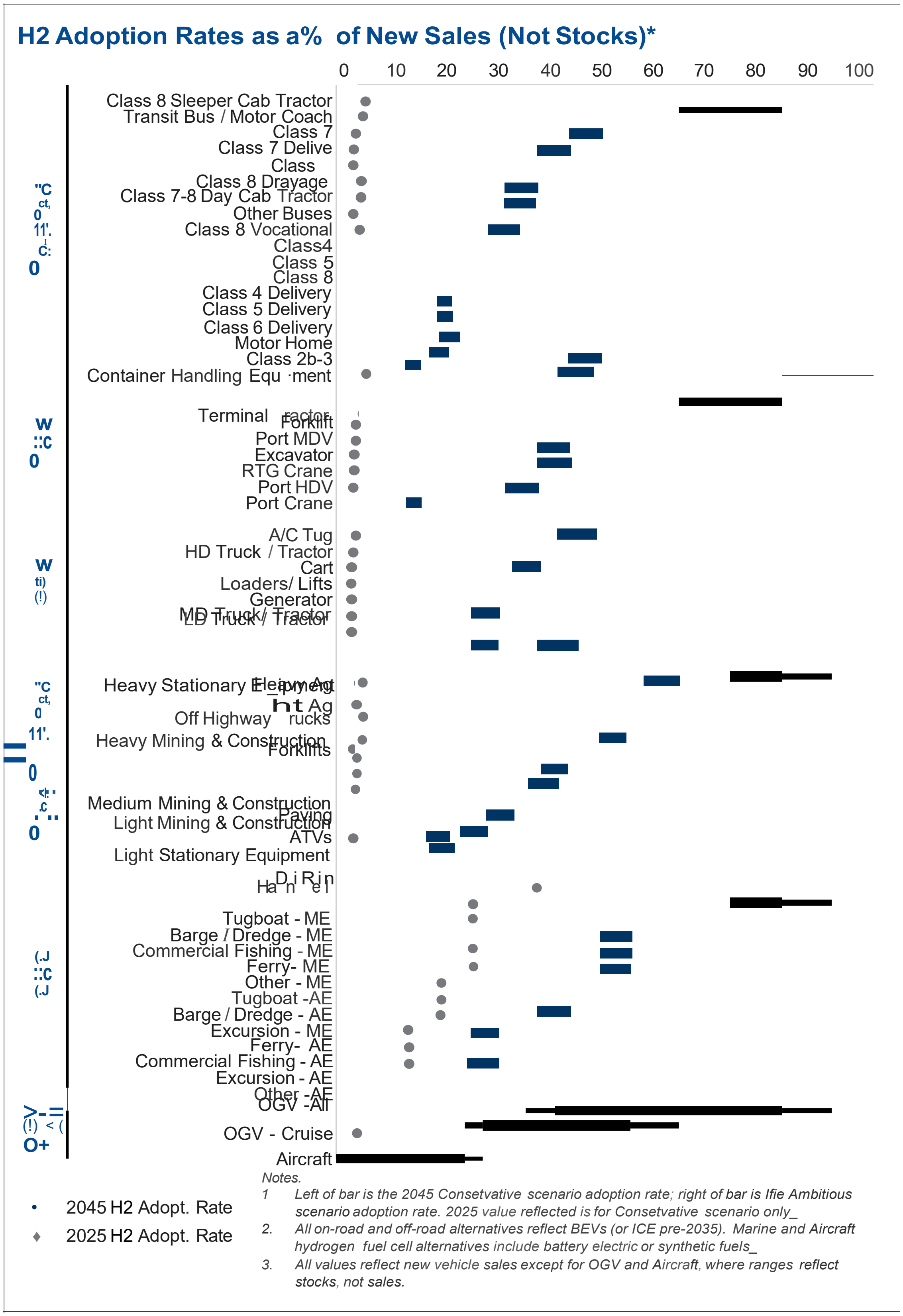
Table 16: Standard Evaluations of Policy & Regulation Variable Across Scenarios

Scenario	2025	2030	2035	2040	2045
Low Scenario	Existing Leg.	Existing Leg.	Existing Leg.	Existing Leg.	Existing Leg.
Medium	Existing Leg.	Existing Leg.	Existing Leg.	Existing Leg.	Existing Leg.
High Scenario	Some H2 Leg.	Some H2 Leg.	Some H2 Leg.	Some H2 Leg.	Some H2 Leg.

Hydrogen Adoption Rates Utilized

From the above assessments, hydrogen adoption rates (vs alternatives) of new vehicle sales were developed by application group from 2025-2045, by scenario. All vehicles in the same application group (as defined above) were assumed to have the same adoption rates.

Figure 3: Hydrogen Adoption Rates of New Vehicle Sales Utilized (2045 Values)



Power

Methodology

To assess hydrogen demand in the Power sector, a yearly hydrogen adoption rate from 2025-2045 was calculated based on detailed input data, and this adoption rate was multiplied by current natural gas consumption to determine aggregate hydrogen demand in the SoCalGas territory.

Facility-Level Fuel Consumption

Current Plant Data is used from EIA 923[55] and EIA 860[56]. Data used includes operator, nameplate capacity, historical generation and fuel consumption on an MMBTU basis, turbine type, summer and winter nameplate capacity, and heat rates. EIA provides data across the following turbine types:

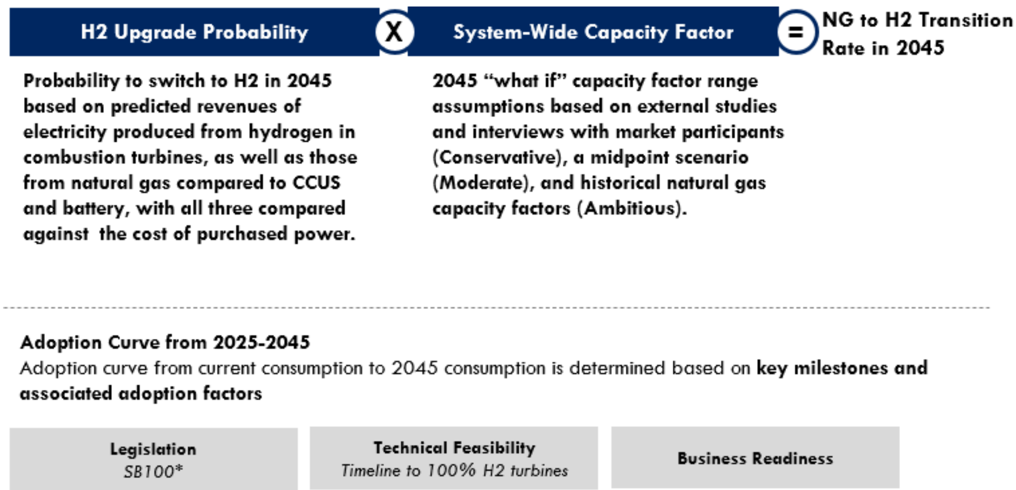
Combined cycle combustion turbine	Combustion turbine
Steam turbine	Combine cycle steam turbine part
Combined cycle single shaft	Internal combustion turbine

From the dataset, current natural gas combustion of power plants measured on an MMBTU basis is used as basis for future hydrogen consumption. Detailed data at the plant level was also gathered through individual external research and included current capacity, turbine OEM and model, and current blending capability. Fuel usage data was found for all plants. Turbine OEM, model, and blending data were only found for a subset of plants.

[55] Form EIA-923 detailed data with previous form data (EIA-906/920) - U.S. Energy Information Administration (EIA)
[56] Form EIA-860 detailed data with previous form data (EIA-860A/860B)

Hydrogen Adoption Rate

Figure 4: Hydrogen Adoption Rate Methodology Diagram



** Although SB100 framework does allow for an emission budget, the analysis conservatively assumed zero emission by 2045 under SB100*

Two key inputs were used to determine the hydrogen adoption rate:

1. Hydrogen upgrade probability: Determines power capacity that will be transitioned to hydrogen by 2045.
2. Capacity Factor: Determines the utilization of capacity once traditional capacity has transitioned.

These two factors were used to quantify the total generation from hydrogen in 2045. Yearly adoption rates were developed on a ramp from 2025-2045, with key milestones guiding the shape of this curve based on legislation, commercial availability, technical feasibility, and business readiness.

Assumptions

Addressable Market

- Only power facilities with a capacity of >1MW have been considered as potential end users in this phase.
- Power facilities were filtered from EIA form 923 2021 dataset[57], which provides data for all power generation facilities in the nation. This dataset was filtered to include only natural gas combustion data (EIA Code: NG). A filter was also applied on the sector name to ensure only facilities within the power sector were included in the model. Sectors included are:
  - Electric utilities
  - NAICS-22 non-cogen
- All facilities in SoCalGas territory and territories where SoCalGas provides wholesale natural gas are considered potential adoptees of hydrogen for this study, except for facilities in SDG&E territory / San Diego, which have been excluded.

[57] Form EIA-923 detailed data with previous form data (EIA-906/920) - U.S. Energy Information Administration (EIA)

Hydrogen Adoption Factor Assumptions

Policy & Legislation

Senate Bill 100 (2018)[58]

- Requires renewable energy and zero-carbon resources to supply 100% of electric retail sales by 2045. Model assumes 100% emission reduction by 2045, although SB100 framework allows an emission budget.
- Provides interim milestone of 60% of electric retail sales to be met by eligible renewable resources by 2030.
- 100% carbon free assumption based on legislative 2045 timelines.

Senate Bill 1020 (2022)[59]

- Requires eligible renewable energy resources and zero-carbon resources supply 90% of all retail sales of electricity by 2035, 95% by 2040, and 100% by 2045. This bill was not factored into the power sector modeling for this first phase but was acknowledged in the report as legislation that could help drive adoption of clean renewable hydrogen adoption. This will be factored in for future demand assessments.

Technical Availability

- Current blending percentage is taken at the plant level, with current turbines in SoCalGas territory capable of 5-75% blending with a majority of gas turbines at 20-30%. However, plant modifications would be required.
- Projected 2030 as a milestone for 100% H2 turbine technical capability.

Commercial Availability

Hydrogen is assessed at price parity with the existing price of incumbent fuels without a carbon price, as shown in the Additional Quantitative Assumptions section. Hydrogen upgrade costs are developed at a plant level across various upgrade ranges. The graph below shows the projected costs for a variety of hydrogen upgrades across different turbine sizes and upgrade percentages, developed based on a green hydrogen FEED study by EPRI[60]. In this FEED study a 30% blend capability for a small GT was estimated at $3,000,000 for the GT upgrades based on 3 scenarios that were evaluated, a short demonstration, and permanent installations with varying blends. As combustion system upgrades are added to the costs it is expected they will significantly increase the overall cost of the upgrade. There are major cost variations which were not evaluated here such as differences among OEMs, the current condition of the power plant units, the potential need for different upgrades between different sites (as some sites may need fuel delivery), combustion variations, control systems and other upgrades including "soft" costs like upgrading their site procedures. Combustion system upgrades that are required for higher hydrogen blends were expected to contribute to a larger cost increase. There was little data on exact

[58] SB 100 Joint Agency Report (ca.gov)

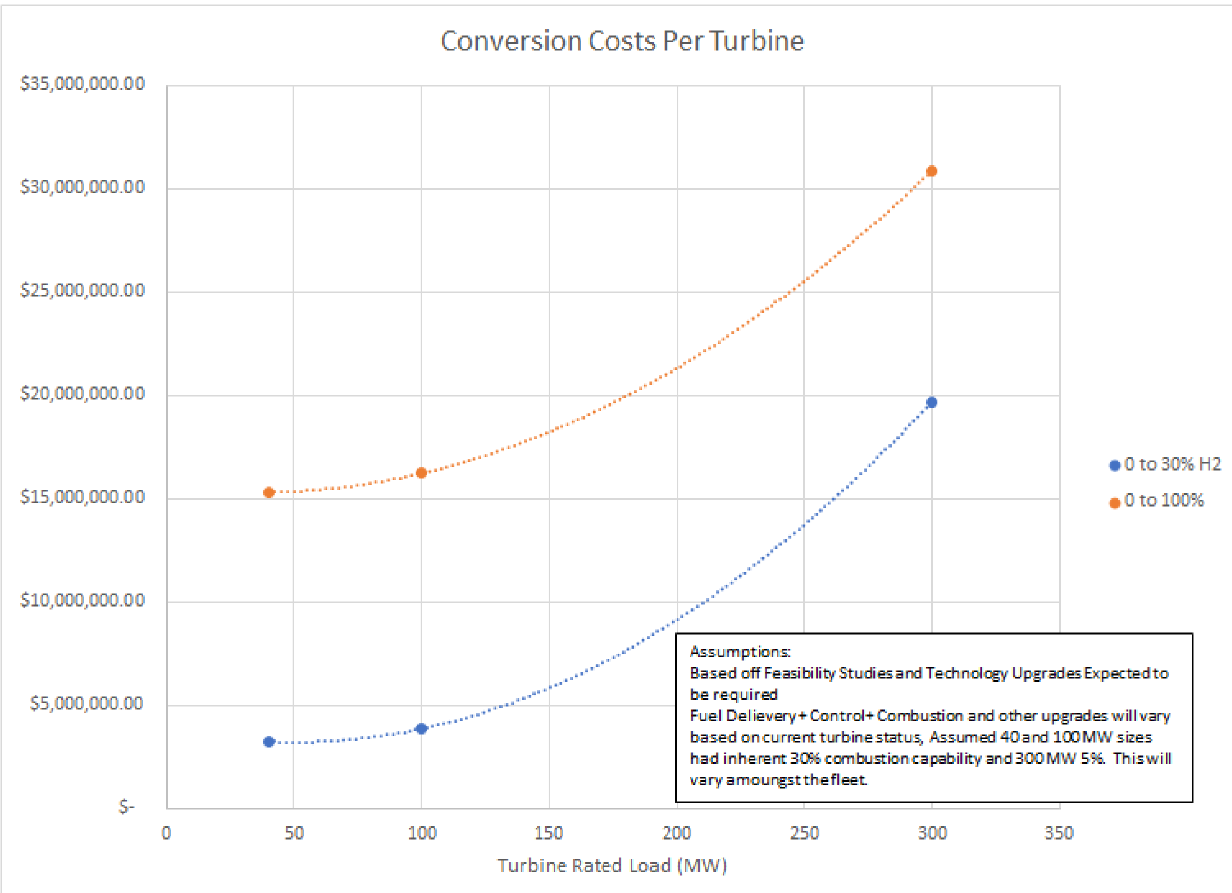
[59] Bill Text - SB-1020 Clean Energy, Jobs, and Affordability Act of 2022. (ca.gov)

[60] Feasibility Study for Green Hydrogen Generation and Cofiring Hydrogen in an Aeroderivative Gas Turbine: Solar, Battery Energy Storage System, Desalination, Electrolyzer, Hydrogen Storage, Natural Gas Blending, and LM2500 Gas Turbine Operation (epri.com)

combustion upgrade costs to rely on for the study. However, FEED study data[61] shows that the cost to upgrade an existing combustion system (already developed) was calculated to be 5% of the total gas turbine cost, which is roughly $0.7 to $2MM/MW[62]. This suggests roughly $4 to $20 million for a combustion retrofit upgrade depending on the system size to achieve 30% hydrogen blends. These numbers may be subject to inflation and other variables.

The cost to upgrade was chosen as the lowest cost between a full upgrade from 0 to 100% hydrogen capability and retrofit costs from the current capability to 100% based on turbine size. Current hydrogen capability was determined based on plant-level research as described in the Blending section below.

Figure 5: Turbine Conversion Costs



Hydrogen is compared to alternatives on a cost and profit basis to determine hydrogen upgrade probability using the following inputs:

[61] Feasibility Study for Green Hydrogen Generation and Cofiring Hydrogen in an Aeroderivative Gas Turbine: Solar, Battery Energy Storage System, Desalination, Electrolyzer, Hydrogen Storage, Natural Gas Blending, and LM2500 Gas Turbine Operation (epri.com)

[62] It is assumed that up to 30% will only require accessory upgrades, and 30 to 100% upgrades require a combustion system upgrade. These numbers do not include construction, labor, contingency, etc and only represent part of the cost estimate

- Battery Install cost: $2M/MWh, CCUS Capital Cost: $1,727/KW, CCUS T&D cost: $3.7/MWh[63]
- Peak Demand Power Cost: $0.50/KW, Revenue Power Charge: $0.12/KW

Business Readiness

- Projected that business readiness will take 5-8 years due to business decision making, permitting, construction for new turbines, and retirement rates of current turbines. This means 2030 is the earliest that hydrogen turbines will move to 100% H2. In the model, transition starts slowly in 2030 and progressively increases as we near 2045. These assumptions were based on interviews with plant operators.

Additional Quantitative Assumptions

Table 17: Power Quantitative Assumptions

Assumption	Value	Explanation
H2 Cost $/Kg	$0.289	This cost was converted to $/mmbtu to have the assumption of price parity with $/mmbtu of natural gas. This is the most justifiable from a "price parity" assumption as the gas turbine's do not require a set mass (kg) of fuel but rather an energy input (mmbtu). Also, if price parity was assumed on a $/kg basis, then hydrogen would actually be ~2.5 times cheaper on a $/mmbtu basis. See the conversion below under NG Cost $/kg.
Electricity Costs $/KWh for Battery Charge	0.2	It is assumed batteries are charged in the daytime when there is an excess of renewables. Therefore, this cost is less than the Revenue Power Charge
Peak Demand Power Cost $/KWh	0.5	When these assets are called upon, it is expected to be when there are not enough renewables to cover the generation required by the grid. Because of this, power prices will increase. For this reason, this price is higher than the Revenue Power Charge
Revenue Power Charge $/KWh	0.22	This is average cost of energy to end use customers based on EIA data. Electric Power Monthly - U.S. Energy Information Administration (EIA)
Time Horizon (Years)	10	The number of years used when calculating costs, revenues, and profit.
Battery Storage Installation Cost $/MWh	$2,000,00	The CapEx cost associated with installation of battery storage at a plant. This includes more than just the battery cost itself and is based on EPRI analysis
CCUS Capital Cost $/KW	$1,727	The 95% carbon capture case on an F Class machine was used for cost data[64]. For this, the $/kW of the "Flue Gas Cleanup" and "Feedwater & Miscellaneous BOP systems" were added together to get the upgrade cost. Source data for these costs were for a new plant, not retrofits, so other cost line items that were more specific to a new plant were not included because the Demand Study is

[63] Cost and Performance Baseline for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity (Technical Report) \| OSTI.GOV

[64] Cost and Performance Baseline for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity (Technical Report) \| OSTI.GOV, page 613

		only comparing against CCUS achieved through plant retrofits.
CCUS Transportation and Storage Cost $/MWh	$3.70	Taken from the same source as above, the cost to transport and store the captured carbon. This may be a conservative estimate and will vary based on location, size, and other variables.
NG Cost $/kg	$0.113	Natural gas cost is widely available and often quoted in $/mmbtu. The model uses Henry Hub Natural Gas Spot Price (Dollars per Million Btu) | EIA.GOV as a source.[65] However, hydrogen is usually quoted in $/kg so for this exercise, the units were converted from $/mmbtu to $/kg. The conversion was done as below: $\frac{\$0.113}{kg_{NG}} * \frac{1kg_{NG}}{55.5MJ} * \frac{1MJ}{0.0009478MMbtu} = \frac{\$2.15}{MMbtu}$
NG MJ/kg	55.5	A property of methane.

Peak Demand and Storage

To provide context to the demand of hydrogen and specifically the peak hydrogen demand requirements, additional storage and operational considerations may be needed to meet 100% load on peak days. This demand study looks at annual hydrogen demand quantities, but this demand will be highly variable throughout the year and will see sharp increases on peak days where turbines are running at 100% load. Depending on the infrastructure in place, hydrogen storage may be needed and will drive additional costs and land requirements not represented in the model.

Blending (Behind-the-Meter)

A switch from blending to 100% hydrogen turbines from 2025-2045 has been integrated into the model, with blending occurring at low levels to start based on current capabilities. Current capabilities have been determined at the plant level where turbine model data is available, based on EPRI modelling of current capabilities shown in the figure below. Blending capability is multiplied by electric fuel consumption (MMBTU) at the plant and aggregated across plants to determine total blending potential inputted to demand sector model. It should be noted that consistent with the Decision, Angeles Link is intended as a project to transport only 100% clean renewable hydrogen in the pipeline, and any analysis of hydrogen blending refers strictly to “behind-the-meter” operations, not within SoCalGas control.

[65] Henry Hub Natural Gas Spot Price (Dollars per Million Btu) (eia.gov)

Figure 6: Current Hydrogen Blending Capabilities of Various Turbines

OEM	Type	Notes	TIT C[F] or Class	H2 % (Vol)	Source
MHPS	Diffusion	N2 Dilution, Water/Stean	1200~1400 [2192~2	up to 100	EPRI
MHPS	Pre-Mix (DLN)	Dry	1600 [2912]	up to 30	EPRI
MHPS	Multi-Cluster	Dry	1650 [3002]	up to 30	EPRI
GE	SN	Single Nozzle (Standard)	B,E Class	up to 100	EPRI
GE	MNQC	Multi-Nozzle Quiet Combu	E,F Class	up to 100	EPRI
GE	DLN 1	Dry	B,E Class	up to 33	EPRI
GE	DLN 2.6+	Dry	F,H Class	up to 20	EPRI
GE	DLN 2.6e	Dry	H Class	up to 50	EPRI
Siemens	DLE	Dry	E Class	up to 30	EPRI
Siemens	DLE	Dry	F Class	up to 30	EPRI
Siemens	DLE	Dry	H Class	up to 30	EPRI
Siemens	ACE	Dry	HL Class	up to 50	EPRI
Ansaldo	Sequential	GT26	F Class	up to 30	EPRI
Ansaldo	Sequential	GT36	H Class	up to 50	EPRI
PSM	LEC-III™	DLE	B, E Class	up to 50	EPRI
PSM	Current Flamesheet™	DLE	Frame 5, 6B, 7E, 9E,	up to 60	EPRI
Baker Hughes	DLN	Frame 6/7/9	Frame 6/7/9	up to 32	EPRI
Baker Hughes	Diffusion	Frame 6/7/9	Frame 6/7/9	up to 100	EPRI
Siemens	DLE	SGT		up to 10-75	EPRI
Siemens	Diffusion	SGT-100,400		up to 65	EPRI
Baker Hughes	DLN	PGT10		up to 8	EPRI
Baker Hughes	DLN	NovaL		up to 30	EPRI
Baker Hughes	DLN	Frame 6/7/9		up to 32	EPRI
Baker Hughes	Diffusion			up to 100	EPRI
Solar	SoLoNOxTM			up to 20	EPRI
Solar	Diffusion			up to 100	EPRI
GE	DLE	TM/LM		up to 35	EPRI
GE	Diffusion	TM/LM		up to 75/85	EPRI
Siemens	DLE	SGT-A35/SGT-A05		up to 15/30	EPRI
Siemens	Diffusion	SGT-A35		up to 100	EPRI

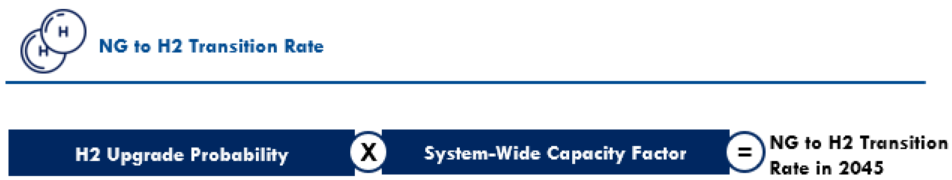
Factors That Could Potentially Limit Adoption

The factors considered included:

1. Hydrogen conversion costs: There remains uncertainty around CapEx, OpEx and additional site upgrade costs. Costs could vary depending on speed to technical viability and learning curves of the various technologies underpinning the transition.
2. Rate of transition to hydrogen: OEMs have announced plans to manufacture turbines that can run on 100% hydrogen fuel by 2030, but timelines may shift in the future.
3. Supply uncertainty: If there is uncertainty in the availability of clean renewable hydrogen, potential off-takers may delay making the necessary investments to transition their operations, resulting in a slower ramp-up than estimated.
4. Availability of alternatives: In the power generation sector, there are a variety of decarbonization alternatives to choose from, including renewables, hydrogen, carbon capture and battery storage. The advancement of non-hydrogen alternatives may impact investment decisions on hydrogen at the facility level.

Adoption Rates

Figure 7: Power Sector Adoption Rate Diagram



Hydrogen Upgrade Probability

A cost module uses the assumptions described below as well as detailed information on existing natural gas plants to make predictions on the decarbonization pathway a utility might choose for that facility. Options included retrofitting combustion turbines to utilize hydrogen, adding CCUS, replacing the capacity with batteries, or power purchase agreements. This module does not take into consideration any policy, regulation, or political factors. It is purely a simplified way of comparing the costs between each of the alternatives and creates a likelihood for each. However, these cost numbers will change on a plant-to-plant basis and each power plant will have other factors to consider as well when deciding how to reduce carbon emissions according to environmental regulations.

Cost estimates for a current gas plant to transition from 0 to 30% and 0 to 100% are provided for different ranges of GT sizes. These are based on Feasibility and Front-End Engineering Design (FEED) studies performed by EPRI based on knowledge from previous hydrogen demonstrations. Based on this data, curves were created to have a cost vs. Megawatt comparison that can be applied to each of the gas turbines in the SoCalGas district. The equation for curves was used to predict the CapEx investment needed to upgrade gas turbines in the SoCalGas service territory. As this study did not have the opportunity to get direct quotes from OEMs or others, the costs estimated here are subject to large potential variation. AACE cost estimates range from Class I to Class V, with Class V being the least accurate with –50% and +100% accuracy. These cost estimates may not be as accurate as Class V as limited information was used in their generation.

The main two capacity alternatives to hydrogen combustion considered for this study are batteries and carbon capture, utilization, and sequestration (CCUS). For the battery option, it was assumed that it costs $2,000,000 per MWh for the CapEx cost of battery installation. These battery costs are based off a 2023 EPRI feasibility study that performed a class IV cost estimate for a 1MW/1MWhr battery configuration[66]. The OpEx cost of the battery option was based on the cost of electricity to charge the battery and assumed this occurred during off-peak periods. For the CCUS option, a U.S. DOE Office of Scientific and Technical Information (OSTI) report was used for costs.[67]

The 95% carbon capture case on an F-class machine was used for cost data. Specifically, the cost data is shown on page 613. Although these costs in the OSTI report are for new plant builds, the $/kW of the "Flue Gas Cleanup" and "Feedwater & Miscellaneous BOP systems" were taken and added together to

[66] Feasibility Study for Green Hydrogen Generation and Cofiring Hydrogen in an Aeroderivative Gas Turbine: Solar, Battery Energy Storage System, Desalination, Electrolyzer, Hydrogen Storage, Natural Gas Blending, and LM2500 Gas Turbine Operation (epri.com)
[67] Cost and Performance Baseline for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity (Technical Report) | OSTI.GOV

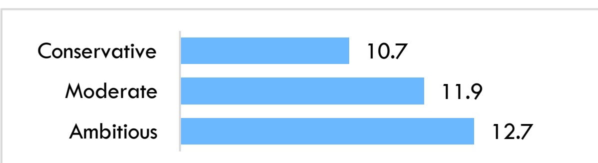
best estimate what the upgrade cost might be to achieve CCUS at an existing plant. As this Demand Study analysis is based on retrofits to current turbines, the other line items in the OSTI cost table were excluded as they are relevant for new plants and not applicable for retrofits.

Hydrogen upgrade probability analysis compares the estimated CapEx costs and selected OpEx costs of the alternatives. Fuel costs of alternatives were included in OpEx costs, as well as the cost of transport and storage for CCUS. The overall logic of this module is that each plant will need to choose one of the three options listed above. Each option is compared to the cost of purchasing power over the same time horizon as this is what would happen in the future if the plants chose none of the three conversion options and chose to shut down. Hydrogen conversion, Battery power, and CCUS all start with an equal chance of being selected. This percentage is adjusted based on the cost over the time horizon compared to the other alternatives. If the alternative is more cost-effective than other options, it will increase in likelihood and vice versa for the opposite scenario.

This is a simplified way of calculating financial predictions and will be heavily based on each power plant. This is intended as an overall comparison between technologies for the region served by SoCalGas.

Once the hydrogen upgrade probability is determined based on the above cost analysis, it is multiplied by total current capacity in SoCalGas' service territory to determine the total projected hydrogen capacity in 2045. The results are shown below:

Figure 8: Projected Hydrogen Capacity by 2045, GW



Capacity Factor

A range of "what-if" capacity factor scenarios were evaluated to determine the total hydrogen demand for power generation. Capacity factors were not modelled and were instead input directly to understand what the potential demand could be across a range of different capacity factors. The probability of each capacity factor was not evaluated. The specific capacity factors used were based on the below:

Table 18: Capacity Factor Scenarios

Scenario	Source	Potential "What If" Scenario
Conservative (C.F. of 10%)	Based on feedback from various market participants (OEMs and operators)	Decline in future capacity factors due to a large shift from power plants to other intermittent renewables
Moderate (C.F. of 20%)	Based on a midpoint between conservative and ambitious scenarios.	Decline in capacity factor associated with combustion turbines from today, however the capacity factor is larger than in the conservative scenario reflecting increased dispatchability needs.

Ambitious (C.F. of 30%)	Based on historical EIA natural gas capacity factor data[68] in California, which has fluctuated between roughly 25%-35% since 2010. Past capacity factors were calculated from generation (table 5) and capacity (table 4) tabs in the linked EIA dataset	Reflects a potential future where hydrogen capacity factors remain similar to past California gas capacity factors

Hydrogen Transition Rate

The future hydrogen capacity and the future hydrogen capacity factor described above are used to calculate the predicted generation from hydrogen in 2045. The calculated level of generation from hydrogen is taken as a percentage of current generation to determine the % of transition to hydrogen in 2045. From here, an adoption curve was developed to reach yearly transition rates. A key inflection point of this curve is 2030, which is the projected milestone for technical feasibility and business readiness. At this point, plants begin progressively moving from low levels of blending to 100% hydrogen, thus causing a slope change in hydrogen demand starting at 2030.

Total Hydrogen Demand

Once yearly transitioned rates have been developed, these transition rates are applied to current consumption to determine yearly hydrogen demand. The formula used for this is below:

HH2 DDRRRRRRRnnLL = ��(CCCCSSSSSSnntt MMMMMMTTMM TTff nnCCttCCSSCCCC ggCCss TTTTnnssCCccSSttAATTnn / MMMMMMTTMM SSSSSS ttTTnn TTff HH2)� ∗ EEffffRRCCRRRRnnCCVV RRRRttRRLL LLff ffRRttRRRRRR ttRRRRttRRnnRR RRssRRRRRR ttLL CCRRRRRRRRnntt� ∗ HHVVLLRRLLRRRRnn TTRRRRnnssRRttRRLLnn RRRRttRR

Current efficiency at a turbine level is used as the starting point for future hydrogen demand, as the source data of natural gas consumption by MMBTU reflects current efficiency. A ratio of 80% is used to reflect the difference in operation and uses between today's turbines and future turbines running on hydrogen. This ratio reflects the assumption that if there is a higher percentage of units being run as flexible units filling demand when renewables are offline, most units (if not all) would be run in single cycle; therefore, the average system-wide efficiency of hydrogen turbines in the future would decrease to around 80% of current natural gas turbine efficiencies. This ratio is based on SME input and analysis.

The conversion of current natural gas consumption at plants in SoCalGas' service territory to hydrogen and the multiplication by the hydrogen transition rate (developed based on hydrogen upgrade probability, capacity factor, and additional adoption factor milestones) delivers the final demand output.

Industrials

Methodology

The potential annual hydrogen demand was quantified for the following industrial sectors:

Table 19: Industrial Subsectors

Sector Priority	Sub-Sector	Hydrogen Opportunities
Primary	Refineries	• Fuel Switching

[68] State Electricity Profile (eia.gov)

		• Direct Process Use for Legacy Fuels • Renewable Diesel and Sustainable Aviation Fuel (SAF) Production
Primary	Food and Beverage	• Fuel Switching
Primary	Metals (Primary Metals and Fabricated Metals)	• Fuel Switching
Primary	Stone, Glass, Cement	• Fuel Switching
Primary	Cogeneration	• Fuel Switching
Secondary	Paper	• Fuel Switching
Secondary	Chemicals	• Fuel Switching
Secondary	Aerospace and Defense	• Fuel Switching

There are three main analysis methodologies for calculating hydrogen demand in the model.

1. Fuel switching from natural gas to hydrogen for non-cogeneration use cases (including refining).
2. Fuel switching from natural gas to hydrogen for cogeneration.
3. Adoption of green hydrogen at refineries for direct process usage in petroleum refining processes and renewable fuels production.

The methodologies used to determine hydrogen demand for each of these three types of end-uses differs and is described in the three sections below.

Fuel switching from natural gas to hydrogen for non-cogeneration use cases (including refining)

The following methodology steps were taken to determine the addressable natural gas demand for fuel switching for non-cogeneration sub-sectors.

Step 1: Base Natural Gas Demand

For all sectors, the base natural gas demand is determined by the current greenhouse gas emissions from natural gas and associated natural gas usage in that sub-sector in SoCalGas' service territory. In order to identify the facilities in the SoCalGas territory, industrial facilities are identified through a combination of the CARB Pollution Map[69] and the EPA FLIGHT dataset[70] (Facility Level Information on Greenhouse Gas Tool). Both tools track GHG emissions from large emissions facilities that are required to or opt to participate in the emissions reporting required by CARB or the EPA.

For most sub-sectors, the CARB Pollution Map is used to identify the base facility emissions. While FLIGHT also identifies high emission-producing facilities, the CARB dataset has a lower minimum threshold for emissions reporting and better captures all large facilities that are potential users of hydrogen. However, FLIGHT captures more information per facility and is used in each sub-sector in different manners depending on the characteristics of that sub-sector. For all fuel switching opportunities, the initial step in determining the base natural gas demand is to estimate the CO2 equivalent emissions from natural gas.

[69] CARB Pollution Mapping Tool
[70] EPA Facility Level GHG Emissions Data

Refineries: Only the FLIGHT dataset was used to determine the natural gas usage from non-cogeneration refinery demand for natural gas. This dataset was used because it contained a detailed break-down of how much natural gas was used for cogeneration and how much was used for refinery processes. The natural gas volumes for refinery processes was separated and used to assess the fuel-switching portion of the refinery demand.

Food and Beverage: The CARB dataset is used to identify the total number of facilities in the food and beverage sectors and the total CO2e GHG emissions. The FLIGHT dataset consists of a subset of these facilities. The FLIGHT data set is used to estimate the estimated percentage of emissions in this sector that stem from natural gas: 99.99%. This figure is then applied to the facility – level GHG emissions identified in the CARB dataset.

Metals: The CARB dataset is used to identify the total number of facilities in the metals and the total CO2e GHG emissions. The FLIGHT dataset consists of a subset of these facilities. The FLIGHT data set is used to estimate the estimated percentage of emissions in this sector that stem from natural gas: 100% This figure is then applied to the facility – level GHG emissions identified in the CARB dataset.

Stone, Glass, and Cement: The CARB dataset is used to identify the total number of facilities in the stone, glass, and cement sector and the total CO2e GHG emissions. The FLIGHT dataset is not utilized in the capture of total emissions as the EPA has different reporting requirements for cement facilities, which are not captured in FLIGHT. Since emissions in this sector stem from natural gas consumption and additional production processes, different assumptions are utilized to determine the estimated GHG emissions from natural gas combustion.

- Cement: 40% of emissions are due to combustion[71]
- Stone and Clay: 100% - natural gas is not assumed to be used in a meaningful way in direct processes.
- Glass: 75% - Average natural gas emissions due to glass production in California as cited in FLIGHT

Paper: The CARB dataset is used to identify the total number of facilities in the paper sector and the total CO2e GHG emissions. EPA's FLIGHT captures cogeneration demand for most paper facilities in SCG territory. For facilities, data is leveraged from Manufacturing Energy Consumption Survey (MECS) to estimate the percent of total natural gas consumption by end use. MECS is a national survey conducted by the US Energy Information Administration (EIA) to collection information on the US manufacturing establishment and their energy-related characteristics and consumption. As part of this survey, natural gas end use is collected by NAICS identified sectors. In the survey, energy usage is broken out into five categories, including Combined Heat and Power (CHP). For facilities where cogeneration demand is not identifiable, the percentage of natural gas used for cogeneration, paper industry wide, is multiplied by the total natural gas emissions to identify emissions from cogeneration.

[71] Alternative Clinker Technologies for Reducing Carbon Emissions in Cement Industry: A Critical Review - PMC (nih.gov)

Chemicals: The CARB dataset is used to identify the total number of facilities in the chemicals sectors that do not produce industrial gases (hydrogen) and the total CO2e GHG emissions. All emissions are assumed to be from natural gas consumption per SME input.

Aerospace and Defense: Facilities in this sector are identified by using publicly available information, specifically focusing on near and around El Segundo, CA. Natural gas usage was identified for one of the major facilities using the CARB dataset and assumed to be similar for the remaining facilities, with the exception of a secondary aerospace manufacturing facility which was assumed a smaller value closer to similar sized manufacturing facilities.

MMBTU Conversion – All Sectors: EIA has developed a methodology to convert CO2 emissions of natural gas to million BTU utilizing fuel rates. Per this methodology, ~117 pounds of CO2 from natural gas emissions are equivalent to 1 MMBTU.

Step 2: Natural Gas Demand by Heating Use Case

Once the current natural gas usage has been determined based on emissions data, the US Energy Information Administration (EIA) Manufacturing Energy Consumption Survey (MECS)[72] is used to understand how current natural gas usage is split across end-uses. As described earlier, the MECS is a national survey conducted by the EIA to collection information on the US manufacturing establishment and their energy-related characteristics and consumption. As part of this survey, natural gas end use is collected by NAICS identified sectors. In the survey, energy usage is broken out into five categories:

- Indirect Uses (boilers): Natural gas does not provide direct heat but provides heat to water which is then used to provide heating through steam or hot water.
- Direct Process Heat: Natural gas is used to provide heating to industrial processes by heating air or the workpiece directly.
- Direct Non-Process Heat: Natural gas is used to fuel heating systems that do not directly contribute to industrial processes (e.g., HVAC)
- Feedstock: Natural gas is used as feedstock for industrial processes
- Indirect Uses - Combined Heat and Power (CHP): Provides on-site electric power, heating, and cooling.

The survey provides the total energy usage across the industry level of granularity. The percentage of natural gas usage for an industry can be used and applied to the base natural gas demand for a sub-sector. However, per SME input, many facilities report boilers as CHP in survey results, not distinguishing between the two indirect natural gas usages. Therefore, the percentage of natural gas usage identified for CHP in MECS is added to the percentage of natural gas usage identified for "Indirect Uses (Boilers)" in MECS.

Table 20: Food & Bev MECS Data

2021 Estimated Natural Gas Consumption (Trillion BTU)	NAICS 311: Food Manufacturing
Indirect Uses (Boilers)	19.51213828
Indirect Uses (CHP)	36.15484447
Direct Process Uses	23.95975804

[72] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis

Direct Non process Uses	0.57388642
Feedstock	2.00860247

2021 Estimated Natural Gas Consumption (%) – CHP Included	**NAICS 311: Food Manufacturing**
Indirect Uses (Boilers)	23.7%
Indirect Uses (CHP)	44.0%
Direct Process Uses	29.1%
Direct Non process Uses	0.7%
Feedstock	2.4%
2021 Estimated Natural Gas Consumption (%) – CHP Excluded	**NAICS 311: Food Manufacturing**
Indirect Uses (Boilers)	67.7%
Indirect Uses (CHP)	0.0%
Direct Process Uses	29.1%
Direct Non process Uses	0.7%
Feedstock	2.4%

The base annual natural gas demand, in MMBTU, per heating use case is determined by multiplying the base demand by the estimated breakdown of natural gas usage for a particular sub-sector. For some sub-sectors, there may be further breakdown of natural gas usage as there are differing MECS percentages within a sub-sector. For example, in the "Metals" sub-sector, the base natural gas annual demand is split into "Primary Metals" and "Fabricated Metals" as MECS identified different breakdowns of heating use-cases for each category.

Step 3: Industry Growth Rate

For each scenario, there are different assumptions utilized on how base natural gas demand will increase or decrease over time.

For the conservative scenario, there is no projected increase in energy consumption in that category to reflect a stagnant market demand for that category's production output.

For the moderate and ambitious scenario, for non-refineries and non-cogeneration sub-sectors, the study estimates industry growth rates using a dataset from EIA's Annual Energy Outlook, entitled "Industrial Sector Macroeconomic Indicators"[73]. The dataset estimates the value of production in each sub-sector from 2022 to 2050. For both scenarios, dataset used in the study was filtered to focus on the "Pacific" market and represent a high industrial growth scenario. The dataset provided the total value of shipments in 2012 dollars and the growth/decline between the total value of shipments for a specific sub-sector or sub-sector category was taken to be the industry growth rate.

When more detailed breakdowns of categories within sub-sectors were available, they were leveraged. For example, the facilities covered in the "Metals" sub-sectors were broken into

[73] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis

“Primary Metals – Steel”, “Primary Metals – Aluminum”, and “Fabricated Metals”. The industry growth rates were then pulled for each category and then applied to the base natural gas demand, split out by heating use case. In instances where there were more industrial growth rate data available than MECS category splits, the natural gas demand was further broken out so that the industry growth rates could be applied appropriately to the natural gas demand from each category. The industry growth rate is then applied to the base natural gas, with the assumption that natural gas consumption will increase or decrease at the same rate as the total volume of shipments.

For refineries, EIA’s Annual Energy Outlook demand was also leveraged, including a table in the report, “Table 24. Refining Industry Energy Consumption” since it provided specifically more information on natural gas usage rate changes. The high economic output scenario was utilized. The difference in total natural gas consumption by the industry, per annum, was then taken to be the industry growth rate.

Step 4: Electrification Adjusted Demand

In order to determine the total addressable market for hydrogen, any potential natural gas demand that can be electrified is removed.

SME input from EPRI was leveraged to estimate the electrification adoption rate of each heating use case by the year 2050. The 2050 adoption rate is then multiplied by a scale which begins at “0” in the year 2021 and then reaches “1” in 2050 at a linear scale.

Table 21: Electrification Potential

Heating Use Case	2050 Electrification Adoption
Indirect Heat (Boilers)	5%
Direct Heating Application	20%
Direct Non process Uses	80%
Feedstock	0%

There are two exceptions: Electrification adoption in 2050 for Food & Beverage boilers is assumed to be 20% per SME input, and direct heating in primary metals is assumed to be 5% per SME input.

The electrified demand for a given year is determined by multiplying the growth-rate adjusted natural gas demand by the electrification adoption rate and this is subtracted from the total natural gas demand to determine the remaining natural gas demand that can be addressed by hydrogen for fuel-switching.

Fuel switching from natural gas to hydrogen for cogeneration

The methodology for hydrogen demand from fuel switching for cogeneration follows a different methodology than and is not related to the methodology described in the fuel switching for non-cogeneration section above. In order to identify the number of cogeneration facilities and annual natural gas demand per facility, EIA Form 923 was leveraged. The survey form collects detailed electric power data – monthly and annually – on electricity generation at the power plant level, specifying which plants are cogeneration facilities. The survey provides the natural gas demand per facility. The survey results from the year 2021 were used for this study[74]. Methodology and assumptions used to determine total electricity demand from cogeneration plants was assumed to be consistent with the power generation sector across all years and for all scenarios for the purpose of this study.

Adoption of green hydrogen at refineries for direct process usage in petroleum and renewable fuels refining

The methodology for hydrogen demand from direct process usage in petroleum and renewable fuels refining is not related to the methodology for hydrogen demand from fuel switching Demand for direct process hydrogen is estimated based upon typical mass consumption of hydrogen (kg) per volume of total throughput, in the case of petroleum refining, or produced fuel, in the case of renewable diesel and sustainable aviation fuel, observed at existing analogous facilities.

Hydrogen Demand for Petroleum Production

The first step in determining direct process hydrogen usage for petroleum refineries is to determine total annual crude oil and feedstocks throughput for the refinery in barrels. For refineries in SCG territory net annual throughput for 2021 was calculated based on refinery nameplate capacity information obtained from the California Energy Commission (CEC)'s California Petroleum Markets report, dated July 14, 2020, and annual utilization rates obtained from CEC's Petroleum Watch 2021[75]. Based on the latter, it is notable that refineries in Southern California operate at 89% utilization, outpacing the state average of 80%.

Future year net throughput estimates are based on extrapolation of 2021 volumes with the following, SME provided fuels market demand estimates applied.

- 2021: 0%
- 2030: -5%
- 2040: -25%
- 2050: -50%

For this analysis, fuels market demand destruction was scaled linearly between the 2030, 2040, and 2050 anchor points.

Total direct process hydrogen demand was determined based upon calculated total refining throughput with typical, aggregate hydrogen consumption rates for desulfurization and hydrocracking applied (source data from a study by Praxair[76] and the California Energy Commission).

This total direct process hydrogen demand is subsequently multiplied by the estimated percentage of H2 demand outsourced by refineries (sourced from the EIA), to determine the split between outsourced demand and internal demand.

[74] Form EIA-923 detailed data with previous form data (EIA-906/920) - U.S. Energy Information Administration (EIA)
[75] Petroleum Watch (ca.gov)
[76] Role of Hydrogen in Removing Sulfur Liquid Fuels (linde.com)

Hydrogen Demand for Renewable Diesel Production

Direct process hydrogen demand for renewable diesel was determined based upon producer sourced annual production volumes, which were then converted from barrels to kilograms using product densities sourced from the University of Missouri to determine total annual mass of renewable diesel produced. Estimated hydrogen consumption ratios – kilogram of hydrogen consumed per kilogram renewable diesel produced – were then applied to the calculated total annual mass-based renewable diesel production to determine the total annual direct process hydrogen demand in kilograms. [78]

Hydrogen Demand for Sustainable Aviation Fuel (SAF)

Total volume of SAF produced was calculated by multiplying total jet fuel production by the percentage of petroleum refinement transitioning to SAF, projected at 25% of the yearly reduction of petroleum production This yearly reduction of petroleum production is set equivalent to the refinery industry growth rate based on EIA Energy Outlook projections[77]. This figure was determined through consultations with industry experts. The result is then multiplied by the tonne H2 per barrel of SAF conversion ratio of 0.005 tonnes of H2/barrel of SAF[78] to give the projected hydrogen demand.

Assumptions

Addressable Market

- Only large facilities have been considered as potential end users in this phase. Large facilities are broadly defined as facilities that have significant natural gas footprint to be included in public emissions reporting data bases or additional facilities in the region identified by subject matter experts.
- Facilities built in conjunction with existing providers of hydrogen (e.g. Air Liquide, Air Products, PraxAir) are not considered to be potential end-users of new hydrogen demand.
- Existing use of grey hydrogen is not considered to be existing demand under the clean renewable hydrogen constraints of the Angeles Link pipeline and hydrogen projections do not include grey hydrogen demand. Only clean, renewable hydrogen use is projected in the demand study. However, clean renewable hydrogen demand arising from the potential switching of grey hydrogen to clean renewable hydrogen at refineries is included in the demand quantities in the ambitious scenario.
- Chemical facilities that currently produce hydrogen are not considered to be potential end-users of new hydrogen demand.
- All facilities in SoCalGas territory and territories where SoCalGas provides wholesale natural gas are considered potential adoptees of hydrogen for this study.

[77] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis
[78] Interviews

Hydrogen Adoption Factor Assumptions

Legislation

Senate Bill 596:

- Requires cement producers to reduce carbon emissions by 40% by 2030 and sets a target for 100% decarbonization by 2045[79]

Technical Feasibility

- For most industrial facilities within SoCalGas's territory, the primary opportunity for hydrogen will be fuel switching for process heat/steam, switching from natural gas-based combustion to hydrogen-based combustion technology.
- An estimated 40% of emissions from the cement industry are from combustion, the remaining emissions are from the production of clinker.
- Hydrogen adoption for industrial and commercial sited cogeneration turbines is expected to follow the same levels of technical feasibility growth as the other cogeneration turbines described in the Power sector section of this report.

Sector Growth

- In the conservative scenario, industry growth is 0% for all sub-sectors as no additional increase in industrial goods production is expected.
- In the moderate and high scenario, natural gas usage is expected to increase in-line with increase in industrial goods production per sub-sector, as forecasted by EIA's Annual Energy Outlook Macroeconomic Indicators dataset[80]
- No additional increase in demand at cogeneration facilities across all scenarios

Adoption Rates

Fuel Switching – Non-Cogeneration

For fuel switching applications of hydrogen, fuel switching adoption rates were evaluated by each end-use case of natural gas in industrial facilities. Subject matter expertise was utilized to evaluate three key adoption parameters over the course of time: Technology Feasibility, Alternatives, Commercial Availability (Capital Investments and Performance Impact), and Business Readiness. Alternatives was separated out from other adoption factors and listed as its own factor instead of legislation due to the lack of legislation in industrial sectors. Legislation has been included as a consideration where legislation exists. The adoption rate status was evaluated at three points in time:

- Short Term: 2025 – 2030
- Medium Term: 2030 – 2040
- Long Term: 2040+

[79] Bill Text: CA SB596 | 2021-2022 | Regular Session | Chaptered | LegiScan
[80] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis

A description of the four adoption rate parameters is below:

- Technology Feasibility: Measures current stage of technology development and expected future technological feasibility
- Alternatives: Measures the strength of decarbonization alternatives such as CCUS that may be used instead of hydrogen for decarbonization and reduce hydrogen adoption
- Commercial Availability: Measures the cost level of hydrogen adoption and equipment upgrades compared to legacy fuels
- Business Readiness: Lag parameter added to determine final adoption rates to reflect business timelines

At each time segment, for each heating use-case per sub-sector, a (Low/Medium/High) rating was assigned to each adoption parameter. These H/M/L categories were each given a percentage out of 100%, with adoption rate parameter-specific percentages described below. Each adoption factor was weighted equally at 33%, and a hydrogen adoption rate for each subsector was determined based on a weighted average of the three adoption rate parameters.

Table 22: Industrials Adoption Rate Parameters

Parameter	Rating	Definition
Technology	Low	The technology is currently in emerging stages of development
	Medium	The technology has been proven but is not commercially available (not proven at scale)
	High	The technology is readily commercially available
Alternatives	Low	Low likelihood of hydrogen adoption due to high prevalence of alternatives
	Medium	Medium likelihood of hydrogen adoption due to some prevalence of alternatives
	High	High likelihood of hydrogen adoption due to lack of viable alternatives
Commercial Availability (Capital Investments and Performance Impact)	Low	The switch to increased hydrogen adoption is less cost competitive compared to legacy technology, excluding fuel costs
	Medium	The switch to increased hydrogen adoption is equally as cost competitive compared to legacy technology, excluding technology costs
	High	The switch to increased hydrogen adoption is more cost competitive compared to legacy technology, excluding technology costs

Technology (Low: 25%, Medium: 50%, High: 75%)

Even in emerging stages of technology development, there are assumed to be some potential off takers of hydrogen technology in pilot or limited deployment capacity. However, at even high technology readiness, there will be some facilities that will not be willing to invest in hydrogen due to reasons such as current equipment not yet having reached retirement age and general lags in technology adoption for certain companies.

Alternative: Option 1 – High CCUS Favorable Facilities (Low: 0%, Medium: 25%, High: 50%)

This alternative option is utilized for adoption rate analysis with high favorability of CCUS (stone, glass, cement, primary metals). Given that CCUS is a viable solution in these industries, it is assumed that companies looking to decarbonize will choose between either hydrogen and CCUS with a split in adoption between the two technologies, lowering the potential market for hydrogen and reducing adoption rate. This is reflected in the limited range from 0-50% between low and high.

Alternative: Option 2 – Low CCUS Favorable Facilities (Low: 0%, Medium: 50%, High: 100%)

This alternative option is utilized for adoption rate analysis with low favorability of CCUS (Refineries, Food & Beverage, Fabricated Metals, Secondary Sub-Sectors). In these sectors, given the lack of viable decarbonization alternatives, hydrogen would proceed to full adoption in a high adoption rate scenario reflected in the range of 0-100% between low and high.

Commercial Availability (Capital Investments & Performance Impact) (Low: 20%, Medium: 50%, High: 80%)

In an environment where 100% hydrogen technology is not competitive with existing equipment, there is some adoption as hydrogen can be blended up to 20% in fuel switching with natural gas applications without significant infrastructure change. However, even in an environment where 100% hydrogen technology is very cost competitive, there will not be 100% adoption due to the capital investments required to integrate new technology versus continue extension of existing assets.

Table 23: Industrials Adoption Rate Weights

Fuel Switching (Refineries, Food & Beverage, Fabricated Metals, Secondary Sub-Sectors)			
Weights	33%	33%	33%
	Tech	**Alternatives**	**Commercial Availability (Capital Investments & Performance Impact)**
Low	25%	0%	20%
Medium	50%	50%	50%
High	75%	100%	80%

Fuel Switching (Stone, Clay, Glass, & Cement, Primary Metals)			
Weights	33%	33%	33%
	Tech	**Alternatives**	**Commercial Availability (Capital Investments & Performance Impact)**
Low	25%	0%	20%
Medium	50%	25%	50%
High	75%	100%	80%

Business Readiness

A logistic delay function is then applied to the base adoption rate in a given year to integrate the timeline when existing equipment is reaching end of life and facilities are ready to evaluate whether they will switch to new hydrogen-based technology. The lag terms are the following, per heating use case:

- Estimated Lag Term for Boilers and High-Direct Process Heat: 20 years.
- Estimated Lag Term for Direct Non-Process Heat: 15 years.

The formula for the final lag adjusted annual adoption rate, starting in the year 2025 is:

$$Adoption\ Rate_{2024} = 0\%$$

$$Annual\ Adoption\ Rate_x = \left(1 - \frac{1}{Lag\ Term}\right) * Annual\ Adoption\ Rate_{x-1} + \frac{Step\ Function\ Adoption\ Rate_x}{Lag\ Term}$$

<u>Adoption Rate Basis – Metals</u>

Technology (Primary and Fabricated Metals):

Table 24: Metals Adoption Rates - Technology

	2025 – 2030	2030 - 2040	2040+
Boilers	Low	Medium	High
Direct Process Heat	Medium	High	High
Direct Non-Process Heat	Medium	High	High

Rationale:

Metals industries in SoCalGas' service territory consist primarily of three types: back-end metal forming operations for steel and aluminum; primary engineered structural shapes (sheets, strips, rings, bars, beams, castings and extrusions) in the primary metals categories; and wide variety of metals fabrication processes supporting robust assembly and sub-assembly supply chains.

The primary fuel end-uses in these sectors generally fall into direct process heating to increase malleability prior to forming operations in the primary space and to drive metallurgical processes to generate the needed hardness, strength, dimensional stability and machinability characteristics of the metal components in downstream secondary processing. A second important yet smaller source of final energy demand is in the production of steam used for cleaning, heating of various process solutions involved in chemical surface treatments and for mill and shop space-heating applications.

A transition to hydrogen for these purposes would require changes in the design of several equipment types, including valve trains, metering, burners and refractories. Flame speed is an issue with traditional pre-combustion burner mixers as the flame can flash backward resulting in loss of ignition and risking dangerous explosion events. Infrared-emitting hydrogen-capable burners are under development that avoid flashback and concerns over thermal NOx formation as are a family of fuel agnostic intelligently modulated burner designs that have a goal of reducing the risk of availability and pricing fluctuations across a variety of potential gaseous and liquid fuels. These designs serve to lessen the risk of migration from hydrogen blends to full hydrogen adoption avoiding further expense in the combustion systems. Beyond retrofits, purpose built 100% hydrogen furnace, oven and boiler systems are being modeled and will be in demonstration over the next 3 to 5 years providing metals industry customers with more efficient by-design hydrogen-fueled process heating alternatives.

Hydrogen-capable valve trains and piping are available today. Burner models and designs are at different stages based on the vendor and application. Some are in demonstration today and could be in a position to gear up for product launch in the next 3-5 years. Flame management and advanced combustion controls systems are less certain as are any materials demonstrations needed for high temperature alloys and refractories. Ongoing government funding and demonstration projects should have these subsystems ready for commercialization in the 5–10-year timeframe.

Production processes in the metals industries will have to change in several ways to enable 100% hydrogen use. The potential for reduced net thermal efficiency of retrofit systems could result in lower throughput and process yields, which could only be overcome by installing additional burners into process heating equipment or increasing the physical burner heating capacity which could face physical limitations and would certainly add to the CapEx and OpEx requirements. More sophisticated process controls, flame management and hydrogen safety systems, including leak detection, may be required, adding to the risk mitigation cost.

Additionally, systems to reduce thermal NOx formation may be required. In most applications it will be necessary to execute careful process change management systems to ensure that product quality is not adversely impacted by flame characteristics such as temperature, length, irradiance, speed, and the new slate of combustion products including water and residual hydrogen.

These are time consuming processes that require extensive testing and proof of process performance to rigorous international product quality standards. Similarly, impacts on Mean Time Between Failure of critical heating system components like burners, tubes, refractories, shells sensors and controls must all be assessed to establish any maintenance cost and downtime penalties that must be accounted for in economic justification calculations. These factors individually can add two to five years to new process adoption and combined serve to dramatically flatten the slope of the adoption curve for these assets which are expected to serve a 10 - 20-year operating life or longer.

Regarding operational characteristics, once the gas fuel leaves the city-gate at distribution pressures, though somewhat elevated compared to hydrocarbon fuels, the pressures are well within comfortable ranges for equipment operators and are very low at the point of application where mixing with air (or oxygen) on its way to the burner-tip. Because of the much lower volumetric density a combination of larger piping size and pressure may be needed to deliver an equivalent btu/hr rated heating system for a given furnace application. If early adoption depends on in situ blending of hydrogen with natural gas, a properly designed and stable blending unit will add to the investment and operation requirements. Industry readiness varies for different levels of blending between 20 and 30% for different elements of the combustion system and other equipment components. Hydrogen combustion also produces a water laden effluent which can impact process and emissions controls, refractory performance and life and products. Impacts of seasonal variation of natural gas heating values with respect to hydrogen blends has not been studied and will need to be understood in terms of process tolerances. This is likely to become less important with higher percentage hydrogen blends.

Alternatives (Primary and Fabricated Metals):

Table 25: Metals Adoption Rates: Alternatives

	2025 – 2030	2030 - 2040	2040+
Boilers	Low	Low	Low
Direct Process Heat	High	Medium	Medium
Direct Non-Process Heat	Low	Low	Low

Rationale:

Direct electrification through resistive/convective, induction heating and to a lesser degree infrared technologies will acquire larger portions of this process heating demand market due to the highly competitive thermal efficiencies of radiant heating, competitive capital costs, alignment with LEAN manufacturing principles (single piece flow, JIT, etc.) and mature technology availability for the past 20+ years.

The other alternative to consider is in situ or within-cluster carbon capture and sequestration or use. Because the current technologies are focused on utility scale emissions effluents, there is not an aggressive effort to downward integrate CCUS at a scale that is economically viable for metals processing furnaces. The effluent streams contain significant excess water and nitrogen that dilute the CO2 stream and make it expensive to concentrate and collect/compress across multiple sites necessary to adapt current system designs. Moving toward oxy-firing might improve the financials but a price penalty for O2 must be paid on the front end and O2 is a substantially more hazardous process gas to manage than hydrogen so risk mitigation across multiple sites would be a concern.

The remaining unelectrified demand is technically convertible to hydrogen combustion systems that could gain share in the higher temperature and high aggregate Btu/hr process thermal demand rates. This is more likely to occur in larger integrated processing facilities where hydrogen supply and associated safety systems, codes and standards and operational practices can be effectively institutionalized. These system-level changes, retrofit costs and workforce retraining costs will provide inertia in the market sub-segments that exhibit a wide dispersion of small to mid-sized enterprises. A recalcitrance level of up to 20% in adoption of hydrogen as a process heating fuel may occur toward the end of the planning period.

Similarly, steam which generally constitutes 20-25% of final energy in primary metals facilities and lower percentages in metals fabrication are convertible to direct electrification options through electrode and medium voltage boilers that are commercially available today. Hydrogen-based combustion systems to retrofit existing boilers in the upper end of the industrial boiler range are under development and demonstrations are eminent. It is expected that the steam boiler demand for steam-based process heat that is not electrified will be fully convertible to hydrogen combustion systems for these industries. These applications are likely to track the adoption profile of the base process heating demand as described above since those conversions will be simplified by the implementation of in-plant hydrogen supply infrastructure and workforce capabilities.

Commercial Availability (Primary and Fabricated Metals):

Table 26: Metals Adoption Rates – Commercial Availability

	2025 – 2030	2030 - 2040	2040+
Boilers	Low	Low	Low
Direct Process Heat	Medium	Medium	Medium
Direct Non-Process Heat	Low	Low	Low

Rationale:

Cost and performance characteristics of hydrogen capable burner systems are the subject of current research studies. It is expected that valve trains, piping, combustion controls, flame management systems, leak detection, burners, and refractories and emissions mitigation systems may all experience long term higher cost when compared with incumbent fossil fuel alternatives.

Some of the primary barriers that stand in the way of a hydrogen transition in the metals industry are a combination of retrofit and replacement costs, uncertainty of ultimate process performance, lack of successful demonstrations, and the viability of low-carbon alternatives.

The servicing of additional capital/debt associated with retrofits and higher cost purpose-built equipment and potential thermal efficiency penalties may diminish the financial feasibility in the short to medium term without significant incentives or regulatory pressure.

Metal manufacturers are conservatively managed businesses in highly competitive markets. Products tend to be commoditized quickly so competitive advantage often hinges on superior operational performance and tight control over all facets of production costs. As a result, there is an aversion to risk particularly when that risk touches the fundamental properties of their products. Process heating in the metals industry is fundamental to the physical/chemical and micro-structure properties of the industry's products so changes in process are slow and deliberate.

Adoption Rate Basis – Food & Beverage

Technology:

Table 27: Food & Bev Adoption Rates - Technology

	2025 – 2030	**2030 - 2040**	**2040+**
Boilers	Low	Medium	High
Direct Process Heat	Low	Medium	High
Direct Non-Process Heat	Medium	High	High

Rationale:

As fuel, hydrogen can be blended with or displace existing natural gas-use (fuel-switching) to generate process heat and steam. It could also be used for fuel cells to produce electricity. This electricity can then be used to power forklifts or back-up generation for refrigeration and HVAC systems.

When the direct combustion of natural gas is replaced by hydrogen, processes such as baking may be affected by increasing the humidity inside of ovens and hence affecting the color, density, and other properties of baked foods. In some cases, this may improve food quality,[139] but a great deal of change will likely be required to test and ensure the impacts of hydrogen flame and combustion byproducts on food quality and safety.

The feasibility of 100% hydrogen-use in the baking process remains to be determined, but some work in this space suggests up to 30% H2 blend does not pose a deterrent to equipment. When hydrogen is used in combustion, the same technical limitations apply to hydrogen blending with natural gas as it does for other industries. The usual limitations of burner capabilities and integrity of transportation lines apply.

For hydrogen use in process heating, the methodologies and processes for hydrogen use would generally be similar to natural gas, with adjustments made in BTU value for the different blends of hydrogen. Differences in piping size, controls and burner sizes and configurations may reach practical physical limits in which case productive capacity of a retrofitted system may need to be derated.

There are a handful of hydrogen equipment manufacturers in the food and beverage industry, including AMF Bakery Systems and RBS Oven Systems,[140] whose ovens can use hydrogen to bake a wide range of food products. These manufacturers offer complete replacements, rather than retrofits.

Alternatives:

Table 28: Food & Bev Adoption Rates - Alternatives

	2025 – 2030	2030 - 2040	2040+
Boilers	Low	Low	Low
Direct Process Heat	High	Medium	Medium
Direct Non-Process Heat	Low	Low	Low

Rationale:

For generating process heat in the food and beverage industry, electrification may be a favorable alternative to hydrogen. Food processing facilities have had some experience with direct electrification by implementing electrode steam boilers to satisfy facility-wide steam demand during off-peak periods through day ahead hourly electricity pricing tariffs. These systems offer considerable energy-related cost-savings for the end-user. These electrode boilers are a well-tested and available alternative for this industry and will likely have a jump-start on the market as decarbonization pressures build.

Industrial heat pumps, heat recovery heat pumps and heat recovery chillers are also likely to grow in this industry because of their cost of power advantages. Air impingement ovens offer greater efficiency than traditional convective heating ovens and should also be viewed as a competitive offering.[142]

The remainder of the fossil-fueled final energy in the food and beverage industry is associated with baking, drying and space conditioning applications. These involve low temperature and again are subject to heavy competitive pressures from electric technologies whose final energy thermal efficiencies are much higher than combustion-based systems. In this space, gas catalytic-style hydrogen-capable burners are under development but are yet to be demonstrated at scale. These units would possess some of the benefits of infrared cooking and baking but are 5 to 10 years from commercialization.

Commercial Availability:

Table 29: Food & Bev Adoption Rates – Commercial Availability

	2025 – 2030	2030 - 2040	2040+
Boilers	Low	Low	Low
Direct Process Heat	Medium	Medium	Medium
Direct Non-Process Heat	Low	Low	Low

Food and beverage facilities often run 24/7, with few idle periods apart from needed maintenance. Since installation of new hydrogen-based equipment can take up to a minimum of 3 months, there would be a significant performance impact in the short term and disrupt businesses with low margins.

Adoption Rate Basis – Stone, Glass, and Cement

Technology:

Table 30: Stone, Glass, Cement Adoption Rates - Technology

	2025 – 2030	2030 - 2040	2040+
Boilers	Low	Medium	High
Direct Process Heat	Medium	High	High
Direct Non-Process Heat	Medium	High	High

Rationale:

Some of the existing equipment used in cement production such as rotary kilns, burners, air-preheaters etc. may have to be modified to enable 100% H2 use. For example, the following systems will have to go through design modifications:

a. Combustion systems: Cement kilns and other high-temperature equipment would need modifications to accommodate the use of hydrogen as the primary fuel. Hydrogen has different combustion characteristics compared to conventional fuels like coal or natural gas. The burners, flame control mechanisms, and temperature management systems would need to be optimized for hydrogen combustion to ensure efficient and stable operations.
b. Storage and handling: Hydrogen has specific requirements for storage and handling due to its low density and high reactivity. Cement plants would need to invest in specialized hydrogen storage infrastructure, such as high-pressure or cryogenic storage tanks, to store the necessary quantities of hydrogen onsite. They may also choose to have on-site H2 production such as electrolyzers. Safety measures and protocols would need to be implemented to handle hydrogen safely.
c. Delivery systems: The existing fuel delivery systems in cement plants, which are designed for conventional fuels, may need modifications or replacement to accommodate the use of hydrogen. This includes pipelines, pumps, and valves, which must be compatible with hydrogen and capable of handling its unique properties.
d. Emissions control: Hydrogen combustion results in different emissions compared to conventional fuels. While hydrogen combustion does not produce carbon dioxide (CO2) emissions, it can lead to increased nitrogen oxide (NOx) emissions. Cement plants would need to incorporate appropriate emissions control technologies to minimize NOx and other pollutant emissions.

Alternatives:

Table 31: Stone, Glass, Cement Adoption Rates - Alternatives

	2025 – 2030	2030 - 2040	2040+
Boilers	Low	Low	Low
Direct Process Heat	Medium	Low	Low
Direct Non-Process Heat	Low	Low	Low

Rationale:

A significant decarbonization alternative in this industry is the application of carbon capture and use or sequestration technologies. Upwards of 55% of all CO2 emissions from cement production are process related whereas, roughly 35% results from fuel combustion. Either CCUS technologies must be applied throughout the industry to address process emissions, or the industry will have to undertake a wholesale change in its raw materials and processes (a pathway that is currently low TRL and fraught with technical and operational risks).

Direct electrification of the kiln faces these issues as well and furthermore concepts to electrically heat the kiln and any residual needs of the pre-calciner after heat recovery are only at bench scale development to date. Furthermore, though potentially highly efficient, electrification of cement production process heat would require tremendous amounts of electric power on a continuous and uninterrupted basis. The cost of electric infrastructure might well be cost prohibitive and achieving the continuous power flows from renewable sources on the grid would demand unprecedented levels of grid scale battery storage. An alternative being considered is dedicated advanced small nuclear reactors for this type of demand. Significant development, cost, safety, and regulatory hurdles will need to be overcome to make this pathway viable even toward the end of the planning horizon.

Commercial Availability:

Table 32: Refineries Adoption Rates – Commercial Availability

	2025 – 2030	2030 - 2040	2040+
Boilers	**Low**	**Low**	**Low**
Direct Process Heat	**Medium**	**Medium**	**Medium**
Direct Non-Process Heat	**Low**	**Low**	**Low**

Given the size of cement facilities, shifting to hydrogen - based equipment on a large scale would necessitate substation investments in hydrogen production, storage, and transportation infrastructure. However, lower levels of blending can still be achieved with modifications to existing technology.

<u>Adoption Rate Basis – Refineries (Fuel Switching)</u>

Technology:

Table 33: Refineries Adoption Rates - Technology

	2025 – 2030	2030 - 2040	2040+
Boilers	Low	Medium	High

Direct Process Heat	Medium	High	High
Direct Non-Process Heat	Medium	High	High

Rationale:

For boilers, burner development is in progression. There are still technological challenges that the industry is working through, namely: high volume hydrogen storage and piping, refractory and tube materials, flame management, and modification to safety solutions. The progression of technology reflects that commercial solutions appear in the medium term, with widespread availability after 2040.

For the other heating use cases, fired heating technology for high hydrogen based technology is in development and widespread commercial availability is expected by 2030.

Alternatives:

Table 34: Refineries Adoption Rates - Alternatives

	2025 – 2030	2030 - 2040	2040+
Boilers	High	Medium	Medium
Direct Process Heat	Medium	Low	Low
Direct Non-Process Heat	Medium	Low	Low

Rationale:

There is very low potential for electrification of boilers in this sub-sector given the steam mass flow requirements. However, while carbon capture will not be meaningful alternatives for relatively low CO2 emitting boilers, it is expected to be a more likely preferred alternative to direct process heating. This is because CCUS is projected to be a more mature technology in the medium term compared to hydrogen and more widely proven.

Commercial Availability:

Table 35: Refineries Adoption Rates – Commercial Availability

	2025 – 2030	2030 - 2040	2040+
Boilers	Low	Medium	Medium
Direct Process Heat	Low	Medium	Medium
Direct Non-Process Heat	Low	Medium	Medium

Rationale:

In the near term, there would be significant capital investments and performance penalties involved in the adoption for hydrogen for fuel switching. Heater and fuel gas system modifications will be very costly and hard to justify versus other decarbonization alternatives. However, as time progresses, innovative technology and a better understanding of the retrofit processes needed will increase the attractiveness of hydrogen-based technology. Further, an increased number of fired heaters are expected to reach end of life in the 2030+ timeframe and high efficiency hydrogen-based technology can serve as an alternative to rebuilding old units.

Adoption Rate Basis – Secondary Sub- Sectors (Paper, Chemical, Aerospace and Defense)

Technology:

Table 36: Secondary Subsectors Adoption Rates - Technology

	2025 – 2030	2030 - 2040	2040+
Boilers	**Low**	**Medium**	**High**
Direct Process Heat	**Low**	**Medium**	**High**
Direct Non-Process Heat	**Medium**	**High**	**High**

Rationale:

For boilers, burner development is in progression. There are still technological challenges that the industry is working through, namely: high volume hydrogen storage and piping, refractory and tube materials, flame management, and modification to safety solutions. The progression of technology reflects that commercial solutions appear in the medium term, with widespread availability after 2040.

There are expected to be less direct process heat applications specific to the secondary sub-sectors but innovations in furnace type technology in other primary sectors could be applied to similar equipment in these sectors.

Direct non-process heat is expected to reach similar levels of technology majority across similar manufacturing sub-sectors (e.g., food and beverage, metals)

Alternatives:

Table 37: Secondary Subsectors Adoption Rates - Alternatives

	2025 – 2030	2030 - 2040	2040+
Boilers	**Low**	**Low**	**Low**
Direct Process Heat	**Medium**	**Medium**	**Medium**
Direct Non-Process Heat	**Low**	**Low**	**Low**

Rationale:

Similar to other manufacturing operations (e.g., food and beverage, metals), there will be significant opportunities to electrify lower temperature equipment such as boilers and direct non-process heat. However, direct process heat will be hard to electrify and given the total emissions output from these facilities, there will be relatively less viability for carbon capture.

Commercial Availability:

Table 38: Secondary Subsectors Adoption Rates - Commercial Availability

	2025 – 2030	2030 - 2040	2040+
Boilers	**Low**	**Low**	**Low**
Direct Process Heat	**Low**	**Low**	**Low**
Direct Non-Process Heat	**Low**	**Low**	**Low**

Rationale:

Given these sectors have relatively low usage of natural gas compared to other primary sectors, there is low incentive for businesses to make significant investments in installing more expensive hydrogen-based technologies and conduct retrofits.

The primary opportunities for businesses to integrate hydrogen will be low levels of hydrogen blending to demonstrate commitments to ESG goals.

Fuel Switching - Cogeneration

The adoption rate methodology for hydrogen use in cogeneration will follow the same methodology and same results that was used to determine the adoption rates for power plants, detailed above in the Power section.

Refineries

Adoption rate assumptions were formed using SME input and analysis of refineries within the Southern California region, and then were validated with industry interviews. A set number of adoption milestones were identified as part of these assumptions and then annual adoption rates were scaled linearly between these dates.

First, it should be noted that approximately 40% of hydrogen is produced on-site, either through steam methane reformed (SMR) based hydrogen or as a byproduct of the petroleum refining process, and the remaining 60% is procured through outside vendors. The adoption milestones are the following:

2025: 0% of grey hydrogen can be transitioned to green hydrogen

2030: 50% of merchant hydrogen, hydrogen procured commercially, can be transitioned from grey hydrogen to green hydrogen. This results in 30% of total refinery demand being satisfied by green hydrogen.

2040: 100% of merchant hydrogen, can be transitioned from grey hydrogen to green hydrogen. This results in 60% of total refinery demand being satisfied by green hydrogen.

2045: 100% of merchant hydrogen and 25% on-site produced hydrogen can be transitioned from grey hydrogen to green hydrogen. This results in 70% of total refinery demand being satisfied by green hydrogen.

These assumptions are conditional that green hydrogen supply is readily available and at cost parity with green hydrogen.

APPENDIX B: Locational Analysis

Angeles Link Phase 1 Demand Study

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Appendix B: Locational Analysis

Mobility

Methodology

The mobility sector differs from Power and Industrials in that there are not specific facilities to model from, and so zip code level data was approximated. The model's core underlying data set, the CARB EMFAC Emissions Database,[81] contains data on vehicle type fuel consumption, by vehicle type, at a county level. So, this county-level data was used and allocated across current gasoline and/or diesel fueling stations by zip code. Since hydrogen refueling—and therefore hydrogen demand—is expected to generally happen at fueling stations, and since hydrogen fueling patterns are expected to largely reflect current gasoline and diesel (namely, diesel) fueling patterns, the locations of existing fueling locations was assumed to be a representative estimate of where future hydrogen fueling demand may be located. Current fueling station locations by type were identified using California Energy Commission data.[82]

On-Road

The locational analysis model takes the following approach to allocating on-road vehicle application demand by zip code:

1. Necessary data is collected:
    a. The CARB EMFAC Emissions Database[83] provides # of gallons of diesel and gasoline sales by county, by vehicle type. Note: 2019 data was used as a pre-covid benchmark for allocations.
    b. California Energy Commission data[84] provides the location (zip code) of all truck stops, hypermarts, cardlock facilities, and gas stations in SoCalGas service territory.
    c. Google Maps provides the location (zip code) of transit bus depots in the SoCalGas service territory.
2. Necessary data is used to determine what the percent of truck stops, gas stations, hypermarts, cardlock facilities and transit bus depots are in each zip code. For example, there are 3 truck stops in Imperial County: 2 (67%) in 92243, 1 in 92275 (33%).
3. Assumptions are made for how much gasoline and/or diesel are sold at each fueling station by type. See below for more detail.
    a. Note: the amount of fuel sold at each location is not readily available public information, otherwise this information would have been used to allocate hydrogen demand across fueling station locations. Instead, each fueling station was assumed to be the same size (based on the type of station and type of fuel it sells).
4. For each vehicle type, the amount of diesel and/or gasoline sold in each county is multiplied by the values from percent of fueling stations (and therefore, percent of fuel) in each zip code to

81 https://arb.ca.gov/emfac/emissions-inventory/
82 https://hub.arcgis.com/datasets/CalEMA::ca-energy-commission-gas-stations/explore
83 https://arb.ca.gov/emfac/emissions-inventory/
84 https://hub.arcgis.com/datasets/CalEMA::ca-energy-commission-gas-stations/explore

determine how much diesel and/or gasoline sales to allocate to each zip code within a specific county.
5. The values of percent diesel and/or gasoline sales by vehicle application and by zip code are multiplied by outputs from the hydrogen demand model to approximate hydrogen demand by zip code, by vehicle application. The percent allocation is assumed to be constant from 2025 to 2045.

Off-Road

The model takes the following approach to allocating off-road vehicle application demand by zip code:

1. Necessary data is collected:
    - The CARB EMFAC Emissions Database85 provides the number of gallons of diesel and gasoline sales by county, by vehicle type.
    - California Energy Commission data86 provides the location (zip code) of all truck stops, hypermarts, cardlock facilities, and gas stations in California (and in SoCalGas service territory).
    - The California Legislative Analyst's Office87 provides the location (zip code) of all ports in California (and in SoCalGas service territory) in addition to the proportional volume of port activity.
    - The Bureau of Transportation Statistics88 provides the location (zip code) of all airports in California (and in SoCalGas service territory) in addition to the proportional volume of airport activity.
2. Necessary data is used to determine the percent of truck stops, cardlock facilities, airports and ports are in each zip code.
3. Assumptions are made to reflect which types of vehicles refuel at each location:
    - GSE and Aircraft refuel at Airports.
    - CHC, OGV and CHE refuel at the Ports.
    - Agricultural equipment refuels at (or receive from) Truck Stops
    - Construction & Mining equipment refuels at Cardlock Facilities
4. For each vehicle type, the number of gallons of diesel sold in a county is multiplied by the percent of associated fueling stations associated with each vehicle type to determine how much diesel sales to allocate to each zip code within a specific county.
5. The values of percent diesel sales by vehicle application and by zip code are multiplied by outputs from the hydrogen demand model to approximate hydrogen demand by zip code, by vehicle application. The percent allocation is assumed to be constant from 2025 to 2045.

Assumptions

The allocation of mobility application hydrogen demand by zip code is contingent on a few key assumptions:

- **That all fuelling locations by type (e.g., Truck Stops) sell the same amount of fuel as other fuelling locations of the same type in a given county.** The amount of fuel sold at each location is

[85] https://arb.ca.gov/emfac/emissions-inventory/
[86] https://hub.arcgis.com/datasets/CalEMA::ca-energy-commission-gas-stations/explore
[87] https://lao.ca.gov/Publications/Report/4618
[88] https://www.transtats.bts.gov/Data_Elements.aspx?Data=1

not readily available public information, otherwise this information would have been used to allocate hydrogen demand across fueling station locations.

- **That current consumption patterns by fuel types will remain constant.** I.e. that current diesel and/or gasoline fuelling patterns are representative of future hydrogen demand fuelling patterns by vehicle application.
- **That vehicle applications refuel at the following types of fueling stations:**

Table 39: Mapping of Fueling Station Type to Vehicle Categories

Vehicle Application	Fueling Locations
LDV	Service Station or Gas Station, Hypermart, Cardlock Facility,
MDV	Service Station or Gas Station, Hypermart, Cardlock Facility, Truck Stops
HDV	Truck Stops
Transit Bus	Transit Bus Depots
CHE	POLA, POLB
GSE	Airports
Agricultural	Truck Stop
C&M	Cardlock Facility
CHC	Ports
OGV	POLA, POLB
Aviation	Airports

- **That diesel and/or gasoline vehicles, by refueling mode, refuel at the various fueling station types according to the following schedules**. For example, that Drayage Trucks fall under "Back to base" operations and refuel 100% at cardlock facilities:

Table 40: Allocations of fueling station type for diesel applications.

Fueling category	Service Station or Gas Station	Hypermart	Cardlock Facility	Truck Stop	Bus Depot
HDV	0%	0%	0%	100%	0%
Back to base	0%	0%	100%	0%	0%
MDV	30%	0%	0%	70%	0%
Gasoline applications	0%	0%	0%	0%	0%
Transit bus	0%	0%	0%	0%	100%

Table 41: Allocations of fueling station type for gasoline applications.

Fueling category	Service Station or Gas Station	Hypermart	Cardlock Facility	Truck Stop	Bus Depot
HDV	0%	0%	0%	0%	0%
Fleets	0%	0%	0%	0%	0%
Other	0%	0%	0%	0%	0%
Gasoline applications	95%	3%	1%	1%	0%

Transit bus	0%	0%	0%	0%	0%

- That SoCalGas service area **reflects the zip codes found in the 11 counties: Imperial, Kern, Kings, Los Angeles, Orange, Riverside, San Bernardino, San Luis Obispo, Santa Barbara, Tulare, Ventura.** Around 30 zip codes fall outside of these counties, so their potential demand is allocated to the zip codes within the defined nearest counties. This assumption does not materially impact the findings of the model which contains 739 zip codes. Since EMFAC fuel consumption data is only available at the county level, the demand for zip codes outside of these counties is not modelled.

Power

Locational demand in the power sector has been estimated based on proportion of current plant natural gas combustion compared to total locational area. Therefore, all plants show some level of hydrogen adoption in the locational analysis. This method was chosen in order to remain agnostic about which power plants will choose to move to hydrogen versus alternatives and is intended to be used to identify potential hotspots of demand rather than to quantify the exact level of demand for each individual zip code.

Limitations of this approach are noted below:

- This method assumes all plants adopt hydrogen at some midpoint percentage between 0 and 100%. In reality, it is likely that some plants will not move to hydrogen, and some plants will move their operations fully to hydrogen as hydrogen turbines become available. The model will overcount and undercount hydrogen demand, respectively. Continued tracking of power plant commitments will help to understand which areas of the locational model may be underestimated and which may be overestimated.
- Given the uneven locational distribution of zip codes, some zip code projections will only include one power plant while some zip codes will include multiple. This may cause large fluctuations between the projection and reality for zip codes with a smaller number of power plants.

Industrials

In order to determine the zip code granularity of the location of hydrogen demand for a particular sub-sector, demand is first determined at a facility level of granularity. The total demand for hydrogen, per annum, is multiplied by the percent of natural gas that facility contributed to the total natural gas consumption in that particular sub-sector. The demand figure represents the probabilistic expected value of demand for that facility. Once the facility – level data has been estimated, it is rolled up to the zip level of granularity.

APPENDIX C: List of H2 Projects

Angeles Link Phase 1 Demand Study

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Appendix C: List of H2 Projects

Mobility

There has been an increase in recent years of clean hydrogen powered vehicle development initiatives, announced vehicle launches from OEMs (original equipment manufacturers, e.g., the auto manufacturers) and announced hydrogen fueling stations from fueling station operators and by the California Energy Commission. These announcements and proposed projects point to the increasing interest by the mobility sector for hydrogen-fueled alternatives to conventional vehicles. Several key announced projects in California and across the U.S. are outlined below:

Table 42: Select Public OEM Hydrogen Vehicle Announcements in the Mobility Sector

Company	Sub-Sector	Type	Hydrogen Potential
Toyota	On-Road HDV	OEM	Toyota and Kenworth successfully complete ZANZEFF Project demonstrating the operation of their Toyota-Kenworth T680 FCEV truck at the Port of Los Angeles.[89]
Hyundai	On-Road	OEM	Hyundai's XCIENT fuel cell truck makes its commercial debut in the U.S. in the summer of 2023, with a range of 450 miles when fully loaded.[90]
Cummins Scania	On-Road	OEM	Cummins provides PEM fuel cell systems to Scania to develop 20 FCEVs in 2024.[91]
Nikola Corporation	On-Road	OEM	Nikola CEO states that their gamma hydrogen fuel cell electric trucks are achieving more than 900 miles of range in a day.[92]
Hyzon	On-Road	OEM	Hyzon manufactures commercial hydrogen-powered fuel-cell vehicles for customers globally. The heavy-duty trucks they have on the road today are the HYHD8-200, they Hymax series, the Refuse, and the HYHD8-110.[93]
Daimler Truck	On-Road	OEM	In 2020, Daimler Truck present the Mercedes-Benz GenH2 Truck powered by a hydrogen fuel cell. On September 26, 2023, the prototype heavy-duty GenH2 Truck covered 1,047 km of distance on one fill of liquid hydrogen.[94]
John Deere	Off-Road	OEM	John Deere presented plans in 2021 to the DOE for hydrogen fueled farming equipment.[95]
CNHi	Off-Road	OEM	CNHi presented plans in 2021 to the DOE for hydrogen fueled farming equipment.[96]
John Deere	Off-Road	OEM	AGCO presented plans in 2021 to the DOE for hydrogen fueled farming equipment.[97]
Komatsu	Off-Road	OEM	Komatsu presented plans in 2021 to the DOE for hydrogen fueled construction and mining equipment.[98], [99]
Toyota	Off-Road	OEM	Toyota offers hydrogen fuel cell forklifts.[100]

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89 https://pressroom.toyota.com/toyota-kenworth-prove-fuel-cell-electric-truck-capabilities-with-successful-completion-of-truck-operations-for-zanzeff-project/

90 https://www.ccjdigital.com/alternative-power/hydrogen-fuel-cell/video/15543046/hyundais-xcient-fuel-cell-truck-makes-its-commercial-debut

91 https://www.cummins.com/news/2022/04/28/cummins-fuel-cells-power-scanias-fuel-cell-electric-trucks

92 https://www.sec.gov/Archives/edgar/data/1731289/000173128923000252/exhibit991firesidechat91323.htm

93 https://www.hyzonmotors.com/vehicles

94 https://media.daimlertruck.com/go/HydrogenRecordRun

95 https://www.energy.gov/sites/default/files/2021-12/922-10-mission-innovation-JD.pdf

96 https://www.energy.gov/sites/default/files/2021-12/922-11-mission-innovation-CNH.pdf

97 https://www.energy.gov/sites/default/files/2021-12/922-12-mission-innovation-AGCO.pdf

98 https://www.energy.gov/sites/default/files/2021-12/923-2-mission-innovation-komatsu.pdf

99 https://www.energy.gov/sites/default/files/2021-12/923-4-mission-innovation-komatsu.pdf

100 https://www.toyotaforklift.com/resource-library/blog/energy-solutions/hydrogen-fuel-cell-forklifts-an-alternative-energy-solution

Hyster	Off-Road	OEM	Hyster offers hydrogen fuel cell forklifts.[101]
STILL	Off-Road	OEM	STILL offers a portfolio of trucks with hydrogen fuel cell systems, such as to tractors, high lift pallet trucks, reach trucks and counterbalanced forklift trucks.[102]
Linde	Off-Road	OEM	Linde offers hydrogen fuel cell forklifts.[103]
First Mode	Off-Road	OEM	In May of 2022, First Mode debuted it's proof-of-concept and the world's first and largest hydrogen-fueled mining haul truck. In 2023, the hydrogen-fueled haul truck successfully completed one full year of operational trials.
Stadler	Rail	OEM	In 2023, Stadler delivered the first hydrogen powered train for American transport—the FLIRT H2. The train is equipped with a power pack that uses modular fuel cells and batteries
Airbus	Aviation	OEM	Airbus in 2020 announced ZEROe, their plan to produce hydrogen combustion and fuel cell commercial aircraft by 2035.[104]

Table 43: Select Public Hydrogen Pilot Project / Demonstration Announcements in the Mobility Sector

Company	Sub-Sector	Type	Hydrogen Potential
AJR Trucking[105]	On-Road	Hydrogen Pilot Project / Demonstration	AJR Trucking, a leading carrier for the US Postal Service, announced the execution of a purchase order of 50 Nikola Tre trucks in May 2023.
Sunline Transit.[106]	On-Road	Hydrogen Pilot Project / Demonstration	Sunline transit operate multiple fuel cell buses, the Flyer XHE40, in its fleet and has dedicated fueling stations to refuel each
Foothill Transit[107]	On-Road	Hydrogen Pilot Project / Demonstration	Foothill Transit operates 33 hydrogen fuel cell buses, the Xcelsior CHARGE H2, and has 19 more on order.
AC Transit[108]	On-Road	Hydrogen Pilot Project / Demonstration	AC Transit operates 36 hydrogen fuel cell buses in its fleet.
Orange County Transit Authority (OCTA)[109]	On-Road	Hydrogen Pilot Project / Demonstration	OCTA operates 10 hydrogen fuel cell buses in its fleet.
Switch Maritime[110]	Commercial Harbor Craft	Hydrogen Pilot Project / Demonstration	The first hydrogen fuel-cell powered 75-passenger commercial ferry is piloted to serve ports in the San Francisco Bay area starting in spring 2023.
ZeroAvia[111]	Aircraft	Hydrogen Pilot Project / Demonstration	ZeroAvia has partnered with Alaska Airlines and in mid-2023 flew a converted Bombardier Q400 aircraft powered by hydrogen fuel cells.
Universal Hydrogen[112]	Aircraft	Hydrogen Pilot Project / Demonstration	Universal Hydrogen in early 2023 flew a converted De Havilland Canada Dash 8 aircraft powered by hydrogen fuel cells.

[101] https://www.hyster.com/en-us/north-america/technology/power-sources/hydrogen-fuel-cells/
[102] https://www.still.co.uk/solution-competence/energy-systems/fuel-cell-technology.html
[103] https://www.linde-mh.com/en/About-us/Innovations-from-Linde/Fuel-Cells.html
[104] Airbus. "ZEROe". (2023) https://www.airbus.com/en/innovation/low-carbon-aviation/hydrogen/zeroe
[105] https://www.ajrtrucking.com/blog/ajr-trucking-announces-order-for-50-nikola-tre-fcevs/#:~:text=COMPTON%2C%20CA%20%E2%80%93%20May%201%2C,FCEV%E2%80%9D)%20trucks%20from%20Tom's%20Truck
[106] https://ww2.arb.ca.gov/lcti-sunline-fuel-cell-buses-hydrogen-onsite-generation-refueling-station-pilot-commercial
[107] https://www.foothilltransit.org/greeningbig
[108] https://www.actransit.org/zeb
[109] https://www.octa.net/about/about-octa/environmental-sustainability/fuel-cell/
[110] https://ww2.arb.ca.gov/lcti-zero-emission-hydrogen-ferry-demonstration-project
[111] ZeroAvia. (2023). https://zeroavia.com/
[112] Universal Aviation. (2023). https://www.universalaviation.aero/

Santa Cruz Hydrogen Fuel Cell (HFC) [113]	Rail	Hydrogen Pilot Project / Demonstration	In Northern California, the Santa Cruz Hydrogen Fuel Cell (HFC) Streetcar project, launched in 2021, represents a pioneering move towards Electric Passenger Rail in the coastal rail corridor.
GTI and Sierra Northern[114]	Rail	Hydrogen Pilot Project / Demonstration	The California Energy Commission awarded GTI and Sierra Northern $4 million to fund the design, integration, and demonstration of a hydrogen fuel cell switching locomotive to support the (H2RAM) initiative.
California Energy Commission (CEC)[115]	On-Road	Hydrogen Pilot Project / Demonstration	The CEC is investing in a network of 100 public hydrogen fueling stations across California, through $27 million of grant funding as part of the Clean Transportation Program.
FirstElement Fuel, Inc.[116]	On-Road	Hydrogen Pilot Project / Demonstration	FirstElement Fuel partners with Hyundai Motor on hydrogen refueling of class 8 fuel cell electric trucks.
Iwatani, Chevron[117]	On-Road	H2 Infrastructure Deployment	Co-developing and operating 30 hydrogen fueling sites in California by 2026, located at existing Chevron-branded retail locations.
Santa Cruz Metropolitan Transport[118]	On-Road	H2 Pilot Project / Demonstration	Santa Cruz Metropolitan Transport District procuring 57 hydrogen-powered, fuel cell buses.

Power

Table 44: Select Public Hydrogen Pilot Project / Demonstration Announcements in the Power Sector

Companies Involved / Project Name	Type	Hydrogen Potential
LADWP Scattergood Repowering Project[119]	Hydrogen turbine upgrade	LADWP is repowering their Scattergood plant with turbines capable of burning significant quantities of hydrogen, with ~400MW of H2 capacity buildout at Scattergood by 2038 • **400MW** Net generation output by 2038
Intermountain Power Project[120]	Hydrogen turbine upgrade	Project is retiring the existing coal-fueled units at the Utah IPP site, installing new natural gas-fueled electricity generating units capable of utilizing hydrogen. • **840MW** Net generation output

113 Memorandum of Understanding between BNSF, Progress Rail, and Chevron
114 https://www.gti.energy/california-energy-commission-awards-funding-to-demonstrate-hydrogen-locomotive-for-rail-applications-in-california/
115 https://www.energy.ca.gov/programs-and-topics/programs/clean-transportation-program
116 https://www.prnewswire.com/news-releases/firstelement-fuel-partners-with-hyundai-motor-on-hydrogen-refueling-of-class-8-fuel-cell-electric-trucks-driving-over-25k-miles-with-zero-emissions-301770655.html
117 https://www.chevron.com/newsroom/2022/q1/chevron-iwatani-announce-agreement-to-build-30-hydrogen-fueling-stations-in-california
118 https://scmtd.com/images/department//ceo/METRO_HydrogenBusPurchase_Release092223FINAL.pdf
119 Los Angeles moves forward with $800m plan to convert 830MW gas-fired power plant to run on green hydrogen | Hydrogen news and intelligence (hydrogeninsight.com)
120 https://www.ipautah.com/ipp-renewed/

PG&E Lodi Hydrogen Power Plant[121]	Hydrogen turbine upgrade	PG&E has successfully installed a Siemens turbine at the Lodi Energy Center that can blend 45% hydrogen with natural gas, greatly reducing emissions. • **225MW** Net generation output as of 2022
Constellation Hillabee Generating Station[122]	Hydrogen blending	Constellation will significantly lower greenhouse gas emissions by blending high concentrations of hydrogen with natural gas, reaching 38% without major modifications to the plant. • **753MW** Net generation output as of 2023
NextEra Energy Blueprint for Real Zero Proposal[123]	Hydrogen turbine upgrade	NextEra Energy envisions converting all of its Florida natural gas firing facilities to hydrogen. Collectively these plants will produce 16GW from green hydrogen. • **16GW** Net generation output by 2040
Equinor & RWE Low Carbon Energy Hub[124]	Hydrogen turbine upgrade & hydrogen pipeline	RWE and Equinor are building gas turbines in Germany served by a hydrogen pipeline between Germany and Norway, moving ~4M tonnes hydrogen/year with a target of 2030 for pipeline construction. • **3GW** H2 power plant capacity, with a pipeline equivalent capacity of 18GW
Siemens[125]	OEM Hydrogen Capability Upgrades	• In 2019, Siemens Gas and Power announced a roadmap to ramp up the hydrogen capability in its gas turbine models to at least 20% by 2020, and 100% by 2030. • Siemens has demonstrated over 38% by volume hydrogen on a G class machine.
General Electric[126]	OEM Hydrogen Capability Upgrades	• GE is aiming to develop a 100% hydrogen turbine by 2030. • GE was awarded $6.6M from DOE to test retrofitting F-class turbines with hydrogen blends. • GE turbines have logged more than 8 million operating hours using blends of hydrogen by over 100 customers in 20 countries. • It is operating a demonstration project to temporarily replace natural gas with a green hydrogen / natural gas blend in NY. • GE has ongoing programs to develop 100% hydrogen capable turbines on E, F and H class turbines

121 Lodi to be base for hydrogen pilot program providing power to NorCal | News | lodinews.com
122 Constellation sets hydrogen-gas plant blending record, but more advances needed for utility-scale use: experts | Utility Dive
123 NextEra Energy | Real Zero
124 Equinor and RWE cooperating on energy security and the energy transition - Equinor
125 Siemens' Roadmap to 100% Hydrogen Gas Turbines (powermag.com)
126 Hydrogen-Fueled Gas Turbines | GE Gas Power

Mitsubishi[127]	OEM Hydrogen Capability Upgrades	• In 2018, Mitsubishi developed a gas turbine that runs on 30% hydrogen and 70% natural gas. Its goal is to develop a turbine that is 100% powered by hydrogen by 2025. • Mitsubishi has demonstrated over 20% by volume hydrogen on a G class machine.

Industrials

Table 45: Select Public Hydrogen Pilot Project / Demonstration Announcements in the Industrials Sector

Companies Involved	Sub-Sector	Hydrogen Potential
AMF Den Boer	Food & Beverage	The Multibake® VITA Tunnel Oven is a direct-fired oven with patent-pending hydrogen-fueled burners that use green energy or hydrogen as its renewable resource.
Mountaintop Beverage West Virginia University (WVU)	Food & Beverage	WVU is developing a hydrogen flexible boiler with DOE grant funding. Mountaintop Beverage will provide access to its facility for sampling data, quality analyses, and to provide industry input.
FLSmidth	Cement	Offers green hydrogen burner kiln for mineral processing that enables up to 100% hydrogen burning, and pilot plant for potential clients to test whether/how to operate with hydrogen.
Cemex	Cement	CEMEX will implement hydrogen injection technology at four of its cement plants in Mexico as part of its Future in Action program.
Cemex, Sandia Labs, and Synhelion	Cement	Field demonstration of fuels production using green H2, CO2 from cement, and high temperature process heat from the sun.
Linde Gas AB and its partner, Ovako	Metals	Steel was heated in pit furnace using 100% hydrogen instead of LPG (liquefied petroleum gas) before rolling; deemed equivalent in character.
Tenova and Tenaris	Metals	A 200-kW burner optimized for high efficiency in steel reheating furnaces; runs with minimum NOx.
Linden Cogeneration and Phillips 66	Industrial Cogeneration	Linden Cogeneration is utilizing Phillips 66 produced refinery off gas containing blending it with natural gas in its cogeneration plant in Linden, New Jersey

[127] Hydrogen-Fueled Gas Turbines | GE Gas Power (mhi.com)

Angeles Link | Water Resources Evaluation

Preliminary Findings: (1) Water Availability Study; and (2) Water Quality Requirements

PRELIMINARY DRAFT

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1. Executive Summary

The California Public Utilities Commission's Decision (D.22-12-055) from December 15, 2022, approving the Memorandum Account for Southern California Gas Company's (SoCalGas) proposed Angeles Link project (Angeles Link) requires SoCalGas to identify the potential sources of hydrogen generation and water and estimate the costs of the hydrogen. (Decision, OP (6)(b).) Pursuant to that requirement, a Water Resources Evaluation is being prepared as part of the Angeles Link Phase One feasibility investigation to identify and characterize potential water supply sources that could support future third-party production of the clean renewable hydrogen that Angeles Link could convey to Central and Southern California including the LA Basin (inclusive of the Ports of Los Angeles and Long Beach).

The purpose of this document is to provide a summary of the preliminary findings of two tasks of the Water Resources Evaluation: (1) the Water Availability Study, which includes a summary of agency outreach efforts; and (2) analysis of water quality requirements for clean renewable hydrogen production. For those two tasks, this preliminary findings document provides an overview of the scope of work (Section 2, *Scope of Work*), the technical approach implemented (Section 3, *Technical Approach*), and the assumptions and preliminary findings of the analysis (Section 4, *Assumptions and Preliminary Findings*). Analysis of other tasks in the Water Resources Evaluation, including the estimated costs for third-party producers to acquire and treat potential water supply sources is ongoing. Preliminary findings for that analysis will be provided at a future date.

Separate from the Water Resources Evaluation, a Demand Study was also prepared as part of the Angeles Link Phase One analyses to define a range of potential scenarios of demand for clean renewable hydrogen that could occur across SoCalGas's service territory by 2045; Angeles Link would serve a portion of this total demand. The Demand Study identified a low or conservative demand scenario of 1.9 million metric tons per year (MMT/Year), which would need approximately 21,311 acre-feet per year (AFY) of water to produce, and a high or ambitious scenario of 5.9 MMT/Year, which would need approximately 66,175 AFY of water to produce.

The Angeles Link system is proposed to transport a portion of that overall production of clean renewable hydrogen, with a proposed low scenario throughput of approximately 0.5 MMT/Year to a high scenario throughput of up to 1.5 MMT/year. Third-party producers would need approximately 5,608 AFY of water to produce the portion of clean renewable hydrogen to meet the low scenario and approximately 16,824 AFY of water to produce the volume to meet the high scenario.

As SoCalGas would not produce clean renewable hydrogen as part of the Angeles Link project, third-party producers will have the responsibility to secure sufficient water supplies for future clean renewable hydrogen production. To inform the potential sources of clean renewable hydrogen generation, the first two tasks of the Water Resources Evaluation, which is yet to be finalized, reached the following preliminary findings:

Water Availability Study

- The volume of water needed for third-party clean renewable hydrogen producers to produce the quantity of clean hydrogen to meet the projected demand across SoCalGas's service territory by 2045 comprises a small percentage of the total amount of water used in California each year.

- The volume of water needed for third-party producers to produce the quantity of clean renewable hydrogen to meet the portion of the projected demand that Angeles Link would transport comprises less than one percent (0.01 -0.03%) of the total amount of water used per year in California.
- Third-party clean renewable hydrogen producers may draw from a menu of water supply sources to meet the water needs to produce the clean renewable hydrogen to meet the overall service territory projected demand and the portion of that demand that would be transported by Angeles Link.
- The water supply sources identified in the Water Availability Study may be considered by third-party clean renewable hydrogen producers to pursue quantities that are sufficient to meet the water needs to produce the clean renewable hydrogen to meet the overall service territory projected demand and the portion of that demand that would be transported by Angeles Link.
- A substantial portion of water demands for clean renewable hydrogen production may be met using existing water supply sources and mechanisms of acquisition. New supply sources may also be developed to support clean renewable hydrogen production projects.
- Shifting water demands and obligations may change over time as water uses in the state evolve, which may present opportunities for new water supply development. These shifts will be documented in water supply providers' UWMP updates, which occur every five years and include water demand and supply availability projections over a 20-year planning horizon.
- The menu of water sources that feed specific clean renewable production projects can be further evaluated and developed on a case-by-case basis as more details as specific clean renewable hydrogen production projects are developed.

Water Quality Requirements

- A review of existing electrolyzer technologies shows that third-party clean renewable hydrogen producers will likely need water that is of "ultrapure" water quality to feed into the electrolyzers.
- Ultrapure water can be obtained through advanced water treatment processes, such as double-pass reverse osmosis (RO) followed by electrodeionization (EDI) as the polishing step.

2. Scope of Work and Technical Approach

The scope of work for the Water Resources Evaluation consisted of a series of tasks to address specific issues associated with water supply and clean renewable hydrogen production, including a Water Availability Study and analysis of water quality requirements for clean renewable hydrogen production. The overall scope of work was informed by and built off pre-feasibility studies and specifically the 2021 SPEC Services water study. The scope of work for certain tasks under the Water Resources Evaluation then expanded on the scope of the 2021 SPEC Services water study as discussed below.

2.2 Water Availability Study

A Water Availability Study was prepared under the Water Resources Evaluation to identify and characterize potential water supply sources to support future third-party production of clean renewable hydrogen that Angeles Link would convey. The Water Availability Study provides a thorough characterization of existing water supply management in Southern California, with descriptions of existing water supply sources, water supply development projects, and water demands in key sectors including urban (municipal and industrial), agricultural, and environmental uses. The scope of work conducted for the Water Availability Study sought to provide a "menu" of potential water supply sources for third-party clean renewable hydrogen producers to pursue.

Applicable state-required land use and water supply planning documents were collected and reviewed, including: Urban Water Management Plans (UWMPs) which are required of supply providers with 3,000 or more service connections or delivering 3,000 AFY or more of water; Groundwater Sustainability Plans (GSPs) addressing individual groundwater basins for compliance with the Sustainable Groundwater Management Act (SGMA); and the California Water Plan maintained by the California Department of Water Resources (DWR) to plan for and provide for the sustainable management of water resources throughout the state.

Outreach with select water agencies was also conducted to inform the analysis of future potential water supply sources that third-party clean renewable hydrogen producers could pursue. This effort was an expansion upon the 2021 SPEC Services water study mentioned above, which did not involve direct inquiries to public agencies or water providers.

The scope of work for agency outreach involved identifying agencies based upon ownership and operation of existing water supply projects and infrastructure, as well as size and location. Virtual meetings were conducted with select agencies and included discussion of the respective agencies' water supply sources, programs, and facilities, as well as potential opportunities for the development of water supply for clean renewable hydrogen production through partnership with future hydrogen producers. Notably, the Metropolitan Water District of Southern California ("Metropolitan"), which serves 26 member agencies, including cities, municipal water districts, and one county water authority, and delivers supplies to 19 million people throughout Los Angeles, Orange, Riverside, San Bernardino, San Diego and Ventura counties, indicated a willingness to willing to work on water exchanges involving the Colorado River or the State Water Project in the future for clean renewable hydrogen production projects. The agency outreach informed consideration of alternative means of developing potential water supply sources for clean renewable hydrogen production, particularly through the treatment of flows that are currently managed as waste streams.

The Water Availability Study also provided an overview of mechanisms to acquire or develop water supply that future clean renewable hydrogen producers could pursue to secure sufficient water supply for their respective projects.

2.3 Water Quality Requirements

An analysis of water quality requirements for clean renewable hydrogen production was conducted to inform characterization of the size and types of treatment infrastructure and processes associated with development of clean renewable hydrogen. The scope of work for assessment of water quality included collecting water quality specifications for the electrolyzers that would be used to generate clean renewable hydrogen and conducting a desktop review to evaluate the efficiency of these systems. Pretreatment requirements for potential water supply sources were assessed, including consideration of electrolyzer efficiencies and cost implications. Water quality requirements were established based on electrolyzer type (e.g., alkaline, polymer electrolyte membrane or solid oxide).

3. Assumptions and Preliminary Findings

This section provides an overview of the assumptions used to inform development and execution of the Water Availability Study and analysis of water quality requirements, as well as preliminary results of the overall scope of work. Table 1, below, presents key assumptions that were used to shape and implement the scopes of work for those tasks of the Water Resources Evaluation.

Table 1 Key Assumptions Informing the Water Availability Study and Analysis of Water Quality Requirements

Study Area	The Study Area for the Water Availability Study is generally defined as the extent of SoCalGas's service territory. Select water resources located outside SoCalGas's service territory were also included based upon resource-specific features and consideration of their potential to contribute to water supply availability for clean renewable hydrogen development. The select resources located outside of SoCalGas's service territory are: ▪ Existing wastewater treatment facilities in the San Joaquin Valley are considered for the potential for treated effluent to be acquired as a supply source. ▪ The Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) program in the San Joaquin Valley, considered as relevant to brackish groundwater. ▪ Treated effluent from San Diego County, considered as a potential supply source depending upon acquisition through an exchange agreement.
Identification of Supply Source Types	▪ Potential supply source types were not eliminated based upon cost, quality, or complexity. Source types are identified based upon location and potential availability. ▪ Potential supply sources were not eliminated based upon water quality or feasibility of acquisition or development. ▪ To avoid interference with current and planned water reuse projects, potential supply sources that are currently reused or planned for reuse based on information in 2020 UWMPs are considered unavailable to future clean hydrogen development at this time.
Supply Acquisition Responsibility	▪ Third-party clean renewable hydrogen producers will identify and develop or acquire water supply in sufficient quantities to meet the water demands of their respective projects. ▪ The "menu" of water supply source types developed as guidance for clean renewable hydrogen producers may not be exhaustive, as additional supply sources may become available due to land use transitions and regulatory requirements. ▪ Clean renewable hydrogen producers may identify and develop or acquire additional water source types in the future, as available.
Source Water Quality and Treatment Requirements	▪ Water sources need treatment to a certain quality before being fed to electrolyzers. Treatment of source water to ultrapure water requires pretreatment and polishing. ▪ Pretreatment removes the bulk of solids, salts, organics, and microorganisms. ▪ Polishing to ultrapure water involves removing impurities including conductivity (ion contents), hardness, total organic carbon, and silica.
Water Demands for Hydrogen Generation	▪ Future clean renewable hydrogen production projects that would utilize Angeles Link have not yet been developed; therefore, water demands of individual projects were not characterized. ▪ As future clean renewable hydrogen projects are proposed via applications submitted to the respective agencies, associated water demands will be incorporated into the applicable water supply planning and management documents, including through coordination between future producers and water managers. ▪ Water demands for clean renewable hydrogen production within SoCalGas' service territory generally, as well as a water demand for Angeles Link specifically, were estimated based on average estimates analyzing potential supply sources of various water qualities.

Table 2, below, identifies key preliminary findings from the Water Availability Study and analysis of water quality requirements.

Table 2 Preliminary Findings of the Water Resources Evaluation

Agency Outreach	Through the agency outreach effort summarized in Section 2.1, input received from the Metropolitan, indicated: ▪ Metropolitan has historically been open to collaboration and negotiations with other water agencies and stakeholders within California to manage water resources effectively. ▪ Out-of-region water exchanges can involve Metropolitan obtaining water from sources outside of its immediate service area in California. The specifics of these exchanges can vary depending on the agreements and arrangements in place at any given time. ▪ Metropolitan is willing to work on exchanges on the Colorado River and the State Water Project. In an exchange, the party seeking water pays into or directly produces new supplies of water that directly benefit Metropolitan's service area, and then exchanges these newly developed supplies for out-of-region imported water supplies. ▪ Potential exchanges are difficult to quantify at this time and must be evaluated on a case-by-case basis for their benefit to the Southern California region's well-being and water supply security.
Potential Water Supply Sources	The Water Availability Study produced a menu of ten potential water supply sources determined to be feasible for future acquisition or development by third-party clean renewable hydrogen producers to support their respective projects. An overview of this menu is provided below. ▪ **Imported surface** from the State Water Project (SWP) system, Colorado River water, and Central Valley Project (CVP) may be purchased from a contractor to the respective project from within the contractor's existing allocations. ▪ **Treated wastewater** is highly treated and disinfected at wastewater treatment facilities where it is available for purchase if not already planned for beneficial reuse; this water would be purchased from the treatment provider. ▪ **Groundwater** sustainably managed by local agencies under the Sustainable Groundwater Management Act (SGMA) or by court-ordered Adjudication Judgement may be available in DWR-designated Low Priority basins, adjudicated areas, or groundwater storage banks. ▪ **Agricultural industry water** includes agricultural field drainage, surface water runoff, subsurface drainage, and used wash water that may be captured or diverted for treatment and reuse. ▪ **Brine line flows** are highly concentrated with salts and other contaminants that could be diverted at the point of origin, or from the brine line directly, for further treatment and reuse. ▪ **Advanced water treatment concentrate** is wastewater from treatment processes that may be diverted at the point of origin for further treatment and reuse. ▪ **Oil and gas (O&G) industry water** includes refinery offset water from reduced or halted refinery operations and produced water that may be treated for reuse. ▪ **Inland brackish groundwater** arises from natural and manmade sources and may be extracted for treatment and reuse. ▪ **Dry weather flows** are on-precipitation flows accumulating in municipal storm sewer systems during dry weather conditions that may be collected and treated for reuse. ▪ **Urban stormwater capture and reuse** refers to stormwater runoff that is captured for storage, treatment, and reuse before reaching discharge outlets during precipitation events. The menu of water sources that feed specific clean renewable production projects can be further evaluated and developed on a case-by-case basis as more details on specific clean renewable hydrogen production projects are developed.

Mechanisms of Acquisition	Existing mechanisms that may be used to acquire water supply for clean renewable hydrogen production include: ▪ **Exchange agreements** developed between future clean renewable hydrogen producers and water agencies with sufficient surplus supply or supply development potential; ▪ **Local water agencies** with supply available for purchase or that may partner with future producers to develop a supply source for mutual benefit; ▪ **Water markets** including around adjudicated groundwater resources and surplus surface flows; ▪ **Land purchase with water rights**, given the sufficient physical availability of water. Clean renewable hydrogen producers may utilize other mechanisms of acquisition, as they become available in the future.
Water Demands for Hydrogen Generation	▪ A substantial portion of water demands for clean renewable hydrogen production may be met using existing water supply sources and mechanisms of acquisition. ▪ The volume of water needed for third-party clean renewable hydrogen producers to produce the quantity of clean hydrogen to meet the projected demand across SoCalGas's service territory by 2045 comprises a small percentage of the total amount of water used in California each year. ▪ The volume of water needed for third-party producers to produce the quantity of clean renewable hydrogen to meet the portion of the projected demand that Angeles Link would transport also comprises a small percentage (0.01-0.03%) of the total amount of water used in the state. ▪ Third-party clean renewable hydrogen producers may draw from a menu of water supply sources to meet the water needs to produce clean renewable hydrogen for the overall service territory projected demand and the portion of that demand that would be transported by Angeles Link. ▪ Water demands will be refined in the future, as clean renewable hydrogen projects are developed, and applications are submitted to the appropriate agencies.
Water Quality Requirements	▪ The water quality required for hydrogen production depends on the type of electrolyzers technology employed. The two main electrolyzer technologies, PEM and alkaline electrolyzers, require ultrapure water, which can be obtained by advanced water treatment processes, such as double-pass reverse osmosis (RO) followed by electrodeionization (EDI) as the polishing step. ▪ For every 36.030 g of water that is electrolyzed, 4.032 g of hydrogen and 31.998 g of oxygen are produced; i.e., for every 1 kg of H_2 produced, 9 kg of H_20 is required from a stoichiometric point of view. One kilogram of water is equivalent to one liter of water, so 9 liters (2.378 gallons) of water is needed to produce 1 kg of hydrogen. ▪ Water quality polishing systems require total dissolved solids (TDS) concentration of less than 350 mg/L and total organic compounds (TOC) concentration of less than 5 mg/L. The potential supply sources identified in the Water Availability Study exceed such limits, with the exception of surface water sources; therefore, pretreatment by RO would be required, and should be accounted for in the infrastructure and cost requirements of future clean renewable hydrogen projects.

Angeles Link | Greenhouse Gas Emissions Preliminary Data and Findings

February 2024

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1 EXECUTIVE SUMMARY

SoCalGas is proposing to develop a clean renewable hydrogen transport system to serve end users in the Central and Southern California area including the LA Basin (inclusive of the Ports of Los Angeles and Long Beach) (Angeles Link or Project). On December 20, 2022, the California Public Utilities Commission (CPUC) issued the "Decision Approving the Angeles Link Memorandum Account to Record Phase One Costs" to track costs for advancing the first studies under Phase One of the Angeles Link Project. In the Decision, clean renewable hydrogen refers to hydrogen that does not exceed 4 kilograms of carbon dioxide equivalent (CO2e) produced on a lifecycle basis per kilogram of hydrogen produced and does not use fossil fuel in the hydrogen production process where fossil fuel is defined as a mixture of hydrocarbons including coal, petroleum, or natural gas, occurring in and extracted from underground deposits.[1]

This greenhouse gas (GHG) study (GHG Study or Study) is one of sixteen studies established to answer questions raised by the CPUC and other parties to the proceeding. The Decision directs (OP 6 (n)) SoCalGas to provide the findings from Phase One feasibility studies demonstrating compliance with environmental laws and public policies. To support environmental laws and public policies, this Study is an initial evaluation of projected greenhouse gas (GHG) emissions associated with Angeles Link, including emissions and reductions attributable to third-party production and storage and end users.

This GHG Study evaluates two types of GHG emissions: direct from hydrogen combustion and indirect from non-renewable electricity and estimates potential GHG emissions associated with new infrastructure (i.e., production[2], storage, and transportation of hydrogen), as well as GHG emissions reductions associated with end users in the mobility, power generation, and hard-to-electrify industrial sectors. The GHG emissions associated with water conveyance for production of hydrogen were not included in the scope of this Study. Projected quantities of displacement of diesel and gasoline by hydrogen fuel cells in the mobility sector; and anticipated replacement of natural gas with hydrogen in the power generation and hard-to-electrify industrial sectors were based on estimated demand values provided by the parallel Demand Study.

The Demand Study, which was relied upon when estimating initial projected GHG emissions, projected economy wide demand in the Central and Southern California areas using three scenarios: low demand, moderate demand, and high demand. These are referred to as conservative, moderate, and ambitious demand, respectively, in the Demand Study (Demand Study Scenarios). In comparison to the Demand Study values noted above, the projected throughput of Angeles Link is estimated to range from 0.5 to 1.5 million metric tonnes per year

[1] California Public Utility Commission Decision Approving Angeles Link Memorandum Account to Record Phase One Costs, December 20, 2022 500167327.PDF (ca.gov)

[2] Production is anticipated to be conducted by a third party.

(MMT/yr.). The three throughput scenarios for the Angeles Link buildout (0.5 MMT/yr, 1.0 MMT/yr., and 1.5 MMT/yr.) align with the low, moderate, and high Demand Scenarios (1.9 MMT/yr., 3.2 MMT/yr., and 5.9 MMT/yr.)

To estimate potential GHG emissions associated with the Project, including those from third-party production and storage and end users, GHG estimates were calculated from initial estimates of the Demand Study. Then the ratio of anticipated hydrogen throughput values for Angeles Link to the projected values in the Demand Study were calculated for each of the conservative (26.85%), moderate (31.12%), and ambitious (25.36%) scenarios. The ratios were applied to the GHG estimated emissions using the Demand Study Scenarios to estimate potential GHG emission reductions associated with Angeles Link Throughput Scenarios. This analysis is shown in Table 1 below. Additionally, GHG emissions minimization opportunities are identified to potentially further reduce such emissions.

Table 1
GHG Reduction Estimates for Demand Study Scenarios Applied to Projected Angeles Link Throughput Scenarios

Demand Scenario	Total Projected Hydrogen Demand (MMT/yr)	Overall GHG Reductions for Demand in 2045 (MMT/yr)	Angeles Link Projected Hydrogen (MMT/yr)	Overall GHG Reductions for Angeles Link in 2045 (MMT/yr)
Low	1.9	16.7	0.5	4.5
Moderate	3.2	24.9	1	7.8
High	5.9	35.7	1.5	9.0

Preliminary key findings for GHG emission reductions based on the Demand Study Scenarios are as follows and are discussed further herein.

- Projected up to nearly 17 and 36 million metric tons of CO2e per year removed from SoCalGas geographic territory by end users by 2045 in low and high demand scenarios of the Demand Study, respectively. (“Low Demand Scenario” and “High Demand Scenario”).
- Mobility GHG emissions are projected to be eliminated with conversion to hydrogen fuel cells.
- Mobility sector comprises 72.5% and 50.3% of overall GHG reductions based on the Low and High Demand Scenarios, respectively. The GHG reductions estimated for the Low and

High Demand Scenarios in 2045 are equivalent to removing approximately 2.7 million and 4 million gasoline passenger vehicles off the roads per year, respectively.[3]

- Power generation and hard to electrify industrial sector GHG emissions are projected to be almost entirely eliminated when fossil fuels are replaced by hydrogen for combustion.
  - Power generation and hard to electrify industrial sectors comprise 41.7% and 8.1% of the overall GHG reductions, respectively, based on the High Demand Scenario.
  - Power generation and hard to electrify industrial sectors comprise 23.6% and 3.9% of overall GHG reductions, respectively, based on the Low Demand Scenario.
  - Infrastructure GHG emissions are projected to be negligible when compared to overall emission reductions at 0.16% and 0.24% of end-user reductions for Low and High Demand Scenarios, respectively.

Preliminary key findings for GHG emission reductions for Angeles Link Throughput Scenarios, which accounts for emissions from not just transmission of hydrogen, but also from third-party production and storage as well as end users, are as follows and are discussed further herein.

- Projected about 4.5 and 9 MMT of CO2e per year removed from SoCalGas's geographic territory by end users by 2045 in Angeles Link Low and High Throughput Scenarios, respectively.
- Mobility GHG emissions (e.g., heavy duty transportation) are projected to be eliminated with conversion to hydrogen fuel cells such as in heavy-duty long-haul vehicles.
  - Mobility sector comprises 72.5% and 50.3% of overall GHG reductions based on the Angeles Link Low and High Throughput value scenarios, respectively. The GHG reductions estimated for the Low and High Throughput Scenarios in 2045 are equivalent to 725,000 and more than 1 million gasoline passenger vehicles driven for one year, respectively. [4]
- Power generation and hard to electrify industrial sector GHG emissions are projected to be almost entirely eliminated when fossil fuels are replaced by hydrogen combustion.
  - Power generation and hard to electrify industrial sectors comprise 41.7% and 8.0% of overall GHG emission reductions, respectively, based on the High Throughput Scenario.

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[3] Greenhouse Gas Equivalencies Calculator | US EPA
[4] Greenhouse Gas Equivalencies Calculator | US EPA

- Power generation and hard to electrify industrial sectors comprise 23.6% and 3.9% of overall GHG emission reductions, respectively, based on the Low Throughput Scenario.

- Infrastructure GHG emissions are projected to be negligible when compared to overall emission reductions at 0.20% and 0.26% of end-user reductions for Low and High Throughput Scenarios, respectively.

2 STUDY APPROACH

The Study estimates GHG combustion emissions associated with the anticipated production, storage, and transportation of hydrogen and estimates GHG combustion emission reductions from end users of hydrogen in the mobility, power generation, and hard to electrify industrial sectors. The parallel Phase One Demand Study provided initial details and scenarios that were used to complete this Study. Additional evaluation of GHG emissions for the estimated ranges of Angeles Link throughput of 0.5 to 1.5 MMT per year of hydrogen was also conducted.

Where applicable, the Study relies on specific technical information from regulatory agencies, transportation agencies, and equipment manufacturers. Research conducted by entities such as academic institutions was evaluated to determine the best available methods for quantifying emissions of GHG from the combustion of hydrogen. When specific information was not available, estimates were made based on availability of related data, or assumptions were developed.

For this Study, GHG emissions from combustion of fossil fuels (diesel, gasoline, and natural gas) are comprised of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O); and GHG emissions from combustion of hydrogen include only N2O. As noted above, two types of GHG emissions were assessed in this study: direct from combustion and indirect from non-renewable electricity. Hydrogen itself, which may result in the atmosphere from potential leakage, is not considered a GHG by the California Air Resources Board (CARB), the Environmental Protection Agency (EPA), or the International Panel for Climate Change (IPCC). However, the potential for hydrogen to theoretically impact climate change, as discussed in some of the scientific literature, is presented in this study report. Technical Research

The Study collected, reviewed, and analyzed technical research studies and information related to GHG emissions associated with the combustion of hydrogen. This analysis included:

- Available literature and studies from research-based academic institutions such as the University of California Irvine (UCI) Combustion Laboratory and the Georgia Institute of Technology and private organizations such as the Electric Power Research Institute (EPRI); and technical data or research identified by stakeholders (CBOSG and PAG members).

- Existing, proposed, and potential future regulatory requirements from federal agencies including the United States Environmental Protection Agency (US EPA), the United States Department of Energy (US DOE), state agencies such as the California Air Resources Board (CARB) and the California Energy Commission (CEC), and local agencies including the nine local air districts located within the geographic scope of this study such as South Coast AQMD and San Joaquin Valley Air Pollution Control District (APCD);
- Technological developments and timelines from manufacturers working on hydrogen technology.
- Technical literature and data releases from government agencies and laboratories including the US DOE and the National Renewable Energy Lab (NREL); and
- Potential GHG minimization opportunities from technological advancements.

3 TECHNICAL APPROACH

The following assessment process (Figure 1) was used for the technical approach of this Study. The approach was based on review of technical research studies, research of anticipated technological advancements, stakeholder input and review of expected evolution of regulatory frameworks.

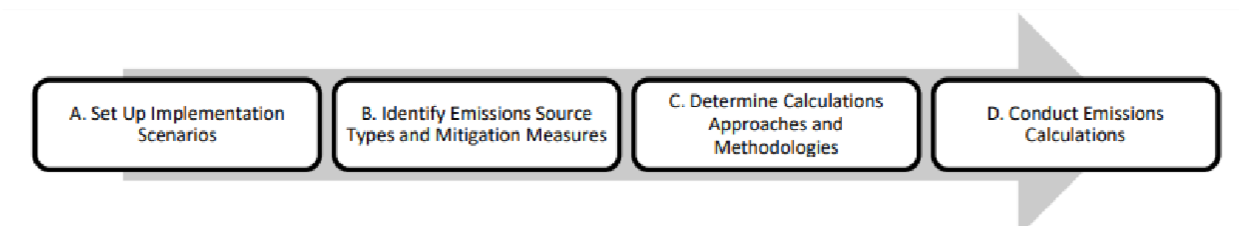

Figure 1. GHG Emissions Assessment Process for GHG Emissions Associated with Angeles Link

3.1 SET UP IMPLEMENTATION SCENARIOS

To evaluate potential GHG emissions and emissions changes associated with Angeles Link, not just from transmission of hydrogen, but also from third party production and storage as well as end users, the timeframe from 2030 to 2045 was used. Consistent with the findings of the Demand Study, end use sectors are anticipated to achieve the ability to accommodate 100% hydrogen fuel use at different times due to availability of technology and feasibility of transitioning existing equipment and building new infrastructure. The use of clean renewable hydrogen as fuel for each end-use sector was evaluated beginning with 2030 based on data from the Demand Study. GHG emissions were calculated using the approaches described in the next steps.

3.2 IDENTIFY EMISSIONS SOURCE TYPES AND MINIMIZATION OPPORTUNITIES

The Study evaluated direct and/or indirect GHG emissions by developing emission calculation approaches and methodologies for the following:

- Infrastructure (Production, Storage, and Transmission) and
- End Users (Mobility, Power Generation, and Hard to Electrify Industrial)

Evaluation of GHG emission minimization opportunities was focused on technologies that minimize combustion temperatures and post-combustion N_2O emission control technology such as catalytic reduction since controlling N_2O is similar to controlling NOx.

The study acknowledges that certain technical literature identified the potential for hydrogen leakage in the production, storage, and transmission of hydrogen. This potential, as well as opportunities to minimize and mitigate the potential for leakage, are discussed in the parallel Phase One Leakage Study Report.

3.2.1 Hydrogen Production

Three potential clean renewable hydrogen production methods were evaluated:

1) Electrolyzers[5] powered by renewable electricity split water molecules into oxygen and hydrogen. This process does not use combustion so there is no potential for GHG emissions from electrolyzers.
2) Biomass gasification[6] is a process that involves heat, steam, and oxygen to convert biomass to hydrogen without combustion. Since this process does not use combustion, there is no potential for GHG emissions from biomass gasification.
3) Renewable natural gas (RNG) fueled steam methane reformers (SMR). Steam methane reforming is a process in which biogas (RNG) reacts with steam in the presence of a catalyst to produce hydrogen and carbon dioxide. This method has GHG emissions, and those potential emissions were evaluated.

3.2.2 Hydrogen *Storage and Transmission*

For the purpose of this Study, hydrogen storage may occur above ground or below ground, and delivered to end users via pipelines. Storage and transmission of hydrogen will require the use of compressors and GHGs from compression are included within the scope of this Study as detailed in Section 6.1.2.

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[5] Hydrogen Production: Electrolysis | Department of Energy

[6] Hydrogen Production: Biomass Gasification | Department of Energy

This Study assumed that compressors will be driven by grid electricity powered electric motors or compressors driven by engines or turbines. It was further assumed that if the compressor drivers are engines or turbines, they will be fueled by 100% clean renewable hydrogen. Additionally, for grid electricity interruptions, hydrogen-fueled back-up electrical generators may also be used, which would likely be driven by internal combustion engines fueled by 100% clean renewable hydrogen.

3.2.3 Hydrogen Industrial End Users

Potential GHG emissions reductions from end users in three key sectors were evaluated: Mobility, Power Generation, and Hard to Electrify Industrial sectors. Information obtained from the parallel Demand Study informed the analysis of end uses in each of these three sectors, as well as their respective subsectors and are noted below:

- Mobility Sector includes heavy-duty trucks, medium-duty vehicles, buses, agriculture, construction & mining, cargo handling equipment, ground support equipment, and commercial harbor craft.
- Turbines are the primary source for potential GHG emissions in power generation.
- Hard to electrify industrial subsectors include energy intensive industries such as refining, food and beverage manufacturing, primary and fabricated metals, stone, glass, and cement, paper, chemical manufacturing, and aerospace & defense.
- Source types with the potential for GHG emissions in the power generation and industrial sectors include hot water boilers, steam generating units, process heaters, furnaces/kilns, internal combustion engines, turbines, and miscellaneous combustion equipment.

3.3 CALCULATION METHODOLOGY

The Study evaluated direct GHG emissions from combustion of fossil fuels and fuel blends based on the type of equipment. Direct GHG emissions comprised of CO_2, CH_4, and N_2O were evaluated for combustion of fossil fuels such as natural gas, diesel, and gasoline. EPA 40 Code of Federal Regulations (CFR) Part 98 "Mandatory Greenhouse Gas Reporting," was selected as the source for fuel based GHG emissions factors for CO_2, CH_4, and N_2O.

A GHG's potential to contribute to the greenhouse effect is referred to as its global warming potential (GWP). Global warming potential is defined by the US EPA as "a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to 1 ton of carbon dioxide (CO_2)."[7] GWPs are developed by scientists within organizations such as the Intergovernmental Panel on Climate Change (IPCC) through thorough review of scientific literature. These GWPs are continually evaluated and updated at intervals based on the most

[7] Understanding Global Warming Potentials | US EPA

recent available data. GWPs are evaluated for various time horizons; typically, over 20, 100, or 500 years. The IPCC Assessment Report 5 (AR5)[8] adopted the GWP for a time horizon of 100 years as a metric from the United Nations Framework Convention on Climate Change (UNFCCC) made operational in the 1997 Kyoto Protocol. AR5 indicates that the uncertainty in GWPs for short-lived gases will be much larger than for gases with lifetimes of a few decades or even a century. The IPCC Report 6 (AR6)[9] report was selected as the source for global warming potentials (GWP) for CO_2, CH_4, and N_2O, as these were the most recently published GWPs.

This Study evaluated whether these GHGs are formed from the combustion of hydrogen. There is agreement within the scientific literature that carbon-based GHG emissions decrease to zero or near zero when combusting 100% hydrogen fuel as there is no carbon in hydrogen.[10] Very small amounts of CO_2 may be emitted due to air having approximately 0.04% (by volume) CO_2.[11] These are not true emissions as CO_2 is already present in the air and not a product of combustion. This CO_2 in the air has the potential to pass through un-combusted and exit through the exhaust stack. Very small amounts of N_2O can potentially form from nitrogen in combustion air. There is no nitrogen in pure hydrogen fuel and the potential for N_2O formation from combustion air is small. [12] Combustion of hydrogen and natural gas blends will result in CO_2, CH_4, and N_2O from the natural gas portion of the blend and potentially very small amounts of N_2O from the hydrogen portion.

For infrastructure, GHG combustion emissions associated with hydrogen production using RNG SMR and engine/turbine compressors fueled by hydrogen were estimated. Information from parallel studies related to design of infrastructure was not available and preliminary assumptions were made to develop GHG combustion emissions estimates. Although there is a potential for leakage associated with infrastructure, detailed project information from parallel studies was not available to develop quantified estimates at the time of this Study.

For end users, based on the emission source type identified, GHG emissions were estimated for combustion of the displaced fossil fuel (diesel, gasoline, natural gas) and for hydrogen combustion, as applicable. Estimating the potential for leakage associated with end users of Angeles Link was not feasible given the high-level assumptions used to develop hydrogen

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[8] AR5 Synthesis Report: Climate Change 2014 — IPCC

[9] IPCC AR6 7SM "The Earth's Energy Budget, Climate Feedbacks and Climate Sensitivity Supplemental Material," Table 7.SM.6 "Tables of Greenhouse Gas Lifetimes, Radiative Efficiencies and Metrics" 7SM - The Earth's Energy Budget, Climate Feedbacks and Climate Sensitivity Supplementary Material (ipcc.ch)

[10] International Energy Agency (IEA), 2019, The Future of Hydrogen - Seizing today's opportunities, report prepared for the G20 by the IEA, June, https://iea.blob.core.windows.net/assets/9e3a3493-b9a6-4b7d-b499-7ca48e357561/The_Future_of_Hydrogen.pdf

[11] Wait, the Atmosphere Is Only 0.04% Carbon Dioxide. How Does It Affect Earth's Climate? (scitechdaily.com)

[12] Colorado, A., V. McDonell and S. Samuelsen, 2017, Direct Emissions of Nitrous Oxide from Combustion of Gaseous Fuels, International Journal of Hydrogen Energy 42(1): 711-719, https://doi.org/10.1016/j.ijhydene.2016.09.202

demand and fuel displacement estimates and the limited amount of information available. For example, specific end user equipment and facility data was not available.

Calculations to estimate emissions were prepared using the following two equations:

*Fuel Throughput x Emissions Factor * GWP = GHG Emissions (equation 1)*

GHG Emission Reductions = Fossil Fuel GHG Emissions – Hydrogen GHG Emissions (equation 2)

GHG emissions were calculated at the unit level and scaled based on activity data quantified using information from the Demand Study. Calculations were prepared for the low, mid, and high scenarios in the Demand Study for each year from 2030 to 2045. The Study evaluated the potential for GHG emissions based on the type of equipment and specific source categories from the Demand Study.

The GHG emissions factors for CO_2, CH_4, and N_2O associated with diesel, gasoline, and natural gas per EPA 40 CFR Part 98, as well as the GWP 20 and GWP 100 values from IPCC AR6,[13] are shown in Table 2 below.

Table 2
Summary of Fossil Fuel GHG Combustion Emission Factors

Pollutant	CO_2 E.F. (kg/MMBtu)	CH_4 E.F. (kg/MMBtu)	N_2O E.F. (kg/MMBtu)
Diesel	73.96	3.0 x 10-3	6.0 x 10-4
Gasoline	70.22	3.0 x 10-3	6.0 x 10-4
Natural Gas	53.06	1.0 x 10-3	1.0 x 10-4
GWP 100	1	27.9	273
GWP 20	1	81.2	273

For combustion of clean renewable hydrogen with GHG emissions comprised entirely of N_2O, since the GWP 20 and GWP 100 for N_2O are both 273, the expected impacts in both short term and long term should be similar. Once each calculation estimates for GHG combustion emissions

[13] IPCC AR6 7SM "The Earth's Energy Budget, Climate Feedbacks and Climate Sensitivity Supplemental Material," Table 7.SM.6 "Tables of Greenhouse Gas Lifetimes, Radiative Efficiencies and Metrics" 7SM - The Earth's Energy Budget, Climate Feedbacks and Climate Sensitivity Supplementary Material (ipcc.ch)

were prepared for new infrastructure and end use sectors, these results were summed to develop an overall estimate using equation 3:

Overall GHG Reductions = End User GHG Reductions - Infrastructure GHG Increases (equation 3)

3.3.1 Conduct Emissions Calculations

The Study prepared emission calculations using the emission factors and activity data compiled for each of the topic areas.

- The tool was designed to conduct calculations at the unit level (per unit equipment count, unit distance, unit throughput, or other unit parameters, as applicable).
- The emissions calculation tool was scaled from unit level information to estimate impacts across the geographic region.
- Emission calculations utilized information from evaluated research, the Demand Study, and other Phase One feasibility studies.

Emissions minimization opportunities can be implemented to reduce GHG (i.e., N_2O) emissions including equipment design opportunities, pre-mixing of air and fuel, management of air to fuel ratio to control combustion temperature, and emerging aftertreatment technologies. N_2O control equipment options also include existing technologies such as selective catalytic reduction (SCR) and non-selective catalytic reduction (NSCR).

4 ASSUMPTIONS AND PRELIMINARY RESULTS BASED ON DEMAND STUDY

Preliminary emissions calculation results, including assumptions, are provided for the following evaluated categories. The projected GHG emissions reductions totals for each end-user subsector were summed to estimate totals for each sector; and then totals for each sector were summed and added to the anticipated GHG emissions from new infrastructure to estimate overall annual GHG emissions reductions anticipated for each year 2030 to 2045.

- Infrastructure: production, storage, and transmission of hydrogen to end-users
- End-Users: mobility, power generation, and hard-to-electrify industrial sectors projected to use hydrogen

This document provides a high-level summary of the preliminary data and findings. Detailed emission calculations based on Demand Study scenarios will be provided as an Appendix to the draft report.

4.1 INFRASTRUCTURE

The preliminary results for potential GHG emission increases from new hydrogen infrastructure based on the Low and High Demand Scenarios data for 2045 are up to 0.16% and 0.24% the magnitude of end-user reductions for Low and High Demand Scenarios, respectively.

4.1.1 Hydrogen Production

Three equipment options were evaluated for hydrogen production to meet the definition of clean renewable hydrogen.

1. Electrolyzers powered by renewable electricity (zero GHG)
2. Biomass gasification (zero GHG)
3. RNG SMR (some GHG due to N_2O)

Multiple scenarios were evaluated to estimate the range of potential GHG emissions. The estimated emissions range from zero GHG associated with the 100% electrolysis and the 100% biomass gasification scenarios to the potential for some GHG emissions for the 100% RNG SMR scenario as detailed below.

GHG emission estimates can be refined once further project details are developed, including assumptions regarding anticipated production processes and proportions of hydrogen intended to be produced from different methods have been identified. Preliminary results are provided for the Low and High Demand Scenarios in Tables 3A and 3B, respectively.

Table 3A
Potential GHG Emissions from Hydrogen Production (CO2e) - Low Demand Scenario

	Emissions (MT CO2e/yr.)				Production Scenario
	2030	2035	2040	2045	
High Estimate	1,043.9	4,121.5	8,875.0	15,156.3	100% SMR (Avg + Std. Dev)
Low Estimate	0.0	0.0	0.0	0.0	100% Electrolysis or Biomass Gasification

Table 3B Potential GHG Emissions from Hydrogen Production (CO2e) - High Demand Scenario					
	Emissions (MT CO2e/yr.)				Production Scenario
	2030	2035	2040	2045	
High Estimate	9,016.9	18,658.3	31,923.2	48,126.1	100% SMR (Avg + Std. Dev)
Low Estimate	0.0	0.0	0.0	0.0	100% Electrolysis or Biomass Gasification

4.1.2 **Storage *and Transmission***

Compressors will be needed for storage and transmission of hydrogen. Three options for types of compressors were evaluated:

1. Electric motor driven compressors (zero GHG)
2. Clean renewable hydrogen fueled reciprocating engine driven compressors (some GHG)
3. Clean renewable hydrogen fueled turbine driven compressors (some GHG)

Emissions of GHG (as N2O) from hydrogen fueled reciprocating engine driven compressors and from turbine driven compressors were conservatively estimated using equation 1:

*Fuel Throughput x Emissions Factor * GWP = GHG Emissions (equation 1)*

Two storage pressure scenarios were evaluated - a low pressure scenario at 290 pounds per square inch (psi) and a high-pressure scenario at 2,900 psi. For the purposes of this Study, the transmission distance was assumed to be 450 miles. These are placeholder estimates since detailed project information from parallel studies is not yet available. GHG emission estimates can be refined once the types, sizes, and quantities of compressors have been further developed. Additionally, development of assumptions regarding above ground and underground storage volumes and pressures can support development of refinement of GHG emission estimates.

Preliminary results for storage and transmission for GHG emissions are provided for the Low Demand Scenario in Tables 4A and 5A, respectively. Preliminary results for storage and transmission for GHG emissions for the High Demand Scenario in Tables 4B and 5B, respectively.

Table 4A Potential GHG Emissions from Hydrogen Storage (CO2e) - Low Demand Scenario						
	Emissions (MT CO2e/yr.)				Scenario	
	2030	2035	2040	2045	Storage Pressure	Power Source
High Estimate	224.1	856.4	1,802.8	3,016.8	2,900 psi	Turbine
Low Estimate	0.0	0.0	0.0	0.0	All Pressures	(Renewable) Electricity

Table 4B Potential GHG Emissions from Hydrogen Storage (CO2e) - High Demand Scenario						
	Emissions (MT CO2e/yr.)				Scenario	
	2030	2035	2040	2045	Storage Pressure	Power Source
High Estimate	1,999.7	4,152.6	7,261.8	11,023.5	2,900 psi	Turbine
Low Estimate	0.0	0.0	0.0	0.0	All Pressures	(Renewable) Electricity

Table 5A Potential GHG Emissions from Hydrogen Transmission (CO2e) - Low Demand Scenario						
	Emissions (MT CO2e/yr.)				Scenario	
	2030	2035	2040	2045	Transmission Distance	Power Source
High Estimate	668.6	2,555.3	5,379.1	9,001.4	450 miles	Hydrogen
Low Estimate	0.0	0.0	0.0	0.0	All Distances	Renewable Electricity

Table 5B Potential GHG Emissions from Hydrogen Transmission (CO2e) - High Demand Scenario						
	Emissions (MT CO2e/yr.)				Scenario	
	2030	2035	2040	2045	Transmission Distance	Power Source
High Estimate	5,135.5	10,664.3	18,649.1	28,309.6	450 miles	Hydrogen
Low Estimate	0.0	0.0	0.0	0.0	All Distances	Renewable Electricity

4.2 END USERS

Consistent with the Decision, Angeles Link is intended to transport clean renewable hydrogen to multiple end user sectors. The focus of the GHG emissions study was on three sectors of end-users identified in the parallel Demand Study: mobility, power generation, and hard to electrify industrial sectors. The Demand Study estimated quantities of diesel and gasoline that may be displaced by hydrogen fuel cells in the mobility sector. The Demand Study also estimated quantities of natural gas that may be displaced by hydrogen fuel in the power generation and hard to electrify industrial sectors. The potential for leakage at end users was not quantified as part of this study.

4.2.1 Mobility

A summary of preliminary results for the anticipated GHG emission reductions for the Mobility sector based on the High Demand Scenario data in 2045 is as follows:

- Mobility is the largest end-user sector of GHG emission reductions at 72.5% and 50.3% of overall reductions for Low and High Demand scenarios, respectively. These emission reductions are due to hydrogen fuel cell substitution for fossil fuels nearly eliminating

GHG emissions. The potential for leakage such as during refueling of vehicles was not quantified as part of this study.

- Low Demand Scenario
  - On-Road Vehicles account for 93.9% of Mobility GHG emission reductions
  - Heavy Duty Vehicles are 58.5% of Mobility GHG reductions
  - Off-Road Vehicles account for 6.1% of Mobility GHG emission reductions
- High Demand Scenario
  - On-Road Vehicles account for 95.6% of Mobility GHG emission reductions
  - Heavy Duty Vehicles are 62.8% of Mobility GHG reductions
  - Off-Road Vehicles account for 4.4% of Mobility GHG emission reductions

The assumptions for the Mobility sector are primarily that diesel and gasoline fuel will be displaced, and vehicles would convert to hydrogen fuel cells with zero emissions. Emission factors for GHG from displaced diesel and gasoline fuel were developed using EMFAC data. The EMFAC model contains sufficient data to estimate CO_2, CH_4, and N_2O emissions for on-road mobile sources, and CO_2 emissions for off-road mobile sources. The EMFAC model does not include CH_4 and N_2O emissions data for off-road mobile vehicles. Research was conducted to estimate the most representative CH_4 and N_2O emissions factors for off-road mobile sources. Fuel consumption was weighted by subcategory of vehicle types. The same two equations previously mentioned were used to conduct the GHG calculations, and the hydrogen emissions value in equation 2 is zero.

*Fuel Throughput x Emissions Factor * GWP = GHG Emissions (equation 1)*

GHG Emission Reductions = Fossil Fuel GHG Emissions – Hydrogen GHG Emissions (equation 2)

The total emissions were calculated by summing totals for each equipment type and are shown in Table 6. Figures 2A and 2B provide graphs for the Low and High Demand scenarios, respectively below. The GHG reductions estimated for the Low Demand Scenario in 2045 are equivalent to 2,700,443 gasoline passenger vehicles driven for one year per EPA Calculator. The GHG reductions estimated for the High Demand Scenario in 2045 are equivalent to 4,000,730 gasoline passenger vehicles driven for one year per EPA Calculator.

Table 6 Mobility GHG Emission Reductions (MT CO2e/yr.)				
	2030	**2035**	**2040**	**2045**
Low	938,981.5	3,810,545.9	7,835,465.7	12,135,169.2
High	4,436,290.1	9,042,108.5	13,974,044.7	17,978,360.2

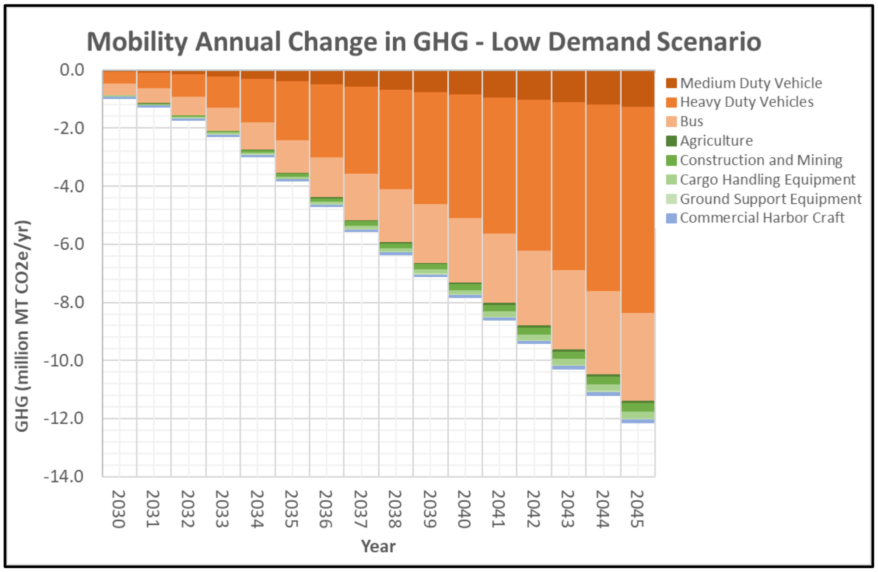

Figure 2A. Mobility Annual Change in GHG -Low Demand Scenario

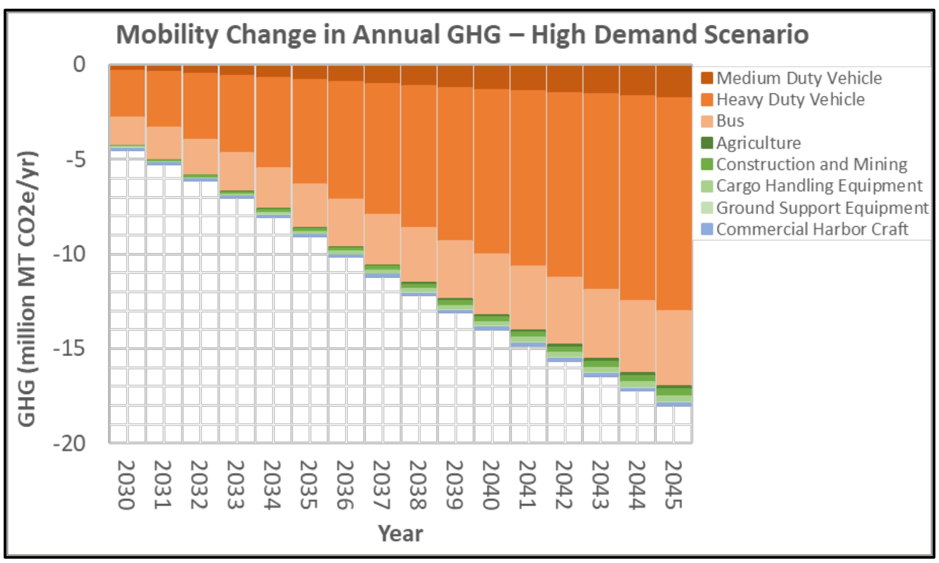

Figure 2B. Mobility Annual Change in GHG - High Demand Scenario

4.2.2 Power Generation

The preliminary results for the anticipated GHG emissions reductions based on the Low and High Demand Scenarios data in 2045 are that the Power Generation sector accounts for 23.6% and 41.7% of overall GHG reductions, respectively. The assumptions that were applied to develop the GHG emissions calculations include that hydrogen will displace natural gas as a fuel with increasing amounts over time (from 2030 to 2045). It should be noted that consistent with the Decision, Angeles Link is intended to transport clean renewable hydrogen in the pipeline, and any analysis of hydrogen blending refers strictly to "behind-the-meter" operations that are not within SoCalGas's control. The potential for leakage at power generation end users such as when hydrogen is transferred from onsite storage or distribution pipelines to onsite hydrogen combustion equipment is acknowledged but was not quantified as part of this study.

This study is focused on estimating GHG emissions reductions anticipated to be associated with use of hydrogen as a fuel in the power generation sector relating to the development of Angeles Link. At the time of this Study, there is not sufficient detailed project information to estimate the quantity of electricity anticipated to be produced using 100% clean renewable hydrogen as a fuel to electric generating equipment, or to estimate the quantity of hydrogen that would be needed to produce a specified quantity of electricity.

For each emission source type identified, calculations to estimate GHG emissions were prepared using the same two equations previously mentioned.

*Fuel Throughput x Emissions Factor * GWP = GHG Emissions (equation 1)*

GHG Emission Reductions = Fossil Fuel GHG Emissions – Hydrogen GHG Emissions (equation 2)

As previously noted, for combustion of clean renewable hydrogen with GHG comprised entirely of N_2O, since the GWP 20 and GWP 100 for N_2O are both 273, the expected impacts in both short term and long term should be similar.

The total emissions were calculated by summing totals for each equipment type and are shown in Table 7. Figures 3A and 3B provide graphs for the Low and High Demand Scenarios, respectively below. The GHG reductions estimated for the Low Demand Scenario in 2045 are equivalent to 769,537 homes' electricity use for one year per EPA Calculator. The GHG reductions estimated for the High Demand Scenario in 2045 are equivalent to 2,907,065 homes' electricity use for one year per EPA Calculator.

Table 7 Power GHG Emission Reductions (million MT CO_2e/yr)				
	2030	**2035**	**2040**	**2045**
Low	0.04	0.61	1.87	3.95
High	0.16	2.30	7.06	14.90

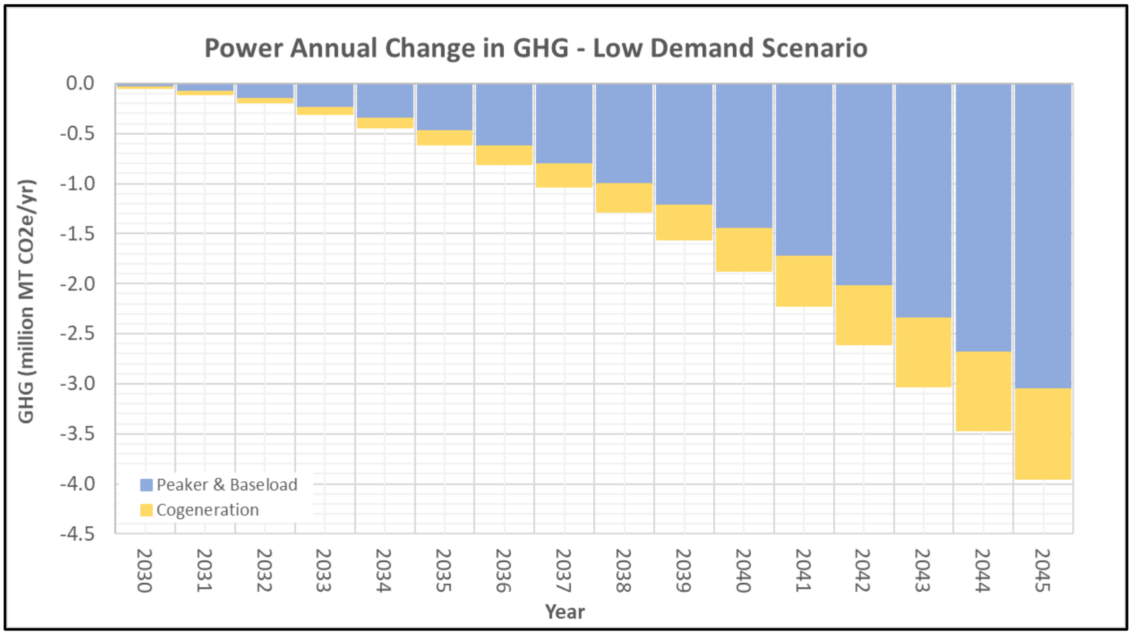

Figure 3A. Power Annual Change in GHG - Low Demand Scenario

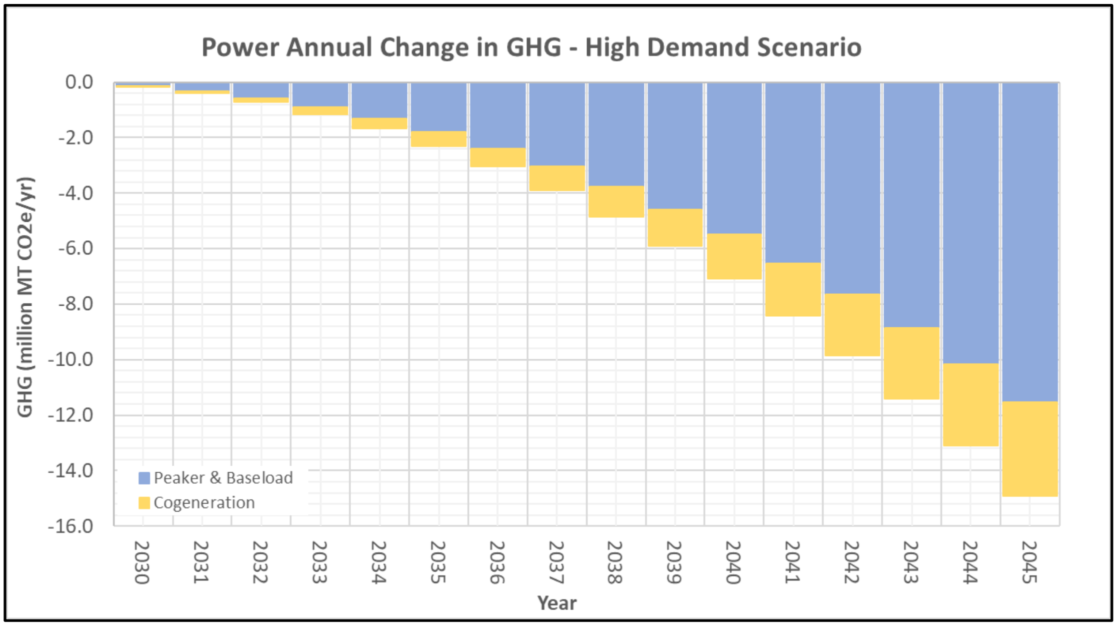

Figure 3B. Power Annual Change in GHG - High Demand Scenario

4.2.3 Hard to Electrify Industrial

The preliminary results for the anticipated GHG emissions reductions associated with the Industrial sector based on the Low and High Demand Scenario data in 2045 are that the Industrial sector accounts for 3.9% and 8.0% of overall GHG reductions, respectively. The assumptions that were applied to develop the GHG emissions calculations include that hydrogen will displace natural gas as a fuel with increasing amounts over time (from 2030 to 2045). It should be noted that consistent with the Decision, Angeles Link is intended as a project to transport only 100% clean renewable hydrogen in the pipeline, and any analysis of hydrogen blending refers strictly to "behind-the-meter" operations, not within SoCalGas control. The potential for leakage at hard to electrify industrial end users such as when hydrogen is transferred from onsite storage or distribution pipelines to onsite hydrogen combustion equipment is acknowledged but was not quantified as part of this study.

For each emission source type identified, calculations to estimate emissions were prepared using the same two equations previously mentioned.

*Fuel Throughput x Emissions Factor * GWP = GHG Emissions (equation 1)*

GHG Emission Reductions = Fossil Fuel GHG Emissions – Hydrogen GHG Emissions (equation 2)

As previously mentioned, for combustion of clean renewable hydrogen with GHG emissions comprised entirely of N_2O, since the GWP 20 and GWP 100 for N2O are both 273, the expected impacts in both short term and long term should be similar.

The total emissions were calculated by summing the totals for each equipment type and are shown in Table 8. Figures 4A and 4B provide graphs for the Low and High Demand scenarios, respectively below. The GHG reductions predicted for the Low Demand Scenario in 2045 are equivalent to 139,007 homes' electricity use for one year per EPA Calculator. The GHG reductions predicted for the High Demand Scenario in 2045 are equivalent to 603,582 homes' electricity use for one year per EPA Calculator.

Table 8
Industrial GHG Emission Reductions (million MT CO_2e/yr)

	2030	2035	2040	2045
Low	0.28	0.45	0.56	0.65
High	1.13	1.91	2.45	2.89

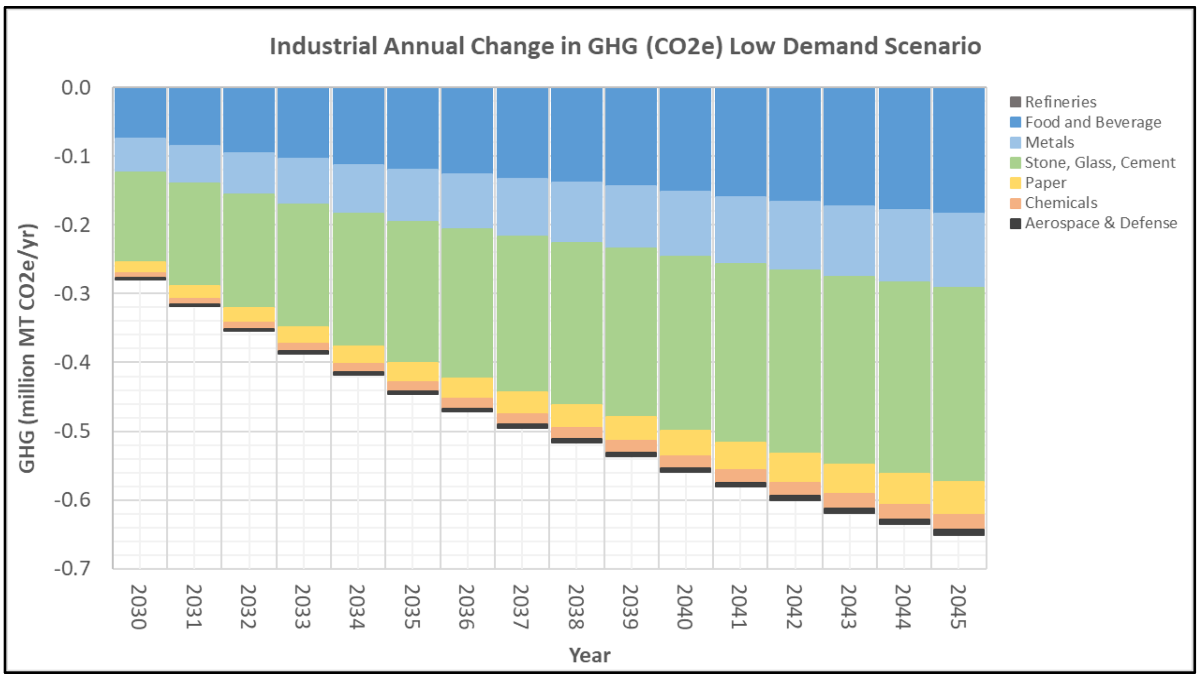

Figure 4A. Industrial Annual Change in GHG (CO2e) - Low Demand Scenario

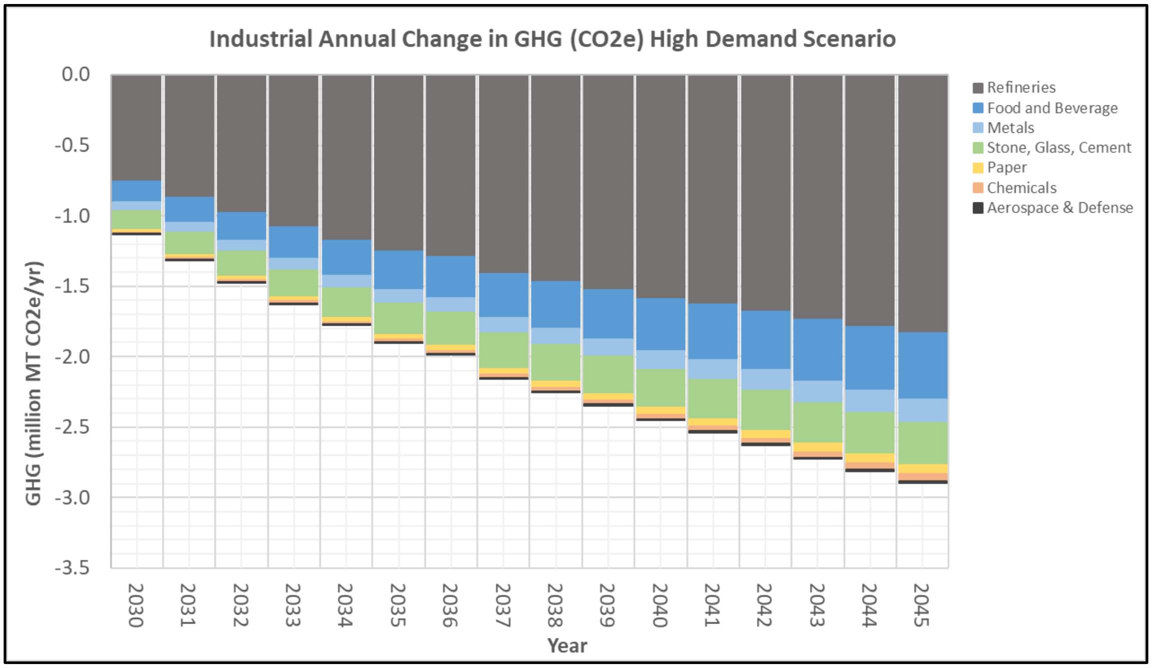

Figure 4B. Industrial Annual Change in GHG (CO2e) – High Demand Scenario

5 OVERALL RESULTS BASED ON DEMAND STUDY SCENARIOS

The anticipated potential minor GHG emissions associated with the new infrastructure were added to the overwhelmingly large anticipated GHG emissions reductions associated with potential end users of hydrogen as defined by the Demand Study. The total GHG reductions predicted for the Low Demand Scenario in 2045 for end-users are equivalent to more than 3,255,000 homes' electricity use for one year per EPA Calculator. The total GHG reductions predicted for the High Demand Scenario in 2045 for end-users are equivalent to more than 6,961,000 homes' electricity use for one year per EPA Calculator. The results are provided in Table 9 and in Figures 5A and 5B below.

In summary:

- Projected up to nearly 17 and 36 million metric tons of CO2e removed per year from SoCalGas territory geographic area by end users by 2045 for Low and High Demand Scenarios, respectively.
- Infrastructure GHG emissions are significantly smaller than end-user reductions.
    - The highest potential infrastructure GHG emissions estimated are 0.16% and 0.24% the magnitude of overall end-user reductions for Low and High Demand Scenarios, respectively.

- Mobility GHG emissions are eliminated with hydrogen substitution when fossil fuels are replaced with hydrogen fuel cells.
    - Mobility comprises 72.5% and 50.3% of overall GHG reductions for Low and High Demand Scenarios, respectively.
- Industrial and Power Generation GHG emissions are almost entirely eliminated when fossil fuels are replaced by hydrogen as a fuel in combustion equipment.
    - Power generation comprises 23.6% and 41.7% of overall GHG reductions for Low and High Demand Scenarios, respectively.
    - Industrial comprises 3.9% and 8.0% of overall GHG reductions for Low and High Demand Scenarios, respectively.

Table 9
Annual Change in GHG Emissions for Demand Scenarios (MT CO2e/yr)

Category	Scenario	2030	2035	2040	2045
End-Users	Low	-1,261,530.3	-4,864,767.0	-10,265,012.2	-16,731,268.5
	Mid	-2,762,723.7	-7,948,980.6	-15,674,832.5	-24,958,278.7
	High	-5,729,290.2	-13,244,417.6	-23,490,552.4	-35,776,967.6
Infrastructure	High - Low	2,053.6	9,032.0	19,625.7	33,099.8
	High - Mid	4,741.4	15,378.2	32,065.1	53,733.8
	High - High	14,808.6	33,100.6	60,430.5	94,550.3
	Low - Low	0.0	0.0	0.0	0.0
	Low - Mid	0.0	0.0	0.0	0.0
	Low - High	0.0	0.0	0.0	0.0

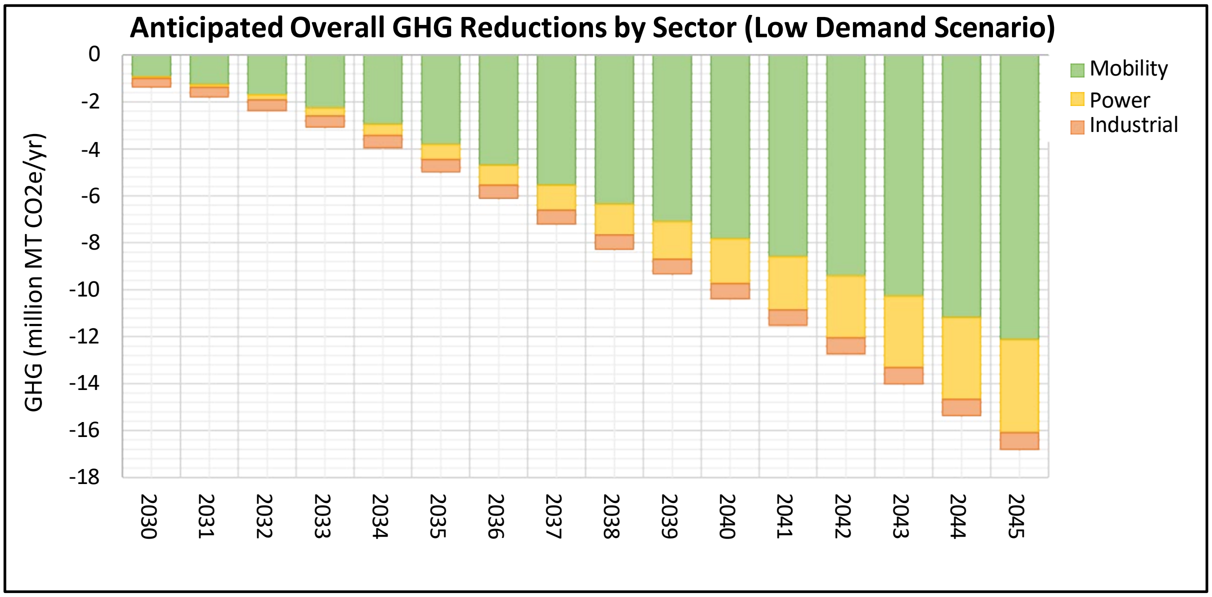

Figure 5A. Anticipated Overall GHG Reductions by Sector (Low Demand)

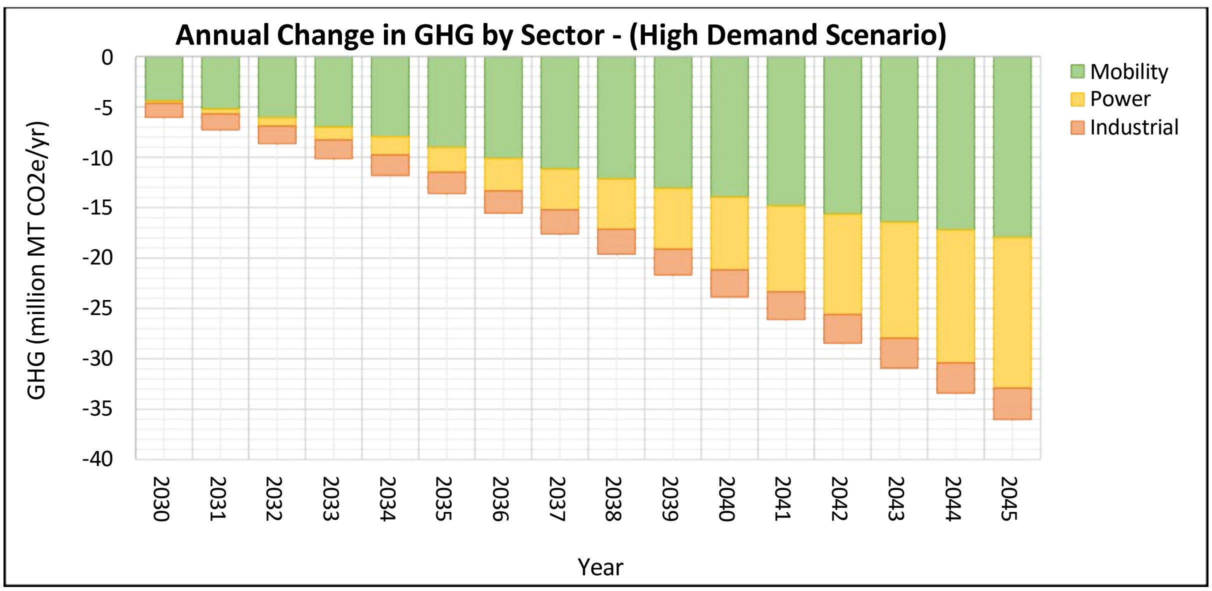

Figure 5B. Anticipated Overall GHG Reductions by Sector (High Demand)

6 ASSUMPTIONS AND PRELIMINARY RESULTS FOR ANGELES LINK THROUGHPUT SCENARIOS

Preliminary emissions calculation results including assumptions are provided for the following categories that were evaluated for the Angeles Link Throughput Scenarios. The projected GHG emissions reductions totals for each end-user subsector were summed to estimate totals for each sector; and then totals for each sector were summed and added to anticipated GHG emissions associated with new infrastructure to estimate the overall annual GHG emissions reductions based upon the Angeles Link Throughput Scenarios and anticipated for each year 2030 to 2045.

- Infrastructure: production, storage, and transmission of hydrogen to end-users
- End-Users: mobility, power generation, and hard-to-electrify industrial sectors projected to use hydrogen

This document provides a high-level summary of the preliminary data and findings. Detailed emission calculations based on the Angeles Link Throughput Scenarios will be provided in the draft report.

6.1 INFRASTRUCTURE

The preliminary results for potential GHG emission increases associated with the new Angeles Link-related infrastructure based on the data for 2045 project that such are up to 0.20% and 0.26% the magnitude of end-user reductions for Angeles Link Throughput Scenarios, respectively.

6.1.1 Hydrogen Production

Three equipment options were evaluated for hydrogen production to meet the definition of clean renewable hydrogen:

1. Electrolyzers powered by renewable electricity (zero GHG)
2. Biomass gasification (zero GHG)
3. RNG SMR (some GHG due to N2O)

Multiple scenarios were evaluated to estimate the range of potential GHG emissions. The range extends from zero GHG associated with 100% electrolysis and 100% biomass gasification scenarios to the potential for some GHG emissions for the 100% RNG SMR scenario. GHG emission estimates can be refined once further project details are developed, including assumptions regarding anticipated production processes and proportions of hydrogen intended to be produced from different methods have been identified. Preliminary results are provided for the Low and High Throughout Scenarios in Table 10.

Table 10 Potential GHG Emissions from Hydrogen Production Based on Angeles Link Throughput Scenarios					
Angeles Link Throughput Scenario	**Emissions (MT CO2e/year)**				**Production Scenario**
	2030	**2035**	**2040**	**2045**	
Low Min	0.0	0.0	0.0	0.0	100% Electrolysis or 100% Biomass Gasification
Low Max	1,043.9	4,121.5	8,875.0	15,156.3	100% SMR
High Min	0.0	0.0	0.0	0.0	100% Electrolysis or 100% Biomass Gasification
High Max	9,016.9	18,658.3	31,923.2	48,126.1	100% SMR

6.1.2 Storage and *Transmission*

Compressors will be needed for storage and transmission of hydrogen. Three options for types of compressors were evaluated.

1. Electric motor driven compressors (zero GHG)
2. Clean renewable hydrogen fueled reciprocating engine driven compressors (some GHG)
3. Clean renewable hydrogen fueled turbine driven compressors (some GHG)

Emissions of GHG (as N2O) from hydrogen fueled reciprocating engine driven compressors and from turbine driven compressors were conservatively estimated using equation 1.

*Fuel Throughput x Emissions Factor * GWP = GHG Emissions (equation 1)*

Two storage pressure scenarios were evaluated - a low pressure scenario at 290 psi and a high-pressure scenario at 2,900 psi. A total transmission distance of 450 miles was evaluated. These are placeholder estimates since detailed project information from parallel studies is not yet available. GHG emission estimates can be refined once the types, sizes, and quantities of compressors have been further developed. Additionally, development of assumptions regarding above ground and underground storage volumes and pressures will support development of refinement of GHG emission estimates. Preliminary results for storage and transmission for GHG emissions are provided in Tables 11 and 12, respectively.

Table 11 Potential GHG Emissions from Hydrogen Storage Based on Angeles Link Throughput Scenarios						
Angeles Link Throughput Scenario	**Emissions (MT CO2e/yr.)**				**Scenario**	
	2030	**2035**	**2040**	**2045**	**Storage Pressure**	**Power Source**
Low Min	0.0	0.0	0.0	0.0	NA	Renewable Electricity
Low Max	69.9	267.1	562.3	941.0	2,900 psi	Turbine Engine
High Min	0.0	0.0	0.0	0.0	NA	Renewable Electricity
High Max	507.2	1,053.2	1,841.7	2,795.7	2,900 psi	Turbine Engine

Table 12 Potential GHG Emissions from Hydrogen Transmission Based on Angeles Link Throughput Scenarios						
Angeles Link Throughput Scenario	**Emissions (MT CO2e/yr.)**				**Scenario**	
	2030	**2035**	**2040**	**2045**	**Transmission Distance**	**Power Source**
Low Min	0.0	0.0	0.0	0.0	NA	Renewable Electricity
Low Max	179.5	6860	1,444.2	2,416.7	450 miles	NA
High Min	0.0	0.0	0.0	0.0	NA	Renewable Electricity
High Max	1,302.4	2,704.6	4,729.7	7,179.7	450 miles	NA

6.2 END USERS

Consistent with the Decision, Angeles Link is intended to transport clean renewable hydrogen to the end user sectors. The focus of the GHG emissions study was on three sectors of end-users: mobility, power generation, and hard to electrify industrial. The Throughput Scenarios estimated quantities of diesel and gasoline that may be displaced by hydrogen fuel cells in the mobility sector. The Throughput Scenarios also estimated quantities of natural gas that may be displaced by hydrogen fuel in the power generation and hard to electrify industrial sectors. The potential for leakage at end users is acknowledged but was not quantified as part of this Study.

6.2.1 Mobility

Summary of preliminary results for the anticipated GHG emission reductions associated with the Mobility sector based on the Low and High Throughput Scenarios for Angeles Link in 2045 are the following.

- Mobility is the largest end-user sector of GHG reductions at 72.5% and 50.3% of overall reductions for Low and High Throughput Scenarios, respectively. These reductions are due to hydrogen fuel cell substitution for fossil fuels nearly eliminating GHG. The potential for leakage such as during refueling of vehicles is acknowledged but was not quantified as part of this study.
    - Low Throughput Scenario
        - On-Road Vehicles account for 93.9% of Mobility GHG reductions
        - Heavy Duty Vehicles are 58.5% of Mobility GHG reductions
        - Off-Road Vehicles account for 6.1% of Mobility GHG reductions
    - High Throughput Scenario
        - On-Road Vehicles account for 95.6% of Mobility GHG reductions
        - Heavy Duty Vehicles are 62.8% of Mobility GHG reductions
        - Off-Road Vehicles account for 4.4% of Mobility GHG reductions

The assumptions associated with the Mobility sector are primarily that diesel and gasoline fuel will be displaced, and vehicles would convert to hydrogen fuel cells with zero emissions. Emission factors for GHG from displaced diesel and gasoline fuel were developed using EMFAC data. The EMFAC model contains sufficient data to estimate CO_2, CH_4, and N_2O emissions for on-road mobile sources, and CO_2 emissions for off-road mobile sources. The EMFAC model does not include CH_4 and N_2O emissions data for off-road mobile vehicles. Research was conducted to estimate the most representative CH_4 and N_2O emissions factors for off-road mobile sources. Fuel consumption was weighted by subcategory of vehicle types. The same two equations previously mentioned were used to conduct the GHG calculations, and the hydrogen emissions value in equation 2 is zero.

*Fuel Throughput x Emissions Factor * GWP = GHG Emissions (equation 1)*

GHG Emission Reductions = Fossil Fuel GHG Emissions – Hydrogen GHG Emissions (equation 2)

The total emissions were calculated by summing totals for each equipment type and are shown in Table 13. Figures 6A and 6B provide graphs for the Low and High Throughput Scenarios, respectively below. The GHG reductions estimated for the Low Throughput Scenario in 2045 are equivalent to 725,000 gasoline passenger vehicles driven for one year per EPA Calculator. The GHG reductions estimated for the High Throughput Scenario in 2045 are equivalent to 1,014,639 gasoline passenger vehicles driven for one year per EPA Calculator.

Table 13
Mobility GHG Emission Reductions Associated with Angeles Link Throughput Scenarios (MT CO2e/yr.)

	2030	2035	2040	2045
Low	252,092.6	1,023,034.4	2,103,622.7	3,257,983.5
High	1,125,103.2	2,293,201.1	3,544,006.9	4,559,555.5

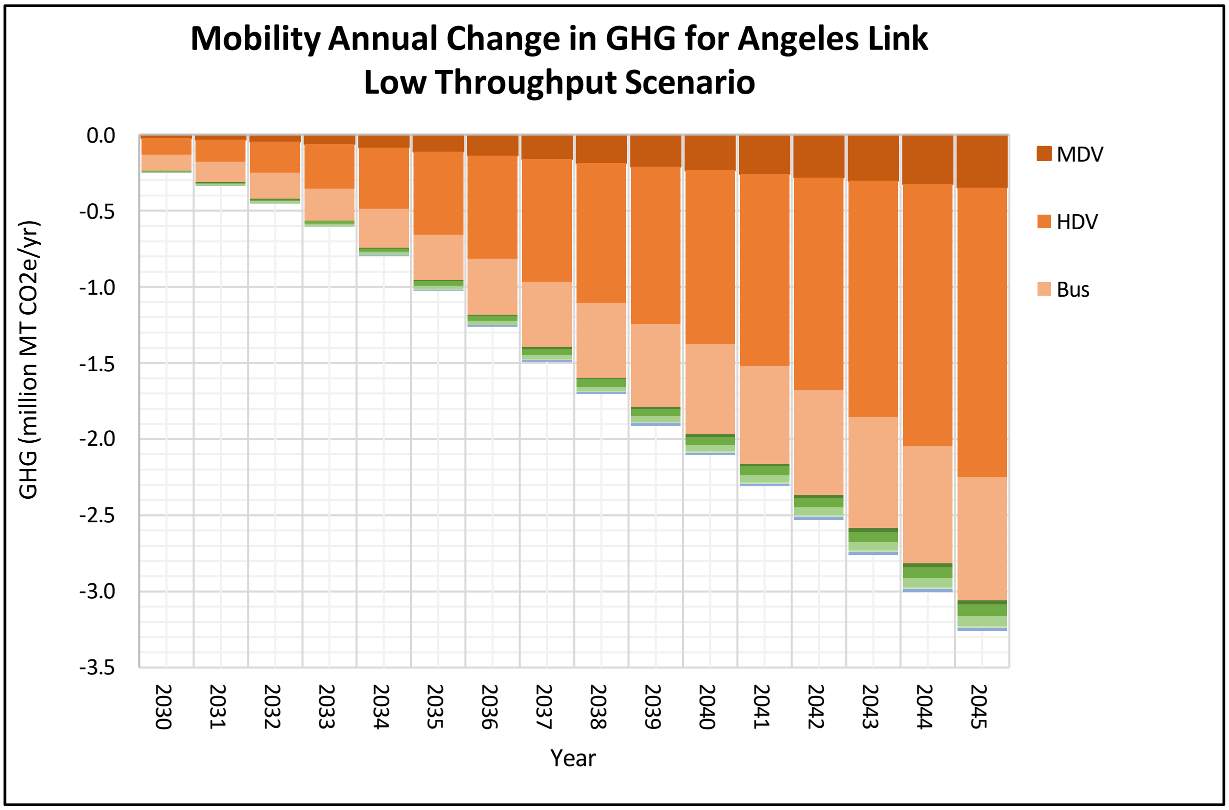

Figure 6A. Mobility Annual Change in GHG for Angeles Link Low Throughput Scenario

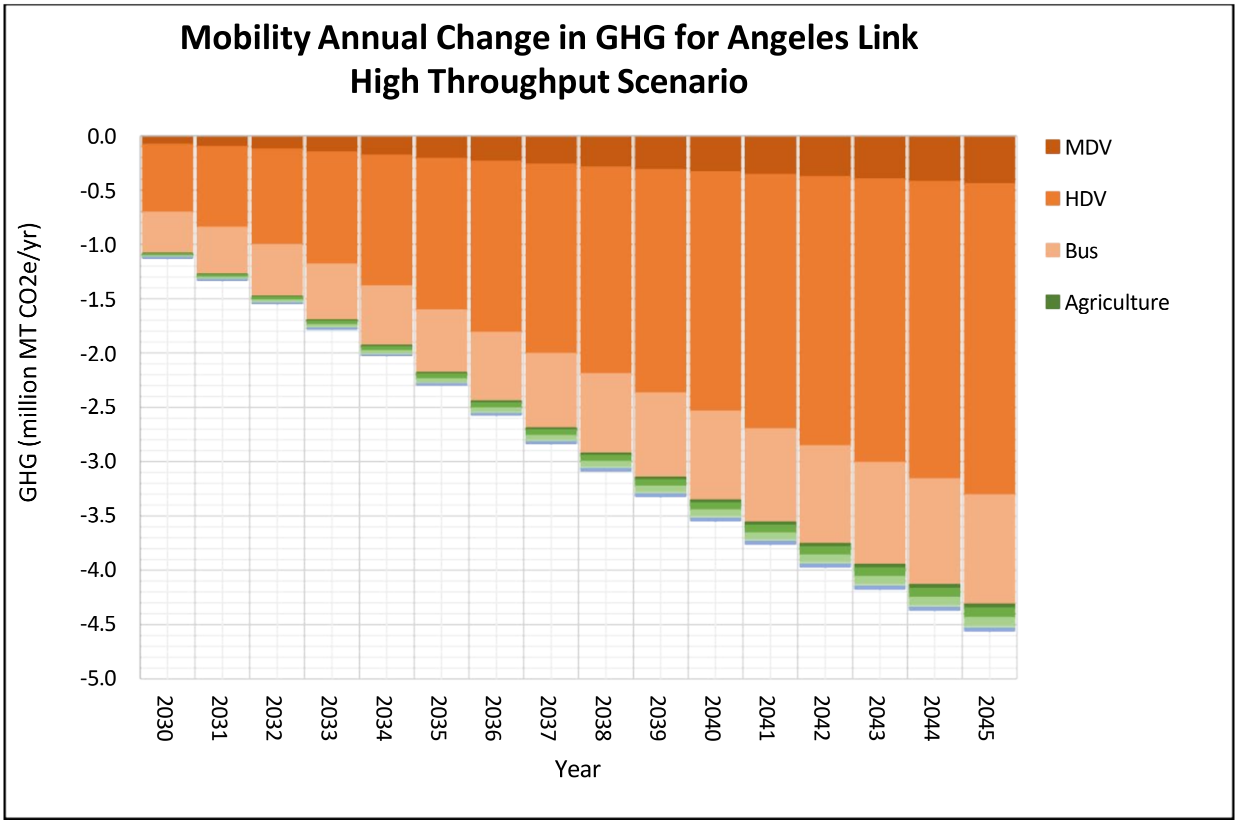

Figure 6B. Mobility Annual Change in GHG for Angeles Link High Throughput Scenario

6.2.2 Power Generation

Preliminary results for anticipated GHG emissions reductions based on the Angeles Link Low and High Throughout Scenarios in 2045 are that the Power Generation sector accounts for 24% and 42% of overall GHG emissions reductions, respectively. The assumptions that were applied to develop the GHG emissions calculations include that hydrogen will displace natural gas as a fuel with increasing amounts over time (from 2030 to 2045). It should be noted that consistent with the Decision, Angeles Link is intended to transport clean renewable hydrogen in the pipeline, and any analysis of hydrogen blending refers strictly to "behind-the-meter" operations that are not within SoCalGas's control. The potential for leakage at power generation end users such as when hydrogen is transferred from onsite storage or distribution pipelines to onsite hydrogen combustion equipment is acknowledged but was not quantified as part of this study.

This Study is focused on estimated GHG reductions anticipated to be associated with use of hydrogen as a fuel in the power generation sector relating to the development of Angeles Link. At the time of this study report, there is not sufficient detailed project information to estimate the quantity of electricity that is anticipated to be produced using 100% clean renewable hydrogen as a fuel to electric generating equipment, or to estimate the quantity of hydrogen that would be needed to produce a specified quantity of electricity.

For each emission source type identified, calculations to estimate GHG emissions were prepared using the same two equations previously mentioned.

*Fuel Throughput x Emissions Factor * GWP = GHG Emissions (equation 1)*

GHG Emission Reductions = Fossil Fuel GHG Emissions – Hydrogen GHG Emissions (equation 2)

As previously mentioned, for combustion of clean renewable hydrogen with GHG comprised entirely of N_2O, since the GWP 20 and GWP 100 for N_2O are both 273, the expected impacts in both short term and long term should be similar.

The total emissions were calculated by summing totals for each equipment type and are shown in Table 14. Figures 7A and 7B provide graphs for the Angeles Link Low and High Throughput Scenarios, respectively below. The GHG reductions estimated for the Low Throughput Scenario in 2045 are equivalent to 206,101 homes' electricity use for one year per EPA Calculator. The GHG reductions estimated for the High Throughput Scenario in 2045 are equivalent to 735,486 homes' electricity use for one year per EPA Calculator.

Table 14
Power GHG Emission Reductions Associated with Angeles Link Throughput Scenarios (MT CO2e/yr.)

	2030	**2035**	**2040**	**2045**
Low	11,529.6	163,266.1	502,046.1	1,059,238.4
High	41,144.2	582,627.2	1,791,588.7	3,779,970.8

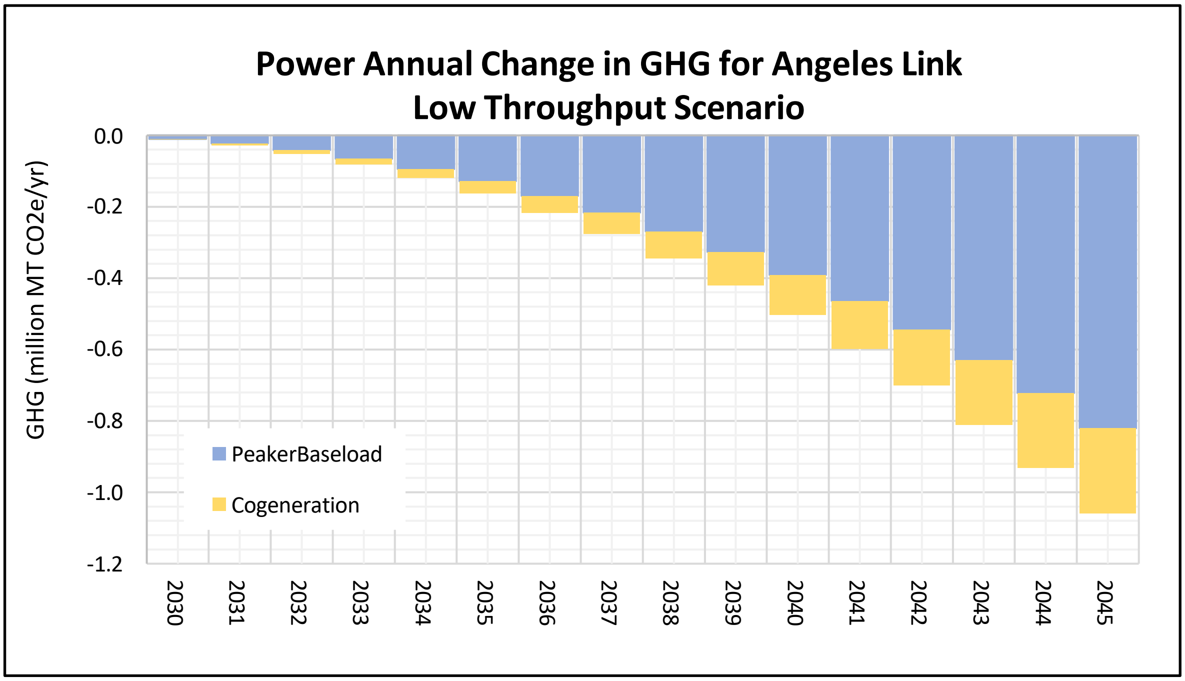

Figure 7A. Power Annual Change in GHG for Angeles Link Low Throughput Scenario

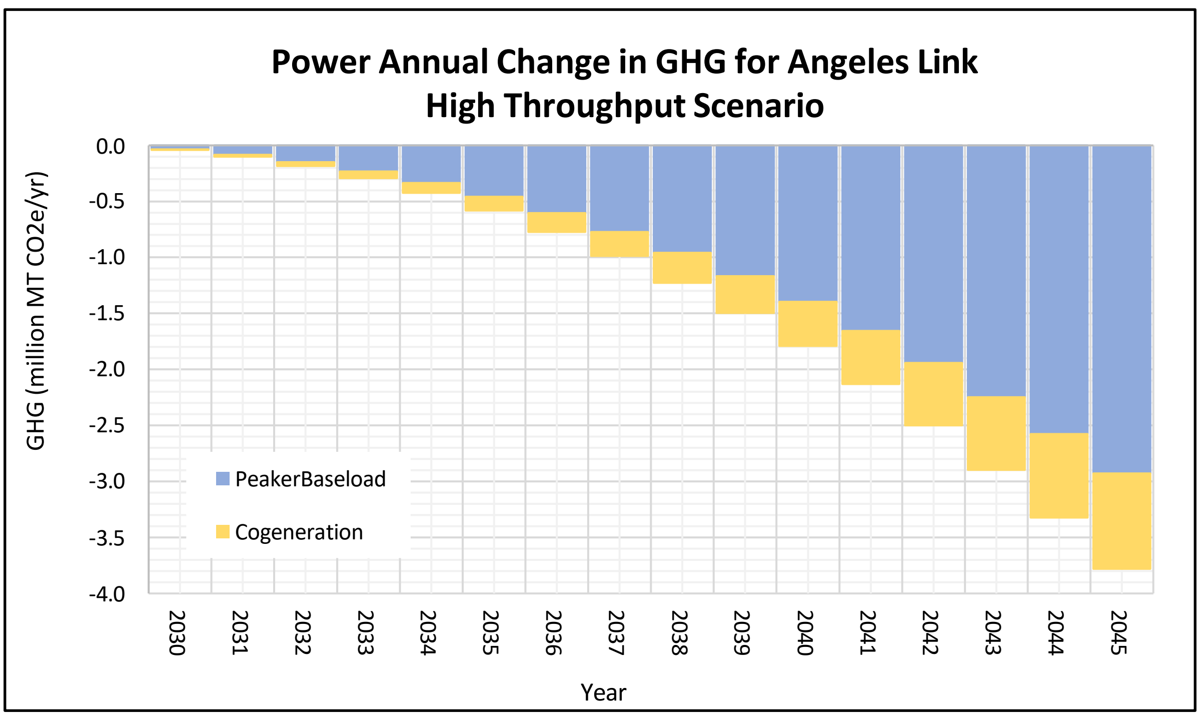

Figure 7B. Power Annual Change in GHG for Angeles Link High Throughput Scenario

6.2.3 Hard to *Electrify Industrial*

The preliminary results for the anticipated GHG emissions reductions associated with the Industrial sector based on the Angeles Link Low and High Throughput Scenario data in 2045 are that the Industrial sector accounts for 4% and 8% of overall GHG emissions reductions, respectively. The assumptions that were applied to develop the GHG emissions calculations include that hydrogen will displace natural gas as a fuel with increasing amounts over time (from 2030 to 2045). It should be noted that consistent with the Decision, Angeles Link is intended to transport clean renewable hydrogen, and any analysis of hydrogen blending refers strictly to "behind-the-meter" operations, not within SoCalGas control. The potential for leakage at hard to electrify industrial end users such as when hydrogen is transferred from onsite storage or distribution pipelines to onsite hydrogen combustion equipment is acknowledged but was not quantified as part of this study.

For each emission source type identified, calculations to estimate emissions were prepared using the same two equations previously mentioned.

*Fuel Throughput x Emissions Factor * GWP = GHG Emissions (equation 1)*

GHG Emission Reductions = Fossil Fuel GHG Emissions – Hydrogen GHG Emissions (equation 2)

As previously noted, for combustion of clean renewable hydrogen with GHG emissions comprised entirely of N_2O, since the GWP 20 and GWP 100 for N_2O are both 273, the expected impacts in both short term and long term should be similar.

Total emissions were calculated by summing totals for each equipment type and are shown in Table 15. Figures 8A and 8B provide graphs for the Angeles Link Low and High Throughput Scenarios, respectively below. The GHG emissions reductions predicted for the Low Throughput Scenario in 2045 are equivalent to 33,992 homes' electricity use for one year per EPA Calculator. The GHG emissions reductions predicted for the High Throughput Scenario in 2045 are equivalent to 142,817 homes' electricity use for one year per EPA Calculator.

Table 15
Industrial GHG Emission Reductions Associated with Angeles Link Throughput Scenarios (MT CO2e/yr.)

	2030	2035	2040	2045
Low	75,066.6	119,765.4	150,225.2	174,697.1
High	286,778.1	483,135.2	621,926.5	733,994.4

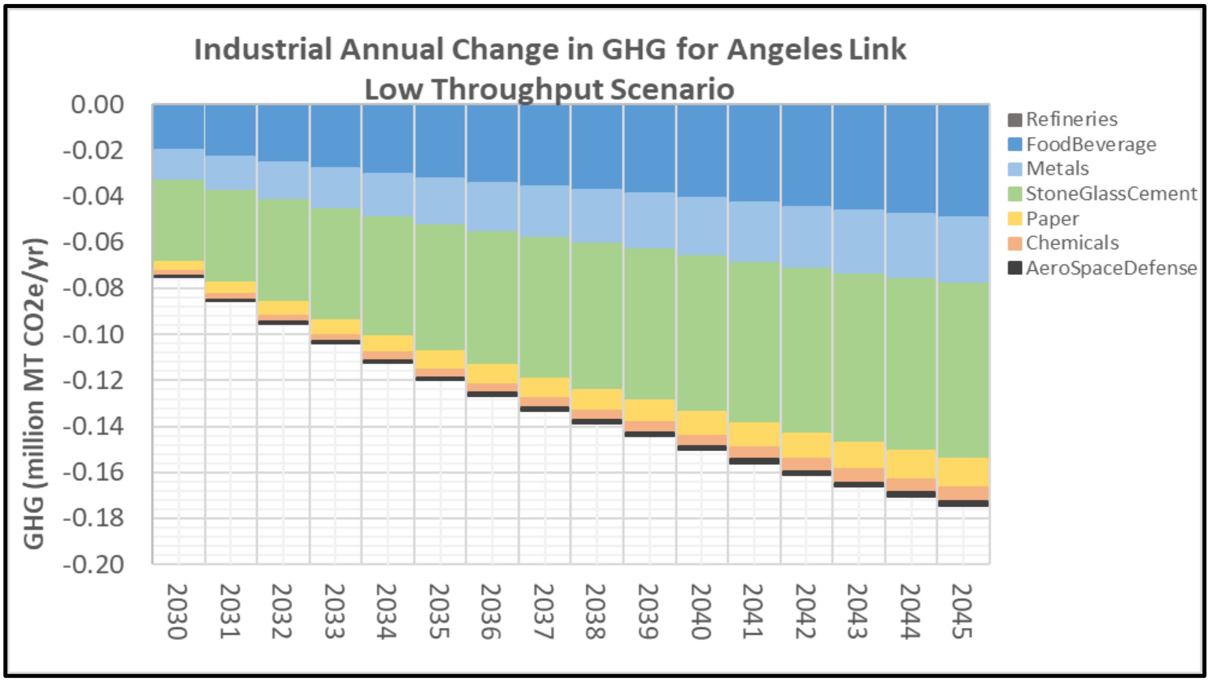

Figure 8A. Industrial Annual Change in GHG for Angeles Link Low Throughput Scenario

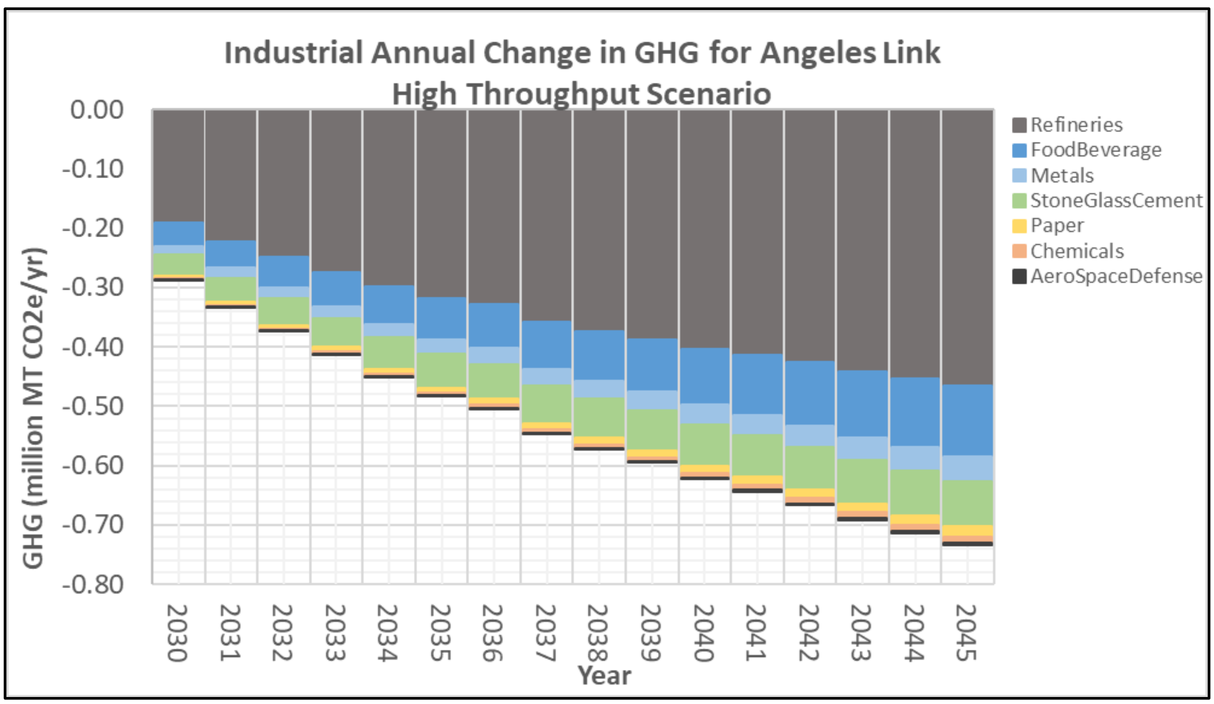

Figure 8B. Industrial Annual Change in GHG for Angeles Link Low Throughput Scenario

7 OVERALL RESULTS FOR ANGELES LINK THROUGHPUT SCENARIOS

Anticipated potential minor GHG emissions associated with new hydrogen infrastructure were added to the potential large anticipated GHG emissions reductions associated with potential end users of hydrogen as defined by the Demand Study. The total GHG emissions reductions projected for the Low Throughput Scenario in 2045 for end-users are equivalent to more than 874,000 homes' electricity use for one year per EPA Calculator. The total GHG emissions reductions predicted for the High Throughput Scenario in 2045 for end-users are equivalent to more than 1,760,000 homes' electricity use for one year per EPA Calculator. The results are provided in Table 16 and in Figures 9A and 9B below.

In summary:

- Projected about 4.5 and 9 million metric tons of CO2e per year removed from SoCalGas territory geographic area by end users by 2045 in Angeles Link Low and High Throughput Scenarios.
- Projected new infrastructure GHG emissions are significantly smaller than end-user reductions.
    - The highest potential infrastructure GHG emissions estimated are 0.20% and 0.26% the magnitude of overall end-user reductions for Angeles Link Low and High throughput scenarios, respectively.
- Mobility GHG emissions are almost entirely eliminated with hydrogen substitution when fossil fuels are replaced with hydrogen fuel cells.
    - Mobility comprises 72.5% and 50.3% of overall GHG reductions for Angeles Link Low and High throughput scenarios, respectively.
- Industrial and Power Generation GHG emissions are almost entirely eliminated when fossil fuels are replaced by hydrogen as a fuel in combustion equipment.
    - Power generation comprises 23.6% and 41.7% of overall GHG emissions reductions for Angeles Link Low and High throughput scenarios, respectively.
    - Industrial comprises 3.9% and 8.0% of overall GHG emissions reductions for Angeles Link Low and High Throughput Scenarios, respectively.

Table 16 Annual Change in GHG Emissions for Angeles Link Throughput Scenarios (MT CO2e/yr.)					
		2030	**2035**	**2040**	**2045**
End-Users	**Low**	-338,688.7	-1,306,065.9	-2,755,894.0	-4,491,919.0
	Mid	-859,848.5	-2,473,978.4	-4,878,512.0	-7,767,819.1
	High	-1,449,269.9	-3,350,568.8	-5,942,196.1	-9,049,541.4
Infrastructure	**Max - Low**	529.7	2,059.7	4,389.2	7,426.8
	Max - Mid	1,270.9	4,030.5	8,373.6	14,094.9
	Max - High	4,096.4	8,498.8	14,667.5	22,180.9
	Min - Low	0.0	0.0	0.0	0.0
	Min - Mid	0.0	0.0	0.0	0.0
	Min - High	0.0	0.0	0.0	0.0

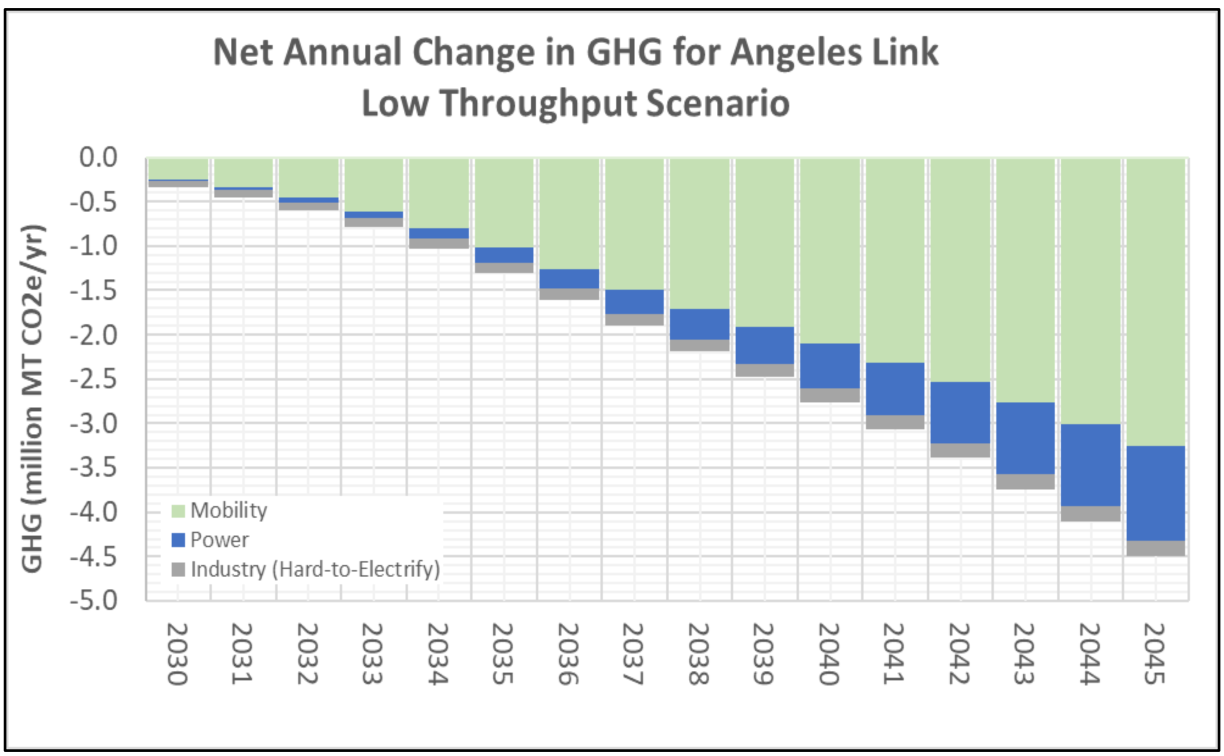

Figure 9A. Net Annual Change in GHG for Angeles Link Low Throughput Scenario

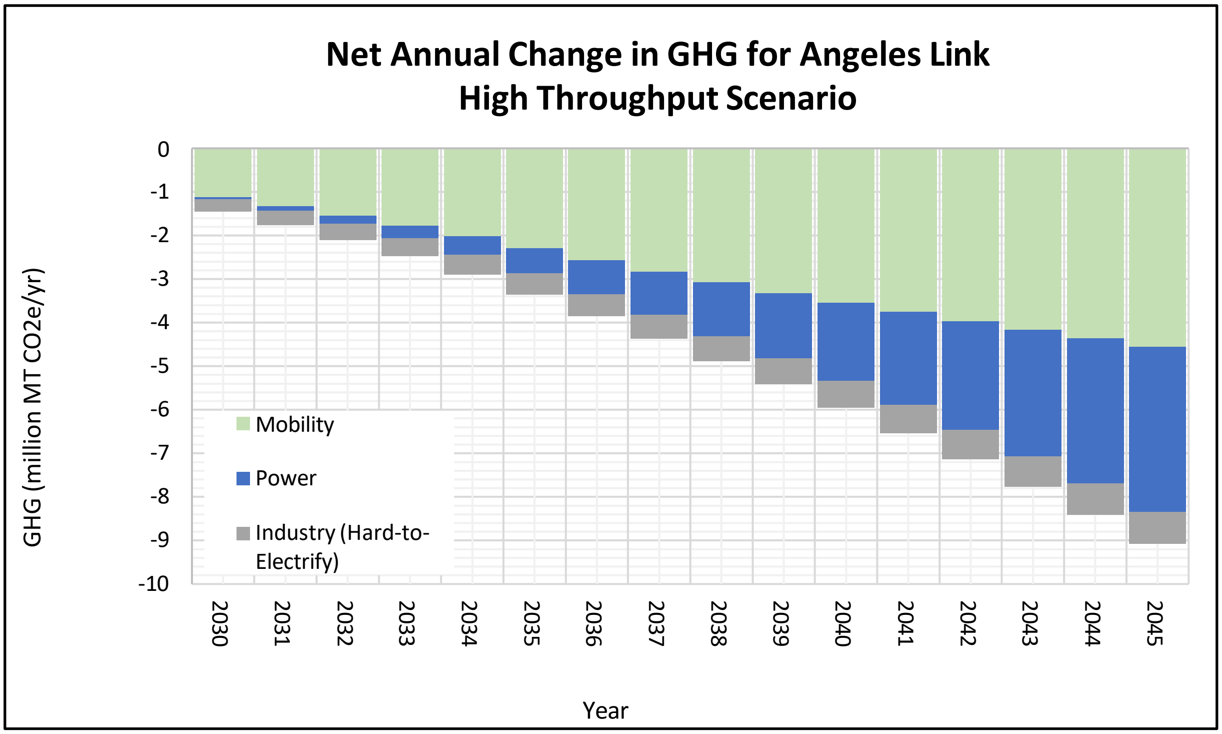

Figure 9B. Net Annual Change in GHG for Angeles Link Low Throughput Scenario

Uncertainty

The uncertainty related to the overall results is primarily with the preliminary level of project details, as well as the potential for leakage of hydrogen to impact anticipated reductions in GHG emissions associated with Angeles Link. As noted herein, the information used for this GHG emissions study is preliminary in nature. With infrastructure design development, including that of third parties, project refinements, detailed information from potential end users, and from technological advancements, these initial GHG combustion emissions reductions can be further refined.

Hydrogen itself is not considered a direct GHG by CARB, US EPA, or the IPCC. There are currently no established or accepted global warming potential values or standards for hydrogen from global climate organizations or regulatory bodies.

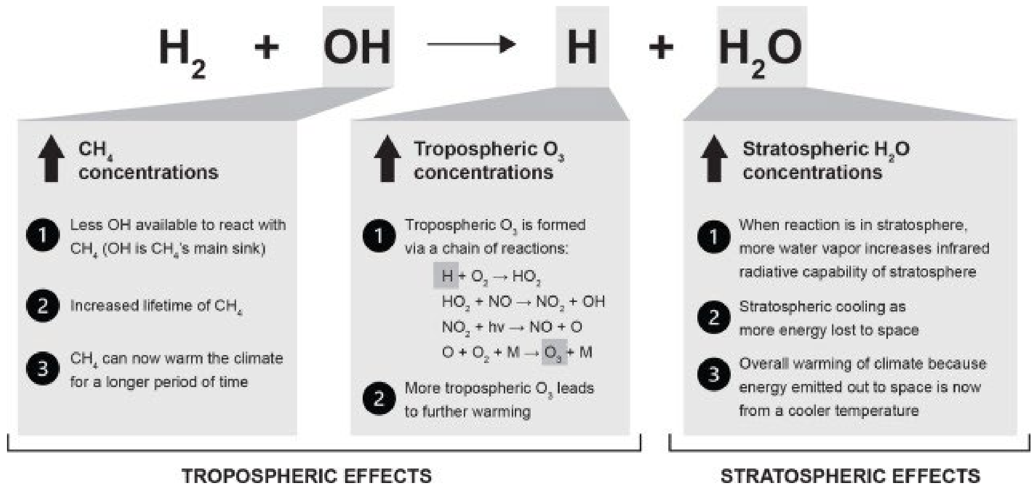

Figure 10. Estimated tropospheric and stratospheric effects of hydrogen

As shown in Figure 8, Certain third-party literature has identified that potential climate impacts may be caused by: 1) Reduction in available hydroxyl radicals to react with methane, potentially prolonging methane's lifetime in the atmosphere; 2) Increased tropospheric concentrations of ozone; and 3) Increased concentrations of water vapor. Scientists have developed a number of estimates of the GWP 20 and GWP 100 for hydrogen. Three articles reviewed provided estimates for the hydrogen GWP for the 20-year time horizon. The 20-year time horizon GWP values are higher than the 100-year time horizon values and include larger ranges of uncertainty. Table 17 summarizes the information that has been compiled based on a review of the available literature. This Study acknowledges that information used for this study is preliminary and, therefore, so are estimates of GHG emissions reductions. There is also information from third-party studies that indicate that the potential for hydrogen leakage may offset some of the impacts of the potential GHG emission reductions associated with the replacement of fossil fuels with hydrogen. Quantification of the potential GHG emissions from leakage associated with Angeles Link and third-party production and storage, is not possible at this time because detailed design and engineering has not yet been developed for the new infrastructure. In addition, regulatory agencies have not adopted leak emission factors or a global warming potential (GWP) for hydrogen. One potential high level conservative approach to estimate the potential impact to climate change would be to assume conservative ranges of leakage rates and GWPs (GWP 100) from the values available in the scientific literature (as summarized in Table 2 of the parallel Leakage Study) and apply those to the Angeles Link Throughput Scenarios being considered. For this theoretical analysis, this value would be assumed to be GHGs, in order to compare the projected GHG reductions estimated in the GHG study report. Based on preliminary calculations, this proposed methodology indicates that the impact to the predicted overall GHG emissions reductions from combustion associated with Angeles Link and third-party production and storage would be very low (i.e., less than 3% for high throughput scenario) when considering the addition of potential GHG emissions from the four leakage sectors evaluated in the parallel Leakage Study.

With infrastructure design development, project refinements, detailed information from potential end users, and technological advancements, these preliminary GHG emissions reduction estimates can be further refined; and estimates of potential effects of hydrogen in the atmosphere associated with the potential for leakage can be further explored.

Table 17
Summary of GWP 20 and GWP 100 Estimates for Hydrogen

GWP100 Range of Estimates	GWP20 Range of Estimates	Date of Article	Article Authors
5 +/- 1	---	January 2020	R. G. Derwent, et al
3.3 +/- 1.4	---	August 2021	R.A. Field, R.G. Derwent
12.8 +/- 5.2	40.1 +/- 24.1	November 2022	D. Hauglustaine, et al
8 +/- 2	---	March 2023	R. G. Derwent
11.6 +/- 2.8	37.3 +/- 15.1	June 2023	M. Sand et al
11.5 +/- 6	34.8 +/- 19	October 2023	N. J. Warwick, et al

8 CONCLUSION

The preliminary GHG combustion emission estimates calculated from data from both the Demand Study Demand Scenarios and Angeles Link Throughput Scenarios are set forth in this Study. The preliminary GHG combustion emission estimates associated with Angeles Link set forth in this study are for informative purposes for Phase One of the Angeles Link project Information from parallel studies in Angeles Link Phase One is still under development, as well as studies by third parties, and data from future end users can be further refined. This study acknowledges that based on available scientific research preliminarily reviewed, there is uncertainty about the potential tropospheric and atmospheric effects associated with leakage of hydrogen. The design details of the Angeles Link infrastructure, as well as further project refinements, may further inform future quantification estimates of GHG emissions.

Angeles Link | Leakage Preliminary Data and Findings

February 2024

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1.0 EXECUTIVE SUMMARY

SoCalGas is proposing to develop a clean renewable hydrogen[1] pipeline system to serve end users in the Central and Southern California area including the Los Angeles Basin (inclusive of the Ports of Los Angeles and Long Beach). The California Public Utilities Commission's Decision (D.22-12-055) from December 15, 2022, approving the Memorandum Account for Southern California Gas Company's (SoCalGas) proposed Angeles Link project (Angeles Link) requires SoCalGas to assess the risks and mitigations associated with the potential for hydrogen leakage. The leakage assessment evaluates the potential for hydrogen leakage associated with new infrastructure (i.e., production[2], compression, storage, and transportation of clean renewable hydrogen), as well as opportunities to minimize the potential for hydrogen leakage (Study).

The objective of this Study is to evaluate through a literature review a range of values for potential hydrogen leakage, as well as opportunities to minimize the potential for leakage. This range of values is presented as percentages for each component of new proposed infrastructure and as percentages for each minimization opportunity. Volumetric estimates of the potential for leakage are not developed since detailed infrastructure information was not available at the time of this Study. This Study does not evaluate the potential for leakage at end users.

The preliminary key findings are presented below and are discussed further within this document.

- As described in the literature reviewed for this Study, potential sources of leakage include production equipment such as electrolyzers, compression equipment such as reciprocating and centrifugal compressors, storage equipment such as aboveground vessels, and transmission infrastructure such as pipelines.
- The magnitude of the potential for hydrogen leakage depends on the type of equipment that is used for production, compression, and storage, how the infrastructure is designed and engineered, whether the pipelines are above ground or below ground, and how the infrastructure is operated and maintained, amongst other factors.
- Leakage estimation methodologies include direct measurement such as leak detection sensors, as well as information published in the literature based on a variety of methodologies including calculations via proxies such as natural gas, laboratory experiments, and theory-based models or simulations.
- Mitigations and opportunities to minimize the potential for leakage from various processes are available in design and engineering of new infrastructure, operation of

[1] In the Decision, clean renewable hydrogen refers to hydrogen that does not exceed 4 kilograms of carbon dioxide equivalent (CO2e) produced on a lifecycle basis per kilogram of hydrogen produced and does not use fossil fuels in the hydrogen production process, where fossil fuels are defined as a mixture of hydrocarbons including coal, petroleum, or natural gas, occurring in and extracted from underground deposits.

[2] Production is anticipated to be conducted by a third party.

equipment and systems, as well as maintenance procedures. In addition to design and engineering, the use of existing and emerging sensor technologies support early identification of leaks and facilitate timely repairs, thereby mitigating leaks.

2.0 STUDY APPROACH

The Study evaluates, through a review of existing technical literature, potential sources of hydrogen leakage and leakage mitigation for the production, compression, storage, and transportation of hydrogen associated with Angeles Link. Where applicable, the Study relies on specific technical information that is available including from other ongoing Phase One feasibility studies and other information primarily from existing technical literature. When specific information is not available, estimates based on availability of related data such as correlations to natural gas or documented assumptions were developed.

2.1 TECHNICAL RESEARCH

The Study collected, reviewed, and analyzed technical literature studies and information related to the potential for hydrogen leakage and opportunities to minimize and mitigate hydrogen leakage. This analysis included the following:

- Studies from research-based academic institutions such as Columbia University and the University of Wyoming and private organizations such as the Frazer-Nash Consultancy.
- Existing, proposed, and potential future regulatory requirements from federal agencies including the United States Environmental Protection Agency (US EPA), the Pipeline and Hazardous Materials Safety Administration (PHMSA), the United States Department of Energy (US DOE), and state agencies such as the California Air Resources Board (CARB) and the California Energy Commission (CEC).
- Technological developments from manufacturers working on hydrogen monitoring technology including sensor development and opportunities to minimize the potential for leakage.
- Technical literature and data releases from public entities and government agencies and laboratories including the US DOE and the National Renewable Energy Lab (NREL), the Environmental Defense Fund (EDF), Netherlands Environment Assessment Agency, and Joint Research Centre (JRC) of the European Commission.

2.1.1 Technical Approach

The technical approach for this Study included identifying sources of potential leakage and opportunities to minimize leakage by reviewing literature published on these topics. Additionally, research was conducted regarding anticipated technological advancements and the expected evolution of regulatory frameworks was considered. Based on the information gathered, leakage estimation methodologies were evaluated.

Two leakage estimation methodologies were identified: total value chain approach (top-down) and component-count level approach (bottom-up). The total value chain approach provides general component (production, compression, storage (above ground & underground), and transmission through pipelines) leakage ranges that are summarized from the literature reviewed. The component-count level methodology relies on project-specific and detailed equipment, process, and component counts. It requires not only the type and number of production, compression, and storage equipment, but also details about the piping, including number of valves, flanges, and connections.

2.1.2 Calculation Methodology

The Study identified the total value chain approach as the most appropriate for preparing high level preliminary estimates of the potential for leakage associated with Angeles Link, including transmission of hydrogen, as well as third party production and storage, since detailed project design and engineering information was not available at the time of this Study. Figure 1 provides a graphic illustration of the estimation procedure. The potential for leakage is provided in the literature as estimated percentages for each of the value chain components (i.e., production, compression, storage, and transmission). These estimates reviewed in the literature were based on calculations via proxies such as natural gas, laboratory experiments, and theory-based models or simulations. At the time of this Study, project design and engineering of the proposed infrastructure had not been developed to the level of detail needed to prepare a meaningful estimate. This total value chain approach calculation methodology could be performed in the future once additional detail is available.

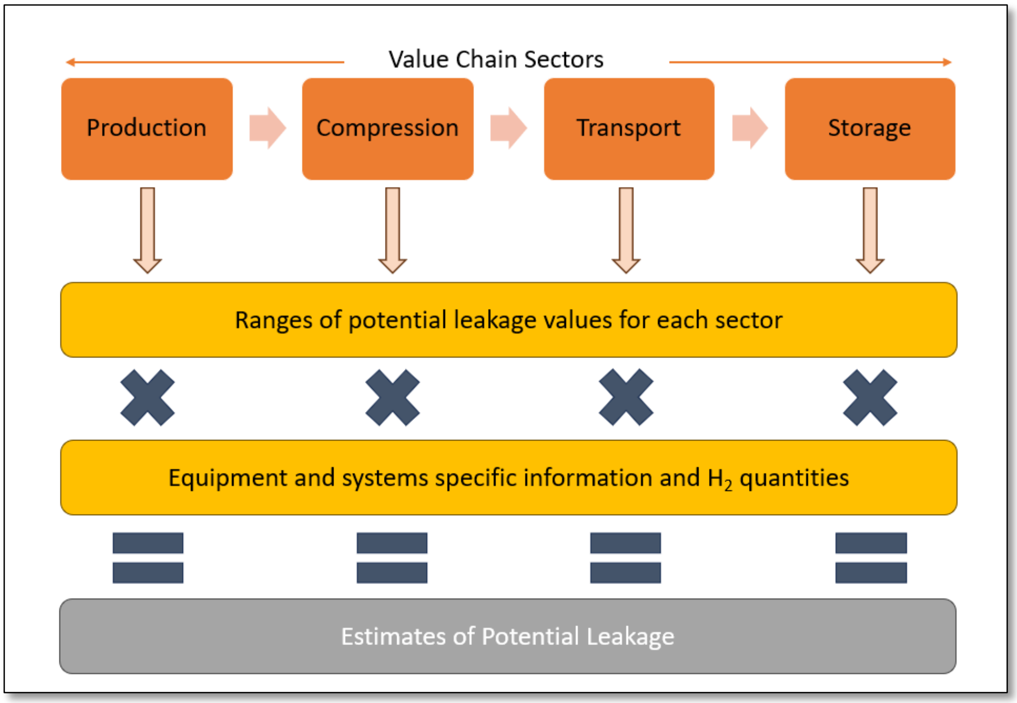

Figure 1 Value Chain Leakage Calculation Procedure

3.0 PRELIMINARY DATA

As measurement technology is further developed over time, and more data is available, more specific estimates of potential for leakage may be developed. It should be noted that consistent with the Decision, Angeles Link is intended as a project to transport only 100% clean renewable hydrogen in the pipeline, and any analysis of hydrogen blending refers strictly to end users' "behind-the-meter" operations, and not hydrogen use within SoCalGas's control.

3.1 SOURCES OF POTENTIAL LEAKAGE

To identify sources of potential hydrogen leakage, this Study evaluated the potential for hydrogen leakage from anticipated equipment and systems that would be associated with Angeles Link, including transmission of hydrogen, as well as third party production and storage. The following potential hydrogen value chain leakage sources were identified in the consulted literature and are evaluated in this report: production, compression, storage (above ground & underground), and transmission through pipelines.

Hydrogen Production: Leakage may occur from production equipment during purging, bleeding, or the process of removal of impurities. Literature reviewed evaluated both electrolyzer and steam methane reformer production options. Leakage may also occur through piping components such as valves and connections. Leakage of hydrogen through the casing of equipment is anticipated to be negligible and could be further mitigated through laminated gaskets and welded joints.

Hydrogen Compression: Hydrogen compression is a subcategory of storage and transmission since both may use compressors. Seals/packing vents of compressors have the potential to release hydrogen. Blowdowns, purging, and other venting processes may result in hydrogen releases.

Hydrogen Storage: For the purpose of this Study, hydrogen storage may occur above ground or below ground. Leakage from above ground storage tanks/vessels may occur from components such as valves and flanges. Leakage from below ground storage such as salt caverns may occur at the surface plant during maintenance activities. Development of assumptions regarding above ground and underground storage volumes and pressures can support refinement of leakage estimates.

Hydrogen Transmission: Hydrogen is anticipated to be transmitted via pipelines to end users. The transmission of hydrogen will require the use of compressors, where seals/packing vents have the potential to release hydrogen. Blowdowns, purging, and other venting processes may result in hydrogen releases. Potential leaks may occur from pipelines components, including valves and connectors, and equipment handling hydrogen.

3.2 LEAK ESTIMATION METHODOLOGIES

Leakage estimation methodologies include direct measurements, as well as calculations via proxies such as natural gas, laboratory experiments, and theory-based models or simulations as discussed in studies evaluated in the literature.

3.2.1 Direct Measurement of Hydrogen Leakage

Direct measurement of hydrogen is in its infancy due primarily to the lack of instrumentation to accurately measure hydrogen at very low concentrations.[3] Current commercially available sensors for industrial applications only have detection levels down to parts per million.[4] Measurement tools with more accuracy may also be used to quantify leakage concentrations such as with sensitivity at the parts per billion level, as well as the ability to respond in seconds and correctly identify hydrogen amongst other compounds. Direct measurement used to estimate leakage is dependent on the sensitivity and accuracy of the instruments used. Emerging detection technologies provide opportunities to further enhance leak detection and

[3] Esquivel-Elizondo, Sofia, Alejandra Hormaza Mejia, Tianyi Sun, Eriko Shrestha, Steven P. Hamburg and Ilissa B. Ocko, 2023, Wide Range in Estimates of Hydrogen Emissions from Infrastructure, Frontiers in Energy Research Vol. 11: 1207208, https://www.frontiersin.org/articles/10.3389/fenrg.2023.1207208/full

[4] Najjar, Y.SH. and Mashareh S, 2019, Hydrogen Leakage Sensing and Control: (Review), Biomedical Journal of Scientific and Technical Research 21(5), https://biomedres.us/pdfs/BJSTR.MS.ID.003670.pdf

measurement. For example, semiconductor sensors and electrochemical sensors have high sensitivity and concentrations of hydrogen less than 10 ppm can be detected.[5]

This Study reviewed several types of leak detection equipment and evaluated anticipated advancements in sensor technology. Specific existing and emerging hydrogen leakage detection technologies reviewed are summarized in Table 1 below. Additional detail regarding each technology follows the table.

Table 1
Summary of Leak Detection Technologies

Technology	Leak Detection Range
Aerodyne Analyzer	10 ppb
Semiconductor Sensors	0.5 ppm to 5,000 ppm
Highly Sensitive Single-Crystalline Silicon Thermopiles Sensors	1 ppm to 20,000 ppm
Electrochemical Sensors	10 ppm and greater
Catalytic Combustion Sensors	1,000 ppm and greater
Detection Tapes	1,000 ppm and greater

Aerodyne Analyzer

Aerodyne Research, Inc., in collaboration with EDF and funding from DOE, developed an analyzer[6] that uses laser spectroscopy to detect and quantify hydrogen concentrations down to 10 parts per billion (ppb). The objective is to be able to quantify hydrogen emissions at the facility level. During testing in January 2023 at Colorado State University, high precision measurements were collected every second with 98% accuracy. The analyzer is portable and can be used in a vehicle or small aircraft to conduct the measurements.

Semiconductor Sensors

As a hydrogen detecting device, the hydrogen sensor is essentially a transducer that transforms the variation of physical or chemical properties into an electrical signal for practical applications. One of the hydrogen detection sensors used for hydrogen leak detection is a semiconductor type gas sensor. This sensor has a sintered structure in which tin oxide is vitrified. The semiconductor type gas sensor does not allow electricity to flow at normal room temperature. When operating

[5] Zhang, Haozhi, Hao Jia, Zao Ni, Ming Li, Ying Chen, Pengcheng Xu and Xinxin Li, 2023, *1ppm-detectable hydrogen gas sensors by using highly sensitive P+/N+ single-crystalline silicon thermopiles*, Microsystems & Nanoengineering: 9(29), https://doi.org/10.1038/s41378-023-00506-2
[6] As Climate Concerns About Hydrogen Energy Grow, New Tech Unveiled at CERAWeek Delivers Unprecedented Results Measuring Leaks, Other Emissions | Environmental Defense Fund (edf.org)

in ambient air conditions, oxygen in air is adsorbed to the sensor surface of the detector. The adsorbed oxygen inhibits the flow of electrons causing high electric resistance and a condition where electricity is difficult to flow (with no oxygen, electricity starts to flow when the sensor is exposed to a high temperature of approximately 752°F). When hydrogen gas is pulled in during the measurement, hydrogen molecules attach to oxygen (oxidation reaction) and oxygen attached to tin oxide decreases. Since the amount of oxygen on the sensor surface decreases, the electric resistance value decreases and electricity starts to flow easily. Leakage of hydrogen gas and gas concentrations are detected through this change of electric current. Figure 2 depicts these principles of a hydrogen leak test using semiconductor sensors.

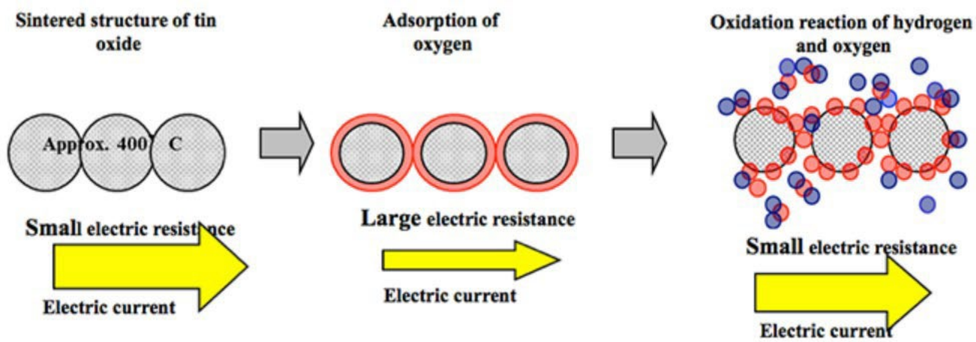

Figure 2 Semiconductor Sensors

For example, the Fukuda portable hydrogen leak detector HDA-0100 is an example of one of these detectors, with a sensitivity range of 0.5 to 5,000 ppm. It is capable of detecting extremely low levels of hydrogen (gas volume: 1×10^{-6} Pa・m3 /s) emitted from capillaries.[7]

According to the variation of electrical and optical properties of semiconductor oxide (SMO) sensors under a hydrogen-containing atmosphere, the SMO hydrogen sensors can be divided into four types: resistance based, work function based, optical and acoustic sensors.[8]

Resistance Based: The typical structure of a resistance-based SMO hydrogen sensor consists of a SMO layer on an insulating substrate and two electrodes, as well as a heater under the sensitive layer. During operation, the sensitive layer will be heated to a certain temperature for enhancement of the sensing performance. This temperature, which depends on the sensitivity of oxide materials used, is typically several hundred degrees Celsius. Resistance of the sensitive layer will change due to exposure to hydrogen gas. Variation depends on the hydrogen concentration and exhibits an approximately linear relationship with the hydrogen concentration within a certain range.

[7] FUKUDA, 2023, *Measurement Principle of Hydrogen Leak Test*, industry webpage accessed October 2023 at https://www.fukuda-jp.com/en/leak/f03/
[8] https://www.mdpi.com/1424-8220/12/5/5517

Work Function Based: This type of hydrogen sensor is operated based on the variation of work function induced by hydrogen. The work function-based sensors are generally formed using metal/oxide/semiconductor (MOS) layers. According to the difference in structure of each layer, these sensors can be divided into three major types: the Schottky diode type, MOS capacitor type and the MOS field-effect transistor (MOSFET) type. Field-effect transistor (FET) and Schottky diode hydrogen sensors are two different types of work function sensors.

Optical: There is a wide range of optical detection techniques available to visualize gas leaks. However, not all optical detection techniques work for hydrogen gas. Raman scattering, which is inelastic light scattering, is the only common optical technique suitable for hydrogen detection, as it is specific to hydrogen and has been shown to be technologically feasible (inelastic scattering from different molecules gives each component a spectral fingerprint). Additionally, optical SMO hydrogen sensors are based on the variation of optical properties of SMO materials or the whole sensor when they are exposed to a hydrogen-containing environment. Most optical hydrogen sensors are based on thin films coated onto the tip or side wall of an optical fiber. These optical fiber-based hydrogen sensors are known as optrodes or optodes.

Acoustic: Acoustic hydrogen sensors operate basing on variation of acoustic wave properties (e.g., resonance frequency) of the piezoelectric materials due to adsorption of hydrogen onto the sensing layers. As known, the resonance frequency of bulk and surface acoustic wave (BAW, SAW) devices is sensitive to the accumulation of mass on the surface of the piezoelectric materials, which is always used to measure the mass of concentration of loading matters in ambient or in liquid conditions and possess ultra-high sensitivity.

Highly Sensitive Single-Crystalline Silicon Thermopiles Sensors

Single-Crystalline Silicon Thermopile is a technology that uses Micro Electro-Mechanical Systems (MEMS) differential thermopile gas sensors (i.e., a set of thermocouples arranged for measuring small quantities of radiant heat), for highly sensitive, rapid detection of trace hydrogen gas in air. The sensor consists of two identical temperature-controlled thermopiles, which detect the very specific temperature change that results from the catalytic reaction of hydrogen on a sensing thermopile. By using single-crystalline silicon with a large Seebeck coefficient (the Seebeck effect is a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances) and high-density thermocouples, the thermopiles exhibit a temperature sensitivity of 28 millivolt per °C and sub millikelvin level temperature resolution. The sensors demonstrate an outstanding yet balanced performance with a detection limit of 1 ppm, a wide linear detection range of 1 ppm to 20,000 ppm and a fast response and recovery time of 1 to 2 seconds. Moreover, the sensors also have good selectivity to hydrogen, repeatability, and long-term stability.[9]

Electrochemical Sensors

Electrochemical hydrogen sensors are devices for detecting hydrogen concentrations that are dependent on electrochemical reactions at the sensing electrode. The signal from an electrochemical cell changes in proportion to the hydrogen concentration at the electrode surface. These sensors have the advantages of room temperature operation and low power consumption. The principle of an electrochemical hydrogen sensor is that hydrogen reacts with the sensing electrode material to produce electron transfer, hydrogen is oxidized at the anode, oxygen is reduced at the cathode, and the concentration of hydrogen is obtained by detecting the change of electrical signal.[10]

Catalytic Combustion Sensors

Catalytic combustion hydrogen sensors comprise sensing elements and catalytic metals such as Palladium, Platinum, and Ruthenium. Hydrogen is spontaneously oxidized at a temperature above its ignition point (1085°F) when the environment does not contain a catalyst or ignition source. However, hydrogen's ignition point decreases to 572 to 932°F in the presence of a catalytic metal such as Platinum. When the temperature of the sensing element increases during an exothermic reaction between hydrogen and oxygen on the surface of the catalytic metal, the resistance value of the sensing element changes, and the hydrogen concentration is measured in terms of the change in the resistance value. Catalytic combustion hydrogen sensors have limited applicability in portable devices because of their high operating temperatures and high power consumption.[11]

Detection Tapes

Detection tapes are one of the simplest and most effective methods of hydrogen detection that have been developed over the past few decades with input from several research and engineering institutions. The hydrogen detection tape changes colors in less than three minutes and at concentrations as low as 1,000 ppm. Research into detection tape has been supported by the US DOE Hydrogen and Fuel Cell Technologies Office and NREL. Made of a silicone base, the chemochromic detection tape relies on partial oxidation of a transition metal oxide, resulting in

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[9] Zhang, Haozhi, Hao Jia, Zao Ni, Ming Li, Ying Chen, Pengcheng Xu and Xinxin Li, 2023, 1ppm-detectable hydrogen gas sensors by using highly sensitive P+/N+ single-crystalline silicon thermopiles, Microsystems & Nanoengineering: 9(29), https://doi.org/10.1038/s41378-023-00506-2

[10] Wang, Chao, Jiaxuan Yang, Jiale Li, Chenglin Luo, Xiaowei Xu, and Feng Qian, 2023, *Solid-state electrochemical hydrogen sensors: A review*, International Journal of Hydrogen Energy: 48 (80) pgs 31377-31391, https://doi.org/10.1016/j.ijhydene.2023.04.167

[11] Leea, Jun-Seo, Jin Woo Ana, Sukang Baeb, and Seoung-Ki Leea, 2022, *Review of Hydrogen Gas Sensors for Future Hydrogen Mobility Infrastructure*, Applied Science and Convergence Technology 31(4) pgs 79-84, https://doi.org/10.5757/ASCT.2022.31.4.79

a change in color in the presence of hydrogen. The tape can be readily used on flanges, welded seams and joints, rigid pipelines, and flexible tubing.[12]

3.2.2 Published Studies Regarding Hydrogen Leakage

The estimates of potential for leakage from components of new Angeles Link infrastructure (production, compression, storage, and transmission) in available literature were reviewed to gather information for potential future implementation of the total value chain approach estimate. Studies published in the literature used various methods to develop the potential for leakage estimates which included assumptions, calculations via proxies such as natural gas, laboratory experiments, and theory-based models or simulations. The publications reviewed appear to generally agree on the need of performing additional research and investigation to generate more refined estimates of the potential for leakage. The study leaned heavily on an article[13] that was prepared by Environmental Defense Fund (EDF) and the National Fuel Cell Research Center at the University of California, Irvine (UCI) in 2023 that compiled information gathered from several articles published in the last several years. A summary of uncontrolled estimates for the total value chain approach that may be applicable to the new Angeles Link infrastructure and the associated production and storage infrastructure of third parties is provided in Table 2 below. These values may be reduced by applying the opportunities to minimize and mitigate leakage discussed elsewhere in this document.

Table 2
Summary of Uncontrolled Leakage Rates Found in the Literature

Component	Values
Production	0.0001%, 0.03%, 0.1%, 0.2%, 0.24%, 0.25%, 0.5%, 0.52%, 4%, 4%
Compression[14]	0.14%, 0.27%
Aboveground Storage	2.77%, 6.52%
Underground Storage	0.02%, 0.06%
Transmission	0.02%, 0.04%, 0.06%, 0.1%, 0.2%, 0.4%, 0.48%, 1%

[12] Fan, Zhiyuan, Hadia Sheerazi, Amar Bhardwaj, Anne-Sophie Corbeau, Kathryn Longobardi, Adalberto Castañeda Vidal, Ann-Kathrin Merz, Dr. Caleb M. Woodall, Mahak Agrawal, Sebastian Orozco-Sanchez, Dr. Julio Friedmann, 2022, Hydrogen Leakage: A Potential Risk for the Hydrogen Economy, report from Colombia Center on Global Energy Policy, July, https://www.energypolicy.columbia.edu/publications/hydrogen-leakage-potential-risk-hydrogen-economy/

[13] Esquivel-Elizondo, Sofia, Alejandra Hormaza Mejia, Tianyi Sun, Eriko Shrestha, Steven P. Hamburg and Ilissa B. Ocko, 2023, Wide Range in Estimates of Hydrogen Emissions from Infrastructure, Frontiers in Energy Research Vol. 11: 1207208, https://www.frontiersin.org/articles/10.3389/fenrg.2023.1207208/full

[14] Compressors may be used for both storage and transmission of hydrogen.

As shown in the above table, there is considerable variability in the values. The background studies were evaluated more closely to determine the assumptions that were used to develop these estimates.

Production

For Production, the 0.0001% estimate is for steam methane reformers. The 0.03%, 0.1%, 0.2%, and 4% estimates are for electrolyzers, and the other 4% is for PEM electrolyzers. The 0.24%, 0.25%, 0.50%, and 0.52% values are based on estimates using conventional fluid mechanics.

- The 0.0001%[15] estimate was presented as the current understanding of losses from steam methane reformers which are typically flared and therefore don't have hydrogen going to the atmosphere.
- The 0.03%[16] estimate was based on the expectation that hydrogen losses in production will drop by 2030 due to maturing technologies such as reduced crossover through the membrane.
- The 0.1%[17] estimate reflects the lower end of a calculation performed to estimate losses for a variety of electrolyzer technologies for hydrogen production for domestic and international supply chains that were evaluated.
- The 0.2%[18] estimate was presented as the current understanding of losses during electrolysis. In addition to inadvertent leakage, the losses are generally due to hydrogen and oxygen crossover through the membrane and to the dryer's regeneration process.
- The 0.24%[19] estimate was predicted using a model with a 50% confidence level using natural gas emission estimates and conventional fluid mechanics to make predictions for hydrogen, in this case for electrolytic production with full recombination of hydrogen from purging and crossover venting,

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[15] Arrigoni, Alessandro and Laura Bravo Diaz, 2022, Hydrogen Emissions from a Hydrogen Economy and their Potential Global Warming Impact, Publications Office of the European Union EUR 31188 EN, ISBN 978-92-76-55848-4, doi:10.2760/065589, JRC130362. https://publications.jrc.ec.europa.eu/repository/handle/JRC130362

[16] Arrigoni, Alessandro and Laura Bravo Diaz, 2022, Hydrogen Emissions from a Hydrogen Economy and their Potential Global Warming Impact, Publications Office of the European Union EUR 31188 EN, ISBN 978-92-76-55848-4, doi:10.2760/065589, JRC130362. https://publications.jrc.ec.europa.eu/repository/handle/JRC130362

[17] Cooper, Jasmin, Luke Dubey, Semra Bakkaloglu, Adam Hawkes, 2022, Hydrogen Emissions from the Hydrogen Value Chain - Emissions Profile and Impact to Global Warming, Science of the Total Environment Vol. 380: 154624, July 15, https://www.sciencedirect.com/science/article/pii/S004896972201717X#s0070

[18] Arrigoni, Alessandro and Laura Bravo Diaz, 2022, Hydrogen Emissions from a Hydrogen Economy and their Potential Global Warming Impact, Publications Office of the European Union EUR 31188 EN, ISBN 978-92-76-55848-4, doi:10.2760/065589, JRC130362. https://publications.jrc.ec.europa.eu/repository/handle/JRC130362

[19] Frazer-Nash Consultancy, 2022, Fugitive Hydrogen Emissions in a Future Hydrogen Economy, prepared for the U.K. Department for Business, Energy & Industrial Strategy (BEIS), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1067137/fugitive-hydrogen-emissions-future-hydrogen-economy.pdf

- The 0.25%[20] estimate was predicted using a model with a 50% confidence level using natural gas emission estimates and conventional fluid mechanics to make predictions for hydrogen, in this case for CCUS enabled production.
- The 0.50%[21] estimate was predicted using a model with a 99% confidence level using natural gas emission estimates and conventional fluid mechanics to make predictions for hydrogen, in this case for CCUS enabled production.
- The 0.52%[22] estimate was predicted using a model with a 99% confidence level using natural gas emission estimates and conventional fluid mechanics to make predictions for hydrogen, in this case for electrolytic production with full recombination of hydrogen from purging and crossover venting.
- The 4%[23] estimate was from a laboratory study of a prototype PEM electrolyzer that found most of the hydrogen losses occurred in the dryer (3.4%).
- The other 4%[24] reflects the upper end of a calculation performed to estimate losses for a variety of electrolyzer technologies for green hydrogen production for domestic and international supply chains that were evaluated.

Compression

- The 0.14% and 0.27% values[25] are the lower and upper limits, respectively, estimated by modeling since data was scarce. Natural gas was used as a proxy and relative leak rates were estimated based on differences in physical properties of natural gas and hydrogen.

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[20] Frazer-Nash Consultancy, 2022, Fugitive Hydrogen Emissions in a Future Hydrogen Economy, prepared for the U.K. Department for Business, Energy & Industrial Strategy (BEIS), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1067137/fugitive-hydrogen-emissions-future-hydrogen-economy.pdf

[21] Frazer-Nash Consultancy, 2022, Fugitive Hydrogen Emissions in a Future Hydrogen Economy, prepared for the U.K. Department for Business, Energy & Industrial Strategy (BEIS), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1067137/fugitive-hydrogen-emissions-future-hydrogen-economy.pdf

[22] Frazer-Nash Consultancy, 2022, Fugitive Hydrogen Emissions in a Future Hydrogen Economy, prepared for the U.K. Department for Business, Energy & Industrial Strategy (BEIS), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1067137/fugitive-hydrogen-emissions-future-hydrogen-economy.pdf

[23] Harrison, Peters, 2013, National Renewable Energy Laboratory, 2013 DOE Hydrogen and Fuel Cells Program Review, Renewable Electrolysis Integrated System Development & Testing, Project ID PD031. https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/review13/pd031_harrison_2013_o.pdf

[24] Cooper, Jasmin, Luke Dubey, Semra Bakkaloglu, Adam Hawkes, 2022, Hydrogen Emissions from the Hydrogen Value Chain - Emissions Profile and Impact to Global Warming, Science of the Total Environment Vol. 380: 154624, July 15, https://www.sciencedirect.com/science/article/pii/S004896972201717X#s0070

[25] Cooper, Jasmin, Luke Dubey, Semra Bakkaloglu, Adam Hawkes, 2022, Hydrogen Emissions from the Hydrogen Value Chain - Emissions Profile and Impact to Global Warming, Science of the Total Environment Vol. 380: 154624, July 15, https://www.sciencedirect.com/science/article/pii/S004896972201717X#s0070

Literature values from a 2015 study[26] of natural gas leakage rates for reciprocating compressors were used as an input to the model.

Aboveground Storage

- The 2.77%[27] is an estimate derived from an uncertainty model to provide probabilistic predictions for hydrogen with a 50% confidence level. Storage was assumed to occur in compressed tanks and leakage rates of 0.005% to 0.01%[28] per hour from compressed gas cylinders was used as an input to the model. Duration of storage has the largest impact on this value and was assumed to be two days.
- The 6.52%[29] is an estimate derived from an uncertainty model to provide probabilistic predictions for hydrogen with a 99% confidence level. Storage was assumed to occur in compressed tanks and leakage rates of 0.005% to 0.01%[30] per hour from compressed gas cylinders was used as an input to the model. Duration of storage has the largest impact on this value and was assumed to be thirty days.

Underground Storage

- The potential for hydrogen leakage from underground storage of hydrogen in salt caverns are predicted to be very low, in the range of 0.02% to 0.06%[31]. Primary leakage potential areas are from the surface plant during maintenance or emergency venting. It is anticipated that technologies could be developed to reduce, or even eliminate these. The number of caverns has the largest impact on the magnitude of the potential for leakage.

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[26] Subramanian, R., Williams, L.L., Vaughn, T.L., Zimmerle, D., Roscioli, J.R., Herndon, S.C., Yacovitch, T.I., Floerchinger, C., Tkacik, D.S., Mitchell, A.L., Sullivan, M.R., Dallmann, T.R., Robinson, A.L., 2015. Methane emissions from natural gas compressor stations in the transmission and storage sector: measurements and comparisons with the EPA greenhouse gas reporting program protocol. Environ. Sci. Technol. 49, 3252–3261. https://doi. org/10.1021/es5060258

[27] Frazer-Nash Consultancy, 2022, Fugitive Hydrogen Emissions in a Future Hydrogen Economy, prepared for the U.K. Department for Business, Energy & Industrial Strategy (BEIS), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1067137/fugitive-hydrogen-emissions-future-hydrogen-economy.pdf

[28] DOE, "Conformable Hydrogen Storage Pressure Vessel."

[29] Frazer-Nash Consultancy, 2022, Fugitive Hydrogen Emissions in a Future Hydrogen Economy, prepared for the U.K. Department for Business, Energy & Industrial Strategy (BEIS), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1067137/fugitive-hydrogen-emissions-future-hydrogen-economy.pdf

[30] DOE, "Conformable Hydrogen Storage Pressure Vessel."

[31] Frazer-Nash Consultancy, 2022, Fugitive Hydrogen Emissions in a Future Hydrogen Economy, prepared for the U.K. Department for Business, Energy & Industrial Strategy (BEIS), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1067137/fugitive-hydrogen-emissions-future-hydrogen-economy.pdf

Transmission

- The 0.02% and 0.06% values[32] were the lower and upper limits estimated by modeling. Natural gas was used as a proxy and leak rates for hydrogen were estimated based on the knowledge related to the type of leak, as well as the flow and physical properties of natural gas and hydrogen. Literature values from a 2015 study[33] of natural gas leakage rates for natural gas pipelines were used as an input to the model. Plastic (polyvinyl chloride and polyethylene) was chosen as the pipeline material to minimize leaks and embrittlement.
- The 0.04%[34] value is an estimate with a 50% confidence level lower limit based on data from the Digest of UK Energy Statistics for natural gas transmission.
- The 0.1%[35] is an estimate for new pipelines dedicated to transport of hydrogen. The estimate was developed by combining a global energy system model and a global atmospheric model to explore the range of impacts of hydrogen on atmospheric chemistry. The role of hydrogen in the global energy system and related emissions were calculated using the global energy system simulation model TIMER which was used to develop a set of widely diverging scenarios with respect to hydrogen application.
- The 0.2% and 0.4% values[36] are the lower and upper estimates for the leakage rate of hydrogen passing through a pipeline based on natural gas leakage rates in local distribution pipelines. Estimates were developed using activity data of miles of pipe, leaks per mile, and average emissions per leak collected from in-field validation studies and pipeline infrastructure information for six locations on the east coast of the United States.[37]

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[32] Cooper, Jasmin, Luke Dubey, Semra Bakkaloglu, Adam Hawkes, 2022, Hydrogen Emissions from the Hydrogen Value Chain - Emissions Profile and Impact to Global Warming, Science of the Total Environment Vol. 380: 154624, July 15, https://www.sciencedirect.com/science/article/pii/S004896972201717X#s0070

[33] Subramanian, R., Williams, L.L., Vaughn, T.L., Zimmerle, D., Roscioli, J.R., Herndon, S.C., Yacovitch, T.I., Floerchinger, C., Tkacik, D.S., Mitchell, A.L., Sullivan, M.R., Dallmann, T.R., Robinson, A.L., 2015. Methane emissions from natural gas compressor stations in the transmission and storage sector: measurements and comparisons with the EPA greenhouse gas reporting program protocol. Environ. Sci. Technol. 49, 3252–3261. https://doi. org/10.1021/es5060258

[34] Frazer-Nash Consultancy, 2022, Fugitive Hydrogen Emissions in a Future Hydrogen Economy, prepared for the U.K. Department for Business, Energy & Industrial Strategy (BEIS), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1067137/fugitive-hydrogen-emissions-future-hydrogen-economy.pdf

[35] van Ruijven, B., J.F. Lamarque, D.P. van Vuuren, T. Kram, and H. Eerens, 2011, Emission scenarios for a global hydrogen economy and the consequences for global air pollution. Glob. Environ. Change 21, 983–994. doi:10.1016/j.gloenvcha.2011.03.013

[36] Fan, Zhiyuan, Hadia Sheerazi, Amar Bhardwaj, Anne-Sophie Corbeau, Kathryn Longobardi, Adalberto Castañeda Vidal, Ann-Kathrin Merz, Dr. Caleb M. Woodall, Mahak Agrawal, Sebastian Orozco-Sanchez, Dr. Julio Friedmann, 2022, Hydrogen Leakage: A Potential Risk for the Hydrogen Economy, report from Colombia Center on Global Energy Policy, July, https://www.energypolicy.columbia.edu/publications/hydrogen-leakage-potential-risk-hydrogen-economy/

[37] Weller, Zachary D., Steven P. Hamburg, and Joseph C. von Fischer. 2020. “A National Estimate of Methane Leakage from Pipeline Mains in Natural Gas Local Distribution Systems.” Environmental Science and Technology 54, no. 14 (July 21): 8958–67. https://doi.org/10.1021/ acs.est.0c00437

- The 0.48%[38] is an estimate with a 99% confidence level lower limit based on data from the Digest of UK Energy Statistics for natural gas transmission.
- The 1%[39] value is based on the current estimated leakage of delivered hydrogen from international transportation via pipelines in Europe. This is predicted to decrease to less than 0.7% by 2030.

3.3 OPPORTUNITIES TO MINIMIZE LEAKAGE

The Study evaluated three primary types of mitigation opportunities: 1) Design and Engineering; 2) Operation; and 3) Maintenance & Repair. Table 3 summarizes these opportunities and provides an estimated range of percent mitigation that may be achieved. Although detailed reduction estimates have not been provided for each mitigation opportunity described, the overall systemwide leakage reductions are expected to be at least 90% with implementation of all of them. Detailed information regarding each of these opportunities follows Table 3.

Table 3
Summary of Opportunities to Minimize and Mitigate the Potential for Leakage

Opportunity[40]	Estimated Reduction Potential
Design and Engineering	Up to 100%
▪ Compressors: Leakage capture and return mechanism with vapor control system	95% or greater
▪ Pipelines: Welded connections and leak tight valves	Up to 100%
Operations	Not quantified at this time
Maintenance and Repair (Leak detection and repair program for valves, flanges, connections, etc.)	89% to 96%

3.3.1 Design and Engineering

Initial design and engineering of the new infrastructure focused on minimizing the potential for leakage provides opportunities for the life of the project, as well as the life of third party production and storage. This includes consideration with respect to the processes, equipment, systems, and materials that will be used in the project. Design-based mitigation measures, where

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38 Frazer-Nash Consultancy, 2022, Fugitive Hydrogen Emissions in a Future Hydrogen Economy, prepared for the U.K. Department for Business, Energy & Industrial Strategy (BEIS), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1067137/fugitive-hydrogen-emissions-future-hydrogen-economy.pdf

39 Arrigoni, Alessandro and Laura Bravo Diaz, 2022, Hydrogen Emissions from a Hydrogen Economy and their Potential Global Warming Impact, Publications Office of the European Union EUR 31188 EN, ISBN 978-92-76-55848-4, doi:10.2760/065589, JRC130362. https://publications.jrc.ec.europa.eu/repository/handle/JRC130362

40 Refers to design & engineering, operations, and maintenance of infrastructure (production, compression, storage and transmission).

possible, may result in up to zero or near-zero leakage or significant potential to minimize leakage and should be implemented during the design and engineering phases as much as possible. The following are opportunities to minimize leakage.

Leak detection system on compressors: Each compressor could also include a leak detection system that monitors the integrity of the diaphragms and static O-rings. Breaches in these components can signal an alarm and or automatically shut down the compressor.[41]

Leakage capture and return mechanism: A collection and recompression system can be used to capture leakage and route it to another portion of the process such as the compressor suction, thereby eliminating leakage. These re-compression systems can be used for any leakage source that can be captured and routed to a closed system. In the case of the compressors, gas leakage thru seals could in many cases be captured and directed to the suction of the unit for reprocessing. Potential leakage reductions from implementing designs to capture and reroute process gas, using vapor control systems, can be estimated to be at least 95%, using data from natural gas operations as a proxy.[42] In the case of electrolyzers, venting and purging is considered one of the main causes of leakage, and when captured, leakage could be reduced significantly.

Purge system: Potential leaks from compressor seals can be mitigated by using a purge system to contain the leakage and prevent it from escaping the seal system.

Dry seals: A similar scenario that occurs in natural gas centrifugal compressors may happen in hydrogen compressors as well. These compressors contain rotating shafts that require seals to prevent high-pressure natural gas from escaping the compressor casing. Traditionally, these seals used high pressure oil as a barrier against escaping gas; these seals are referred to as “wet seals”. Alternatively, centrifugal compressors can be equipped with mechanical seals, called “dry seals,” which have substantially lower emissions.

Compressors with diaphragms: Diaphragm compressors are designed for zero leakage through the sealing. A diaphragm compressor is a positive displacement machine which consists of a hydraulic system and a gas compression system. Triple metal diaphragm compressors are unique because they are leak free and non-contaminating since they do not utilize dynamic seals and the diaphragm set completely isolates the process gas from the hydraulic system.

Storage Vessels: Engineering and design considerations include: 1) optimize/reduce the total surface storage to meet system operational needs; 2) use the combination commercial vessel size and design pressure that decreases the number of total required vessels; 3) minimize the number of connections and valves; and 4) evaluate alternate gas storage technologies being developed, which could be commercial in the near future.

Transmission via Pipeline: Design to minimize potential for leakage by reducing the number of pipe connections, by using welded connections rather than flanges, and by ensuring that the valves are leak tight. Welded pipes are continuous, minimizing leak points, whereas flanged

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[41] PDC Machine, 2023, *Diaphragm Compressors*, industry brochure, https://www.pdcmachines.com/wp-content/uploads/2023/02/PDC_Brochure_V21_USA_SM.pdf

[42] US EPA, 2023c, Natural Gas STAR Program: Vapor Recovery Units, webpage, https://www.epa.gov/natural-gas-star-program/vapor-recovery-units

connections can leak at the flanged connection. Leak tight valves have additional packing in the valve to minimize the leaks for the valve stem. Welded joints in place of flanged joints can also reduce the potential for leaks.

3.3.2 Operations

- Operations of the infrastructure to enhance leakage minimization opportunities are associated with operators' knowledge, which is linked to having staff with the proper level of experience and training and detailed written operations procedures. Operational staff with the knowledge and expertise for safe and efficient operation of hydrogen infrastructure requires training. The hydrogen economy will require the development of a new work force or/and the retraining of existing workers to operate future hydrogen facilities. In reference to training, there are several organizations that provide operator training services,[43] [44] and it is expected that when the market grows, more organizations will be added to the list. Operations manuals detailing procedures should contain the information regarding the operation of the systems and facilities. The manual could include day-to-day activities necessary for the facility, its systems, equipment, and occupants/users to perform their intended functions. These functions may include required safety and environmental protection protocols, as well as opportunities to minimize potential for hydrogen leakage.

3.3.3 Maintenance and Repair

- Studies have shown that many different mechanisms can affect the need for maintenance or contribute to the failure of an equipment part such as packing wear on a valve in place.[45] Having a regular maintenance program offers opportunities to minimize the potential for leakage from infrastructure. For example, a predictive or condition-based maintenance approach is one in which operating conditions are monitored and maintenance decisions are based on either performance or defined conditions. Leak detection and repair programs are used across the natural gas industry and result in reductions in overall system leakage. These same practices can be adopted by the hydrogen industry to increase the likelihood that valves and other components are maintained leak tight.

- Timely repair in conjunction with timely leak detection can minimize leakage by reducing the leak duration. Traditional leak detection methodologies include conducting regular screening of components using sensors or optical imaging instruments. Sensors can be used for regular/frequent/continuous screening of potential sources of leakage.

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[43] US DOE, 2023f, Education, Office of EERE webpage, https://www.hydrogen.energy.gov/program-areas/education

[44] GTI Energy, 2024, Hydrogen Training, webpage, https://www.gti.energy/training-events/training-overview/hydrogen-training/

[45] INGAA, 2018, Improving Methane Emissions from Natural Gas Transmission and Storage, August, https://ingaa.org/wp-content/uploads/2018/08/34990.pdf

- High-performance hydrogen gas sensors with low-concentration detection limits, wide measurement ranges, and fast responses can be used to monitor potential for leakage and facilitate timely repairs to minimize potential for leakage to the atmosphere. The potential reductions potential is estimated to range from 89%[46] to 96%[47].

4.0 PRELIMINARY FINDINGS

This Study summarizes potential sources of leakage, leakage estimation methodologies, and opportunities to mitigate and minimize the potential for leakage. Data reported in literature that was reviewed from the last two decades shows significant variation in estimates for potential hydrogen leakage. This indicates that additional research and investigation of hydrogen leakage is required for more detailed predictions. With more accurate measurements of hydrogen leakage and implementation of mitigation strategies, the likelihood of infrastructure with the potential for leakage can be minimized.[48] [49] [50]

This Study found that there is not enough available data to estimate the volumetric potential for leakage associated with Angeles Link, including third party production and storage, using the value chain or component-level approaches. Significantly more data and information are needed to use either of these methodologies.

Uncertainty

The uncertainty related to the overall results is primarily due to the fact that information used for this Study is preliminary, and secondarily related to the limited amount of information available regarding actual leak measurement data for hydrogen. With infrastructure design development, project refinements, and detailed information from technological data measurement and collection advancements, these initial estimates can be further refined.

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[46] California State University, Fullerton. 2012. Estimation of Methane Emissions from the California Natural Gas System (California Energy Commission), website: http://www.energy.ca.gov/2014publications/CEC-500-2014- 072/CEC-500-2014-072.pdf

[47] Pacific Gas and Electric Company's Comments on the Revised Draft Regulation Proposal for Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities, https://ww2.arb.ca.gov/sites/default/files/classic/isd/cc/oil-gas/meetings/pge_02262016.pdf

[48] Hauglustaine, D., F. Paulot, W. Collins, R. Derwent, M. Sand and O. Boucher, 2022, Climate benefit of a future hydrogen economy, Comm. in Earth & Environment, 3 Article 295, https://doi.org/10.1038/s43247-022-00626-z

[49] Ocko, I. and S. Hamburg, 2022, For hydrogen to be a climate solution, leaks must be tackled, Environmental Defense Fund blog, March, https://www.edf.org/blog/2022/03/07/hydrogen-climate-solution-leaks-must-be-tackled

[50] Warwick, N.J., A.T. Archibald, P.T. Griffiths, J. Keeble, F.M. O'Connor, J.A. Pyle, and K.P. Shine, 2023, Atmospheric composition and climate impacts of a future hydrogen economy, Atmospheric Chemistry and Physics 23(20) 12451-13467, https://doi.org/10.5194/acp-23-13451-2023

5.0 CONCLUSION

Preliminary findings and data for leakage related to Angeles Link, including third party production and storage, as set forth in this Study and are for informative purposes for Phase One of the Angeles Link project. Information from parallel studies related to hydrogen infrastructure is still evolving. These preliminary findings and data may be further refined in response to feedback from the Planning Advisory Group (PAG) and Community Based Organization Stakeholder Group (CBOSG).

This Study acknowledges that while limited data exists in the literature for actual measurements of hydrogen for production, compression, storage, and transmission of clean renewable hydrogen, measurement technologies and calculation methodologies related to hydrogen are anticipated to develop further over time. As signification enhancements have been made for natural gas leak detection and mitigation over the past decades, it is anticipated that developments will similarly be made for hydrogen to minimize the potential for leakage to the atmosphere. The design details of the Angeles Link infrastructure, as well as further project refinements, will inform future refinements of the evaluation of the potential for leakage and opportunities to minimize leakage of hydrogen.

Dear PAG and CBOSG Members,

The purpose of this letter is to provide a brief explanation of minor revisions that have recently been made to the Angeles Link NOx Evaluation Preliminary Data and Findings ("NOx Study"), which was first shared with PAG and CBOSG members on February 28, 2024. After receiving feedback on the NOx Preliminary Data & Findings, it came to our attention that a portion of the study describing reductions of NOx emissions for the mobility sector was unclear with respect to role clean renewable hydrogen will play in reducing emissions.

Specifically, the NOx Study notes in multiple sections that "[m]obility NOx emissions (e.g., primarily heavy duty transportation) are projected to be eliminated with conversion to hydrogen fuel cells," and the "[m]obility sector comprises 99.8% and 99.6% of overall NOx reductions based on the low and high demand scenarios, respectively." To clarify, the NOx Preliminary Data & Findings does not claim that reductions in mobility-related NOx emissions will be attributable nearly exclusively to the replacement of existing vehicles with hydrogen fuel cell fleets. Instead, SoCalGas anticipates that a mix of zero emission vehicles (ZEVs) comprised of hydrogen fuel cell electric vehicles (FCEVs) and battery electric vehicles (BEVs) will result in the elimination of NOx emissions. In the NOx Preliminary Data & Findings, SoCalGas was attempting to convey that, with respect to Angeles Link, between 99.8% and 99.6% of the NOx emissions related to the project will be attributable to the use of clean renewable hydrogen in the mobility sector.

In order to clarify this point, SoCalGas has made minor revisions to the NOx Study, as demonstrated in the attached redline comparison. Specifically, SoCalGas revised the NOx Preliminary Data & Findings to explain that the identified NOx reductions are those associated with the anticipated fossil fuel displacement with FCEVs, which will make up a portion of the ZEV market. Again, these changes are intended to clarify that the use of clean renewable hydrogen in the mobility sector will be the source of nearly all of Angeles Link's NOx reductions, but the study does not conclude that FCEVs will be the only ZEVs in California's transportation future.

We hope this updated NOx Preliminary Data & Findings clarifies these points and we look forward to additional feedback.

Thank you,

Sincerely,

Amy Kitson

Angeles Link Director
Engineering & Technology

Angeles Link | NOx Evaluation
Preliminary Data and Findings

~~February~~ March 2024 (Revised)

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Tables

1. Executive Summary

SoCalGas is proposing to develop a clean renewable hydrogen[1] transport system to serve end users in the Central and Southern California area including the LA Basin (inclusive of the Ports of Los Angeles and Long Beach) (Angeles Link). On December 20, 2022, the California Public Utilities Commission (CPUC) issued the "Decision Approving the Angeles Link Memorandum Account to Record Phase One Costs" to track costs for advancing the first studies under Phase One of the Angeles Link Project. The Decision requires (OP 6 (h)) SoCalGas to assess potential NOx emissions associated with Angeles Link, including appropriate controls to mitigate such emissions.

The purpose of this study is to assess the potential for both NOx emissions increases and reductions associated with Angeles Link, which accounts for emissions from not just transmission of hydrogen, but also from to third party production and storage as well as end users. This NOx assessment evaluates potential NOx and other air emissions associated with new hydrogen infrastructure (i.e., production[2], storage and transportation), as well as potential NOx emissions associated with end users in the mobility, power generation, and hard-to-electrify industrial sectors. The NOx emissions associated with water conveyance for production of hydrogen were not included in the scope of this study.

The study also identified potential NOx emission minimization opportunities to reduce potential NOx emissions. Although NOx is the primary focus of this emissions assessment, the study also includes a high-level assessment of other potential emissions, with a focus on volatile organic compounds (VOC) which is a precursor to ozone, and diesel particulate matter (DPM), which is the primary pollutant associated with diesel combustion.

Projected quantities of displacement of diesel and gasoline by hydrogen fuel cells in the mobility sector, and anticipated replacement of natural gas with hydrogen in the power generation and hard-to-electrify industrial sectors were based on estimated demand values provided by the parallel Demand Study. The Demand Study, which was relied on when estimating projected NOx emissions, projected economy wide demand in the Central and Southern California areas using three scenarios: low demand, moderate demand, and high demand. These are referred to as conservative, moderate, and ambitious demand, respectively, in the Demand Study.

In comparison to the Demand Study values, the projected throughput of Angeles Link is estimated to range from 0.5 to 1.5 million metric tonnes per year (MMT/yr). The three throughput scenarios for the Angeles Link buildout (0.5 MMT/yr, 1.0 MMT/yr, and 1.5 MMT/yr) align with the low,

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[1] In the Decision, clean renewable hydrogen refers to hydrogen that does not exceed 4 kilograms of carbon dioxide equivalent (CO2e) produced on a lifecycle basis per kilogram of hydrogen produced and does not use fossil fuel in the hydrogen production process, where fossil fuel is defined as a mixture of hydrocarbons including coal, petroleum, or natural gas, occurring in and extracted from underground deposits. (D.22-12-057)

[2] Production is anticipated to be conducted by a third party.

moderate and high Demand Scenarios (1.9 MMT/yr, 3.2 MMT/yr, and 5.9 MMT/yr). To estimate the potential NOx emissions associated with the project, including those from not just transmission of hydrogen, but also from third party production and storage as well as end users, the results for NOx and other pollutants were calculated using the estimates based on the Demand Study data. The ratio of anticipated hydrogen throughput values for Angeles Link to projected values in the Demand Study were then calculated for each of the conservative (26.85%), moderate (31.12%), and ambitious (25.36%) scenarios. These ratios were applied to the NOx and other pollutants estimated emissions using the Demand Study scenarios to determine NOx and other pollutants estimates associated with Angeles Link Throughput Scenarios. This analysis is shown in Table 1 below.

Table 1. NOx Reduction Estimates for Demand Study Scenarios Applied to Projected Angeles Link Throughput Scenarios

Demand Scenario	Total Projected Hydrogen Demand (MMT/yr)	Overall NOx Reductions for Demand in 2045 (tpy)	Angeles Link Projected Hydrogen (MMT/yr)	Overall NOx Reductions Associated with Angeles Link in 2045 (tpy)
Low	1.9	13,732	0.5	3,763
Moderate	3.2	17,003	1	5,292
High	5.9	20,271	1.5	5,141

The preliminary key findings for NOx emissions reductions based on the Demand Study scenarios are discussed below and further within this document.

- Overall NOx emissions are projected to potentially be reduced by approximately 13,700 tons per year and 20,000 tons per year in 2045 based on the low and high demand scenarios of the Demand Study, respectively. ("Low Demand Scenario" and "High Demand Scenario"). This is equivalent to removing approximately 69,000 to 100,000 diesel semi-trailer trucks per year from the roads.[3]
- Mobility NOx emissions (e.g., primarily heavy duty transportation) will be reduced with the conversion to zero emission vehicles (ZEVs). Options for ZEVs include hydrogen fuel cell electric vehicles (FCEVs) and battery electric vehicles (BEVs). The Demand Study projected the anticipated fossil fuel displacement associated with FCEVs only. The associated NOx reductions ~~are projected to be eliminated~~ were estimated only for ~~with~~

[3] Alternative Fuels Data Center: Maps and Data - Average Annual Vehicle Miles Traveled by Major Vehicle Category (energy.gov)

conversion to ~~hydrogen fuel cells~~ FCEVs; this study does not project emission reductions related to fossil fuel displacement that will be associated with BEVs.

  - Mobility sector comprises 99.8% and 99.6% of overall NOx reductions related to Angeles Link (i.e., associated with conversion to FCEVs) based on the low and high demand scenarios, respectively.

- Power generation and the hard-to-electrify industrial sector's permitted NOx emissions are projected to stay the same or decrease. In reaching this determination, the study concluded that permitted NOx emissions would stay the same or decrease given the air Districts' need to achieve ozone attainment.[4]
  - Power generation sector comprises 0.11% and 0.25% of the overall NOx reductions based on the low and high demand scenarios, respectively.
  - Hard to electrify industrial sector comprises 0.13% and 0.31% of the overall NOx reductions based on the low and high demand scenarios, respectively.
- Projected NOx reductions in 2037 based on the Low Demand Scenario and High Demand Scenario are up to 9% and 20%, respectively, of South Coast Air Quality Management District (AQMD)'s forecasted NOx emissions in 2037.
- Projected DPM reductions based on the Low Demand Scenario and High Demand Scenario are projected to be up to 40% and 82%, respectively, of South Coast AQMD's forecasted PM2.5 Emissions in 2037.
- Projected VOC reductions based on the Low Demand Scenario and High Demand Scenario are up to 17% and 28%, respectively, of South Coast AQMD's forecasted VOC Emissions in 2037.
- Infrastructure NOx emissions are projected to be minor in nature when compared to overall NOx emissions reductions at 3.4% and 9.6% of end-user reductions for the low and high demand scenarios, respectively.

The preliminary key findings for NOx emissions reductions associated with Angeles Link throughput scenarios, which accounts for emissions not just from transmission of hydrogen, but also from third party producers and storage as well as end users, are discussed below and further within this document.

- Overall NOx emissions are projected to be reduced by more than 3,750 tons per year and 5,100 tons per year in 2045 based on the low and high throughput scenarios, respectively, for Angeles Link.
- Mobility NOx emissions (e.g., primarily heavy duty transportation) ~~are projected to be eliminated with conversion to hydrogen fuel cells~~ will be reduced with the conversion to ZEVs. Options for ZEVs include FCEVs and BEVs. The Demand Study projected the

[4] SoCalGas anticipates that industrial end users will continue to comply with applicable Clean Air Act and local, state, and federal air permit requirements when transitioning to hydrogen fuel. SoCalGas does not support relaxation of current NOx emissions standards.

anticipated fossil fuel displacement associated with FCEVs only. The associated NOx reductions were estimated only for with conversion to FCEVs; this study does not project emission reductions related to fossil fuel displacement that will be associated with BEVs.

  - Mobility sector comprises 99.8% and 99.6% of end-user NOx reductions related to Angeles Link (i.e., associated with conversion to FCEVs) based on the low and high throughput scenarios, respectively.

- Power generation and hard to electrify industrial sector's permitted NOx emissions are projected to stay the same or decrease.
  - Power generation sector comprises 0.13% and 0.32% of the overall NOx reductions based on the low and high throughput scenarios, respectively.
  - Hard to electrify industrial sector comprises 0.04% and 0.09% of the overall NOx reductions based on the low and high throughput scenarios, respectively.
- Projected NOx reductions in 2037 based on the low and high throughput scenarios are up to 2.5% and 5.1%, respectively, of South Coast AQMD's forecasted NOx emissions in 2037.
- Projected DPM reductions based on the low and high throughput scenarios are up to 10.5% and 20.8%, respectively, of South Coast AQMD's forecasted PM2.5 emissions in 2037.
- Projected VOC reductions based on the low and high throughput scenarios are up to 4.4% and 7.2%, respectively, of South Coast AQMD's forecasted VOC emissions in 2037.
- Infrastructure NOx emissions are projected to be minor in nature when compared to overall NOx emissions reductions at 4.9% and 9.6% of end-user reductions for the low and high demand scenarios, respectively.

2. Study Approach

The study estimates NOx emissions associated with anticipated production, storage, and transportation of hydrogen and estimates NOx emission reductions from end users of hydrogen in the mobility, power generation, and hard to electrify industrial sectors. Additionally, potential NOx emissions minimization opportunities are identified to further reduce NOx emissions. The parallel Angeles Link Phase One Demand Study provides details and scenario options needed to complete this study. Additional evaluation of NOx emissions for the estimated ranges of Angeles Link throughput of 0.5 to 1.5 MMT per year of hydrogen was also conducted.

Where applicable, the study relies on specific technical information available from regulatory agencies, transportation agencies, and equipment manufacturers. Research conducted by entities such as academic institutions was evaluated to determine best available methods for quantifying emissions of NOx from combustion of hydrogen. EPA calculation methodologies were also used to estimate NOx emission factors for hydrogen. Relevant local air district requirements regarding NOx emission limitations for combustion units were considered. When specific information was not available, estimates were made based on availability of related data and assumptions, which are explained within the relevant section of the study. The study also includes a high-level assessment of other potential emissions with a focus on VOC and DPM.

2.1 TECHNICAL RESEARCH

The study collected, reviewed, and analyzed technical research studies and information related to NOx emissions associated with hydrogen combustion. This analysis included:

- Available literature and studies from research-based academic institutions such as University of California Irvine (UCI) Combustion Laboratory and Georgia Institute of Technology and private organizations such as Electric Power Research Institute (EPRI);
- Existing, proposed, and potential future regulatory requirements from federal agencies including United States Environmental Protection Agency (US EPA), United States Department of Energy (US DOE), state agencies such as California Air Resources Board (CARB) and California Energy Commission (CEC), and local agencies including the nine local air districts located within the geographic scope of this study such as South Coast AQMD and San Joaquin Valley Air Pollution Control District (APCD);
- Technological developments and timelines from manufacturers working on hydrogen technology;
- Technical literature and data releases from government agencies and laboratories including the US DOE and the National Renewable Energy Lab (NREL); and
- Potential NOx emissions minimization opportunities from technological advancements.

The study researched available literature and studies to evaluate:

- How NOx is formed from hydrogen combustion;
- How NOx might be controlled when combusting hydrogen; and
- How to quantify the formation of NOx from hydrogen combustion.

Preliminary information reviewed regarding the formation of NOx indicated:

- NOx may be formed via three pathways during combustion: thermal NOx, fuel NOx, and prompt NOx.
- Information regarding the formation of NOx was reviewed from publications by US EPA and other regulatory agencies, academia, and research institutions.
- Control of NOx emissions from hydrogen combustion begins with designing equipment to account for unique properties of hydrogen, as outlined in available studies and reports, including government publications by US EPA and US DOE.
- Aftertreatment such as three-way catalysts, selective catalytic reduction, and lean NOx traps provide demonstrated NOx minimization opportunities.

Technical Approach

The following assessment process (Figure 1) was used for this study's technical approach. The approach was based on review of technical research studies, research of anticipated technological advancements, and review of expected evolution of regulatory frameworks.

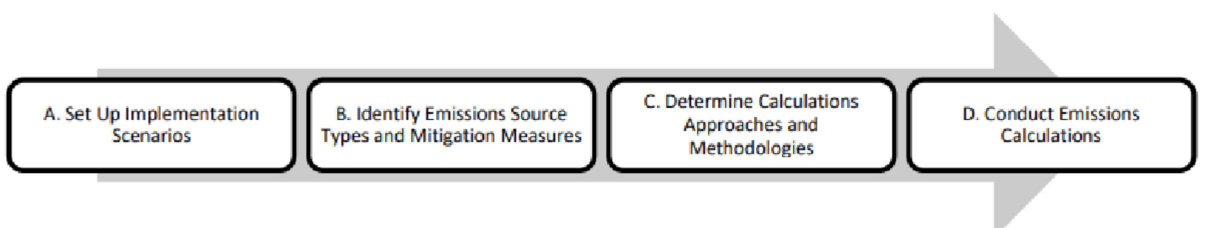

Figure 1. NOx Emissions Assessment Process for NOx Emissions Associated with Angeles Link

SET UP IMPLEMENTATION SCENARIOS

To evaluate potential NOx emissions and emissions changes associated with Angeles Link, including those from not just transmission of hydrogen, but also from third party production and storage as well as end users, the timeframe from 2030 to 2045 was considered. End use sectors are anticipated to achieve the ability to accommodate 100% hydrogen fuel use at different times due to availability of technology and feasibility of transitioning existing equipment to hydrogen use and building new hydrogen infrastructure. Use of clean renewable hydrogen, as defined by the Decision, as fuel for each end-use sector was evaluated beginning with 2030 based on details obtained from the Demand Study. Potential NOx emissions were calculated using approaches described in the next steps.

IDENTIFY EMISSIONS SOURCE TYPES AND MINIMIZATION OPTIONS

The study evaluated NOx and other emissions potentially associated with the following by developing emission calculation approaches and methodologies.

- Infrastructure (Production, Storage, and Transmission)
- End Users (Mobility, Power Generation, and Hard to Electrify Industrial Sectors)

NOx emissions are a result of combustion of fuel. NOx is created from the conversion of nitrogen in fuel and ambient air at elevated temperatures resultant from combustion. Evaluation of NOx emission minimization opportunities focused on technologies that minimize combustion temperatures and post-combustion NOx emission control technology such as catalytic reduction.

Hydrogen Production

Three potential clean renewable hydrogen production options were evaluated. Each of these three options qualifies as producing clean renewable hydrogen because, for each of them, less than 4 kilograms of CO_2e are produced on a lifecycle basis per kilogram of hydrogen produced and fossil fuels, defined as a mixture of hydrocarbons including coal, petroleum, or natural gas, occurring in and extracted from underground deposits, are not used.

1) Electrolyzers[5] powered by renewable electricity to split water molecules into oxygen and hydrogen. This process does not use combustion so there is no potential for NOx emissions associated with electrolyzers.

2) Biomass gasification[6] is a process that involves heat, steam, and oxygen to convert biomass to hydrogen without combustion. Since this process does not use combustion, there is no potential for NOx emissions associated with biomass gasification.

3) Renewable natural gas (RNG)[7] fueled steam methane reformers (SMR). Steam methane reforming is a process in which biogas (RNG) reacts with steam in the presence of a catalyst to produce hydrogen and carbon dioxide. This option has NOx emissions and those potential emissions were evaluated.

[5] Hydrogen Production: Electrolysis | Department of Energy
[6] Hydrogen Production: Biomass Gasification | Department of Energy
[7] Renewable Natural Gas | US EPA

Hydrogen Storage and Transmission

For the purpose of this study, hydrogen storage may occur above ground or below ground, and hydrogen is delivered to end users via pipelines. Storage and transmission of hydrogen requires the use of compressors.

It was conservatively assumed that compressors will be driven by grid electricity[8] powered electric motors or compressors driven by engines or turbines. If compressor drivers are engines or turbines, it was assumed that they will be fueled by 100% clean renewable hydrogen. Additionally, for grid electricity interruptions, hydrogen-fueled back-up electrical generators may also be used, which were assumed to be driven by internal combustion engines fueled by 100% clean renewable hydrogen.

Hydrogen Industrial End Users

Potential NOx emissions source types from end users in three key sectors were evaluated: Mobility, Power Generation, and Hard to Electrify Industrial sectors. Information obtained from the parallel Demand Study informed the analysis of end uses in each of these three sectors, as well as their respective subsectors.

- Mobility Sector includes heavy-duty trucks, medium-duty vehicles, buses, agriculture, construction & mining, cargo handling equipment, ground support equipment, and commercial harbor craft.
- Turbines are the primary source for potential NOx emissions in power generation.
- Hard to electrify industrial subsectors include energy intensive industries such as refining, food and beverage manufacturing, primary and fabricated metals, stone, glass, and cement, paper, chemical manufacturing, and aerospace & defense.
- Source types with the potential for NOx emissions in the power generation and industrial sectors include hot water boilers, steam generating units, process heaters, furnaces/kilns, internal combustion engines, turbines, and miscellaneous combustion equipment.

Calculation Methodology

For each emission source type identified, potential NOx emissions were estimated for combustion of the displaced fossil fuel (diesel, gasoline, natural gas) and for combustion of clean renewable hydrogen, as applicable. Calculations to estimate emissions were prepared using the following two equations.

[8] Anticipate that green tariff, i.e., renewable electricity will be purchased for electric motor driven compressors.

Fuel Throughput x Emissions Factor = Emissions (equation 1)

Emission Reductions = Fossil Fuel Emissions – Hydrogen Emissions (equation 2)

Potential NOx emissions were calculated at the unit level and scaled based on activity data quantified using information from the Demand Study. Calculations were prepared for the low, mid, and high scenarios in the Demand Study for each year from 2030 to 2045. The study evaluated potential for NOx emissions based on the type of equipment and specific source categories.

Local air district rules were reviewed to determine NOx emission factors for natural gas combustion to estimate emissions associated with the new hydrogen infrastructure, as well as with stationary end user sectors (i.e., power generation and hard to electrify industrial). Then a correction factor was applied to estimate NOx from hydrogen combustion. Volumetric (ppmv) correction factors can be utilized to convert natural gas emissions factors to equivalent values for pure hydrogen and blended hydrogen-natural gas fuels. After applying this correction factor, NOx in ppmv can be converted to a mass emissions rate using the EPA Method 19 equation. This conversion uses the oxygen correction factor, F-factor, and stoichiometric/unit conversions. Through this approach, a representative emissions factor for natural gas can be converted to an approximate hydrogen or hydrogen-blend emissions factor. These generated emissions factors were compared against manufacturers test data and specification sheets to verify that they fell within an expected range. This methodology was utilized to develop emissions factors for hydrogen fueled internal and external combustion units. The detailed process to estimate NOx emissions from hydrogen combustion is provided in Appendix A.

Inherent in preparation of the NOx emissions estimates was the assumption that permitted NOx emissions would stay the same or decrease given the requirements to make progress towards achieving ozone attainment in several air districts the SoCalGas territory encompasses. [9]

SoCalGas anticipates that industrial end users will continue to comply with applicable Clean Air Act and air districts' permit requirements when transitioning to hydrogen fuel. Specifically, an assumption was made that the California regulatory environment would not allow for an increase in permitted NOx emissions at stationary sources. It has been observed that innovations l in NOx technology has often been catalyzed and driven by the adoption of stringent air quality regulations, and such adoptions, coupled with other factors such as market competition and economies of scale, stimulate advancements and reduce the costs of emission controls as these adoptions becomes more widespread.[10]

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[9] Jack Brouwer, UCI, Angeles Link Planning Advisory Group meeting, December 15, 2023.
[10] Sonia Yeh, et. al., Technology Innovations and Experience Curves for Nitrogen Oxides Control Technologies, 2005, [Technology innovations and experience curves for nitrogen oxides control technologies (Journal Article) | OSTI.GOV]

For the purposes of this study, it was assumed that adjustments to the hydrogen combustion process such as lowering of combustion temperature[11] and modifying air/fuel ratios,[12] and technological advancements[13] to NOx emission controls[14] would be in place so permitted NOx emissions would stay the same or decrease with the combustion of hydrogen in equipment in the power generation and hard to electrify industrial sectors. Based upon review of existing technical literature, while there is uncertainty given limited actual measurements of NOx for 100% hydrogen combustion applications, actual NOx emissions, which can differ from permitted NOx, may also stay the same or decrease for most end user applications depending on combustion conditions such as temperature and residence time. Advancements in hydrogen combustion technology and post-combustion treatment are anticipated to close this gap between actual NOx emissions associated with natural gas combustion and hydrogen combustion once hydrogen specific design considerations are more broadly applied.

Conduct Emissions Calculations

The study prepared emission calculations using emission factors and activity data compiled for each of the topic areas.

- The tool was designed to conduct calculations at the unit level (per unit equipment count, unit distance, unit throughput, or other unit parameters, as applicable).
- The emissions calculation tool was scaled from unit level information to estimate impacts across the geographic region that Angeles Link spans.
- Emission calculations utilized information from evaluated research, the Demand Study, and other Phase One feasibility studies.

There are several modeling studies and direct measurement studies related to NOx emissions from hydrogen combustion. Research completed for this study did not reveal published hydrogen-specific combustion emission factors for NOx. Multiple modeling studies have demonstrated that equipment can be designed to minimize the formation of NOx emissions from hydrogen combustion, typically by reducing combustion temperature or residence time. Results from direct measurement studies are variable, and most were completed on equipment originally designed to combust natural gas rather than hydrogen.

Few manufacturers have published NOx emissions data from hydrogen combustion in their units. With the bulk of hydrogen combustion technology still in development, the availability of actual NOx emissions data specific to hydrogen combustion is low at this time of this evaluation.

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[11] S.K., Alavandi, et. al., 2007, https://www.sciencedirect.com/science/article/abs/pii/S0360319907007276
[12] L. Wang, et. al., 2004 Interactions among soot, thermal radiation, and NOx emissions in oxygen-enriched turbulent nonpremixed flames: a computational fluid dynamics modeling study - ScienceDirect
[13] K. Kammer Hansen, Electrochemical Removal of NOx Using Oxide-Based Electrodes – A Review, 2018, (electrochemsci.org)
[14] Alves, et. al., 2021, A comprehensive review of NOx and N2O mitigation from industrial streams - ScienceDirect

Emissions minimization methodologies can be implemented to reduce NOx emissions including equipment design, pre-mixing of air and fuel, management of air to fuel ratio to control combustion temperature, and emerging aftertreatment technologies. NOx control equipment options also include existing technologies such as selective catalytic reduction (SCR) and non-selective catalytic reduction (NSCR).

3. Assumptions and Preliminary Results for NOx Based on Demand Study

Preliminary emissions calculation results including assumptions are provided for the following evaluated categories Projected NOx emissions reductions totals for each end-user subsector were summed to determine totals for each sector; and then totals for each sector were summed and added to anticipated NOx emissions associated with new infrastructure to estimate overall annual potential NOx emissions reductions anticipated for each year 2030 to 2045 for each demand scenario.

- Infrastructure: production, storage, and transmission of hydrogen to end-users
- End-Users: mobility, power generation, and hard-to-electrify industrial sectors projected to use hydrogen

The study provides a high-level summary of the preliminary data and findings. Detailed emission calculations based on Demand Study scenarios will be provided as an Appendix to the draft report.

3.1 INFRASTRUCTURE

Summary of preliminary results for anticipated NOx emission increases for new infrastructure based on the Low and High Demand scenario data in 2045 are as follows:

For Low Demand Scenario, new infrastructure NOx emissions are up to 4.0% the magnitude of end-user reductions.

For High Demand Scenario, new infrastructure NOx emissions are up to 8.3% the magnitude of end-user reductions.

Production

Three equipment options were evaluated for production to meet the definition of clean renewable hydrogen.

1. Electrolyzers powered by renewable electricity (zero NOx)
2. Biomass gasification (zero NOx)
3. RNG SMR (some NOx)

Multiple scenarios were evaluated to estimate the range of low to high NOx emissions. The range extends from zero NOx associated with the 100% electrolysis and the 100% biomass gasification scenarios to the highest potential NOx emissions for the 100% RNG SMR scenario. Equation 1 was used to conduct the NOx emissions calculations.

Fuel Throughput x Emissions Factor = Emissions (equation 1)

NOx emission estimates can be refined once assumptions regarding anticipated third party hydrogen production processes have been developed and/or proportions of hydrogen intended to be produced from different methods have been identified. Preliminary results for potential NOx emissions from hydrogen production are provided for the Low Demand Scenario and High Demand Scenario in Tables 1A and 1B, respectively.

Table 1A. Potential NOx Emissions from Hydrogen Production - Low Demand Scenario

	Potential Emissions (ton NOx/yr)				
	2030	**2035**	**2040**	**2045**	**Production Scenario**
High Estimate	14.4	57.0	122.8	209.7	100% RNG SMR (Avg + Std. Dev)
Low Estimate	0.0	0.0	0.0	0.0	100% Electrolysis or Biomass Gasification

Table 1B. Potential NOx Emissions from Hydrogen Production -High Demand Scenario					
	Potential Emissions (ton NOx/yr)				
	2030	**2035**	**2040**	**2045**	**Production Scenario**
High Estimate	124.77	258.19	441.74	665.95	100% RNG SMR (Avg + Std. Dev)
Low Estimate	0.0	0.0	0.0	0.0	100% Electrolysis or Biomass Gasification

Storage and Transmission

Compressors will be needed for storage and transmission of hydrogen. Three options for types of compressors were evaluated.

1. Electric motor driven compressors (zero NOx)
2. Clean renewable hydrogen fueled reciprocating engine driven compressors (some NOx)
3. Clean renewable hydrogen fueled turbine driven compressors (some NOx)

Potential emissions of NOx from hydrogen fueled reciprocating engine driven compressors and turbine driven compressors were calculated using equation 1.

Fuel Throughput x Emissions Factor = Emissions (equation 1)

NOx emission factors were developed by using engine emission factors from South Coast AQMD Rule 1110.2 "Emissions from Gaseous and Liquid Fueled Engines"[15] and turbine emission factors from South Coast AQMD Rule 1134 "Emissions of Oxides of Nitrogen from Stationary Gas Turbines"[16] and then adjusted with the correction factor method previously described to estimate potential hydrogen combustion emissions.

Two storage pressure scenarios were evaluated. A low pressure scenario at 290 pounds per square inch (psi) and a high pressure scenario at 2,900 psi. A transmission distance of 450 miles was evaluated. These are placeholder estimates since preliminary information from parallel studies is not yet available. Emission estimates can be refined once the types, sizes, and quantities of compressors have been further developed. Additionally, development of assumptions regarding above ground and underground storage volumes and pressures will support development of refinement of emission estimates.

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[15] Rule 1110.2 Clean (aqmd.gov)
[16] http://www.aqmd.gov/docs/default-source/rule-book/reg-xi/rule-1134.pdf?sfvrsn=4

Preliminary results for storage and transmission for potential NOx emissions are provided for the Low Demand Scenario in Tables 2A and 3A, respectively. Preliminary results for storage and transmission for potential NOx emissions for the Low and High Demand Scenarios in Tables 2B and 3B, respectively.

Hydrogen Storage

Table 2A. Potential NOx Emissions from Hydrogen Storage - Low Demand Scenario

	Emissions (ton NOx/yr)				Scenario	
	2030	2035	2040	2045	Storage Pressure	Power Source
High Estimate	7.1	27.2	57.3	96.0	2,900 psi	H2 Reciprocating Engine
Low Estimate	0.0	0.0	0.0	0.0	NA	Renewable Electricity

Table 2B. Potential NOx Emissions from Hydrogen Storage - High Demand Scenario

	Emissions (ton NOx/yr)				Scenario	
	2030	2035	2040	2045	Storage Pressure	Power Source
High Estimate	54.7	113.7	198.8	301.8	2,900 psi	H2 Reciprocating Engine
Low Estimate	0.0	0.0	0.0	0.0	NA	Renewable Electricity

Hydrogen Transmission

Table 3A. Potential Emissions from Hydrogen Transmission -Low Demand Scenario

	Emissions (ton NOx/yr)				Scenario	
	2030	2035	2040	2045	Transmission Distance	Power Source
High Estimate	21.3	81.3	171.1	286.3	450 miles	Hydrogen
Low Estimate	0.0	0.0	0.0	0.0	All Distances	Renewable Electricity

Table 3B. Potential Emissions from Hydrogen Transmission -High Demand Scenario						
	Emissions (ton NOx/yr)				**Scenario**	
	2030	**2035**	**2040**	**2045**	**Transmission Distance**	**Power Source**
High Estimate	163.3	339.2	649.2	900.4	450 miles	Hydrogen
Low Estimate	0.0	0.0	0.0	0.0	All Distances	Renewable Electricity

END USERS

Consistent with the Decision, Angeles Link is intended to transport only 100% clean renewable hydrogen to end user sectors. The focus of the NOx emissions study was on three sectors of hydrogen end-users: mobility, power generation, and hard to electrify industrial, and estimating NOx emissions reductions based upon the findings of the Demand Study and anticipated annual throughput of Angeles Link.

Mobility

Summary of preliminary results for the anticipated NOx emission decreases associated with the Mobility sector based on the Low and High Demand Scenario data in 2045 are the following.

- Mobility is the main end-user source of NOx emission reductions at 99.8% an d 99.6% of end-user reductions (i.e., associated with conversion to FCEVs) for Low and High Demand scenarios, respectively. These reductions are due to ~~hydrogen fuel cell~~ FCEVs substitution for fossil fuels providing a 100% NOx emissions reduction.
  - Low Demand Scenario
    - On-Road Vehicles account for 85.1% of Mobility NOx emission reductions
      - Heavy Duty Vehicles are 73.8% of Mobility NOx emission reductions
    - Off-Road Vehicles account for 14.9% of Mobility NOx emission reductions
  - High Demand Scenario
    - On-Road Vehicles account for 87.4% of Mobility NOx emission reductions
      - Heavy Duty Vehicles are 77.4% of Mobility NOx emission reductions
    - Off-Road Vehicles account for 12.6% of Mobility NOx emission reductions

Assumptions for the Mobility sector are based on the projected hydrogen demand that would displace ~~primarily that~~ diesel and gasoline fuel ~~will be displaced~~ and for vehicles that are projected to ~~would~~ convert to FCEVs with zero NOx emissions. This study did not project emission reductions due to fossil fuel displacement that will be associated with BEVs. Emission factors for NOx from displaced diesel and gasoline fuel were developed using EMFAC data. Fuel consumption was weighted by subcategory of vehicle types. The same two equations previously mentioned were used to conduct the NOx calculations, and the hydrogen emissions value in equation 2 is zero.

Fuel Throughput x Emissions Factor = Emissions (equation 1)

Emission Reductions = Fossil Fuel Emissions – Hydrogen Emissions (equation 2)

The total emissions were calculated by summing totals for each equipment type and are shown in Table 4. Figures 2A and 2B provide graphs for the low and high demand scenarios, respectively.

Table 4. Mobility NOx Emission Reductions (tpy)

	2030	2035	2040	2045
Low	1,117.4	4,745.3	9,431.4	14,717.4
Mid	2,865.6	7,489.7	12,966.9	18,126.0
High	5,589.4	11,508.4	17,559.9	22,332.6

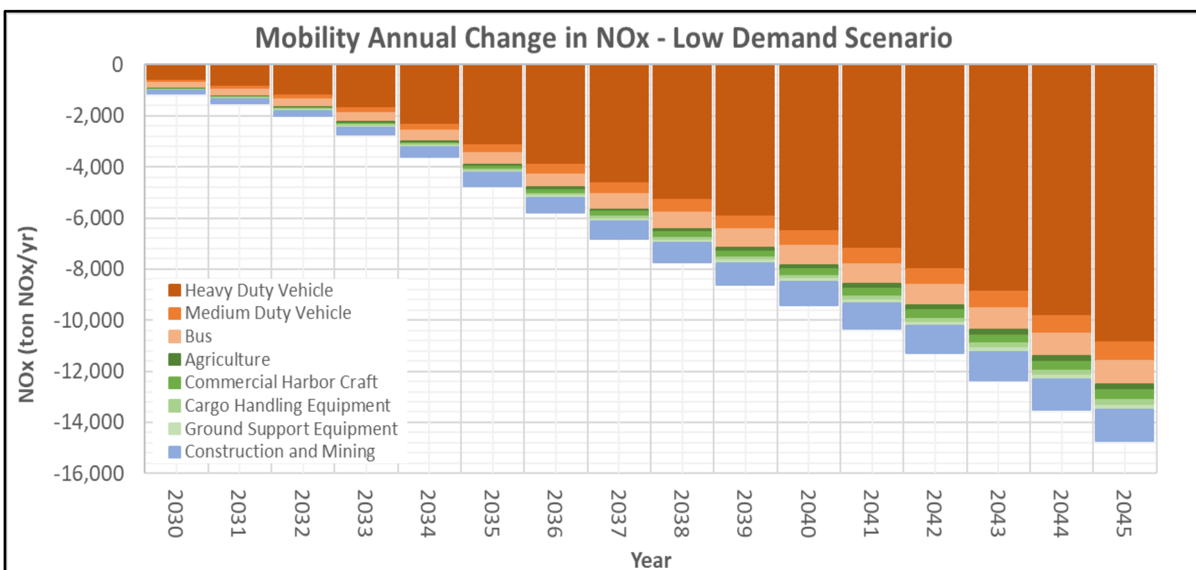

Figure 2A. Anticipated NOx Emission Reductions for Mobility Sector (Low Demand)

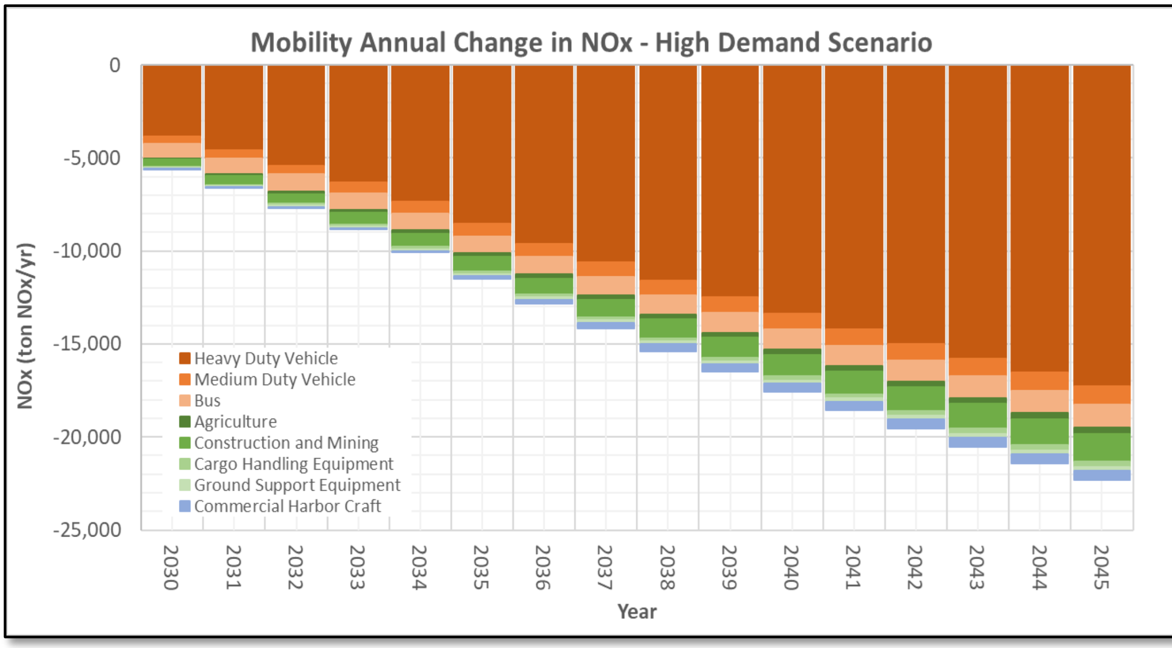

Figure 2B. Anticipated NOx Emission Reductions for Mobility Sector (High Demand)

Power Generation

The preliminary results for anticipated NOx emissions fora the Power Generation sector based on the Low Demand Scenario and High Demand Scenario data in 2045 are that the Power Generation sector accounts for 0.1% and 0.3%, respectively, of overall NOx reductions. Assumptions that were applied to develop the NOx emissions calculations include that hydrogen will displace natural gas as a fuel with increasing amounts over time (from 2030 to 2045). It should be noted that consistent with the Decision, Angeles Link is intended as a project to transport only 100% clean renewable hydrogen in the pipeline, and any analysis of hydrogen blending refers strictly to “behind-the-meter” operations that are not within SoCalGas’s control.

It is worth noting that there may be additional reductions beyond those evaluated in this study for the potential replacement of power generation with non-combustion technologies such as fuel cells.[17]

Inherent in preparation of the NOx emissions estimates was the assumption that permitted NOx emissions would stay the same or decrease given the requirements to make progress towards achieving ozone attainment in several air districts that the SoCalGas territory encompasses. Academicians from UCI have expressed agreement with this assumption indicating that they anticipate overall power generation NOx emissions will decrease most importantly because

[17] Jack Brouwer, UCI, Angeles Link Planning Advisory Group meeting, December 15, 2023.

South Coast AQMD will require NOx reductions to meet State Implementation Plan (SIP) requirements.[18]

SoCalGas anticipates that industrial end users will continue to comply with applicable Clean Air Act and air Districts' permit requirements when transitioning to hydrogen fuel. SoCalGas does not support relaxation of current NOx emissions standards.

Hydrogen usage in the Power Generation sector is anticipated to evolve over time, beginning with hydrogen/natural gas blends on or before 2025 and 100% hydrogen fuel use by 2031 as the technology becomes more available. It was assumed that blended fuels will continue to be used while the in-use units age out. These assumptions are consistent with the evaluation of the transition from blended fuels to 100% pure hydrogen fuels by the Demand Study. For each emission source type identified, calculations to estimate emissions were prepared using the same two equations previously mentioned.

Fuel Throughput x Emissions Factor = Emissions (equation 1)

Emission Reductions = Fossil Fuel Emissions – Hydrogen Emissions (equation 2)

The NOx emission factors selected were the most restrictive NOx emission factors from the current air district rules for natural gas combustion. These natural gas combustion emission factors were then converted to represent estimated NOx emission factors from hydrogen combustion using the correction factor approach previously described in the Calculation Methodology section of this document. This information is summarized in Table 5.

The total emissions were calculated by summing totals for each equipment type and are shown in Table 6. Figures 3A and 3B provide graphs for the low and high demand scenarios, respectively below.

Table 5. Natural Gas and Hydrogen Combustion Emission Factor Values for Power Generation

Sub-Sector	Equipment Category	NOx 100% Natural Gas EF (lb/MMBtu)	NOx EF District	NOx EF Rules	Note	NOx 100% Hydrogen EF (lb/MMBtu)
Baseload and Peaker	General External Combustion	0.0145	South Coast	1146, 1146.1, 1146.2	Average of Multiple	0.0136
	Reciprocating Engine	0.0405	South Coast	1110.2	Single Factor	0.0381
	Turbine	0.0083	South Coast	1135	Average of Multiple	0.0078

[18] Jack Brouwer, UCI, Angeles Link Planning Advisory Group meeting, December 15, 2023.

Table 5. Natural Gas and Hydrogen Combustion Emission Factor Values for Power Generation

Sub-Sector	Equipment Category	NOx 100% Natural Gas EF (lb/MMBtu)	NOx EF District	NOx EF Rules	Note	NOx 100% Hydrogen EF (lb/MMBtu)
Cogeneration	General External Combustion	0.0145	South Coast	1146, 1146.1, 1146.2	Average of Multiple	0.0136
	Reciprocating Engine	0.0405	South Coast	1110.2	Single Factor	0.0381
	Turbine	0.0074	South Coast	1134	Single Factor	0.0069

A source of uncertainty for stationary combustion calculations at the time of this study was the lack of manufacturers emissions data and stack testing data for pure hydrogen combustion. There is minimal existing emissions data for pure hydrogen and blended hydrogen combustion as the technology is largely still in development. Of the hydrogen combustion data that is available, large variations were noted in emission results. As technology is further developed over time, and more data is available, more specific emissions factors may be developed for NOx emissions from pure hydrogen combustion.

Table 6. Power Generation NOx Emission Reductions (tpy)

	2030	2035	2040	2045
Low	0.2	2.9	9.0	19.0
High	0.7	11.0	33.9	71.7

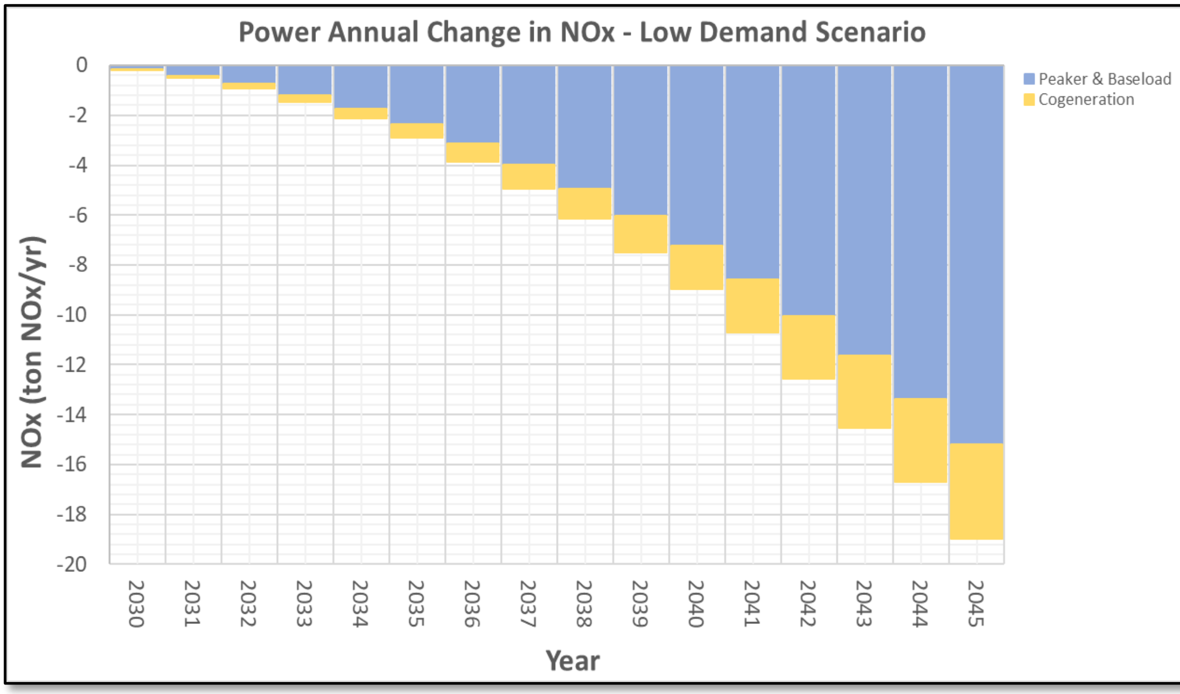

Figure 3A. Anticipated NOx Reductions for Power Generation Sector (Low Demand)

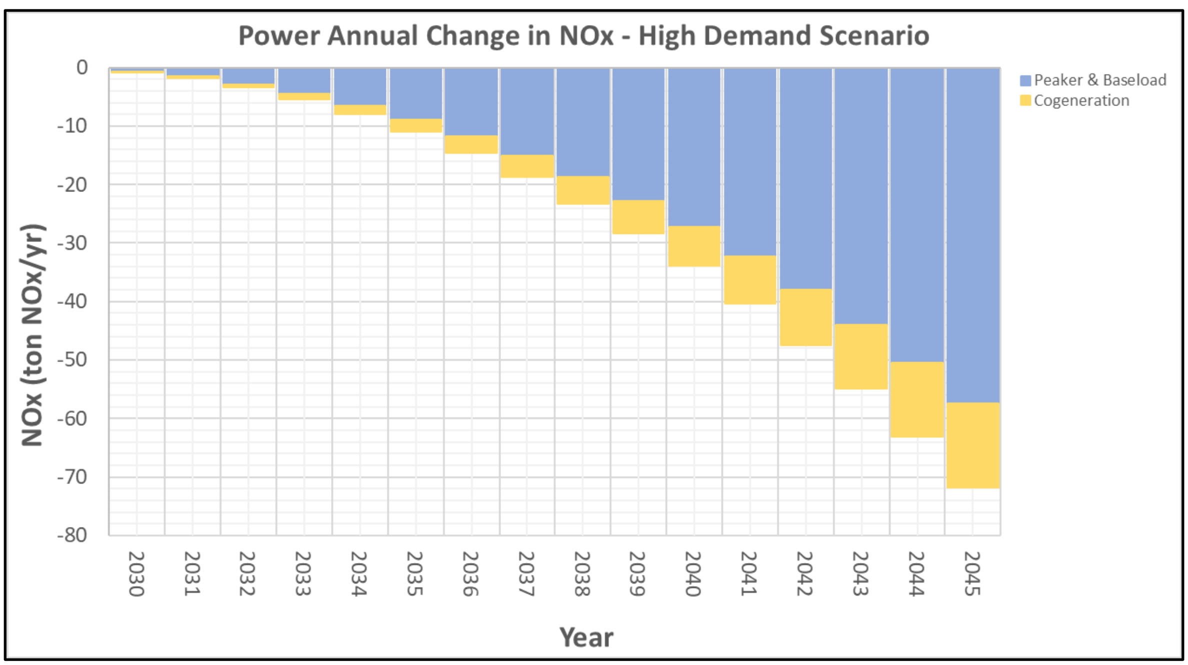

Figure 3B. Anticipated NOx Reductions for Power Generation Sector (High Demand)

As hydrogen fuel has approximately one-third the heat content of natural gas fuel, switching current combustion equipment without modifications from natural gas to hydrogen would be expected to use about three times as much volume of hydrogen as natural gas to provide the same heat input to the combustion process.

In addition, the pounds of NOx per MW-hr of electricity produced is dependent on several factors including the design and efficiency of the combustion equipment. Combustion technology specific to hydrogen and turbines of the future are expected to have performance and emissions of NOx comparable to today's natural gas-fueled turbines.[19] Maximizing efficiency and minimizing emissions with respect to pounds of NOx per MW-hr of electricity produced is expected to evolve over time.

For example, technologies like fuel/air premixing and the concept of micromixers, i.e., replacing a single large reaction with a series of very small reaction to reduce time at temperature to reduce the amount of NOx emissions, is being explored by numerous turbine manufacturers including Solar Turbines, GE, Siemens, Mitsubishi, and Kawasaki.[20] They have examined the concept of small mixers for use with hydrogen fuels. Other combustion technology, like fuel/air staging, exhaust gas recirculation, after-treatment and engine controls are some examples of other developing technologies.

In addition, some of the features of hydrogen like fast flame propagation, low ignition energy, and a wide operating range, allow for optimization and improvement of the combustion process.[21] The technological combustion evolution is laying the groundwork for combustion science to overcome operability and emissions. These emerging developments in NOx control and efficiency technologies are anticipated to further mitigate NOx emissions from hydrogen combustion, including the increase in hydrogen volumes for heat input equivalency, in the future.

Hard to Electrify Industrial

Preliminary results for anticipated NOx emissions for the Industrial sector based on the High Demand Scenario data in 2045 are that the Industrial sector accounts for 0.09% of overall NOx emission reductions. This NOx emissions estimate assumed that permitted NOx emissions would stay the same or decrease given the requirements to make progress towards achieving ozone attainment in several air districts that the SoCalGas territory encompasses.

[19] H2IQ Hour: Addressing NOx Emissions from Gas Turbines Fueled with Hydrogen: Text Version https://www.energy.gov/eere/fuelcells/h2iq-hour-addressing-nox-emissions-gas-turbines-fueled-hydrogen-text-version
[20] H2IQ Hour: Addressing NOx Emissions from Gas Turbines Fueled with Hydrogen: Text Version https://www.energy.gov/eere/fuelcells/h2iq-hour-addressing-nox-emissions-gas-turbines-fueled-hydrogen-text-version
[21] Zbigniew Stępień, 2021, Energies | Free Full-Text | A Comprehensive Overview of Hydrogen-Fueled Internal Combustion Engines: Achievements and Future Challenges (mdpi.com)

Assumptions applied to develop the NOx emissions calculations include that hydrogen will displace natural gas as a fuel with increasing amounts over time (from 2030 to 2045). For industrial end-user calculations, it was assumed that 100% of initial hydrogen demand would be blended with natural gas until 2030, when heavy-duty equipment capable of combusting pure hydrogen would be commercially available. The assumption that heavy-duty industrial equipment capable of combusting pure hydrogen would be available by 2030 was based on manufacturer statements. Once pure hydrogen fuel combustion technology becomes available in 2030, it was assumed that blended fuel equipment would be retired or phased out over time until 100% of hydrogen demand would be utilized by equipment combusting pure hydrogen fuel in 2050. To estimate equipment-phase out, it was assumed industrial combustion equipment would have a lifespan of 20 years. Therefore, if sales of blended equipment end in 2030 and equipment has a lifespan of 20 years, then by 2050 all hydrogen combustion equipment in operation would be capable of combusting pure hydrogen. The rate of natural gas and hydrogen consumption/blending from 100% natural gas to 100% hydrogen is assumed to change about 4% a year. Equipment-level blended hydrogen combustion as a percentage of overall hydrogen consumption is depicted in Table 7 below.

Table 7. Equipment-level Hydrogen-Natural Gas Blending Percentages

Source	Percent of Total H2 Demand as Blend					
	2025	2030	2035	2040	2045	2050
Engine	100	80	60	40	20	0
Turbine	100	80	60	40	20	0
External Combustion	100	80	60	40	20	0
Oven	100	80	60	40	20	0

It was also assumed that the hydrogen-natural gas percentage for blended hydrogen would vary by equipment-type. Blending for reciprocating engines, turbines, general external combustion units, and ovens were estimated based on manufacturer specification sheets and direct measurement studies reviewed in the literature. Estimated equipment-level hydrogen-natural gas blending percentages are shown in Table 8 below.

Table 8. Equipment Level Hydrogen Natural Gas Blending Ratios for Industrial End-users	
Source	**H2 to Natural Gas Ratio**
Engine	25%
Turbine	57%
External Combustion	22%
Oven	22%

For each emission source type identified, calculations to estimate emissions were prepared using the same two equations previously mentioned.

Fuel Throughput x Emissions Factor = Emissions (equation 1)

Emission Reductions = Fossil Fuel Emissions – Hydrogen Emissions (equation 2)

NOx emission factors selected were the most restrictive NOx emission factors from the current air district rules for natural gas combustion. These natural gas combustion emission factors were then converted to represent estimated NOx emission factors from hydrogen combustion using the correction factor approach previously described in the Calculation Methodology section of this document. This information is summarized in Table 9 below.

Table 9. Natural Gas and Hydrogen Combustion Emission Factor Values for Industrial

Sub-Sector	Equipment Category	NOx 100% Natural Gas EF (lb/MMBtu)	NOx EF District	NOx EF Rules	Note	NOx 100% Hydrogen EF (lb/MMBtu)
Food and Beverage	General External Combustion	0.0145	South Coast	1146, 1146.1, 1146.2	Average of Multiple	0.0136
	Oven	0.0492	SJV	4309	Single Factor	0.0462
	Reciprocating Engine	0.0405	South Coast	1110.2	Single Factor	0.0381
	Turbine	0.0092	South Coast	1134	Single Factor	0.0087
Metals Stone, Glass, Cement Paper	General External Combustion	0.0145	South Coast	1146, 1146.1, 1146.2	Average of Multiple	0.0136
	Oven	0.0492	SJV	4309	Single Factor	0.0462

Table 9. Natural Gas and Hydrogen Combustion Emission Factor Values for Industrial						
Sub-Sector	**Equipment Category**	**NOx 100% Natural Gas EF (lb/MMBtu)**	**NOx EF District**	**NOx EF Rules**	**Note**	**NOx 100% Hydrogen EF (lb/MMBtu)**
Chemicals Aerospace and Defense	Reciprocating Engine	0.0405	South Coast	1110.2	Single Factor	0.0381
	Turbine	0.0092	South Coast	1134	Single Factor	0.0087
Refineries	General External Combustion	0.0145	South Coast	1146, 1146.1, 1146.2	Average of Multiple	0.0136
	Reciprocating Engine	0.0405	South Coast	1110.2	Single Factor	0.0381
	Turbine	0.0074	South Coast	1109.1	Single Factor	0.0069

Total emissions were calculated by summing totals for each equipment type and are shown in Table 10. Figures 4A and 4B provide graphs for the low and high demand scenarios, respectively below.

A source of uncertainty for the stationary combustion calculations at this time of this study was lack of manufacturers emissions data and stack testing data for pure hydrogen combustion. There is minimal existing emissions data for pure hydrogen and blended hydrogen combustion as the technology is largely still in development. Of the hydrogen combustion data that is available, large variations were noted in emission results. As technology is further developed over time, and more data is available, more specific emissions factors may be developed for NOx emissions from the combustion of hydrogen.

Table 10. Industrial NOx Emission Reductions (ton NOx/yr)				
	2030	**2035**	**2040**	**2045**
Low	2.7	4.3	5.4	6.2
High	7.4	12.5	16.2	19.3

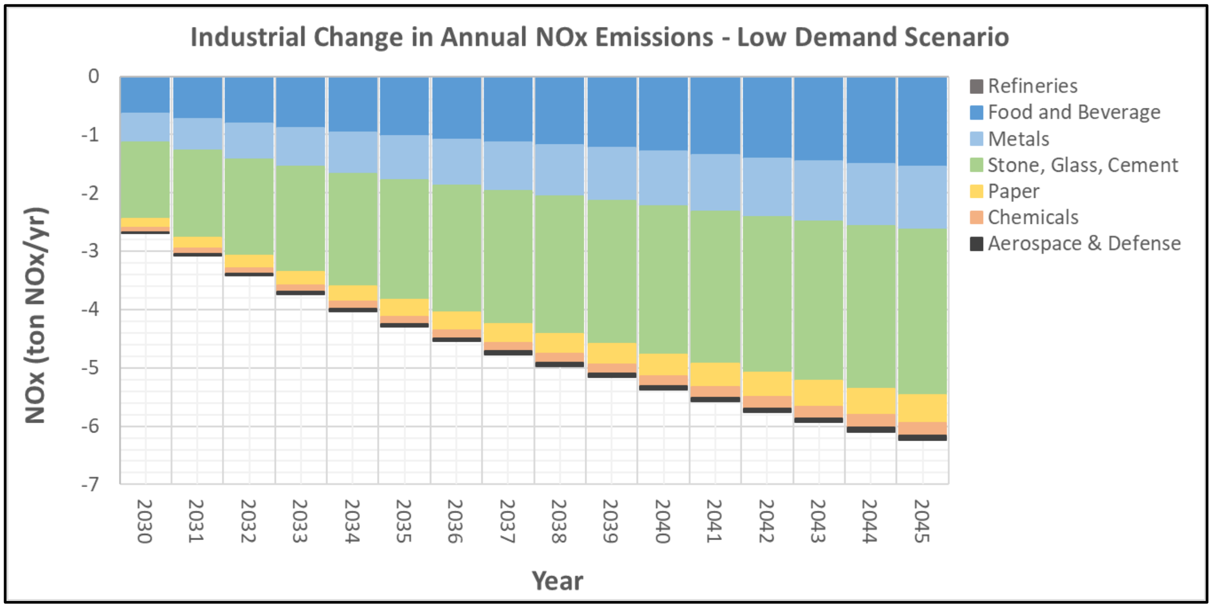

Figure 4A. Anticipated NOx Reductions for Hard-to-Electrify Industrial Sector (Low Demand)

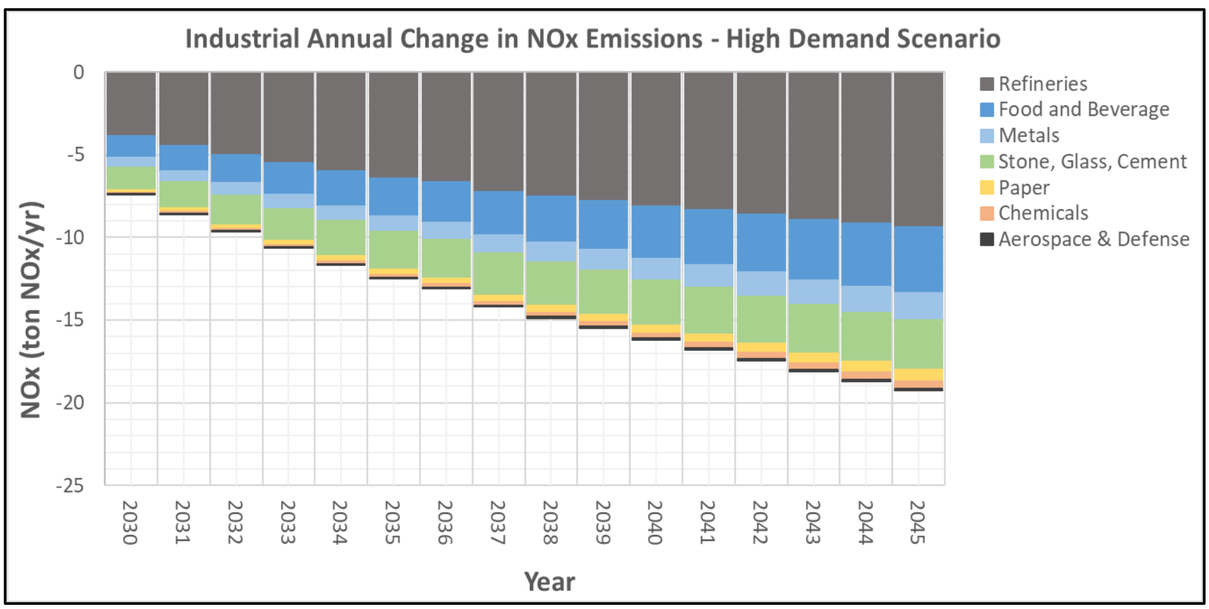

Figure 4B. Anticipated NOx Reductions for Hard-to-Electrify Industrial Sector (High Demand)

4. Overall NOx Results Based on Demand Study Scenarios

Anticipated potential NOx emissions for new infrastructure were added to anticipated NOx emissions reductions for potential end users of hydrogen as defined by the Demand Study. The results are provided in Table 11, and in Figures 5A and 5B below. In summary:

- Overall NOx emissions are expected to potentially be reduced by about 13,700 tons per year and 20,000 tons per year in 2045 based on low and high demand scenarios of the Demand Study, respectively.
- Mobility NOx emissions (e.g., primarily heavy duty transportation) ~~are eliminated with conversion to hydrogen fuel cells~~ will be reduced with the conversion to ZEVs. Options for ZEVs include FCEVs and BEVs. The Demand Study projected the anticipated fossil fuel displacement associated with FCEVs only. The associated NOx reductions were estimated only for the conversion to FCEVs; this study does not project emission reductions related to fossil fuel displacement that will be associated with BEVs.
    - Mobility sector comprises 99.8% and 99.6% of overall NOx reductions related to Angeles Link (i.e., associated with conversion to FCEVs) based on the low and high demand scenarios, respectively.
- Power generation and hard to electrify industrial sector's permitted NOx emissions are expected to stay the same or decrease.
    - Power generation sector comprises 0.1% and 0.3% of end-user NOx reductions based on low and high demand scenarios, respectively.
    - Hard to electrify industrial sector comprises 0.04% and 0.09% of end-user NOx reductions based on low and high demand scenarios, respectively.
- Infrastructure NOx emissions are minor in nature when compared to overall NOx emissions reductions at 4.0% and 8.3% of end-user reductions for low and high demand scenarios, respectively.

Table 11. Annual Change in NOx Emissions (ton NOx/yr)					
Category	**Use Scenario**	**2030**	**2035**	**2040**	**2045**
End-Users	**Low**	-1,120.3	-4,752.5	-9,445.7	-14,742.6
	Mid	-2,869.6	-7,502.6	-12,995.8	-18,180.0
	High	-5,597.5	-11,531.9	-17,610.1	-22,423.7
Infrastructure	**Max - Low**	62.7	275.6	599.0	1,010.2
	Max - Mid	103.9	336.9	702.5	1,177.2
	Max - High	358.0	776.0	1,392.2	2,152.3
	Min - Low	0.0	0.0	0.0	0.0
	Min - Mid	0.0	0.0	0.0	0.0
	Min - High	0.0	0.0	0.0	0.0

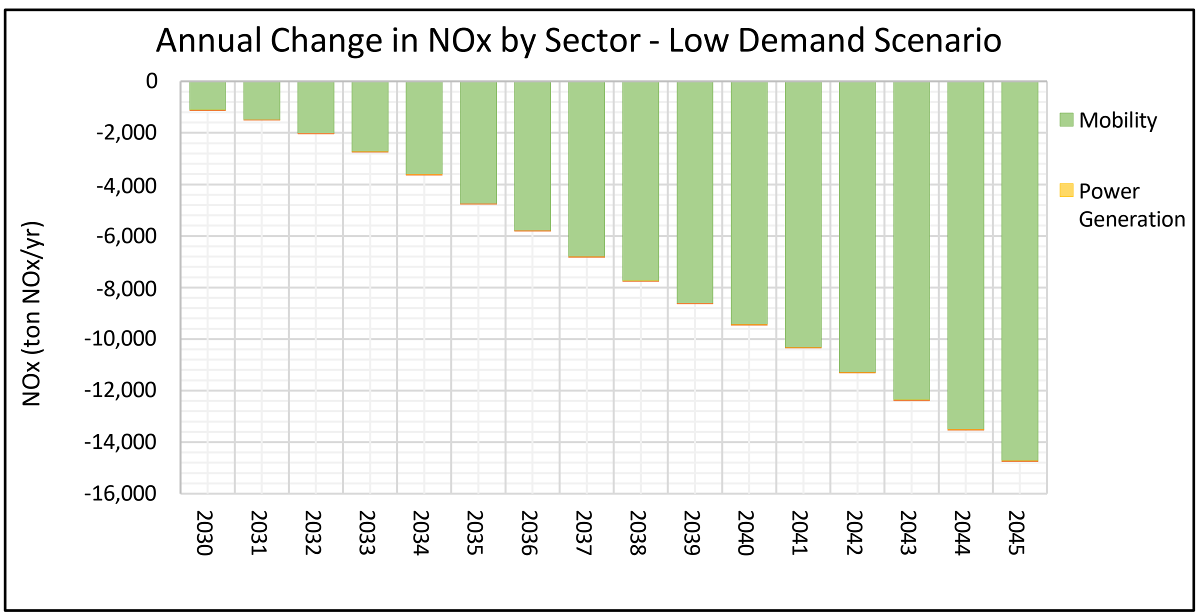

Figure 5A. Anticipated Overall NOx Reductions by Sector (Low Demand)

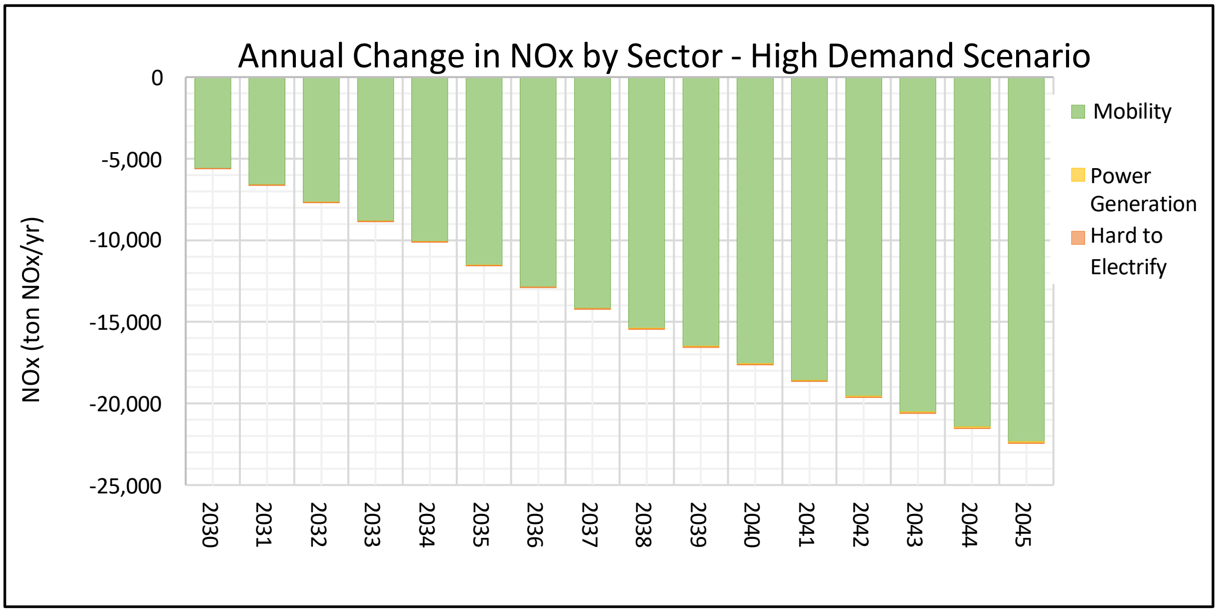

Figure 5B. Anticipated Overall NOx Reductions by Sector (High Demand)

Uncertainty

The uncertainty related to the overall results is primarily due to the fact that information used for this Phase One feasibility study is preliminary. With infrastructure design development, project refinements, detailed information from potential end users, and from technological advancements, these initial NOx emissions estimates can be further refined.

5. Additional Pollutants Evaluated Based on Demand Study

This study also provides a high-level analysis of anticipated reductions in particulate matter (PM) and volatile organic compounds (VOC) emissions with results shown in Table 10 below. For each displaced fossil fuel (natural gas, gasoline, and diesel) an estimated total emission reduction for the fifteen-year period from 2030 to 2045 is provided.

Hydrogen is a clean-burning, non-carbon containing fuel that specifically eliminates diesel particulate matter (DPM) when replacing diesel. Also, multiple studies indicate hydrogen fuel substitution of non-diesel fossil fuels almost entirely reduces PM emissions in spark-ignited engines and turbines. In fact, projected DPM reductions are up to 40% and 82% of South Coast AQMD's forecasted PM2.5 emissions in 2037 for the low and high demand scenarios, respectively.

Hydrogen usage does not produce direct VOC emissions and may be eliminated when replacing fossil fuels. Hydrogen fuel substitution of fossil fuels almost entirely reduces VOC emissions in spark-ignited engines (negligible amounts likely attributable to lubricating oil). Projected VOC reductions are up to 17% and 28% of South Coast AQMD's forecasted VOC emissions in 2037 for the low and high demand scenarios, respectively.

Table 10. Anticipated Overall PM and VOC Reductions

Fuel	Fuel Displaced (2030-2045)			PM Reductions (2030-2045)			VOC Reductions (2030-2045)		
	(MMBtu)			(total tons for 15 years)			(total tons for 15 years)		
	Low	Mid	High	Low	Mid	High	Low	Mid	High
Natural Gas	592,493,061	1,260,630,622	2,322,715,242	2,106	4,481	8,257	1,524	3,243	5,975
Gasoline	459,746,030	570,181,410	741,754,594	22,987	28,509	37,088	277,285	343,892	447,372
Diesel	835,067,889	1,202,280,078	1,704,606,289	129,436	186,353	264,214	34,691	49,946	70,814
Total	**1,887,306,980**	**3,033,092,110**	**4,769,076,126**	**154,529**	**219,343**	**309,559**	**313,500**	**397,081**	**524,161**

6. Assumptions and Preliminary Results for NOx Emissions Associated with Angeles Link

Preliminary emissions calculation results including assumptions are provided for the following evaluated source categories. Projected NOx emissions reductions totals for each end-user subsector were summed to determine totals for each sector; and then totals for each sector were summed and added to anticipated NOx associated with new infrastructure to estimate overall annual potential NOx emissions reductions anticipated for each year 2030 to 2045 for low and high Angeles Link throughput scenarios.

- Infrastructure: production, storage, and transmission of hydrogen to end-users
- End-Users: mobility, power generation, and hard-to-electrify industrial sectors projected to use hydrogen

The study provides a high-level summary of the preliminary data and findings. Detailed emission calculations based on throughput scenarios will be provided in the draft report.

6.1 INFRASTRUCTURE

Summary of preliminary results for anticipated NOx emission increases for new infrastructure based on low and high throughput scenario data in 2045 are the following.

For Low Throughput Scenario, new infrastructure NOx emissions are up to 5.8% the magnitude of end-user reductions.

For High Throughput Scenario, new infrastructure NOx emissions are up to 8.3% the magnitude of end-user reductions.

Production

Three equipment options were evaluated for production to meet the definition of clean renewable hydrogen.

1. Electrolyzers powered by renewable electricity (zero NOx)
2. Biomass gasification (zero NOx)
3. RNG SMR (some NOx)

Multiple scenarios were evaluated to estimate the range from low to high NOx emissions. The range extends from zero NOx associated with the 100% electrolysis and the 100% biomass gasification scenarios to the highest potential NOx emissions for the 100% RNG SMR scenario. Equation 1 was used to conduct the NOx emissions calculations.

Fuel Throughput x Emissions Factor = Emissions (equation 1)

NOx emission estimates can be refined once assumptions regarding the anticipated hydrogen production processes have been developed and/or the proportions of hydrogen intended to be produced from different methods has been identified. Preliminary results for potential NOx emissions from hydrogen production are provided for the Low and High Throughput Scenarios in Table 11.

Table 11. Potential NOx Emissions from Hydrogen Production (tons/year)

Throughput Scenario	Emissions (tons/year)				Production Scenario
	2030	2035	2040	2045	
Low Min	0.0	0.0	0.0	0.0	100% Electrolysis or 100% Biomass Gasification
Low Max	3.9	15.3	33.0	56.3	100% SMR
High Min	0.0	0.0	0.0	0.0	100% Electrolysis or 100% Biomass Gasification
High Max	31.64	65.28	112.03	168.89	100% SMR

Storage and Transmission

1. Compressors will be needed for storage and transmission of hydrogen. Three options for types of compressors were evaluated: Electric motor driven compressors (zero NOx)
2. Clean renewable hydrogen fueled reciprocating engine driven compressors (some NOx)
3. Clean renewable hydrogen fueled turbine driven compressors (some NOx)

Potential emissions of NOx from hydrogen fueled reciprocating engine driven compressors and from turbine driven compressors were calculated using equation 1:

Fuel Throughput x Emissions Factor = Emissions (equation 1)

NOx emission factors were developed using engine emission factors from South Coast AQMD Rule 1110.2 "Emissions from Gaseous and Liquid Fueled Engines"[22] and turbine emission factors from South Coast AQMD Rule 1134 "Emissions of Oxides of Nitrogen from Stationary Gas

[22] Rule 1110.2 Clean (aqmd.gov)

Turbines"[23] and then adjusted with the correction factor method previously described to estimate potential hydrogen combustion emissions.

Two storage pressure scenarios were evaluated. A low pressure scenario at 290 psi and a high pressure scenario at 2,900 psi. The total transmission distance analyzed was adjusted to 450 miles to reflect the most recent information available. These are placeholder estimates since preliminary information from parallel studies is not yet available. Emission estimates can be refined once the types, sizes, and quantities of compressors have been further developed. Additionally, development of assumptions regarding above ground and underground storage volumes and pressures will support development of refinement of emission estimates. Preliminary results for storage and transmission for potential NOx emissions are provided in Tables 12 and 13, respectively.

Table 12. Potential NOx Emissions from Storage (tpy)

Throughput Scenario	Emissions (tons/yr)				Scenario	
	2030	2035	2040	2045	Storage Pressure	Power Source
Low Min	0.0	0.0	0.0	0.0	NA	Renewable Electricity
Low Max	1.9	7.3	15.4	25.8	2,900 psi	H2 Reciprocating Engine
High Min	0.0	0.0	0.0	0.0	NA	Renewable Electricity
High Max	13.9	28.8	50.4	76.5	2,900 psi	H2 Reciprocating Engine

[23] http://www.aqmd.gov/docs/default-source/rule-book/reg-xi/rule-1134.pdf?sfvrsn=4

Table 13. Potential NOx Emissions from Transmission (tons/yr)						
Throughput Scenario	**Emissions (tons/yr)**				**Scenario**	
	2030	**2035**	**2040**	**2045**	**Transmission Distance**	**Power Source**
Low Min	0.0	0.0	0.0	0.0	NA	Renewable Electricity
Low Max	5.7	5.7	45.9	76.9	450 miles	H2 Reciprocating Engine
High Min	0.0	0.0	0.0	0.0	NA	Renewable Electricity
High Max	41.4	41.4	150.4	228.4	450 miles	H2 Reciprocating Engine

7. End Users

The focus of the NOx emissions study was on three sectors of hydrogen end-users: mobility, power generation, and hard to electrify industrial. The Throughput Scenarios estimated quantities of diesel and gasoline that ~~may~~ are anticipated to be replaced by ~~hydrogen fuel cells~~ FCEV in the mobility sector. The Throughput Scenarios also estimated quantities of natural gas that may be replaced by hydrogen fuel in the power generation and hard to electrify industrial sectors.

7.1 MOBILITY

Summary of preliminary results for anticipated NOx emission decreases for the Mobility sector based on the Angeles Link low and high throughput scenarios in 2045 are:

- Mobility is the main end-user source of NOx reductions at 99.8% and 99.6% of end-user reductions (i.e., associated with conversion to FCEVs) for low and high throughput scenarios, respectively. These reductions are due to ~~hydrogen fuel cell~~ FCEVs substitution for fossil fuels providing a 100% NOx emissions reduction. This study does not project emission reductions related to fossil fuel displacement that will be associated with BEVs.
    - Low Throughput Scenario
        - On-Road Vehicles account for 85.1% of Mobility NOx emission reductions
            - Heavy Duty Vehicles are 73.8% of Mobility NOx emission reductions
        - Off-Road Vehicles account for 14.9% of Mobility NOx emission reductions
    - High Throughput Scenario
        - On-Road Vehicles account for 87.4% of Mobility NOx emission reductions
            - Heavy Duty Vehicles are 77.4% of Mobility NOx emission reductions
        - Off-Road Vehicles account for 12.6% of Mobility NOx emission reductions

Assumptions for the Mobility sector are based on the projected hydrogen demand that would displace ~~primarily that~~ diesel and gasoline fuel ~~will be displaced and~~ for vehicles that are projected to ~~would~~ convert ~~to hydrogen fuel cells~~ FCEVs with zero NOx emissions. Emission factors for NOx from displaced diesel and gasoline fuel were developed using EMFAC data. Fuel consumption was weighted by subcategory of vehicle types. The same two equations previously mentioned were used to conduct the NOx calculations, and the hydrogen emissions value in equation 2 is zero.

Fuel Throughput x Emissions Factor = Emissions (equation 1)

Emission Reductions = Fossil Fuel Emissions – Hydrogen Emissions (equation 2)

Total emissions were calculated by summing totals for each equipment type and are shown in Table 14. Figures 6A and 6B provide graphs for low and high throughput scenarios, respectively.

Table 14. Mobility NOx Emission Reductions for Angeles Link (tpy)

	2030	2035	2040	2045
Low	300.0	1,274.0	2,532.1	3,951.2
High	1,417.5	2,918.7	4,453.4	5,663.9

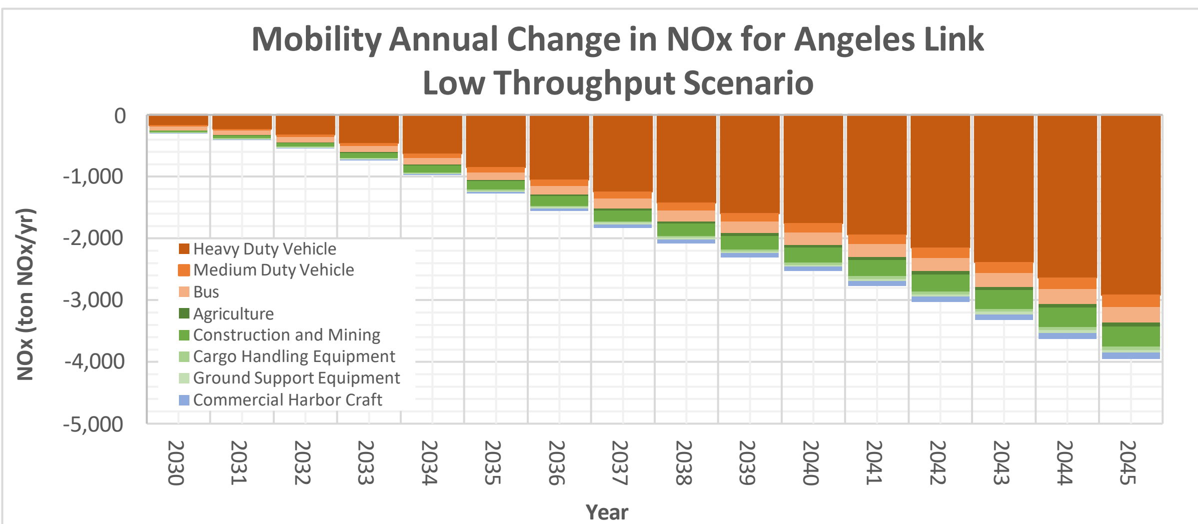

Figure 6A. Anticipated NOx Emission Reductions for Mobility Sector (Low Throughput)

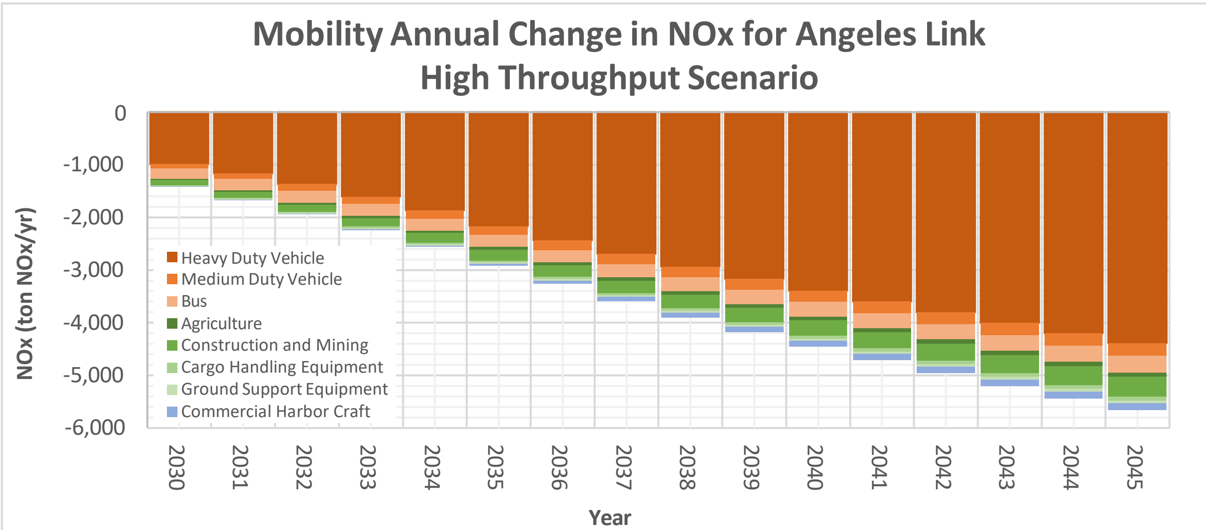

Figure 6B. Anticipated NOx Emission Reductions for Mobility Sector (High Throughput)

Power Generation

Preliminary results for anticipated NOx emission reductions based on the low and high throughput scenarios in 2045 are that the Power Generation sector accounts for 0.1% and 0.3% of overall NOx reductions, respectively. Assumptions applied to develop NOx emissions calculations include that hydrogen will displace natural gas as a fuel with increasing amounts over time (from 2030 to 2045). It is worth noting that there may be additional reductions beyond those contemplated in this study associated with the potential replacement of power generation with non-combustion technologies such as fuel cells.[24]

The NOx emissions estimates assumed permitted NOx emissions would stay the same or decrease given the requirements to make progress towards achieving ozone attainment in several of the air districts that the SoCalGas territory encompasses. Academicians from UCI have expressed agreement with this assumption indicating that they anticipate overall power generation NOx emissions will decrease most importantly because South Coast AQMD is likely to require NOx reductions to meet State Implementation Plan (SIP) requirements.[25]

Specifically, an assumption was made that the California regulatory environment would not allow for an increase in permitted NOx emissions at stationary sources. In fact, air quality regulations have often stimulated technological advancements and reduced costs of emission controls as adoption becomes more widespread.[26] As such, it was assumed that adjustments to the hydrogen combustion process such as lowering of combustion temperature[27] and modifying

[24] Jack Brouwer, UCI, Angeles Link Planning Advisory Group meeting, December 15, 2023.
[25] Jack Brouwer, UCI, Angeles Link Planning Advisory Group meeting, December 15, 2023.
[26] Sonia Yeh, et. al., Technology Innovations and Experience Curves for Nitrogen Oxides Control Technologies, 2005, [Technology innovations and experience curves for nitrogen oxides control technologies (Journal Article) | OSTI.GOV]
[27] S.K., Alavandi, et. al., 2007, https://www.sciencedirect.com/science/article/abs/pii/S0360319907007276

air/fuel ratios,[28] and technological advancements[29] to NOx emission controls[30] would be in place so that the permitted NOx emissions would stay the same or decrease with the combustion of hydrogen in equipment in the power generation and hard to electrify industrial sectors. Based upon a review of existing technical literature, while there is uncertainty given limited actual measurements of NOx for 100% hydrogen combustion applications, actual NOx emissions, which can differ from permitted NOx, may also stay the same or decrease for most end user applications depending on combustion conditions such as temperature and residence time. Advancements related to hydrogen combustion technology and post-combustion treatment are anticipated to close this gap between actual NOx emissions associated with natural gas combustion and hydrogen combustion once hydrogen specific design considerations are more broadly applied.

Hydrogen usage in the Power Generation sector is anticipated to begin with hydrogen/natural gas blends on or before 2025 and begin to use 100% hydrogen fuel by 2031 as the technology becomes more available. It was assumed that blended fuels will continue to be used while the in-use units age out. The transition from blended fuels to 100% pure hydrogen fuels was evaluated by the Demand Study. For each emission source type identified, calculations to estimate emissions were prepared using the same two equations previously mentioned.

Fuel Throughput x Emissions Factor = Emissions (equation 1)

Emission Reductions = Fossil Fuel Emissions – Hydrogen Emissions (equation 2)

The NOx emission factors selected were the most restrictive NOx emission factors from the current air district rules for natural gas combustion. These natural gas combustion emission factors were then converted to represent estimated NOx emission factors from hydrogen combustion using the correction factor approach previously described in the Calculation Methodology section of this document. This information is summarized in Table 15 below.

[28] L. Wang, et. al., 2004 Interactions among soot, thermal radiation, and NOx emissions in oxygen-enriched turbulent nonpremixed flames: a computational fluid dynamics modeling study - ScienceDirect
[29] K. Kammer Hansen, Electrochemical Removal of NOx Using Oxide-Based Electrodes – A Review, 2018, (electrochemsci.org)
[30] Alves, et. al., 2021, A comprehensive review of NOx and N2O mitigation from industrial streams - ScienceDirect

Table 15. Natural Gas and Hydrogen Combustion Emission Factor Values for Power Generation						
Sub-Sector	**Equipment Category**	**NOx 100% Natural Gas EF (lb/MMBtu)**	**NOx EF District**	**NOx EF Rules**	**Note**	**NOx 100% Hydrogen EF (lb/MMBtu)**
Baseload and Peaker	General External Combustion	0.0145	South Coast	1146, 1146.1, 1146.2	Average of Multiple	0.0136
	Reciprocating Engine	0.0405	South Coast	1110.2	Single Factor	0.0381
	Turbine	0.0083	South Coast	1135	Average of Multiple	0.0078
Cogeneration	General External Combustion	0.0145	South Coast	1146, 1146.1, 1146.2	Average of Multiple	0.0136
	Reciprocating Engine	0.0405	South Coast	1110.2	Single Factor	0.0381
	Turbine	0.0074	South Coast	1134	Single Factor	0.0069

Total emissions were calculated by summing totals for each equipment type and are shown in Table 16. Figures 7A and 7B provide graphs for the low and high throughput scenarios, respectively below.

A source of uncertainty for the stationary combustion calculations at the time of this study was the lack of manufacturers' emissions data and stack testing data for pure hydrogen combustion. There is some existing emissions data for pure hydrogen and blended hydrogen combustion as the technology of combusting pure hydrogen is still in development. Of the hydrogen combustion data that is available, large variations were noted in emission results. As technology is further developed over time, and more data is available, more specific emissions factors may be developed for NOx emissions from pure hydrogen combustion.

Table 16. Power Generation NOx Emission Reductions for Angeles Link (tpy)				
	2030	**2035**	**2040**	**2045**
Low	0.1	0.8	2.4	5.1
High	0.2	2.8	8.6	18.2

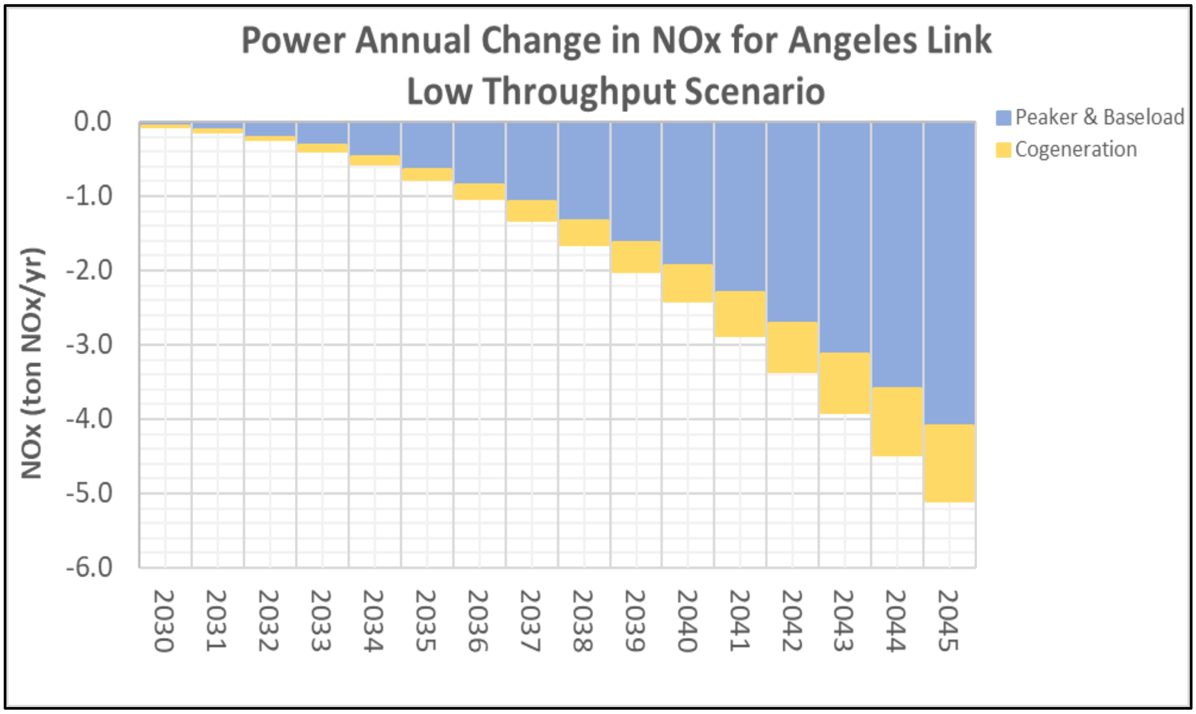

Figure 7A. Anticipated NOx Reductions for Power Sector (Low Throughput)

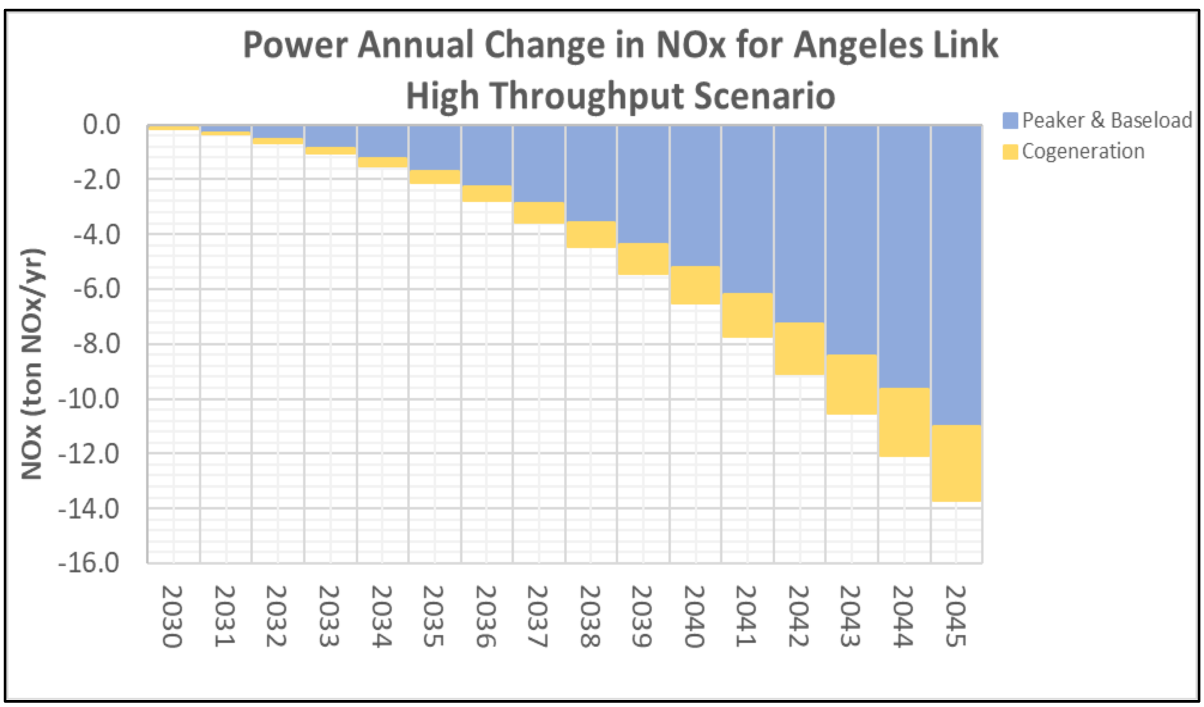

Figure 7B. Anticipated NOx Reductions for Power Sector (High Throughput)

Hard to Electrify Industrial

The preliminary results for the anticipated NOx emissions associated with the Industrial sector based on the low and high Angeles Link throughput data in 2045 are that the Industrial sector accounts for 0.04% and 0.09% respectively, of overall NOx reductions. Inherent in preparation of the NOx emissions estimates was the assumption that permitted NOx emissions would stay the same or decrease given the requirements to make progress towards achieving ozone attainment in several of the air districts that the SoCalGas territory encompasses.

The assumptions that were applied to develop the NOx emissions calculations include that hydrogen will displace natural gas as a fuel with increasing amounts over time (from 2030 to 2045). It should be noted that consistent with the Decision, Angeles Link is intended as a project to transport only 100% clean renewable hydrogen in the pipeline, and any analysis of hydrogen blending refers strictly to “behind-the-meter” operations, and not hydrogen within SoCalGas’s control.

For industrial end-user calculations, it was assumed that 100% of initial hydrogen demand would be blended with natural gas until 2030, when heavy-duty equipment capable of combusting pure hydrogen would be commercially available. The assumption that heavy-duty industrial equipment capable of combusting pure hydrogen would be available by 2030 was based on manufacturer statements. Once pure hydrogen fuel combustion technology becomes available in 2030, it was assumed that blended fuel equipment would be retired or phased out over time until 100% of hydrogen demand would be utilized by equipment combusting pure hydrogen fuel in 2050. To estimate equipment-phase out, it was assumed industrial combustion equipment would have a lifespan of 20 years. Therefore, if sales of blended equipment end in 2030 and equipment has an assumed lifespan of approximately 20 years, then by 2050 hydrogen combustion equipment in operation should be capable of combusting pure hydrogen based on the assumed lifespan of blended equipment of 20 years. The rate of natural gas and hydrogen consumption/blending from 100% natural gas to 100% hydrogen is assumed to change about 4% a year. Equipment-level blended hydrogen combustion as a percentage of overall hydrogen consumption is depicted in Table 17 below.

Table 17. Equipment-level Hydrogen-Natural Gas Blending Percentages						
Source	**Percent of Total H2 Demand as Blend**					
	2025	**2030**	**2035**	**2040**	**2045**	**2050**
Engine	100	80	60	40	20	0
Turbine	100	80	60	40	20	0
External Combustion	100	80	60	40	20	0
Oven	100	80	60	40	20	0

It was also assumed that the hydrogen-natural gas percentage for blended hydrogen would vary by equipment-type. Blending for reciprocating engines, turbines, general external combustion units, and ovens were estimated based on manufacturer specification sheets and direct measurement studies reviewed in the literature. Estimated equipment-level hydrogen-natural gas blending percentages are shown in Table 18 below.

Table 18. Equipment Level Hydrogen Natural Gas Blending Ratios for Industrial End-users	
Source	**H2 to Natural Gas Ratio**
Engine	25%
Turbine	57%
External Combustion	22%
Oven	22%

For each emission source type identified, calculations to estimate emissions were prepared using the same two equations previously mentioned.

Fuel Throughput x Emissions Factor = Emissions (equation 1)

Emission Reductions = Fossil Fuel Emissions – Hydrogen Emissions (equation 2)

The NOx emission factors selected were the most restrictive NOx emission factors from the current air district rules for natural gas combustion. These natural gas combustion emission factors were then converted to represent estimated NOx emission factors from hydrogen combustion using the correction factor approach previously described in the Calculation Methodology section of this document. This information is summarized in Table 19 below.

Table 19. Natural Gas and Hydrogen Combustion Emission Factor Values for Industrial						
Sub-Sector	**Equipment Category**	**NOx 100% Natural Gas EF (lb/MMBtu)**	**NOx EF District**	**NOx EF Rules**	**Note**	**NOx 100% Hydrogen EF (lb/MMBtu)**
Food and Beverage	General External Combustion	0.0145	South Coast	1146, 1146.1, 1146.2	Average of Multiple	0.0136
	Oven	0.0492	SJV	4309	Single Factor	0.0462
	Reciprocating Engine	0.0405	South Coast	1110.2	Single Factor	0.0381
	Turbine	0.0092	South Coast	1134	Single Factor	0.0087
Metals Stone, Glass, Cement Paper Chemicals Aerospace and Defense	General External Combustion	0.0145	South Coast	1146, 1146.1, 1146.2	Average of Multiple	0.0136
	Oven	0.0492	SJV	4309	Single Factor	0.0462
	Reciprocating Engine	0.0405	South Coast	1110.2	Single Factor	0.0381
	Turbine	0.0092	South Coast	1134	Single Factor	0.0087
Refineries	General External Combustion	0.0145	South Coast	1146, 1146.1, 1146.2	Average of Multiple	0.0136
	Reciprocating Engine	0.0405	South Coast	1110.2	Single Factor	0.0381
	Turbine	0.0074	South Coast	1109.1	Single Factor	0.0069

The total emissions were calculated by summing totals for each equipment type and are shown in Table 20. Figures 8A and 8B provide graphs for the low and high Angeles Link throughput scenarios, respectively below.

A source of uncertainty for the stationary combustion calculations at the time of this study was the lack of manufacturers emissions data and stack testing data for pure hydrogen combustion. There is minimal existing emissions data for pure hydrogen and blended hydrogen combustion as the technology is largely still in development. Of the hydrogen combustion data that is available, large variations were noted in emission results. As technology is further developed over time, and more data is available, more specific emissions factors may be developed for NOx emissions from the combustion of hydrogen.

Table 20. Industrial NOx Emission Reductions Associated with Angeles Link (tpy)				
	2030	2035	2040	2045
Low	0.7	1.2	1.4	1.7
High	1.9	3.2	4.1	4.9

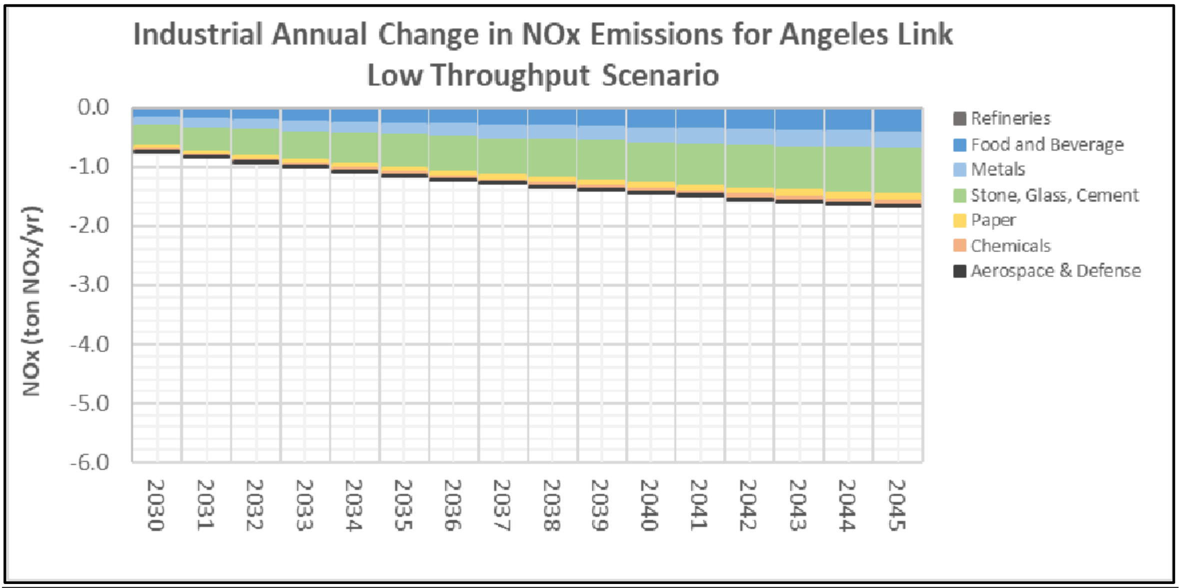

Figure 8A. Anticipated NOx Reductions for Industrial Sector (Low Throughput)

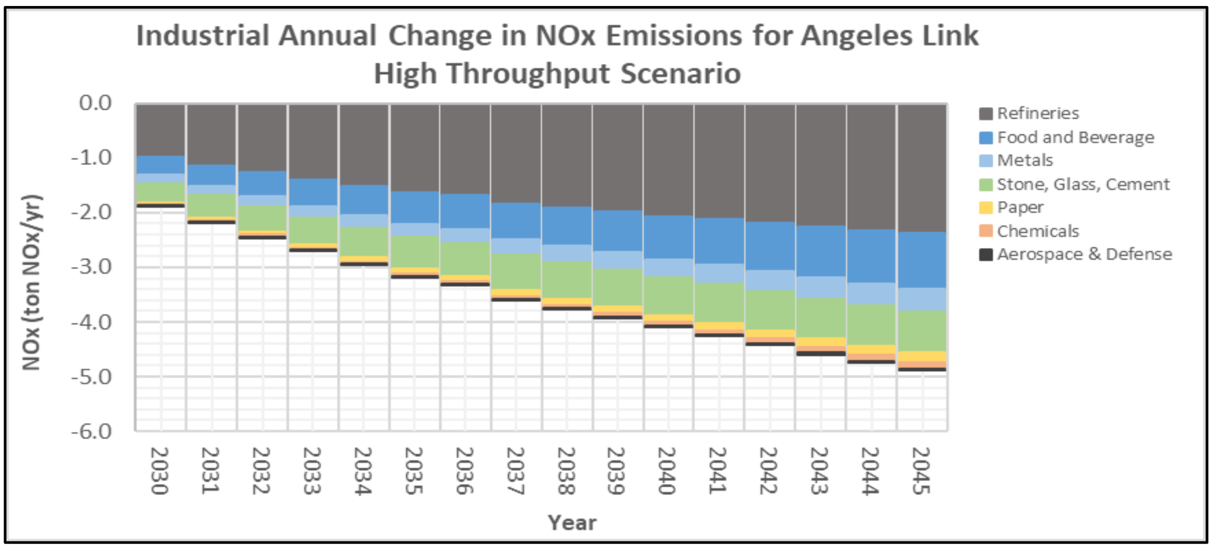

Figure 8B. Anticipated NOx Reductions for Industrial Sector (High Throughput)

8. Overall NOx Results Associated with Angeles Link

Anticipated potential NOx emissions for new infrastructure were added to anticipated NOx emissions reductions associated with potential end users of hydrogen as defined by the Demand Study. The results are provided in Table 21, and in Figures 9A and 9B below. In summary:

- Overall NOx emissions are expected to potentially be reduced by more than 3,700 tons per year and 5,100 tons per year in 2045 based on the low and high throughput scenarios of the Demand Study, respectively.
- Mobility NOx emissions (e.g., primarily heavy duty transportation) ~~are eliminated with conversion to hydrogen fuel cells~~ will be reduced with the conversion to ZEVs. Options for ZEVs include FCEVs and BEVs. The Demand Study projected the anticipated fossil fuel displacement associated with FCEVs only. The associated NOx reductions were estimated only for conversion to FCEVs; this study does not project emission reductions related to fossil fuel displacement that will be associated with BEVs.
  - Mobility sector comprises 99.8% and 99.6% of end-user NOx emission reductions related to Angeles Link (i.e., associated with conversion to FCEVs) based on low and high throughput scenarios, respectively.
- Power generation and hard to electrify industrial sector permitted NOx emissions are expected to stay the same or decrease.
  - Power generation sector comprises 0.1% and 0.3% of the end-user NOx emission reductions based on low and high throughput scenarios, respectively.
  - Hard to electrify industrial sector comprises 0.04% and 0.09% of the end-user NOx emission reductions based on low and high throughput scenarios, respectively.
- Infrastructure NOx emissions are minor in nature when compared to overall NOx emissions reductions at 4.0% and 8.3% of end-user reductions for low and high throughput scenarios, respectively.

Table 21. Annual Change in NOx Emissions Associated with Angeles Link (ton NOx/yr)					
		2030	**2035**	**2040**	**2045**
End-Users	**Low**	-300.8	-1,275.9	-2,535.9	-3,958.0
	Mid	-893.1	-2,335.0	-4,044.7	-5,658.2
	High	-1,419.6	-2,924.7	-4,466.2	-5,686.9
Infrastructure	**Max - Low**	11.5	44.4	94.3	158.9
	Max - Mid	27.3	86.3	178.9	300.4
	Max - High	87.0	180.3	312.9	473.8
	Min - Low	0.0	0.0	0.0	0.0
	Min - Mid	0.0	0.0	0.0	0.0
	Min - High	0.0	0.0	0.0	0.0

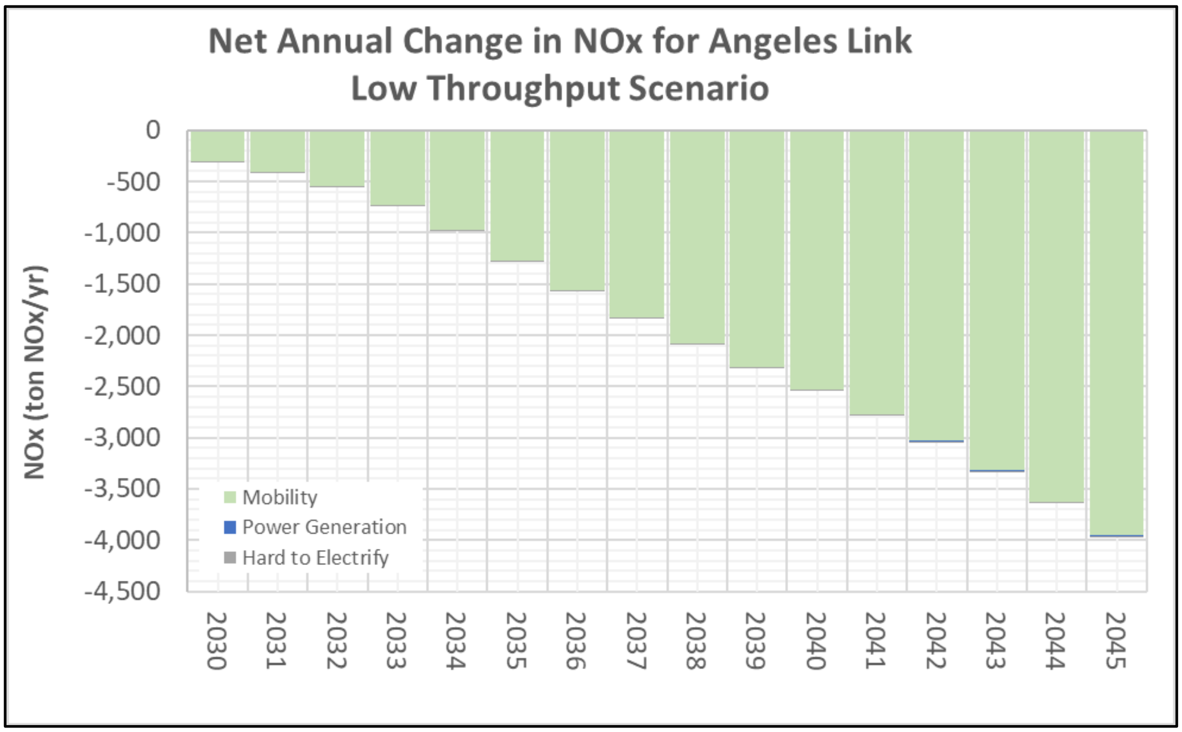

Figure 9A. Overall Projected NOx Reductions for Angeles Link (Low Throughput)

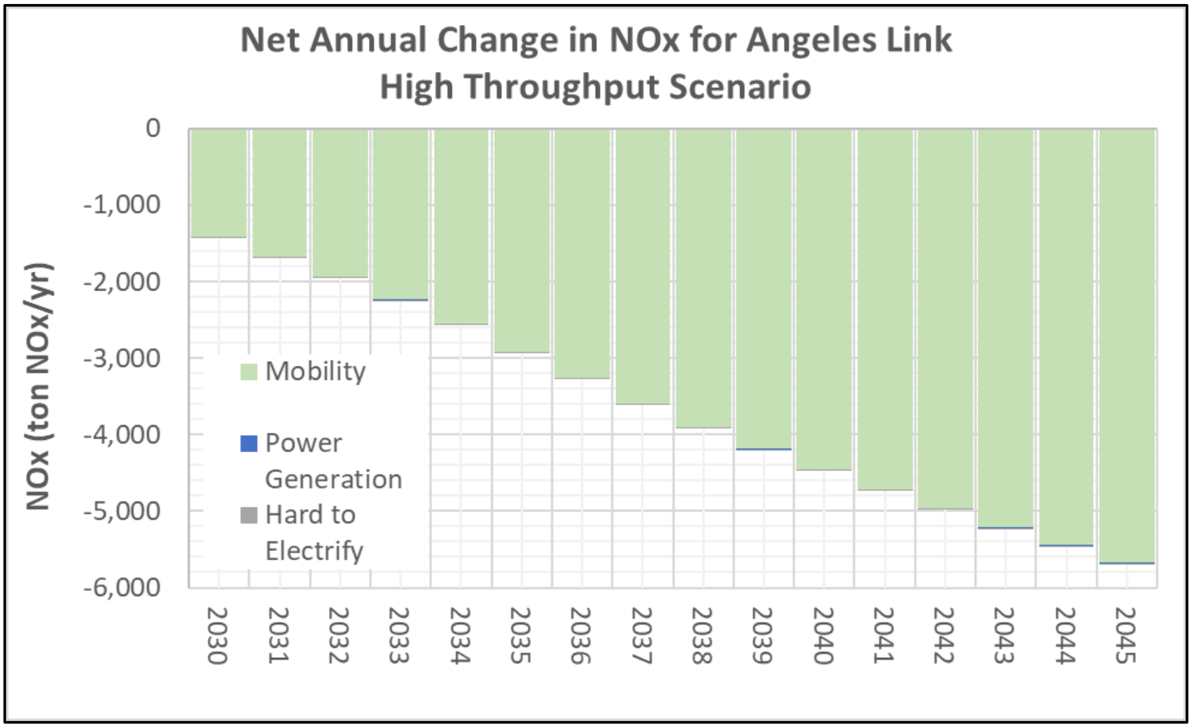

Figure 9B. Overall Projected NOx Reductions Associated With Angeles Link (High Throughput)

Uncertainty

The uncertainty related to the overall results is primarily due to the fact that information used for this Phase One feasibility study is preliminary. With infrastructure design development, project refinements, detailed information from potential end users, and from technological advancements, these initial NOx emissions estimates can be further refined.

9. Additional Pollutants Evaluated Associated with Angeles Link

This study also provides a high-level analysis of anticipated reductions in particulate matter (PM), which is the primary pollutant associated with diesel combustion and, volatile organic compounds (VOC) emissions. For each displaced fossil fuel (natural gas, gasoline, and diesel) an estimated total emission reduction for the fifteen-year period from 2030 to 2045 is provided.

Hydrogen is a clean-burning, non-carbon containing fuel that specifically eliminates diesel particulate matter (DPM) when replacing diesel. Also, multiple studies indicate hydrogen fuel substitution of non-diesel fossil fuels almost entirely reduces PM emissions in spark-ignited engines and turbines. In fact, projected DPM reductions are about 10.5% and 24.3% of South Coast AQMD's forecasted PM2.5 emissions in 2037 for the low and high throughput scenarios, respectively.

Hydrogen usage does not produce direct VOC emissions and may be eliminated when replacing fossil fuels. Hydrogen fuel substitution of fossil fuels almost entirely reduces VOC emissions in spark-ignited engines (negligible amounts likely attributable to lubricating oil). Projected VOC reductions are about 4.4% and 7.2% of South Coast AQMD's forecasted VOC emissions in 2037 for the low and high throughput scenarios, respectively.

Refer to results of this analysis shown in Table 22.

10. Conclusion

The preliminary NOx emission estimates calculated from data from both the Demand Study Demand Scenarios and Angeles Link Throughput Scenarios are set forth in this Study. The preliminary NOx combustion emission estimates associated with Angeles Link set forth in this study are for informative purposes for Phase One of the Angeles Link project. Information from parallel studies related to hydrogen infrastructure is still evolving and data from future end users can be further refined. This study acknowledges that limited data exists in the literature for actual measurements of NOx emissions associated with combustion of clean renewable hydrogen and that combustion technology and post-combustion treatment technology is anticipated to develop over time. As refinements have been made for natural gas combustion over the past decades, it is anticipated that developments will similarly be made for hydrogen combustion to minimize NOx emissions. The design details of the Angeles Link infrastructure, as well as further project refinements will inform future quantification estimates for NOx emissions and NOx minimization opportunities.

Table 22. Anticipated Overall PM and VOC Reductions Associated with Angeles Link from 2030 - 2045									
Fuel	**Fuel Displaced by Angeles Link (MMBtu)**			**PM Reductions (total tons for 15 years)**			**VOC Reductions (total tons for 15 years)**		
	Low	**Mid**	**High**	**Low**	**Mid**	**High**	**Low**	**Mid**	**High**
Natural Gas	159,069,279	392,348,797	589,072,023	565	1,395	2,094	409	1,009	1,515
Gasoline	123,430,086	177,458,794	188,119,005	6,172	8,873	9,406	74,444	107,030	113,460
Diesel	224,194,435	374,188,231	432,311,226	34,750	57,999	67,008	9,314	15,545	17,959
Total	**506,693,800**	**943,995,822**	**1,209,502,253**	**41,487**	**68,267**	**78,508**	**84,167**	**123,584**	**132,934**

Appendix A: Process to Estimate NOx Emission Factors for Hydrogen Combustion

In the absence of published NOx emissions factors for hydrogen combustion, the following approach was used to develop hydrogen emissions factors based on studies that evaluated volumetric variation of NOx emissions between hydrogen fuel and methane fuel.

NOx emissions are measured from combustion stacks as a volumetric value in parts per million by dry volume (ppmvd). Due to differences in the exhaust properties of methane and hydrogen, for an identical mass emission rate of NOx, measured NOx ppmvd values from pure hydrogen combustion are 37% greater than natural gas. This is because hydrogen exhaust has a higher water content which results in a more concentrated NOx ppmvd value when a sample is dehydrated and corrected for oxygen.[31] Therefore, volume-based emissions estimates of NOx are not directly comparable between these fuel types. Some studies and manufacturer data report NOx emissions on a volume basis without converting to a mass-basis. In these cases, NOx emissions may inaccurately appear to increase between hydrogen and methane/fossil fuels even if they are not increasing on a mass basis. Some permits and regulations provide a volumetric basis for NOx emission limitations in parts per million by volume (ppmv) at fifteen percent Oxygen (O2) for internal combustion units, three percent O2 for external combustion units, and nineteen percent O2 for ovens. Regulating agencies will need to consider these volumetric differences when determining emission limitations for pollutants from the combustion of hydrogen.

Volumetric emissions values can be converted to a mass basis (lb/mmbtu, lb/hr, or ton/yr) using a fuel-dependent proportionality value. These proportionality values are typically referred to as a “fuel factor” or an “F-factor.” Fuel factors do not vary significantly between carbon-based fossil fuels but do vary significantly between fossil fuels and hydrogen. It is imperative to use accurate fuel factors, and it has been noted in scientific literature that some studies do not properly utilize fuel factors for these conversions. This can skew results resulting in an apparent increase in NOx emissions when combusting hydrogen fuels when an increase in mass-basis NOx emissions is not occurring.[32] This study utilized the method for calculating fuel factors outlined in a textbook authored by Jahnke (1993),[33] which follows the same process as the US EPA’s Method 19. This method was used to calculate fuel factors for pure hydrogen and blended hydrogen-methane fuels. Table 19-2 “F-Factors for Various Fuels” from US EPA’s Method 19 – Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxide Emission Rates provides fuel factors for commonly used fuels, including natural gas. This table lists 8,710 dscf/mmbtu as the EPA published fuel factor for natural gas. This value was used in the

[31] Douglas, C.M., et al., 2022, Pollutant Emissions, Ibid

[32] Douglas, C., B. Emerson, T. Lieuwen, T. Martz, R. Steele, B. Noble, 2022, Nox Emissions from Hydrogen-Methane Fuel Blends, Georgia Tech Strategic Energy Institute short paper, https://research.gatech.edu/sites/default/files/inline-files/gt_epri_nox_emission_h2_short_paper.pdf

[33] Jahnke, J.A., 1993, Continuous Emissions Monitoring, John Wiley & Sons

calculations for this study. The US EPA has not published an approved fuel factor for hydrogen fuel, so the fuel factors calculated using the described method were utilized.

Equation A-5[34] below was utilized to calculate the Fd factor, oxygen based, dry factor. The percentage mass of each constituent within the fuel blend was multiplied by the appropriate factor as provided in the equation, summed, and divided by the GCV (HHV) value for the fuel blend in units of btu/lb. The calculated Fd is for the stoichiometric scenario. Values are then corrected to the appropriate oxygen level for the reporting basis (3%, 15%, or 19%, based on the equipment type).

Equation 1

$$F_d = \frac{10^6[3.64(\%H) + 1.53(\%C) + 0.57(\%S) + 0.14(\%N) - 0.46(\%O)]}{GCV} \quad \text{English units} \quad \text{(A-5)}$$

Note: Units for the conversion factors in the expressions are 10^{-5} kJ/J and 10^6 Btu/million Btu for GCV expressed in kilojoules per kilogram and in Btu per pound, respectively. The constants in the expressions are given in units of standard cubic meters per kilogram (e.g., 22.7 scm/kg) and standard cubic feet per pound (e.g., 3.64 scf/lb).

The equation below depicts the calculation of the F-factor for pure hydrogen @ 68F. Per Equation A-5 above, "Specific Weighted H2" = 364.0 scf/lb = 3.64 * 100 = 3.64 * (%H2).

Equation 2

$$\text{Fd (H2 @ 68 F) (scf/MMBtu)} = \text{Specific Weight H2} \ \frac{\text{scf}}{\text{lb}} \times \text{Conv (Btu-MMBtu)} \ \frac{\text{Btu}}{\text{MMBtu}} \div \text{HHV-lb H2} \ \frac{\text{Btu}}{\text{lb}}$$

$$\text{Fd (H2 @ 68 F) (scf/MMBtu)} = 364 \ \frac{\text{scf}}{\text{lb}} \times 1{,}000{,}000 \ \frac{\text{Btu}}{\text{MMBtu}} \div 60{,}920 \ \frac{\text{Btu}}{\text{lb}} = 5975.05 \ \text{(scf/MMBtu)}$$

Volumetric (ppmvd) correction factors were utilized to convert emissions factors for pure natural gas to applicable factors for blended fuel mixes and pure hydrogen. These correction factors account for differences in the exhaust properties of methane and hydrogen which, for an identical mass emission rate (lb/MMBtu), will have measured ppmvd (corrected to 15% O2) values that are roughly 37% greater for hydrogen than natural gas. This is because, holding all combustion conditions the same, hydrogen exhaust has a higher water and oxygen content than natural gas. Stack gas samples (ppmvd) are dehydrated and oxygen-corrected before testing, and this sample preparation process differentially skews measured ppmvd values between natural gas and hydrogen. This results in more concentrated ppmvd values from hydrogen exhaust. These correction factors vary in magnitude across a spectrum of fuels from pure natural gas to pure hydrogen and were applied to pure natural gas emissions factors to develop representative blended or pure hydrogen emissions factors. These correction factors can also be applied in

[34] Jahnke, J.A., 1993, Ibid

reverse to develop representative blended or pure natural gas emissions factors from pure hydrogen emissions factors. A plot of the correction factor over a range of hydrogen-natural gas fuel blends is depicted below, as well as this data in tabular form. Note that the data below depicts results from this publication at 1 bar of pressure, reactant temperature of 300K, and adiabatic flame temperature of 2000K. The publication also includes results, which are very similar (and not included below or used in this study), for 2 bar of pressure, reactant temperature of 700K, and adiabatic flame temperature of 2000K.[35] It was assumed that the correction factor from Douglas et al. was representative of all equipment types and fuel blends in this study where it was applied.

[37] Douglas, C., et al, 2022, Nox Emissions from Hydrogen-Methane Fuel Blends, Ibid

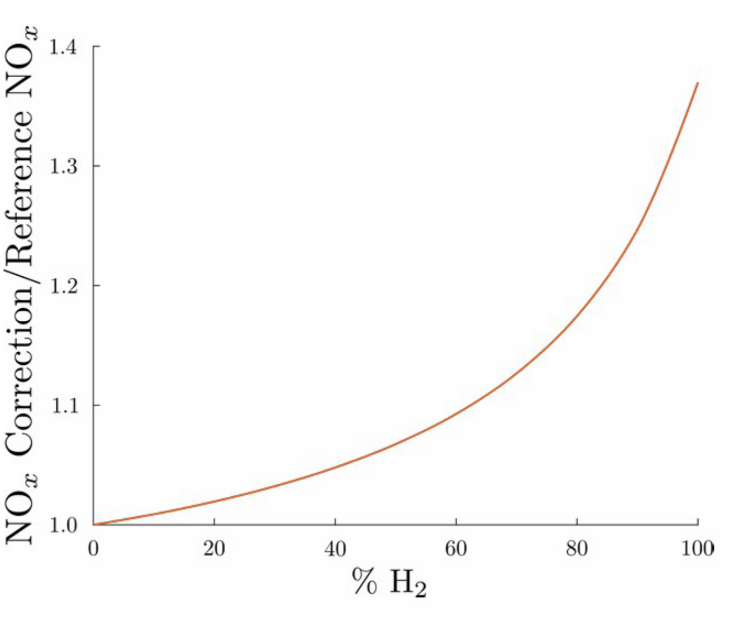

Figure 1 Correction Factor Plot Over a Range of Hydrogen-natural Gas Fuel Blends[36]

Table 1 Tabular Correction Factor Values for Hydrogen-Natural Gas Fuel Blends[37]

1 bar, 300 K reactants, Tad = 2000 K

Fuel % H_2	Fuel % CH_4	Prod. %CO_2	Prod. %H_2O	Prod. %O_2	NO_x corr.	Ratio
0	100	7.69	15.38	3.70	0.4264	1.000
20	80	7.15	16.07	3.82	0.4347	1.019
40	60	6.39	17.03	4.00	0.4468	1.048
60	40	5.27	18.45	4.25	0.4659	1.092
80	20	3.46	20.74	4.66	0.5008	1.174
100	0	0.00	25.13	5.45	0.5840	1.370

Representative NOx mass emissions factors for hydrogen and hydrogen-natural gas blends were calculated from NOx mass emission limits and BACT requirements from local regulations. Where emissions limits were given in lb/MMbtu rather than ppmvd, the following equation was used to convert to lb/MMbtu to ppmvd.

Equation 3

$$\text{NOx NG EF Conc (ppm)} = \text{NG NOx EF } \frac{\text{lb}}{\text{MMBtu}} \div \text{MW (NO2) } \frac{\text{lb}}{\text{pmole}} \times \text{Molar Volume @ 68 F } \frac{\text{scf}}{\text{pmole}} \div \text{O2 Correction } \frac{\text{scf}}{\text{scf}} \div \text{Fd NG } \frac{\text{scf}}{\text{MMBtu}} \times \text{Conv (Conc-ppm) } \frac{\text{scf-ppm}}{\text{scf}}$$

To convert to a representative emissions factor, ppmvd emissions factors were then multiplied by the appropriate correction factor for the given hydrogen percentage of the fuel, ranging from 0 for 0% hydrogen in the fuel, to 1.37 for 100% hydrogen in the fuel (see table above). Once

[36] Douglas, C., et al, 2022, Nox Emissions from Hydrogen-Methane Fuel Blends, Ibid

[37] Douglas, C., et al, 2022, Nox Emissions from Hydrogen-Methane Fuel Blends, Ibid

multiplied by the correction factor, the ppmvd emissions factor was representative of ppmvd emissions from hydrogen combustion. Corrected ppmvd values could then be converted back to a mass basis as demonstrated in the equation below.

Equation 4

$$\text{Blend NOx EF (lb NOx/MMBtu)} = \text{NOx NG EF Conc } \frac{\text{ppm}}{} \times \text{Correction Blend-H2 Ratio } \frac{\text{ppm}}{\text{ppm}} \div \text{Conv (Conc-ppm) } \frac{\text{scf-ppm}}{\text{scf}} \div \text{Volume @ 68 F } \frac{\text{scf}}{\text{pmole}} \times \text{MW (NO2) } \frac{\text{lb}}{\text{pmole}} \times \text{Fd Blend } \frac{\text{scf}}{\text{MMBtu}} \times \text{O2 Correction } \frac{\text{scf}}{\text{scf}}$$

The figure below demonstrates the overall impact of the correction factor approach (as depicted in the two equations above) on a mass basis emissions factor of 1 as the percentage of hydrogen in fuel increases. As the percentage of hydrogen in the fuel blend increases, the correction factor increases. However, this conversion is also driven by the ratio of the f-factor in the 1st equation to the f-factor in the second equation which decreases as the percentage of hydrogen in a fuel increases. As a result, when a natural gas lb/MMBtu emissions factor is converted to a representative pure hydrogen emissions factor (by converting the natural gas lb/MMBtu value to a volumetric value [ppmvd] using the fuel factor for natural gas of 8710.00 dscf/MMBtu, then multiplying by the correction factor to determine the representative hydrogen volumetric value [ppmvd], and then converting from the hydrogen volumetric value [ppmvd] to a hydrogen lb/MMBtu value by using the calculated fuel factor for hydrogen of 5975.05 dscf/MMBtu, as outlined above), the resultant pure hydrogen emissions factor is approximately 6% smaller. It should be noted that the “choppy” slope of this function is due to the “piecewise” nature of the tabular correct factor data used to develop this function.

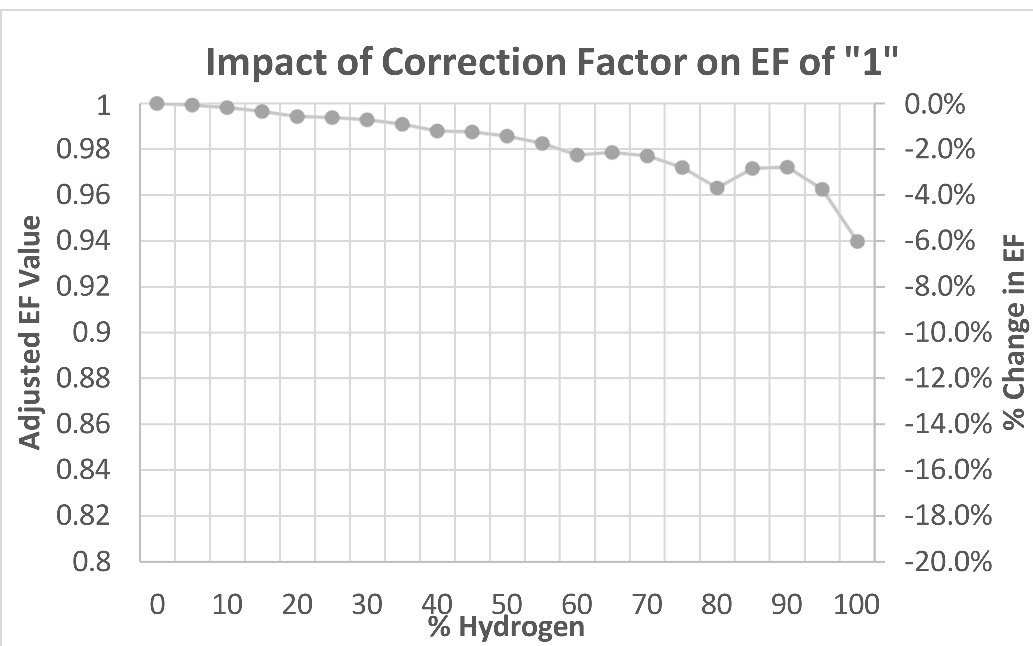

Figure 2 Impact of Correction Factor on Emission Factor of "1"

The reduction in lb/MMBtu factors between natural gas and pure/blended hydrogen fuels is primarily attributable to the differences in the natural gas and hydrogen fuel factors. The fuel factor for pure and blended hydrogen fuels is always less than the fuel factor for natural gas. When the ratio of the pure/blended hydrogen fuel factor to the natural gas fuel factor is multiplied by the correction factor the result is less than 1. This ratio ranges from 0.94 – 1 depending on the percentage of hydrogen in the fuel, with 1 and 0.94 corresponding to 0% hydrogen and 100% hydrogen in the fuel, respectively. Therefore, the mass basis (lb/MMBtu) emissions factor for pure hydrogen combustion is calculated as 6% less than the mass basis emissions factor for pure natural gas.

Fossil fuel and hydrogen fuel consumption activity data from the Demand Study and was used to determine project scenario emissions and emissions reductions from displaced fossil fuels associated with the adoption of hydrogen as a fuel source in the Angeles Link market. Activity data from the Demand Study was provided for sub-sectors of the Hard to Electrify Industrial sector and Power Generation sector, for which general NOx emissions factors were not available. NOx emissions factors for these industry sectors were not available because NOx emissions factors are typically developed at an equipment-level. Equipment-specific emissions factors compiled from the air districts (regulatory emission limits and BACT requirements) and inventory data from the CARB Standard Emission Tool, both within the geographic-scope of this project, were used to develop calculations for the industry and Power Generation sectors with data from the Demand Studies.

A review of regulatory information was performed, and four equipment categories were identified for which distinct emissions factors and BACT limitations were available that could be applied to all the combustion information provided in the CARB inventories. These equipment-specific emissions factors were used to estimate the energy throughput for each equipment category using the NOx emissions reported in the CARB inventories. From this information, weighted emissions factors were developed at an industry sector-level or equipment-level based on overall energy throughput to a particular category of equipment. Similarly, this throughput data developed from the CARB inventories was used to determine the fraction of energy consumption in a particular industry sector being used by a particular equipment category. While the emissions factors from air district regulations and BACT only apply to fossil fuels, the correction factor approach outlined above was used to convert them to an equivalent factor for pure or blended-hydrogen fuels.

<u>Uncertainty</u>

Using this specific calculation method, NOx emissions will always be lower for 100% H2 compared to 100% NG. This is based on a significant assumption that combustion conditions will be the same between these fuels (temperature, pressure, residence time).

This correction factor method is the best method that was identified during research and there are strong indications that hydrogen combustion technology (with and without after-treatment) can have lower NOx emissions compared to natural gas equipment.

However, there is still uncertainty surrounding NOx emission from H2 combustion. The existing body of research includes conflicting data and is difficult to draw definite conclusions. There are opportunities for additional scientific inquiry and potentially alternative methods to estimate NOx emissions from hydrogen combustion.

The takeaway from this body of research is that NOx emissions will stay the same or decrease where hydrogen is substituted for natural gas in combustion applications.

APPENDIX 2 – PAG/ CBOSG WRITTEN COMMENTS

February 23, 2024

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Planning Advisory Group Facilitator

Emily Grant
Angeles Link Senior Public Affairs Representative
Southern California Gas Company

Alisa Lykens
Director
Insignia Environmental

Subject: Environmental Defense Fund and Natural Resources Defense Council Comments on the Demand Study Draft Report

As a follow-up to the demand study draft report shared on January 17, Environmental Defense Fund (EDF) and the Natural Resources Defense Council (NRDC) provides the following comments and feedback.

First, EDF and NRDC find the projected demand figures as provided in the demand study draft report to be **incredibly high**, even compared to ambitious projections from various other sources. For example, the "conservative" demand scenario from the draft report projects 1.9 million tons of hydrogen demand per year by 2045 in Southern California Gas (SoCalGas) territory alone; the figures range as high as 5.9 million tons in the "ambitious" scenario. In comparison, the California Air Resources Board's (CARB) 2022 update to Scoping Plan projects 1.93 million tons of hydrogen supply for the *entire state of California* per year by 2045.[1] In fact,

[1] CARB, "Hydrogen Supply", *AB 32 GHG Inventory Sectors Modeling Data Spreadsheet – 2022 Scoping Plan*. Accessible at: https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2022-scoping-plan-documents; and CARB, "Final Energy Demand", *California PATHWAYS Model – 2017 Scoping Plan*. Accessible at https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2017-scoping-plan-documents. Hydrogen amounts calculated using energy content value of 120MJ/kg.

using the same numbers from the 2022 Scoping Plan update, the ambitious demand scenario as laid out in the draft report would result in almost 24% of state-wide energy demand being met through hydrogen demand just in SoCalGas territory.[2] EDF and NRDC believe that, compared to these existing state energy and hydrogen supply scenarios, the results of the demand study are unrealistically high. As such, EDF and NRDC respectfully requests SoCalGas' response to the following questions:

1. Did SoCalGas and the consultants supporting the drafting of the report consider existing scenarios for hydrogen demand in California (in particular, those published by state agencies) as a part of the demand study process? If so, which scenarios were considered?
2. If the scenarios were considered, can SoCalGas and the consultants supporting the drafting of the report provide a detailed justification for why the highly ambitious figures included in the demand study draft report diverge so significantly with certain existing scenarios (specifically, CARB Scoping Plan Projections)?
    a. If the scenarios were not considered, can SoCalGas and the consultants supporting the drafting of the report provide a detailed justification of why they were not considered?

EDF and NRDC believe a detailed explanation of the demand study process would add credibility to the study's findings; and would allow the Public Advisory Group to better engage with SoCalGas on constructive discussions regarding Angeles Link. We also recommend that the demand study draft report be amended to include a section on the comparative analysis of the draft report demand scenarios and other existing hydrogen demand scenarios for California.

Second, EDF and NRDC note that the current draft report **does not take hydrogen costs into account**, which would no doubt be extremely significant in determining actual future hydrogen demand. Given various on-going policy and economic developments—including the 45V Federal Production Tax Credit—eventual cost of hydrogen is as of now uncertain. However, we believe it would be possible and prudent for SoCalGas to incorporate a potential range of hydrogen costs (*e.g.*, low-, mid-, and high-cost scenarios) into the demand study that can be further adjusted as hydrogen costs are fully determined in the future. This would provide

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[2] CARB, "Final Energy Demand".

stakeholders with a reasonable scope of hydrogen demand figures through which PAG members can provide feedback and comments for SoCalGas. The purpose of the current Phase 1 of the Angeles Link Project is to understand how the potential project may end up benefiting SoCalGas ratepayers and at what cost to them. The cost of hydrogen is a key factor in that determination—and must be incorporated into the demand study final report.

Third, the demand study must focus on the **portion of hydrogen demand that can be expected to be served by the Angeles Link pipeline**, particularly in the mobility sector. Again, the purpose of the Phase 1 studies is to gain a better understanding of the requirements and justification for the Angeles Link pipeline. Any demand study conducted as part of these studies, then, should focus specifically on hydrogen demand most efficiently served by the Angeles Link project. While hydrogen demand across the entire SoCalGas territory can serve as important context, it is not the main focus of the Phase 1 studies. The draft report alludes to this key distinction; for example, on page 16, the report identifies "geographic demand analysis with a focus on mobility to better understand at a granular level how demand will be distributed across SoCalGas' service territory". Mobility is assumed to be a significant part of overall demand projections—ranging as high as 53% of total demand in the "conservative" scenario. It is highly likely that some level of "last-mile" delivery will be required to transport hydrogen to the various hydrogen charging stations that are geographically removed from the Angeles Link delivery point. In such cases, it is important to distinguish between hydrogen demand potentially best served by the Angeles Link project and that best served by other forms of hydrogen supply (e.g., trailer/tanker transport from production sources or on-site production) given the "last-mile" delivery requirements.

EDF and NRDC recommend the demand study be revised to explicitly distinguish *overall* hydrogen demand (broken down by sector) and portions of demand (broken down by sector) *best served* by a potential Angeles Link project under SoCalGas demand projections. Doing so will be line with the requirements for the Phase 1 studies.

Respectfully,

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February 23, 2024

Informal Comments of the Public Advocates Office on
Southern California Gas Company's Draft Angeles Link Demand Report

The Public Advocates Office at the California Public Utilities Commission (Cal Advocates) provides these comments on Southern California Gas Company's (SoCalGas) draft *Angeles Link Demand Report* (Report) issued in January 2024.

As a general matter, the Report does not actually project or forecast demand, and is not a demand study. Instead, by SoCalGas's own description, it assesses "total potential demand."[1] Such an assessment is more analogous to a policy paper than a demand study, and Cal Advocates is not clear how this information functions as a feasibility study meant to identify the demand and end uses of the project.[2]

The Report devotes significant time identifying federal and state laws, regulations, programs, and funding initiatives (collectively, legislation) that aim to promote sustainable energy, including renewable hydrogen. The Report employs the legislation to promote SoCalGas's suggestion of key areas where further legislative action may facilitate renewable hydrogen's integration into California's energy portfolio. For example, the Report acknowledges that, for renewable hydrogen to help satisfy California's policy objective of achieving 100% retails sales from renewables and zero-carbon electricity by 2045, as SoCalGas claims it can do, additional laws are required because "the combustion of hydrogen in not [Renewable Portfolio Standard (RPS)] compliance nor is zero-carbon resources defined to include hydrogen."[3]

The legislative discussion, however, is very similar to the policy justification SoCalGas made in its Application (A.) 22-02-007 proceeding pleadings. We are past that point. While specific legislation will inform the types of decisions regulations, businesses, and consumers may make, we expected to see surveys conducted by SoCalGas that gathered demand information from real participants in the three sectors identified in the Report. We also expected to see interview summaries with actors that will drive demand, such as

[1] Report at 4.

[2] Decision (D.) 22-12-055, Ordering Paragraph 6(a) at 76.

[3] Report at 19, internal citation omitted.

industrial customers. However, new information derived from independent fact finding and research is absent from the Report.

Instead, it appears that the Report relies heavily on publicly available information and studies conducted by federal and state agencies, and other institutions. We expected the function of this instant demand analysis exercise was to specifically identify the end-users for renewable hydrogen and forecast renewable hydrogen demand specific to SoCalGas' service territory. Yet, most of the information provided in the Report is already known. Further, as described below, the demand forecast that the Report does present relies on unreasonable assumptions and is unrealistic when compared to the California Energy Commission's (CEC) renewable hydrogen demand analysis.

Unrealistic Renewable Hydrogen Price Assumptions

The Report suffers from unrealistic simplifying assumptions used to forecast renewable hydrogen demand in SoCalGas' service territory. The simplifying assumptions are: (1) Price of Hydrogen; (2) Power System Reliability & Capacity Factors; and (3) Readily Available Hydrogen.[4] For the purposes of providing a more realistic projection of renewable hydrogen demand in SoCalGas' service territory, the decision to forgo an attempt to forecast renewable hydrogen prices and costs trajectories raises serious questions about the Report's accuracy or usefulness.

The law of demand generally states that as the price for a good increases, the demand for the good decreases. This economic principle cannot be ignored when forecasting the demand of a particular good, especially when that good is vying for market share in a competitive market that houses equivalent and less costly goods. Here, the Report acknowledges that renewable hydrogen is in direct competition with other low-carbon alternatives; namely, electric (either direct electrification or battery), synthetic fuels (such as renewable diesel), and carbon capture, utilization and storage (CCUS).[5] Yet, the Report does not attempt to estimate renewable hydrogen costs for the three demand scenarios it identifies. Nor does it forecast renewable hydrogen costs over time and compare a hydrogen cost trajectory with competing low-carbon alternatives.

Instead, the Report either omits the renewable hydrogen prices or assumes that the price of renewable hydrogen is equivalent to the price of natural gas. But the cost of renewable hydrogen is a key barrier that can't be overlooked, as acknowledged in A.22-02-007. There, parties provided evidence that renewable hydrogen

[4] Report at 15.

[5] Report at 15.

costs are currently prohibitive at scale and serve as a barrier to wider adoption.[6,7] The CEC recognizes the cost barrier, having informed the Commission that "[o]ne challenge is the cost of methods for [renewable] hydrogen is several times the cost of the fossil fuel-based systems. New innovations are needed in the conversion process and used to generate [renewable] hydrogen so equipment costs and conversion costs can be lowered substantially."[8] The CEC's proposed Final 2023 Integrated Energy Policy Report (IEPR) repeatedly identifies renewable hydrogen costs as a barrier.[9]

Because current information suggests that renewable hydrogen is expensive, it is important that reasonable cost estimates are included in the demand forecast calculations. Since there is a natural relationship between prices and demand, and renewable hydrogen will compete against other fuels and technologies in the marketplace, renewable hydrogen prices are integral components of consumer demand. Omitting or using unrealistic prices delivers unreliable demand projections.

<u>CEC's proposed Final 2023 IEPR</u>

The Report's demand analysis appears unrealistic when compared to the preliminary analysis of using clean and renewable hydrogen identified in the CEC's proposed Final 2023 IEPR. The Report presents three demand modeling scenarios over the 2025-2045 period in SoCalGas' service territory.[10] The three demand modeling scenarios are: (1) conservative; (2) moderate, and (3) ambitious. The Report's modeling results indicated "1.9 Million (M) tonnes per year (TPY) of hydrogen by 2045 in its conservative scenario, 3.2M TPY in the moderate scenario, and 5.9M TPY in the ambitious scenario."[11] The three demand modeling scenarios focus on demand for renewable hydrogen in the mobility, power generation, and industrial sectors.[12] In most cases, the Report's scenarios project more hydrogen demand for the power generation and mobility sectors in

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[6] See, The Protect Our Communities Foundation Opening Brief, filed July 29, 2022; in A.22-02-007; and The Public Advocates Office's Protest of the Application of Southern California Gas Company for Authority to Establish a Memorandum Account for the Angeles Link Account (Cal Advocates Protest) at 4, filed March 21, 2022; in A.22-02-007.

[7] In its proposed Final 2023 EIPR, the CEC states "[w]hile the [CARB] 2022 Scoping Plan Update includes 9 GW capacity of hydrogen-based electricity generation, these power plants are never dispatched because of cost; therefore, no hydrogen is used in the electric sector." (See, CEC proposed Final 2023 IEPR at 78).

[8] See, Cal Advocates Protest at 4. See also, Application of the California Energy Commission for Approval of Electric Program Investment Charge Proposed 2021-2025 Investment Plan, Attachment 1 at A-45, filed November 21, 2021; in A.21-11-021.

[9] CEC proposed Final 2023 IEPR at 80, 83, and 86-89.

[10] Report at 4-5.

[11] Report at 4.

[12] Report at 4-5.

SoCalGas' service territory than the demand the CEC projects for those respective sectors in the entire state of California.

Power Generation Sector

With respect to the power generation sector, the Report provides the total expected renewable hydrogen demand in the power sector for the three scenarios.

Table 1[13]

Total Expected Clean Renewable Hydrogen Demand in the Power Sector in 2045

Conservative	Moderate	Ambitious
0.7M TPY	1.6M TPY	2.7 TPY

In the proposed Final 2023 IEPR, the CEC conducted a preliminary analysis of using clean and renewable hydrogen in electric power generation.[14] The CEC examined two scenarios: (1) the first scenario builds from the California Air Resources Board (CARB) 2022 Scoping Plan Update; and (2) the CEC developed a second scenario of growth of clean renewable hydrogen in the electricity sector based on a report developed for the CEC by the University of California at Irvine (UCI).[15] For both scenarios, the CEC's analysis identified renewable hydrogen consumed in 2045 for the state of California.

Table 2[16]

Scenarios of Clean and Renewable Hydrogen in the Electric Sector in 2045

Scenario Factors	2022 CARB Scoping Plan Update	UCI Study
Hydrogen consumed in 2045	1,883,960M TPY	350,000M TPY

[13] Report, Figure 16 at 52.

[14] The CEC stated that "[f]or this initial analysis of adoption of hydrogen in the electricity sector, staff did not conduct new capacity expansion modeling and instead developed two scenarios from previous analyses focused on California." See, CEC proposed Final 2023 IEPR at 78.

[15] CEC proposed Final 2023 IEPR at 78.

[16] CEC proposed Final 2023 IEPR, Table 3 at 80.

In the first scenario, the CEC's proposed Final 2023 IEPR analysis shows that the CEC's hydrogen consumption forecast in the electric sector for the entire state of California is approximately 1.9M TPY per year in 2045. In contrast, the Report's moderate scenario for the power generation sector projects a near equivalent demand for renewable hydrogen (1.6 M TPY) just in SoCalGas' service territory in 2045. When comparing the Reports' ambitious scenario to the CEC's first scenario, the Report indicates that SoCalGas' service territory's demand for renewable hydrogen will exceed the CEC's hydrogen consumption forecast for the entire state in 2045 by approximately 0.8M TPY.

With respect to the second scenario, the CEC's proposed Final 2023 IEPR analysis forecasts California to consume approximately 350,000M TPY in 2045. The CEC's estimate for California generally in 2045 is approximately 0.35M TPY less than the Report's conservative forecasted demand for SoCalGas' service territory.

Mobility Sector

With respect to the mobility sector, the Report provides the total expected renewable hydrogen demand in the mobility sector for three scenarios.

Table 3

Total Expected Mobility Sector Clean Renewable Hydrogen Demand in 2045[17]

Conservative	Moderate	Ambitious
1.0M TPY	1.2M TPY	1.7 TPY

In the proposed Final 2023 IEPR, the CEC conducted a preliminary scenarios of using for using hydrogen in the transportation (mobility) sector.[18] The CEC examined two scenarios: (1) the first scenario uses the CARB 2022 Scoping Plan Update; and (2) the CEC staff developed a second scenario of potential adoption of hydrogen in the transportation sector using the modeling tools used in the CEC's transportation energy

[17] Report, Figure 10 at 23.

[18] CEC proposed Final 2023 IEPR at 84-88.

demand forecast, with several modifications.[19] For both scenarios, the CEC's analysis identified transportation (mobility) hydrogen demand in 2040 for the entire state of California.

Table 4

Scenarios of Clean and Renewable Hydrogen in the Transportation Sector in 2040[20]

Scenario Factors	2022 CARB Scoping Plan Update	Modified AATE 3
Hydrogen consumed in 2040	971,049M TPY	307,771M TPY

The Report's scenarios and the CEC's proposed Final 2023 IEPR scenarios focus on two separate demand years. The Report analyzed demand through 2045, whereas the CEC's proposed Final 2023 IEPR focused on demand through 2040.

In the first scenario, the CEC's proposed Final 2023 IEPR analysis shows that the CEC's hydrogen consumption forecast in the transportation (mobility) sector for the entire state of California is approximately 0.97M TPY per year in 2040. The Report's conservative scenario for the mobility sector projects approximately 0.6M TPY of renewable hydrogen just in SoCalGas' service territory in 2040.[21] When comparing the Reports' moderate and ambitious scenarios to the CEC's first scenario, the Report indicates that SoCalGas' service territory's demand for renewable hydrogen is approximately 1.0M TPY and 1.2M TPY respectively in 2040.[22]

With respect to the second scenario, the CEC's proposed Final 2023 IEPR analysis shows that it forecasts California to consume approximately 307,771M TPY in 2040. The CEC's estimate for the entire state of California in 2040 is approximately 0.3M TPY less than the Report's conservative forecasted demand in SoCalGas' service territory.

<u>Factually Inaccurate Information</u>

The Report errs in its summary and characterization of key legislation. For example, it states "SB 100 and SB 1020 are key pieces of legislation driving power-sector decarbonization in California. The legislation accelerates the state's Renewables Portfolio Standard (RPS) program to 90% by 2035 with 100% renewables

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[19] CEC proposed Final 2023 IEPR at 84.

[20] CEC proposed Final 2023 IEPR, Table 4 at 85.

[21] Report, Figure 10 at 23.

[22] Report, Figure 10 at 23.

and zero-carbon electricity by 2045."[23] Neither SB 100 nor SB 1020 accelerates the RPS target to 90% by 2035. Instead, SB 100 increased the state's RPS target from 50% to 60% retail sales from renewable resources by 2030. It also established a state policy goal of achieving 100% retail sale from renewable resources and zero-carbon resources by 2045. In other words, SB 100 revised the RPS target upwards and established a more ambitious 100% target that is the subject of the Integrated Resources Plan (IRP) proceeding. SB 1020 subsequently revised existing state "IRP" policy to "provide that eligible renewable energy resources and zero-carbon resources supply 90% of all retail sales of electricity to California end-use customers by December 31, 2035. . ."[24] Thus, SB 1020 established gradual compliance targets for the state to achieve 100% retails sales from renewables and zero-carbon electricity by 2045. It appears that the Report conflates the RPS target with the state's larger policy target that is being considered in the Commission's IRP proceeding.

Such basic inaccuracies are concerning because the statute is fixed and should be easy to accurately depict. It raises the question of whether there are other basic factual errors. SoCalGas should ensure that its Report accurately captures the relevant facts.

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[23] Report at 19.

[24] SB 1020 (Chapter 361, Statutes of 2022) (emphasis added) available at: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB1020

The Utility Consumers' Action Network
(Angeles Link PAG Member)

Feedback for SoCalGas Regarding
Angeles Link Demand Report Draft

Date: February 26, 2024

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I. Feedback Summary

- SoCalGas' "conservative" demand forecast over-estimates clean hydrogen demand by more than a factor of ten. SoCalGas should revise its forecast based on reliable third-party data and modeling.[1]
- SoCalGas' exclusion of hydrogen pricing invalidates the demand study results. SoCalGas should update the study to include the impact of hydrogen prices on hydrogen demand.[2]
- SoCalGas's hydrogen demand forecast conflicts with forecasts by several California Agencies. SoCalGas should use power system modeling results reported by the CPUC, CEC, and CARB that find the power sector will have zero clean hydrogen demand through 2045.[3]
- SoCalGas used the Argon National Laboratory's TechScape model to help evaluate mobility sector demand. However, prior to using TechScape, SoCalGas changed several of the model's most important inputs including hydrogen fuel costs, fuel cell costs, hydrogen storage costs, and battery costs. Those changes invalidate SoCalGas' mobility sector outputs. SoCalGas should use ANL's published TechScape results to inform its mobility modeling.[4]
- SoCalGas bases its hydrogen demand claims on its opinions about self-selected "adoption factors" instead of reliable third-party research. SoCalGas should establish a demand forecast using unbiased third-party research.[5]

II. Background

- On August 29, 2023, SoCalGas hosted a Planning Advisory Group (PAG) meeting that included a presentation on the Demand Study Analysis Technical Approach and Preliminary Outputs.
- On September 7, 2023, SoCalGas met with UCAN and Cal Advocates regarding SoCalGas' demand study research.
- On September 18, 2023, SoCalGas provided 10 slides by email. The data on the slides were mostly unresponsive to UCAN and Cal Advocate's requests during the September 7th meeting.
- On September 19, 2023, UCAN emailed SoCalGas its unanswered questions on the preliminary demand study.
- On September 25, 2023, UCAN submitted feedback to SoCalGas on the preliminary demand study without having received any response from SoCalGas to its questions. UCAN noted that SoCalGas' preliminary demand forecast appeared to be at least 10 times too high.
- On September 29, 2023, SoCalGas provided 13 slides by email responding to UCAN's written questions.

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[1] *Infra,* see Section IX.
[2] *Infra,* see footnote 23 and 31.
[3] *Infra,* see Section IV (A, B, and C).
[4] *Infra,* see Section VI.
[5] *Infra,* see Section VI.

- On October 21, 2023, UCAN submitted feedback to SoCalGas that noted SoCalGas' demand projections were at least 10 times higher than demonstrated by available data.
- On December 15, 2023, SoCalGas hosted a PAG meeting which included a presentation on the Demand Study Draft Report.
- On January 17, 2024, SoCalGas made the Draft Demand Study available to the PAG and requested feedback on the draft.[6] UCAN submits the following feedback.

III. SoCalGas' Draft Document fails to meet the demand study requirements of D.22-12-055 and investigates hydrogen demand beyond the scope of the decision's authorization.

SoCalGas' Draft Demand Study ("Draft Document") exceeds the scope of research authorized by D.22-12-055 by researching hydrogen demand outside of the LA Basin.

D.22-12-055 states that "[t]he objective of the Angeles Link Project is to develop a clean renewable hydrogen energy transport system to serve the Los Angeles Basin."[7] The Commission ordered SoCalGas to complete "[i]dentification of the demand and end uses for the Angeles Link Project (Project)."

In violation of the decision, the Draft Document repeatedly reports hydrogen demand assertions for the SoCalGas service territory instead of the LA Basin,[8] and states that it will refuse to complete a LA Basin specific analysis until after Phase 1.[9] The Commission stated a Phase 2 application must include the required findings from Phase 1.[10] Thus, the Draft Document states SoCalGas' intent to violate D.22-12-055. SoCalGas should revise the Draft Document to avoid violations of the Commission's orders in D.22-12-055.

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[6] SoCalGas, Angeles Link Demand Report Draft (January 2024) ("Draft Document"), [distributed to PAG members by email link on January 17, 2024).
[7] D.22-12-055, available at https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M500/K167/500167327.PDF.
[8] Draft Document, p. 3, 4, 5, 9, 16, 17, 19, 20, 21, 29, 32, 34, 38, 40, 42, 43, 44, 47, 50, 52, 56, 58, 60, 64, and 68.
[9] Draft Document, p. 16, (SoCalGas states that assessment for "future phases of Angeles Link include… [g]eographic demand analysis with a focus on mobility to better understand at a granular level how demand will be distributed across SoCalGas' service territory.").
[10] D.22-12-055, pp. 75-76, Ordering Paragraph ("OP") 6.

IV. Power Sector: SoCalGas' Draft Document cites three studies from California agencies that have found zero hydrogen use in the power sector through 2045, but SoCalGas misrepresents or ignores those findings.

SoCalGas makes numerous false claims about power sector hydrogen demand. The Draft Document should be corrected to align with power sector modeling findings by California Agencies. The California Public Utilities Commission ("CPUC" or "Commission"), the California Air Resources Board ("CARB") and the California Energy Commission ("CEC") have each reviewed the optimal mix of clean energy resources needed to meet the 2045 statutory requirement for the power sector. Each of these California agencies have completed modeling that determines a cost-effective resource mix does not include hydrogen between now and 2045.

In contrast, SoCalGas claims that by 2045 the power sector will use between 0.7 and 2.7 million tons per year ("MTPY") of hydrogen.[11] SoCalGas should revise its Draft Document to align with the studies completed by the California agencies, studies that SoCalGas cites in the Draft Document.

A. The SB 100 Report finds zero hydrogen use in the power sector through 2045 in scenarios that meet statutory requirements.

The Senate Bill ("SB") 100 Report states that the 2045 target set by SB 100 will require no hydrogen use in its least-cost scenario.[12] The SB 100 Report was completed by the CEC, CPUC, and CARB. The Draft Document cites the SB 100 study but ignores the SB 100 findings.[13]

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[11] Draft Document, Figure 4, p. 7.

[12] California Energy Commission. "SB 100 Joint Agency Report". (September 3, 2021), p. 6 and Figure 3, p. 10, ("The "core scenarios," shown Table 1, modeled for the 2021 Report are consistent with the joint agencies' interpretation of the statute and include only commercialized technologies with publicly available cost and performance data.") available at https://www.energy.ca.gov/publications/2021/2021-sb-100-joint-agency-report-achieving-100-percent-clean-electricity.

[13] Draft Document, p. 42.

B. The CPUC's 2023 IRP modeling finds zero hydrogen use in the power sector through 2045 in scenarios that meet statutory requirements.

The CPUC completed power system modeling in its Integrated Resource Plan ("IRP") proceeding. The modeling completed and adopted in the February 22, 2024, decision, D.24-02-047, found that the energy resource mix would include zero hydrogen-fueled generation or storage between now and 2045.[14] The modeling was completed by the CPUC's Energy Division and its consultant Energy and Environmental Economics ("E3").

The Draft Document cites the IRP proceeding and claims that "if hydrogen was included in the CPUC's Integrated Resource Plan and was eligible for SB100, that could increase hydrogen demand."[15] That Draft Document statement is false. The IRP modeling team did consider hydrogen and determined that hydrogen technologies are one of several technologies that "are nascent… [and] uncertain if they can reach maturity and hit the longevity, cost, and efficiency targets projected by industry. Thus, for the foreseeable future these resources are likely only to be considered in sensitivity-type analysis in IRP, and not for core portfolios."[16]

The IRP modeling team includes power sector technologies in its core modeling that are commercially available.[17] The Draft Document should not make assumptions about hydrogen demand in the power sector that conflict with the CPUC's findings.

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[14] CPUC, Proceeding R.20-05-003, 2023 Preferred System Plan Proposed Decision, p. 14 ("Planned & Selected Capacity, Long-Term (GW)"), available at https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2023-irp-cycle-events-and-materials/2024-01-12-presentation-summarizing-updated-servm-and-resolve-analysis.pdf.
[15] Draft Document, p. 19.
[16] CPUC, Inputs & Assumptions 2022 – 2023 Integrated Resource Planning (October 2023) ("IRP I&A"), pp. 97-98, available at https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2023-irp-cycle-events-and-materials/inputs-assumptions-2022-2023_final_document_10052023.pdf.
[17] IRP I&A, p. 52.

C. CARB's 2022 Scoping Plan finds zero hydrogen use in the power sector through 2045.

CARB's scoping plan assumes zero hydrogen use in the power sector between now and 2045. In contrast, the Draft Document falsely claims that "CARB has projected in their 2022 Scoping Plan that hydrogen will play a larger role in serving future load growth and be part of the resource mix that helps California meet its SB100 retail sales target."[18] In support of its claim, the Draft Document cites Figure 4-5 of the 2022 Scoping Plan and claims "9 GW of incremental capacity" by 2045. To know how many GW of capacity are shown in the figure, SoCalGas' staff would have needed to download the spreadsheet cited in the Figure 4-5 footnote.[19] The workbook's "electricity" sheet shows that in 2045 the Hydrogen CT capacity is 9,325 MW (i.e. 9.32 GW).[20] Thus, SoCalGas' claim relative to the 9 GW of capacity is correct, but generation *capacity* does not determine hydrogen use.

The Draft Document goes on to claim that "[t]he relatively high hydrogen demand projected in the power sector positions power generation as a key source of the demand."[21] That statement by SoCalGas is false. The same CARB workbook that lists 9.32 GW of hydrogen turbine capacity, also includes a sheet titled "Electric Sector Combustion Fuels," which shows that the Scoping Plan assumes *zero* hydrogen used in every year though the 2045 time-horizon.[22] The sheet suggests that the hydrogen turbine capacity is only anticipated to be used in emergency scenarios, scenarios that CARB's modeling finds so unlikely at to require zero hydrogen use.

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[18] Draft Document, p. 19.
[19] 2022 Scoping Plan, Footnote 327 ("See https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp-PATHWAYS-data-E3.xlsx for the capacity build-out by resource type."), available at https://ww2.arb.ca.gov/sites/default/files/2023-04/2022-sp.pdf.
[20] Scoping Plan Pathways Data, Sheet "Electricity", see https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp-PATHWAYS-data-E3.xlsx.
[21] Draft Document, p. 19.
[22] Scoping Plan Pathways Data, Sheet "Electric Sector Combustion Fuels", see https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp-PATHWAYS-data-E3.xlsx.

The 2022 Scoping Plan, the SB 100 Report, and 2023 IRP modeling all forecast zero hydrogen use in the power sector through 2045. The Draft Document should remove all inaccurate and misleading statements related to hydrogen use in the power sector.

V. Industrial Sector: SoCalGas should assume no demand in the industrial sector until hydrogen costs less than current industrial energy fuels or until legislation requires industrial users to transition to zero carbon fuels.

SoCalGas' should assume zero clean hydrogen demand in the industrial sector because the energy sources currently used by industry cost less than clean hydrogen. The Draft Document does not appear to make any effort to determine when clean hydrogen may be cost effective for industrial users. Instead, the Draft Document excludes fuel costs and/or technology costs.[23]

SoCalGas also makes specific unsupported assumptions for its industrial sector claims. Regarding co-generation capacity factors, SoCalGas makes an arbitrary assumption when it claims 10%, 20%, and 30% capacity factors by scenario for clean hydrogen co-gen facilities.[24] SoCalGas' co-gen assertion is significant because hydrogen use at co-generation facilities represents most of the hydrogen demand for the industrial sector in two of the three SoCalGas scenarios. SoCalGas needs to base the cogeneration capacity factor on research rather than its own unsupported assertions. SoCalGas' own research found that CARB forecasts "all cogeneration to be retired by 2045."[25] Despite that statement in the Draft Document, SoCalGas refused to assume full cogeneration retirement in its demand scenarios.

SoCalGas appears to have collected a significant amount of data on the industrial sector, but not the work required to determine hydrogen demand. To correct the Draft Document, SoCalGas should remove co-generation from the industrial demand forecast, use reliable third party research to determine the full range of clean energy alternatives for industrial heat (e.g. SoCalGas makes the false

[23] Draft Document, Appendix, Table 22, p. 46.
[24] Draft Document, Table 8, p. 59.
[25] Draft Document, p. 8.

assumption that only process heat temps < 400°F can be electrified), only forecast clean hydrogen demand for use cases in which hydrogen is the low-cost option, and only forecast hydrogen demand if the industrial use case has a legislatively-mandated clean energy requirement. Until these changes are made, the industrial sector forecast will remain inaccurate.

VI. Mobility Sector: SoCalGas's Draft Document makes numerous unsupported assertions and based on those assertions falsely claims to have modeled hydrogen demand in the mobility sector.

The Draft Document's mobility sector outputs lack credibility because they exclude conclusions from reliable third-party sources. The Draft Document makes assertions about hydrogen demand in the mobility sector based *solely* on SoCalGas' opinions. SoCalGas should complete a mobility analysis for the Draft Document that uses reliable third-party sources to establish a mobility sector demand forecast.

There are two main flaws in the Draft Document's mobility section's demand forecast framework. First, SoCalGas' overall framework of the mobility section uses four "adoption rate factors" – (1) policy & legislation, (2) commercial readiness, (3) technical feasibility, and (4) business readiness) – that are set according to SoCalGas' opinion. Thus, all factors used to determine FCEV adoption rate are subjectively determined by a company that would profit from high clean hydrogen demand. That framework ensures that the demand study will over forecast demand.

The second flaw is the Draft Document's misuse of ANL's TechScape model. While the Draft Document cites the TechScape model as the basis for the determination of the cost effectiveness of FCEVs compared to alternatives,[26] the Draft Document ignores ANL's published findings. ANL researchers, using the TechScape model have found that fuel cell electric vehicles ("FCEV") are not cost competitive with battery electric vehicles ("BEV") during any year through 2050 for every on-road medium- and

[26] The Draft Document cites the BEAN model. The BEAN model has been renamed TechScape.

heavy-duty vehicle class through a 2050 time horizon.[27] That ANL finding is true even for Class 8 heavy-duty long-haul vehicles,[28] which is the class that SoCalGas forecasts will see a near 100% FCEV market share in 2045.[29]

Figure 1, below, is a screen capture from the 2023 TechScape analysis. The figure shows TechScape's TCO comparison of Class 8, long-haul trucks for Conventional, FCEV, and BEV options through 2050.

Figure 1: ANL, TechScape Total Cost of Ownership (TCO) by Vehicle Category[30]

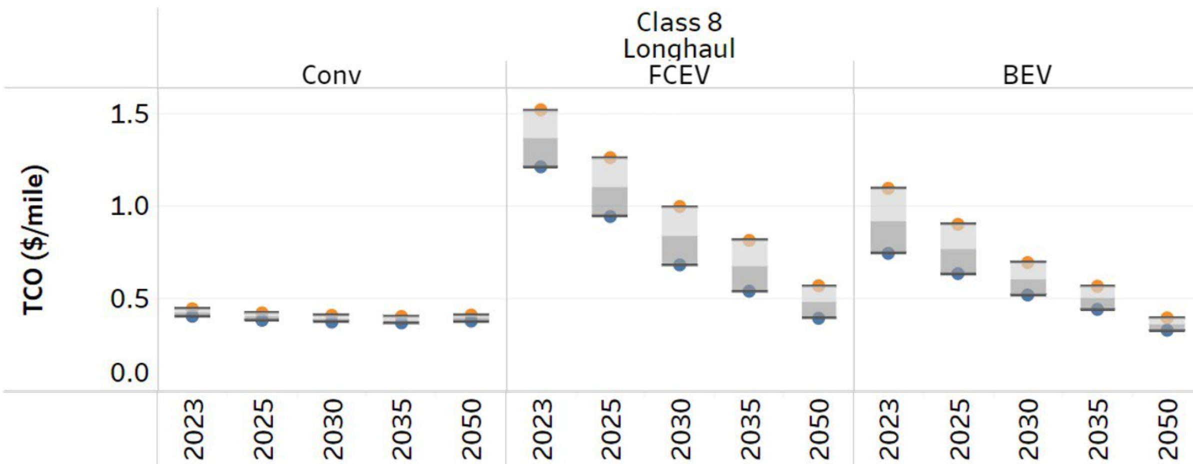

Figure 1 shows that, in every year, FCEVs are more expensive than conventional Class 8 long-haul trucks and BEV long-haul trucks. By 2050, TechScape finds that BEVs' TCO will still be lower than conventional vehicles. SoCalGas did not include this data in its Draft Document despite claiming to use the TechScape model. SoCalGas' mobility sector claims depart significantly from ANL's TechScape modeling outputs.

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[27] Argon National Laboratory, TechScape 2023 modeling for medium and heavy-duty vehicles, https://vms.taps.anl.gov/analytics/md-hd-truck-future-technology-prediction/.
[28] *Ibid.*
[29] Draft Document, Figure 12, p. 35.
[30] See TechScape, MD/HD Future Technology Prediction (From 2023 Model) [last accessed February 25, 2024], https://vms.taps.anl.gov/analytics/md-hd-truck-future-technology-prediction/.

It appears that the main strategy that SoCalGas used to contradict the ANL's findings was to change the most important TechScape modeling inputs before using the TechScape model.[31] SoCalGas changed the following inputs:

- hydrogen fuel costs[32]
- fuel cell costs[33]
- hydrogen storage costs[34]
- battery costs[35]

Possibly the most impactful change that SoCalGas made was to eliminate the effect of fuel costs in its analysis by assuming that the cost of hydrogen is the same as the alternative carbon-emitting fuel (natural gas or diesel). The Draft Document's appendix notes that setting the cost of hydrogen equal to the cost of natural gas resulted in a hydrogen cost of $0.289/kg for the power sector.[36] In contrast, the U.S. DOE reports that in October 2023 the cost of hydrogen at vehicle filling stations in the U.S. averaged $32.32/gallon of gasoline equivalent ("GGE").[37] GGE is nearly identical to 1 kg of hydrogen. Thus, the real world price of hydrogen at filling stations is 111 times higher than the price of hydrogen that SoCalGas assumed for power sector hydrogen.[38] On an apples-to-apples basis, the DOE-reported hydrogen price at filling stations is 11 times higher than the price of compressed natural gas (CNG) at filling stations.[39] If SoCalGas wants the study to be taken seriously, then it needs to include the cost of

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[31] Draft Document, p. 31 ("CapEx and OpEx (excluding fuel cost) analysis were conducted to determine if and when FCEV and BEV technologies would achieve relative cost parity with each other and with traditional vehicles."); Draft Document, Appendix, p. 22-23 (On these pages SoCalGas explained that it changed ANL's inputs for fuel cell costs, hydrogen storage costs, battery costs.)
[32] Draft Document, Appendix, p. 22-23 (SoCalGas changed fuel cell costs, hydrogen storage costs, battery costs, hydrogen commodity costs)
[33] Draft Document, Appendix, p. 22-23
[34] *Ibid.*
[35] *Ibid.*
[36] Draft Document, Appendix, Table 17, p. 32.
[37] Clean Cities Alternative Fuel Price Report, (October 2023), footnote 4, p. 4, available at https://afdc.energy.gov/files/u/publication/alternative_fuel_price_report_october_2023.pdf.
[38] $32.32/GGE / $0.289/kg = 111.8339.
[39] Clean Cities Alternative Fuel Price Report, (October 2023), p. 4, (H2 at $32.32/GGE / CNG at $2.85/GGE = 11.34).

hydrogen, the cost of the resource being studied. The cost of a resource has a significant effect on consumer demand.

In summary, ANL's TechScape finding is that the TCO of on-road FCEVs will never reach parity with BEVs or conventional vehicles. In contrast, the Draft Document claims that FCEVs will see Class 8 Sleeper Cab adoption of approximately 90-98% in 2045.[40]

SoCalGas should eliminate the bias from its adoption rates by aligning its adoption forecasts with reliable third-party research. SoCalGas' opinions carry little weight due to SoCalGas' conflict of interest. The mobility sector framework and findings in the draft document should be discarded and replaced with unbiased third-party research.

VII. Until SoCalGas completes a demand study that uses third-party research, work spent on other Phase 1 requirements waste resources.

UCAN again notes for SoCalGas that until it completes a reasonable demand study, resources spent on other Phase 1 topic areas will likely waste resources and will be unrecoverable. Because SoCalGas has moved forward with Phase 1 research beyond the demand study, SoCalGas has likely recorded many hours of work that provide no value to theoretical future hydrogen ratepayers. Those theoretical ratepayers should not be held accountable for improper research sequencing by SoCalGas.

VIII. SoCalGas should release its work papers and spreadsheets used in its demand analysis to allow PAG members to provide fulsome feedback.

The Commission requires SoCalGas to release its data to the public. To UCAN's knowledge, SoCalGas has not requested confidential treatment of the data it has collected or the spreadsheets it has produced. Because it has not requested confidential treatment of its documents in Phase 1, D.22-12-055

[40] Draft Document, Figure 12, p. 35.

requires SoCalGas to release "the data, findings, and results of the Phase One studies."[41] UCAN continues to ask for the work papers and spreadsheets that SoCalGas has used or produced related to the Draft Document. SoCalGas' continued refusal to release its workpapers keeps UCAN from completing a full evaluation of the Draft Document. SoCalGas' withholding of its work papers also violates D.22-12-055.[42]

IX. UCAN has determined that SoCalGas' lowest-demand scenario overestimates clean hydrogen demand by at least a factor of 10.

SoCalGas' Draft Document contains so many errors and false inputs that it is difficult to use the document to draw any conclusion as to future clean hydrogen demand. UCAN estimates that even SoCalGas' lowest-demand scenario overestimates clean hydrogen demand by at least a factor of 10. In support of this statement, UCAN provides the following facts:

- **Power Sector:** CPUC, CEC, and CARB modeling all forecast zero clean hydrogen demand in the power sector through 2045 (i.e., SB 100 report, 2022 CARB Scoping Plan, CPUC IRP modeling).
- **Mobility Sector:** Argon National Laboratory's TechScape modeling tool forecasts that BEVs will have a lower total cost of ownership compared to FCEVs for every on-road vehicle type through 2050.
- **Industrial Sector:** SoCalGas provided no data on cost-effective clean hydrogen for industrial purposes.

The three bullets above demonstrate that the power, mobility, and industrial sectors each will see negligible clean hydrogen demand through 2045 based on current conditions. In fact, the only use cases where hydrogen demand may develop are marine shipping and aviation. However, the technological development for those two use cases is in such an early stage that it is impossible to make any reliable forecast. UCAN agrees with Draft Document's statement that, for marine and aviation

[41] D.22-12-055, p. 31.
[42] D.22-12-055, OP 7, p. 77.

applications, “the inter-state and international aspect of these applications mean that adoption of a new standard fuel could take many years.”

Research and empirical data show that the demand claims made in SoCalGas’ Draft Document are false. SoCalGas should update its clean hydrogen forecast based on the best available data. Once SoCalGas has completed a revised Draft Document, it should submit the document to the PAG for review and feedback.

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March 29, 2024

VIA EMAIL TO
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Re: Angeles Link Planning Advisory Group (PAG) Feedback of Air Products and Chemicals Inc. on the Preliminary GHG Emissions Evaluation, Hydrogen Leakage Assessment, NOx Emissions Assessment, Water Resources Evaluation, and Feedback on the Pipeline Routing Discussion at the March 5th PAG Meeting

Air Products and Chemicals, Inc. ("Air Products") submits the following feedback concerning the Preliminary Findings of the four Angeles Link technical studies that are now available: Greenhouse Gas Emissions Evaluation, Hydrogen Leakage Assessment, Nitrogen Oxide (NOx) & other Air Emissions Assessment, and Water Resource Evaluation. Air Products expects that the below feedback will be addressed in the final Studies and in Southern California Gas Company's (SoCalGas) quarterly reporting. Air Products also welcomes any response that SoCalGas may wish to provide to the comments below.

General Comments

Air Products has procedural concerns around data and information access related to the technical studies that SoCalGas is required to perform pursuant to D.22-12-055. D.22-12-055 directed SoCalGas to make the data, findings, and results of the Phase One Studies available to the public, absent a specific request for confidential treatment of data in accordance with General Order 66-D.[1] Despite this direction, Air Products had difficulty accessing data and information on which the draft Phase One Studies rely.

For example, the February 2024 Water Resources Evaluation Preliminary Findings: (1) Water Availability Study; and (2) Water Quality Requirements states that its "overall scope of work was informed by and built off pre-feasibility studies and specifically the 2021 SPEC Services

[1] D.22-12-055 at 31.

water study."[2] Despite the fact that the Water Resources Evaluation was based on the 2021 SPEC Services study, the study was not provided to the PAG. Air Products requested a copy of the SPEC Services study to better evaluate the underpinnings of the Water Resources Evaluation, but a response was not provided for nearly two weeks. When Air Products was finally able to review the report provided by SoCalGas, it was heavily redacted throughout the water demand section, as well as throughout regional water reports provided by other contractors. Air Products was therefore unable to access the data on which the SPEC Services, and ultimately the draft Water Resources Evaluation, was based.

Air Products urges SoCalGas to provide links to any documents which are relied upon by the draft Studies, and that the unredacted underlying data be provided. Failure to provide the underlying data or documentation prevents a full review of the draft Study. As discussed below, there are questions regarding the Water Resources Evaluation study that might have been answered with complete, transparent, and timely transmittal of the referenced reports.

Comments on Specific Preliminary Findings

Air Products provides the following feedback on the Preliminary Findings for the Greenhouse Gas Emissions Evaluation, Hydrogen Leakage Assessment, Nitrogen Oxide (NOx) & other Air Emissions Assessment, and Water Resource Evaluation.

<u>Greenhouse Gas Emissions Evaluation</u>

Air Products provides the following feedback on the February 2024 Greenhouse Gas Emissions Preliminary Data and Findings (GHG Emissions Preliminary Study).

The GHG Emissions Preliminary Study purports to capture emissions directly related to hydrogen combustion and indirectly from non-renewable electricity and estimates of emissions associated with new infrastructure, as well as GHG emissions reductions associated with end user in the mobility, power generation, and hard-to-electrify industrial sectors.[3]

Unfortunately, however, there are gaps in the scope of GHG emissions covered. First, the GHG Emissions Preliminary Study itself concedes that the GHG emissions associated with water conveyance for production of hydrogen were not included in the scope of the Study.[4] While acknowledging this deficiency, the Study fails to provide any explanation of why it was omitted from the Study, and whether this evaluation will be included in the scope of any other study. Consideration of the GHG emissions associated with water conveyance is critical to understanding overall GHG emission impacts. Facilities for the electrolytic production of hydrogen will likely need to be operated in proximity to renewable energy generation resources that may be in remote locations geographically distant from water sources. Therefore, the emissions associated with water transportation could be significant, and at a minimum should be

[2] Preliminary Findings: (1) Water Availability Study; and (2) Water Quality Requirements at 4.
[3] GHG Emissions Preliminary Study at 4.
[4] *Id.*

evaluated and considered in this Study. The Water Availability Study, discussed below, further reinforces the idea that SoCalGas is assuming that water could be supplied from anywhere in SoCalGas's service territory, and from select sources outside that service territory, exacerbating transportation needs and potential impacts.[5]

Second, the Study fails to appropriately account for the emissions impacts of electric generation associated with various production methods—whether electrolytic, biomass gasification, or renewable natural gas fueled steam methane reformers (SMR).[6] Any of these production methods may rely upon grid energy during the production process, for ancillary demands, or in transient conditions, and those emissions do not appear to be captured in the Study. Even for electrolyzers powered by renewable energy, unless the renewable generation produces the sufficient energy to meet demand in all hours, electrolyzers may depend on some grid energy, which will result in emissions consistent with the grid resource mix at that time.

Third, similar to water conveyance, which is expressly excluded, the Study does not seem to take into account the transportation and other feed preparation emissions associated with biomass gasification. Inevitably, any biomass gasification process will require harvesting and transportation of the required biomass feedstock to the production facility, and perhaps feed preparation (e.g., torrefaction or other processes to remove moisture or condition the feed). As with water, the transportation distances associated with accessing available and appropriate feedstocks may be significant and emissions associated with this transport, or any pre-treatment do not seem to be included.

Hydrogen Leakage Assessment

Air Products provides the following feedback on the February 2024 Leakage Preliminary Data and Findings (Leakage Preliminary Study).

Air Products is concerned that the Study estimates a leak rate from aboveground compressed gas storage vessels that appears to be off by several orders of magnitude. Table 2 summarizes uncontrolled leakage rates found in available literature.[7] The figures for aboveground storage are several orders of magnitude greater than the leakage rates for all other components listed in Table 2.[8] The leakage rates for aboveground storage were pulled from the Environmental Defense Fund, 2024, Wide Range in Hydrogen Emissions from Infrastructure,[9] which in turn takes the values from Frazer-Nash Consultancy, 2022, Fugitive Hydrogen Emissions in a Future Hydrogen Economy, prepared for the U.K. Department for Business, Energy & Industrial

[5] Water Availability Study at 6.
[6] *See id.* at 9.
[7] *See* Leakage Preliminary Study at 12, Table 2
[8] *Id.*
[9] Esquivel-Elizondo, S., Mejia, A. H., Sun, T., Shresta, E., Hamburg, S. P., Ocko, I. B. Wide Range in Estimates of Hydrogen Emissions from Infrastructure. *Front. Energy Res.*, **11**, 2023. https://doi.org/10.3389/fenrg.2023.1207208

Technology.[10] A review of that study reveals that Frazer-Nash used Department of Energy (DOE) target hydrogen loss rates for high pressure on-board storage tanks, but these targets appear to be based on acceptable range loss in mobile fuel cell applications[11] and are not appropriate for stationary aboveground pressurized tanks. Those DOE targets are dramatically higher than the few actual measured permeation rates found for polymer composite tanks.[12] For steel aboveground tanks, the DOE does not appear to publish a target but the hydrogen loss rate is expected to be negligible.[13] Air Products would expect that leakage rates for above ground pressurized storage vessels designed for hydrogen should therefore be significantly less than 1%, not the 2.7 – 6.5% listed in Table 2.

Nitrogen Oxide (NOx) & other Air Emissions Assessment

Air Products provides the following feedback on the March 2024 (Revised) NOx Evaluation Preliminary Data and Findings (NOx Preliminary Study).

First, the NOx Preliminary Study should clarify whether the emissions reductions assumed for refineries are solely based on reductions in their natural gas demand and that this natural gas demand can be replaced with hydrogen in the high throughput case (see Figure 8A). Refineries have sources of NOx emissions that cannot be reduced or eliminated through hydrogen adoption (e.g., direct process emissions from some units). Also, many refineries have on-site hydrogen production plants that require supplemental natural gas as feedstock and this feedstock cannot be replaced with hydrogen. It is unclear whether the NOx Preliminary Study takes these factors into account when the emission reductions from refineries are estimated.

Second, the NOx Preliminary Study also has numerous tables purporting to list blending percentages, e.g., Table 7, Table 8, Table 17, and Table 18. SoCalGas should clarify whether the percentages offered in those table reflect blending percentages based upon volume or energy. These tables also seem to be in direct conflict with statements in the report implying that SoCalGas is not accounting for blending as this occurs behind the meter at customers' facilities. Please clarify what is or is not being accounted for from blending in terms of NOx impacts from the project.

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[10] *See id.* at 15, n. 29 & n.31.

[11] DOE Technical Targets for Hydrogen Storage Systems for Material Handling Equipment, Dept. of Energy, accessed 26 March 2024. https://www.energy.gov/eere/fuelcells/doe-technical-targets-hydrogen-storage-systems-material-handling-equipment

[12] Mahytec, "Datasheet for 500 bar 160-300l Hydrogen Storage." 2021. https://www.mahytec.com/wp-content/uploads/2021/07/CL-DS7-Data-Sheet_500bar-EN.pdf

[13] (a) Abdin, Z., Khalipour, K., Catchpole, K. Projecting the Levelized Cost of Large Scale Hydrogen Storage for Stationary Applications. *Ener. Conv. and Management,* **270**, 2022, 116241. https://doi.org/10.1016/j.enconman.2022.116241 ; (b) Reuss, M., Grube, T., Robinius, M., Preuster, P., Wasserscheid, P., Stolten, D. Seasonal Storage and Alternative Carriers: A Flexible Hydrogen Supply Chain Model. *Applied Energy*, **200**, 2017, 290-302. http://dx.doi.org/10.1016/j.apenergy.2017.05.050

Water Resources Evaluation

Air Products provides the following feedback on the February 2024 Water Resources Evaluation Preliminary Findings: (1) Water Availability Study; and (2) Water Quality Requirements.

First, regarding the Water Availability Study, the Study appears flawed in that it evaluates water availability broadly, including on a state-wide basis, rather than based upon the projected locations of production facilities.[14] According to the presentation at the March 5th, 2024, PAG Meeting, SoCalGas's pipeline routing study has already identified several locations for potential production. The Water Availability Study should be targeted to those locations. Instead, the Water Availability Study assumed the study area to be the entire SoCalGas service territory, and select sources located outside that service territory.[15] If water is not specifically available at the point of production, then the water will need to be transported which requires additional energy and results in greenhouse gas emissions as discussed above.

Second, the Study assumes that "Third-party clean renewable hydrogen producers will identify and develop or acquire water supply in sufficient quantities to meet water demands on their respective projects."[16] The Study thus effectively punts on a key issue that SoCalGas was required to determine in Phase 1: "Identification of the potential sources of hydrogen generation *and water*."[17]

Third, regarding the Water Quality Requirements set forth in Table 2: Preliminary Findings of the Water Resources Evaluation, the specified treatment approach does not encompass all of the pre-treatment steps that are most likely required to make raw water a suitable feed source for reverse osmosis. The water sources identified in the Water Availability Study are expected to vary by location and to contain suspended solids, heavy metals, organics and hydrocarbons in different amounts that require removal prior to treatment using reverse osmosis for removal of total dissolved solids and further polishing using ultraviolet systems, electro deionization systems and mixed bed ion exchange systems for removal of residual ionizable species and organics. Air Products requests that for each potential raw water source, SoCalGas include a table that identifies the specific water purification steps.

Furthermore, the stoichiometric water requirement of 9 kg of water for every 1 kg of hydrogen produced does not appear to include total raw water requirements, but instead only the treated ultrapure (UPW) water. The Water Quality Requirements should be clarified to note whether the estimated water requirement is based upon raw water or UPW.

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[14] *See, e.g.,* Water Availability Study at 3 (comparing projected demand to total statewide water demand per year in California).
[15] Water Availability Study at 6.
[16] Water Availability Study at 6.
[17] D.22-12-055 at OP 6(b)(emphasis added).

This distinction between raw water consumption and UPW also needs to be clarified in other areas of Table 2. For example, it is unclear whether the potential water demands set forth in the third paragraph of the Executive Summary refer to raw water or UPW, nor does the Study identify what assumptions were used concerning the expected recovery rate of UPW from raw water. In addition, the Study fails to indicate whether cooling water needs for the electrolyzer and the remaining plant water demand were included in the estimated demand. Air Products requests that SoCalGas clarify these issues in its final Study.

Section 2.3, on Page 5: There is reference to a study that was conducted to analyze the water quality requirements based on electrolyzer technologies used for hydrogen production and to establish the treatment approach to produce ultrapure water (UPW) from the identified potential water sources. It would be helpful to review the findings from that study. Details such as water quality characteristics for each of the potential water sources, available flows/volumes, purchase cost of source water ($/kgal), and UPW treatment goals for hydrogen production (as mentioned above) would be helpful for further evaluation/project feasibility.

<u>March 5th Pipeline Routing Discussion</u>

Much of what is under development by the private sector for new hydrogen infrastructure does not align with the Link studies and proposed utility hydrogen pipelines, nor do the Link studies overlap with ARCHES published plans. The Link mapping proposal with routes from the Pacific Ocean to the eastern state border presented in the recent PAG meeting are designed to track the existing SoCalGas rights of way for current gas transmission and distribution lines, and not necessarily drawn to compliment or supplement long-term future potential delivery needs. Instead, the Link preferred routes appear to duplicate or compete with existing dedicated pipelines that have been in service for decades and have been identified for expansion in ARCHES and with end users in the Los Angeles basin. While some of the ARCHES production is generally shown along with end uses in the mapping and preferred routing for the Link, the presentation did not make clear that some of these hydrogen consumers are already being serviced by existing hydrogen service providers with plans in place for buttressing existing hydrogen pipeline use and truck transport to support new users in the Los Angeles, Long Beach port complex and surrounding industrial areas. The Link PAG materials that map multiple pipeline segments into the Los Angeles coastal areas and weave throughout the California desert leave the PAG participants to assume that the SoCalGas Link is included in the ARCHES framework, when in fact it appears from public ARCHES documents and brief treatment during the presentation that only two small portions of the proposed Link have been identified as pipelines that may be located in the San Joaquin Valley and near Lancaster for longer-term potential development.

The ARCHES systems analysis on the other hand identifies production, end uses, and delivery points developed by a variety of ARCHES partners that will be the underpinning framework to support hydrogen market lift-off in California. There are more than 400 hydrogen entities in ARCHES working together to plan near term infrastructure investments to advance renewable hydrogen supply and delivery. The ARCHES systems plan is a living document borne out of a public-private partnership, supported by industry and academia, including the University of California Office of the President and Lawrence Livermore Labs. The United States Department of Energy recognized the ARCHES collective effort as one of the more advanced national hubs with more than 30 Tier 1 project proponents working diligently to finalize the $1.2 billion statewide award. These ARCHES partners include entities who have decades of hydrogen experience, who are actively advancing their projects, including new supply, new fueling stations, expanding existing dedicated hydrogen pipelines and hydrogen delivery fleets to serve new users statewide, including the Long Beach - Los Angeles port complex and regional industrial users including new electric sector users. The new green renewable hydrogen supply, new fueling (stationary and mobile) capability for maritime, ports, industrial and power needs are in various stages of development and permitting – well ahead of the timeline envisioned for the Link and SoCalGas' current process to move from studying and learning how hydrogen markets and systems work to requesting authority to transition to a hydrogen utility.

Air Products recommends that SoCalGas' withdraw the proposal to advance more than 400 miles of proposed hydrogen pipelines and limit review to the small segments referenced in the ARCHES framework, as 1) none of the proposed Link is needed in the near-term for hydrogen market lift-off, 2) SoCalGas studies released to date have flaws showing a lack of technical understanding and 3) the studies do not result in a demonstrated need for such a significant ratepayer investment in a major new hydrogen pipeline system.

Conclusion

Air Products appreciates the opportunity to provide this input on the feedback concerning the Preliminary Findings of the four Angeles Link technical studies that are now available: Greenhouse Gas Emissions Evaluation, Hydrogen Leakage Assessment, Nitrogen Oxide (NOx) & other Air Emissions Assessment, Water Resource Evaluation and the preliminary information on preferred pipeline routes.

In summary, there are gaps in this analysis in a number of key areas. The result of SoCalGas' efforts in the past 15 months to invest in a CPUC sanctioned process to learn the basics of hydrogen production, the market for hydrogen end uses, and how to plan hydrogen systems requirements has made little progress and indicates lack of readiness to enter the hydrogen sector. California is home to the second largest hydrogen market in the United States, which has been in operation for more than 60 years. There are many hydrogen companies and service providers in California with decades of proven production, storage and delivery experience and strong safety records who are operating effectively, managing hydrogen supply, and investing in hydrogen infrastructure based on specific, identified industrial, transportation and other market needs. Those legacy market participants are developing new supply, storage, fueling, dispensing and transportation solutions through private investment to meet the ARCHES goals.

To date in the studies, there is insufficient needs determination in the analysis, a demonstrated lack of understanding of basic hydrogen production and supply requirements and not a compelling reason for advancing 400+ miles of the Link build-out. Further, the ambitious

Angeles Link plans and mapping is redundant to or misaligned with the existing market needs and published ARCHES plans. The two small segments of the Link referenced in the ARCHES plan are not critical to the overall success of Phase 1 of ARCHES. The information published by SoCalGas in the PAG meetings is not aligned with existing statewide and economy-wide hydrogen expansion plans and have the potential to be misleading and confusing.

Respectfully,

Miles Heller Director, Global Greenhouse Gas,
Hydrogen, and Utility Regulatory Policy

March 29, 2024

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Submitted via email to ALP1_Study_PAG_Feedback@insigniaenv.com.

Feedback for Southern California Gas Company on the Angeles Link Project GHG Water and Leakage Reports

Communities for a Better Environment (CBE) submits this letter of feedback to Southern California Gas Company (SoCalGas) on the Greenhouse Gas Emissions Preliminary Data and Findings ("GHG study"), Leakage Preliminary Data and Findings ("leakage study"), and Water Resources Evaluation ("water study").

Greenhouse Gas Emissions Preliminary Data and Findings

The Greenhouse Gas Emissions preliminary findings ("GHG study") fails to examine significant sources of climate pollution that must be explored to establish an accurate depiction of the ALP's greenhouse gas impacts. The GHG study is in large part premised on the prior, draft Demand Report, which as several parties have raised, seriously overestimates hydrogen demand and ALP throughput by failing to consider cost and making *significant* assumptions about hydrogen technology adoption. Particularly, in order to remedy the GHG study's failings, it is critical that the final report:

- Correct the demand study failures raised by UCAN, EDF, and NRDC and utilize revised hydrogen demand inputs to assess GHG emissions impacts of the ALP.[1]
- Correct assumptions that underestimate the GHG emissions from hydrogen production processes.
    - The GHG study assumes that electrolysis of hydrogen will not produce GHG emissions during the 2030-2045 period. While CBE strongly advocates for hydrogen to be produced exclusively through electrolysis powered by wind and solar, there are no laws or regulations which mandate this and there is a significant threat that hydrogen electrolysis will be powered by GHG emitting energy sources in California between 2030-2045. The GHG study must not undercount GHG emissions from electrolysis by assuming that all electrolysis will have no climate emissions.
    - The GHG study assumes that biomass gasification will not produce GHG emissions during the study period. The process of biomass gasification produces GHG emissions which are not always avoided or mitigated. The GHG study must not undercount GHG emissions from biomass gasification by assuming that all gasification will have no climate emissions.

[1] Utility Consumers' Action Network, Feedback for SoCalGas Regarding Demand Study Technical Approach/Data & Preliminary Findings, Sept. 25, 2023; Environmental Defense Fund & Natural Resources Defense Council, Environmental Defense Fund and Natural Resources Defense Council Comments on the Demand Study Draft Report, Feb. 23, 2024; UCAN, Feedback for SoCalGas Regarding Angeles Link Demand Report Draft, Feb. 26, 2024.

    - The GHG study appears to undercount GHG emissions from steam reforming of methane gas. Without greater availability of inputs and assumptions it is difficult to fully analyze the accuracy of the study with respect to SMR. The GHG study must not undercount GHG emissions from SMR.
- Specify and include hydrogen leakage on GHG impacts of the ALP.
    - The GHG study excludes the known climate impacts of hydrogen leakage. Hydrogen's physical properties make it difficult to effectively contain and transport, making leakage a significant concern. Despite acknowledging available leakage data and climate impacts in the GHG study and leakage study, the GHG study does not include these figures in ALP emissions estimates. The GHG study must include hydrogen leakage from all points of hydrogen use supported by the ALP in its final GHG emissions results.
- Study lifetime GHG impacts of the ALP including under a robust hydrogen alternatives scenario.
    - The GHG study analyzes a 15-year window of climate emissions, from 2030-2045 only, and presents results without disclosure of assumptions around hydrogen alternatives adoption. Based on the data available, the GHG study fails to examine decarbonization pathways that rely heavily on direct electrification of end-uses with renewable electricity. Rather, based on the flawed data of the Demand Study, the GHG study's limited window excludes crucial future impacts such as extended reliance on and intensification production of methane to produce hydrogen, and continued acceleration of direct electrification eliminating emissions ahead of hydrogen.

Leakage Preliminary Data and Findings

The preliminary leakage report fails to explore end-use leakage estimates or provide specific leakage figures for any link in the ALP's hydrogen chain. Specific figures for hydrogen leakage are necessary to assess climate and public safety impacts of the ALP.

Water Resources Evaluation

The preliminary water resources report fails to assess and report back on issues that are critical for assessing the environmental impact or basic feasibility of supplying hydrogen to the Angeles Link project. The water study does not address any environmental impacts of the project's water draw despite the gas industries' long history of imperiling water resources for low-income, rural, and marginalized communities. Substantially more information is needed, at this early stage, to understand the ALP's water impacts. Particularly, the water study must:

- Study safeguards must be followed to ensure the ALP's water draw does not compete for resources serving water strapped communities.
- Study and include present conditions analysis of drinking water supply in communities that water may be drawn from.
- Study and include energy costs and emissions estimates to purify and deliver water used to supply the ALP.
- Financial costs to develop, purify, deliver, or contract for water used to supply the ALP.
- Study and include water impacts from electricity production required to support water purification, electrolysis or other processes required to supply hydrogen to the ALP.

- Study and include data on size or potential impacts of waste streams from water treatment or other wastewater streams.

Respectfully Submitted.

Theo Caretto
Associate Attorney
Communities for a Better Environment

CC:
Emily Grant, SoCalGas
Chester Britt, Arellano Associates
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April 5, 2024

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Submitted via email to ALP1_Study_PAG_Feedback@insigniaenv.com.

Feedback for Southern California Gas Company on Angeles Link Project Revised NOx Evaluation Preliminary Data and Findings

Communities for a Better Environment (CBE) submits this letter of feedback to Southern California Gas Company (SoCalGas) on the Revised Angeles Link Project NOx Evaluation Preliminary Data and Findings ("NOx study").

As an initial matter, the NOx study results were tainted by the erroneous findings of the draft Demand Report, which as several parties have raised, seriously overestimates hydrogen demand and ALP throughput by failing to consider cost and making significant assumptions about hydrogen technology adoption. This study's reliance on that report's enormous "Ambitions" demand scenario results in heavily skewed NOx emissions data. Because NOx emissions estimates and further assumptions detailed below are not made available in this study, it is difficult to examine or discern the full scale of impacts from this misstep.

In the list of phase one requirements outlined in section 11 of the Decision, the PUC states that SoCalGas shall provide assessments of NOx emissions resulting from the Project, including appropriate controls to mitigate NOx emissions. In producing the assessment, the PUC directs SoCalGas to address concerns raised by Sierra Club and CEJA regarding the environmental justice harms of NOx emissions related to hydrogen use in power generation, and industrial facilities. Further, the Decision directs SoCalGas to engage with DAC and ESJ groups to identify potential community impacts such as NOx emissions. As outlined further below, the study fails to meet the requirements of the Decision because it does not provide data on NOx emissions resulting from the project or acknowledge environmental justice concerns.

The study fails to report NOx emissions resulting from the Project.

The NOx study repeatedly fails to clearly represent projected emissions numbers by presenting "emissions reductions" instead of emissions. The study uses a two-part equation to calculate emissions and emissions reductions but fails to provide the numbers used to calculate both formulas and specifically does not include emissions numbers. Further, the study provides little to no background on the sources of data or specific methodology beyond referencing the flawed Demand Study, which is not cited with specificity. By failing to provide the emissions factor, the study fails to address the requirements of the decision. And, consequentially, by failing to provide emissions data, the study has not presented the basic information necessary for fruitful discussion concerning hydrogen use NOx emissions or its community impacts. In doing so, the study prevents groups from meaningfully responding to or engaging with SoCalGas on the issue of NOx emissions.

The study fails to adequately examine NOx emissions in industrial facilities and from electricity generation.

The NOx study centers its results on the 99.6-99.8% NOx emissions reductions that will result were mobility sectors to transition from diesel and gasoline combustion to hydrogen fuel cell electric vehicles (FCEVs). By framing all other NOx emissions around these supposed mobility emissions reductions, the study fails to properly analyze NOx emissions from industrial facilities and electricity generation, which the study quantifies as representing 0.49% of reductions instead of providing emissions data. In fact, Appendix A of the study regarding methodology finds that "NOx emissions will stay the same or decrease where hydrogen is substituted for natural gas in combustion applications," indicating that a significant amount of NOx emissions are to be expected from industrial facilities and electricity generation which the study does not acknowledge.

Further in discord, the study states that NOx emissions will decrease most importantly because the South Coast AQMD will require NOx reductions to meet State Implementation Plan (SIP) requirements. This unfoundedly assumes SIP reduction requirements are met via hydrogen FCEV's. Furthermore, by relying on existing legislation as a measure of projected NOx emission, the study is presupposing that NOx emissions regulation will continue to be necessary in industrial facilities, and electricity generation despite touting widespread emissions reductions. Despite this, the study fails to provide the relevant NOx emissions data for industrial facilities and electric generation.

The study fails to identify and examine appropriate controls to mitigate NOx emissions.

The study repeatedly presents unknown, uncertain technological advances as a means of mitigating NOx emissions. By failing to clearly identify the controls and whether and how they may be appropriate to mitigate NOx emissions, the study fails to meet the explicit phase one requirements of the decision. Further, stakeholder groups cannot have meaningful discussions regarding NOx emission control technologies where the basis for discussion has not been provided.

The study further fails to acknowledge or analyze the technological feasibility or cost of NOx emissions control technology. The study also fails to analyze the applicability and feasibility of the various production, storage and transmission methods and technologies mentioned which result in varying NOx emissions. The feasibility and applicability of hydrogen technology with varying NOx emissions directly affects projected NOx emissions data provided by the study.

The revised mobility language does not correct calculations to include market available hydrogen alternatives.

The NOx study was revised to address concerns raised regarding the omission of other NOx emission reducing technologies, such as battery electric vehicles (BEV) in the mobility analysis. However, the revision only included a mention of BEVs as an alternative while the language and analysis remained unchanged. This failure to adequately revise the mobility analysis is indicative of the misleading premise at the heart of the NOx study, that emissions reductions from the mobility sector can categorically indicate NOx emissions and associated risk analysis across the other end-use analyses. Further, the study's skewed emissions reductions results are predominantly a result of assumed developments in hydrogen fuel cell heavy duty vehicles, which are not currently widely available on the market. Failure to provide analysis of the availability of heavy-duty FCEVs calls into question the timeline and emissions calculations provided.

Further, the NOx study fails to examine decarbonization pathways that include direct electrification of end-uses with renewable electricity. The study continues to perpetuate the flawed assumptions of the Deman Study, by examining a limited window which excludes crucial future impacts such as extended reliance on and intensification of methane production to produce hydrogen, and continued acceleration of direct electrification eliminating emissions ahead of hydrogen. While uncertainty exists in all facets of developing technology, phase one studies are meant to provide a reasonable background for project research, development, and discussion with stakeholders. Later arriving alternatives and environmental justice studies cannot remedy these failings because the core results are skewed by the above-identified omissions and miscounts. Avoiding the realities of technology feasibility and alternatives at this early-stage stymies fruitful research and prevents meaningful stakeholder engagement.

Respectfully Submitted,

Theo Caretto
Associate Attorney
Communities for a Better Environment

CC:
Emily Grant, SoCalGas
Chester Britt, Arellano Associates
Alma Marquez, Lee Andrews Group
Angeles Link PAG Service List

From: Michael Colvin
To: alpag@socalgas.com; ALP1 Study PAG Feedback
Cc: Emily Grant
Subject: New EDF paper on H2 from our science team
Date: Friday, March 1, 2024 1:10:16 PM
Attachments: image001.png

You don't often get email from mcolvin@edf.org. Learn why this is important

Dear Angeles Link PAG folks,

Environmental Defense Fund's hydrogen science team has just published a new peer-reviewed paper in the journal *Environmental Science & Technology*. The purpose of this study is to show the importance of including overlooked factors in hydrogen climate impact assessments, so that we have accurate foundations to make the best policy, investment, and deployment decisions for a clean energy transition with hydrogen. This paper shows hydrogen deployment can be better or worse for the climate when three critical (but typically overlooked) factors are included in lifecycle assessments: the **indirect warming effects of hydrogen emissions, observed methane emissions intensities, and near-term timescales**.

This study builds upon our prior publication on the climate impacts of hydrogen by looking at eight specific hydrogen (production-to-end use) pathways -- including blue and green H2 scenarios across the industrial, power and transportation sectors. With the new hydrogen economy still in its infancy, this study points to one concrete way that we can ensure that we maximize the climate benefits of hydrogen: robust climate accounting.

You can find the study here, and EDF's statement here.

Please let us know if you have any questions about this study, or if you or your teams would like a briefing.

Best
Michael

Michael Colvin
Director, California Energy Program

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March 28, 2024

Chester Britt
Planning Advisory Group Facilitator

Emily Grant
Angeles Link Senior Public Affairs Representative
Southern California Gas Company

Alisa Lykens
Director
Insignia Environmental

Subject: Environmental Defense Fund Comments on Greenhouse Gas Emissions and Leakage Preliminary Reports

As a follow-up to the draft reports on greenhouse gas (GHG) emissions and leakage preliminary data and findings reports shared on March 14, 2024, Environmental Defense Fund (EDF) submits the following comments.

First, EDF reiterates **the concerns raised in the EDF and Natural Resources Defense Council (NRDC) Joint Comments** shared February 23, 2024, with regards to the level of hydrogen demand projected in the Angeles Link draft demand study. The findings of the GHG emissions draft report are based on the demand figures from the draft Demand Study which, as the Joint Comments pointed out, are incredibly high compared to analogous projections of hydrogen demand.[1] As a result, the emissions reductions impact found in the GHG emissions draft report would also be far higher than what could be expected from other data sources and analyses. Moreover, because the draft Demand Study did not take the cost of hydrogen into account—and therefore overlooks a key factor that would *actually* determine the level of supply and demand—EDF notes that the GHG emissions draft report is similarly incomplete. This limitation should be clearly stated in the executive summary of the final GHG emissions report.

Second, EDF strongly recommends that **references to the role of hydrogen as an indirect GHG be included in the executive summaries** of the final GHG emissions report and the final Leakage report. The draft GHG emissions report includes a discussion on the current research and

[1] GHG Draft Report at 4; EDF-NRDC Joint Comments on the Demand Study Draft report at 1.

findings around hydrogen's climate impacts, while noting various gaps that still exist.[2] The climate impacts of hydrogen leakage are directly relevant to the overall climate impacts of the Angeles Link Project; and have been consistently highlighted by EDF as a key concern.[3] Given this direct relevance and significance, the potential climate impacts of hydrogen leakage should be highlighted in the executive summaries of the GHG and leakage reports.

Third, **specific leakage figures and their climate impacts should be included** in the GHG and leakage reports. Both the draft GHG and leakage reports decline to provide specific figures on the amount and climate impacts of hydrogen leakage potentially associated with the Angeles Link project, citing a lack of detailed infrastructure information or consensus figures on leakage.[4] EDF notes, however, that the same objections could be raised against any demand figures or GHG emissions impact figure provided in the draft reports. Instead, SoCalGas provides those figures through a series of assumptions, resulting in a range of potential impacts based on different input values. EDF believes applying the same process to the impacts of hydrogen leakage would be both possible and consistent. In fact, the draft GHG report lays out this exact process and implies that such calculations do exist:

> One potential high level conservative approach to estimate the potential impact to climate change would be to assume conservative ranges of leakage rates and GWPs (GWP 100) from the values available in the scientific literature (as summarized in Table 2 of the parallel Leakage Study) and apply those to the Angeles Link Throughput Scenarios being considered. […] Based on preliminary calculations, this proposed methodology indicates that the impact to the predicted overall GHG emissions reductions from combustion associated with Angeles Link and third-party production and storage would be very low (i.e., less than 3% for high throughput scenario) when considering the addition of potential GHG emissions from the four leakage sectors evaluated in the parallel Leakage Study.[5]

Leakage values and associated climate impacts should be provided as low-, medium-, and high-scenarios using the range of inputs already identified by SoCalGas in Table 17 of the GHG Draft Report and Table 2 of the Leakage Draft Report.[6]

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[2] GHG Draft Report at 39-41.
[3] EDF Phase 1 Study Topics and Scope of Work Comments at 1.
[4] GHG Draft Report at 40; Leakage Draft Report at 3.
[5] GHG Draft Report at 40.
[6] GHG Draft Report at 41 and Leakage Draft Report at 12.

Respectfully,

Michael Colvin
Director, California Energy Program

Joon Hun Seong
Senior Energy Decarbonization Analyst

Environmental Defense Fund
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San Francisco, CA 94105
Email: mcolvin@edf.org
Email: jseong@edf.org

March 29, 2024

Submitted via email to ALP1_Study_PAG_Feedback@insigniaenv.com.

RE: Feedback on the Preliminary Data and Findings of the Angeles Link Project and CBOSG Process

Food & Water Watch, as part of the Community Based Organization Stakeholder Group (CBOSG), submits this letter of feedback regarding the preliminary data and findings of the Angeles Link Project by the Southern California Gas Company (SoCalGas) and the CBOSG process. Concerns relating to the preliminary data and findings and the CBOSG process are as follows:

Preliminary Data and Findings Reporting:

Water Resource Evaluation:

The report provided by SoCalGas relies on broad assumptions about water availability across a vast service territory, and fails to reflect local water scarcity issues, environmental constraints, and the specific needs of diverse communities within the service area. In the report, SoCalGas claims that the volume of water needed for the project would be 0.01-0.03% of the total amount of water used in the state of California. The state continues to be impacted by severe climate conditions which has resulted in water scarcity for many communities. There needs to be an in-depth analysis of the environmental impact of extracting vast quantities of water in a state that is impacted by periods of drought, as well as the environmental impact of intensive water treatment processes and the energy required for those processes.

In addition to the environmental impact, there is no clarity on how the project's water demands and treatment processes might affect local water rates, availability, or the socioeconomic dynamics of communities within SoCalGas's service territory.

NOx Emissions Evaluation:

Although the report's findings claim a significant reduction in NOx emissions, the report relies on assumptions and generalizations. The report applies a uniform methodology across different sectors (mobility, power generation, industrial) without considering sector-specific variations in technology readiness, hydrogen utilization efficiencies, and existing infrastructure which could oversimplify the complex dynamics of NOx emissions reductions. The estimation of NOx emissions reductions also heavily relies on the regulatory environment and the adoption of best available control technologies.

Therefore, if regulatory standards evolve or if anticipated NOx control technologies do not perform as expected, the projected NOx emissions reductions may be accurate.

Leakage and Environmental Impact:

The report acknowledges that hydrogen leakage would be harmful, as well as the potential sources for leakage when it comes to the production, compression, storage, and transmission of hydrogen. And yet, this report fails to provide detailed volumetric estimates of potential leakage and heavily relies on the assumed advancement of leak detection and mitigation technologies without concrete timelines or proof of viability.

Greenhouse Gas Emissions Analysis:

Although the report claims the potential for significant reductions in greenhouse gas (GHG) emissions across various demand scenarios, this heavily depends on assumptions regarding the availability, scalability, and adoption rates of hydrogen technology across those sectors. The environmental impacts of hydrogen leakage are not fully accounted for in this analysis. There are indirect GHG implications of hydrogen, notably its impact on methane levels.

There needs to be an alternatives study to the Angeles Link Project that analyzes how the projected GHG reductions from the Angeles Link project compare with potential reductions achievable through clean energy projects.

Community Based Organization Stakeholder Group Process:

There continues to be a lack of transparency from SoCalGas, such as the ratepayer impacts, environmental justice impacts, and safety impacts of the Angeles Link Project, as well as the intended use of the hydrogen. During CBOSG meetings, SoCalGas has claimed that the hydrogen would be used for what they claim are hard to electrify sectors. Yet, given that SoCalGas held a tour of their Hydrogen Model House in Downey for the CBOSG members and has been attempting to pipe hydrogen into communities such as the campus of the University of California Irvine and Orange Cove, which has not been disclosed to the CBOSG, SoCalGas needs to be honest about plans of having hydrogen for residential use. There is also the issue of SoCalGas rushing this phase of the project. SoCalGas must provide an updated and clear timeline for Phase One.

Sincerely,

Andrea Vega
Southern California Senior Organizer
Food & Water Watch

March 28th, 2024
California Public Utilities Commission (CPUC)
505 Van Ness
Avenue San Francisco, CA 94102

RE: Feedback on the Preliminary Findings of the four Angeles Link and CBO Stakeholder Process

To the California Public Utilities Commission (CPUC),

I am reaching out to articulate deep-seated concerns regarding the Angeles Link Project, drawing upon insights from the Preliminary Data and Findings reports. These documents unveil substantial flaws that call for an in-depth evaluation by the CPUC.

Equally alarming are the issues arising from the Community-Based Organization (CBO) Stakeholder process tied to the same project. This process has notably fallen short in several key areas: it has failed to sufficiently engage tribal communities, has suffered from transparency deficits, and has been marked by irrelevant meeting activities and instances of misinformation. Collectively, these issues significantly detract from the integrity of the stakeholder engagement efforts, undermining the foundational principles of inclusive and transparent project development.

Preliminary Data and Findings Reporting:

Water Resource Evaluation Concerns:

The assertion that the project's water demands will comprise a mere 0.01-0.03% of California's total water usage fails to account for the regional water scarcity crises and the environmental impacts of extracting vast quantities of water. The report relies on broad assumptions about water availability and demand across a vast service territory. This generalized approach might not accurately reflect local water scarcity issues, environmental constraints, and the specific needs of diverse communities within the service area. It also does not account for all of the other Hydrogen Projects that will be competing for that water. The reliance on a broad spectrum of water sources, including treated wastewater and groundwater, does not fully mitigate the potential strain on California's water resources, especially under drought conditions. The assumption of ultrapure water being attainable through advanced treatment underscores a heavy dependency on technologies that may not be scalable or economically feasible across the required service territories.

NOx Emissions Evaluation Shortcomings:

While the reports propose significant NOx emissions reductions, the methodologies and assumptions applied—especially the reliance on unproven hydrogen combustion technologies and the anticipated widespread adoption of hydrogen fuel cells—cast doubt on the projected outcomes. The lack of empirical data to support these claims, combined with a generalized approach that overlooks sector-specific variations and potential regulatory changes, undermines the credibility of the findings.

Leakage and Environmental Impact:

The acknowledgement of hydrogen leakage as a potential source of environmental harm is alarming. Despite mitigation strategies, the absence of detailed volumetric estimates and reliance on literature for leakage rates highlight a significant gap in understanding the true environmental footprint of the project. This oversight could have detrimental impacts on greenhouse gas concentrations and atmospheric chemistry, particularly concerning the indirect effects on methane levels.

Greenhouse Gas Emissions Analysis Deficiencies:

The reports' optimistic projections of GHG emissions reductions are predicated on assumptions regarding the clean production of hydrogen and its end-use applications. However, the potential indirect increase in atmospheric methane due to hydrogen leakage could negate the environmental benefits. Furthermore, the comparative analysis lacks consideration of other renewable energy technologies or energy storage solutions, presenting a skewed perspective on the project's environmental advantages.

CBO Stakeholder Process:

The Angeles Link Project's CBO Stakeholder Process fails to meet the standard of the CPUC's Environmental and Social Justice Action Plan. It has significant shortcomings in aligning with the stated goals and methodologies prescribed for ensuring environmental justice, community engagement, transparency, and safety. These discrepancies not only raise concerns about the project's execution but also its potential impacts on vulnerable communities and the environment.

Inadequate Tribal and Community Engagement:

The lack of robust engagement with local tribal leaders and communities directly conflict with the CPUC's emphasis on inclusive stakeholder engagement and the need for consent from tribal communities for projects of this nature. This oversight undermines the trust and collaborative potential crucial for the success of projects with significant environmental and social footprints.

Lack of Transparency:

The issues of transparency, particularly in stakeholder identification and access to critical project documents, along with non inclusive scheduling of meetings, detract from the process's integrity.

These factors contribute to a lack of accountability and inclusivity, falling short of the CPUC's guidelines that advocate for clear, accessible, and participatory engagement processes.

Misinformation and Rushed Process:

The stakeholder process appears to have been unduly rushed, leading to inconsistencies in information provided by SoCalGas employees. This has resulted in confusion and concerns over the credibility of the information being shared. For instance, contradictory statements regarding the use of ammonia storage and misleading claims about hydrogen's impact as a greenhouse gas have been particularly troubling. It is concerning to note misinformation such as hydrogen being presented as not a greenhouse gas and incorrect references to the IPCC report's findings on hydrogen's impact. Socal Gas keeps saying the project is for hard to electrify sectors and then offer tours of the Hydrogen Model House and push testing on communities like UCI students and Orange Cove. This is clearly dishonest.

Environmental Justice and Community Impact:

The project's documents and reports fail to comprehensively detail the environmental justice assessments and the specific strategies to mitigate negative impacts on disadvantaged communities. This gap points to a broader issue of ensuring that environmental justice principles are not only considered but are central to the project planning and execution phases, as emphasized in the CPUC's action plan.

Cost Justification and Transparency:

The absence of a detailed financial breakdown and the lack of clarity regarding the project's cost-effectiveness and impact on ratepayers raise concerns about economic transparency and accountability. These elements are crucial for justifying the project's investments and ensuring that the economic implications for the communities involved are transparent and equitable.

Technology and Safety Risks:

While the project acknowledges the technological and safety risks associated with large-scale hydrogen infrastructure, the provided documents lack detailed plans for addressing these risks comprehensively. This falls short of the CPUC's guidelines for rigorous safety assessments and transparent communication of mitigation strategies to stakeholders.

Conclusion:

Considering these factors, it is imperative to re-evaluate the Angeles Link Project in light of its current alignment with CPUC's overarching goals for environmental justice, community engagement, and transparent, responsible energy infrastructure development. Prioritizing projects that demonstrate a clear commitment to environmental sustainability, safety, economic transparency, and, most importantly, respect for the voices and rights of all communities involved, will be crucial in moving forward.

Sincerely,
Faith Myhra (she/they)
Member
Protect Playa Now
Writing from the traditional, ancestral, and unceded territory of the Tongva, Kizh, and Chumash People.

Feedback on Four Preliminary Finding Reports
3/29/24

Physicians for Social Responsibility - Los Angeles remains deeply concerned about the Community Based Organization Stakeholder Group process that has unfolded to date, and the proposed Angeles Link project overall, given a lack of adequate and accurate information needed to fully assess the project, and a lack of opportunity to discuss and resolve potential project flaws.

While meetings have been information heavy at times, there has been little room for substantive questions and conversation regarding the information offered, and meetings have given priority to presenters who share the perceived benefits of the project while disregarding important questions about safety, water consumption, and environmental justice. For many of us in CBOs, it can be difficult to find time to read through and respond adequately to hundreds of pages of information within such a short timeframe. Therefore, the feedback that SoCalGas and the CPUC have been getting so far should be considered partial and incomplete.

Additionally, despite repeated requests for SoCalGas to get representation from local Indigenous Tribes and organizations, the only Indigenous recognition I've seen is during the land acknowledgements where SoCalGas commits to honoring the original stewards of the land.

General concerns regarding the water report include: a lack of specificity around where water will be sourced; a disregard for localized water concerns and an attempt to minimize water consumption concerns by speaking of the water needs as a percentage of the overall state consumption rather than in regards to the specific source; an unrealistic over-reliance on recycled and treated water given the required energy, cost and additional waste streams needed for that approach; and a lack of regard for resilience questions that arise from depending on additional water in a drought-prone region that already exceeds its local water availability.

The Greenhouse Gas analysis fails to address serious concerns regarding the warming impact of hydrogen leakage, which has the potential to negate some or potentially all of the greenhouse gas benefits of green hydrogen compared to methane. Also, disregarding or providing incomplete information about the emissions (climate and air pollutant) impacts of production methods and proposed end uses of the delivered hydrogen paints an incomplete picture of the overall climate impacts of the Angeles Link project. Generally, there is also a lack of clarity about how and where exactly SoCalGas plans to store hydrogen.

As for the Leakage report, without accurate information about projected hydrogen leakage rates throughout the entire process and the related harms, including at end uses, it is impossible to assess the full environmental impact of this project. As previously mentioned, a failed approach to preventing hydrogen leakage would not only increase the cost of this project, but also negate any potential climate benefits of the project.

The NOx report claims that the project will result in significant reductions in NOx pollution, but utilizes creative accounting to demonstrate these claims. Without a clear understanding of the end uses for hydrogen, particularly in the electricity generation sector, and what they would be displacing, it seems odd that SoCalGas is able to make such confident claims about NOx reductions. Additionally, it is important to note that even if there is an overall reduction in NOx emissions statewide, if the remaining emissions become increasingly concentrated in certain communities, this project would perpetuate environmental racism and injustice. This is particularly concerning as we are aware that SoCalGas intends to use existing rights of way and connect to end uses in existing environmental justice communities.

Overall, Physicians for Social Responsibility - Los Angeles feels that this project is being unnecessarily rushed, with potentially enormous consequences for environmental justice communities, ratepayers, and SoCalGas' credibility. We urge an intentional shift to more substantive meetings, a more reasonable timeline, a commitment to living the values that SoCalGas espouses, and more responsiveness to the questions and concerns that have been raised to date. We look forward to continuing to engage on this proposed project.

APPENDIX 3 – SOCALGAS RESPONSES TO COMMENTS

Angeles Link Phase 1
Quarterly Report (Q1 2024)

Appendix 3: SoCalGas Response to Comments

Prepared by SoCalGas
with technical input from
Insignia

Table of Contents

Acronyms and Abbreviations

Acronym/Abbreviation	Definition
AFY	Acre-Feet Per Year
ARCHES	Alliance for Renewable Clean Hydrogen Energy Systems
BACT	Best Available Control Technology
BARCT	Best Available Retrofit Control Technology
BEV	Battery-Electric Vehicles
CARB	California Air Resources Board
CBOSG	Community Based Stakeholder Group
CEC	California Energy Commission
CEJEST	Climate & Economic Justice Screening Toll
CEQA	California Environmental Quality Act
CIELO	Comunidades Indigenas en Liderazgo
CPUC	California Public Utilities Commission
D	Decision
DACS	Disadvantaged Communities
ESJ	Environmental Social Justice
FCEVs	Fuel Cell Zero Vehicles
GHG	Greenhouse Gas
G.O.	General Order
GWP	Global Warming Potential
H2IE	H2 Innovation Experience
HSP	Hydrogen Safety Panel
IEPR	Integrated Energy Policy Report
Kg	Kilogram
LCFS	Low Carbon Fuel Standard
LCOH	Levelized Cost of Delivered Hydrogen
M	Million
MMT	Million Metric Tons
NEPA	National Environmental Policy Act
NREL	National Renewable Energy Lab
NSCR	Non-Selective Catalytic Reduction
NOx	Nitrogen Oxide
NRHP	National Register of Historic Places
NZEFC	National Zero-Emission Freight Corridor Strategy
OEM	Original Equipment Manufacturer’s
PAG	Planning Advisory Group

Acronym/Abbreviation	**Definition**
RD	Renewable Diesel
SAF	Sustainable Aviation Fuel
SB	Senate Bill
SCR	Selective Catalytic Reduction
SCAQMD	South Coast Air Quality Management District
SGMA	Sustainable Groundwater Management Act
SMR	Steam Methane Reformation
SNCR	Selective Non-Catalytic Reduction
TCO	Total Cost of Ownership
TPY	Tonnes Per Year
UWMP	Urban Water Management Plans
UCI	University of California Irvine
UCD	University of California Davis
UCLA	University of California Los Angeles
USDOE	United States Department of Energy

1 Overview

Appendix 3 to the Quarterly Report includes the written comment letters received from the Planning Advisory Group (PAG) and Community Based Stakeholder Group (CBOSG) during the first quarter (January to March) of 2024, and SoCalGas's responses to the comment letters. SoCalGas's responses below address stakeholder feedback based on available information as of the end of Q1 2024, unless otherwise noted. During this time period, there were two distinct groups of comment letters submitted to SoCalGas. The first group of comments were provided by PAG/CBOSG members on SoCalGas's Draft Demand Study. The second group of comments were provided by PAG/CBOSG members on SoCalGas's Preliminary Data and Findings for the following studies: Greenhouse Gas (GHG) Emissions Evaluation; Hydrogen Leakage Assessment; Water Resource Evaluation; and Nitrogen Oxide (NOx) and other Air Emissions Assessment.

Table 1: Index of Comment Letters Received During Q1 2024, lists the comment letters for each group.

Table 1: Index of Comment Letters Received During Q1 2024			
Comment Letter	**Date of Letter**	**Commenter**	**Response No.**
Draft Demand Study Commenters			
1	February 23	Environmental Defense Fund (EDF) & Natural Resources Defense Council (NRDC)	1-1 to 1-4
2	February 23	Public Advocates Office (CalPA)	2-1 to 2-4
3	February 23	The Utility Consumers' Action Network (UCAN)	3-1 to 3-13
Preliminary Data and Findings (NOx, GHG, Leakage, and Water)			
4	March 29	Air Products	4-1 to 4-13
5	March 29	Communities for a Better Environment (CBE)	5-1 to 5-12
6	April 5	CBE	6-1 to 6-10
7	March 1	EDF	7-1
8	March 28	EDF	8-1 to 8-4
9	March 29	Food and Water Watch (FWW)	9-1 to 9-8
10	March 25	Protect Playa Now (PPN)	10-1 to 10-12
11	March 28	PPN	11-1 to 11-13
12	March 29	Physicians for Social Responsibility – Los Angeles (PSR-LA)	12-1 to 12-7

All written comment letters from PAG/CBOSG members have been coded with a number to facilitate identification and tracking (see Table 1). These comment letters were reviewed and divided into individual comments, based on themes, issues, or concerns. Individual comments and the responses to them were assigned corresponding numbers (e.g., 1-1, 1-2). To aid readers and commenters, electronically bracketed comments have been applied to this document, with the corresponding responses provided immediately following the comments.

Global responses were prepared to address similar issues that were raised in multiple comment letters. These responses are provided below. These include:

Global Response 1 – Demand Study

Global Response 2 – Stakeholder Engagement Process

Global Response 3 – Potential Indirect GHG Emissions from Water

Global Response 4 – Leakage Estimates and Climate Change Impacts

Global Response 5 – Water Availability, Local Community Impacts and Affordability

2 Global Responses

2.1 Global Response 1 – Demand Study

Among other things, the three comment letters received from PAG members on the Angeles Link Demand Draft Report (Demand Study) state the projections of future demand for clean renewable hydrogen in the Mobility, Power Generation, and Industrial sectors in SoCalGas's service territory contained in the Demand Study may be too high and do not adequately account for the current and projected cost of clean renewable hydrogen.

Demand

Hydrogen demand projections published over the past few years by government agencies and researchers vary on methodology and outcomes. Some government agency reports referenced in the comment letters, such as the California Air Resources Board' (CARB) 2022 Scoping Plan (Scoping Plan)[1], forecast total hydrogen demand in California closer to the Demand Study's conservative scenario of 1.9 million (M) tonnes per year[2] (TPY) of hydrogen in SoCalGas's service territory by 2045. The California Energy Commission's (CEC) 2023 Integrated Energy Policy Report (IEPR) uses the Scoping Plan as the basis for one of its two hydrogen demand scenarios for power generation and transportation, and forecasts statewide demand for clean renewable hydrogen in 2045 as high as 2.9M TPY. This is double the hydrogen demand the Scoping Plan considered for 2040 (estimated at 1,475,000 MT/year).[3] Other recent projections, such as those released by the Alliance for Renewable Clean Hydrogen Energy Systems (ARCHES), greatly exceed all the Demand Study's scenarios, including the ambitious scenario of 5.9M TPY. When looking at these projections holistically, the Demand Study's conclusions are near or within the range of recently released projections of hydrogen demand in California.

SoCalGas is aware that there may be sector-by-sector discrepancies between some of the government agency hydrogen demand forecasts referenced in the comment letters and its Demand Study. While SoCalGas has reviewed the referenced reports in response to stakeholder comments, the Demand Study projections were not based on agency forecasts. SoCalGas's Demand Study projections were based on independently developed assumptions and analysis of potential hydrogen uptake in the SoCalGas service territory. Specifically, for each sector analyzed, assumptions were made on how legislation, technical feasibility, commercial availability, and business readiness could impact hydrogen consumption. SoCalGas's Demand Study was developed with the support of two organizations, Accenture and Electric Power Research Institute**.** Analysis was based on the latest market and technology information and was peer reviewed by experts at third parties, including National Renewable Energy Lab (NREL), South Coast Air Quality Management District (SCAQMD), University of California Los Angeles (UCLA), UC Irvine (UCI), and UC Davis (UCD).

SoCalGas considers the assessment of the potential hydrogen demand within SoCalGas service territory as an important initial step in the Angeles Link Phase 1 studies. SoCalGas can use information about the potential hydrogen market in its service territory to inform which sectors and regions could be served by Angeles Link. In addition, this data served as a starting point to determine the expected range of throughput scenarios that could be served by Angeles Link. These data and scenarios were in turn used

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1 2022 CARB Scoping Plan. Accessible at: https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2022-scoping-plan-documents

2 One metric tonnes is equal to approximately 1.10 US tons.

3 IEPR Update. Accessible at: 2022 Integrated Energy Policy Report Update (ca.gov) p. 105.

as a basis to various Phase 1 studies such as the GHG Emissions Evaluation and NOx and other Air Emissions Assessment.

Table 2 below, provides a comparison of demand projections by 2045 from various forecasts by agency or entity.

Table 2: Comparison of Demand Projection Near or by 2045			
Agency or Entity	**Demand Projections (Million Metric Tonnes)**	**Date Published**	**Area**
ARCHES	17[4]	October 2023	State of California
CARB 2022 Scoping Plan[5]	1.9[6]	December 2022	State of California
CEC 2023 Integrated Energy Policy Report	2.9[7]	February 2024	State of California
NREL H2@Scale[8]	22 – 41	October 2020	United States
UC Davis California Hydrogen Analysis Project Report [9]	2.5[10]	April 2023	State of California
U.S. Department of Energy (USDOE) National Clean Hydrogen Strategy and Roadmap 2023 (Roadmap)[11]	20 (2040)[12] 50 (2050)	June 2023	United States

4 Includes power generation, transportation (mobility), maritime, ports, and industry US DOE OCED, "California Regional H2Hub Community Briefing", slide 26. Accessible at: https://www.energy.gov/sites/default/files/2023-10/H2Hubs_California_Community_Briefing.pdf

5 2022 CARB Scoping Plan. Accessible at: https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2022-scoping-plan-documents

6 Internal conversion of 0.2315 exajoules to tonnes that includes commercial, industrial, oil & gas extraction, petroleum refining, residential, TCU (transportation communication and utilities) and transportation; excludes electric generation.

7 Includes the quantity of hydrogen reported used in transportation in 2040 and CEC staff's estimate of the amount of clean and renewable hydrogen required to replace fossil gas combusted for electricity generation in 2045 as reported in the CARB 2022 Scoping Plan Update. Accessible at: https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2023-integrated-energy-policy-report

8 Includes refineries, metals, ammonia, biofuel, synthetic HC (methanol), and light-duty and medium/heavy-duty FCEVs. Accessible at: https://www.nrel.gov/news/program/2020/study-shows-abundant-opportunities-for-hydrogen-in-a-future-integrated-energy-system.html

9 Fulton et al. UC Davis. 2023. Accessible at: https://escholarship.org/uc/item/27m7g841

10 Includes key industries of ports, bio-refining, turbine electricity generation, chemicals, cement, possibly fertilizer (ammonia), steel, and institutional buildings, with overall demand more than 50% in the transportation sector. Accessible at: https://escholarship.org/uc/item/27m7g841

11 USDOE 2023. Accessible at: https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf?sfvrsn=c425b44f_5

12 Includes power-to-liquid fuels, methanol, blending in natural gas for heat, energy storage/power sector, steel, biofuels, trucks, ammonia, refining and petrochemicals, and additional demands.

Table 2: Comparison of Demand Projection Near or by 2045			
Agency or Entity	**Demand Projections (Million Metric Tonnes)**	**Date Published**	**Area**
SoCalGas Demand Study	1.9 conservative 3.2 moderate 5.9 ambitious	January 2024	SoCalGas service territory

Many of the analyses that underpin the agency reports referenced in the comment letters were also initiated prior to or soon after significant clean hydrogen announcements, including the enactment of Senate Bill (SB) 1075 (Skinner) in September 2022 and U.S. DOE's selection of ARCHES for up to $1.2 billion in federal hydrogen hub funding in October 2023. For example, the SB 100 Joint Agency Report referenced in one of the comment letters was published in September 2021; one year prior to the enactment of SB 1075 and two years prior to ARCHES award announcement. The 2022 CARB Scoping Plan was initiated in June 2021 and approved in December 2022; three months after the enactment of SB 1075 and 10 months prior to the ARCHES announcement. The 2023 CEC IEPR uses the 2022 Scoping Plan as the basis for multiple hydrogen demand scenarios and was approved in February 2024. The 2023 IEPR also states: "The initial assessment presented in this IEPR is not a forecast of adoption based on economic or other factors, but instead reflects exploratory 'what if' scenarios" for hydrogen." The 2023 IEPR also cites ARCHES' funding selection and states: "To complement the strong momentum and alignment of state and federal opportunities and in response to direction in SB 1075, CARB, in consultation with CEC, CPUC, the California Workforce and Development Board, and other partner agencies, [we] will be developing a comprehensive analysis of hydrogen. This includes analyzing and making recommendations on the increased production, deployment, and use of low-carbon intensity hydrogen." The analysis is currently under development, with expected stakeholder engagement opportunities in late 2024.

For comparative purposes, SoCalGas assumes statewide demand figures could be split 50/50 between SoCalGas's service territory (in Central and Southern California) and the remaining part of California. This is likely a conservative estimate since SoCalGas's customer base of approximately 21 million customers is more than the majority of the approximate CA population of 39.5 million[13], and SoCalGas service territory also contains both the Port of Los Angeles and Port of Long Beach, which are considered to be some of the most active Ports in the nation.[14]

While there may be differences in the amount of hydrogen demand projected in all the referenced studies, there is consensus among agencies and researchers that projected demand exists in the power, mobility, and industrial sectors, that demand in those sectors is expected to grow over the next two decades, and that additional analysis is needed to better forecast what demand will be.

13 https://data.census.gov/profile/California?g=040XX00US06

14 Both ports together handle approximately 29% of all containerized international waterborne trade in the U.S. as documented in the Port of Los Angeles, FACTS AND FIGURES, available at: https://www.portoflosangeles.org/business/statistics/facts-and-figures.

Cost

To arrive at an initial, unconstrained estimate of total potential clean renewable demand in SoCalGas's service territory, the current or forecasted cost of clean renewable hydrogen from a commodity perspective was not factored into the Demand Study. Given the nation's efforts[15] to achieve commercial-scale hydrogen deployment and continued opportunities for federal funding, it is expected that a focus on regional networks will allow scaling and facilitate market liftoff for the hydrogen market.

While, the Demand and High-Level Economics and Cost Effectiveness Studies do not intend to address market driven commodity-based hydrogen price forecasts, SoCalGas is evaluating the levelized cost of delivered hydrogen (LCOH) [16] associated with potential configurations of Angeles Link in the Phase 1 High-Level Economics and Cost Effectiveness Study, and then comparing to other clean renewable hydrogen alternatives and non-hydrogen alternatives.

Analysis of price elasticity of hydrogen demand will be included in a future phase of Angeles Link planning. This analysis could include parameters of supply and demand as well as the impact of various measures such as current federal and state efforts on the hydrogen market is better understood. Such efforts include significant and ongoing measures such as the U.S. DOE Hydrogen Hubs and demand side incentives, the 45V Tax Credit, and California's Low Carbon Fuel Standard (LCFS), which aim to spur capital investments that can enable the hydrogen market to mature and result in further cost reductions.

2.2 Global Response 2 – Stakeholder Engagement Process

PAG and CBOSG members stated in comment letters that SoCalGas has not been transparent with information, has provided too much information which can make it difficult for members to review and comment on materials, is moving too fast with Phase 1, and has not had adequate tribal representation in its PAG and CBOSG.

SoCalGas has been transparent and inclusive in the development of its Angeles Link feasibility studies. To date, SoCalGas has collectively held 22 meetings and workshops and 16 1x1 meetings with the PAG and CBOSG. The purpose in forming a PAG and CBOSG was to engage stakeholders through a transparent and inclusive process to solicit input in the development of Angeles Link early and at each step in the feasibility study process. SoCalGas identified four milestones in Phase One to allow meaningful opportunities for PAG and CBOSG input: (1) the Scope of Work description for the studies, (2) the Technical Approach for the studies, (3) Preliminary Findings and Data, and (4) the Draft Reports. To SoCalGas's knowledge, it is unprecedented for California investor-owned utilities to create diverse stakeholder advisory groups such as the PAG and CBOSG to provide technical input and other feedback into a project's feasibility and design at this early stage of the process.

SoCalGas understands it has shared a lot of information with its PAG and CBOSG members. We have done so to be transparent and inclusive. In order to make information more accessible and easier to comment for the PAG and CBOSG, SoCalGas has presented Preliminary Data and Findings in a new format. SoCalGas will continue to make all available information accessible to members in its Living Library.

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[15] https://www.energy.gov/articles/biden-harris-administration-releases-first-ever-national-clean-hydrogen-strategy-and

[16] SoCalGas is using the levelized cost of energy framework (which considers asset related costs across the hydrogen value chain over its lifetime).

SoCalGas understands it has held several meetings with the PAG and CBOSG and that some may feel the process could be moving quickly. SoCalGas stated in its Angeles Link application that its Phase 1 process would be completed in 12-18 months and is working diligently to provide its deliverables on time and within budget. SoCalGas has met with its PAG and CBOSG once a quarter and added supplemental workshops in response to PAG and CBOSG feedback. SoCalGas will continue to work with its PAG and CBOSG to determine the appropriate meeting cadence and identify better ways for members to provide feedback on studies and process.

SoCalGas has three members of its CBOSG who represent tribal communities. In response to PAG and CBOSG feedback, SoCalGas has also reached out to other organizations who represent tribal communities in Los Angeles and the Central Valley and will extend opportunities for them to join the PAG and/or CBOSG in Phase 1 or subsequent phases of the project. SoCalGas is preparing an Environmental Analysis study that evaluates cultural and tribal cultural resources based on a records search and desktop information. During future phases, SoCalGas will also perform a detailed cultural and tribal cultural resources assessment, including field surveys, to identify locations of sensitivity along the preferred pipeline routes.

2.3 Global Response 3 – Potential Indirect GHG Emissions from Water

Some commenters expressed concern about the potential for indirect greenhouse gas (GHG) emissions from the conveyance and treatment of water to supply third-party clean renewable hydrogen producers. The Water Resources Evaluation evaluates potential water supply sources third-party clean renewable hydrogen producers may pursue and evaluates water quality treatment processes that may be required for those identified sources to meet production needs. However, the study does not speculate on which particular water sources may supply specific third-party production projects. More information on the water supply sources that may feed specific clean renewably hydrogen projects may be available and evaluated on a case-by-case basis as more details on specific clean renewable hydrogen projects are developed. Analysis of the potential GHG emissions associated with water conveyance and treatment for hydrogen production was outside of the scope of the Phase 1 Water Resources Evaluation. In response to stakeholders expressing concern about potential GHG emissions related to water supply development, the study was expanded to include a high-level, qualitative consideration of potential indirect emissions from water conveyance and treatment. This qualitative analysis is in progress and will be provided to the PAG/CBOSG upon completion of the draft Water Resources Evaluation.

2.4 Global Response 4 – Leakage Estimates and Climate Change Impacts

Multiple stakeholders noted the absence of volumetric leakage estimates in the Leakage Preliminary Data & Findings document and the absence of potential impacts from leakage to climate change in the Greenhouse Gas Preliminary Data & Findings document. In response to these stakeholder concerns, the draft Leakage Assessment will include a preliminary high-level range of estimates of the potential for leakage associated with Angeles Link infrastructure as well as leakage associated with third-party producers and storage. This range of volumetric estimates was prepared using the median and mean leakage values found in the literature and summarized in Table 2 of the Leakage Preliminary Data & Findings documents. The median and mean values were applied to the low, medium, and high Angeles Link throughput scenarios to derive the volumetric estimates. The draft GHG report takes this range of estimates to the next step by applying the lowest and highest of the range of estimated global warming potential (GWP) 20 and GWP 100 values for hydrogen found in the literature as identified in Table 17 of the GHG Preliminary Data & Findings document. The resulting effective GHG values are then compared to the overall GHG emission reductions provided in the Draft GHG Study Report to determine the anticipated lower and upper bound impacts to the projected GHG reductions associated with the potential for leakage The draft Leakage study report was issued in May 2024.

2.5 Global Response 5 – Water Availability, Local Community Impacts and Affordability

Some stakeholders expressed concerns related to water supply/availability and potential local community impacts associated with water supply for clean renewable hydrogen production. Commenters also expressed concerns about affordability associated with water supply for production.

Water Availability

Water supply management throughout California is conducted on state, regional, and local levels, with the availability of water sources varying by location, climatic conditions, and existing and anticipated demands. Agencies must manage their respective supply sources throughout seasonal and annual fluctuations to accommodate existing demands and obligations in key sectors including municipal and industrial ("M&I" or "urban"), agricultural, and environmental sectors. Regulatory requirements are in place for agencies to manage water resources sustainably. For example, local water agencies plan for and provide the amount of water they anticipate being needed within their respective service areas based upon population growth projections, land use planning and zoning, and project proposals submitted to the local land use agency. Water supply providers with 3,000 or more service connections or delivering 3,000 acre-feet per year (AFY) of water are required to prepare Urban Water Management Plans (UWMPs), which are updated every five years and evaluate potential supply and demand projections. In less populated areas where UWMPs do not exist, other sustainable supply management mechanisms are implemented. For instance, the Sustainable Groundwater Management Act (SGMA) applies to all groundwater basins in the state and requires local entities to manage groundwater basin(s) within their jurisdiction in such a manner that the entire basin is in a sustainable (balanced) condition by 2042. Third-party clean renewable hydrogen producers would pursue water supplies managed according to all applicable regulatory requirements in place to balance California's water supplies and demands.

The Water Resources Evaluation will evaluate water availability for clean renewable hydrogen production by identifying potential water sources third party producers may pursue, including water supply sources that would not compete with the needs of other water users. The study also will quantify the water needed to produce certain volumes of clean renewable hydrogen. The study will provide a number of water supply sources for third-party clean renewable hydrogen producers to produce clean renewable hydrogen to meet the overall SoCalGas service territory projected demand and the portion of that demand that would be transported or served by Angeles Link. As noted in the Preliminary Findings for the Water Resources Evaluation, the volume of water needed for third-party producers to produce clean renewable hydrogen to meet the portion of the projected demand that Angeles Link would transport comprises less than one percent of the total amount of water used per year in California.

Potential for Local Community Impacts to Water Supply

It is anticipated that third party clean renewable production projects would undergo thorough environmental review, including a review of potential impacts associated with water supply development, pursuant to the California Environmental Quality Act (CEQA) and/or the National Environmental Policy Act (NEPA), as applicable, at the time such projects are proposed. As a component of the CEQA/NEPA analysis, local community impacts would be evaluated through several resource areas, including but not limited to, hydrology and water quality, land use and planning, and biological resources (including creeks, waterways and wetlands).

Affordability

SoCalGas understands concerns around affordability related to water needed by third-party producers of clean renewable hydrogen. Water rates in California are set by public processes and are based on a variety of factors. Ultimately, third-party clean hydrogen producers will select the water sources that may supply specific production projects, and that selection may inform future rate setting of a local water agency.

3 Stakeholder Comment Letters

3.1 Comment Letter 1 – Environmental Defense Fund (EDF) and Natural Resources Defense Council (NRDC)

Comment Letter 1 - Draft Report (Demand)

Environmental Defense Fund

NRDC

February 23, 2024

Chester Britt
Planning Advisory Group Facilitator

Emily Grant
Angeles Link Senior Public Affairs Representative
Southern California Gas Company

Alisa Lykens
Director
Insignia Environmental

__Subject:__ Environmental Defense Fund and Natural Resources Defense Council Comments on the Demand Study Draft Report

As a follow-up to the demand study draft report shared on January 17, Environmental Defense Fund (EDF) and the Natural Resources Defense Council (NRDC) provides the following comments and feedback.

First, EDF and NRDC find the projected demand figures as provided in the demand study draft report to be **incredibly high**, even compared to ambitious projections from various other sources. For example, the "conservative" demand scenario from the draft report projects 1.9 million tons of hydrogen demand per year by 2045 in Southern California Gas (SoCalGas) territory alone; the figures range as high as 5.9 million tons in the "ambitious" scenario. In comparison, the California Air Resources Board's (CARB) 2022 update to Scoping Plan projects 1.93 million tons of hydrogen supply for the *entire state of California* per year by 2045.[1] In fact,

Comment 1-1

[1] CARB, "Hydrogen Supply", *AB 32 GHG Inventory Sectors Modeling Data Spreadsheet – 2022 Scoping Plan*. Accessible at: https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2022-scoping-plan-documents; and CARB, "Final Energy Demand", *California PATHWAYS Model – 2017 Scoping Plan*. Accessible at https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2017-scoping-plan-documents. Hydrogen amounts calculated using energy content value of 120MJ/kg.

using the same numbers from the 2022 Scoping Plan update, the ambitious demand scenario as laid out in the draft report would result in almost 24% of state-wide energy demand being met through hydrogen demand just in SoCalGas territory.[2] EDF and NRDC believe that, compared to these existing state energy and hydrogen supply scenarios, the results of the demand study are unrealistically high. As such, EDF and NRDC respectfully requests SoCalGas' response to the following questions:

1. Did SoCalGas and the consultants supporting the drafting of the report consider existing scenarios for hydrogen demand in California (in particular, those published by state agencies) as a part of the demand study process? If so, which scenarios were considered? **Comment 1-1**
2. If the scenarios were considered, can SoCalGas and the consultants supporting the drafting of the report provide a detailed justification for why the highly ambitious figures included in the demand study draft report diverge so significantly with certain existing scenarios (specifically, CARB Scoping Plan Projections)?
   a. If the scenarios were not considered, can SoCalGas and the consultants supporting the drafting of the report provide a detailed justification of why they were not considered?

EDF and NRDC believe a detailed explanation of the demand study process would add credibility to the study's findings; and would allow the Public Advisory Group to better engage with SoCalGas on constructive discussions regarding Angeles Link. We also recommend that the demand study draft report be amended to include a section on the comparative analysis of the draft report demand scenarios and other existing hydrogen demand scenarios for California.

Second, EDF and NRDC note that the current draft report **<u>does not take hydrogen costs into account</u>**, which would no doubt be extremely significant in determining actual future hydrogen demand. Given various on-going policy and economic developments—including the 45V Federal Production Tax Credit—eventual cost of hydrogen is as of now uncertain. However, we believe it would be possible and prudent for SoCalGas to incorporate a potential range of hydrogen costs (*e.g.*, low-, mid-, and high-cost scenarios) into the demand study that can be further adjusted as hydrogen costs are fully determined in the future. This would provide **Comment 1-2**

[2] CARB, "Final Energy Demand".

stakeholders with a reasonable scope of hydrogen demand figures through which PAG members can provide feedback and comments for SoCalGas. The purpose of the current Phase 1 of the Angeles Link Project is to understand how the potential project may end up benefiting SoCalGas ratepayers and at what cost to them. The cost of hydrogen is a key factor in that determination—and must be incorporated into the demand study final report. **Comment 1-2**

Third, the demand study must focus on the **portion of hydrogen demand that can be expected to be served by the Angeles Link pipeline**, particularly in the mobility sector. Again, the purpose of the Phase 1 studies is to gain a better understanding of the requirements and justification for the Angeles Link pipeline. Any demand study conducted as part of these studies, then, should focus specifically on hydrogen demand most efficiently served by the Angeles Link project. While hydrogen demand across the entire SoCalGas territory can serve as important context, it is not the main focus of the Phase 1 studies. The draft report alludes to this key distinction; for example, on page 16, the report identifies "geographic demand analysis with a focus on mobility to better understand at a granular level how demand will be distributed across SoCalGas' service territory". Mobility is assumed to be a significant part of overall demand projections—ranging as high as 53% of total demand in the "conservative" scenario. It is highly likely that some level of "last-mile" delivery will be required to transport hydrogen to the various hydrogen charging stations that are geographically removed from the Angeles Link delivery point. In such cases, it is important to distinguish between hydrogen demand potentially best served by the Angeles Link project and that best served by other forms of hydrogen supply (e.g., trailer/tanker transport from production sources or on-site production) given the "last-mile" delivery requirements. **Comment 1-3**

EDF and NRDC recommend the demand study be revised to explicitly distinguish *overall* hydrogen demand (broken down by sector) and portions of demand (broken down by sector) *best served* by a potential Angeles Link project under SoCalGas demand projections. Doing so will be line with the requirements for the Phase 1 studies. **Comment 1-4**

Response to Comment 1-1, 1-2, 1-3 and 1-4: Please see Global Response 1.

3.2 Comment Letter 2 – Public Advocates Office (CalPA)

Comment Letter 2 - Draft Report (Demand)

The Public ADVOCATES OFFICE

February 23, 2024

Informal Comments of the Public Advocates Office on
Southern California Gas Company's Draft Angeles Link Demand Report

The Public Advocates Office at the California Public Utilities Commission (Cal Advocates) provides these comments on Southern California Gas Company's (SoCalGas) draft *Angeles Link Demand Report* (Report) issued in January 2024.

As a general matter, the Report does not actually project or forecast demand, and is not a demand study. Instead, by SoCalGas's own description, it assesses "total potential demand."[1] Such an assessment is more analogous to a policy paper than a demand study, and Cal Advocates is not clear how this information functions as a feasibility study meant to identify the demand and end uses of the project.[2]

The Report devotes significant time identifying federal and state laws, regulations, programs, and funding initiatives (collectively, legislation) that aim to promote sustainable energy, including renewable hydrogen. The Report employs the legislation to promote SoCalGas's suggestion of key areas where further legislative action may facilitate renewable hydrogen's integration into California's energy portfolio. For example, the Report acknowledges that, for renewable hydrogen to help satisfy California's policy objective of achieving 100% retails sales from renewables and zero-carbon electricity by 2045, as SoCalGas claims it can do, additional laws are required because "the combustion of hydrogen in not [Renewable Portfolio Standard (RPS)] compliance nor is zero-carbon resources defined to include hydrogen."[3]

The legislative discussion, however, is very similar to the policy justification SoCalGas made in its Application (A.) 22-02-007 proceeding pleadings. We are past that point. While specific legislation will inform the types of decisions regulations, businesses, and consumers may make, we expected to see surveys conducted by SoCalGas that gathered demand information from real participants in the three sectors identified in the Report. We also expected to see interview summaries with actors that will drive demand, such as

Comment 2-1

[1] Report at 4.

[2] Decision (D.) 22-12-055, Ordering Paragraph 6(a) at 76.

[3] Report at 19, internal citation omitted.

The Public Advocates Office
California Public Utilities Commission
505 Van Ness Avenue, San Francisco, CA 94102-3298
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industrial customers. However, new information derived from independent fact finding and research is absent from the Report.

Instead, it appears that the Report relies heavily on publicly available information and studies conducted by federal and state agencies, and other institutions. We expected the function of this instant demand analysis exercise was to specifically identify the end-users for renewable hydrogen and forecast renewable hydrogen demand specific to SoCalGas' service territory. Yet, most of the information provided in the Report is already known. Further, as described below, the demand forecast that the Report does present relies on unreasonable assumptions and is unrealistic when compared to the California Energy Commission's (CEC) renewable hydrogen demand analysis.

Comment 2-1

Unrealistic Renewable Hydrogen Price Assumptions

The Report suffers from unrealistic simplifying assumptions used to forecast renewable hydrogen demand in SoCalGas' service territory. The simplifying assumptions are: (1) Price of Hydrogen; (2) Power System Reliability & Capacity Factors; and (3) Readily Available Hydrogen.[4] For the purposes of providing a more realistic projection of renewable hydrogen demand in SoCalGas' service territory, the decision to forgo an attempt to forecast renewable hydrogen prices and costs trajectories raises serious questions about the Report's accuracy or usefulness.

Comment 2-2

The law of demand generally states that as the price for a good increases, the demand for the good decreases. This economic principle cannot be ignored when forecasting the demand of a particular good, especially when that good is vying for market share in a competitive market that houses equivalent and less costly goods. Here, the Report acknowledges that renewable hydrogen is in direct competition with other low-carbon alternatives; namely, electric (either direct electrification or battery), synthetic fuels (such as renewable diesel), and carbon capture, utilization and storage (CCUS).[5] Yet, the Report does not attempt to estimate renewable hydrogen costs for the three demand scenarios it identifies. Nor does it forecast renewable hydrogen costs over time and compare a hydrogen cost trajectory with competing low-carbon alternatives.

Instead, the Report either omits the renewable hydrogen prices or assumes that the price of renewable hydrogen is equivalent to the price of natural gas. But the cost of renewable hydrogen is a key barrier that can't be overlooked, as acknowledged in A.22-02-007. There, parties provided evidence that renewable hydrogen

[4] Report at 15.

[5] Report at 15.

2

costs are currently prohibitive at scale and serve as a barrier to wider adoption.[6,7] The CEC recognizes the cost barrier, having informed the Commission that "[o]ne challenge is the cost of methods for [renewable] hydrogen is several times the cost of the fossil fuel-based systems. New innovations are needed in the conversion process and used to generate [renewable] hydrogen so equipment costs and conversion costs can be lowered substantially."[8] The CEC's proposed Final 2023 Integrated Energy Policy Report (IEPR) repeatedly identifies renewable hydrogen costs as a barrier.[9]

Because current information suggests that renewable hydrogen is expensive, it is important that reasonable cost estimates are included in the demand forecast calculations. Since there is a natural relationship between prices and demand, and renewable hydrogen will compete against other fuels and technologies in the marketplace, renewable hydrogen prices are integral components of consumer demand. Omitting or using unrealistic prices delivers unreliable demand projections.

Comment 2-2

<u>CEC's proposed Final 2023 IEPR</u>

The Report's demand analysis appears unrealistic when compared to the preliminary analysis of using clean and renewable hydrogen identified in the CEC's proposed Final 2023 IEPR. The Report presents three demand modeling scenarios over the 2025-2045 period in SoCalGas' service territory.[10] The three demand modeling scenarios are: (1) conservative; (2) moderate, and (3) ambitious. The Report's modeling results indicated "1.9 Million (M) tonnes per year (TPY) of hydrogen by 2045 in its conservative scenario, 3.2M TPY in the moderate scenario, and 5.9M TPY in the ambitious scenario."[11] The three demand modeling scenarios focus on demand for renewable hydrogen in the mobility, power generation, and industrial sectors.[12] In most cases, the Report's scenarios project more hydrogen demand for the power generation and mobility sectors in

Comment 2-3

[6] See, The Protect Our Communities Foundation Opening Brief, filed July 29, 2022; in A.22-02-007; and The Public Advocates Office's Protest of the Application of Southern California Gas Company for Authority to Establish a Memorandum Account for the Angeles Link Account (Cal Advocates Protest) at 4, filed March 21, 2022; in A.22-02-007.

[7] In its proposed Final 2023 EIPR, the CEC states "[w]hile the [CARB] 2022 Scoping Plan Update includes 9 GW capacity of hydrogen-based electricity generation, these power plants are never dispatched because of cost; therefore, no hydrogen is used in the electric sector." (See, CEC proposed Final 2023 IEPR at 78).

[8] See, Cal Advocates Protest at 4. See also, Application of the California Energy Commission for Approval of Electric Program Investment Charge Proposed 2021-2025 Investment Plan, Attachment 1 at A-45, filed November 21, 2021; in A.21-11-021.

[9] CEC proposed Final 2023 IEPR at 80, 83, and 86-89.

[10] Report at 4-5.

[11] Report at 4.

[12] Report at 4-5.

SoCalGas' service territory than the demand the CEC projects for those respective sectors in the entire state of California.

Power Generation Sector

With respect to the power generation sector, the Report provides the total expected renewable hydrogen demand in the power sector for the three scenarios.

Table 1[13]

Total Expected Clean Renewable Hydrogen Demand in the Power Sector in 2045

Conservative	Moderate	Ambitious
0.7M TPY	1.6M TPY	2.7 TPY

Comment 2-3

In the proposed Final 2023 IEPR, the CEC conducted a preliminary analysis of using clean and renewable hydrogen in electric power generation.[14] The CEC examined two scenarios: (1) the first scenario builds from the California Air Resources Board (CARB) 2022 Scoping Plan Update; and (2) the CEC developed a second scenario of growth of clean renewable hydrogen in the electricity sector based on a report developed for the CEC by the University of California at Irvine (UCI).[15] For both scenarios, the CEC's analysis identified renewable hydrogen consumed in 2045 for the state of California.

Table 2[16]

Scenarios of Clean and Renewable Hydrogen in the Electric Sector in 2045

Scenario Factors	2022 CARB Scoping Plan Update	UCI Study
Hydrogen consumed in 2045	1,883,960M TPY	350,000M TPY

[13] Report, Figure 16 at 52.

[14] The CEC stated that "[f]or this initial analysis of adoption of hydrogen in the electricity sector, staff did not conduct new capacity expansion modeling and instead developed two scenarios from previous analyses focused on California." See, CEC proposed Final 2023 IEPR at 78.

[15] CEC proposed Final 2023 IEPR at 78.

[16] CEC proposed Final 2023 IEPR, Table 3 at 80.

4

In the first scenario, the CEC's proposed Final 2023 IEPR analysis shows that the CEC's hydrogen consumption forecast in the electric sector for the entire state of California is approximately 1.9M TPY per year in 2045. In contrast, the Report's moderate scenario for the power generation sector projects a near equivalent demand for renewable hydrogen (1.6 M TPY) just in SoCalGas' service territory in 2045. When comparing the Reports' ambitious scenario to the CEC's first scenario, the Report indicates that SoCalGas' service territory's demand for renewable hydrogen will exceed the CEC's hydrogen consumption forecast for the entire state in 2045 by approximately 0.8M TPY.

With respect to the second scenario, the CEC's proposed Final 2023 IEPR analysis forecasts California to consume approximately 350,000M TPY in 2045. The CEC's estimate for California generally in 2045 is approximately 0.35M TPY less than the Report's conservative forecasted demand for SoCalGas' service territory.

Comment 2-3

Mobility Sector

With respect to the mobility sector, the Report provides the total expected renewable hydrogen demand in the mobility sector for three scenarios.

Table 3

Total Expected Mobility Sector Clean Renewable Hydrogen Demand in 2045[17]

Conservative	Moderate	Ambitious
1.0M TPY	1.2M TPY	1.7 TPY

In the proposed Final 2023 IEPR, the CEC conducted a preliminary scenarios of using for using hydrogen in the transportation (mobility) sector.[18] The CEC examined two scenarios: (1) the first scenario uses the CARB 2022 Scoping Plan Update; and (2) the CEC staff developed a second scenario of potential adoption of hydrogen in the transportation sector using the modeling tools used in the CEC's transportation energy

[17] Report, Figure 10 at 23.

[18] CEC proposed Final 2023 IEPR at 84-88.

demand forecast, with several modifications.[19] For both scenarios, the CEC's analysis identified transportation (mobility) hydrogen demand in 2040 for the entire state of California.

Table 4

Scenarios of Clean and Renewable Hydrogen in the Transportation Sector in 2040[20]

Scenario Factors	2022 CARB Scoping Plan Update	Modified AATE 3
Hydrogen consumed in 2040	971,049M TPY	307,771M TPY

Comment 2-3

The Report's scenarios and the CEC's proposed Final 2023 IEPR scenarios focus on two separate demand years. The Report analyzed demand through 2045, whereas the CEC's proposed Final 2023 IEPR focused on demand through 2040.

In the first scenario, the CEC's proposed Final 2023 IEPR analysis shows that the CEC's hydrogen consumption forecast in the transportation (mobility) sector for the entire state of California is approximately 0.97M TPY per year in 2040. The Report's conservative scenario for the mobility sector projects approximately 0.6M TPY of renewable hydrogen just in SoCalGas' service territory in 2040.[21] When comparing the Reports' moderate and ambitious scenarios to the CEC's first scenario, the Report indicates that SoCalGas' service territory's demand for renewable hydrogen is approximately 1.0M TPY and 1.2M TPY respectively in 2040.[22]

With respect to the second scenario, the CEC's proposed Final 2023 IEPR analysis shows that it forecasts California to consume approximately 307,771M TPY in 2040. The CEC's estimate for the entire state of California in 2040 is approximately 0.3M TPY less than the Report's conservative forecasted demand in SoCalGas' service territory.

Factually Inaccurate Information

Comment 2-4

The Report errs in its summary and characterization of key legislation. For example, it states "SB 100 and SB 1020 are key pieces of legislation driving power-sector decarbonization in California. The legislation accelerates the state's Renewables Portfolio Standard (RPS) program to 90% by 2035 with 100% renewables

[19] CEC proposed Final 2023 IEPR at 84.

[20] CEC proposed Final 2023 IEPR, Table 4 at 85.

[21] Report, Figure 10 at 23.

[22] Report, Figure 10 at 23.

and zero-carbon electricity by 2045."[23] Neither SB 100 nor SB 1020 accelerates the RPS target to 90% by 2035. Instead, SB 100 increased the state's RPS target from 50% to 60% retail sales from renewable resources by 2030. It also established a state policy goal of achieving 100% retail sale from renewable resources and zero-carbon resources by 2045. In other words, SB 100 revised the RPS target upwards and established a more ambitious 100% target that is the subject of the Integrated Resources Plan (IRP) proceeding. SB 1020 subsequently revised existing state "IRP" policy to "provide that eligible renewable energy resources and zero-carbon resources supply 90% of all retail sales of electricity to California end-use customers by December 31, 2035. . ."[24] Thus, SB 1020 established gradual compliance targets for the state to achieve 100% retails sales from renewables and zero-carbon electricity by 2045. It appears that the Report conflates the RPS target with the state's larger policy target that is being considered in the Commission's IRP proceeding.

Such basic inaccuracies are concerning because the statute is fixed and should be easy to accurately depict. It raises the question of whether there are other basic factual errors. SoCalGas should ensure that its Report accurately captures the relevant facts.

Comment 2-4

[23] Report at 19.

[24] SB 1020 (Chapter 361, Statutes of 2022) (emphasis added) available at: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB1020

Response to Comment 2-1: The Demand Study projects potential clean renewable hydrogen demand in SoCalGas's service territory. A large driver of the estimated hydrogen demand is based on analysis of public policies that set future decarbonization goals motivating sectors to adopt zero emission solutions. SoCalGas does not propose public policies as part of its Demand Study. Considering public reports and data was an important aspect to developing the Demand Study, and while publicly available data was used, additional assumptions and analyses were conducted beyond that in order to estimate potential hydrogen adoption rates. In addition, to inform our demand assessment, interviews were held with organizations and companies from various sectors, who could be end users supported by Angeles Link. The list of organizations that participated in these interviews can be found in the Demand Draft Report. SoCalGas agrees that decarbonization goals are widely known and easily accessible, however the pathways to get there are what are sometimes more diverse and debatable. SoCalGas acknowledges this and developed a hydrogen estimate using reasonable assumptions and methodologies while considering other publicly available studies during the process.

Please also see Global Response 1.

Response to Comment 2-2 and 2-3: Please see Global Response 1.

The 2022 Carb Scoping Plan Update estimates 1.9 tonnes per year (TPY) for the power generation sector. If 50% is allocated to SoCalGas, this would equal 950K TPY, which is higher than the Demand Study's conservative scenario of 705K TPY in 2045.

For the transportation sector, the CARB Scoping Plan Update estimates 1 million TPY in 2045. If 50% is allocated to SoCalGas, this would equal 500K TPY, which is within a reasonable range of SoCalGas's 2040 estimate of 623K TPY.

Response to Comment 2-4: SoCalGas acknowledges Cal Advocates' comment and will refine the language to further clarify the intended point which is that California's legislation, specifically SB 100 and SB 1020, is driving decarbonization in the Power Generation sector in California.

3.3 Comment Letter 3 – The Utility Consumers' Action Network (UCAN)

Comment Letter 3 - Draft Report (Demand)

UCAN
UTILITY CONSUMERS' ACTION NETWORK
San Diego's Utility Watchdog

The Utility Consumers' Action Network
(Angeles Link PAG Member)

Feedback for SoCalGas Regarding
Angeles Link Demand Report Draft

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UCAN – 1

I. Feedback Summary

- SoCalGas' "conservative" demand forecast over-estimates clean hydrogen demand by more than a factor of ten. SoCalGas should revise its forecast based on reliable third-party data and modeling.[1] Comment 3-1
- SoCalGas' exclusion of hydrogen pricing invalidates the demand study results. SoCalGas should update the study to include the impact of hydrogen prices on hydrogen demand.[2] Comment 3-2
- SoCalGas's hydrogen demand forecast conflicts with forecasts by several California Agencies. SoCalGas should use power system modeling results reported by the CPUC, CEC, and CARB that find the power sector will have zero clean hydrogen demand through 2045.[3] Comment 3-3
- SoCalGas used the Argon National Laboratory's TechScape model to help evaluate mobility sector demand. However, prior to using TechScape, SoCalGas changed several of the model's most important inputs including hydrogen fuel costs, fuel cell costs, hydrogen storage costs, and battery costs. Those changes invalidate SoCalGas' mobility sector outputs. SoCalGas should use ANL's published TechScape results to inform its mobility modeling.[4] Comment 3-4
- SoCalGas bases its hydrogen demand claims on its opinions about self-selected "adoption factors" instead of reliable third-party research. SoCalGas should establish a demand forecast using unbiased third-party research.[5] Comment 3-5

II. Background

Comment 3-6

- On August 29, 2023, SoCalGas hosted a Planning Advisory Group (PAG) meeting that included a presentation on the Demand Study Analysis Technical Approach and Preliminary Outputs.
- On September 7, 2023, SoCalGas met with UCAN and Cal Advocates regarding SoCalGas' demand study research.
- On September 18, 2023, SoCalGas provided 10 slides by email. The data on the slides were mostly unresponsive to UCAN and Cal Advocate's requests during the September 7th meeting.
- On September 19, 2023, UCAN emailed SoCalGas its unanswered questions on the preliminary demand study.
- On September 25, 2023, UCAN submitted feedback to SoCalGas on the preliminary demand study without having received any response from SoCalGas to its questions. UCAN noted that SoCalGas' preliminary demand forecast appeared to be at least 10 times too high.
- On September 29, 2023, SoCalGas provided 13 slides by email responding to UCAN's written questions.

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[1] *Infra*, see Section IX.
[2] *Infra*, see footnote 23 and 31.
[3] *Infra*, see Section IV (A, B, and C).
[4] *Infra*, see Section VI.
[5] *Infra*, see Section VI.

- On October 21, 2023, UCAN submitted feedback to SoCalGas that noted SoCalGas' demand projections were at least 10 times higher than demonstrated by available data.
- On December 15, 2023, SoCalGas hosted a PAG meeting which included a presentation on the Demand Study Draft Report.
- On January 17, 2024, SoCalGas made the Draft Demand Study available to the PAG and requested feedback on the draft.[6] UCAN submits the following feedback.

Comment 3-6

III. SoCalGas' Draft Document fails to meet the demand study requirements of D.22-12-055 and investigates hydrogen demand beyond the scope of the decision's authorization.

SoCalGas' Draft Demand Study ("Draft Document") exceeds the scope of research authorized by D.22-12-055 by researching hydrogen demand outside of the LA Basin.

D.22-12-055 states that "[t]he objective of the Angeles Link Project is to develop a clean renewable hydrogen energy transport system to serve the Los Angeles Basin."[7] The Commission ordered SoCalGas to complete "[i]dentification of the demand and end uses for the Angeles Link Project (Project)."

In violation of the decision, the Draft Document repeatedly reports hydrogen demand assertions for the SoCalGas service territory instead of the LA Basin,[8] and states that it will refuse to complete a LA Basin specific analysis until after Phase 1.[9] The Commission stated a Phase 2 application must include the required findings from Phase 1.[10] Thus, the Draft Document states SoCalGas' intent to violate D.22-12-055. SoCalGas should revise the Draft Document to avoid violations of the Commission's orders in D.22-12-055.

Comment 3-7

[6] SoCalGas, Angeles Link Demand Report Draft (January 2024) ("Draft Document"), [distributed to PAG members by email link on January 17, 2024).

[7] D.22-12-055, available at https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M500/K167/500167327.PDF.

[8] Draft Document, p. 3, 4, 5, 9, 16, 17, 19, 20, 21, 29, 32, 34, 38, 40, 42, 43, 44, 47, 50, 52, 56, 58, 60, 64, and 68.

[9] Draft Document, p. 16, (SoCalGas states that assessment for "future phases of Angeles Link include... [g]eographic demand analysis with a focus on mobility to better understand at a granular level how demand will be distributed across SoCalGas' service territory.").

[10] D.22-12-055, pp. 75-76, Ordering Paragraph ("OP") 6.

IV. Power Sector: SoCalGas' Draft Document cites three studies from California agencies that have found zero hydrogen use in the power sector through 2045, but SoCalGas misrepresents or ignores those findings.

SoCalGas makes numerous false claims about power sector hydrogen demand. The Draft Document should be corrected to align with power sector modeling findings by California Agencies. The California Public Utilities Commission ("CPUC" or "Commission"), the California Air Resources Board ("CARB") and the California Energy Commission ("CEC") have each reviewed the optimal mix of clean energy resources needed to meet the 2045 statutory requirement for the power sector. Each of these California agencies have completed modeling that determines a cost-effective resource mix does not include hydrogen between now and 2045.

In contrast, SoCalGas claims that by 2045 the power sector will use between 0.7 and 2.7 million tons per year ("MTPY") of hydrogen.[11] SoCalGas should revise its Draft Document to align with the studies completed by the California agencies, studies that SoCalGas cites in the Draft Document.

A. The SB 100 Report finds zero hydrogen use in the power sector through 2045 in scenarios that meet statutory requirements.

The Senate Bill ("SB") 100 Report states that the 2045 target set by SB 100 will require no hydrogen use in its least-cost scenario.[12] The SB 100 Report was completed by the CEC, CPUC, and CARB. The Draft Document cites the SB 100 study but ignores the SB 100 findings.[13]

Comment 3-8

[11] Draft Document, Figure 4, p. 7.
[12] California Energy Commission. "SB 100 Joint Agency Report". (September 3, 2021), p. 6 and Figure 3, p. 10, ("The "core scenarios," shown Table 1, modeled for the 2021 Report are consistent with the joint agencies' interpretation of the statute and include only commercialized technologies with publicly available cost and performance data.") available at https://www.energy.ca.gov/publications/2021/2021-sb-100-joint-agency-report-achieving-100-percent-clean-electricity.
[13] Draft Document, p. 42.

B. The CPUC's 2023 IRP modeling finds zero hydrogen use in the power sector through 2045 in scenarios that meet statutory requirements.

The CPUC completed power system modeling in its Integrated Resource Plan ("IRP") proceeding. The modeling completed and adopted in the February 22, 2024, decision, D.24-02-047, found that the energy resource mix would include zero hydrogen-fueled generation or storage between now and 2045.[14] The modeling was completed by the CPUC's Energy Division and its consultant Energy and Environmental Economics ("E3").

The Draft Document cites the IRP proceeding and claims that "if hydrogen was included in the CPUC's Integrated Resource Plan and was eligible for SB100, that could increase hydrogen demand."[15] That Draft Document statement is false. The IRP modeling team did consider hydrogen and determined that hydrogen technologies are one of several technologies that "are nascent… [and] uncertain if they can reach maturity and hit the longevity, cost, and efficiency targets projected by industry. Thus, for the foreseeable future these resources are likely only to be considered in sensitivity-type analysis in IRP, and not for core portfolios."[16]

The IRP modeling team includes power sector technologies in its core modeling that are commercially available.[17] The Draft Document should not make assumptions about hydrogen demand in the power sector that conflict with the CPUC's findings.

Comment 3-8

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[14] CPUC, Proceeding R.20-05-003, 2023 Preferred System Plan Proposed Decision, p. 14 ("Planned & Selected Capacity, Long-Term (GW)"), available at https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2023-irp-cycle-events-and-materials/2024-01-12-presentation-summarizing-updated-serwm-and-resolve-analysis.pdf.
[15] Draft Document, p. 19.
[16] CPUC, Inputs & Assumptions 2022 – 2023 Integrated Resource Planning (October 2023) ("IRP I&A"), pp. 97-98, available at https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2023-irp-cycle-events-and-materials/inputs-assumptions-2022-2023_final_document_10052023.pdf.
[17] IRP I&A, p. 52.

C. CARB's 2022 Scoping Plan finds zero hydrogen use in the power sector through 2045.

CARB's scoping plan assumes zero hydrogen use in the power sector between now and 2045. In contrast, the Draft Document falsely claims that "CARB has projected in their 2022 Scoping Plan that hydrogen will play a larger role in serving future load growth and be part of the resource mix that helps California meet its SB100 retail sales target."[18] In support of its claim, the Draft Document cites Figure 4-5 of the 2022 Scoping Plan and claims "9 GW of incremental capacity" by 2045. To know how many GW of capacity are shown in the figure, SoCalGas' staff would have needed to download the spreadsheet cited in the Figure 4-5 footnote.[19] The workbook's "electricity" sheet shows that in 2045 the Hydrogen CT capacity is 9,325 MW (i.e. 9.32 GW).[20] Thus, SoCalGas' claim relative to the 9 GW of capacity is correct, but generation *capacity* does not determine hydrogen use.

The Draft Document goes on to claim that "[t]he relatively high hydrogen demand projected in the power sector positions power generation as a key source of the demand."[21] That statement by SoCalGas is false. The same CARB workbook that lists 9.32 GW of hydrogen turbine capacity, also includes a sheet titled "Electric Sector Combustion Fuels," which shows that the Scoping Plan assumes *zero* hydrogen used in every year though the 2045 time-horizon.[22] The sheet suggests that the hydrogen turbine capacity is only anticipated to be used in emergency scenarios, scenarios that CARB's modeling finds so unlikely at to require zero hydrogen use.

Comment 3-8

[18] Draft Document, p. 19.
[19] 2022 Scoping Plan, Footnote 327 ("See https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp-PATHWAYS-data-E3.xlsx for the capacity build-out by resource type."), available at https://ww2.arb.ca.gov/sites/default/files/2023-04/2022-sp.pdf.
[20] Scoping Plan Pathways Data, Sheet "Electricity", see https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp-PATHWAYS-data-E3.xlsx.
[21] Draft Document, p. 19.
[22] Scoping Plan Pathways Data, Sheet "Electric Sector Combustion Fuels", see https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp-PATHWAYS-data-E3.xlsx.

The 2022 Scoping Plan, the SB 100 Report, and 2023 IRP modeling all forecast zero hydrogen use in the power sector through 2045. The Draft Document should remove all inaccurate and misleading statements related to hydrogen use in the power sector. Comment 3-8

V. Industrial Sector: SoCalGas should assume no demand in the industrial sector until hydrogen costs less than current industrial energy fuels or until legislation requires industrial users to transition to zero carbon fuels.

SoCalGas' should assume zero clean hydrogen demand in the industrial sector because the energy sources currently used by industry cost less than clean hydrogen. The Draft Document does not appear to make any effort to determine when clean hydrogen may be cost effective for industrial users. Instead, the Draft Document excludes fuel costs and/or technology costs.[23]

SoCalGas also makes specific unsupported assumptions for its industrial sector claims. Regarding co-generation capacity factors, SoCalGas makes an arbitrary assumption when it claims 10%, 20%, and 30% capacity factors by scenario for clean hydrogen co-gen facilities.[24] SoCalGas' co-gen assertion is significant because hydrogen use at co-generation facilities represents most of the hydrogen demand for the industrial sector in two of the three SoCalGas scenarios. SoCalGas needs to base the cogeneration capacity factor on research rather than its own unsupported assertions. SoCalGas' own research found that CARB forecasts "all cogeneration to be retired by 2045."[25] Despite that statement in the Draft Document, SoCalGas refused to assume full cogeneration retirement in its demand scenarios. Comment 3-9

SoCalGas appears to have collected a significant amount of data on the industrial sector, but not the work required to determine hydrogen demand. To correct the Draft Document, SoCalGas should remove co-generation from the industrial demand forecast, use reliable third party research to determine the full range of clean energy alternatives for industrial heat (e.g. SoCalGas makes the false

[23] Draft Document, Appendix, Table 22, p. 46.
[24] Draft Document, Table 8, p. 59.
[25] Draft Document, p. 8.

assumption that only process heat temps < 400°F can be electrified), only forecast clean hydrogen demand for use cases in which hydrogen is the low-cost option, and only forecast hydrogen demand if the industrial use case has a legislatively-mandated clean energy requirement. Until these changes are made, the industrial sector forecast will remain inaccurate. Comment 3-9

VI. Mobility Sector: SoCalGas's Draft Document makes numerous unsupported assertions and based on those assertions falsely claims to have modeled hydrogen demand in the mobility sector.

The Draft Document's mobility sector outputs lack credibility because they exclude conclusions from reliable third-party sources. The Draft Document makes assertions about hydrogen demand in the mobility sector based *solely* on SoCalGas' opinions. SoCalGas should complete a mobility analysis for the Draft Document that uses reliable third-party sources to establish a mobility sector demand forecast.

There are two main flaws in the Draft Documert's mobility section's demand forecast framework. First, SoCalGas' overall framework of the mobility section uses four "adoption rate factors" – (1) policy & legislation, (2) commercial readiness, (3) technical feasibility, and (4) business readiness) – that are set according to SoCalGas' opinion. Thus, all factors used to determine FCEV adoption rate are subjectively determined by a company that would profit from high clean hydrogen demand. That framework ensures that the demand study will over forecast demand. Comment 3-10

The second flaw is the Draft Document's misuse of ANL's TechScape model. While the Draft Document cites the TechScape model as the basis for the determination of the cost effectiveness of FCEVs compared to alternatives,[25] the Draft Document ignores ANL's published findings. ANL researchers, using the TechScape model have found that fuel cell electric vehicles ("FCEV") are not cost competitive with battery electric vehicles ("BEV") during any year through 2050 for every on-road medium- and

[25] The Draft Document cites the BEAN model. The BEAN model has been renamed TechScape.

heavy-duty vehicle class through a 2050 time horizon.[27] That ANL finding is true even for Class 8 heavy-duty long-haul vehicles,[28] which is the class that SoCalGas forecasts will see a near 100% FCEV market share in 2045.[29]

Figure 1, below, is a screen capture from the 2023 TechScape analysis. The figure shows TechScape's TCO comparison of Class 8, long-haul trucks for Conventional, FCEV, and BEV options through 2050.

Figure 1: ANL, TechScape Total Cost of Ownership (TCO) by Vehicle Category[30]

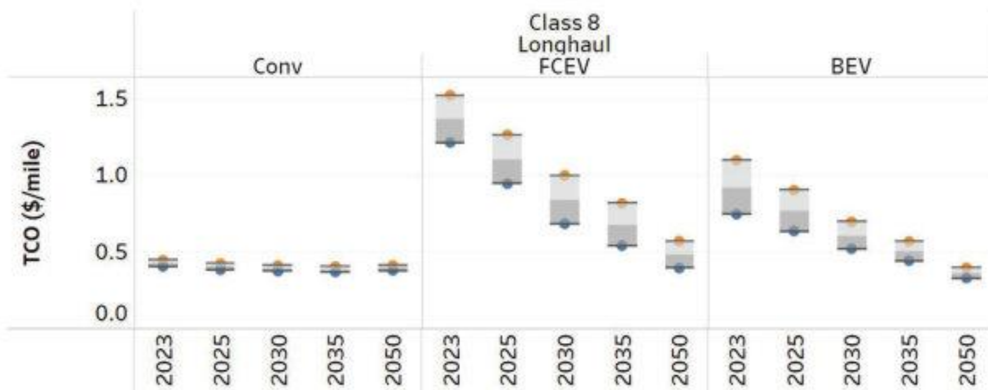

Figure 1 shows that, in every year, FCEVs are more expensive than conventional Class 8 long-haul trucks and BEV long-haul trucks. By 2050, TechScape finds that BEVs' TCO will still be lower than conventional vehicles. SoCalGas did not include this data in its Draft Document despite claiming to use the TechScape model. SoCalGas' mobility sector claims depart significantly from ANL's TechScape modeling outputs.

Comment 3-10

[27] Argon National Laboratory, TechScape 2023 modeling for medium and heavy-duty vehicles, https://vms.taps.anl.gov/analytics/md-hd-truck-future-technology-prediction/.
[28] *ibid.*
[29] Draft Document, Figure 12, p. 35.
[30] See TechScape, MD/HD Future Technology Prediction (From 2023 Model) [last accessed February 25, 2024], https://vms.taps.anl.gov/analytics/md-hd-truck-future-technology-prediction/.

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It appears that the main strategy that SoCalGas used to contradict the ANL's findings was to change the most important TechScape modeling inputs before using the TechScape model.[31] SoCalGas changed the following inputs:

- hydrogen fuel costs[32]
- fuel cell costs[33]
- hydrogen storage costs[34]
- battery costs[35]

Possibly the most impactful change that SoCalGas made was to eliminate the effect of fuel costs in its analysis by assuming that the cost of hydrogen is the same as the alternative carbon-emitting fuel (natural gas or diesel). The Draft Document's appendix notes that setting the cost of hydrogen equal to the cost of natural gas resulted in a hydrogen cost of $0.289/kg for the power sector.[36] In contrast, the U.S. DOE reports that in October 2023 the cost of hydrogen at vehicle filling stations in the U.S. averaged $32.32/gallon of gasoline equivalent ("GGE").[37] GGE is nearly identical to 1 kg of hydrogen. Thus, the real world price of hydrogen at filling stations is 111 times higher than the price of hydrogen that SoCalGas assumed for power sector hydrogen.[38] On an apples-to-apples basis, the DOE-reported hydrogen price at filling stations is 11 times higher than the price of compressed natural gas (CNG) at filling stations.[39] If SoCalGas wants the study to be taken seriously, then it needs to include the cost of

Comment 3-10

[31] Draft Document, p. 31 ("CapEx and OpEx (excluding fuel cost) analysis were conducted to determine if and when FCEV and BEV technologies would achieve relative cost parity with each other and with traditional vehicles."); Draft Document, Appendix, p. 22-23 (On these pages SoCalGas explained that it changed ANL's inputs for fuel cell costs, hydrogen storage costs, battery costs.)
[32] Draft Document, Appendix, p. 22-23 (SoCalGas changed fuel cell costs, hydrogen storage costs, battery costs, hydrogen commodity costs)
[33] Draft Document, Appendix, p. 22-23
[34] *Ibid.*
[35] *Ibid.*
[36] Draft Document, Appendix, Table 17, p. 32.
[37] Clean Cities Alternative Fuel Price Report, (October 2023), footnote 4, p. 4, available at https://afdc.energy.gov/files/u/publication/alternative_fuel_price_report_october_2023.pdf.
[38] $32.32/GGE / $0.289/kg = 111.8339.
[39] Clean Cities Alternative Fuel Price Report, (October 2023), p. 4, (H2 at $32.32/GGE / CNG at $2.85/GGE = 11.34).

hydrogen, the cost of the resource being studied. The cost of a resource has a significant effect on consumer demand.

In summary, ANL's TechScape finding is that the TCO of on-road FCEVs will never reach parity with BEVs or conventional vehicles. In contrast, the Draft Document claims that FCEVs will see Class 8 Sleeper Cab adoption of approximately 90-98% in 2045.[40]

SoCalGas should eliminate the bias from its adoption rates by aligning its adoption forecasts with reliable third-party research. SoCalGas' opinions carry little weight due to SoCalGas' conflict of interest. The mobility sector framework and findings in the draft document should be discarded and replaced with unbiased third-party research.

Comment 3-10

VII. Until SoCalGas completes a demand study that uses third-party research, work spent on other Phase 1 requirements waste resources.

UCAN again notes for SoCalGas that until it completes a reasonable demand study, resources spent on other Phase 1 topic areas will likely waste resources and will be unrecoverable. Because SoCalGas has moved forward with Phase 1 research beyond the demand study, SoCalGas has likely recorded many hours of work that provide no value to theoretical future hydrogen ratepayers. Those theoretical ratepayers should not be held accountable for improper research sequencing by SoCalGas.

Comment 3-11

VIII. SoCalGas should release its work papers and spreadsheets used in its demand analysis to allow PAG members to provide fulsome feedback.

The Commission requires SoCalGas to release its data to the public. To UCAN's knowledge, SoCalGas has not requested confidential treatment of the data it has collected or the spreadsheets it has produced. Because it has not requested confidential treatment of its documents in Phase 1, D.22-12-055

Comment 3-12

[40] Draft Document, Figure 12, p. 35.

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requires SoCalGas to release "the data, findings, and results of the Phase One studies."[41] UCAN continues to ask for the work papers and spreadsheets that SoCalGas has used or produced related to the Draft Document. SoCalGas' continued refusal to release its workpapers keeps UCAN from completing a full evaluation of the Draft Document. SoCalGas' withholding of its work papers also violates D.22-12-055.[42]

Comment 3-12

IX. UCAN has determined that SoCalGas' lowest-demand scenario overestimates clean hydrogen demand by at least a factor of 10.

SoCalGas' Draft Document contains so many errors and false inputs that it is difficult to use the document to draw any conclusion as to future clean hydrogen demand. UCAN estimates that even SoCalGas' lowest-demand scenario overestimates clean hydrogen demand by at least a factor of 10. In support of this statement, UCAN provides the following facts:

- **Power Sector:** CPUC, CEC, and CARB modeling all forecast zero clean hydrogen demand in the power sector through 2045 (i.e., SB 100 report, 2022 CARB Scoping Plan, CPUC IRP modeling).
- **Mobility Sector:** Argon National Laboratory's TechScape modeling tool forecasts that BEVs will have a lower total cost of ownership compared to FCEVs for every on-road vehicle type through 2050.
- **Industrial Sector:** SoCalGas provided no data on cost-effective clean hydrogen for industrial purposes.

Comment 3-13

The three bullets above demonstrate that the power, mobility, and industrial sectors each will see negligible clean hydrogen demand through 2045 based on current conditions. In fact, the only use cases where hydrogen demand may develop are marine shipping and aviation. However, the technological development for those two use cases is in such an early stage that it is impossible to make any reliable forecast. UCAN agrees with Draft Document's statement that, for marine and aviation

[41] D.22-12-055, p. 31.
[42] D.22-12-055, OP 7, p. 77.

applications, "the inter-state and international aspect of these applications mean that adoption of a new standard fuel could take many years."

Research and empirical data show that the demand claims made in SoCalGas' Draft Document are false. SoCalGas should update its clean hydrogen forecast based on the best available data. Once SoCalGas has completed a revised Draft Document, it should submit the document to the PAG for review and feedback.

Comment 3-13

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Response to Comment 3-1: Please see Global Response 1 and Response to Comment 3-4, 3-5, and 3-10, and 3-13.

Response to Comment 3-2 and 3-3: Please see Global Response 1.

Response to Comment 3-4: The Demand Study used replacement values that increased costs for fuel cells and H2 storage, and decreased costs for batteries. These adjustments were based on the advice of consultant subject matter experts. The adjustments to these cost values effectively made it more challenging for fuel cell zero vehicles (FCEVs) to reach cost competitiveness with alternatives, compared to the default cost values from ANL's BEAN model. If the original ANL BEAN values are used instead of the replacement values, this would actually increase the expected hydrogen demand volumes in the mobility market.

Response to Comment 3-5: Please see Global Response 1.

The adoption factors and assessments were recommended by third party consultants. The National Zero-Emission Freight Corridor (NZEFC) Strategy report recently published by the U.S. DOE and Joint Office of Energy includes analysis informed by similar factors, such as industry need, commercial readiness, and signals from policymakers and regulators[17]. These similarities to the U.S. DOE's report show that the adoption factors used in the Demand Study are not unique to the study.

Response to Comment 3-6: SoCalGas acknowledges UCAN's summary of interactions.

Response to Comment 3-7: Please see Global Response 1.

Response to Comment 3-8: Please see Global Response 1.

Various power generation operators are actively converting facilities to use hydrogen (i.e., LADWP involvement in IPP Renewed[18]; LADWP's plans to convert its Scattergood power generation facilities to run on hydrogen[19], and Northern California Power Authority (NCPA) plans to develop a hydrogen-fueled power plant Lodi, CA[20].

Response to Comment 3-9: Please see Global Response 1 and Response to Comment 3-5.

California's Priority Climate Action Plan (PCAP) iterates that California has a statutory goal to "reduce anthropogenic emissions by at least 85% below 1990 levels and achieving carbon neutrality by 204521". Further, decarbonizing industrial facilities will benefit low-income and disadvantaged communities and will "primarily depend upon replacing or reducing existing fossil fuel use with a mix of electrification, solar thermal heat, biomethane, low- or zero-carbon hydrogen22. In addition, CARB 2022 Scoping Plan for Achieving Net Neutrality identifies the scaling up of renewable hydrogen for the hard-to-electrify sectors as playing a key role in the State achieving carbon neutrality by 2045 or earlier. As can be seen by the growing ARCHES network, which includes industrial companies, the use of hydrogen is considered

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17 US DOE, "National Zero-Emission Freight Corridor Strategy", pg. 12, Accessible at: https://driveelectric.gov/files/zef-corridor-strategy.pdf

18 https://www.ladwp.com/sites/default/files/2024-03/SLTRP%202024%20Overview%20Presentation.pdf (at 11); https://ipprenewed.com/about/

19 https://www.ladwp.com/community/construction-projects/west-la/scattergood-generating-station-units-1-and-2-green-hydrogen-ready-modernization-project

20 https://www.publicpower.org/periodical/article/ncpa-plans-hydrogen-fueled-power-plant

21 https://www.epa.gov/system/files/documents/2024-03/california-cprg-priority-climate-action-plan.pdf

22 https://www.epa.gov/system/files/documents/2024-03/california-cprg-priority-climate-action-plan.pdf

an important pathway to decarbonize and could be supported by Angeles Link pipeline infrastructure that would transport hydrogen to these industrial facilities.

Response to Comment 3-10: Please see Global Response 1, Response to Comment 3-4, and Response to Comment 3-5.

Several factors influence the adoption of one zero emission vehicle over another. For example, third-party analysis examining the bus fleet of AC Transit, over a 12-year life cycle, describes that fuel cell electric vehicles have an estimated lower total cost of ownership (TCO) compared to battery electric vehicles as reflected in the chart below.[23]

Similarly, a recent April 23, 2024 study by the National Petroleum Council models the potential TCO for heavy duty transportation across different vehicle types:[24]

This independent third-party research and data indicates the potential for FCEVs to compete with battery electric options. Finally, adoption forecasts should consider other factors in addition to cost such as range, duty cycles, payload, refueling/charging infrastructure, which impact the choices fleet operators make.[25] We consider the adoption factors used in the Demand Study to estimate the potential hydrogen demand in mobility as reasonable.

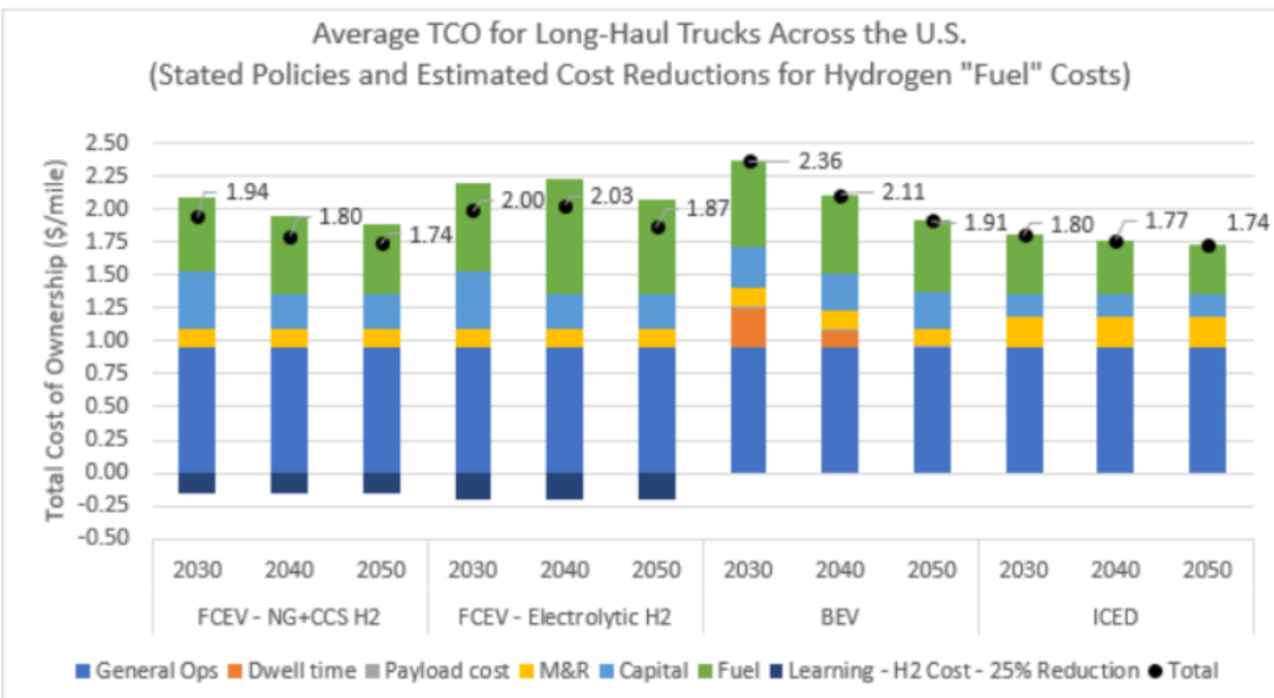

Figure 5-42. Total Cost of Ownership for Heavy-Duty Transportation—Stated Policies

23 Hydrogen Fuel Cell Bus Info Page: The "Better" Electric Bus" Accessible at: www.californiahydrogen.org

24 See NPC, "Harnessing Hydrogen: A Key Element of the U.S. Energy Future" at 29. Accessible at: harnessinghydrogen.npc.org/files/H2-CH_5-Demand_Drivers-2024-04-30.pdf

25 See discussion starting at page 59 in section "IV. Hydrogen Demand in the Transportation Sector" https://harnessinghydrogen.npc.org/files/H2-CH_5-Demand_Drivers-2024-04-30.pdf

Appendix 3: SoCalGas Response to Comments

Response to Comment 3-11: Please see Global Response 1 and Response to Comment 2-1.

Consistent with the Decision, SoCalGas is conducting Phase 1 feasibility studies, and cost recovery for Phase 1 activities, including for conducting the Demand Study, will be addressed in a future proceeding.

Response to Comment 3-12: SoCalGas has provided PAG and CBOSG members with access to materials in the Living Library, which includes a detailed technical appendix.

In addition, SoCalGas will make data, findings, and results specific to the Demand Study available to the public in an unredacted form, subject to any potential confidentiality assertions SoCalGas may make in accordance with the requirements of GO 66-D.

Response to Comment 3-13: Please see Global Response 1 and Response to Comment 3-1.

3.4 Comment Letter 4 – Air Products

Comment Letter 4 – Preliminary Data and Findings (NOx, GHG, Leakage, and Water)

AIR PRODUCTS

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March 29, 2024

VIA EMAIL TO
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Emily Grant
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Southern California Gas Company
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Re: Angeles Link Planning Advisory Group (PAG) Feedback of Air Products and Chemicals Inc. on the Preliminary GHG Emissions Evaluation, Hydrogen Leakage Assessment, NOx Emissions Assessment, Water Resources Evaluation, and Feedback on the Pipeline Routing Discussion at the March 5th PAG Meeting

Air Products and Chemicals, Inc. ("Air Products") submits the following feedback concerning the Preliminary Findings of the four Angeles Link technical studies that are now available: Greenhouse Gas Emissions Evaluation, Hydrogen Leakage Assessment, Nitrogen Oxide (NOx) & other Air Emissions Assessment, and Water Resource Evaluation. Air Products expects that the below feedback will be addressed in the final Studies and in Southern California Gas Company's (SoCalGas) quarterly reporting. Air Products also welcomes any response that SoCalGas may wish to provide to the comments below.

General Comments

Comment 4-1

Air Products has procedural concerns around data and information access related to the technical studies that SoCalGas is required to perform pursuant to D.22-12-055. D.22-12-055 directed SoCalGas to make the data, findings, and results of the Phase One Studies available to the public, absent a specific request for confidential treatment of data in accordance with General Order 66-D.[1] Despite this direction, Air Products had difficulty accessing data and information on which the draft Phase One Studies rely.

For example, the February 2024 Water Resources Evaluation Preliminary Findings: (1) Water Availability Study; and (2) Water Quality Requirements states that its "overall scope of work was informed by and built off pre-feasibility studies and specifically the 2021 SPEC Services

[1] D.22-12-055 at 31.

water study."[2] Despite the fact that the Water Resources Evaluation was based on the 2021 SPEC Services study, the study was not provided to the PAG. Air Products requested a copy of the SPEC Services study to better evaluate the underpinnings of the Water Resources Evaluation, but a response was not provided for nearly two weeks. When Air Products was finally able to review the report provided by SoCalGas, it was heavily redacted throughout the water demand section, as well as throughout regional water reports provided by other contractors. Air Products was therefore unable to access the data on which the SPEC Services, and ultimately the draft Water Resources Evaluation, was based.

Air Products urges SoCalGas to provide links to any documents which are relied upon by the draft Studies, and that the unredacted underlying data be provided. Failure to provide the underlying data or documentation prevents a full review of the draft Study. As discussed below, there are questions regarding the Water Resources Evaluation study that might have been answered with complete, transparent, and timely transmittal of the referenced reports.

Comment 4-1

Comments on Specific Preliminary Findings

Air Products provides the following feedback on the Preliminary Findings for the Greenhouse Gas Emissions Evaluation, Hydrogen Leakage Assessment, Nitrogen Oxide (NOx) & other Air Emissions Assessment, and Water Resource Evaluation.

<u>Greenhouse Gas Emissions Evaluation</u>

Air Products provides the following feedback on the February 2024 Greenhouse Gas Emissions Preliminary Data and Findings (GHG Emissions Preliminary Study).

The GHG Emissions Preliminary Study purports to capture emissions directly related to hydrogen combustion and indirectly from non-renewable electricity and estimates of emissions associated with new infrastructure, as well as GHG emissions reductions associated with end user in the mobility, power generation, and hard-to-electrify industrial sectors.[3]

Unfortunately, however, there are gaps in the scope of GHG emissions covered. First, the GHG Emissions Preliminary Study itself concedes that the GHG emissions associated with water conveyance for production of hydrogen were not included in the scope of the Study.[4] While acknowledging this deficiency, the Study fails to provide any explanation of why it was omitted from the Study, and whether this evaluation will be included in the scope of any other study. Consideration of the GHG emissions associated with water conveyance is critical to understanding overall GHG emission impacts. Facilities for the electrolytic production of hydrogen will likely need to be operated in proximity to renewable energy generation resources that may be in remote locations geographically distant from water sources. Therefore, the emissions associated with water transportation could be significant, and at a minimum should be

Comment 4-2

[2] Preliminary Findings: (1) Water Availability Study; and (2) Water Quality Requirements at 4.
[3] GHG Emissions Preliminary Study at 4.
[4] *Id.*

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evaluated and considered in this Study. The Water Availability Study, discussed below, further reinforces the idea that SoCalGas is assuming that water could be supplied from anywhere in SoCalGas's service territory, and from select sources outside that service territory, exacerbating transportation needs and potential impacts.[5] Comment 4-2

Second, the Study fails to appropriately account for the emissions impacts of electric generation associated with various production methods—whether electrolytic, biomass gasification, or renewable natural gas fueled steam methane reformers (SMR).[6] Any of these production methods may rely upon grid energy during the production process, for ancillary demands, or in transient conditions, and those emissions do not appear to be captured in the Study. Even for electrolyzers powered by renewable energy, unless the renewable generation produces the sufficient energy to meet demand in all hours, electrolyzers may depend on some grid energy, which will result in emissions consistent with the grid resource mix at that time. Comment 4-3

Third, similar to water conveyance, which is expressly excluded, the Study does not seem to take into account the transportation and other feed preparation emissions associated with biomass gasification. Inevitably, any biomass gasification process will require harvesting and transportation of the required biomass feedstock to the production facility, and perhaps feed preparation (e.g., torrefaction or other processes to remove moisture or condition the feed). As with water, the transportation distances associated with accessing available and appropriate feedstocks may be significant and emissions associated with this transport, or any pre-treatment do not seem to be included. Comment 4-4

Hydrogen Leakage Assessment

Air Products provides the following feedback on the February 2024 Leakage Preliminary Data and Findings (Leakage Preliminary Study).

Air Products is concerned that the Study estimates a leak rate from aboveground compressed gas storage vessels that appears to be off by several orders of magnitude. Table 2 summarizes uncontrolled leakage rates found in available literature.[7] The figures for aboveground storage are several orders of magnitude greater than the leakage rates for all other components listed in Table 2.[8] The leakage rates for aboveground storage were pulled from the Environmental Defense Fund, 2024, Wide Range in Hydrogen Emissions from Infrastructure,[9] which in turn takes the values from Frazer-Nash Consultancy, 2022, Fugitive Hydrogen Emissions in a Future Hydrogen Economy, prepared for the U.K. Department for Business, Energy & Industrial Comment 4-5

[5] Water Availability Study at 6.
[6] *See id.* at 9.
[7] *See* Leakage Preliminary Study at 12, Table 2
[8] *Id.*
[9] Esquivel-Elizondo, S., Mejia, A. H., Sun, T., Shresta, E., Hamburg, S. P., Ocko, I. B. Wide Range in Estimates of Hydrogen Emissions from Infrastructure. *Front. Energy Res.*, **11**, 2023. https://doi.org/10.3389/fenrg.2023.1207208

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Technology.[10] A review of that study reveals that Frazer-Nash used Department of Energy (DOE) target hydrogen loss rates for high pressure on-board storage tanks, but these targets appear to be based on acceptable range loss in mobile fuel cell applications[11] and are not appropriate for stationary aboveground pressurized tanks. Those DOE targets are dramatically higher than the few actual measured permeation rates found for polymer composite tanks.[12] For steel aboveground tanks, the DOE does not appear to publish a target but the hydrogen loss rate is expected to be negligible.[13] Air Products would expect that leakage rates for above ground pressurized storage vessels designed for hydrogen should therefore be significantly less than 1%, not the 2.7 – 6.5% listed in Table 2. **Comment 4-5**

Nitrogen Oxide (NOx) & other Air Emissions Assessment

Air Products provides the following feedback on the March 2024 (Revised) NOx Evaluation Preliminary Data and Findings (NOx Preliminary Study).

First, the NOx Preliminary Study should clarify whether the emissions reductions assumed for refineries are solely based on reductions in their natural gas demand and that this natural gas demand can be replaced with hydrogen in the high throughput case (see Figure 8A). Refineries have sources of NOx emissions that cannot be reduced or eliminated through hydrogen adoption (e.g., direct process emissions from some units). Also, many refineries have on-site hydrogen production plants that require supplemental natural gas as feedstock and this feedstock cannot be replaced with hydrogen. It is unclear whether the NOx Preliminary Study takes these factors into account when the emission reductions from refineries are estimated. **Comment 4-6**

Second, the NOx Preliminary Study also has numerous tables purporting to list blending percentages, e.g., Table 7, Table 8, Table 17, and Table 18. SoCalGas should clarify whether the percentages offered in those table reflect blending percentages based upon volume or energy. These tables also seem to be in direct conflict with statements in the report implying that SoCalGas is not accounting for blending as this occurs behind the meter at customers' facilities. Please clarify what is or is not being accounted for from blending in terms of NOx impacts from the project. **Comment 4-7**

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[10] *See id.* at 15, n. 29 & n.31.

[11] DOE Technical Targets for Hydrogen Storage Systems for Material Handling Equipment, Dept. of Energy, accessed 26 March 2024. https://www.energy.gov/eere/fuelcells/doe-technical-targets-hydrogen-storage-systems-material-handling-equipment

[12] Mahytec, "Datasheet for 500 bar 160-3001 Hydrogen Storage." 2021. https://www.mahytec.com/wp-content/uploads/2021/07/CL-DS7-Data-Sheet_500bar-EN.pdf

[13] (a) Abdin, Z., Khalipour, K., Catchpole, K. Projecting the Levelized Cost of Large Scale Hydrogen Storage for Stationary Applications. *Ener. Conv. and Management*, **270**, 2022, 116241. https://doi.org/10.1016/j.enconman.2022.116241 ; (b) Reuss, M., Grube, T., Robinius, M., Preuster, P., Wasserscheid, P., Stolten, D. Seasonal Storage and Alternative Carriers: A Flexible Hydrogen Supply Chain Model. *Applied Energy*, **200**, 2017, 290-302. http://dx.doi.org/10.1016/j.apenergy.2017.05.050

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Water Resources Evaluation

Air Products provides the following feedback on the February 2024 Water Resources Evaluation Preliminary Findings: (1) Water Availability Study; and (2) Water Quality Requirements.

First, regarding the Water Availability Study, the Study appears flawed in that it evaluates water availability broadly, including on a state-wide basis, rather than based upon the projected locations of production facilities.[14] According to the presentation at the March 5th, 2024, PAG Meeting, SoCalGas's pipeline routing study has already identified several locations for potential production. The Water Availability Study should be targeted to those locations. Instead, the Water Availability Study assumed the study area to be the entire SoCalGas service territory, and select sources located outside that service territory.[15] If water is not specifically available at the point of production, then the water will need to be transported which requires additional energy and results in greenhouse gas emissions as discussed above. **Comment 4-8**

Second, the Study assumes that "Third-party clean renewable hydrogen producers will identify and develop or acquire water supply in sufficient quantities to meet water demands on their respective projects."[16] The Study thus effectively punts on a key issue that SoCalGas was required to determine in Phase 1: "Identification of the potential sources of hydrogen generation *and water*."[17] **Comment 4-9**

Third, regarding the Water Quality Requirements set forth in Table 2: Preliminary Findings of the Water Resources Evaluation, the specified treatment approach does not encompass all of the pre-treatment steps that are most likely required to make raw water a suitable feed source for reverse osmosis. The water sources identified in the Water Availability Study are expected to vary by location and to contain suspended solids, heavy metals, organics and hydrocarbons in different amounts that require removal prior to treatment using reverse osmosis for removal of total dissolved solids and further polishing using ultraviolet systems, electro deionization systems and mixed bed ion exchange systems for removal of residual ionizable species and organics. Air Products requests that for each potential raw water source, SoCalGas include a table that identifies the specific water purification steps. **Comment 4-10**

Furthermore, the stoichiometric water requirement of 9 kg of water for every 1 kg of hydrogen produced does not appear to include total raw water requirements, but instead only the treated ultrapure (UPW) water. The Water Quality Requirements should be clarified to note whether the estimated water requirement is based upon raw water or UPW. **Comment 4-11**

[14] *See, e.g.*, Water Availability Study at 3 (comparing projected demand to total statewide water demand per year in California).
[15] Water Availability Study at 6.
[16] Water Availability Study at 6.
[17] D.22-12-055 at OP 6(b)(emphasis added).

This distinction between raw water consumption and UPW also needs to be clarified in other areas of Table 2. For example, it is unclear whether the potential water demands set forth in the third paragraph of the Executive Summary refer to raw water or UPW, nor does the Study identify what assumptions were used concerning the expected recovery rate of UPW from raw water. In addition, the Study fails to indicate whether cooling water needs for the electrolyzer and the remaining plant water demand were included in the estimated demand. Air Products requests that SoCalGas clarify these issues in its final Study.

Section 2.3, on Page 5: There is reference to a study that was conducted to analyze the water quality requirements based on electrolyzer technologies used for hydrogen production and to establish the treatment approach to produce ultrapure water (UPW) from the identified potential water sources. It would be helpful to review the findings from that study. Details such as water quality characteristics for each of the potential water sources, available flows/volumes, purchase cost of source water ($/kgal), and UPW treatment goals for hydrogen production (as mentioned above) would be helpful for further evaluation/project feasibility.

Comment 4-11

March 5th Pipeline Routing Discussion

Much of what is under development by the private sector for new hydrogen infrastructure does not align with the Link studies and proposed utility hydrogen pipelines, nor do the Link studies overlap with ARCHES published plans. The Link mapping proposal with routes from the Pacific Ocean to the eastern state border presented in the recent PAG meeting are designed to track the existing SoCalGas rights of way for current gas transmission and distribution lines, and not necessarily drawn to compliment or supplement long-term future potential delivery needs. Instead, the Link preferred routes appear to duplicate or compete with existing dedicated pipelines that have been in service for decades and have been identified for expansion in ARCHES and with end users in the Los Angeles basin. While some of the ARCHES production is generally shown along with end uses in the mapping and preferred routing for the Link, the presentation did not make clear that some of these hydrogen consumers are already being serviced by existing hydrogen service providers with plans in place for buttressing existing hydrogen pipeline use and truck transport to support new users in the Los Angeles, Long Beach port complex and surrounding industrial areas. The Link PAG materials that map multiple pipeline segments into the Los Angeles coastal areas and weave throughout the California desert leave the PAG participants to assume that the SoCalGas Link is included in the ARCHES framework, when in fact it appears from public ARCHES documents and brief treatment during the presentation that only two small portions of the proposed Link have been identified as pipelines that may be located in the San Joaquin Valley and near Lancaster for longer-term potential development.

The ARCHES systems analysis on the other hand identifies production, end uses, and delivery points developed by a variety of ARCHES partners that will be the underpinning framework to support hydrogen market lift-off in California. There are more than 400 hydrogen entities in ARCHES working together to plan near term infrastructure investments to advance renewable hydrogen supply and delivery. The ARCHES systems plan is a living document borne out of a

Comment 4-12

public-private partnership, supported by industry and academia, including the University of California Office of the President and Lawrence Livermore Labs. The United States Department of Energy recognized the ARCHES collective effort as one of the more advanced national hubs with more than 30 Tier 1 project proponents working diligently to finalize the $1.2 billion statewide award. These ARCHES partners include entities who have decades of hydrogen experience, who are actively advancing their projects, including new supply, new fueling stations, expanding existing dedicated hydrogen pipelines and hydrogen delivery fleets to serve new users statewide, including the Long Beach - Los Angeles port complex and regional industrial users including new electric sector users. The new green renewable hydrogen supply, new fueling (stationary and mobile) capability for maritime, ports, industrial and power needs are in various stages of development and permitting – well ahead of the timeline envisioned for the Link and SoCalGas' current process to move from studying and learning how hydrogen markets and systems work to requesting authority to transition to a hydrogen utility.

Air Products recommends that SoCalGas' withdraw the proposal to advance more than 400 miles of proposed hydrogen pipelines and limit review to the small segments referenced in the ARCHES framework, as 1) none of the proposed Link is needed in the near-term for hydrogen market lift-off, 2) SoCalGas studies released to date have flaws showing a lack of technical understanding and 3) the studies do not result in a demonstrated need for such a significant ratepayer investment in a major new hydrogen pipeline system.

Comment 4-12

Conclusion

Air Products appreciates the opportunity to provide this input on the feedback concerning the Preliminary Findings of the four Angeles Link technical studies that are now available: Greenhouse Gas Emissions Evaluation, Hydrogen Leakage Assessment, Nitrogen Oxide (NOx) & other Air Emissions Assessment, Water Resource Evaluation and the preliminary information on preferred pipeline routes.

In summary, there are gaps in this analysis in a number of key areas. The result of SoCalGas' efforts in the past 15 months to invest in a CPUC sanctioned process to learn the basics of hydrogen production, the market for hydrogen end uses, and how to plan hydrogen systems requirements has made little progress and indicates lack of readiness to enter the hydrogen sector. California is home to the second largest hydrogen market in the United States, which has been in operation for more than 60 years. There are many hydrogen companies and service providers in California with decades of proven production, storage and delivery experience and strong safety records who are operating effectively, managing hydrogen supply, and investing in hydrogen infrastructure based on specific, identified industrial, transportation and other market needs. Those legacy market participants are developing new supply, storage, fueling, dispensing and transportation solutions through private investment to meet the ARCHES goals.

To date in the studies, there is insufficient needs determination in the analysis, a demonstrated lack of understanding of basic hydrogen production and supply requirements and not a compelling reason for advancing 400+ miles of the Link build-out. Further, the ambitious

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Angeles Link plans and mapping is redundant to or misaligned with the existing market needs and published ARCHES plans. The two small segments of the Link referenced in the ARCHES plan are not critical to the overall success of Phase 1 of ARCHES. The information published by SoCalGas in the PAG meetings is not aligned with existing statewide and economy-wide hydrogen expansion plans and have the potential to be misleading and confusing. **Comment 4-13**

Respectfully,

Miles Heller Director, Global Greenhouse Gas,
Hydrogen, and Utility Regulatory Policy

Response to Comment 4-1: Air Products expressed concerns around transparency and access to data. As directed by the Decision,[26] SoCalGas will make the data, findings, and results of its Phase 1 feasibility studies available to the public and not redacted, unless SoCalGas asserts confidentiality of the data in accordance with General Order (G.O.) 66-D.

As noted, SoCalGas provided the 2021 SPEC Services in redacted form based upon confidentiality claims made at the time of that publication consistent with General Order (GO) 66-D, given certain sensitive information contained therein.

The Draft Water Resources Evaluation does not rely on the conclusions of the SPEC Services evaluation and instead relies on publicly available data to determine water sources and availability.

Response to Comment 4-2: Please refer to Global Response 3.

Response to Comment 4-3: The Draft GHG Study Report assumes that production of hydrogen will use renewable electricity with zero GHG emissions regardless of production method – electrolysis, biomass gasification, or steam methane reforming. The GHG Study assumes that no grid electricity would be used for production since grid electricity may result in hydrogen being produced using fossil fuels which would be in conflict with the definition for "clean renewable hydrogen" as defined by the Decision. The Decision includes in its definition of "clean renewable hydrogen" a prohibition on the use of "any fossil fuel in the production process," where "fossil fuel" is defined as "a mixture of hydrocarbons including coal, petroleum, or natural gas, occurring in or extracted from underground deposits."[27] The Draft GHG Study Report assumes that in the case that electricity is temporarily unavailable for any reason, backup generators fueled by clean renewable hydrogen may be utilized.

Response to Comment 4-4: The Draft GHG Study Report does not evaluate GHG emissions associated with water conveyance or the transportation of other materials such as biomass to potential production sites or biomass feed preparation, as those details are beyond the scope of this feasibility study. The removal of moisture from biomass on-site at a biomass gasification facility may or may not be required. This is dependent on the biomass available in the area of operation and the supply chain process at the specific facility. Given this uncertainty, the assumption was made in the Draft GHG Study Report that biomass would be procured ready for combustion, and removal of moisture would not be required on-site. In response to stakeholder feedback, the Draft GHG Study will be supplemented with a summary of the lifecycle carbon intensity values of third-party production options (electrolysis, biomass gasification, and steam methane reforming) that were compiled based on a review of the limited literature available for each of the three production options evaluated in the Draft GHG Study Report. The supplemental analysis will appear in Appendix B of the Draft GHG Study Report.

Please also refer to Global Comment 3.

Response to Comment 4-5: SoCalGas acknowledges that different types of above ground storage vessels may have lower leakage rates than identified in the evaluated literature. The draft Leakage Study Report has incorporated this comment that leakage from aboveground storage vessels should be less than 1%.

Response to Comment 4-6: For refineries, hydrogen demand data from the following were excluded: legacy process feedstock, demand for renewable diesel (RD), and demand for sustainable aviation fuel (SAF). These sources of hydrogen for refineries were excluded from stationary combustion calculations for NOx because they were deemed either non-combustion (i.e., legacy process feedstock, which is not combusted, will not contribute to NOx) or outside of the boundaries of this analysis (i.e., demand for,

[26] D.22-12-055 at 77, OP 7.

[27] *Id.* at 42.

and the combustion of, RD and SAF were outside of the boundaries of the industrial sectors in this study). The exclusion of these sources of hydrogen will be documented in the draft NOx & Other Air Emissions Assessment.

Response to Comment 4-7: SoCalGas is designing Angeles Link to deliver pure clean renewable hydrogen to end users in Central and Southern California. In order to estimate NOx reductions at end users, assumptions regarding hydrogen adoption rates were made. These assumptions were based on information regarding currently available equipment and technologies and their anticipated evolution over time. This includes the referenced blending percentages, which are on a volume basis.

Response to Comment 4-8 and 4-9: Air Products correctly notes that the Water Resources Evaluation considers water availability holistically in Central and Southern California. The Decision requires that "SoCalGas shall provide the findings from its Phase 1 feasibility studies" including "identification of the potential sources of hydrogen generation and water." [28] To identify the potential sources of water for hydrogen generation, the study evaluates the large menu of potential water sources third-party producers may pursue for production. Separate from the Water Resources Evaluation, SoCalGas evaluates potential geographic areas of clean renewable hydrogen production in the Production Study. While the Water Resources Evaluation evaluates the potential water sources third-party producers may pursue, the study does not speculate which particular water sources may supply specific third-party production projects. More information on the water supply sources that may feed specific clean renewable hydrogen projects may be available and could be evaluated on a case-by-case basis as more details on specific clean renewable develop. In response to potential indirect GHG emissions from water conveyance, please refer to Global Comment 3.

The Water Resources Evaluation will provide the background and supporting detail around the Preliminary Data and Findings.

Response to Comment 4-10: SoCalGas concurs with Air Products that different potential water sources identified in the Water Resources Evaluation Preliminary Data and Findings will vary by location and may contain different contaminants that will require different treatment processes before being fed into electrolyzers. The draft report will provide information about water purification and specific treatment processes for each potential water source identified in order for each source to meet the identified water quality requirements for clean renewable hydrogen production.

Response to Comment 4-11: The Water Resources Evaluation clarifies that the stoichiometric water requirement of approximately 9 kg of water for every 1kg of hydrogen is for ultrapure water. Raw water demands will be larger than this requirement because of treatment losses. Accounting for treatment losses, the report will provide estimates of raw water demands needed for the volume of clean renewable hydrogen production that would meet the estimated demand in SoCalGas's service territory, as well as the raw water demands needed for the volume of clean renewable hydrogen that Angeles Link could transport. The draft report will provide the assumptions supporting those raw water demand estimates, including for cooling.

Response to Comment 4-12: SoCalGas disagrees with Air Products' narrow perception of the State's envisioned hydrogen market and need for at-scale, open access pipeline transport system dedicated to public use connecting multiple sources of clean renewable hydrogen supply with all potential end-users in Central and Southern California, inclusive of but not limited to the ARCHES segments. As envisioned, Angeles Link could support the integration of more renewable electricity resources like solar and wind and could significantly reduce greenhouse gas emissions from electric generation, industrial processes, heavy-duty trucks, and other hard-to-electrify sectors of the Central and Southern California economy.

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[28] *Id.* at 75-76.

Angeles Link could also significantly decrease demand for natural gas, diesel, and other fossil fuels in the LA Basin, helping accelerate California's and the region's climate and clean air goals. Angeles Link is envisioned as a long-term investment in decarbonization both in the near and long-term. In the near term, portions of Angeles Link (e.g. ARCHES segments) would provide necessary connections to help launch California's hydrogen economy, and the broader Angeles Link project will help scale to support expected demand, promote the transport of clean renewable hydrogen to end users, and leverage expansion of H2Hub as hydrogen is adopted more widely.

As described in Global Response 1, the Draft Demand Study shows greater and more diverse demand than Air Products perceives and that can be met by Angeles Link serving Central and Southern California in support of the State's decarbonization goals. Angeles Link would serve hard-to-electrify industries like dispatchable electric generation, heavy-duty trucking, and industrial processes. SoCalGas's Draft Demand Study demonstrates that there is sufficient potential demand to continue advancing further studies.

With respect to electric power needs, contrary to Air Products' assertions, the purpose and need for the project is not limited to new electric sector users since existing electric end users would benefit from the reliability and resiliency of Angeles Link. Building the Angeles Link system to provide a clean substitute fuel for natural gas – clean renewable hydrogen - could also help reduce demand for natural gas currently served by Aliso Canyon while providing clean firm power and supporting energy system reliability and resiliency. In conjunction with other future clean energy projects and reliability efforts, Angeles Link can support decreased reliance on Aliso Canyon. Information derived from Phase 2 activities would allow for the consideration of the role of clean renewable hydrogen and Angeles Link, along with other potential resources, to facilitate the optimal long-term solution to reduce reliance on Aliso Canyon.

Response to Comment 4-13: SoCalGas is conducting its Phase 1 feasibility analysis, which will ultimately result in the identification of several preferred pipeline configurations to transport clean renewable hydrogen. The purpose of the Angeles Link project is to support California's decarbonization goals, optimize service to all potential end-users of the Angeles Link system, enhance energy system reliability, resiliency, and flexibility, and provide a cost effective and affordable open access clean renewable hydrogen transportation system, among other goals. The project would provide reliable, lower cost hydrogen to various end-users, both in the public and private sectors. Open-access, common carrier hydrogen pipelines dedicated to public use in California can facilitate market growth and scalability and are consistent with the Department of Energy's Pathways to Commercial Liftoff: Clean Hydrogen materials. Such infrastructure is pivotal for supporting the burgeoning hydrogen economy and making clean renewable hydrogen accessible to multiple hard –to-electrify sectors within the LA Basin and throughout the Central and Southern California region. SoCalGas's Angeles Link project is aligned with ARCHES' initiative to "accelerate renewable hydrogen projects and the necessary infrastructure. This drive supports a transition to a zero-carbon economy. ARCHES prioritizes environmental and energy justice, equity, the improved quality of life for our communities, and the creation of good green careers for our workforce."[29]

[29] Powering California's Transition to Renewable Energy. Accessible at: https://archesh2.org/

3.5 Comment Letter 5 – Communities for a Better Environment (CBE)

Comment Letter 5 – Preliminary Data and Findings (NOx, GHG, Leakage, and Water)

March 29, 2024

Southern California Gas Company
555 West Fifth Street,
Los Angeles, CA 90013

Submitted via email to ALP1_Study_PAG_Feedback@insigniaenv.com.

Feedback for Southern California Gas Company on the Angeles Link Project GHG Water and Leakage Reports

Communities for a Better Environment (CBE) submits this letter of feedback to Southern California Gas Company (SoCalGas) on the Greenhouse Gas Emissions Preliminary Data and Findings ("GHG study"), Leakage Preliminary Data and Findings ("leakage study"), and Water Resources Evaluation ("water study").

Greenhouse Gas Emissions Preliminary Data and Findings

The Greenhouse Gas Emissions preliminary findings ("GHG study") fails to examine significant sources of climate pollution that must be explored to establish an accurate depiction of the ALP's greenhouse gas impacts. The GHG study is in large part premised on the prior, draft Demand Report, which as several parties have raised, seriously overestimates hydrogen demand and ALP throughput by failing to consider cost and making *significant* assumptions about hydrogen technology adoption. Particularly, in order to remedy the GHG study's failings, it is critical that the final report: **Comment 5-1**

- Correct the demand study failures raised by UCAN, EDF, and NRDC and utilize revised hydrogen demand inputs to assess GHG emissions impacts of the ALP.[1] **Comment 5-2**
- Correct assumptions that underestimate the GHG emissions from hydrogen production processes.
    - The GHG study assumes that electrolysis of hydrogen will not produce GHG emissions during the 2030-2045 period. While CBE strongly advocates for hydrogen to be produced exclusively through electrolysis powered by wind and solar, there are no laws or regulations which mandate this and there is a significant threat that hydrogen electrolysis will be powered by GHG emitting energy sources in California between 2030-2045. The GHG study must not undercount GHG emissions from electrolysis by assuming that all electrolysis will have no climate emissions. **Comment 5-3**
    - The GHG study assumes that biomass gasification will not produce GHG emissions during the study period. The process of biomass gasification produces GHG emissions which are not always avoided or mitigated. The GHG study must not undercount GHG emissions from biomass gasification by assuming that all gasification will have no climate emissions.

[1] Utility Consumers' Action Network, Feedback for SoCalGas Regarding Demand Study Technical Approach/Data & Preliminary Findings, Sept. 25, 2023; Environmental Defense Fund & Natural Resources Defense Council, Environmental Defense Fund and Natural Resources Defense Council Comments on the Demand Study Draft Report, Feb. 23, 2024; UCAN, Feedback for SoCalGas Regarding Angeles Link Demand Report Draft, Feb. 26, 2024.

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- o The GHG study appears to undercount GHG emissions from steam reforming of methane gas. Without greater availability of inputs and assumptions it is difficult to fully analyze the accuracy of the study with respect to SMR. The GHG study must not undercount GHG emissions from SMR. **Comment 5-3**
- Specify and include hydrogen leakage on GHG impacts of the ALP.
  - o The GHG study excludes the known climate impacts of hydrogen leakage. Hydrogen's physical properties make it difficult to effectively contain and transport, making leakage a significant concern. Despite acknowledging available leakage data and climate impacts in the GHG study and leakage study, the GHG study does not include these figures in ALP emissions estimates. The GHG study must include hydrogen leakage from all points of hydrogen use supported by the ALP in its final GHG emissions results. **Comment 5-4**
- Study lifetime GHG impacts of the ALP including under a robust hydrogen alternatives scenario.
  - o The GHG study analyzes a 15-year window of climate emissions, from 2030-2045 only, and presents results without disclosure of assumptions around hydrogen alternatives adoption. Based on the data available, the GHG study fails to examine decarbonization pathways that rely heavily on direct electrification of end-uses with renewable electricity. Rather, based on the flawed data of the Demand Study, the GHG study's limited window excludes crucial future impacts such as extended reliance on and intensification production of methane to produce hydrogen, and continued acceleration of direct electrification eliminating emissions ahead of hydrogen. **Comment 5-5**

Leakage Preliminary Data and Findings

The preliminary leakage report fails to explore end-use leakage estimates or provide specific leakage figures for any link in the ALP's hydrogen chain. Specific figures for hydrogen leakage are necessary to assess climate and public safety impacts of the ALP. **Comment 5-6**

Water Resources Evaluation

The preliminary water resources report fails to assess and report back on issues that are critical for assessing the environmental impact or basic feasibility of supplying hydrogen to the Angeles Link project. The water study does not address any environmental impacts of the project's water draw despite the gas industries' long history of imperiling water resources for low-income, rural, and marginalized communities. Substantially more information is needed, at this early stage, to understand the ALP's water impacts. **Comment 5-7** Particularly, the water study must:

- Study safeguards must be followed to ensure the ALP's water draw does not compete for resources serving water strapped communities. **Comment 5-8**
- Study and include present conditions analysis of drinking water supply in communities that water may be drawn from. **Comment 5-9**
- Study and include energy costs and emissions estimates to purify and deliver water used to supply the ALP. **Comment 5-10**
- Financial costs to develop, purify, deliver, or contract for water used to supply the ALP.
- Study and include water impacts from electricity production required to support water purification, electrolysis or other processes required to supply hydrogen to the ALP. **Comment 5-11**

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- Study and include data on size or potential impacts of waste streams from water treatment or other wastewater streams. **Comment 5-12**

Respectfully Submitted.

Theo Caretto
Associate Attorney
Communities for a Better Environment

CC:
Emily Grant, SoCalGas
Chester Britt, Arellano Associates
Alma Marquez, Lee Andrews Group

Response to Comment 5-1: The Draft GHG Study Report will include estimates of GHG emissions associated with projected Angeles Link infrastructure, third-party producers and storage providers, and end-users based on anticipated Angeles Link hydrogen throughput scenarios (0.5 million metric tonnes per year (MMT/yr), 1.0 MMT/yr, and 1.5 MMT/yr). For further response related to assumptions in the Demand Study, please refer to Global Response 1.

Response to Comment 5-2: Please refer to Global Response 1, Response to Comment 1-1 to 1-4, and Response to Comment 3-1 to 3-13.

The Draft GHG Study Report will include estimates of GHG emissions associated with projected Angeles Link infrastructure, third-party producers and storage providers, and end-users based on anticipated Angeles Link hydrogen throughput scenarios (0.5 MMT/yr, 1.0 MMT/yr, and 1.5 MMT/yr).

Response to Comment 5-3: This GHG feasibility study is based on information currently available, and the analysis and corresponding conclusions are expected to evolve over time. The Draft GHG Study Report assumes that production of hydrogen will use renewable electricity with zero GHG emissions regardless of production method (i.e., electrolysis, biomass gasification, or steam methane reforming). The GHG Study assumes that no grid electricity would be used for production since grid electricity may result in hydrogen being produced using fossil fuels which would be in conflict with the definition for "clean renewable hydrogen" as defined in the Decision. The Decision includes in its definition of "clean renewable hydrogen" a prohibition on the use of "any fossil fuel in the production process," where "fossil fuel" is defined as "a mixture of hydrocarbons including coal, petroleum, or natural gas, occurring in or extracted from underground deposits."[30] The Draft GHG Study Report notes that in the case that electricity is temporarily unavailable for any reason, backup generators fueled by clean renewable hydrogen may be utilized.

For production from biomass gasification, the removal of moisture from biomass on-site at a biomass gasification facility may or may not be required. This is dependent on the biomass available in the area of operation and the supply chain process at the specific facility. Given this uncertainty, the assumption was made in the Draft GHG Study Report that biomass would be procured ready for combustion, and removal of moisture would not be required on-site. For production from steam methane reformation (SMR), the Draft GHG Study Report evaluated potential GHG emissions using RNG as a feedstock and hydrogen as a fuel for the heating equipment.

In response to stakeholder feedback, the Draft GHG Study will be supplemented with a summary of the lifecycle carbon intensity values of third-party production options (electrolysis, biomass gasification, and steam methane reforming) that were compiled based on a review of the limited literature available for each of the three production options evaluated in the Draft GHG Study Report. The supplemental analysis will appear in Appendix B of the Draft GHG Study Report.

Response to Comment 5-4: Please refer to Global Response 4.

[30] D.22-12-055 at 42.

Response to Comment 5-5: SoCalGas understand this comment's request to evaluate alternatives to the Project to reduce GHG emissions, including electrification. The Project Options & Alternatives Study (Alternatives Study) evaluates several alternatives to Angeles Link, including (i) hydrogen delivery alternatives, which includes a localized hydrogen hub; and (ii) non-hydrogen alternatives, which includes electrification.

The Alternatives Study evaluates electrification as an alternative to the Project as a combination of a system level transformation and through end-use case level technology changes, including the grid infrastructure required to support growing electric load for the system level transformation.

In response to the comment concerning the analysis of a 15-year window from 2030-2045, the GHG analysis used that window for purposes of the feasibility analysis based on an anticipated general implementation window for operation of the Project. In addition, SoCalGas has only accounted for GHG reductions from the displacement of fossil fuels with hydrogen for electric generation, mobility and hard-to-electrify industrial sectors.

In response to the comment that the draft GHG Study does not account for potential production of methane to produce hydrogen, the draft GHG Study evaluated potential GHG emissions from the identified production methods in a manner that would be consistent with the definition of "clean renewable hydrogen" in the Decision. That definition includes a prohibition on the use of "any fossil fuel in the production process," where "fossil fuel" is defined as "a mixture of hydrocarbons including coal, petroleum, or natural gas, occurring in or extracted from underground deposits."[31]

Response to Comment 5-6: The Leakage Study evaluated potential for leakage associated with anticipated Angeles Link infrastructure (e.g. pipeline and compression), as well as third-party production and third-party storage. Leakage associated with end users is out of scope for the study and would involve assumptions with a wide array of unknown variables. As will be explained in the draft GHG Study Report, the anticipated impact of leakage based on a preliminary high-level estimate to overall GHG emission reductions is very small.

Response to Comment 5-7: SoCalGas acknowledges and shares CBE's commitment to disadvantaged communities. The proposed Angeles Link Project does not include production of clean renewable hydrogen. Third-party producers will be responsible for acquiring and developing water supplies to support clean renewable hydrogen projects. The Water Resources Evaluation prepared for the Angeles Link feasibility stage identifies potential water sources third-party producers may pursue for their production projects. It is anticipated that third-party clean renewable production projects would undergo thorough environmental review, including a review of potential impacts associated with water supply development, pursuant to the CEQA and/or NEPA, as applicable, at the time such projects are proposed. As a component of the CEQA/NEPA analysis, local community impacts would be evaluated through several resource areas. For further response related to analysis of water supplies, please refer to Global Response 5.

In addition, to address potential impacts of construction and operation of the Angeles Link pipeline system and in response to feedback from the Angeles Link CBOSG, an Environmental Social Justice (ESJ) Plan is in development. The ESJ Plan will outline the proposed future engagement activities tailored to ESJ and disadvantaged communities (DACS), to be executed in Phase 2 of the Project, subject to CPUC approval. Additionally, as outlined in the draft ESJ Plan, a Community Benefits Plan will also be developed in consultation with the CBOSG. SoCalGas's Phase 1 Environmental and Environmental Social Justice

31 *Id*.

Analysis will also identify the ESJ and DAC communities near the conceptual pipeline corridors for the Project using the CalEnviroScreen and the Climate & Economic Justice Screening Toll (CEJEST).

Response to Comment 5-8 and 5-9: Please refer to Global Response 5.

Response to Comment 5-10: Clean renewable hydrogen production is not part of the proposed Angeles Link Project, and third-party producers would be responsible for developing, purifying, and delivering water supplies for clean renewable hydrogen production. To support cost estimates related to water purification needed for third-party production, the Water Resources Evaluation estimates energy consumption through kilowatt hours per year required for purification processes for each potential water source identified in the study. To support the feasibility analyses during Phase 1, the study will include cost estimates related to water acquisition, conveyance, and purification for third-party producers to produce clean renewable hydrogen. With respect to potential GHG emissions associated with water conveyance and treatment for third-party clean renewable hydrogen production, please refer to Global Response 3.

Response to Comment 5-11: An analysis of water impacts from the electricity production that may be required to support water purification or electrolysis, or other processes required for the production of clean renewable hydrogen is outside of the scope of the Water Resources Evaluation.

Response to Comment 5-12: The Water Resources Evaluation will include information on waste streams from water treatment. Specifically, the study will evaluate the volume of potential water losses from treatment of the potential identified water sources third-party producers may pursue. In addition, the study will evaluate the potential for water purification processes to produce a concentrate, or high-salinity waste liquid, that will need to be managed. The study will provide cost estimates for the management of that concentrate, including through discharge to existing brine disposal facilities or through evaporation ponds.

3.6 Comment Letter 6 – Communities for a Better Environment (CBE)

Comment Letter 6 – Preliminary Data and Findings (NOx, GHG, Leakage, and Water)

April 5, 2024

Southern California Gas Company
555 West Fifth Street,
Los Angeles, CA 90013

Submitted via email to ALP1_Study_PAG_Feedback@insigniaenv.com.

Feedback for Southern California Gas Company on Angeles Link Project Revised NOx Evaluation Preliminary Data and Findings

Communities for a Better Environment (CBE) submits this letter of feedback to Southern California Gas Company (SoCalGas) on the Revised Angeles Link Project NOx Evaluation Preliminary Data and Findings ("NOx study").

As an initial matter, the NOx study results were tainted by the erroneous findings of the draft Demand Report, which as several parties have raised, seriously overestimates hydrogen demand and ALP throughput by failing to consider cost and making significant assumptions about hydrogen technology adoption. This study's reliance on that report's enormous "Ambitions" demand scenario results in heavily skewed NOx emissions data. Because NOx emissions estimates and further assumptions detailed below are not made available in this study, it is difficult to examine or discern the full scale of impacts from this misstep. **Comment 6-1**

In the list of phase one requirements outlined in section 11 of the Decision, the PUC states that SoCalGas shall provide assessments of NOx emissions resulting from the Project, including appropriate controls to mitigate NOx emissions. **Comment 6-2** In producing the assessment, the PUC directs SoCalGas to address concerns raised by Sierra Club and CEJA regarding the environmental justice harms of NOx emissions related to hydrogen use in power generation, and industrial facilities. **Comment 6-3** Further, the Decision directs SoCalGas to engage with DAC and ESJ groups to identify potential community impacts such as NOx emissions. As outlined further below, the study fails to meet the requirements of the Decision because it does not provide data on NOx emissions resulting from the project or acknowledge environmental justice concerns. **Comment 6-4**

The study fails to report NOx emissions resulting from the Project.

The NOx study repeatedly fails to clearly represent projected emissions numbers by presenting "emissions reductions" instead of emissions. The study uses a two-part equation to calculate emissions and emissions reductions but fails to provide the numbers used to calculate both formulas and specifically does not include emissions numbers. Further, the study provides little to no background on the sources of data or specific methodology beyond referencing the flawed Demand Study, which is not cited with specificity. By failing to provide the emissions factor, the study fails to address the requirements of the decision. And, consequentially, by failing to provide emissions data, the study has not presented the basic information necessary for fruitful discussion concerning hydrogen use NOx emissions or its community impacts. In doing so, the **Comment 6-5**

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study prevents groups from meaningfully responding to or engaging with SoCalGas on the issue of NOx emissions. **Comment 6-5**

The study fails to adequately examine NOx emissions in industrial facilities and from electricity generation.

The NOx study centers its results on the 99.6-99.8% NOx emissions reductions that will result were mobility sectors to transition from diesel and gasoline combustion to hydrogen fuel cell electric vehicles (FCEVs). By framing all other NOx emissions around these supposed mobility emissions reductions, the study fails to properly analyze NOx emissions from industrial facilities and electricity generation, which the study quantifies as representing 0.49% of reductions instead of providing emissions data. In fact, Appendix A of the study regarding methodology finds that "NOx emissions will stay the same or decrease where hydrogen is substituted for natural gas in combustion applications," indicating that a significant amount of NOx emissions are to be expected from industrial facilities and electricity generation which the study does not acknowledge. **Comment 6-6**

Further in discord, the study states that NOx emissions will decrease most importantly because the South Coast AQMD will require NOx reductions to meet State Implementation Plan (SIP) requirements. This unfoundedly assumes SIP reduction requirements are met via hydrogen FCEV's. Furthermore, by relying on existing legislation as a measure of projected NOx emission, the study is presupposing that NOx emissions regulation will continue to be necessary in industrial facilities, and electricity generation despite touting widespread emissions reductions. Despite this, the study fails to provide the relevant NOx emissions data for industrial facilities and electric generation. **Comment 6-7**

The study fails to identify and examine appropriate controls to mitigate NOx emissions.

The study repeatedly presents unknown, uncertain technological advances as a means of mitigating NOx emissions. By failing to clearly identify the controls and whether and how they may be appropriate to mitigate NOx emissions, the study fails to meet the explicit phase one requirements of the decision. Further, stakeholder groups cannot have meaningful discussions regarding NOx emission control technologies where the basis for discussion has not been provided.

The study further fails to acknowledge or analyze the technological feasibility or cost of NOx emissions control technology. The study also fails to analyze the applicability and feasibility of the various production, storage and transmission methods and technologies mentioned which result in varying NOx emissions. The feasibility and applicability of hydrogen technology with varying NOx emissions directly affects projected NOx emissions data provided by the study. **Comment 6-8**

The revised mobility language does not correct calculations to include market available hydrogen alternatives.

The NOx study was revised to address concerns raised regarding the omission of other NOx emission reducing technologies, such as battery electric vehicles (BEV) in the mobility **Comment 6-9**

2

analysis. However, the revision only included a mention of BEVs as an alternative while the language and analysis remained unchanged. This failure to adequately revise the mobility analysis is indicative of the misleading premise at the heart of the NOx study, that emissions reductions from the mobility sector can categorically indicate NOx emissions and associated risk analysis across the other end-use analyses. Further, the study's skewed emissions reductions results are predominantly a result of assumed developments in hydrogen fuel cell heavy duty vehicles, which are not currently widely available on the market. Failure to provide analysis of the availability of heavy-duty FCEVs calls into question the timeline and emissions calculations provided. **Comment 6-9**

Further, the NOx study fails to examine decarbonization pathways that include direct electrification of end-uses with renewable electricity. The study continues to perpetuate the flawed assumptions of the Deman Study, by examining a limited window which excludes crucial future impacts such as extended reliance on and intensification of methane production to produce hydrogen, and continued acceleration of direct electrification eliminating emissions ahead of hydrogen. While uncertainty exists in all facets of developing technology, phase one studies are meant to provide a reasonable background for project research, development, and discussion with stakeholders. Later arriving alternatives and environmental justice studies cannot remedy these failings because the core results are skewed by the above-identified omissions and miscounts. Avoiding the realities of technology feasibility and alternatives at this early-stage stymies fruitful research and prevents meaningful stakeholder engagement. **Comment 6-10**

Respectfully Submitted,

Theo Caretto
Associate Attorney
Communities for a Better Environment

CC:
Emily Grant, SoCalGas
Chester Britt, Arellano Associates
Alma Marquez, Lee Andrews Group
Angeles Link PAG Service List

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Response to Comment 6-1: The Draft NOx and other Air Emissions Assessment (NOx Study) evaluates the potential NOx emissions associated with the three demand scenarios (Conservative, Moderate, and Ambitious) from SoCalGas's Demand Study. Those demand scenarios reflect an estimate of total hydrogen market potential within SoCalGas's service territory. The NOx Study also assesses NOx emissions for the potential throughput scenarios for Angeles Link 0.5 MMT/Y, 1.0 MMT/Y and 1.5 MMT/Y), which represent a portion of the estimated market potential within SoCalGas's service territory. In response to comments concerning the demand scenarios in SoCalGas's Demand Study, please refer to Global Response 1 and Response to Comments 1-1 to 3-12.

Response to Comment 6-2: The Draft NOx Study Report assesses potential emissions and discusses opportunities to mitigate NOx emissions.

Response to Comment 6-3: SoCalGas shares CBEs' commitment to disadvantaged communities and is committed to evaluating the potential impacts of hydrogen use in power generation and industrial facilities. The Draft NOx Study assess the potential for both NOx emissions increases and reductions associated with Angeles Link, as well as potential NOx emissions increases and decreases from third-party production and third-party storage, as well as from end users. Specifically, the Draft NOx Study evaluates potential NOx and other air emissions associated with new hydrogen infrastructure (i.e., third-party production, third-party storage, and transmission), as well as potential NOx emissions associated with end users in the mobility, power generation, and hard-to-electrify industrial sectors.

In addition, in response to feedback from the Angeles Link CBOSG, an Environmental and Social Justice Community Engagement Plan (ESJ Plan) is in development. The ESJ Plan will provide a framework for engaging ESJ communities and DACs during Phase 2 of the Project and will describe how SoCalGas's engagement strategies align with the goals of the CPUC's Environmental Social Justice Action Plan and other state and federal ESJ goals. Additionally, the engagement that follows from the ESJ Plan will help shape the development of a Community Benefits Plan. The Community Benefits Plan will be developed in consultation with the CBOSG to meaningfully provide benefits to communities that could be affected by the construction and operation of Angeles Link.

SoCalGas also recognizes the position paper released in October 2023 by a coalition of nine environmental justice organizations throughout California titled, "*Equity Principles for Hydrogen*" (Equity Principles).[32] SoCalGas believes the Equity Principles is a foundational document that can help guide the company as SoCalGas proceeds with Angeles Link to foster meaningful conversation with environmental justice communities. SoCalGas sees significant alignment between many of the values and positions outlined in the Equity Principles and SoCalGas's vision for Angeles Link, as the Equity Principles underscore the importance of incorporating equity, sustainability, and environmental justice considerations when planning the future of hydrogen infrastructure in California. SoCalGas's response to the Equity Principles was provided in May 2024, and SoCalGas will incorporate the Equity Principles and that Response as attachments into the forthcoming ESJ Plan.

Response to Comment 6-4: Please refer to Response 6-3.

Response to Comment 6-5: SoCalGas recognizes the Preliminary Data and Findings provided a summary of the Draft NOx Study's initial findings and did not include all underlying data or assumptions supporting the underlying findings. The Preliminary Findings were intended to provide a preliminary summary of the analysis, with the full analysis and underlying assumptions to be included in the draft report. The Draft NOx Study will include the excel files used to prepare the calculations that produced the results provided in the report. Additionally, the report and its appendix contain detailed information and

[32] Equity Principles for Hydrogen. Accessible at: https://www.cbecal.org/wp-content/uploads/2023/10/Equity-Hydrogen-Initiative-Shared-Hydrogen-Position-1.pdf

descriptions regarding how the emission factors were developed, including assumptions and data used to prepare the calculations.

Response to Comment 6-6: The Draft NOx Study Report will provide detailed information regarding anticipated NOx reductions and how those estimates were developed for each of the end-user sectors, including power generation and hard-to-electrify industrial.

Response to Comment 6-7: The Draft NOx Study Report will provide detailed information regarding anticipated NOx reductions and how those estimates were developed for each of the end-user sectors, including power generation and hard-to-electrify industrial. Local Air Districts' obligations to meet state and federal ambient air quality standards necessitate the need for combustion equipment to continue to meet current and future emission limits as defined by the local air districts, CARB and the federal EPA. For example, air permitting of new and modified equipment requires New Source Review including applicable emission limits such as Best Available Control Technology (BACT) and Best Available Retrofit Control Technology (BARCT).

Response to Comment 6-8: The Draft NOx Study Report discusses opportunities to mitigate NOx emissions, including evaluation of control technology. Information in the Draft NOx Study Report regarding production, storage, and transmission methods is based on information provided in the parallel Phase 1 studies such as the Production Study and the Pipeline Sizing and Routing Study. SoCalGas completed this analysis using the best available information at the time of the study during this feasibility stage. NOx mitigation opportunities exist in two general categories that encompass many considerations. One is design, equipment designed to combust H2 specifically will incorporate various elements like fuel air mixture, temperature, flame detection, flow rate and combustion chamber design and a number of other parameters to optimize equipment performance specific to H2 combustion. The second factor is control equipment, an example is NOx control equipment like NOx storage and reduction (NSR) catalysts are a well-known and broadly used technology to reduce NOx emissions from combustion engines, which may also be applied for hydrogen fueled engines in the future.

Response to Comment 6-9: In response to stakeholder input, SoCalGas reissued its NOx Study Preliminary Data and Findings to clarify that the study only includes projected reductions from fossil fuel displacement using hydrogen and does not take into account NOx reductions from BEVs.

Response to Comment 6-10: SoCalGas is conducting all Phase 1 studies to provide the information and analysis related to the proposed Project and its potential future impacts that is possible to provide during this feasibility phase of the Project. In response to this comment concerning the Demand Study, please refer to Global Response 1. In response to the comment concerning an analysis of other decarbonization pathways, such as electrification, please refer to Response 5-5.

3.7 Comment Letter 7 – Environmental Defense Fund (EDF)

Comment Letter 7 – Preliminary Data and Findings (NOx, GHG, Leakage, and Water)

From:	Michael Colvin
To:	alpag@socalgas.com; ALP1 Study PAG Feedback
Cc:	Emily Grant
Subject:	New EDF paper on H2 from our science team
Date:	Friday, March 1, 2024 1:10:16 PM
Attachments:	image001.png

You don't often get email from mcolvin@edf.org. Learn why this is important

Dear Angeles Link PAG folks,

Environmental Defense Fund's hydrogen science team has just published a new peer-reviewed paper in the journal *Environmental Science & Technology*. The purpose of this study is to show the importance of including overlooked factors in hydrogen climate impact assessments, so that we have accurate foundations to make the best policy, investment, and deployment decisions for a clean energy transition with hydrogen. This paper shows hydrogen deployment can be better or worse for the climate when three critical (but typically overlooked) factors are included in lifecycle assessments: the **indirect warming effects of hydrogen emissions, observed methane emissions intensities, and near-term timescales**.

This study builds upon our prior publication on the climate impacts of hydrogen by looking at eight specific hydrogen (production-to-end use) pathways -- including blue and green H2 scenarios across the industrial, power and transportation sectors. With the new hydrogen economy still in its infancy, this study points to one concrete way that we can ensure that we maximize the climate benefits of hydrogen: robust climate accounting.

You can find the study here, and EDF's statement here.

Comment 7-1

Please let us know if you have any questions about this study, or if you or your teams would like a briefing.

Best

Michael

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Response to Comment 7-1: SoCalGas appreciates this information and has incorporated this article and the article's applicable information in the Draft Greenhouse Gas Emissions Evaluation. SoCalGas will continue to engage with EDF for further input on hydrogen emissions accounting.

3.8 Comment Letter 8 – Environmental Defense Fund (EDF)

Comment Letter 8 – Preliminary Data and Findings (NOx, GHG, Leakage, and Water)

Environmental Defense Fund

March 28, 2024

Chester Britt
Planning Advisory Group Facilitator

Emily Grant
Angeles Link Senior Public Affairs Representative
Southern California Gas Company

Alisa Lykens
Director
Insignia Environmental

Subject: Environmental Defense Fund Comments on Greenhouse Gas Emissions and Leakage Preliminary Reports

As a follow-up to the draft reports on greenhouse gas (GHG) emissions and leakage preliminary data and findings reports shared on March 14, 2024, Environmental Defense Fund (EDF) submits the following comments.

First, EDF reiterates **the concerns raised in the EDF and Natural Resources Defense Council (NRDC) Joint Comments** shared February 23, 2024, with regards to the level of hydrogen demand projected in the Angeles Link draft demand study. The findings of the GHG emissions draft report are based on the demand figures from the draft Demand Study which, as the Joint Comments pointed out, are incredibly high compared to analogous projections of hydrogen demand.[1] As a result, the emissions reductions impact found in the GHG emissions draft report would also be far higher than what could be expected from other data sources and analyses. Moreover, because the draft Demand Study did not take the cost of hydrogen into account—and therefore overlooks a key factor that would *actually* determine the level of supply and demand—EDF notes that the GHG emissions draft report is similarly incomplete. This limitation should be clearly stated in the executive summary of the final GHG emissions report. **Comment 8-1**

Second, EDF strongly recommends that **references to the role of hydrogen as an indirect GHG be included in the executive summaries** of the final GHG emissions report and the final Leakage report. The draft GHG emissions report includes a discussion on the current research and **Comment 8-2**

[1] GHG Draft Report at 4; EDF-NRDC Joint Comments on the Demand Study Draft report at 1.

findings around hydrogen's climate impacts, while noting various gaps that still exist.[2] The climate impacts of hydrogen leakage are directly relevant to the overall climate impacts of the Angeles Link Project; and have been consistently highlighted by EDF as a key concern.[3] Given this direct relevance and significance, the potential climate impacts of hydrogen leakage should be highlighted in the executive summaries of the GHG and leakage reports. **Comment 8-2**

Third, **<u>specific leakage figures and their climate impacts should be included</u>** in the GHG and leakage reports. Both the draft GHG and leakage reports decline to provide specific figures on the amount and climate impacts of hydrogen leakage potentially associated with the Angeles Link project, citing a lack of detailed infrastructure information or consensus figures on leakage.[4] EDF notes, however, that the same objections could be raised against any demand figures or GHG emissions impact figure provided in the draft reports. Instead, SoCalGas provides those figures through a series of assumptions, resulting in a range of potential impacts based on different input values. EDF believes applying the same process to the impacts of hydrogen leakage would be both possible and consistent. In fact, the draft GHG report lays out this exact process and implies that such calculations do exist: **Comment 8-3**

> One potential high level conservative approach to estimate the potential impact to climate change would be to assume conservative ranges of leakage rates and GWPs (GWP 100) from the values available in the scientific literature (as summarized in Table 2 of the parallel Leakage Study) and apply those to the Angeles Link Throughput Scenarios being considered. [...] Based on preliminary calculations, this proposed methodology indicates that the impact to the predicted overall GHG emissions reductions from combustion associated with Angeles Link and third-party production and storage would be very low (i.e., less than 3% for high throughput scenario) when considering the addition of potential GHG emissions from the four leakage sectors evaluated in the parallel Leakage Study.[5]

<u>Leakage values and associated climate impacts should be provided as low-, medium-, and high-scenarios</u> using the range of inputs already identified by SoCalGas in Table 17 of the GHG Draft Report and Table 2 of the Leakage Draft Report.[6] **Comment 8-4**

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[2] GHG Draft Report at 39-41.
[3] EDF Phase 1 Study Topics and Scope of Work Comments at 1.
[4] GHG Draft Report at 40; Leakage Draft Report at 3.
[5] GHG Draft Report at 40.
[6] GHG Draft Report at 41 and Leakage Draft Report at 12.

Respectfully,

Michael Colvin
Director, California Energy Program

Joon Hun Seong
Senior Energy Decarbonization Analyst

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Response to Comment 8-1: The Draft Greenhouse Gas Emissions Evaluation (GHG Study) evaluates the potential GHG emissions associated with the three demand scenarios (Conservative, Moderate, and Ambitious) from SoCalGas's Demand Study. Those demand scenarios reflect an estimate of total market potential within SoCalGas's service territory. The GHG Study also assesses GHG emissions for the potential throughput scenarios for Angeles Link (0.5 MMT/Y, 1.0 MMT/Y and 1.5 MMT/Y), which represent a portion of the estimated market potential within SoCalGas's service territory. SoCalGas acknowledges that the Demand Study did not address the commodity cost of hydrogen. In response to comments concerning the demand scenarios in SoCalGas's Demand Study, please refer to Global Response 1 and Response to Comments 1-1 to 3-12.

Response to Comment 8-2: SoCalGas appreciates this comment. The Draft GHG Study will include information on the climate considerations for hydrogen leakage. The Draft GHG Study will address how a literature review identifies hydrogen as anticipated to have indirect climate impacts. The draft Leakage Assessment refers to the GHG Study as a high-level analysis of how leakage may impact climate change (e.g., GWP).

Response to Comment 8-3: In response to stakeholder feedback, the draft Leakage Assessment includes a preliminary high-level range of estimates of the potential for leakage associated with Angeles Link infrastructure and third-party producers and storage. This estimate was based on the range of leakage values found in the literature and summarized in Table 2 of the Leakage Preliminary Data & Findings applied to the low, medium, and high Angeles Link throughput scenarios. The draft GHG report utilizes these estimates by applying the range of estimated GWP 100 values. These values are then compared to the overall GHG emission reductions that will be provided in the Draft GHG Study.

Response to Comment 8-4: This comment requests leakage values and associated climate impacts to be provided as low, medium, and high scenarios. The Draft GHG Study includes that analysis. The Draft GHG Study provides a range of potential leakage values and the associated climate impacts for the low, medium, and high throughput scenarios for Angeles Link. The draft Leakage Assessment includes a preliminary high-level range of estimates of the potential for leakage associated with Angeles Link infrastructure and third-party producers and storage. These estimates were based on the range of leakage values found in the literature and summarized in Table 2 of the Leakage Preliminary Data & Findings. The Draft GHG Study applies the ranges of leakage estimates for the low, medium, and high Angeles Link throughput scenarios too the range of estimated GWP 100 and GWP 20 values as identified in Table 17 of the GHG Preliminary Data & Findings document. These values are then compared to the overall GHG emission reductions provided in the Draft GHG Study.

3.9 Comment Letter 9 – Food and Water Watch (FWW)

Comment Letter 9 – Preliminary Data and Findings (NOx, GHG, Leakage, and Water)

March 29, 2024

Submitted via email to ALP1_Study_PAG_Feedback@insigniaenv.com.

RE: Feedback on the Preliminary Data and Findings of the Angeles Link Project and CBOSG Process

Food & Water Watch, as part of the Community Based Organization Stakeholder Group (CBOSG), submits this letter of feedback regarding the preliminary data and findings of the Angeles Link Project by the Southern California Gas Company (SoCalGas) and the CBOSG process. Concerns relating to the preliminary data and findings and the CBOSG process are as follows:

Preliminary Data and Findings Reporting:

Water Resource Evaluation:

The report provided by SoCalGas relies on broad assumptions about water availability across a vast service territory, and fails to reflect local water scarcity issues, environmental constraints, and the specific needs of diverse communities within the service area. In the report, SoCalGas claims that the volume of water needed for the project would be 0.01-0.03% of the total amount of water used in the state of California. The state continues to be impacted by severe climate conditions which has resulted in water scarcity for many communities. There needs to be an in-depth analysis of the environmental impact of extracting vast quantities of water in a state that is impacted by periods of drought, as well as the environmental impact of intensive water treatment processes and the energy required for those processes. **Comment 9-1**

In addition to the environmental impact, there is no clarity on how the project's water demands and treatment processes might affect local water rates, availability, or the socioeconomic dynamics of communities within SoCalGas's service territory. **Comment 9-2**

NOx Emissions Evaluation:

Although the report's findings claim a significant reduction in NOx emissions, the report relies on assumptions and generalizations. The report applies a uniform methodology across different sectors (mobility, power generation, industrial) without considering sector-specific variations in technology readiness, hydrogen utilization efficiencies, and existing infrastructure which could oversimplify the complex dynamics of NOx emissions reductions. The estimation of NOx emissions reductions also heavily relies on the regulatory environment and the adoption of best available control technologies. **Comment 9-3**

Therefore, if regulatory standards evolve or if anticipated NOx control technologies do not perform as expected, the projected NOx emissions reductions may be accurate. **Comment 9-3**

Leakage and Environmental Impact:

The report acknowledges that hydrogen leakage would be harmful, as well as the potential sources for leakage when it comes to the production, compression, storage, and transmission of hydrogen. And yet, this report fails to provide detailed volumetric estimates of potential leakage and heavily relies on the assumed advancement of leak detection and mitigation technologies without concrete timelines or proof of viability. **Comment 9-4**

Greenhouse Gas Emissions Analysis:

Although the report claims the potential for significant reductions in greenhouse gas (GHG) emissions across various demand scenarios, this heavily depends on assumptions regarding the availability, scalability, and adoption rates of hydrogen technology across those sectors. The environmental impacts of hydrogen leakage are not fully accounted for in this analysis. There are indirect GHG implications of hydrogen, notably its impact on methane levels. **Comment 9-5**

There needs to be an alternatives study to the Angeles Link Project that analyzes how the projected GHG reductions from the Angeles Link project compare with potential reductions achievable through clean energy projects. **Comment 9-6**

Community Based Organization Stakeholder Group Process:

There continues to be a lack of transparency from SoCalGas, such as the ratepayer impacts, environmental justice impacts, and safety impacts of the Angeles Link Project, as well as the intended use of the hydrogen. During CBOSG meetings, SoCalGas has claimed that the hydrogen would be used for what they claim are hard to electrify sectors. Yet, given that SoCalGas held a tour of their Hydrogen Model House in Downey for the CBOSG members and has been attempting to pipe hydrogen into communities such as the campus of the University of California Irvine and Orange Cove, which has not been disclosed to the CBOSG, SoCalGas needs to be honest about plans of having hydrogen for residential use. **Comment 9-7** There is also the issue of SoCalGas rushing this phase of the project. SoCalGas must provide an updated and clear timeline for Phase One. **Comment 9-8**

Sincerely,

Andrea Vega
Southern California Senior Organizer
Food & Water Watch

Response to Comment 9-1: SoCalGas appreciates this comment concerning drought conditions, climate change, and potential local impacts of water usage. Please refer to Global Response 5 and to response to Comment 5-7.

Response to Comment 9-2: SoCalGas understands concerns around affordability. Please refer to Global Response 5.

Response to Comment 9-3: SoCalGas agrees that there are a number of variables that could impact potential NOx emissions associated with new hydrogen infrastructure by 2045. The Draft NOx Study evaluates the potential for both NOx emissions increases and reductions associated with Angeles Link. The estimates account for emissions from the transmission of hydrogen, as well as from third-party production, third-party storage, and end users. The Draft NOx Study also identifies minimization opportunities to reduce NOx emissions. As more details of the Project become available in future phases, the analysis of potential NOx emissions associated with the Project may become more refined and may be further updated based on any changes to applicable regulations and/or available NOx control technologies. While SoCalGas recognizes the potential for the conclusions to be refined as the Project, the regulatory environment, and potential control technology advance, the Draft NOx Study provides its analysis based on the best information available during this feasibility stage.

Response to Comment 9-4: In direct response to stakeholder feedback on the initial findings of the leakage study, the leakage study expanded its analysis to include preliminary high-level volumetric estimates of the potential for leakage based on a range of values derived from a literature review. The analysis was developed using the low, medium, and high Angeles Link throughput scenarios. The range of high-level leakage estimates will also be incorporated into the parallel Angeles Link Phase 1 Greenhouse Gas (GHG) Emissions Evaluation to account for the range of potential leakage when considering the overall expected GHG reductions associated with Angeles Link. The incorporation of the potential leakage rates into the GHG Study supplements the analysis of the role hydrogen leakage may play as an indirect GHG. In response to the comment concerning the identified mitigation technologies, the Leakage Study provides its analysis based on the best information available during this feasibility stage. The analysis of potential mitigation strategies may evolve as more details of the Project are refined in future phases, and as applicable regulations and potential mitigation technologies or strategies advance.

Response to Comment 9-5: The Draft Greenhouse Gas Emissions Evaluation (GHG Study) evaluates the potential GHG emissions associated with the three demand scenarios (Conservative, Moderate, and Ambitious) from SoCalGas's Demand Study, which analyzes potential demand for clean renewable hydrogen across the mobility, power generation, and industrial sectors. Those demand scenarios reflect an estimate of total market potential within SoCalGas's service territory. The GHG Study also assesses GHG emissions for the potential throughput scenarios for Angeles Link (0.5 MMT/Y, 1.0 MMT/Y and 1.5 MMT/Y), which represent a portion of the estimated market potential within SoCalGas's service territory. Assumptions on the scalability and adoption rates of hydrogen use across the three sectors are built into the Demand Study. In response to the comment concerning those underlying assumptions in the Demand Study, please refer to Global Response 1 and to Responses to Comments 1-1 to 3-12. For additional information on the incorporation of potential hydrogen leakage into the GHG emissions analysis in the GHG Study, please refer to Response to Comment 9-4.

Response to Comment 9-6: SoCalGas appreciates this comment concerning the comparison of the potential GHG emission reductions associated with Angeles Link and the potential GHG reductions associated with potential alternatives to the Project. The separate Angeles Link Phase 1 Project Options & Alternatives Study (Alternatives Study) will evaluate several decarbonization alternatives to Angeles Link, including alternative methods to deliver clean renewable hydrogen to end users and non-hydrogen alternatives such as electrification. A quantitative analysis of potential GHG emissions associated with those potential alternatives is outside of the scope of the analysis for the Phase 1 feasibility analyses. However, the separate Phase 1 Environmental Study will provide a high-level qualitative analysis of potential GHG emissions impacts associated with the alternatives. In addition, it is anticipated that more analysis comparing the Project's potential GHG impacts to potential GHG impacts associated with potential alternatives will be conducted as the Project undergoes the expected environmental review in future phases.

Response to Comment 9-7: Please see Global Response 2. Preliminary Data and Findings Information about cost effectiveness, environmental social justice, and safety were not available and therefore not presented in the first quarter. Preliminary Data and Findings on those three studies will be discussed in upcoming meetings or workshops.

The objective of the Angeles Link is to transport clean renewable hydrogen to hard-to-electrify sectors in the Central Valley and the Los Angeles Basin. SoCalGas does not include plans to transport blended hydrogen into residential uses with the Angeles Link. SoCalGas's hydrogen home called the H2 Innovation Experience (H2IE) and SoCalGas's proposed demonstration projects at the University of Irvine and in Orange Cove are distinct projects[33] and are separate from SoCalGas's proposed Angeles Link Project. SoCalGas' intent in providing an optional tour of its H2IE to PAG and CBOSG members was purely informational and not intended to demonstrate how the Angeles Link could function. SoCalGas received positive feedback during and after the tour from CBOSG and PAG members.

Response to Comment 9-8: Please see Global Response 2.

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[33] *See* A.22-09-006, Joint Amended Application of Southern California Gas Company, San Diego Gas & Electric Company, Pacific Gas and Electric, and Southwest Gas Corporation to Establish Hydrogen Blending Demonstration Projects, filed March 1, 2024.

3.10 Comment Letter 10 – Protect Playa Now (PPN)

Comment Letter 10 – Preliminary Data and Findings (NOx, GHG, Leakage, and Water)

From:	Grant, Emily
To:	Alma Marquez; Protect Playa
Cc:	ALP1 Study CBO Feedback; Harriel, Mike
Subject:	RE: Inquiry: Preliminary Data and Findings Feedback and Additional Questions
Date:	Tuesday, April 2, 2024 11:52:46 AM
Attachments:	image001.png

Hi Faith –

Thanks for your email, as well as your patience while I was out of the office.

As Alma mentioned, we submitted your questions and feedback to Insignia so SoCalGas can begin the response process. There are numerous staff and subject matter experts who work on addressing stakeholder feedback, and as we move further into the Phase One studies, the number and depth of questions, comments, and suggestions is growing. To make sure we are adequately and transparently responding to every comment submitted, sticking to the process is key.

With that said, Insignia now has your email below and will track it with the feedback received within this comment period. Our responses, along with your original communication, will be included in our Quarterly Report. The Quarterly Report will also include other stakeholder feedback submitted in the feedback windows, as well as our responses.

Please let me know if you have any questions about this process. As I stated above, when SoCalGas implemented this last year, we found it's the best way to respond to all of our stakeholders, and in the most transparent way possible.

Thank you,

Emily Grant
Regional Public Affairs Manager
Angeles Link | SoCalGas
714-388-4889

From: Alma Marquez <almarquez@leeandrewsgroup.com>
Sent: Monday, March 25, 2024 5:24 PM
To: Protect Playa <protectplayanow@gmail.com>
Cc: ALP1_Study_CBO_Feedback@insigniaenv.com; Harriel, Mike <MHarriel@socalgas.com>; Grant, Emily <EGrant1@socalgas.com>
Subject: [EXTERNAL] RE: Inquiry: Preliminary Data and Findings Feedback and Additional Questions

Hello Faith,

Thank you for reaching out to us regarding your feedback and additional questions. I am forwarding Insignia your questions to have the Subject Matter Experts review your concerns and get back to you with responses. The team is doing their best to get back to all the questions we have received during this period. I also wanted to share that Emily is out on vacation this week however, feel free to continue to reach out for any other questions.

Thank you again for reaching out and I look forward to continue working with you on Angeles Link.

Best regards,

ALMA MARQUEZ
Vice President of Government Relations| Lee Andrews Group, Inc.

700 S. Flower Street, Suite 1275
Los Angeles, CA 90017
Office: 213.891.2965, Ext. 103 | 562-922-3564
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Lee Andrews GROUP
Moving your ideas forward

From: Protect Playa <protectplayanow@gmail.com>
Sent: Monday, March 25, 2024 8:00 AM
To: Alma Marquez <almarquez@leeandrewsgroup.com>; Grant, Emily <EGrant1@socalgas.com>
Subject: Inquiry: Preliminary Data and Findings Feedback and Additional Questions

Good Morning Emily and Alma,

I hope this message finds you well. As I am in the process of finalizing my feedback on the Preliminary Data and Findings reports, I've come across several questions that I believe would benefit from further clarification. To ensure the completeness and accuracy of my feedback, I would greatly appreciate it if you could provide detailed answers to these inquiries or direct me to the appropriate contact who can assist me with these matters.

Additionally, I have a few questions that are not directly related to the reports but are relevant to the overall project context. I am keen to gather insights on these topics as well.

Thank you for your time and assistance. I look forward to your guidance and am ready to provide any additional information if needed.

Draft Water Resources Evaluation Results Doc: Comment 10-1

1. Could you share how you're planning to tackle the unique water availability and environmental challenges in different local areas? Comment 10-1
2. I'm curious about how the project's need for water might affect our local communities, especially in terms of water prices and any socioeconomic impacts. Could you shed some light on this?

NOx Preliminary Data and Findings:

1. I'd love to learn more about the NOx control technologies that are being considered for hydrogen combustion. Specifically, how well do they work outside the lab, in the real world? Comment 10-2
2. Could you give me a breakdown of the costs involved in this project, including setting up the infrastructure? I'm particularly interested in understanding how this might affect our ratepayers now and in the future. Comment 10-3

Leakage Preliminary Data and Findings:

1. Given the hopeful perspective on new leak detection and mitigation tech, are there any backup plans in case these technologies don't progress as hoped or run into practical hurdles? Comment 10-4

GHG Preliminary Data and Findings:

1. I'm curious about the specific limits we've set for hydrogen leakage to make sure shifting to a hydrogen economy doesn't accidentally bump up atmospheric methane levels. How were these limits decided on? Comment 10-5

Phase 1 and 2:

1. Could you let me know when we're expecting to wrap up Phase 1? I've heard there have been some adjustments to the schedule, and I'd love to get updated on the new timeline. Comment 10-6
2. After we complete Phase 1, will the CBOSG continue to be involved in Phase 2? I'm curious about how their participation will evolve. Comment 10-7
3. Financial Models and Analyses Request: "Would it be possible to share the detailed financial models and cost-benefit analyses? I'm particularly interested in learning about the impact on ratepayers, the funding strategies, and how this project compares with alternative energy projects. Comment 10-8

Preliminary Routing and Configuration:

1. I understand one of our Phase 1 goals was to map out connections between areas of hydrogen production and demand. Could you share information about the facilities or companies involved in hydrogen production and demand that we're planning the transmission for? Comment 10-9
2. Could we have a closer look at the map to see which communities the corridors under evaluation will affect? A more detailed map would really help us visualize the project's scope. Comment 10-10
3. During the 'Preliminary Routing and Configuration' talk, it was mentioned that Cultural and Tribal Resources are being considered. Since we don't have local tribal leaders directly involved yet, how is SoCalGas gathering this important information? Comment 10-11

PAG-CBO Environmental Justice Deck: Comment 10-12

1. The 'PAG-CBO Environmental Justice Deck' talked about 'boots on the ground' outreach during Phase Two. How does SoCalGas plan to ensure that the community feedback received at this stage will genuinely influence the project's design and mitigation strategies? **Comment 10-12**

Sincerely,
Faith Myhra
Pronouns: she/they
Writing from the traditional, ancestral, and unceded territory of the Tongva, Kizh, and Chumash People.
ProtectPlayaNow.org [protectplayanow.org]
Twitter [twitter.com]
Facebook [facebook.com]
Youtube [youtube.com]

Response to Comment 10-1: Please refer to Global Response 5.

Response to Comment 10-2: The Draft NOx Study evaluates potential mitigation measures that could be implemented to further reduce NOx emissions, including with equipment design, control of combustion temperature, and application of existing and emerging aftertreatment technologies. The technologies are described further in the Draft NOx Study. Existing technologies include selective catalytic reduction (SCR), selective non-catalytic reduction (SNCR), and non-selective catalytic reduction (NSCR). Emerging technologies discussed in the NOx Study include electron beam irradiation and electrochemical reduction. The NOx Study provides its analysis of potential mitigation measures based on the best information available during this feasibility stage. The analysis of potential mitigation strategies may evolve as more details of the Project are refined in future phases, and as applicable regulations and potential mitigation technologies or strategies advance.

Response to Comment 10-3: Given that Angeles Link is in the feasibility stage, SoCalGas does not yet have a detailed estimate for the Angeles Link project but expects to have one when it submits its CPCN Application in the future. With respect to ratepayer impacts, currently, the Phase 1 Decision authorizes SoCalGas to record costs up to $26 million (with a potential for a 15% increase upon request and showing) for Phase 1 activities. These costs will be presented for reasonableness review and rate recovery in a CPUC proceeding in the future.

Please also refer to Global Response 2.

Response to Comment 10-4: The Leakage Study provides its analysis on potential mitigation measures based on the best information available during this feasibility stage. The analysis of potential mitigation strategies may evolve as more details of the Project are refined in future phases, and as applicable regulations and potential mitigation technologies or strategies advance. The Draft Leakage Study was released in May 2024.

Response to Comment 10-5: SoCalGas is not aware of regulatory limits that apply to hydrogen leakage. For additional information on estimated volumetric leakage rates that were added to the Draft Leakage Study and will be incorporated into the Draft Greenhouse Gas Emissions Evaluation Report (GHG Study), please refer to Response to Comment 9-4.

Response to Comment 10-6: SoCalGas's anticipated schedule is to complete the Phase 1 feasibility studies for Angeles Link in Q3 2024. SoCalGas will file an application with the CPUC to move forward with Phase 2 at a future date.

Response to Comment 10-7: SoCalGas values the time and commitment of the CBOSG and will continue engaging local community-based organizations throughout subsequent phases of the Project.

Response to Comment 10-8: In response to the comment requesting information on potential Project costs and potential impacts to ratepayers, please refer to Response to Comment 10-3. In response to the comment concerning costs of the Project as compared to alternatives, the Angeles Link Phase 1 High-Level Economic Analysis and Cost Effectiveness Study will evaluate the cost effectiveness of the Project against alternatives and determine a methodology to measure cost effectiveness between alternatives. The alternatives evaluated include alternative methods of delivery clean renewable hydrogen to end users, as well as non-hydrogen alternatives such as electrification. The High-Level Economic Analysis and Cost Effectiveness Study will determine the potential levelized cost of clean renewable hydrogen to be delivered to end users and will compare that levelized cost to the identified alternatives.

Response to Comment 10-9: Angeles Link is proposed as a non-discriminatory pipeline system that is dedicated to public use and would transport clean renewable hydrogen from regional third-party production and storage sites to end users in Central and Southern California, including the Los Angeles Basin. The separate Phase 1 Demand Study, released for public review in January 2024, identifies potential demand centers that may receive the clean renewable hydrogen that Angeles Link would transport. The separate Phase 1 Production Planning & Assessment identifies regions that may be suitable for clean renewable hydrogen production, including the San Joaquin Valley in California, an area near the City of Lancaster, and an area near the City of Blythe. In addition, potential hydrogen production areas have been identified by California's proposed hydrogen hub through the ARCHES. [34] At this stage in the feasibility analysis, the preferred routes for Angeles Link are being developed to connect those identified demand centers with those potential production areas. Those preferred routes will be detailed in the Preliminary Routing/Configuration Analysis (Routing Study).

Response to Comment 10-10: In response to requests by PAG/CBOSG members, SoCalGas shared an updated map of the preliminary pipeline corridors under evaluation, which includes city names. This has been shared to the Living Library in the Informational Materials section.

Response to Comment 10-11: Please refer to Global Response 2.

In response to the comment concerning considering cultural and tribal resources, SoCalGas intends to identify several preferred routes for the Project in the Routing Study at the conclusion of Phase 1. At that time, SoCalGas will be able to identify tribes near the pipeline routes to further engage and understand local tribal interests and concerns. Additionally, as part of Phase 1 feasibility studies, SoCalGas is preparing an Environmental Analysis study that evaluates cultural and tribal cultural resources based on a records search and desktop information. During future phases, SoCalGas will also perform a detailed cultural and tribal cultural resources assessment, including field surveys, to identify locations of sensitivity along the preferred pipeline routes. As part of the anticipated environmental review process under the CEQA, formal tribal consultation would also occur subject to Assembly Bill (AB) 52[35] when SoCalGas applies for approval of the Project with the CPUC.

Response to Comment 10-12: SoCalGas remains committed to a robust stakeholder engagement process that will continue to inform the development of the Project in this phase and in future phases. Feedback received from the PAG and CBOSG has resulted in process improvements and changes to some Angeles Link feasibility studies. SoCalGas continues to solicit input from the PAG and CBOSG in its feasibility studies and will use those studies to inform subsequent phases.

For more information on the stakeholder engagement process, please refer to Global Response 2.

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[34] Renewable, clean hydrogen power is coming to California. Here's what you need to know. Accessible at: https://www.universityofcalifornia.edu/news/renewable-clean-hydrogen-power-coming-california-heres-what-you-need-know

[35] AB 52 requires public agencies to consult with tribes during the CEQA process. Accessible at: Tribal Cultural Resources (AB 52) - Office of Planning and Research (ca.gov)

3.11 Comment Letter 11 – Protect Playa Now (PPN)

Comment Letter 11 – Preliminary Data and Findings (NOx, GHG, Leakage, and Water)

March 28th, 2024
California Public Utilities Commission (CPUC)
505 Van Ness
Avenue San Francisco, CA 94102

RE: Feedback on the Preliminary Findings of the four Angeles Link and CBO Stakeholder Process

To the California Public Utilities Commission (CPUC),

I am reaching out to articulate deep-seated concerns regarding the Angeles Link Project, drawing upon insights from the Preliminary Data and Findings reports. These documents unveil substantial flaws that call for an in-depth evaluation by the CPUC.

Equally alarming are the issues arising from the Community-Based Organization (CBO) Stakeholder process tied to the same project. This process has notably fallen short in several key areas: it has failed to sufficiently engage tribal communities, has suffered from transparency deficits, and has been marked by irrelevant meeting activities and instances of misinformation. Collectively, these issues significantly detract from the integrity of the stakeholder engagement efforts, undermining the foundational principles of inclusive and transparent project development.

Comment 11-1

Preliminary Data and Findings Reporting:

Water Resource Evaluation Concerns:

The assertion that the project's water demands will comprise a mere 0.01-0.03% of California's total water usage fails to account for the regional water scarcity crises and the environmental impacts of extracting vast quantities of water. The report relies on broad assumptions about water availability and demand across a vast service territory. This generalized approach might not accurately reflect local water scarcity issues, environmental constraints, and the specific needs of diverse communities within the service area. It also does not account for all of the other Hydrogen Projects that will be competing for that water. The reliance on a broad spectrum of water sources, including treated wastewater and groundwater, does not fully mitigate the potential strain on California's water resources, especially under drought conditions. The assumption of ultrapure water being attainable through advanced treatment underscores a heavy dependency on technologies that may not be scalable or economically feasible across the required service territories.

Comment 11-2

NOx Emissions Evaluation Shortcomings:

While the reports propose significant NOx emissions reductions, the methodologies and assumptions applied—especially the reliance on unproven hydrogen combustion technologies and the anticipated widespread adoption of hydrogen fuel cells—cast doubt on the projected

Comment 11-3

outcomes. The lack of empirical data to support these claims, combined with a generalized approach that overlooks sector-specific variations and potential regulatory changes, undermines the credibility of the findings. Comment 11-3

Leakage and Environmental Impact:

The acknowledgement of hydrogen leakage as a potential source of environmental harm is alarming. Despite mitigation strategies, the absence of detailed volumetric estimates and reliance on literature for leakage rates highlight a significant gap in understanding the true environmental footprint of the project. This oversight could have detrimental impacts on greenhouse gas concentrations and atmospheric chemistry, particularly concerning the indirect effects on methane levels. Comment 11-4

Greenhouse Gas Emissions Analysis Deficiencies:

The reports' optimistic projections of GHG emissions reductions are predicated on assumptions regarding the clean production of hydrogen and its end-use applications. However, the potential indirect increase in atmospheric methane due to hydrogen leakage could negate the environmental benefits. Furthermore, the comparative analysis lacks consideration of other renewable energy technologies or energy storage solutions, presenting a skewed perspective on the project's environmental advantages. Comment 11-5

CBO Stakeholder Process:

The Angeles Link Project's CBO Stakeholder Process fails to meet the standard of the CPUC's Environmental and Social Justice Action Plan. It has significant shortcomings in aligning with the stated goals and methodologies prescribed for ensuring environmental justice, community engagement, transparency, and safety. These discrepancies not only raise concerns about the project's execution but also its potential impacts on vulnerable communities and the environment. Comment 11-6

Inadequate Tribal and Community Engagement:

The lack of robust engagement with local tribal leaders and communities directly conflict with the CPUC's emphasis on inclusive stakeholder engagement and the need for consent from tribal communities for projects of this nature. This oversight undermines the trust and collaborative potential crucial for the success of projects with significant environmental and social footprints. Comment 11-7

Lack of Transparency:

The issues of transparency, particularly in stakeholder identification and access to critical project documents, along with non inclusive scheduling of meetings, detract from the process's integrity. Comment 11-8

These factors contribute to a lack of accountability and inclusivity, falling short of the CPUC's guidelines that advocate for clear, accessible, and participatory engagement processes. Comment 11-8

Misinformation and Rushed Process:

The stakeholder process appears to have been unduly rushed, leading to inconsistencies in information provided by SoCalGas employees. This has resulted in confusion and concerns over the credibility of the information being shared. For instance, contradictory statements regarding the use of ammonia storage and misleading claims about hydrogen's impact as a greenhouse gas have been particularly troubling. It is concerning to note misinformation such as hydrogen being presented as not a greenhouse gas and incorrect references to the IPCC report's findings on hydrogen's impact. Socal Gas keeps saying the project is for hard to electrify sectors and then offer tours of the Hydrogen Model House and push testing on communities like UCI students and Orange Cove. This is clearly dishonest. Comment 11-9

Environmental Justice and Community Impact:

The project's documents and reports fail to comprehensively detail the environmental justice assessments and the specific strategies to mitigate negative impacts on disadvantaged communities. This gap points to a broader issue of ensuring that environmental justice principles are not only considered but are central to the project planning and execution phases, as emphasized in the CPUC's action plan. Comment 11-10

Cost Justification and Transparency:

The absence of a detailed financial breakdown and the lack of clarity regarding the project's cost-effectiveness and impact on ratepayers raise concerns about economic transparency and accountability. These elements are crucial for justifying the project's investments and ensuring that the economic implications for the communities involved are transparent and equitable. Comment 11-11

Technology and Safety Risks:

While the project acknowledges the technological and safety risks associated with large-scale hydrogen infrastructure, the provided documents lack detailed plans for addressing these risks comprehensively. This falls short of the CPUC's guidelines for rigorous safety assessments and transparent communication of mitigation strategies to stakeholders. Comment 11-12

<u>Conclusion:</u>

Considering these factors, it is imperative to re-evaluate the Angeles Link Project in light of its current alignment with CPUC's overarching goals for environmental justice, community engagement, and transparent, responsible energy infrastructure development. Prioritizing projects that demonstrate a clear commitment to environmental sustainability, safety, economic Comment 11-13 transparency, and, most importantly, respect for the voices and rights of all communities involved, will be crucial in moving forward. Comment 11-13

Sincerely,
Faith Myhra (she/they)
Member
Protect Playa Now
Writing from the traditional, ancestral, and unceded territory of the Tongva, Kizh, and Chumash People.

Response to Comment 11-1: Please see Global Response 2.

Response to Comment 11-2: The Water Resources Evaluation analyzes potential available water sources holistically in Central and Southern California in order to provide information on all of the potential sources third-party producers may pursue to produce clean renewable hydrogen. Clean renewable hydrogen production is not a part of Angeles Link and would be pursued by third parties. While the Water Resources Evaluation evaluates the potential water sources third-party producers may pursue, the study does not speculate which particular water sources may supply specific third-party production projects. More information on the water supply sources that may feed specific clean renewable hydrogen projects may be available and could be evaluated on a case-by-case basis as more details on specific clean renewable hydrogen production projects develop. For additional information related to potential local impacts associated with water resources for clean renewable hydrogen production, please refer to Global Response 5.

Response to Comment 11-3: The Draft NOx and other Air Emissions Assessment (NOx Study) evaluates the potential NOx emissions associated with the three demand scenarios (Conservative, Moderate, and Ambitious) from SoCalGas's Demand Study. Those demand scenarios reflect an estimate of total market potential within SoCalGas's service territory. The NOx Study also assesses NOx emissions for the potential throughput scenarios for Angeles Link (0.5 MMT/Y, 1.0 MMT/Y and 1.5 MMT/Y), which represent a portion of the estimated market potential within SoCalGas's service territory. In response to this comment raising concerns about the underlying assumptions about hydrogen adoption in the Demand Study, please refer to Global Response 1 and Response to Comments 1-1 to 3-12.

Response to Comment 11-4: In response to this comment concerning evaluating potential leakage rates in the Draft Hydrogen Leakage Report, please see Global Response 4.

Response to Comment 11-5: In response to the comment concerning potential climate change impacts related to potential hydrogen leakage, please see Global Response 4. In response to the comment concerning a comparative analysis of other potential renewable energy technologies or storage solutions, the separate Phase 1 feasibility analysis in the Draft Project Options & Alternatives Study will evaluate several potential alternatives to the Project, including alternative methods to deliver clean renewable hydrogen to end users and non-hydrogen alternatives such as electrification.

Response to Comment 11-6, 11-7, and 11-8: Please see Global Response 2. An Environmental and Social Justice Plan (ESJ Plan) is in development.

Response to Comment 11-9: Please see Global Response 2, Global Response 3, Global Response 4 and Response to Comment 9-7.

Response to Comment 11-10: SoCalGas appreciates the concerns related to potential impacts to environmental justice communities. Preliminary Findings and Date on Environmental and Social Justice was provided to the PAG and CBOSG on June 24, 2024. An ESJ Plan is in development. For more information on the ESJ Plan and ESJ analysis, please refer to Response to Comment 5-7.

Response to Comment 11-11: In response to the comment concerning costs of the Project and potential impacts to ratepayers, please refer to Response to Comment 10-3.

Response to Comment 11-12: Safety is foundational in all construction and operation and maintenance activities as SoCalGas designs the Angeles Link pipeline delivery system. Preliminary Findings on SoCalGas's Draft Plan for Applicable Safety Requirement (Safety Study) evaluates potential safety concerns involved with the transportation of hydrogen and was issued to the PAG and CBOSG for feedback on 4/12/24.

Response to Comment 11-13: SoCalGas appreciates your feedback and will continue to engage with the CPUC and stakeholders to inform the development of Angeles Link and to enable community stakeholders to meaningfully voice their input.

3.12 Comment Letter 12 – Physicians for Social Responsibility – Los Angeles (PSR-LA)

Comment Letter 12 – Preliminary Data and Findings (NOx, GHG, Leakage, and Water)

Feedback on Four Preliminary Finding Reports
3/29/24

Physicians for Social Responsibility - Los Angeles remains deeply concerned about the Community Based Organization Stakeholder Group process that has unfolded to date, and the proposed Angeles Link project overall, given a lack of adequate and accurate information needed to fully assess the project, and a lack of opportunity to discuss and resolve potential project flaws.

While meetings have been information heavy at times, there has been little room for substantive questions and conversation regarding the information offered, and meetings have given priority to presenters who share the perceived benefits of the project while disregarding important questions about safety, water consumption, and environmental justice. For many of us in CBOs, it can be difficult to find time to read through and respond adequately to hundreds of pages of information within such a short timeframe. Therefore, the feedback that SoCalGas and the CPUC have been getting so far should be considered partial and incomplete. **Comment 12-1**

Additionally, despite repeated requests for SoCalGas to get representation from local Indigenous Tribes and organizations, the only Indigenous recognition I've seen is during the land acknowledgements where SoCalGas commits to honoring the original stewards of the land. **Comment 12-2**

General concerns regarding the water report include: a lack of specificity around where water will be sourced; a disregard for localized water concerns and an attempt to minimize water consumption concerns by speaking of the water needs as a percentage of the overall state consumption rather than in regards to the specific source; an unrealistic over-reliance on recycled and treated water given the required energy, cost and additional waste streams needed for that approach; and a lack of regard for resilience questions that arise from depending on additional water in a drought-prone region that already exceeds its local water availability. **Comment 12-3**

The Greenhouse Gas analysis fails to address serious concerns regarding the warming impact of hydrogen leakage, which has the potential to negate some or potentially all of the greenhouse gas benefits of green hydrogen compared to methane. Also, disregarding or providing incomplete information about the emissions (climate and air pollutant) impacts of production methods and proposed end uses of the delivered hydrogen paints an incomplete picture of the overall climate impacts of the Angeles Link project. Generally, there is also a lack of clarity about how and where exactly SoCalGas plans to store hydrogen. **Comment 12-4**

As for the Leakage report, without accurate information about projected hydrogen leakage rates throughout the entire process and the related harms, including at end uses, it is impossible to assess the full environmental impact of this project. As previously mentioned, a failed approach to preventing hydrogen leakage would not only increase the cost of this project, but also negate any potential climate benefits of the project. **Comment 12-5**

The NOx report claims that the project will result in significant reductions in NOx pollution, but utilizes creative accounting to demonstrate these claims. Without a clear understanding of the end uses for hydrogen, particularly in the electricity generation sector, and what they would be displacing, it seems odd that SoCalGas is able to make such confident claims about NOx reductions. Additionally, it is important to note that even if there is an overall reduction in NOx emissions statewide, if the remaining emissions become increasingly concentrated in certain communities, this project would perpetuate environmental racism and injustice. This is particularly concerning as we are aware that SoCalGas intends to use existing rights of way and connect to end uses in existing environmental justice communities. **Comment 12-6**

Overall, Physicians for Social Responsibility - Los Angeles feels that this project is being unnecessarily rushed, with potentially enormous consequences for environmental justice communities, ratepayers, and SoCalGas' credibility. We urge an intentional shift to more substantive meetings, a more reasonable timeline, a commitment to living the values that SoCalGas espouses, and more responsiveness to the questions and concerns that have been raised to date. We look forward to continuing to engage on this proposed project. **Comment 12-7**

Response to Comment 12-1: SoCalGas appreciates this comment and has adjusted the PAG/CBOSG meetings to truncate presentations and allow for greater time for questions and answers during each meeting. For additional information concerning the stakeholder process, please also refer to Global Response 2.

Response to Comment 12-2: please refer to Global Response 2.

Response to Comment 12-3: In response to comments concerning water usage for clean renewable hydrogen production, please refer to Global Response 5 and Response to Comments 4-8 through 4-10. In addition, in response to the comment concerning recycled and treated water as potential water sources, the Water Resources Evaluation identifies a large list of potential water sources third-party clean renewable hydrogen producers may pursue and does not estimate which sources certain producers may pursue over others for particular production projects.

Response to Comment 12-4: In response to comments concerning hydrogen leakage and potential climate change impacts, please refer to Global Response 4. In response to comments concerning potential greenhouse gas emissions (GHG) impacts associated with third-party production and end uses of production, the GHG Emissions Evaluation Draft Report evaluates the direct GHG emissions associated with hydrogen combustion associated with new infrastructure (i.e., third-party production, third-party storage, and transmission of hydrogen), as well as GHG emissions reductions associated with displaced fossil fuels by end users in the mobility, power generation, and hard-to-electrify industrial sources. The potential for leakage at end users was not incorporated into the Draft Leakage Assessment because equipment-specific details for end users was not available and end users were considered out of scope for that assessment. Storage of clean renewable hydrogen, including the portions of the clean renewable hydrogen that Angeles Link may transport, would be constructed and operated by third parties.

Response to Comment 12-5: The draft Leakage Assessment is focused on the potential for leakage associated with the Angeles Link infrastructure (e.g. pipeline and compression), and third-party production and storage. Estimating leakage for end users is out of scope of this feasibility study. In response to stakeholder feedback, the draft Leakage Assessment identifies the magnitude of the potential for leakage as a range of volumetric estimates. These volumetric estimates feed into the draft GHG Evaluation where the range of GWP 20 and 100 are applied. The estimated impact to overall GHG reductions is also provided.

Response to Comment 12-6: SoCalGas remains committed to evaluating potential impacts of the Project to environmental and social justice communities. In response to the comment concerning potential underlying assumptions in the Draft Nitrogen Oxide (NOx) and other Air Emissions Assessment (NOx Study), the NOx Study evaluates the potential NOx emissions associated with the three demand scenarios (Conservative, Moderate, and Ambitious) from SoCalGas's Demand Study. Those demand scenarios reflect an estimate of total market potential within SoCalGas's service territory across the mobility, power generation, and industrial sectors. The NOx Study also assesses NOx emissions for the potential throughput scenarios for Angeles Link (0.5 MMT/Y, 1.0 MMT/Y and 1.5 MMT/Y), which represent a portion of the estimated market potential within SoCalGas's service territory. In response to this comment raising concerns about the underlying assumptions about hydrogen adoption in the Demand Study, please refer to Global Response 1 and Response to Comments 1-1 to 3-12.

In response to comments concerning potential NOx emissions in certain communities, maps provided estimated NOx reductions have been added to the NOx study.

Community considerations will continue to be a vital part of SoCalGas's stakeholder engagement process to inform the identification of a preferred route in Phase 2.

Response to Comment 12-7: Please see Global Response 2.

4 References

Bailey, Stephanie, Jennifer Campagna, Mathew Cooper, Quentin Gee, Heidi Javanbakht, and Ben Wender. 2023. 2023 Integrated Energy Policy Report. California Energy Commission. Publication Number: CEC-100-2023-001-CMF.

Cochran, Jaquelin, and Paul Denholm, eds. 2021. The Los Angeles 100% Renewable Energy Study. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-79444. https://maps.nrel. gov/la100/

Long, JCS, E Baik, JD Jenkins, C Kolster , K Chawla , A Olson , A Cohen , M Colvin , S M Benson , RB Jackson , DG Victor, SP Hamburg. 2024. "California needs clean firm power, and so does the rest of the world. Three detailed models of the future of California's power system all show that California needs carbon-free electricity sources that don't depend on the weather."

Fulton, L.; Jenn, A.; Yang, C.; Burke, A.; Acharya, T.; Li, X., et al. (2023). California Hydrogen Analysis Project: The Future Role of Hydrogen in a Carbon-Neutral California: Final Synthesis Modeling Report. *UC Davis: Hydrogen Pathways Program*. Retrieved from https://escholarship.org/uc/item/27m7g841

Ruth, Mark, Paige Jadun, Nicholas Gilroy, Elizabeth Connelly, Richard Boardman, A.J. Simon, Amgad Elgowainy, and Jarett Zuboy. 2020. The Technical and Economic Potential of the H2@Scale Concept within the United States. Golden, CO: National Renewable Energy Laboratory. NREL/TP- 6A20-77610. https://www.nrel.gov/docs/fy21osti/77610.pdf

APPENDIX 4 –

ATTENDEE LIST FOR PLANNING ADVISORY GROUP AND COMMUNITY BASED ORGANIZATION STAKEHOLDER GROUP MEETINGS AND WORKSHOP, INCLUDING THOSE INVITED

PAG February 15 Invitee List

Organization	First name	Last name
Agricultural Energy Consumers Association	Michael	Boccadoro
Air Products	JP	Gunn
Air Products	Lorraine	Paskett
Air Products	Seth	Hilton
Air Products	Miles	Heller
Air Products	Vince	Wiraatmadja
ARCHES	Angelina	Galiteva
ARCHES	Tyson	Eckerle
Bizfed	Sarah	Wiltfong
Bloom Energy	Christina	Tan
California Air Resources Board	Steve	Cliff
California Energy Commission	Rizaldo	Aldas
California Hydrogen Business Council	Katrina	Fritz
California Manufacturers and Technology Association	Lance	Hastings
California Manufacturers and Technology Association	Robert	Spiegel
California Public Utilities Commission	Arthur (Iain)	Fisher
California Public Utilities Commission	Christopher	Arroyo
California Public Utilities Commission	Christopher	Myers
California Public Utilities Commission	Matthew	Taul
California Public Utilities Commission	Jack	Chang
California Public Utilities Commission	Sasha	Cole
California Public Utilities Commission	Nick	Zanjani
California Public Utilities Commission	Nathaniel	Skinner
California Public Utilities Commission	Kaj	Peterson
California Public Utilities Commission	Benjamin	Tang
California Water Data Consortium	Deven	Upadhay
City of Long Beach*	Mario	Cordero
Clean Energy	Nora	Sheriff
Clean Energy Strategies representing the Utility Consumers' Acti	Tyson	Siegele
Communities for a Better Environment	Theo	Caretto
Communities for a Better Environment	Shara	Burwell
Communities for a Better Environment	Roberto	Cabrales
Earth Justice	Sara	Gersen
Energy Independence Now	Brian	Goldstein
Environmental Defense Fund	Joon Hun	Seong
Environmental Defense Fund	Michael	Colvin
Environmental Justice League	Russell	Lowery
GoBiz	Deedee	Myers
Green Hydrogen Coalition	Nick	Connell
Green Hydrogen Coalition	Hope	Fasching
Harbor Trucking Association	Karla	Sanchez
Harbor Trucking Association	Matthew	Schrap
Independent Energy Producers Association*	Jan	Smutny Jones
Independent Energy Producers Association*	Sara	Fitzsimon

PAG February 15 Invitee List

Organization	First name	Last name
International Longshore and Warehouse Union Local 13	Sal	DiConstanzo
International Longshore and Warehouse Union Local 13	Mark	Jurisic
International Longshore and Warehouse Union Local 13	Sophia	Dubrovich
Local Union 250	Nathaniel	Williams
Local Union 250	Hector	Carbajal
Los Angeles Department of Water and Power	Aaron	Guthrey
Los Angeles Department of Water and Power	Marty	Adams
Los Angeles Department of Water and Power	Paul	Habib
Los Angeles Department of Water and Power	Nermina	Rucic
Los Angeles Department of Water and Power	Jesse	Vismonte
Metropolitan Water District	Deven	Upadhyay
Natural Resources Defense Council	Pete	Budden
Port of Los Angeles	Mike	Galvin
Port of Los Angeles	Tim	DeMoss
Protect our Communities Foundation	Malinda	Dickenson
Reimagine LA	Rashad	Rucker-Trapp
Reimagine LA	Raul	Claros
Sierra Club	Monica	Embrey
Sierra Club	Katherine	Ramsey
South Coast AQMD	Maryam	Hajbabaei
South Coast AQMD	Sam	Cao
South Coast AQMD	Aaron	Katzenstein
Southern CA Water Coalition	Charley	Wilson
Southern California Association of Governments	Kome	Ajise
Southern California Generation Coalition	Norman	Pedersen
Southern California Leadership Council	Richard	Lambros
Southern California Pipe Trades	Rodney	Cobos
The United Association	Aaron	Stockwell
UC Davis Insitutue of Transportation Studies	Lukas	Wernert
UC Davis Sustainable Transportation Energy Pathways	Lew	Fulton
UCI Advanced Power and Energy Program	Jack	Brouwer
University of CA Riverside	Arun	Raju
Utility Reform Network (TURN)	Marcel	Hawiger
Utility Reform Network (TURN)	Marna	Paintsil Anning
Utility Workers Union of America 483	Ernest	Shaw
Utility Workers Union of America 483	Robin	Downs
Utility Workers Union of America 483	Anthony	Flores
Utility Workers Union of America Local 132	Joe	Moreno
Utility Workers Union of America Local 132	Mike	Cormode

February PAG Workshop - February 15, 2024

Organization	First name	Last name	In Person	Zoom
PAG				
Air Products	JP	Gunn		x
Air Products	Miles	Heller		x
California Energy Commission	Rizaldo	Aldas		x
California Hydrogen Business Council	Katrina	Fritz		x
California Public Utilities Commission	Arthur (Iain)	Fisher		x
California Public Utilities Commission	Christopher	Arroyo		x
California Public Utilities Commission	Matthew	Taul		x
California Public Utilities Commission	Sasha	Cole		x
California Public Utilities Commission	Nathaniel	Skinner		x
California Public Utilities Commission	Benjamin	Tang		x
Clean Energy Strategies representing the Utility Consu	Tyson	Siegele		x
Communities for a Better Environment	Theo	Caretto		x
Environmental Defense Fund	Joon Hun	Seong		x
Environmental Defense Fund	Michael	Colvin		x
Green Hydrogen Coalition	Hope	Fasching		x
Los Angeles Department of Water and Power	Aaron	Guthrey		x
Los Angeles Department of Water and Power	Xinhe	Li		x
South Coast AQMD	Sam	Cao		x
South Coast AQMD	Aaron	Katzenstein		x
Southern CA Water Coalition*	Charley	Wilson	x	
Southern California Generation Coalition	Norman	Pedersen		x
Southern California Pipe Trades	Rodney	Cobos		x
The United Association	Aaron	Stockwell		x
UC Davis Insitutue of Transportation Studies	Lukas	Wernert		x
UCI Advanced Power and Energy Program	Jack	Brouwer		x
Non PAG				
Arellano Associates*	Chester	Britt	x	
Arellano Associates*	Stevie	Espinoza	x	
Arellano Associates	Nancy	Verduzco		x
Arellano Associates*	Keven	Michele	x	
California Strategies	Marybel	Batjer		x
Insignia Environmental	Armen	Keochekian		x
Insignia Environmental	Julie	Roshala		x
Lee Andrews Group*	Alma	Marquez	x	
Lee Andrews Group*	Alyssa	Martinez	x	
SoCalGas*	Neil	Navin	x	
SoCalGas*	Darrell	Johnson	x	
SoCalGas*	Emily	Grant	x	
SoCalGas*	Jill	Tracy	x	
SoCalGas	Andy	Carrasco	x	
SoCalGas	Frank	Lopez	x	
SoCalGas	Pearl	Hsu		x

Attachment A

PAG February 15 Workshop Attendee Roster

#	First Name	Last Name	Affiliation
PAG Members			
1	JP	Gunn	Air Products
2	Miles	Heller	Air Products
3	Rizaldo	Aldas	California Energy Commission
4	Katrina	Fritz	California Hydrogen Business Council
5	Arthur (Iain)	Fisher	California Public Utilities Commission
6	Christopher	Arroyo	California Public Utilities Commission
7	Matthew	Taul	California Public Utilities Commission
8	Sasha	Cole	California Public Utilities Commission
9	Nathaniel	Skinner	California Public Utilities Commission
10	Benjamin	Tang	California Public Utilities Commission
11	Tyson	Siegele	Clean Energy Strategies representing the Utility Consumers' Action Network
12	Theo	Caretto	Communities for a Better Environment
13	Joon Hun	Seong	Environmental Defense Fund
14	Michael	Colvin	Environmental Defense Fund
15	Hope	Fasching	Green Hydrogen Coalition
16	Aaron	Guthrey	Los Angeles Department of Water and Power
17	Xinhe	Li	Los Angeles Department of Water and Power
18	Sam	Cao	South Coast AQMD
19	Aaron	Katzenstein	South Coast AQMD
20	Charley	Wilson	Southern CA Water Coalition*
21	Norman	Pedersen	Southern California Generation Coalition
22	Rodney	Cobos	Southern California Pipe Trades
23	Aaron	Stockwell	The United Association
24	Lukas	Wernert	UC Davis Insitute of Transportation Studies
25	Jack	Brouwer	UCI Advanced Power and Energy Program
Non-PAG Members			
26	Chester	Britt	Arellano Associates*
27	Stevie	Espinoza	Arellano Associates*
28	Nancy	Verduzco	Arellano Associates
29	Keven	Michele	Arellano Associates*
30	Marybel	Batjer	California Strategies
31	Armen	Keochekian	Insignia Environmental
32	Julie	Roshala	Insignia Environmental
33	Alma	Marquez	Lee Andrews Group*
34	Alyssa	Martinez	Lee Andrews Group*
35	Neil	Navin	SoCalGas*

#	First Name	Last Name	Affiliation
Non-PAG Members			
36	Darrell	Johnson	SoCalGas*
37	Emily	Grant	SoCalGas*
38	Jill	Tracy	SoCalGas*
39	Andy	Carrasco	SoCalGas
40	Frank	Lopez	SoCalGas
41	Pearl	Hsu	SoCalGas

*attended in-person

CBOSG March 4th Q1 Invitee List

Organization	First Name	Last Name
Protect Playa Now	Faith	Myhra
Protect Playa Now	Kevin	Weir
Ballona Wetland Institute	Marcia	Hanscom
Ballona Wetland Institute	Marcia	Hanscom
California Greenworks	Mike	Meador
California Greenworks	Jessy	Shelton
California Greenworks	Michael	Berns
Communities for a Better Environment	Theo	Caretto
Communities for a Better Environment	Roberto	Cabrales
Communities for a Better Environment	Ambar	Rivera
Communities for a Better Environment	Roselyn	Tovar
Communities for a Better Environment	Jay	Parepally
Communities for a Better Environment	Lauren	Gallagher
Breathe Southern California	Marc	Carrel
Breathe Southern California	Tigran	Agdaian
Nature for All	Belen	Bernal
Nature for All	Steven	Ochoa
Climate Action Campaign	Ayn	Craciun
Climate Action Campaign	Lexi	Hernandez
Vote Solar	Andrea	Leon-Grossmann
Food and Water Watch	Andrea	Vega
Food and Water Watch	Chirag	Bhakta
Defend Ballona Wetlands	Robert Roy	van de Hoek
Defend Ballona Wetlands	Jackson	Garland
Physicians for Social Responsibility - Los Angeles	Alex	Jasset
Go Green Initiative	Jill	Buck
Chinatown Service Center	Daisy	Ma
Chinatown Service Center	Kerry	Situ
Soledad Enrichment Action	Enrique	Aranda
Soledad Enrichment Action	Nathan	Aranda
Communities for Responsible Community Development	Ricardo	Mendoza
Communities for Responsible Community Development	Kenta	Estrada-Darley
Watts/Century Latino Organization	Autumn	Ybarra
Little Tokyo Community Council	Kristin	Fukushima
Little Tokyo Community Council	Chris	Fukushima
Reimagine LA Foundation	Rashad	Trapp
Reimagine LA Foundation	Shawna	Andrews
Reimagine LA Foundation	Raul	Claros
Mexican American Opportunity Foundation	Ciriaco "Cid"	Pinedo
Watts Labor Community Action Committee	Timothy	Watkins
Watts Labor Community Action Committee	Thelmy	Alvarez
LA Black Workers Center/Care at Work, UCLA Labor Center	Andrea	Slater
LA Black Workers Center/Care at Work, UCLA Labor Center	Deja	Thomas
LA Black Workers Center/Care at Work, UCLA Labor Center	Andrea	Slater
Alma Family Services	Lourdes	Caracoza
Alma Family Services	Aida	Vega
Alma Family Services	Diego	Rodriguez
Southside Coalition of Community Health Centers	Andrea	Williams
Southside Coalition of Community Health Centers	Lucy	Castro
Greater Zion Church Family	Michael	Fisher
Greater Zion Church Family	Danny	Harrison
Greater Zion Church Family	Aquyla	Walker
Faith and Community Empowerment (FACE)	Hyepin	Im
YMCA of Greater Los Angeles	Gerry	Salcedo
Parents, Educators/Teachers, and Students in Action (PESA)	Seymour	Amster
Parents, Educators/Teachers, and Students in Action (PESA)	Ella	Cavlan
Parents, Educators/Teachers, and Students in Action (PESA)	Olivia	Fike
Parents, Educators/Teachers, and Students in Action (PESA)	Araksya	Nordikyan
Los Angeles Indigenous People's Alliance	Luis R.	Pena

CBOSG March 4th Q1 Invitee List		
Organization	**First Name**	**Last Name**
Los Angeles Indigenous People's Alliance	Jamie	Patino
California Native Vote Project	Rene	Williams
Comunidades Indigenas en Liderazgo (CIELO)	Odilia	Romero

CBOSG March Q1 Meeting Attendees

CBOSG				
Organization	**First Name**	**Last Name**	**In Person**	**Zoom**
Ballona Wetlands Institute	Marcia	Hanscom	X	
Breathe Southern California	Marc	Carrel		X
California Greenworks	Jessy	Shelton	X	
California Greenworks	Michael	Berns	X	
Coalition for Responsible Community Development	Ricardo	Mendoza	X	
Coalition for Responsible Community Development	Kenta	Estrada-Darley	X	
Defend Ballona Wetlands	Roy	van de Hoek	X	
Faith and Community Empowerment (FACE)	Hyepin	Im		X
Food and Water Watch	Andrea	Vega		X
Go Green Initiative	Jill	Buck	X	
Little Tokyo Community Council	Kristin	Fukushima		X
Los Angeles Indigenous People's Alliance	Luis	Pena	X	
Mexican American Opportunity Foundation	Cid	Pinedo	X	
Parents, Educators/Teachers, Students in Action (PESA)	Ella	Cavlan	X	
Parents, Educators/Teachers, Students in Action (PESA)	Craig	Mendoza		X
Physicians for Social Responsibility-LA	Alex	Jasset		X
Protect Playa Now	Kevin	Weir		X
Reimagine LA	Rashad	Rucker-Trapp	X	
Soledad Enrichment Action	Enrique	Aranda	X	
Soledad Enrichment Action	Nguyet	Galaz	X	
Soledad Enrichment Action	Nathan	Arias	X	
Southeast Rio Vista YMCA	Gerry	Salcedo	X	
Southside Coalition of Community Health Centers	Andrea	Williams		X
Watts Labor Community Action Committee	Thelmy	Alvarez	X	
Watts/Century Latino Organization	Autumn	Ybarra		X
LA Black Workers Center/Care at Work, UCLA Labor Center	Andrea	Slater		X
Non CBOSG				
California Public Utilities Commission	Sasha	Cole		X
California Public Utilities Commission	Christopher	Arroyo		X
California Strategies	Marybel	Batjer		X
JTM Academy	Amaree	El Jamii	X	
JTM Academy	Bryan	Barnett	X	
JTM Academy	B. Andre	Halloway	X	
TOTAL CBOs				**23**

PAG March Invitee List

Organization	First name	Last name
Agricultural Energy Consumers Association	Michael	Boccadoro
Air Products	JP	Gunn
Air Products	Lorraine	Paskett
Air Products	Seth	Hilton
Air Products	Miles	Heller
Air Products	Vince	Wiraatmadja
ARCHES	Angelina	Galiteva
ARCHES	Tyson	Eckerle
Bizfed	Sarah	Wiltfong
Bloom Energy	Christina	Tan
California Air Resources Board	Steve	Cliff
California Energy Commission	Rizaldo	Aldas
California Hydrogen Business Council	Katrina	Fritz
California Manufacturers and Technology Association	Lance	Hastings
California Manufacturers and Technology Association	Robert	Spiegel
California Public Utilities Commission	Arthur (Iain)	Fisher
California Public Utilities Commission	Christopher	Arroyo
California Public Utilities Commission	Christopher	Myers
California Public Utilities Commission	Matthew	Taul
California Public Utilities Commission	Jack	Chang
California Public Utilities Commission	Sasha	Cole
California Public Utilities Commission	Nick	Zanjani
California Public Utilities Commission	Nathaniel	Skinner
California Public Utilities Commission	Kaj	Peterson
California Public Utilities Commission	Benjamin	Tang
California Water Data Consortium	Deven	Upadhay
CIty of Burbank	Anthony	D'aquila
City of Long Beach - Long Beach Water	Diana	Tang
City of Long Beach - Utilities	Tony	Foster
City of Long Beach - Utilities	Dennis	Burke
City of Long Beach - Utilities	Heather	Hamilton
City of Long Beach*	Mario	Cordero
Clean Energy	Nora	Sheriff
Clean Energy Strategies representing the Utility Consumers' Acti	Tyson	Siegele
Communities for a Better Environment	Theo	Caretto
Communities for a Better Environment	Shara	Burwell
Communities for a Better Environment	Roberto	Cabrales
Earth Justice	Sara	Gersen
Energy Independence Now	Brian	Goldstein
Environmental Defense Fund	Joon Hun	Seong
Environmental Defense Fund	Michael	Colvin
Environmental Justice League	Russell	Lowery
GoBiz	Deedee	Myers
Green Hydrogen Coalition	Hope	Fasching

PAG March Invitee List

Organization	First name	Last name
Green Hygroden Coalition	Sergio	Dueñas
Green Hygroden Coalition	Janice	Lin
Harbor Trucking Association	Karla	Sanchez
Harbor Trucking Association	Matthew	Schrap
Independent Energy Producers Association*	Jan	Smutny Jones
Independent Energy Producers Association*	Sara	Fitzsimon
International Longshore and Warehouse Union Local 13	Sal	DiConstanzo
International Longshore and Warehouse Union Local 13	Mark	Jurisic
International Longshore and Warehouse Union Local 13	Sophia	Dubrovich
Local Union 250	Nathaniel	Williams
Local Union 250	Hector	Carbajal
Los Angeles Department of Water and Power	Aaron	Guthrey
Los Angeles Department of Water and Power	Marty	Adams
Los Angeles Department of Water and Power	Paul	Habib
Los Angeles Department of Water and Power	Nermina	Rucic
Los Angeles Department of Water and Power	Jesse	Vismonte
Los Angeles Department of Water and Power	Xinhe	Le
Los Angeles Department of Water and Power	Eric	Hill
Metropolitan Water District	Deven	Upadhyay
Natural Resources Defense Council	Pete	Budden
Port of Los Angeles	Mike	Galvin
Port of Los Angeles	Tim	DeMoss
Protect our Communities Foundation	Malinda	Dickenson
Reimagine LA	Rashad	Rucker-Trapp
Reimagine LA	Raul	Claros
Sierra Club	Monica	Embrey
South Coast AQMD	Maryam	Hajbabaei
South Coast AQMD	Sam	Cao
South Coast AQMD	Aaron	Katzenstein
South Coast AQMD	Vasileios	Papapostolou
Southern CA Water Coalition	Charley	Wilson
Southern California Association of Governments	Kome	Ajise
Southern California Generation Coalition	Norman	Pedersen
Southern California Leadership Council	Richard	Lambros
Southern California Pipe Trades	Rodney	Cobos
Southern California Public Power Authority	Charles	Guss
The United Association	Aaron	Stockwell
UC Davis Insitutue of Transportation Studies	Lukas	Wernert
UC Davis Sustainable Transportation Energy Pathways	Lew	Fulton
UCI Advanced Power and Energy Program	Jack	Brouwer
University of CA Riverside	Arun	Raju
Utility Reform Network (TURN)	Marcel	Hawiger
Utility Reform Network (TURN)	Marna	Paintsil Anning
Utility Workers Union of America 483	Ernest	Shaw

PAG March Invitee List

Organization	First name	Last name
Utility Workers Union of America 483	Robin	Downs
Utility Workers Union of America 483	Anthony	Flores
Utility Workers Union of America Local 132	Joe	Moreno
Utility Workers Union of America Local 132	Mike	Cormode

March PAG Meeting - March 5, 2024

PAG				
Organization	**First name**	**Last name**	**In Person**	**Zoom**
Air Products	Lorraine	Paskett		x
Air Products	Miles	Heller		x
Bizfed	Sarah	Wiltfong		x
California Energy Commission	Rizaldo	Aldas		x
California Public Utilities Commission	Arthur (Iain)	Fisher		x
California Public Utilities Commission	Christopher	Arroyo		x
California Public Utilities Commission	Matthew	Taul		x
California Public Utilities Commission	Sasha	Cole		x
California Public Utilities Commission	Benjamin	Tang		x
City of Burbank*	Anthony	D'aquila		x
City of Long Beach - Utilities*	Dennis	Burke	x	
City of Long Beach - Utilities*	Heather	Hamilton	x	
Clean Energy Strategies representing the Utility Consumers' Action Network	Tyson	Siegele		x
Communities for a Better Environment	Theo	Caretto		x
Earth Justice	Sara	Gersen		x
Environmental Defense Fund	Joon Hun	Seong		x
Green Hygroden Coalition	Sergio	Dueñas		x
Los Angeles Department of Water and Power	Jesse	Vismonte		x
Natural Resources Defense Council	Pete	Budden		x
Port of Los Angeles*	Mike	Galvin	x	
South Coast AQMD	Maryam	Hajbabaei		x
South Coast AQMD	Xinhe	Le		x
South Coast AQMD	Vasileios	Papapostolou		x
Southern CA Water Coalition*	Charley	Wilson	x	
Southern California Generation Coalition*	Norman	Pedersen	x	
Southern California Public Power Authority	Charles	Guss		x
The United Association	Aaron	Stockwell		x
University of CA Riverside	Arun	Raju		x
Utility Workers Union of America 483*	Ernest	Shaw	x	
Utility Workers Union of America 483*	Robin	Downs	x	
Non PAG				
Arellano Associates*	Chester	Britt	x	
Arellano Associates*	Stevie	Espinoza	x	
Arellano Associates	Nancy	Verduzco		x
Arellano Associates*	Keven	Michele	x	
California Strategies	Marybel	Batjer		x
Insignia Environmental	Armen	Keochekian		x
Insignia Environmental	Anniken	Lydon		x
Lee Andrews Group*	Alma	Marquez	x	
Lee Andrews Group*	Antonia	Issaevitch	x	
SoCalGas*	Emily	Grant	x	
SoCalGas*	Jill	Tracy	x	
SoCalGas	Andy	Carrasco		x
SoCalGas	Frank	Lopez	x	

March PAG Meeting - March 5, 2024

PAG				
Organization	First name	Last name	In Person	Zoom
SoCalGas	Pearl	Hsu		x
SoCalGas*	Chanice	Allen	x	
SoCalGas*	Katrina	Regan	x	
SoCalGas*	Yuri	Freedman	x	
SoCalGas*	Amy	Kitson	x	
SoCalGas*	Larry	Andrews	x	

Attachment A

PAG March 5 Meeting Attendee Roster

#	First Name	Last Name	Affiliation
PAG Members			
1	Lorraine	Paskett	Air Products
2	Miles	Heller	Air Products
3	Sarah	Wiltfong	Bizfed
4	Rizaldo	Aldas	California Energy Commission
5	Arthur	Fisher	California Public Utilities Commission
6	Christopher	Arroyo	California Public Utilities Commission
7	Mattew	Taul	California Public Utilities Commission
8	Sasha	Cole	California Public Utilities Commission
9	Benjamin	Tang	California Public Utilities Commission
10	Anthony	D'aquila	City of Burbank
11	Dennis	Burke	City of Long Beach – Utilities *
12	Heather	Hamilton	City of Long Beach – Utilities *
13	Tyson	Siegele	Clean Energy Strategies representing the Utility Consumers' Action Network
14	Theo	Caretto	Communities for a Better Environment
15	Sara	Gersen	Earth Justice
16	Joon Hun	Seong	Environmental Defense Fund
17	Sergio	Dueñas	Green Hydrogen Coalition
18	Jesse	Vismonte	Los Angeles Department of Water and Power
19	Pete	Budden	Natural Resources Defense Council
20	Mike	Galvin	Port of Los Angeles *
21	Maryam	Hajbabaei	South Coast AQMD
22	Xinhe	Le	South Coast AQMD
23	Vasileios	Papapostolou	South Coast AQMD
24	Charley	Wilson	Southern CA Water Coalition *
25	Norman	Pedersen	Southern California Generation Coalition *
26	Charles	Guss	Southern California Public Power Authority
27	Aaron	Stockwell	The United Association
28	Arun	Raju	University of CA Riverside
29	Ernest	Shaw	Utility Workers Union of America 483 *
30	Robin	Downs	Utility Workers Union of America 483 *
Non-PAG Members			
31	Chester	Britt	Arellano Associates*
32	Stevie	Espinoza	Arellano Associates*
33	Nancy	Verduzco	Arellano Associates
34	Keven	Michel	Arellano Associates*
35	Marybel	Batjer	California Strategies

#	First Name	Last Name	Affiliation
Non-PAG Members			
36	Armen	Keochekian	Insignia Environmental
37	Anniken	Lydon	Insignia Environmental
38	Alma	Marquez	Lee Andrews Group *
39	Antonia	Issaevitch	Lee Andrews Group *
40	Emily	Grant	SoCalGas *
41	Jill	Tracy	SoCalGas *
42	Andy	Carrasco	SoCalGas
43	Frank	Lopez	SoCalGas *
44	Pearl	Hsu	SoCalGas
45	Chanice	Allen	SoCalGas *
46	Katrina	Regan	SoCalGas *
47	Yuri	Freedman	SoCalGas *
48	Amy	Kitson	SoCalGas *
49	Larry	Andrews	SoCalGas *

*attended in-person

APPENDIX 5 – TRANSCRIPTS

REGAL
COURT REPORTING

In the Matter Of:

SoCalGas Angeles Link: Planning Advisory Group

TRANSCRIPT OF PROCEEDINGS

February 15, 2024

Case No: N/A

CERTIFIED COPY

In Re: SoCalGas

Angeles Link: Planning Advisory Group February Workshop

February 15, 2024

CERTIFIED COPY

Reported By: Drew Ivers, CSR 14501

APPEARANCES

Chester Britt
Stevie Espinoza
Nancy Verduzco
Keven Michele
Marybel Batjer
Armen Keochekian
Julie Roshala
Alma Marquez
Alyssa Martinez
Neil Navin
Darrell Johnson
Emily Grant
Jill Tracy
Andy Carrasco
JP Gunn
Miles Heller
Rizaldo Aldas
Katrina Fritz
Arthur (Iain) Fisher
Christopher Arroyo
Matthew Taul
Sasha Cole
Nathaniel Skinner
Benjamin Tang

Tyson Siegele
Theo Caretto
Joon Hun Seong
Michael Colvin
Hope Fasching
Aaron Guthrey
Xinhe Li
Sam Cao
Aaron Katzenstein
Charley Wilson
Norman Pedersen
Rodney Cobos
Aaron Stockwell
Lukas Wernert
Jack Brouwer
Frank Lopez
Pearl Hsu

In re: SoCalGas

February 15, 2024

Angeles Link: Planning Advisory Group February Workshop

CHESTER BRITT: All right. We will go ahead and get started.

Welcome, Everyone.

It dawned on me this morning when I was here that the last time we saw each other was the beginning of December. So we have gone through the holidays and made it through Valentine's as well. Good to see everyone again. We are excited to begin to share with you some of the work studies, preliminary findings.

Before we do that, let me go through housekeeping items. This is the Planning Advisory Group Workshop. We want to welcome you. Most of you, I think, previously have attended some of our workshop. If you are a first timer, we will give you some information on how you can catch up with us, and we have a living library where you will have access to those files we are going through and really make sure that you understand what's going on.

My name is Chester Britt. I'm the executive vice president with Arellano Associates, and I am serving as the PAG facilitator. So I want to welcome you today.

A couple housing keeping items. This meeting will be recorded both video and audio and a court reporter will be transcribing the meeting. So when you speak, please announce yourself before you speak. It's very important that the court reporter can understand who's talking. So if you will do that for us, that will be greatly appreciated it.

The Zoom microphones are muted by us to eliminate any background noise here in the room. You will need to unmute your microphone when called on to speak. So when we see your hand raised and we want to call on you, we will mention your name and then you'll need to unmute yourself, and we will unmute you on our end, and we all will able to hear each other.

We encourage you to turn on your camera so we can better engage with you. We actually have a big screen here in person. And it helps us to help see you. If you wouldn't mind doing that, at least for sure when you are talking, that will be very helpful. We will welcome it during the meeting as well.

You can also use the Zoom chat to provide any input and ask questions through out the meeting. So the Zoom chat is a feature that we encourage you to use. We are looking at that and tracking it. There are people that will answer any basic questions that they can answer. And if it's something for the group, then I'll be able to read that off, if necessary, to get some feedback and dialogue going about those chats. We are keeping track of that, just so you know. And you should feel comfortable using that. If you would like to speak during the presentation, raise your hand. There are sections in the agenda where we are going to slow down and take people's input and comments. And if you raise your hand, we will make sure to call on you. And we will mix that with the people in the room that would want to speak as well. And then in -- in-house, we have a -- scattered around the table some wireless microphones. And we would ask when you speak in person, if you would directly speak into the microphone so that everyone can hear.

Our agenda today is: Arrival and continental breakfast. We have food in the back. If you haven't grabbed anything, feel free to do that. We will do a roll call in just a moment where we will introduce ourselves. We will have some opening remarks and an Arches update by Neil. We will talk about water resources. And then we have a member discussion. We will have a short break. Then we will go through hydrogen leakage. And we will have an update on GHG and NOX. We will have another member discussion. And then talk about next steps in our upcoming meeting.

Just in case you need to leave early, you should be aware that we are doing both a PAG and COB SG meeting in early March as quarter -- as our normal quarterly meetings, which we will be talking about later in the agenda. But just to point that out, that is coming up.

So let's begin a roll call. I already introduced myself. I'll pass the microphone in the room. We will do all the introductions in house. And then we will transition to

people online.
EMILY GRANT: Good morning, everybody. Emily Grant. I am the outreach manger with Angeles Link.
DARRELL JOHNSON: Good morning and welcome. I am Darrel Johnson. And I am the programs manager, Air and Greenhouse Gas.
CHARLEY WILSON: Charley Wilson, Southern California Water Coalition.
FRANK LOPEZ: Good morning. Frank Lopez, Director of Regional Public Affairs SoCalGas.
ANDY CARRASCO: Good morning, everyone. Andy Carrasco, Vice President of communication Local Government and Community Affairs.
NEIL NAVIN: Good morning, everyone. I am Neil Navin. I am the Chief Clean Fuels Officer for Southern California Gas.
JILL TRACY: Good morning, everyone. I am Jill Tracy. SoCalGas, Angeles Link Regulatory and Policy.
BRENDA EELLS: Good morning. I'm Brenda Eells with Rincon Consultants.
ALMA MARQUEZ: I am Alma Marquez with Lee Andrew's Group CBO lead facilitator. Good morning.
CHESTER BRITT: All right. That's everyone in the room. I am going to go now to people online. When I call your name, just unmute yourself and just introduce yourself and your organization. That will be great.
So the first person I see is Aaron Guthrey. Aaron, can

you unmute yourself?

AARON GUTHREY: Good morning. And this is Aaron Guthery, LAP WP. Thank you.

CHESTER BRITT: Thank you.

The next person I see is Aaron. It looks like Katzenstein.

AARON KATZENSTEIN: Yeah. Hi. Good morning. It's Aaron Katzenstein for South Coast AQMD.

CHESTER BRITT: Welcome.

Norman Pedersen.

NORMAN PEDERSEN: Norman Pedersen, Southern California Generation Coalition.

CHESTER BRITT: Missing you in person, Norman. Usually you are standing right in front of me.

Aaron Stockwell.

AARON STOCKWELL: Good morning, everybody. Aaron Stockwell, California State Pipe Trains Counsel.

CHESTER BRITT: Welcome.

Armen Keochekian.

ARMEN KEOCHEKIAN: Yeah. Hi. Good morning. This is Armen Keochekian checking in with Insignia Environmental.

CHESTER BRITT: Welcome.

We have Arthur Fisher.

ARTHUR FISHER: Good morning. This is Arthur Fisher with the Public Advocates Office.

CHESTER BRITT: Welcome.
Benjamin Tang.
BENJAMIN TANG: Good morning. This is Benjamin Tang with the Public Advocates Office.
CHESTER BRITT: Thank you.
Christopher Arroyo.
CHRISTOPHER ARROYO: Good morning. Christopher Arroyo, Public Utilities Commission.
CHESTER BRITT: Welcome. Drew Ivers. I think that's our court reporter. So I don't need to introduce them.
Let me see. Hope Fasching.
HOPE FASCHING: Hi, everyone. Hope Fasching, Senior Policy Analyst at the Greenhouse Hydrogen Coalition. Thank you.
CHESTER BRITT: Thank you. Welcome, Hope. Joon Seong.
JOON SEONG: Hi. Joon Seong, Senior Analyst at Enviromental Defense Fund.
CHESTER BRITT: JP Gunn. No. All right.
Julia -- or Julie Roshala.
JULIE ROSHALA: Good morning. Julie Roshala with Insignia.
CHESTER BRITT: Thank you.
Katrina Fritz.
KATRINA FRITZ: Hi, everyone. Katrina Fritz with California Hydrogen Business Council. Thanks.
CHESTER BRITT: Yeah. Good to see you, Katrina.

Lukas Wernet -- Wernert.
LUKAS WERNET: Good morning, everyone. Lukas Wernet European Union Fellow at UC Davis.
CHESTER BRITT: Welcome.
Marybel Batjer.
MARYBEL BATJER: Good morning. This is Marybel Batjer, and I am with California Strategies. Formally with the CPUC.
CHESTER BRITT: Welcome. Matthew Taul.
MATTHEW TAUL: Matthew Taul, Senior Engineer Public Advocate Safety.
CHESTER BRITT: Good to see you.
Michael Colvin.
MICHAEL COLVIN: Michael Colvin with the Enviromental Defense. And apologies I'm not in the room. I am fighting a cold. So I though I would save everyone from some germs.
CHESTER BRITT: It's okay. Thank you for keeping your distance.
Pearl Hsu. Pearl, are you there?
All right. Miles Heller.
MILES HELLER: Mile Heller with Air Products.
CHESTER BRITT: Welcome.
Rizaldo Aldas.
RIZALDO ALDAS: Hi. Good morning, everybody. This is Rizaldo Aldas, Research Division from California Air Energy Commission. Thank you.

CHESTER BRITT: Thank you.

Rodney Cobos.

RODNEY COBOS: Good morning. Rodney Cobos with the California Pipe Train.

CHESTER BRITT: Welcome.

Sam Cao.

SAM CAO: Good morning. Sam Cao at South Coast Air Management District.

CHESTER BRITT: All right. Theo Caretto.

THEO CARETTO: This is Theo Caretto for Communities for a Better Environment.

CHESTER BRITT: Welcome.

Tyson Siegele.

TYSON SIEGELE: Hello. This is Tyson Siegele. I am here on behalf of Utility Consumers Action Network.

CHESTER BRITT: Welcome, Tyson.

Looks like Xinhe Li.

XINHE LI: Good morning. This Xinhe from LAD WP.

CHESTER BRITT: Welcome. I think that was everyone that I saw. If I did not call your name, please raise your hand, and I will circle back and allow you to introduce yourself. I think I got everyone. Let's assume I did. If I didn't, please raise your hand. We will love to have you introduce yourself. And I don't see anyone else brand new in the room. So we are going to go ahead and get started. I'm going to go ahead and pass it on over to Neil Navin. He's the Chief Clean Fuels Officer for SoCalGas. He's going to provide some open remarks -- opening remarks and provide an Arches update.

NEIL NAVIN: All right. Thank you. Again, welcome. We have been studying Angeles Link here for almost a year at this point. When we have been studying Angeles Link in the phase one studies. We made a number of important assumptions about the scope of Angeles Link when we started this work. The assumptions considered that Angeles Link would be or could be one of the nation's largest clean, renewable hydrogen delivery systems. As we have spoken up before, that it will be a high pressure, nondiscriminatory pipeline system that is dedicated to pipeline use.

As envisioned in our work, Angeles Link could transport clean, renewable hydrogen from a regional third party production, storage sites to end users to extend across approximately 450 miles.

Importantly, this is sort of a small -- relatively small amount of pipeline when you consider the extent of natural gas systems we have today in Southern California.

As we have been analyzing this work, Angeles Link, the pipeline, the infrastructure, we have been looking at a range of pressures between 200 and 1200 PSI. That is pound per square inch. A pipeline can range anywhere up to 36 inches. The pipeline itself can certainly being envision the routed to maximize the existing use of right of ways where possible. And the system was as envision sized in the study. Size to be about half a million and 1.5 million metric tons of hydrogen delivered annually.

As we have looked at this work, the intent always been for that clean, renewable hydrogen to be delivered to the LA Basin. And that work will ultimately serve to support loads served by Aliso Canyon gas storage facility. And, ultimately, help to facilitate the retirement of this asset over time and certainly with the other support of clean energy projects.

Importantly, we are analyzing the potential for Angeles Link to significantly improve regional national air quality. And we will likely talk about that today and other get-togethers.

As we know, the LA Basin is among one of the worst air quality basins in the country. We've been doing that with you and with your support and feedback as through many PAG and CBO sessions to date. We are getting to a point where we also want to talk a little bit more about Arches. In our last meeting, I think, when we came together, Arches just won the 1.2 billion from the DOE. And I should be clear. That's the total award, vision award. I think the award comes out in phases. That award is part of a larger $8 billion program to advance hydrogen nationally. But California through Arches winning one of those seven awards is a big deal.

The decision that authorized Angeles Link and established the effort to put together a PAG meeting and the PAG meeting and CBO groups and authorized that work, also directed SoCalGas to work with Arches and join Arches in pursuit of those federal dollars.

As we envisioned Angeles Link, Angels Link would perform an important connective role in the infrastructure in California as to what I said previously, bring hydrogen from producers and storage facilities into Central and Southern California, including the LA Basin. And to do that, as a member of Arches and then clearly part of Angeles Link overall, focusing that work on support of electrifying sectors in the economy and accelerating the goals of Arches.

That same CPUC decision that, again, called upon SoCalGas gas to stand up for a PAG structure and for us to join Arches. Also, contemplated that our work with Arches and Angeles Link aligned to both secure the federal funding but also accelerate hydrogen work in California.

So we are at a point now where a moment really arrived where our phase one work continues. And that SoCalGas will accelerate our effort to file a phase two application in support of our work for Angeles Link broadly. And also in support of our work to support Arches.

The phase two work will identify preferred system routes. The intention will be to develop 30 percent engineering design. Advance our community engagement effort. Redefine environmental and EJ work safety reliability and other studies. With the phase two, Arches -- Angeles Link authorization, we will be able to support Arches critical DOE application requirements for federal funding.

So over the past year we've been making really significant progress in our continued work. There remains vital necessary work to continue to wrap up our phase one work. But we are very excited about the opportunity that exist to support the state, support Arches, and support the advancement of hydrogen broadly.

With that, again, I want to welcome you to our PAG meeting. I look forward to a great set of discussions. We have a packed agenda with a lot of study updates. And so I'll pass it back, and we will proceed to the efforts to look at the studies. So thank you.

CHESTER BRITT: All right. Thank you, Neil.

I'm now going to now introduce Jill Tracy, Senior Director Regulatory and Policy with SoCalGas and Brenda Eells, Principal and Environmental Planning Renewable Energy Infrastructure with Rincon. And they are going to give a preview of the water resource evaluation study.

JILL TRACY: Thank you, Chester. And I think somebody got a question. Are we going to do questions at the end?

CHESTER BRITT: We can take some questions. They might have something to do, obviously, with what Neil was presenting.

JILL TRACY: Yeah. I thought we will take questions at the end of the presentations.

CHESTER BRITT: Absolutely. Yes. We can do that.

JILL TRACY: Thank you, Chester.

All right. Good morning, everyone. And thank you for attending today's PAG -- hello. Okay. Sorry about that.

As Neil just mentioned, these are very exciting times as hydrogen is developing, not only across our nation but right here in California. And your input is equally important to everyone here at SoCalGas. As well as the commission and other critical stakeholders as we continue down this groundbreaking path as we decarbonize energy.

As part of this CPUC final decision, SoCalGas is required to identify potential sources of hydrogen and water and to estimate the cost of hydrogen. This water study presentation covers preliminary data for the following tasks: Agency coordination, water resources and availability, and water purification.

It is my sincere pleasure to introduce Brenda Eells with Rincon as our presenter for the water study. Brenda's professional history is focused on enviromental planning of renewable energy infrastructure projects with -- over 25 years of experience. And a little known fact about Brenda is that she lives with her family on a sailboat in Ventura Harbor and has done so for over 20 years. And, yes. She has three kids and two cats, so if during the break anybody wants to ask her about that. I was absolutely fascinated by this. So I thought it was really super. So I'll pass it over to Brenda. Thank you.

BRENDA EELLS: Thank you for that very warm welcome, Jill.

Before I jump into the preliminary results of the water availability study, I want to provide an overview of the work Rincon has been doing to help find water for or clean, renewable hydrogen production. Rincon started supporting SoCalGas in 2021 by working with SPEC services in the development of a series of prefeasibility water supply analysis reports that were specific to the production hub at that time. These reports were precursor to the phase one water availability study that we are talking about today.

In addition to Angeles Link, Rincon has also been supporting the developer side of large renewable energy projects in the Central Valley that would use solar PV to produce green hydrogen. One project in particular has given us the opportunity to see clean, renewable hydrogen products for the developer side. And to really dig into some of the water sources and the feasibility of those sources that we have been evaluating in the water for Angeles Link.

So let's jump in. At its most basic, the water availability study identifies and characterizes potential water sources needed to identify developer production of a clean, renewable hydrogen that Angeles Link can convey throughout Central and Southern California.

This map shows an outline of SoCalGas service territory. As you can see and already know, the service territory covers most of Southern California. The study area for the water study was initially defined solely as SoCalGas service territory. But as the study progressed, we reconsidered the extent of the study area as we found potential water supply sources located near but outside the service territory, including wastewater treatment facilities in the San Joaquin Valley.

The study also identifies potential opportunities for future hydrogen producers to get involved in existing programs to develop supply for their respected projects, such as the Central Valley salinity alternatives for long-term sustainability or CD salts, which is working to mitigate high salinity groundwater in the Central Valley.

In addition to defining the study area, our study approach also included review with previous studies, including the prefeasibility analyses conducted in 2021. This water availability study considered the findings and recommendations of the 2021 efforts, including looking more closely at recycle water in the form of treated wastewater as a potential supply source.

We also reviewed a suite of water supply planning documents throughout the state. Urban water management plans are prepared by water agencies that serve more than 3,000 connections and include availability projections for the anticipated demands within their respected service territories.

Groundwater sustainability plans are prepared for groundwater basins to reverse overdraft conditions, which is where more water leaves the basin and replenishes every year. The California Water Plan provides high level policy guidance for water supply management throughout the state.

This water study also included coordination with key water supply agencies. The input and guidance we received from the agencies was used to inform the direction of the study, including the identification of potential supply sources that weren't previously considered.

Simply put, water supply management in California is complex. There are many different agencies involved and even different types of regulations that can apply depending upon the location and water supply source. This is partially because laws and regulations have been enacted in reaction to land use, changes, and population growth as opposed to proactively guiding how and where water supply is developed.

The water availability study includes a thorough overview of the agencies and the regulations involved in water supply management with the goal of helping future hydrogen producers navigate the regulatory landscape as they develop supply for their respective projects.

Water demands and availability also shift throughout the state depending on climate conditions. For example, Southern California receives a lot of water from the state water project, which sources water from the Sierra Nevada snowpack. With climate change, the snowpack is melting at different rates and time than when state water project infrastructure was constructed back in the 30s. So there are a lot of adjustments in state policy in -- as well as on the local level to maximize those delivers in the face of changing conditions. The water availabiity study addresses those changes to help inform future supply availability.

The table on this slide shows some big water number. These numbers reflect the total amount of applied water use from California for urban, agricultural, and environmental purposes on average between 1998 and 2018.

The California Department of Water Resources defines applied water use as total amount of water diverted from any source to meet the uses of urban and agricultural sectors and water dedicated to the environment, including water applied for groundwater recharge.

Water that would be used for the production of clean renewable hydrogen would also be applied water use under the urban category, which covers municipal and industrial uses.

These graphics present those applied water use numbers we saw in the last slide and show how water use varies across the state. And surprisingly, environmental needs are highest in the north. Agricultural needs are highest in the central portion of the state and urban needs are highest in Southern California.

These donut graphics also show how water use differs during dry years based on historical drought conditions. And during wet years when drought conditions are not present. The water availability study presents these ranges in order to help inform how water availability can vary throughout the year and year to year.

This table shows estimated water needs to meet the total projected hydrogen demand for the SoCalGas service territory. This slide is not Angeles Link specific. This is the water required to meet the larger Southern California hydrogen demand.

As you can see, there are conservative estimates and ambitious estimates, which refer to the amount of hydrogen that can be potentially produced. The implied water use numbers we saw two slides ago are used here to show how water demand for hydrogen production compare to overall water use in California.

As you can see under both wet and drier conditions, water demand for hydrogen production represent 300th of a percent of total statewide use under the conservative production scenario. And just over a tenth of a percent under the ambitious production scenario.

Angeles Link will convey a portion of the total demand for clean, renewable hydrogen in Southern California. This table, similar to the previous slide, compares the water needs of hydrogen production to apply water use rates throughout the state. But this table just focuses on just the amount of hydrogen conveyed by Angeles Link. This table shows a low scenario and a high scenario senior referring to the potential total through foot of clean, renewable hydrogen in the Angeles Link system.

Similar to the last slide, this table also shows that the water demands will be small compared to statewide applied water uses. With a low scenario representing up to 100th of a percent of statewide uses and a high scenario of 300th of a percent statewide uses.

Again, we show wet weather condition, as well as dry weather condition to help future hydrogen producers to consider how water availability differ across years and to plan their supply sources to account for those fluctuations.

It's not always easy or intuitive to get a scale of the water qualities we are talking about so we prepared this bar chart with a simple comparison. The first bar is the amount of water in acre feet, the Coachella Golf Course is used annually for irrigation. The second and third bars are the amount of water that will been required annually for the low and high hydrogen through -- put scenarios for Angeles Link.

This table identifies potential water supply sources SoCal identified through the water availability study. You can see from list that we focused on water supplies that could be developed from flows that are currently managed as waste as well as by reusing water that is typically disposed of after use.

I'm going to run through each of these to give you an idea of what each of these categories look like.

We start with imported surface water. This category refers to the three main water supply projects in California that deliver imported surface water to Central and Southern California. These include the state water project, which sources water from the Sierra Nevada snowpack and conveys it through the San Francisco Bay Delta area to Southern California. The Central Valley Project, which sources water from Lake Shasta in far Northern California and conveys it to primarily agricultural uses and for flood control in Central California and the Colorado River project, which imports water from the Colorado River at California boarder with Arizona and conveys it through the desert regions of Southern California into Los Angeles and the Colorado River after that.

Next is treated wastewater. This refeed to recycle water once it's put to new beneficial use. This is wastewater that's been collected within municipal sewer system and treated at a local facility. Local groundwater is considered as a potential supply source only where the resource is in a positive balanced condition.

Agricultural industry water is water that has been used to wash produce before distribution to customers, as well as irrigation flows that can be collected from agricultural fields.

Next is Brine Line Flows. A brine line is basically a waste disposal pipeline that takes very salty water mainly from industrial processes and transports it for disposal, very often to the ocean.

Advance Water Treatment Concentrate is a potential supply source consisting of high salinity wastewater produced from treatment processes.

Oil and Gas Industry Water is water that is currently used in refineries and productions fields in the oil and gas fields, which are slowly being phased out under state directives.

Inland Brackish Water is really salty groundwater that concentrates in inland areas. To be a potential supply source that salty water would be extracted and treated for use.

Dry Weather Flow are flows that enter storm water systems outside of wet weather condition like runoff of watering lawns and washing cars.

Finally, Urban Storm Water Capture and Reuse refer to capturing storm water flows before they reach discharge point, which eventually take the runoff to the ocean.

Water availabiity study provides detailed information on each of these three sources types, which future hydrogen producers can use as sort of a menu to use in developing supply for their respected projects. The study also identifies where additional data collection and analysis can be conducted to further inform the menu of water supply options.

The process of producing hydrogen through electrolysis requires really clean water. Any of the water supply sources we went through on the previous slide, would require water treatment quality.

The extent of water quality treatment needed will depend on the quality of the source water. For instance, treated wastewater and imported surface water, typically have pretty high water quality but will still need some treatment to polish it to ultrapure standards.

Other potential sources like those that are currently managed as waste or nuisance, will require more treatment because they contain things like salt and solid that need to be removed before the water can be polished to ultrapure standards.

Water quality treatment is an important consideration for hydrogen producers because it requires infrastructure and capital. And this information will help inform future hydrogen producer's consideration of where their supply sources come from.

This slide presents some of the existing methods available to acquire a water supply. There are a lot of different variations that can occur within each method. For the purposes of today, I'm going to overview of four key mechanisms.

Exchange agreements, this is commonly used in Southern and Central California to make water supply available to areas of greatest need. This is basically a trade between water agencies. Where one agency makes some of its supply available to another agency in exchange for a supplement or alternative supply from the receiving agency.

Local water agencies are those that service urban municipal and industrial uses, in which have urban water management plans. Hydrogen producers may be able to purchase locally available water directly from a local water agency or potentially partner with a local water agency to develop a new supply source, such as collecting and treating one of the waste streams mentioned previously.

Water markets refer to systems and stayed and trade that have been established to move limited water resources around between designated user. We say this particularly in adjudicate groundwater basins where the use of groundwater is directed by court order.

Finally, there is land purchase with water rights. This is a historic way of acquiring water where the rights to use surface or groundwater resources is attached to land ownership. Now, the existence of water rights does not necessary mean water is available. But the water available study provides information on those variables to help hydrogen producers consider which mechanisms will best serve their needs of perspective projects.

As we wrap up, this line presents an overview some of the key findings of the water availability study. Compared to the total amount of water applied for urban, agricultural, and environment usage throughout the state. Water demands for Angeles Link will represent a small percentage of applied water use.

SoCalGas's water study has been developed to provide guidance to future clean, renewable hydrogen producers in securing water supply for their respected projects. The study includes a menu of supplied source options, which may be refined with future phases of analysis. The study includes an overview of the current supply acquisition methods that could be used by future hydrogen producers. And the study identifies opportunities for future hydrogen producers to explore, such forming partnerships with each other and with water and waste water management agencies.

With that, thank you, and I'll hand this back to Jill.

JILL TRACY: Thank you, Brenda.

Big thanks to Brenda for the presentation previewing our preliminary findings for water agency coordination, water resources, and availability and water purification. Preliminary findings and data will be published by uploading onto our living library by next Friday, February 23.

And I would like to reiterate that the preliminary data results have demonstrated that water needed for three party production of clean, renewable hydrogen that Angeles Link will transport is less than one percent of total annual water needs in California, specifically .01 to .03 percent of total annual water needs. And we are looking forward to your feedback on our preliminary results and findings. And then please note also that the water study will be authenticated as the production studies further refined. With that said, I'll turn it over to Chester.

CHESTER BRITT: All right. Thank you so much.

We have a few people that have raised their hand. I'll go to those. We also have someone that has chatted. Again, if would you like to ask questions about the water presentation that we just heard, please raise your hand, and we will get to you. And if you would like to chat something, feel free to do that.

When I call on your name, please make sure to announce your name, speak directly into the microphone, try to be concise and focus on the discussion topic. We do have quite a few people online today. So I want to be respectful of everyone's opportunity to speak. And we just want to remind you as well, that verbal comment is not the only way to provide input. You can also, after the meeting, reach out to us, and we will document that as well.

And if you need to provide written input after the meeting, we will collect those as well.

So I'm going to go ahead and get started with Arthur. I think you were the first to raise your hand. If you can unmute your microphone, we should be able to hear you.

ARTHUR FISHER: Thank, Chester. My hand has been up since Neil started talking about Arches. So I actually have a question about Arches and also about what Neil said in regards to accelerating the effort to file phase two of the Angeles Link project.

Do we have a date or approximate date for phase two when we could expect the application?

NEIL NAVIN: Arthur, we do not yet have a date. We will certainly come back to this group when we do have a date and make sure you are among the first people to know when our filing of the application is likely to take place.

ARTHUR FISHER: Okay. Thank you.

NEIL NAVIN: No. Date yet.

ARTHUR FISHER: And then to the water study, I just have one general observation. No criticism to the water study here. It would be very usually useful information to understand the energy budget of the different types of water purification, so we can actually understand the greenhouse gas risk associated with the different water sources. I guess is -- I know that's a wide scope of study, I think that is going to be a very important variable in understanding the benefits of the hydrogen production.

CHESTER BRITT: All right. Brenda, do you have anything -- that was more of a statement than a question. I mean, we are collecting your input Arthur. Was that actually a question?

ARTHUR FISHER: So the question is: Is that being captured anywhere?

BRENDA EELLS: The energy budget related to water purification; is that right?

ARTHUR FISHER: Yeah. You presented a whole host of different water sources, which is going to have different energy budgets in making them pure enough for use hydrogen production. I'm wondering if we have a description? Or analyst? Or assessment of the energy budget associated with each different source.

BRENDA EELLS: No. I honestly don't know if it's captured in any Angeles Link task, but it's not something that we have cover in the water availability report.

ARTHUR FISHER: Okay. So I think that is -- this is an observation to SoCalGas. I think that will be important to capture to at least understand the cost -- the GHG costs, potential for the different sources.

CHESTER BRITT: All right. Doe you want to add anything, Jill? Jill is going to add something.

JILL TRACY: Okay. Arthur, that's a helpful question. We would welcome written comments in that regard during the comment period. It is not within the scope of the water study at this time. But it may be evaluated in future phases of the feasibility studies for the project.

ARTHUR FISHER: So is it in the scope of any of the studies?

JILL TRACY: Not to my understanding.

ARTHUR FISHER: Okay. Thank you.

JILL TRACY: You're welcome.

CHESTER BRITT: Thank you Arthur.

Tyson Siegele, I see your hand raised. I think you are next. I am going to go to you. If you can unmute yourself, we should be able to hear you.

TYSON SIEGELE: Hi. Tyson Siegele with UCAN. I am interested in hearing a little bit more just like Arthur was about the -- about Arches as well phase two. To begin with on begin two, in terms of that filing, am I understanding correctly that -- that's going to be accelerated to where phase one will not be completed prior to the phase two application submittal?

NEIL NAVIN: Tyson, this is Neil. The intention is to accelerate the application for phase two. We haven't set a date yet, but it very likely to be before the final report for phase one. Yes.

TYSON SIEGELE: Understood. Thank you. Then in terms of Arches, there has been relatively a little information that as been made public, at least the last time I looked. Is the 1.2 billion finalized? Or is that still in discussion with -- with the DOE?

NEIL NAVIN: Again, this is Neil. So, Tyson, far be it for me to speak on behalf off Arches. I'll just give you a very high level of what I know. Arches is in discussions with the DOE. I think quite -- that is quite public. Where they are precisely? I do not know. I do know from the structure of the grant, that the dollars are issued in tranches. But the indicative award for -- and for -- subject to check of course, for California was $1.2 billion over the period of a grant. That's about what I know, Tyson, at that point.

TYSON SIEGELE: Understood. Thank you. The next question is I had is regarding some reporting that has occurred around Arches and lobbying the Arches is doing on the three pillars related to -- related to green hydrogen or being able to use other hydrogen sources, other than green hydrogen. There have been several PAG members that have signed a letter asking for Arches to stop lobbying against the three pillars.

Is that something that SoCalGas has committed to -- to using the three pillars for hydrogen production in Angeles Link?

NEIL NAVIN: You know, Tyson, I think the three pillars questions are probably addressed to Arches themself. But we have been clear about the hydrogen that we intend to deliver as part of project, which is clean renewable hydrogen with a specific GHG signature to that. I don't recall it sitting here today. We are broadly supported of the state of California's goals to reduce greenhouse gas. We haven't taken a position publicly on the issue of the three pillars.

Again, our support of Angeles Link being a decarbonization project that supports the state its Goal for GHG.

And, Tyson, do you have any questions about the water presentation?

TYSON SIEGELE: Just one more piece. So I dropped in the chat a link to the letter regarding the three pillars. With -- in term of three pillars, if green hydrogen is actually green, then it does have to have the three pillar. That's something that, as you can see, several of the PAG members have signed the letter in support of the three pillars and would really hope that SoCalGas would -- would endorse only moving hydrogen that's green. Only hydrogen that is produced that meets the criteria of the three pillars. I can't remember of the three pillars. So in terms of Arches, that is the last piece there.

Then the other initial comments that I have are, again, more related to regulatory issues. But they definitely are -- are very important issues that need to be discussed. Number one is, the PAG quarterly report for Q3 was released in between the last PAG meeting and this PAG meeting. And in that quarterly report, the full feedback from the PAG members was not included. And that's a violation of the Angeles Link file decision. I wanted to call your attention to that so that can be corrected. In the report there where excerpts out of the documents that were submitted to SoCalGas, feedback that was submitted to SoCal gas. I can't speak for the other PAG members. I know that not all of the information, not all of the data that -- that you can submit during that quarter is included in that document. And so do you have a date in determines of when SoCalGas can reissue that document to correct that error?

JILL TRACY: Tyson, this is Jill Tracy. Thank you for your comments on Q3 reports. We have a tight timeframe today. So I would like to go back to any questions -- take it back to Chester to address any questions that the many members in attendance might have on water, which is a very, very important topic that we have been studying for quite awhile. And then get to leakage. Then if there is addition time, Tyson, then we can either take it offline if you would like to have a separate call to discuss the Q3 reports or if we have time at the end of this session. Is that okay?

TYSON SIEGELE: No. That was all I have on the Q3 report. I am happy to go back to water. I have several other issues that, you know, I would like to share with SoCalGas to make sure that SoCalGas is able to correct any of the errors that are related to violation of the final decision.

CHESTER BRITT: So, Tyson --

TYSON SIEGELE: So whenever that appropriate time is, let me know, and I'm happy to do that.

CHESTER BRITT: Yeah. We made sure that you have access to Emily and others to talk about any issues you have between meetings. But let's just focus, as Jill mentioned, on the water study since we have limit time. So if you have any specific water questions, let's take those. We have other people that have raised their hand. I wanted to make sure we get to them.

TYSON SIEGELE: Sure. Okay. On water, the one question I had is: With the review of water here, is this water study based on the quantity of hydrogen demand that is listed in the SoCalGas draft demand studies?

CHESTER BRITT: So I'm going back to a couple slides that point that out. This slide, if I'm not mistaken, is the overall demand. 1.9 and the 5.9 on the left-hand column are alluding to the conservative and ambitious demand study findings. And then the blue numbers on the right column are the water being associated with that demand.

Then the following table then transition to what is required low and high scenario to Angeles Link specifically. And then that highlight column in blue is the water related to what is need to produce those low and high scenarios for Angeles

Link. Is that correct?

BRENDA EELLS: That is correct. Thank you, Chester.

CHESTER BRITT: I got it.

TYSON SIEGELE: And will there be any other scenarios in terms of the amount of hydrogen that the particular study will take a look at?

CHESTER BRITT: I'm not sure I understand the question. I mean, this is a low and high scenario. So I'm assuming the range for Angeles Link will be somewhere in between them.

So are you asking if we are going to look at something outside of the 1.5 as a high scenario number?

TYSON SIEGELE: Or below the low scenario.

CHESTER BRITT: I mean, right now that's my understanding of what would be the range for Angeles Link transmission; is that correct?

NEIL NAVIN: Tyson, if you will note the attempt of the study, certainly the water study, to look at water availability. So if we presuppose the low hydrogen demand study is A scenario, a low demand scenario. And the water required to do that is .01 percent of the annual water use in California. If it's something lower than that, will be a smaller fraction. And we are unlikely to analyze anything below that.

TYSON SIEGELE: Okay. Understood. Thank you.

CHESTER BRITT: All right. Thank you.

Theo Caretto, you are next. If you can unmute your microphone.

If you can just announce yourself for court reporter. I know I didn't. Just as a formality.

THEO CARETTO: Sure. This is Theo Caretto, Communities for a Better Environment.

I wanted to ask about the numbers that you all looked at for the water study and whether those are the net demands of water for the Angeles Link project and whether the study -- that project gross demand. Because, you know, the gross demands have water needed, even if the water is in a way recycled back into fresh water. Supplies can be really impactful in water drought across the SoCal and the west generally.

BRENDA EELLS: This is Brenda Eells. My understanding is that the numbers in the water availability study are inclusive of water that would be required for hydrogen production as well as water -- excess water that will act for loss during treatment to bring it up to the ultrapure standards necessary for electrolysis.

Does that answer the question?

THEO CARETTO: No. Not particularly. I guess what I'm asking is, for instance, many power projection methods use a great deal of water. If they are -- if the water use is water that's cycled through and then later returned out of the system, there's a greater water stress when that answer is being used but doesn't not -- that water is necessary, like, a net water loss in the system. It's just a greater water stress because you need that water even if it's not all being used up and, like, you know, not available after it's been used.

BRENDA EELLS: If I understand the question, I think the answer is -- I think the answer is no that the water availability study is specific to water required for hydrogen production and the loss associated with treatment. We don't address the water associated with energy production that's for hydrogen production.

THEO CARETTO: Okay. Understood. Thank you.

I also shared the question that Arthur Fisher raised. So I won't ask again, but the question about the energy budget needed for water purification. I want to flag that's also an issue that Communities for a Better Environment is extremely concerned about what and wanted -- would like to see information on.

And then I guess another question I think you mentioned something I think Brittany -- Brenda, sorry, about water from local water sources not being drawn unless there's, like, excessive from that source. And I guess I'm curious how that sort of accounting is done to ensure community needs are all met before water is drawn from certain sources that can go either to hydrogen or to community needs.

BRENDA EELLS: Yeah. I think I can answer that. That's statement was specific to local groundwater. And the idea is that local ground water only be an option if the project were not located in an area of an over-drafted ground water basin.

And I think the answer to the second part of your question in terms of, like, local water agency and available supply is that just like any other large project that has water needs, that developer is going to go to a local water agency and ask for water in a lot of cases. And so the local agency is going to consider that in the overall framework of their urban water plan and determine if they can meet that need sustainably. And if that's not possible, then we have this menu of other options that developers can investigate to meet their water demands.

THEO CARETTO: Okay. I understand that. Those are all my questions for now. Thank you and thanks for the report back.

CHESTER BRITT: Thank you, Theo.

And the next person up is Aaron Katzenstein.

AARON KATZENSTEIN: Hi, thank for information on the water usage. I just had a quick question --

CHESTER BRITT: I'm sorry, Aaron. Just introduce yourself.

AARON KATZENSTEIN: Aaron Katzenstein South Coast AQMD. There is a previous report on the transportation use of hydrogen from the pipeline. And from that, I was wondering if you calculated how much diesel and gasoline might be offset from that transportation usage. I think that can be tied into the water usage report also on how much water refinery use to produce that gas right now. And that can be an offset of that water usage.

NEIL NAVIN: This is Neil. I'll just take a quick try at it. So, Aaron, that's a very good question.

Again, maybe for the benefit of the wider group, the refining of the hydrogen carbon refinery, broadly. Refineries use a lot of water in the production of things like diesel fuel. And we will be clear in our study, Aaron, weather we've taken into potential reduce use of water. That will otherwise have gone to produce things like diesel that we will seek to displace. We have, Aaron, made some -- have studied the diesel that we might other produce -- reduce use of, not produce. Reduce the use in some of our other air quality studies as example. So you may see that here coming up shortly.

The water question is something that we are sensitive to. I don't believe we have actually taken the reduced use of refinery water into consideration yet. We will note whether have or not in the study to make sure that is clear.

CHESTER BRITT: All right. The next person is Michael Colvin. Michael, you can unmute yourself and announce yourself.

MICHAEL COLVIN: Good morning, everyone. Michael Colvin with Environmental Defense Fund. I'm just checking you can hear me in the room.

CHESTER BRITT: Yes. We can hear you great.

MICHAEL COLVIN: Thank you, Chester.

MR. EUFPLT: I have two brief questions for Neil.

Neil, the decision to authorize Angeles Link in the common statements you were making on Arches. The requirement really was driven around defraying cost recorded in the memo account from any federal funds that were available. And so I'm wondering as you are proceeding into your phase two, if you have an estimate of the money that has been allocated into Arches and how much that money can be defrayed of the memo account to help reduce repaired cost impact. And if you have an estimate now or if not, when you will have that available to PAG to understand before you submit your phrase two application.

NEIL NAVIN: Thank you, Michael. No estimate yet of the potential defrayed. As I mentioned before, Arches and DOE are currently -- we believe or we understand is negotiations. So there may be an opportunity for update at a later meeting, Michael. No estimate yet of what that might be.

MICHAEL COLVIN: Okay. Understood. My informal suggestion to you is having reread that order in the paragraph after your comments this morning is that you are really are going to have that number nailed down prior to any submittal back to the POC. Their intent is really trying to defray cost of the memo account and making certain that things are affordable. I think very much top of my mind, I want to make certain that we are bringing the commission back to the right rock.

I also have a question on the water study. Similar to the question that Arthur asked but a little different. When identifying the different sources of water, I think you done a good job sort of identifying the sources. The one thing that is not necessary identified yet, in my mind, is the embedded energy in the treatment and conveyance of each of those water sources. Some of them are very energy intensive for SoCalGas. Some of them are relatively not energy intensive. I think Arthur's question was really about getting the energy required to get the water treated and up to right level of the quality. But I'm more curious about the transformed/conveyance of the water to be able to get it to Angeles Link projection for production use. I'm wondering if this scope of this study or some other future studies can be thinking about the embedded energy cost there trying to identify which water source is selected.

BRENDA EELLS: This is Brenda Eells. I think I can safely say that the water availability report addresses the cost of conveyance. As information to hydrogen producers as sort of a unit cost. But does not have in its scope currently the energy cost of pro- -- treating the water. I think that's your question.

CHESTER BRITT: Is that your question, Michael? Okay. You're waving. I think you're muted. You need to be unmuted.

MICHAEL COLVIN: I know the system muted me again and I wasn't able --

CHESTER BRITT: Sorry. The waving was effected. I saw it.

MICHAEL COLVIN: Oh, good. Brenda, I think the question is not so much of the treatment of getting the water ready hydrogen production usage. It's more of the unit of water that is coming from a waste water treatment facility versus its own unit of water that is coming from desalivation plant are going to have very different energy cost.

And, frankly, water pricing doesn't accurately reflect the overall cost of energy. It's something that the commission has been wrestling with for over ten years. I have water energy stock background from 2012, 2013. And so the reason why I'm asking this is I don't necessary want Angeles Link to be relying upon a water source that is inherently energy intensive. And therefore undoing or eroding some of the benefits of water production of electro hydrogen production because we have chosen inherently dirty or inherently energy intensive water resource. So I was trying to figure out if we could visualize or realize those embedded energy cost so that way we can make some smarter water resource choices.

Looks like Jill wants to correct me on something.

JILL TRACY: I don't want to correct you on something, and you are not feeling well. I hope to see you in person in March at our next quarter meeting.

MICHAEL COLVIN: I probably won't, I have a long standing vacation that was plan.

JILL TRACY: That's excellent news. We are missing you dearly.

I think your comment is a really good one but not within the water scope at this time. But I do think it's information that absolutely critical to evaluate and possible future phases of the project. I would like to reiterate, Angeles Link transports clean, renewable energy and production is really with third party producer. I just wanted to remind you.

MR. EUFPLT: No. Thank you. That's a helpful clarification. I'm going back to mute. Thank you for presentation.

CHESTER BRITT: Thank you. All right. I don't see anyone with their hand raised.

Oh, in person. Here we go. Charley Wilson.

CHARLEY WILSON: I can't have water in my title and not attribute --

CHESTER BRITT: There you go. I wasn't go to say anything.

CHARLEY WILSON: Mine is more of a comment just to strength the study. It's one thing to do a historical reference. Yes. All of those things are sound. In the same way the energy sector is going through a radical transformation. The water industry in California is going to through or will go through that same radical transformation. So to the extent that you can forecast out, and it's a mythical exercise I realize, location becomes really important on the production. Particularly as you look at things like conveyance. And opportunity for historical conveyance may not necessary be there in the future, like Colorado, State Water Project, LA Aqueduct. That radically changes the questions that are being asked here about cost of production. Location becomes important. And having energy intensive you are not only now producing water, but now you got to move it in a way historically you have not had to do it before. It's the two-way system you are all dealing.

To the degree you can in recognition of, you know, the Govern's forecast will be ten percent loss in total water availability is important. Water rights changes will be coming important. Just because of you have them, does not mean you will get to exercise them. There's a lot of people selling water rights without being able to extract water.

Future conservation requirements become important when you put this into a portfolio I think it addresses -- start to address some of the -- the back of the envelope, some folks I talked to walking about the needs and their still is this question -- open-end question about the future energy requirements. They are still talking about roughly doubling the cost for acre foot per water. You are talking roughly 3000 plus acre or foot by the time plug that in. So it's part of the affordability equation.

CHESTER BRITT: All right. Thank you, Charley.

On our agenda, we are going to have a five-minute break just to give everyone a chance to go to the restroom or grab something to drink.

And then we will come back and we will conclude our meeting with presentation on the preview of hydrogen leakage and GHG Nox update. And then we will have that following a member discussion. So we will adjourn at 11:20. We will come back together. Thank you so much.

(Recess held.)

CHESTER BRITT: I want to introduce our next speaker you should be familiar with, Darrel Johnson at SoCalGas manager for environmental studies. And he's going to be making a presentation on the hydrogen leakage assessment. And then he's also going to be providing an update of GHG and NOX emission as well.

I'm going to turn it over to Darrel, and you can make your presentation.

DARRELL JOHNSON: Thank you very much, Chester. Happy to be back. So maybe just a little review of what's CPC decision asked us to do in the hydrogen leaked assessment. That was evaluated hydrogen leakage associated in the infrastructure and hydrogen production, hydrogen compression, hydrogen storage both above ground and below ground, and hydrogen transmission. And also to evaluate opportunities to minimize or mitigate hydrogen leakage. And as a note, I wanted to say within our assessment, that we did not conduct a volume metric because we didn't have the detailed infrastructure that is necessary to do that. And a lot of folks probably in the audience are familiar with, you know, how commissions are reported normally as a specific activity times and admission factor. Next slide.

So as part of technical approach, we have gone through before, we reviewed a lot of technical information as part of this study for leakage. We looked at research based from academic based institutions like Colombia University, University Of Wyoming, Frazier Nash Consultants. We also looked at literature presentations and data entry from other entities and agencies, like the National Renewable Energy Laboratory, Joint Research Center and the Energy Defense Fund. We looked at a lot of regulatory requirements both federal, state, and local agencies like United States Environmental Protection Agency, Department of Energy, The Pipeline and Hazardous Material Safety Administration, California Air Resources Board, and California Energy Commission to name a few.

And the final quadrant was technology and manufacturing of technology in advancement that measure or minimize leakage. We looked at a number of companies and facilities there, Aerodyne and Fukuda, PDC Machines and some of their leak detection devices and sensors. Next slide, please.

So the methodology that we examined when considering the leak assessment really came from two methods. We considered the top down approach, which is the total value approach, which provide component leakage and ranges or rates. Some arise from the various value chain sectors. And we looked at a component counter approach similar to what I said, you know, activity time factors. That requires specific project information and equipment detail and process components aren't available at this point in the process.

And so we elected to choice number one the value chain sector, and we will provide some of the leakage rates within each of those value chain sectors, production, compression, transportation, and storage.

Next slide, please.

Some of the leak detection technology that was observed in our research and reviewed of the, you know, scientific information came out with a number of a different types of technology for leak detection. They range in their ability to detect, and I have here listed on the slide some of those ranges like Aerodyne is 10 part per billion and semiconductor sensor are half percent per million up to 5,000 PPM and so on and forth. The ranges all are very small at 10 parts per billion and got to a higher level at 1,000 part per million and greater for things like catalytic combustion sensors and conduction tape as you say, you need a lot of tools in the tool kit. Next slide, please.

So those look like ranges within the value chain area are what we are listing here on the slide from the various literature and studies that we're reviewing. There's a number of studies. A lot of them are fairly recent times because it's evolving as we speak.

So in the production sector, we had ranges all the way up from one thousandth of a percentage to 11,000 to up to 4 percent. For different elements of production, say, for example, the one ten thousand of a percent was associated with the steam methane reformer technology and the .2 percent estimated for losses across the electrolyzers associated with the losses of hydrogen and oxygen cross the membrane from dryer generation processes.

And our compression value chain component, the Copper, et al, study show a lower and upper limit of .14 to .274 for nature gas -- using gas as a proxy for hydrogen.

And our above ground storage, the process that we used there was we took the Frazier and Nash and, you know, the leak rate was really associated with the resident time of storage. And so the leak rate range two 2.77, which was associated with two days of storage, and you all the way up to 6.5 of a month of storage at a fairly high confidence level.

The underground storage, which was a primary based on salt caverns was predicted to be very low and it was 0.2 to 0.6.

And then we went to transmission. There's a lot of studies in this area that provided a large range of potential leak rate values. All the way from .02 up to .48. But, you know, say .01 was estimated for new pipelines dedicate to transport of hydrogen that came from the global energy system model. So suffice to say, the summary covers a lot of different potential ranges in the various value change based on the studies. I would compare this to what's happening in the last ten years with natural gas. This is where we are at this point in time. This is the emerging and evolving process.

Next slide, please.

We also tried to identify some opportunities to minimize leakage. And looking at design and engineering, these are just a couple of data and study points that provided information in this regard. For compressors estimated reduction potential was fairly high. Similar to what's going on with capture and control equipment with nature gas at 95 percent greater for leak capture and return mechanism with vapor control systems.

Pipeline welded connections and leak values potentially up to 100 percent based on the Fraizer Nash and Arrigoni studies we weren't able to quantify at this time in the operational minimization. However, from a maintenance or repair standpoint, kind of the leak detection and repair program for valves, flanges and threaded connections, like the carbon and gas program in place for natural gas. The Arrigoni and Fullerton and PG&E represent about an opportunity for 89 to 96 percent of reduction potential.

So there's -- there are with design and engineering with the continued detection and repair process, there's a good opportunity -- potential opportunity to reduce emission and leakage. Next slide.

So wanted to use some of the leakage to answer some answers or request that were made previously about greenhouse gas and the global warming potential hydrogen itself.

So there's a number of studies and have represented six here where they, you know, approximate or estimate the global warming potentials for the 100 year estimate and the 20 year estimate. Literature speaks to the indirect aspect of hydrogen as a global warming gas. In of itself, is not a greenhouse gas, but it reacts chemically in the atmosphere to affect other greenhouse gases. Ox Hydroxyl that normally limits the time for certain gases, like methane in the stratosphere is impacted by the additional hydrogen and can lead to the prolonged methane lifetime in the atmosphere.

There's also a potential of increase levels or concentration of ozone in the troposphere and increase concentration of water vapor in the stratosphere. So because these are studies that range goes all the way from 3.3 to about 12.8 for the 100 year and 35 to 40 for the 20 year estimate. I would say not unlike what we experience in the global warming potential for methane with the IPPC estimates that is also an evolving process and these numbers may change.

Next slide.

So I wanted to go back and giving you an update if you will. We will provide the preliminary findings for SoCalGas service territory previously. And that's 1.9 to 5.9 projection in milli metrics times per year. Now, I would like to provide you some of the preliminary findings associated with Angeles Link. And just at a very high level for NOX, you know, for NOX we were projecting or estimating that will give about a 20,000 ton per year reduction ambitious or high scenario. And with the build-out perimeter of 1.5, that number would be 5,141 tons per year for a NOX reduction associated with Angeles Link.

Also, relative to our greenhouse gas number, we are projecting for the SoCalGas service territory and the demand study about 35 million metric tons per hour of greenhouse gas reduction. And the Angeles Link build-out would provide about 9 million metric tons per year.

So I wanted to provide that updated and alignment with our previous preliminary finding associated with our service territory and align with the Angeles Link.

Now, I'm open for any questions. Thank you.

CHESTER BRITT: All right. Thank you, Darrel.

Does anyone have any questions? I don't see any hands raised for Darrel's presentation. All right. Tyson, you raised your hand. You're first up. You can unmute yourself, and we will unmute you as well. Go ahead.

TYSON SIEGELE: Tyson Siegele with Utility Consumer Action Network.

Darrel, thanks for the updates on NOX emission and the information you provided today. The -- one of the pieces that we had discussed in the previous meeting on NOX emission was the inaccurate calculation that was completed on NOX emission for power plants for the -- it really appeared that the industrial sector was incorrectly calculated also well because it wasn't calculated on an absent space. It wasn't calculated on an equal number of what hours to equal number of what hours from a nature gas generation to hydrogen generation.

This is just my recollection, in that meeting that you have said that now that you know that is something that so interest to -- to the planning Advisory Group to understand what an apple to apple comparison for that is. Is that something that was emigrated into to these updated NOX numbers? Or is that yet to be done?

DARRELL JOHNSON: Thank you for the question, Tyson. I can say that is yet to be done. These numbers presented today are specifically through the input for Angeles Link and the original estimates based on fuel substitution.

TYSON SIEGELE: Got it. Do you know when you'll be able to provide that to the Planning Advisory Group? Is that going to be in an upcoming meeting? Or in another venue?

DARRELL JOHNSON: I haven't -- or I don't know right now exactly when that information will be available. It's something we are looking into it, and I have asked for some of that information from our -- our contractor, but we don't have it at this point. I'll update you or let you know, and I can reach out to you directly when we have more along those lines and will be able to ensure that we provide some detail to that regard in the final study.

TYSON SIEGELE: Thank you, Darrel.

CHESTER BRITT: Thank you. Next person up, I think, is Jack Brouwer. Good to see you, Jack. Unmute yourself.

JACK BROUWER: Hi. Just wanted to note --

CHESTER BRITT: Sorry. Jack, can you just introduce yourself to the court reporter?

JACK BROUWER: Yeah. Sorry Jack Brouwer from UC Irvine. Just wanted to note that you do have some very good references for the global warming potential studies that have been published previously. But there's some modern studies that I think you should include. In particular, the Ako and Humberg (phonetic) study that was just published just a couple years ago from Environmental Defense Fund. There are also Juan and Caldera paper that can shortly there after from Stanford. And then there's a new one. It's not published yet. But that EDF is talking -- is holding some workshops right now to discuss with the community.

These are receiving a lot of attention. So I think you should absolutely include those in your list of those in the study. I don't think it's going to change the numbers that much. It going to be about just what you noted. I think you should acknowledge some really good recent work. Okay? Good work with regarding global warming potential. I don't agree with the leakage rates. That's some of the papers I have included. Then, you can argue against or for those considerations going forward.

DARRELL JOHNSON: I just wanted to say Jack. If you can share. I jotted down a couple names.

JACK BROUWER: I can give you those three references directly.

DARRELL JOHNSON: Yeah. I appreciate that greatly. Listen, it evolves the research that we are doing. So anyone has additional research that is beneficial and let me know. I'm already providing what's available; right? So that this is most informative information that -- or the study provides informative information.

Jack, you know how it goes when it comes to leak rates. This whole scientific piece is going to grow; right? We were using the 1996 numbers for natural gas for a long time. I think this is an emerging and a lot to come. Thank you for that.

JACK BROUWER: I really hope, and I just -- I wrote a paper. I'm trying to encourage hydrogen community to invest in better understanding and approximately the leakage rate that we should expect from infrastructure. I think we also have an opportunity because we are just beginning to produce this infrastructure to actually make measurements. I'm glad you were talking about that earlier. Measurements cann confirm what the science says with leakage rates. So, anyways, I think we can have another decade or two investing in understanding it better.

DARRELL JOHNSON: As do I. Thank you, sir.

CHESTER BRITT: Thank you, Jack.

Theo Caretto, you can unmute and introduce yourself.

THEO CARETTO: Yeah. This is Theo Caretto for Community for a Better Environment. Yeah. I appreciate this leakage data. I'm aware that SoCalGas is also working on safety assessments. I fell like it's pertinent to flag here that, in addition to climate impact that this leakage can have, there is also very serious safety impacts that hydrogen leakage can have.

And sort of to that point, just this morning in Wilmington -- in the neighborhood of Wilmington, in the city of Los Angeles. A nature gas tanker truck sprung a leak and exploded and that explosion resulted in injuries in a number of firefighters and significant damage to the surrounding area. Which is extremely tragic and concerning. It's also sort of par for the course for the impacts that gas infrastructure in injustice communities and will continue to have if hydrogen perpetrates the systemic racist and injustice sighting of infrastructure in communities. There's been a lot of reporting on the explosion. But there hasn't been a significant coordinated emergency response, that you might see in an explosion if this occurred in wealthier communities that don't see huge tragedies like this on a monthly basis. And that tragedy comes on the heel of an enormous pipeline leakage at Wilmington oil joint site that was operated By Warren Resources. Just wanted to flag the significant harmful real world consequences of fossil gas and other industrial gas infrastructure and environmental justice communities.

I also wanted to ask about the leakage issue. I saw that is sort of address the global warming and GHG impacts of hydrogen leakage. But the extent that this is considered SMR or other forms of fossil gas reformation to produce hydrogen. It's also really important to consider the leakage of those fossil gases. If you are forming methane, there's methane leakage that has climate impacts. If you are reforming other fossil gasses like biogas or ethanol, et cetera. It's extremely important to also have information on those. And I didn't see that those sources of GHG emission. I wanted to ask whether they were and I just missed it.

DARRELL JOHNSON: So we are looking at -- and those numbers I shared -- and thank you for the question. The number I shared within the production segment were primary are three considerations that we're having steam methane report of steam methane reformation and electrolysis. And biomass -- those -- that's what we are doing in those research. And so the value chain of leakage numbers were associated in the -- those three areas.

CHESTER BRITT: All right. The next person is Matthew Taul. Matthew, unmute yourself and introduce yourself. Thank you.

MATTHEW TAUL: Hi, there. Can you all hear me?

CHESTER BRITT: We can.

MATTHEW TAUL: This is Matthew Taul, Public Advocates Office Engineer. If I can ask that the slides be rolled back to estimate for transportation. I think there was a range given. 1 to .48. Yeah. This slide. Just some questions on that. I guess on the details. Is 0.16 percent estimate for new pipeline. Is that unit length? Or are there parameters going into the 0.1 percent? For instance, I can image the length of the pipeline affect how much leakage occurs. The operating pressure, the pipeline parameters. So many different parameters that can affect that. I am wondering what went into that 0.1 percent global estimate?

DARRELL JOHNSON: Actually, Matthew, that's a great question. I mean, normally, you would have an activity factor like miles of pipeline associated with transmission pipeline. I don't have that -- that study unit of measure memorize. I can provide that information for you at some point in the future. Not a problem. I would imagine it's associated with an activity like length in this particular case. I can run that to the ground so you can know for sure.

CHESTER BRITT: Any other questions, Matthew? You have to unmute yourself again or we do. One of -- someone have to unmute you.

MATTHEW TAUL: I appreciate it. Thank you. I -- obviously, thank you for providing the data here. Our team will look into that and try to find that as well. This is just another, perhaps, suggestion, which is -- I'm not seeing anywhere on here the possibility of the non-pipeline alternative. I know at the start of the work study, there were some language about providing these analyses and these reports in an alternative's approach on the pipeline approach or small pipeline basin in a look alike of hydrogen approach. Obviously, when it comes to transmission, a non-pipeline alternative starts to issue those kind of issues. I would be interested to learn how SoCalGas is estimating these for not just the pipeline option, the larger project being proposed, and the wire basin approach, the in basin look alike projection. So just more of a statement on that one. Thank you.

MR. STPHAO: Thank you.

CHESTER BRITT: All right. Our next person who has their hand up is Michael Colvin. If you can unmute yourself.

MICHAEL COLVIN: Thank you. Michael Colvin Environment Defense Fund. If you can go forward one slide, that would be great. I apologies. One more. I wanted to hit the last one for the -- one more again. Apologize. I miss counted. I think this is the one I'm looking for thank you.

Darrel, I think this is a really thoughtful summary piece of analysis. I commend you and your team getting it down to a digestible level like this.

One other place that -- for future work, that I would recommend is looking at the Angeles Link project under each one of these low and high scenarios. When you are looking at GHG and NOX production, I think sector -- break down of that by sector, so we can see what's driving these numbers. Is it reductions? Are we getting the biggest bang for the buck in reductions in the heavy industry sector, in electric generation in residential. What's your estimates are? How you think that's going to be handled?

I know Angeles Link has -- this is going to be meant for the hard electrify parts in the economy. So I think uplifting, not just generic service territory or generic kind of project wide. Here's the core end uses that we anticipate Angeles Link is surveying. I think it might be a similar number. I think it would be very helpful, digestible number for the PAG and

Angeles Link to have.

I also wanted to note in the chat, I put the link to a couple other people that might be of help. And I wanted to thank Jack Brouwer for the shout out for the EDF's work. I swear he's not on the payroll. We appreciate the collaboration.

DARRELL JOHNSON: Michael, thank you for that. And we will have that break down. This was just, you know, kind of a snapshot to do a high level overview. We will be providing that sector in comparison to build-out versus the territory. So thank you, and I appreciate you putting that extra information in the link, and I hope you feel better.

CHESTER BRITT: All right. Saw the thumbs up, Tyson. You have your hand up again. Let's go back to you.

TYSON SIEGELE: Hello. Tyson Siegele. Representing Utility Consumer Network. I was curious about the production method that you are assuming for the emission here. One of the pieces that I mentioned earlier was production of green hydrogen that uses the three pillars. And discussion of using that as a criteria for hydrogen that's transported through Angeles Link or not. It sounds like SoCalGas has not made a decision on that. If that's the case, if there are -- if there's possibly of nongreen hydrogen going through the Angeles Link, and I'm just going to drop-in another link here that provides. Within that article there's quite a bit of links to research I think would helpful.

The -- the -- and so what I'm getting to here. The emission, I think, will have a significantly indifferent profile. If you are either assuming three pillars production or assuming not having three pillars production, is that something that you have considered within the emission research that you have done so for?

DARRELL JOHNSON: So as you noted, I don't know if a discussion has been made relative to the three pillars. So basically for the numbers that you see today, it is basically a potential fuel slot for the demand; right? Which is how we are looking at production. What is anticipated, you know, demand and associated emission consideration from that study. So each and all of these studies are, you know, relying on one another. I will simply say that I think that some of the choices and decisions you may be referring to is future consideration but haven't been made into the numbers at this time.

TYSON SIEGELE: Understood. And in terms of the overall demand versus Angeles Link that you are showing in this slide. It looks like the Angeles Link is simply a percentage of the overall demand. In each of those, I know that in the demand study, there's a good break of which -- which usage of hydrogen is assumed under. I -- then maybe this is something that is going to be share in a future study. It would be interesting if you have anything that you can share right now in terms of is the Angeles Link hydrogen going to be to a greater or lesser extent. For instance, to transportation or to power or to industry. Do you -- do you have anything on that that you can share?

CHESTER BRITT: So, Tyson. No, at this time, this is based on the original break out of demand study. And proportion of the build-out is a small portion of the ultimate demand emission associated with the build-out. You know, that is a good perspective. The demand use in the various sectors is what is driving emissions or supply in various sectors is what is driving emissions.

TYSON SIEGELE: Got it. I think that's all the questions.

CHESTER BRITT: Okay. Thank you, Tyson.

Anyone else have any thought before we move on to conclude our agenda? No. Okay.

I'm going to keep going here. I am going to next introduce Andy Carrasco, who is the Vice President of Communication of Local Government and Community Affairs for SoCalGas. He's going to name our closing remarks today.

ANDY CARRASCO: Yeah. Absolutely. Thank you very much everyone for attending. We really appreciate everyone's collaboration and showing up today. Just take that moment to say thank you. Definitely to your engagement to the process of Angeles Link.

I can tell you that, you know, advancing the work of

Angeles Link is very important. This process in itself is doing that. So just thank you. I do want to queue up. And, Chester, earlier you said -- our first quarterly meeting of the year is taking place on March 5th at the Long Beach Airport Marriott from 10:00 a.m. to 2:00 p.m. Our team will soon share that information with detail of the topics and the material that will be covered on that date. And if you get a chance to show up in person, we are also having an opportunity to tour the Long Beach Airport itself. That will follow that meeting. So lookout for more information on that March 5 date.

Also, the coming weeks, we plan to share preliminary study findings of water leakage, greenhouse grass -- gas, and NOX emissions. Lookout for us to ensure about those as well.

Again, thank you very much for the collaboration and appreciate the ideas, concerns, the suggestion, and everyone who has dropped links and reports onto our chat and forwarding those accordingly. Look forward to your continue participation. We hope to you see you on March 5th. That will wrap it up.

CHESTER BRITT: Yeah. Pretty much.

I just wanted to remind everyone. You do have access to reach out to Emily between meetings, if you want to reach out and ask any follow-up questions.

And as Andy mentioned, our next quarterly meetings are going to be at unique locations. So we will really want to encourage you guys to come in person. It really is an opportunity for us to see each other face to face. We will have a much longer agenda with a lot of information. So I would encourage that. It's still available online, if you need to participate online.

With that, I wanted to thank everyone who did take time out of their day to be on this meeting. This concludes our meeting. Thank you so much.

(Meeting adjourned.)

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That the foregoing Proceedings was taken before me at the time and place therein set forth.

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BEFORE THE

COMMUNITY BASED ORGANIZATION

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STATE OF CALIFORNIA

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TRANSCRIPTION OF PROCEEDINGS

Listening Session

Monday, March 4, 2024

Reported by:

CHRISTINA RODRIGUEZ
Hearing Reporter

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BEFORE THE

COMMUNITY BASED ORGANIZATION

STAKEHOLDER GROUP

STATE OF CALIFORNIA

TRANSCRIPT OF PROCEEDINGS, taken via Zoom, commencing at 10:00 a.m. and concluding at 2:00 p.m. on Monday, March 4, 2024, reported by Christina L. Rodriguez, Hearing Reporter.

APPEARANCES:

PRESENTERS:

Lee Andrews Group:	Alma Marquez
SoCalGas:	Maryam Brown Frank Lopez Emily Grant Armando Torrez Yuri Freedman Amy Kitson Katrina Regan Chanice Allen Larry Andrews
Arellano Associates:	Chester Britt
Los Angeles Technical Trade College:	Marcia Wilson

ATTENDEES:

Ballona Wetlands Institute:	Marcia Hanscom
Breath Southern California:	Marc Carrel
California Greenworks:	Jessy Shelton Michael Berns
Coalition for Responsible Community Development:	Ricardo Mendoza Kenta Estrada-Darley
Defend Ballona Wetlands:	Roy Van De Hoek
Faith and Community Empowerment:	Hyepin Im
Food and Water Watch:	Andrea Vega
Go Green Initiative:	Jill Buck
Little Tokyo Community Council:	Kristin Fukushima

ATTENDEES (Continued)

Los Angeles Indigenous People's Alliance:	Luis Pena
Mexican American Opportunity Foundation:	Cid Pinedo
Parents, Educators/Teachers, Students and Action:	Ella Cavlin Craig Mendoza
Physicians for Social Responsibility LA:	Alex Jasset
Protect Playa Now:	Kevin Weir
Reimagine LA:	Rashad Rucker-Trapp
Soledad Enrichment Action:	Enrique Aranda Nathan Arias
Southeast Rio Vista YMCA:	Gerry Salcedo
Southside Coalition of Community Health Centers:	Andrea Williams
Watts Labor Community Action Committee:	Thelmy Alvarez
Watts/Century Latino Organization:	Autumn Ybarra
LA Black Workers Center/Care at Work, UCLA Labor Center:	Andrea Slater
California Public Utilities Commission:	Sasha Cole Christopher Arroyo
California Strategies:	Marybel Batjer
JTM Academy:	Amaree El Jamii Bryan Barnett Andre Halloway

ATTENDEES (Continued)

ZOOM ATTENDEES:

Nancy Verduzco
Stevie Espinoza
Pearl Hsu
Isaac Martinez
Anniken Lydon
Emily Grant
Alyssa Martinez

Hybrid Proceedings, Monday, March 4, 2024

ALMA MARQUEZ, LEE ANDREWS GROUP: Thank you again for being here this morning and welcome. First, I'd like to start off with a few housekeeping rules. We do have some restrooms over to your left, my right. So if you'd like to take quick break, please do so. And also, I believe we have all of our folks that have RSVP online are here as well.

My name Alma Marquez, and I am the is Vice President of Government Relations at Lee Andrews Group and the CBO's stakeholder group lead facilitator. Again, welcome to this morning's hearing. I also have here to my left, Chester Britt, will be also facilitating this morning's meeting with some member discussion.

So with that, I'd like to escort the next slide. That's us. This meeting is being recorded. As you all know, we have a transcriber that will be taking down everyone's notes so we could make sure that everything here is accurately represented. If you like to speak, please make sure that you raise your hand. We do have some folks that'll be passing around a microphone for this hearing for this morning, afternoon's meeting.

And we also would like to invite our Zoom folks to please make sure to un-mute yourself to allow yourselves to speak. And as I mentioned earlier, we do have a court reporter. So please make sure you say your name and organization to make sure we have all of the information accurate.

And we with that, I'd like to introduce our first person who would like to go over our agenda. Our wonderful Emily Grant, who is our SoCalGas Community Manager, will be leading us through the agenda.

EMILY GRANT, SoCalGas: Thank you, Alma. Good morning everybody. It's so nice to see all of you. We really appreciate your time and being with us today, so thank you so much in advance.

So like Alma said, we're going to start off as we always do at SoCalGas with a safety moment and then we're going to go into roll call. And then we get to hear from out fantastic hosts here today at LA Trade-Tech College so we're really looking forward to that. Then we're going to move into another fantastic welcome from our SoCalGas President, Maryam Brown. We're so excited to have her today.

Then we're going to move into Routing

Presentation. We're going to go over with you the process by which we would identify preferred routes for Angeles Link, which is really exciting. Then we'll move into our safety study and our Safety Presentation. And we'll do a walk-the-walls activity, get you up and moving a little bit to go over our safety study.

Then we're going to move into lunch. We're going to take some time together and sit down for lunch, and we're going to be served by the culinary students here at LA Trade-Tech which is super exciting.

After that, we'd love to hear -- if you remember from our December meeting, we were going to go into hearing updates from you all about what's going on with your organizations, and we ran out of time because the discussion was so great in December. So after lunch, we'll take a moment to hear from you, what's going on with your organizations.

And then we will end the day with a workforce presentation. And then we'll break out into small groups and go over some of the things we heard about from the workforce presentation, and get your feedback on that.

And then, lastly, we're going to move into an intro of our Community Benefits Plan and what we can expect in June with the work that we'll be doing together on that. And that is it. Thank you.

ALMA MARQUEZ, LEE ANDREWS GROUP: Thank you, Emily. Also, before we get started, I hope everyone has picked up a folder. It has an agenda of what Emily has just relayed as well as three worksheets that you will be -- find very helpful through the three presentations that we just shared with you. So if you have not received one, please do so as it will be very helpful for today's meeting.

And with that, I'd like to introduce, first, Armando Torrez, who will be giving us our SoCalGas safety moment. He is the Regulatory and Policy Manager for SoCalGas.

ARMANDO TORREZ, SoCalGas: Thank you, Alma. So yes, I'm happy to share a safety moment with you all today. But, first, I would like to just do a very quick introduction for myself as I am new to the Angeles Link team.

So as Alma stated, my name is Armando Torrez. I am the Regulatory and Policy Manager for Angeles Link. I've now been with the team for about two months. And during that time, I've had a lot of very engaging and inciteful conversations. But -- and I'm not just saying this because I'm here -- the most exciting conversations were one involved in this meeting, so thank you all for having me here today.

So my safety moment is a seasonal. And it is going to be related to the upcoming daylight savings time change that we're all going to be experiencing this upcoming Sunday. Typically when we hear "daylight savings time safety moment," it typically has something to do with maybe refreshing your batteries in your smoke detector or your carbon monoxide tester. Or, you know, certifying and testing your fire extinguisher; something related to kind of a, like, a reminder.

And these are all very good and critical pieces to remember, but mine are more focussed on personal safety. So as we embrace the annual tradition of spring forward into daylight savings time, it's crucial to shed light on the less discussed aspects of this time adjustment. Particularly, concerning our health and safety. And while we might enjoy the extra hour of daylight in the evenings, the transition is not without its challenges.

Today I want to highlight four key areas affected by the shift to daylight savings time. These four areas are: Your mood, your appetite, your cognitive function, and the risk of heart attacks and strokes.

First, the change in time can significantly impact our mood. The loss of an hour sleep may seem minor, but it can disrupt our sleep cycles leading to hormonal imbalance. This disruption can cause feelings of depression, anxiety, increase of irritability, and mental exhaustion. The anxious mood not only makes it difficult to fall asleep, but can also lead to a vicious cycle of sleep deprivation.

Second, our appetite. The adjustment to daylight savings time can confuse our body's internal clock, affecting the hormones called ghrelin and leptin which could regulate hunger. Sleep deprivation could cause these hormones to send mixed signals leading to increased cravings and overeating; it's a subtle change that can have a significant impact on our dietary habits.

Third, cognitive impacts. Research from the Journal of Applied Psychology highlights a start reality. The Monday following the shift to daylight savings time sees a noticeable increase in workplace injuries and severity of those injuries. Moreover, studies have shown a spike in traffic accidents on this day attributed to tiredness and decreased alertness. Our memory, performance, and concentration skills take a hit, emphasizing the need for a heightened awareness during this period.

And then, lastly, and perhaps the most alarmingly, is the increase in health risks. A study recently published in the British Medical Journal reveals a 24% percent increase in the risk of heart attacks the Monday after we spring forward. Additionally, there's an 8% percent increase in ischemic strokes during this time. These statistics are a sobering reminder of the physical toll in the time change can exert on our bodies.

In light of these findings, it is necessary that we take proactive steps to mitigate these risks. Prioritizing sleep, maintaining a healthy diet, and practicing mindfulness to managed stress and being extra cautious on the roads can all contribute to a smoother transition into daylight savings times.

As we adjust our clocks, lets also adjust our habits and routines to prioritize our health and safety. By being aware and prepared, we can ensure that the transition into daylight savings time is a seamless and safe as possible for ourselves and for our communities. Thank you.

ALMA MARQUEZ, LEE ANDREWS GROUP: Thank you, Armando. Next I'd like to invite Enrique Aranda who will be leading us in our land acknowledgement. Fun fact, Enrique has been part of every meeting and has not missed one single one for the last 12 months as of today. Thank you, Enrique. I've noticed, and we appreciate your feedback.

ENRIQUE ARANDA, SOLEDAD ENRICHMENT ACTION: Good day friends and relatives. Blessings to all. I am honored to give the land acknowledgement this morning. I've lived my life believing that the land is our relative and she holds all of us accountable.

As we begin, we must acknowledge colonialism as an ongoing process. That this possesses indigenous land, life, and resources wherever we call home. We acknowledge that this land is the land where you might live, work, and raise families. Is on an indigenous land that was taken from its original caretakers. With gratitude and respect, we honor the indigenous peoples on this conceptual land we gather such as today.

The diverse of our communities are the Tongva, the Tataviam, the Serrano, the Kihz, and the Chumash people who for generations that care for this lands to make our home care today. We honor and pay our deepest respect to the elders and descendents, past, present, and emerging. As it continues the stewardship of these lands and waters for generations to come.

We acknowledge the colonization resulted in lands leader, disease, subjugations, slavery, relocation, broken promises, genocide, and multi-generation trauma. This acknowledgement today demonstrates our responsibility and our commitment, the truth, the healing, and reconciliation. And more importantly, to elevating the stories, the culture, and the community of the original caretakers of this region. We are grateful for the opportunity to live and work on these ancestral lands. We also celebrate the resilience, the strength, and the way we inspired the indigenous peoples and are dedicated to create a collaborative accountable and respectful relations with the indigenous nations, the local tribal governments such as and in no order, the Fernandeno Tataviam Band of Mission Indians; the Gabrielino Tongva Indian's of California Tribal Council. The Gabrielino Tongva of San Gabriel Band of Missions Indians; the Gabrielino Band of Missions Indians of Kizh nation; and finally, the San Fernando Band of Missions Indians. Thank you.

ALMA MARQUEZ, LEE ANDREWS GROUP: Thank you, Enrique.

With that, I'd like to have our first presenters speak today. She is from LA Trade-Tech. She is our wonderful Dr. Marcia Wilson who is our Vice Dean of Academic Affairs at LA Trade-Tech. And for what I understand has been here for quite a bit and has held multiple hats so too many to share, but I'm sure she'll share some with us.

And as -- is giving us the honor of being here this morning, I understand she's had quite a bit of meetings this morning already, but she snuck out to join us to greet you all this morning. So with that said, Dr. Marcia Wilson.

MARCIA WILSON, La TECHNICAL TRADE COLLEGE: Thank you. Good morning, everyone. I have the urge to part my hair this way and sit up straight so you recognize me.

Anyway, so welcome to Trade-Tech. We really love having our community partners hosting here on our campus. We were so lucky to have built -- this is our most recent build for our campus and its been used for so many community partners and I'm so glad that SoCal Edison and the Angeles Link group could be here this morning. I wanted to share with you guys a little bit about what we do for workforce development.

So in my role as -- being the -- the name of where I work is Pathway Innovation and Institutional Effectiveness. And so that pathway innovation part, I am the dean of pathway innovation. We also have a dean, but I'm the dean of pathway innovation. What that means is that I work with all of our community members to do partnerships that are beneficial to our community and that do things a little bit outside of what traditional community colleges do.

So that includes kind of the innovative projects, the startup projects. And we begin working on sustainability and working on careers in this green economy back in the 2006, 2007, before there was this thing where people really understood what a green job was. So I do have a hand out here, I'll leave with you guys, kind of highlighting what we have in terms of our relationships and with the community and also a description of our green programs.

So we've done a lot with SoCal Edison and our Construction Maintenance and Utilities Department. We've had some great partnerships. We refer all of our electrical folks to you guys. We, you know, you'll see as your drive away, you'll see our pole climbing yard on the corner of Flower and Washington. And we also have worked with SoCal Edison. We've given your scholarships to our students. We've really worked very closely with you and we're very honored to have you as part of our family here at Trade-Tech.

So I just want to highlight, we have -- at Trade-Tech, we have nine pathways. So our college's divided up into nine pathways. One of those pathways is the traditional liberal arts and transfer pathway where those are students who want to transfer to any four-year college university.

We also -- then the other eight are our career and technical education pathways. And so one of them here in the culinary arts building and so it's culinary arts. The three that are featured on here are advanced transportation and manufacturing pathway, our applied science's pathway, and our construction maintenance and utilities pathway. And those are the most relevant to most of the work that you do in this group and the community.

We also have designer and media arts which has our fashion program, our signed graphics program. We also have cosmetology so if you ever want to come over and get a facial. Or we also have a barber shop in there and, you know, you get your hair done. And so we have our cosmetology pathway.

We have our health and related science pathway as all the pre reqs and also our nursing program. And then -- lets see. I think that's it. That's nine, right? I think I covered all nine. I always forget one. Oh, business and civic engagement. That's the one. I knew I was forgetting one.

So we also have a business and civic

engagement. We have a labor center here where we work with our labor unions. And I'm very luckily to run and partnership with the Coalition For Responsible Community Development. We have a co-located work source center here on our campus that is managed by CRCD. And we also have several student services program. So we have Project Tipping Point for our foster youth; and we also have CRCD Academy for our disconnected youth; and we have a co-located high school or early college academy here on campus.

So we really do recognize that the community and community college is very important and so that is what we do. So I'm just going to leave this for you. This kind of just describes our programs that we have, and it is in our advanced transportation manufacturing pathway.

We have our heavy duty and trucks. We have our hybrid and electrical vehicle. We have the only rail vehicle technology program west of the Mississippi. We also have our applied science's program where we have chemical technology, bio technology, process tech, as well as -- and we have industrial safety regulation in bio manufacturing certificates that people could get in less than a year. And we also have our construction maintenance utilities, CMU, pathway which is probably our most extensive list. And it includes all of our energy programs. You know, our program in water. We have all of our utility programs, our alignment programs, electrical, plumbing, HVAC, carpentry.

And so I will leave it at that. I'll be here if you have any questions. They have my number, and I'm right across the way. So if you need something or have any questions during the day or during lunch, just let me know and I'll be real glad to come back and share with you any additional information and answer any questions you might have. Thank you.

ALMA MARQUEZ, LEE ANDREWS GROUP: Thank you, Dr. Wilson.

And with that, I'd like to go into our self introductions. That way you can see all the wonderful people. CRCD is one of our partners, Dr. Marcia Wilson, so I'm that they're part of your programs. So with that, lets go ahead and start with Cid. If you could please state your name, we have a microphone, and the name of your organization.

CID PINEDO, MEXICAN AMERICAN OPPORTUNITY FOUNDATION: Good morning. Cid Pinedo. The presidency of the Mexican American Opportunity Foundation. I got to tell you really quickly, I spent about 12 years working in the community college system so it's nice to be back on a campus. Thank you.

ALMA MARQUEZ, LEE ANDREWS GROUP: Thank you, Cid.

ROY VAN DE HOEK, DEFEND BALLONA WETLANDS: My name is Roy, full name Robert Van De Hoek, Defend Ballona Wetlands. Cooperative organization with other groups in the Los Angeles area on the coast. Ballona Wetlands are between LAX Airport and Marina del Ray. And it's got 640 acres of natural area and surrounding it -- it's just. Okay.

ALMA MARQUEZ, LEE ANDREWS GROUP: Thank you, Roy, for making the drive.

GERRY SALCEDO, SOUTHEAST RIO VISTA YMCA: Good morning. My name is Gerry Salcedo. I'm the Executive Director of the Southeast Rio Vista YMCA. I apologize for missing the last few meetings, but I'm back.

ALMA MARQUEZ, LEE ANDREWS GROUP: You have to catch up to Enrique's score card.

GERRY SALCEDO, SOUTHEAST RIO VISTA YMCA: No pressure.

ENRIQUE ARANDA, SOLEDAD ENRICHMENT ACTION: Good morning. Buenos dias. Enrique Aranda with Soledad Enrichment Action. I direct development. I'm happy to be here with my colleagues, my boss, and actually my colleague.

NATHAN ARIAS, SOLEDAD ENRICHMENT ACTION: Good morning. My name is Nathan Arias. I'm the presidency of Soledad Enrichment Action.

ALMA MARQUEZ: And thank you, Nathan, for allowing Enrique to be out the office for so many times. He's represented you well.

NGUYET GALAZ, SOLEDAD ENRICHMENT ACTION: Good morning. My name is Nguyet, and I'm with SEA, Soledad Enrichment Action.

MARCIA HANSCOM, BALLONA WETLANDS INSTITUTE: Good morning. Marcia Hanscom with the Ballona Wetlands Institute in Playa del Rey. We do side typic research, archival history, and public education.

BRYAN BARNETT, JTM ACADEMY: Good morning, everyone. My name is Bryan Barnett. Here with SoCalGas and I'm a graduate of JTM Academy.

ANDRE HALLOWAY, JTM ACADEMY: Good morning, everyone. My name is Andre Halloway. I'm also with SoCalGas and a proud graduate of JTM Academy.

AMAREE EL JAMII, JTM ACADEMY: Good morning everyone. My name is Amaree El Jamii. Executive Director of the James Timothy Mitchell Academy to help folks get into the mechanical trades and utility sectors. We also work in partnership with the Los Angeles Urban League under a program called the

Construction Career Academy.

MICHAEL BERNS, CALIFORNIA GREENWORKS: Good morning, everybody. This is my first meeting, happy to be here. I'm with California Greenworks as director of projects and programs.

ALMA MARQUEZ, LEE ANDREWS GROUP: Welcome, Michael.

JESSY SHELTON, CALIFORNIA GREENWORKS: Hi, not my first meeting. But here with California Greenworks as well. I'm the program coordinator. Oh, Jessy Shelton.

ALMA MARQUEZ, LEE ANDREWS GROUP: And we like Jessy. She always shows up.

LUIS PENA, LOS ANGELES INDIGENOUS PEOPLE'S ALLIANCE: Buenos dias. Good morning. My name is Luis Pena, I'm here representing the Los Angeles Indigenous People's Alliance. We focus on the protection, preservation, and promotion of indigenous cultures in different aspects.

ALMA MARQUEZ, LEE ANDREWS GROUP: Welcome back, Luis.

JILL BUCK, GO GREEN INITIATIVE: Good morning. My name is Jill Buck. I'm the founder and CEO of the Go Green Initiative. We work with K-12 school districts throughout the nation. Those that are in environmental justice communities to do two things: Protect children's health from environmental toxins and conserve natural resources for future generations. Thanks.

ELLA CAVLIN, PESA: Hi, everybody. Good morning. My name is Ella Cavlin. I'm the director of Government Relations at Parents, Educators/Teachers, Students in Action. We service youth all around LA county providing rehabilitative support. Diverting them from the juvenile system, doing mental health counseling, workforce development, academic support. All types of things just to help empower them to do what they can.

ALMA MARQUEZ, LEE ANDREWS GROUP: And she gets to work with the best boss ever.

KENTA ESTRADA-DARLEY, COALITION FOR RESPONSIBLE COMMUNITY DEVELOPMENT: Good morning. Kenta Estrada-Darley with the Coalition For Responsible Community Development. Always great to be here at LA Trade-Tech Community College. Thank you for the safety update. Will not be driving on Monday. At least not until later.

JILL TRACY, SoCalGas: All right. Jill Tracy, Senior Director with SoCalGas. It's a beautiful campus, and thank you for having us here.

FRANK LOPEZ, SoCalGas: Good morning,

everyone. Frank Lopez, Director of Regional Public Affairs for SoCalGas.

ANDY CARRASCO, SoCalGas: Good morning, everyone. I'm Andy Carrasco, Vice President here at SoCalGas of Community Affairs, Local Government and Communications. And I did take note of the purple over here. I know that's your colors. So there you go.

NEIL NAVIN, SoCalGas: Good morning. Neil Navin, I'm Senior Vice President and Chief Clean's Officer for SoCalGas.

MARYAM BROWN, SoCalGas: Good morning. Maryam Brown, President of SoCalGas.

ALMA MARQUEZ, LEE ANDREWS GROUP: We'll continue with Chester.

CHESTER BRITT, ARELLANO ASSOCIATES: All right. I'm Chester Britt with Arellano Associates. And I help facilitate the pack and I assist Alma on facilitating the CBSOG.

AMY KITSON, SoCalGas: Good morning. My name is Amy Kitson, I'm the Director of Angeles Link Engineering and Technology. And we look forward to -- my team looks forward to all the great presentations today.

KATRINA REGAN, SoCalGas: Good morning, everyone. I'm Katrina Regan, I'm the Engineering and

Technology Development Manager for Angeles Link.

CHANICE ALLEN, SoCalGas: Good morning. I'm Chanice Allen, Engineering and Technology Project Manager.

LARRY ANDREWS, SoCalGas: Hi, my name is Larry Andrews. I'm the Director of Emergency Management for SoCalGas Strategies and Operations.

ALMA MARQUEZ, LEE ANDREWS GROUP: Okay. And we're going to go ahead and get started on our Zoom participants. And with that, I'd like to introduce Andrea Williams. If you could please un-mute yourself and state your name and the organization you're representing.

ANDREA WILLIAMS, SOUTHSIDE COALITION OF COMMUNITY HEALTH CENTERS: Hi, everyone. I'm Andrea Williams, the Executive Director of the Southside Coalition of Community Health Centers.

ALMA MARQUEZ, LEE ANDREWS GROUP: Welcome, Andrea.

And we have Sasha Cole. If you can un-mute yourself.

SASHA COLE, CALIFORNIA PUBLIC UTILITIES COMMISSION: Sure. I'm Sasha Cole, I'm the Senior Analyst on the renewable gas team at CPU's Energy Division.

ALMA MARQUEZ, LEE ANDREWS GROUP: Thank you.

And we're going to have Andrea Slater un-mute herself please.

ANDREA SLATER, LA BLACK WORKERS CENTER/CARE AT WORK, UCLA LABOR CENTER: Hi, I'm Andrea Slater. And I'm Director of Care at Work with the UCLA Labor Center.

ALMA MARQUEZ, LEE ANDREWS GROUP: Welcome, Andrea.

And Christopher Arroyo, if you can un-mute yourself.

CHRISTOPHER ARROYO, CALIFORNIA PUBLIC UTILITIES COMMISSION: Good morning. Christopher Arroyo, I'm a hydrogen analyst at the CPUC.

ALMA MARQUEZ, LEE ANDREWS GROUP: Welcome, Christopher.

And we have Kristin Fukushima, if you can un-mute yourself. We'll come back to Kristin.

Andrea Vega, if you can un-mute yourself, please.

ANDREA VEGA, FOOD AND WATER WATCH: Good morning, everyone. Andrea Vega, Senior Organizer for Food and Water Watch.

ALMA MARQUEZ, LEE ANDREWS GROUP: Welcome, Andrea.

Autumn Ybarra, if you can please un-mute yourself.

AUTUMN YBARRA, WATTS/CENTURY LATINO ORGANIZATION: Good morning. Autumn Ybarra, the Chief Executor for the Watts/Century Latino Organization.

ALMA MARQUEZ, LEE ANDREWS GROUP: Welcome, Autumn.

And we have Kevin Weir. If you can un-mute yourself.

KEVIN WEIR, PROTECT PLAYA NOW: Good morning. This is Kevin Weir with Protect Playa Now.

ALMA MARQUEZ, LEE ANDREWS GROUP: And we have Craig Mendoza.

CRAIG MENDOZA, PESA: Hello. My name is Craig Mendoza. I'm a social work intern and Parents Educators Students in Action.

ALMA MARQUEZ, LEE ANDREWS GROUP: Welcome, Craig.

And we have Christina Rodriguez. If you can un-mute yourself.

CHRISTINA RODRIGUEZ, KENNEDY COURT REPORTERS: Good morning. My name is Christina Rodriguez, and I'm the court reporter for today's hearing.

ALMA MARQUEZ, LEE ANDREWS GROUP: Thank you.

And we have Rashad Rucker-Trapp, if you can un-mute yourself.

RASHAD RUCKER-TRAPP, REIMAGINE LA: Good morning, everyone. My name is Rashad Rucker-Trapp. City Commissioner also Executive Director for Reimagine La Foundation. Look forward to -- look excited about this meeting. I'm also en route to join you guys in person. So I'm looking forward to that.

ALMA MARQUEZ, LEE ANDREWS GROUP: Thank you, Rashad.

And we have Alex Jasset. If you could un-mute yourself.

ALEX JASSET, PHYSICIANS FOR SOCIAL RESPONSIBILITY-LA: Good morning, everyone. My name is Alex Jasset. I'm the Director of Energy Justice at Physicians For Social Responsibility Los Angeles. Thank you.

ALMA MARQUEZ, LEE ANDREWS GROUP: Thank you.

And Thelmy Alvarez, if you can un-mute yourself.

THELMY ALVAREZ, WATTS LABOR COMMUNITY ACTION COMMITTEE: Hi. Good morning, everybody. I'm Thelmy Alvarez, Director of Climate Services for the Watts Labor Community Action Committee. I'm also just in the parking lot so I'll be joining you in just a few minutes. And also, wow, what a packed meeting. This is awesome.

ALMA MARQUEZ, LEE ANDREWS GROUP: We'll make sure we'll have a chair for you.

And we have Hyepin Im. If you can please un-mute yourself.

HYEPIN IM, FAITH AND COMMUNITY EMPOWERMENT:

Good morning. Hyepin Im. President, CEO of Faith and Community Empowerment.

ALMA MARQUEZ, LEE ANDREWS GROUP: Okay. And I believe -- if I have not called you, if you can please un-mute yourself. But I believe I've covered 99.9% of everybody. Did I miss anyone? I know Kristin Fukushima.

MARYBEL BATJER, CALIFORNIA STRATEGIES: Good morning. This is Marybel Batjer. Partner at California Strategies and former President of the CPUC. Good morning.

ALMA MARQUEZ, LEE ANDREWS GROUP: Morning.

Kristin Fukushima is with Little Tokyo Community Center, and she is joining us here. Okay. And with that, I'd like to then have us have our warm welcome from our SoCalGas President, Maryam Brown, who will be giving us some opening remarks.

MARYAM BROWN, SoCalGas: Thank you so much, Alma.

I want to thank all of you for attending the March -- Angeles Link March CBO meeting. I especially want to thank our host at the La Trade and Tech College. Everything about this campus and the 16,000 students that attended embodies the idea of shaping the future. And SoCalGas's Angeles Link proposal is about shaping the future so it's very fitting in that way.

And Dean Wilson, your point about communities, I also think what's also fitting is that this college has been a part of the community, the fabric of southern California for decades and so has SoCalGas for about as long if not even longer and so I just really appreciate being a part of this community with you here and in southern California and Los Angeles.

You know, Dr. Dean Wilson, I am -- I especially appreciate what it is that you do here in your introductory remarks. I am the daughter of a professor and I am the granddaughter of a dean and it makes me very aware of the incredible legacy that institutions like this have in our community so thank you very much for what it is that you do.

I want to also thank all of the members of the CBO for being here, especially those that traveled to be here in person. The Angeles Link and CBO had approximately 20 meetings over this past year. That's almost two a month in that engagement. And it has involved about 50 different organizations across the entire span of government and industry and environment and environmental justice and labor and academia, and the fruits of it are very, very clear.

Your engagement in this dialog about Angeles Link without a doubt has made us smarter about this project. You have helped us identify the things that matter most. And even more, you've understand why they matter so much. So thank you for that. And I think the issues that have consistently resonated the most, especially with the CBO, are among the topics that we're going to go deeper on today.

So a deeper dive on routing. And I'm really looking forward to Katrina Regan's presentation to you all on where we are on our routing deliberations. I actually asked Katrina to give me a preview of the presentation because I wanted to make sure that I could track the logic and the sequence and that it made sense to me. And it did and I really look forward to your feedback on the approach that we've taken in narrowing what we think the path forward for Angles Link would be.

There will also be a presentation on safety and emergency management by Larry Andrews. And let me tell you, if you've ever heard of any kind of emergency foxhole, you want Larry Andrews by your side. And but I especially appreciate and I ask this question the safety conversation was absolutely at the top of our list to go deep with the CBO group, but I actually specifically asked who asked for the emergency response deep dive and my team told me that it was Food and Water that asked for that. And there aren't a lot of opportunities that I get to thank Food and Water Watch for their recommendations but I'm going to take that moment right now because I thought that was a brilliant suggestion, and I look forward to going deeper on that.

I know that initiate is also very important. Food Water and Watch is Aliso Canyon and it continues to be a major priority for SoCalGas as we move forward with Angeles Link, that it continues to provide a pathway to be able to close Aliso Canyon overtime together with other investments that will absolutely be required to make sure that our energy system is reliable and performs that we need it to for our economies to thrive for our quality of life to be able to be there.

The third major category or presentation is on workforce. And Chanice, I'm really looking forward to the presentation that you're going to be providing the team. And I really am glad that Andre Hallowman -- I called you Benjamin.   I think your first name is Benjamin -- my son is Benjamin and so that's why I went there. Andre, I'm really looking forward to yours as well as Bryan Barnett's presentation about your experience in the SoCalGas workforce. What these jobs are, what they mean.

And to me, Angeles Link is about a just continuation of the exact same really good paying jobs just using cleaner fuels overtime. It makes so much sense in that way. So thank you for taking the time to talk about the experience you've had with the training program with Amaree and what it can do. And imagine that on a bigger and grander scale with the job's opportunity with Angeles Link. Angeles Link does not exist in a vacuum. Angeles Link -- and nothing that we do does. I don't think we want it to.

Angeles Link is part of a broader momentum in the state, in the country, around the globe, around bringing cleaner fuels like hydrogen to our economy. We're very proud and excited that the state's effort in a state prior partnership called ARCHES was successful last year in October to be identified for up to $1.2 billion dollars in federal funds to support a hydrogen hubs here in the State of California. And Angeles Link is part of that ARCHES' partnership. And that's not just -- while that's a significant amount of federal funding, that is that I think provides an incredible catalyst.

I think what's also important is it really is a vow of confidence in the opportunity for the clean energy transition to take place here in California and especially here in southern California. Another major momentum around hydrogen, and specifically Angeles Link, is that California Energy Commission which is basically like the DOE of California. They publish their recent energy planning report earlier this year and it specifically calls out the initiative of Angeles Link and the potential that it has to be able to support the clean energy transition.

And, you know, what it is that I think that we're seeing is Angeles Link is shifting from being a white board concept to being something very tangible. And that has gotten shaved very much by all of you and the conversations that we've been having with you. And I think if I could be so bold, I do think history has its eyes on this kind of conversation. And I just really appreciate being a part of it with you. So thanks for your time today.

ALMA MARQUEZ, LEE ANDREWS GROUP: Thank you, Maryam.

CHESTER BRITT, ARELLANO ASSOCIATES: Alright. I want to thank Maryam Brown for being here today. I think I speak for the CBOSG and expressing our gratitude that she took the time to be here. Is there any questions before we move on in the agenda for Maryam? I mean she's here. I think she would welcome any questions that the CBOSG might have. Any thoughts or questions.

There we go, Roy.

(Microphone off)

MARYAM BROWN, SoCalGas: No, in the original concept of Angeles Link, the idea is that this would provide enough displacement of traditional natural gas to be able to reduce the need for Aliso Canyon if you combine it with other investments that will be needed. More investments in renewable electricity. More investments in demand response energy efficiency. But in our view, it is one of the important pieces that helps to fill that gap on Aliso Canyon.

CHESTER BRITT, ARELLANO ASSOCIATES: I'm sorry. Can we just wait until we get the microphone because the people online won't be able to hear you. And for the court reporter, just give your name and organization.

MARCIA HANSCOM, BALLONA WETLANDS INSTITUTE: Sure. Marcia Hanscom, Ballona Wetlands Institute. I think what he was saying was what about Playa del Rey, which we've talked about in some of these meetings. You know, it has less than one percent of gas of the state and consider the most dangerous according to the CCST's.

MARYAM BROWN, SoCalGas: Marcia, I definitely appreciate your commitment to this issue, and I know you've been attending some of the preview CBO's and raised this question and concern. I think one thing that will be helpful as Katrina walks through the routing determination and really put more color on where it is that we see Angeles Link going, I think that it's going to be able to help us answer questions over the long term.

But I do think this is a process that takes time to really figure out what it is that Angeles Link can be. And we've made huge progress and in part because of the engagement of yourself and from others and I think we have a ways to go to figure out long-term broader infrastructure questions like that.

I'm sorry? I think, well, we believe the Playa del Rey facility is safe, but I understand the perspective that you're bringing and I appreciate the question and that it will remain top of mind and what I would ask is you continue strong commitment raising these questions, asking these questions as we figure out the path forward on Angeles Link and just broadly energy infrastructure in the state broadly, which I think really is what your question is and I think we want to answer that as much as you do.

CHESTER BRITT, ARELLANO ASSOCIATES: Alright. Oh, there's one more. And then we're going to move on.

ROY VAN DE HOEK, DEFEND BALLONA WETLANDS: My initial comment was just a "softballish" question. He mentioned along with Aliso Canyon and you did that, but I'm trying to think of other gas company facilities that should be mentioned too briefly by like Montebello. Or is that still considered one of your active places? Or did you close down Montebello?

MARYAM BROWN, SoCalGas: On Montebello, I'm going to pass the mic to probably Neil. I think he's closer to the status of that initiative.

NEIL NAVIN, SoCalGas: Yeah. Thank you, Robert. So Montebello does not actually today play a part into natural gas to our system. It is in the process to a final disposition. Again, overtime. But today it is not an active natural gas facility.

CHESTER BRITT, ARELLANO ASSOCIATES: Alright. Thank you, Neil.

We're going to now transition to the presentation so we can keep on with our agenda. I want to ask everyone to open up their folder and grab this sheet. It's labeled "routing" at the very top. If you don't have a folder, just raise your hand and we'll have staff that will walk around and make sure you grab it.

This sheet is designed to kind of summarize the presentation. It's two-sided. If you look at the back side, there's going to be a series of questions that after the presentation we'll go through with you. It has a place for you to also take some notes. It has some kind of glossary of terms, some key findings in the presentation that Regan is going to give.

But I want to just now transition into introducing Katrina Regan. She's an engineering and technology development manager. She's going to making the presentation on routing. And if you could just give her your attention, that will be great.

PRESENTATION BY KATRINA REGAN

KATRINA REGAN, SoCalGas: Hello, everyone. Good morning. Excited to talk to you today about routing. Today you're going to see a preview of the preliminary findings with a routing configuration studies which as you may imagine is an important component of our Phase 1 studies.

So since we kicked off Phase 1 in January 2023, keep in mind that there have been significant developments. Most notably, the creation of original clean hydrogen hub being the successful efforts of ARCHES application to the Department of Energy, the DOE. And so today, you'll see a little bit more about our work with ARCHES as well. So lets get into it here.

So first, we'll begin by revisiting the core objectives that really drove this study forward. So as you saw in our description and the technical approach that we sent out, the goal of this feasibility study was to start with a broad perspective. Focusing on a range of potential different options. As we integrate a variety of other data, some from this study and some from others, we can then better identify and consider several preferred routes for hydrogen pipeline.

And this allows us to leverage potential but also allows us to understand important things like the communities, terrain, and environmental factors. So today you'll see a preview of our process for this evaluation; you'll see the potential corridors that we began with for the evaluation; and you'll see what we're considering and looking at throughout the process. Evaluations are still underway, and so while we'll be sharing maps today, I know everyone is excited to see maps. We are -- the preferred routes have not yet been selected.

All right. In Phase 2, that would consist of identifying one preferred option and conducting refined, designed engineering and environmental studies with a appropriate system. Following the discussion today and the presentations, you'll receive the preliminary findings and those will detail the assumptions that guided the evaluation process, the corridors that were included in evaluation, and the notable features that were in the process of identifying. We're really welcoming your insights and feedback on that, so this is collaborative and I think your collaboration will help make this a very thorough decision making process. So thank you.

One moment just so we can get the Zoom presentation caught up.

CHESTER BRITT, ARELLANO ASSOCIATES: Oh, yeah. So let me just briefly interrupt and just mention we're going to make the transition so people online can see the presentation. Right now you should be just seeing the speakers but we're going to be technically making that switch.

ALMA MARQUEZ, LEE ANDREWS GROUP: Yes, while we wait for this technical issue to be resolved, lets go ahead and go around the table and give quick updates that would like to share with the rest of the -- with everyone here. And lets go ahead and start with Roy, if you could just be real brief so we can make sure we stay on time with our agenda.

ROY VAN DE HOEK, DEFEND BALLONA WETLANDS: Roy, again, Robert Van De Hoek, Defend Ballona Wetlands. We are working collaboratively and, like, a -- with citizens groups and both nature and culture groups around the coastal area. And we do education programs, teaching about nature and culture. We include indigenous people's discussions and ideas and concepts. There are a number of Ballona organizations, but there are also schools.

We did a -- I was looking over at the dean and she's left -- but East La College came with 50 students earlier this year and we gave those 50 students -- they're all in environmental studies -- program and volunteers. And so, for example, we did see a lot of wildlife and we did walk in the open area of the Ballona Wetlands that has one of your oil wells and gas wells combined at that spot. And we talked about repurposing those above ground well sites to make them wildlife areas like for -- there's like a stairway that goes down 15 feet below the ground in many of these well sites at the Ballona Wetlands. And they are, like, they're manmade cement structures but they're like a -- if you can connect them to nature, they'd be like a grotto in nature, like cave.

And they should stay in place because we could have about a dozen kinds of bats that would use them; raccoons. We also have some of our birds like some of our Swallows like to be in a cave when they nest. And they're, like, already made with a stairway that goes down and around and they have water sometimes in the bottom. And so there's, like a -- that concept of repurposing. And they're historic. They're more than 50 year old structures so they have -- they should stay in place. And the 50 students from East La College that really gravitated towards it from all different majors. But just one example of our education program.

ALMA MARQUEZ, LEE ANDREWS GROUP: Thanks, Roy.

Just to keep our meeting moving forward, just give brief announcements of what's going on. If you can just share your name. If there's multiple people here from your organization, if you could have just one person report out, that'd be great.

And with that, Gerry.

GERRY SALCEDO, SOUTHEAST RIO VISTA YMCA: Gerry Salcedo, Southeast Rio Vista YMCA. Our YMCA is currently busy. We're a loading center, so this past weekend and today and tomorrow will be very busy in the city of Maywood and also currently working on looking for donors and sponsors and partners for our upcoming three signature events. Our first one is a backpack giveaway. We try to raise funds so that we can give away backpacks filled with school supplies. And so anybody's interested or willing to help me out, please E-mail me or contact me at any time. Thank you.

ALMA MARQUEZ, LEE ANDREWS GROUP: Okay. We're going to go ahead and conclude our reprint out after this presentation since we have our technical issue going. But rest assure, we want to hear all about your updates, trust me. And we'll also post it afterwards.

So with that, lets go ahead and have Amy continue her -- Katrina continue her presentation. Thank you.

KATRINA REGAN: Alright, everyone. I'm back. So just kind of a reminder so what we just discussed, right, we were looking at the purpose of Angeles Link, right, open access, connecting production with off take and the broad range of corridors that we looked at to evaluate.

So next here we have our different segment evaluation features. So the routing evaluation included the assessment of many important features as you probably recall from our technical approach we were going to consider and we are considering social, environmental, and engineering. The goal was to understand the different factors that could apply to different route options. So the preliminary findings report will include comprehensive lists of these features and how they were defines for our purposes of our evaluation process.

As you may recall from previous discussions, a pivot served as the primary third party cloud based application which we used to map all of these features. And during the evaluation of the various pipeline corridors which we'll be looking at today, we broke up the corridors in two segments to allow for more managerial analysis. And as you'll see in these maps, we start with a broad range of options which will be further narrowed down at the conclusion of our study.

And so while our focus remained at a high level during this exploratory stage, particular emphasis was placed on minimizing impacts on environmental and social content including disadvantage communities and specie's habitats. And we're feasible avoiding it. So while we also considered special factors for engineering, design, and construction purposes, we do recognize that detailed refinement is something that will occur in subsequent basis.

Another key consideration is environmental justice. Justice40 is an important national initiative and it seeks to deliver 40% percent of the benefits of certain federal investments to disadvantage communities that face burdens that are related to climate change. So information that we collect during this feasibility evaluation that we're currently in will help support our contributions and provide a foundation for our community benefits plan.

In the draft report that you'll receive, you will see quantitatively how these features apply to various pipeline corridors that were evaluated. And the potential routes will be included in the final and draft reports and will consider community impacts, access to production in demand, cost and more. And you'll see this later in the presentation. This conversation.

So as we've said in initially setting up the foundation for our routing evaluation, we cast a very broad net and aim to focus our attention first on areas most suitable for placement of hydrogen pipeline in central and southern California. So to do this, we really did -- again, we started with a wide range of different existing data collections from federally recognized state exempts and other publicly available information.

So first, we'll talk about energy corridors on federal lands. So to improve energy delivery, multiple government agencies are working together to establish are coordinated network of federal energy corridors that are on federal lands throughout the US. These would be agency preferred siting locations for infrastructure that includes hydrogen pipelines and would provide both the industry and public with a greater certainty in infrastructure planning while also protecting the environment.

So specifically, this is Section 368 of the Energy Policy Act of 2005. It directs the secretaries of agriculture, commerce, defense, energy and the interior to designate corridors for this energy infrastructure.

Moving forward, we'll discuss the Alternative Fuels Data Center, or AFDC. So this is another government collaboration. This one is between the Department of Energy and the Department of Transportation. And these maps developed with data from the Federal Highway Administration and the AFDC itself support plans to make it easier and more efficient to access alternative fuels like hydrogen for vehicles and fueling infrastructure purposes.

And then the National Pipeline Mapping System, or NPMS, is another data set. This one contains the locations of information about gas transmission pipelines and other assets that are under the jurisdiction of the pipeline and Hazardous Material Safety Administration. And NPMS is used by government officials. It's used by pipeline operators and general public for a whole host of different tasks that include emergency response, smart growth planning, critical infrastructure protection, and environmental protections. And the NPMS does include SoCalGas transmission line pipelines assets as well.

And then finally, our efforts extended to joining ARCHES; the alliance for renewable clean hydrogen energy systems and to becoming a partner in support of the development of a clean regional hydrogen hub. SoCalGas supports the deep organization of California economy, and therefore we look to align or corridor siting with the great work that ARCHES has been engaged on.

So as you'll see later in the presentation, both production and off take sites that were identified by ARCHES have been aligned with the areas that we evaluated. And it really underscores the harmony between the effort that we're engaged on here and the strategic vision for progress in the state toward decarbonizing California.

So next, lets take a look at the SoCalGas and natural gas transmission system. So SoCalGas owns and operates today over a 100,000 miles of pipeline that's been established over the past 150 years. The illustration that you see here is just a smaller subset of a larger -- our entire existing system. These are pipelines that are categorized as transmission lines. And these lines are typically characterized by higher pressure and larger diameters. They play a role in facilitating gas movement over large distances across the service territory.

And as I said before, the SoCalGas and natural gas pipeline system is even larger than the map you see here; these are just the transmission lines. Leveraging these existing transmission corridors means that the land has already undergone prior disturbance. Potentially string lining the permitting process and reducing environmental impact.

In Phase 1, we'll also be publishing maps in our Knox study to illustrate potential air quality benefits from Angeles Link for the communities near these corridors.

So next -- alright. So here are the first visualization of all of the corridors that are being evaluated by the Phase 1 studies. And you can see that it's overlaid with our existing SoCalGas transmission's system. As you may be able to tell even just from this map, 75% percent of the corridors that were assessed overlapped with existing SoCalGas assets. Underlying closely with the corridors highlighted in the federal energy and the other federal initiatives that we discussed a little bit earlier.

So at first glance, I can appreciate that this appears very broad. And it is because we started -- when we started, we look to evaluate a wide range of different routes and then narrow them down to a set of preferred routes which we will do at the conclusion of the study.

So as Neil shared back in January, I think at one of our workshop meetings, propose routes are currently estimated to be up to 450 miles in length and seek to take clean renewable hydrogen from where it's being produced to -- and users in central and southern California including La based and in those areas of highest concentrated demand.

So our evaluation process for Phase 1 really spanned multiple counties. And that includes counties like Orange, Riverside, San Bernardino, LA, Kern, and Kings. And some of these corridors -- the ones that you see here may jog your memory or ring a bell, and that's because they include a variety of the routes that were initially researched within the SPEC reports that we published back in 2022. The intention was to take that foundation and build upon it. Taking a more tailored approach now that's more precise specific to the objectives to Angeles Link and to the state especially as we leave in new information from the other Phase 1 studies.

And so notably, not every corridor identified here will be pursued for Angeles Link, but we are considering them. And at the conclusion of Phase 1, we'll present several preferred routes in the draft report. So today we aim to provide insight into the evaluation process and these assumptions that underpin the various different Phase 1 studies.

So next here, as we evaluate the corridors we're taking information from all of our Phase 1 studies and we're integrating that material. So this illustration starts off providing what that interconnectivity looks like between the different studies. So for example here you can see how the areas in yellow have ben identified for clean renewable hydrogen production within the production study assessment that's been completed in Phase 1.

By leveraging these corridors between as the unifying element between our different studies like production and demand and environment, we can really start to clearly integrate the data so that we evaluate system pathways from multiple angles. And this integration is the basis for how we determine which pathways hold the most promise in both the short-term and the long-term.

So again, while we're evaluating a wide variety of corridors right now, the goal of our next phase is to pursuit a single preferred route. We cast a wide net here to explore multiple options and accommodate multiple elements which would support development and optimization. And this gives us the ability to carefully consider those potential impacts on neighboring communities, the environment, and system operations as a whole.

So the intent of this illustration is to show you while SoCalGas is not producing hydrogen, incorporating multiple studies together through the same platform really provides an optimal basis to start that comprehensive analysis process.

Move forward, we'll take a look at the overlap here between our corridors assessed for hydrogen feasibility in our Phase 1 studies and the ARCHES identified production and off-take sites. So this analysis holds a pretty significant importance because aligning with the great work that's been done by ARCHES and the state's decarbonization objectives is integral to our analysis. And it's important to look at the location of where these projects have been identified by ARCHES so that Angeles Link further supports both the hydrogen economy southern and central California and also accessing the associated benefits with it.

SoCalGas is grateful for the opportunity to submit several proposed segments within the ARCHES evaluation process and is excited that some of those were chosen for the application. So while ARCHES and the DOE are still in negotiations, we're eager to hear the results of their conversations later this year. And we acknowledge that it's really collaborative partnerships like this that are going to help us achieve our collective goals and efforts to decarbonize California.

So we've discussed a different couple pieces and now on this slide, we can start to see how the layers begin to converge. So you can see the corridors being evaluated for feasibility alongside the areas identified in the production study, and the production off take sites that are part of the ARCHES hub. So this slide really gives a comprehensive visualization. It brings everything together, all of the elements that we just discussed into a single view and gives you a look into the process that we're in the midst of.

So it's important to note that in the draft and final report for this study, several preferred routes will be presented. We do not have preferred routes developed today. And so today the study is still at that evaluation stage. And your comments and feedback are critical and welcomed.

All right. So we've discussed where we started. We've discussed those assumptions and the process we've gone through to determine what was considered. So now lets talk a little bit about the evaluation process. So as you can see here, there's a wide variety of different and important information that's being collected within this study and the other Angeles Link Phase 1 studies.

Integrating the information as you saw on the previous slide will allow for evaluation and the identification of several preferred routes at the end of Phase 1 based on potential. And so building a thorough database, understanding around the different elements here and the various elements of the different routes creates insight into what should be evaluated further and what additional benefits can be achieved.

So since we kicked off in Phase 1 for January 2023, there have been significant developments. Most notably the creation of a regional clean hydrogen hub via ARCHES successful efforts on the application to the DOE. And so our study will continue forward to finish the analysis we set out to complete and we'll be incorporating important new information as well as your input and feedback as it's received.

So next, I'd like to share some illustrations of what a few conceptual examples of a preferred route may look like. Okay. So these slides here -- and I'll show two conceptual examples. These slides represent examples of potential routes with the goal being to move hydrogen from where it's being produced to La basin and the areas of highest concentrate demand. While also considering things like resiliency and reliability as well as environmental and social impacts.

On these slides, you can see the two segments that ARCHES included in the application to the DOE. One is in San Joaquin Valley, and one is near Lancaster. While ARCHES and the DOE are still in negotiations on funding, we are excited to share any updates that we receive with you. These routes present a variety of opportunities. They help us and allow us to connect to other potential hydrogen networks and storage while create opportunities to access to production potential and pathways to move hydrogen to areas of more concentrated demand with predominantly existing rights of way.

And in Phase 1, we initially studied a wide area. We broadly considered how to bring hydrogen into La basin from different production areas and at end of Phase 1, we'll identify those corridors with the most potential for future pursuit and refinement.

So I am closing our next steps. So as we've said before, the objectives of the Phase 1 study is to identify and recommend several preferred routes for the Angeles Link pipeline system. We're looking for those routes with the most potential to deliver value with least impact while understanding things like terrain and environmental work requirements. We're very excited that ARCHES secured the award for California and we're eager to learn more about their negotiations with the DOE. And following the discussion today, you will receive the preliminary findings report.

In the final and draft report for the full study which we we'll be able to share near the end of Phase 1, maps and underlying findings and data will be provided to illustrate potential pipeline corridors.

And this will be preliminary in nature still, so there will definitely be an opportunity to provide feedback, make adjustments and address or minimize impacts.

And then in Phase 2, the research would be refined and more detail will be added. So we'll be expanding our outreach. We will complete further refinement of the system, it's components, and an identified route. And we do expect it to be a really dynamic process which is why it is so vital to get your collaborative feedback and advice now at this early stage. The goal remains the same and consistent throughout this process. We aim to chart out a pipeline route that is sufficient, sustainable, and harmonious with the environment and communities. So thank you very much.

CHESTER BRITT, ARELLANO ASSOCIATES: Thank you, Katrina. That was a tremendous presentation. If you could go to the next slide. I just wanted -- I can go to the next slide. We actually have for this discussion three panel members to assist Katrina; Yuri Freedman who is the Senior Director of Business Development. I'm sure most of you are familiar with Yuri. He's online -- actually, he's not here in person like he normally is, but he's made numerous presentations over the last year that you've been a part of. Amy Kitson, to my left, she's the Angeles Link of Engineering and Technology; as well as Frank Lopez, to my right, who is the Regional Public Affairs Director.

So this topic is very detailed. We have a lot of slides. If you can turn to the back of your handout, there's four specific questions that we wanted to make sure that we address. You're free to ask your own questions if you like, but we wanted to make sure that we at least cover these. And I want to go back to, I think it was this slide, that talked about the process that Katrina was mentioning. And the first question is can you provide feedback on the process SoCalGas has undertake to evaluate the existing utility corridors for the proposed pipeline. There's a number of things that are listed on here, and I'm just curious if you feel like this is a complete list, are there things missing, do you agree or disagree with some of the things that are on the list, do you think it's worth adding some things that aren't on there or would you like to discuss one of those in particular. I would love for the CBSOG to weigh-in on the process of evaluation.

ALMA MARQUEZ, LEE ANDREWS GROUP: I see Jill raising her hand.

CHESTER BRITT, ARELLANO ASSOCIATES: Yes, please. And one of the things that we've been doing in the past, is if you want to speak in person, just turn your card like this and then I know that you're actually -- exactly.

Go ahead, Jill.

JILL BUCK, GO GREEN INITIATIVE: Would it be possible to go back to the slide that has engineering, environment and social on there.

CHESTER BRITT, ARELLANO ASSOCIATES: Sure.

JILL BUCK, GO GREEN INITIATIVE: Because here's the question I keep asking. And, you know, let me preface this by saying I'm a child advocate. That's why I do what I do --

CHESTER BRITT, ARELLANO ASSOCIATES: And I'm so sorry to interrupt you, could you just introduce yourself for the court reporter.

PRESENTATION 1 COMMENTS

JILL BUCK, GO GREEN INITIATIVE: Jill Buck, Founder and CEO of the Go Green Initiative.

So one of the things that we talked about under the social column is how much better this project is than fossil fuels and some of the human health impacts in terms of relativity to fossil fuels.

But one of the things I haven't heard yet is what are the absolute human health impacts of this project so that we can evaluate the social impact of the communities that might receive a pipeline. And one of the other things that I'm interested in is the proximity to schools.

I see on the slide proximity to buildings, disadvantage communities, but one of the things that my organization is most concerned about is the proximity to a huge hub of little bodies in schools in disadvantaged communities; and, you know, the proximity of that infrastructure to those little folks.

So those are my two questions in terms of the process that are taken to evaluate. What is the human health impact of the infrastructure? And especially on little bodies because children are not just little adults; and, also, have you evaluated the proximity to schools so that --

CHESTER BRITT, ARELLANO ASSOCIATES: Yeah. Katrina, would you like to weigh in on that?

KATRINA REGAN, SOCALGAS: Sure. Thank you so much for your question and comment. I think that's great feedback. I think we can take a look at what's included in proximity to school's isn't something. I believe we'll be able to add that.

On the health side of things, I do know that our Knox maps will be published as part of our Knox evaluation on study at the end of phase one too. So that will definitely be something included.

FRANK LOPEZ, SOCALGAS: Frank Lopez, Director of Regional Public Affairs. Thank you for your questions.

So yes, absolutely. We're going to be mapping schools. Not just schools, but really any sensitive facility along these corridors. I think once we get to a point where we actually have some preferred routes, we're going to need to do a -- do more of a deeper dive and actually do an assessment of all of the facilities that are along those corridors and find creative ways of how to engage those communities.

Also to provide input in the engineering and design process so it's not just some desktop study where we're, you know, looking at these things on paper, but actually speaking to human beings who can potentially be impacted. I first see that we'll do part of our phase two as well.

ELLA CAVLIN, PESA: Hi, everybody. I'm Ella Cavlin from PESA, again. So I don't know too much about gas pipelines and all of that. I am a social worker myself so I do think a lot about community impacts in a lot of different ways. And I know that often times different infrastructure like this is put into often times marginalized communities which creates a lot of those health impacts.

And I know we were talking about the data sets that were used to figure out where these corridors will be and there's discussion of it going to ones that are already created in all of that. There weren't names of the places on the maps. I'm not from LA, so I don't know everything by the map, but I'm wondering are you considering other places as well?

Where I don't know if the ones that are already existing that are in these communities that are often utilized for these type of infrastructures, but I'm wondering are you thinking about creating new ones in places that may be -- would create a little more equity if one of those things are created. If there are certain health impacts that it's not going directly to communities that are targeted by this.

FRANK LOPEZ, SOCALGAS: Yeah, that's a great question. So if you look back to the map, and I don't know if you want pull up the one that has all the hydrogen corridors that were assessed, you'll notice that to the extent possible we did try maximize the areas where we do have existing infrastructure on rights of way. But there are also new routes where we don't have existing infrastructures.

So we did look at a wide range of corridors -- right, Katrina? As part of your presentation -- obviously some of these areas are also areas where there could be disadvantage communities. We are doing an environmental justice and assessment and trying to map out where these communities are located.

One of the things that's also important to us is not just avoiding and mitigating impact cities, communities, but also making sure these communities receive the benefits that could come from these types of facilities like air quality benefits.

Community benefits associated with its infrastructure so it's not just about mitigating impacts and trying to avoid communities. Also making sure these communities are benefiting from those investments as well.

MARCIA HANSCOM, BALLONA WETLANDS INSTITUTE: Hi. Marcia Hanscom, Ballona Wetlands Institute. For me, a couple questions. One, will we be able to see a more detailed maps so we know exactly where that little X is or that little box. Would that be -- because it's hard to answer some of these questions without knowing the exact.

Like -- and, for instance, this map you got here, I have a hard time seeing where the actual production sites are because this blue is a little close to that blue and, you know, it'd be nice to see those separated out.

AMY KITSON, SOCALGAS: Thank you, Marcia, for that question. As Katrina said, that more detailed evaluation and visual will be at the draft report in phase one. This is still very high level and conceptual at this time, so what we're looking for feedback now is are we looking at the correct criteria and things like that.

And then -- so as we progress at the end of phase one, it will show those more detailed routes.

MARCIA HANSCOM, BALLONA WETLANDS INSTITUTE: So you're not expecting to answer these questions today? Like what impacts do you see on these communities and what kind of community benefits if we can't tell exactly where the the community is.

FRANK LOPEZ, SOCALGAS: Well I think it could be helpful to get feedback on the themes and topics that we want to get address. But if you also have feedback of the process itself of the way that we share the information with you -- but you're the first to see --

MARCIA HANSCOM, BALLONA WETLANDS INSTITUTE: You answered question one. But two and three seem hard to answer at this point.

FRANK LOPEZ, SOCALGAS: I would just limit your feedback to those two. If there are other areas where you think we can improve in the way that we're communicating the information and delivering it -- I've seen this presentation multiple times, it is a lot of information to digest, and it is sometimes a little difficult to communicate.

We're looking for feedback on both the teams, the criteria that we should be evaluating, but also the way that we're presenting information. So I think at some point, yes, we're going to have to actually show a route that will have more detailed location about exactly where this could go. We're not there yet. But that is our intention --

MARCIA HANSCOM, BALLONA WETLANDS INSTITUTE: And also under environment, that category on the other slide. It will be great to have some things related to climate change like sea level rise and tsunami areas because climate is having bigger storms.

And, also, I know you said "service land," so where are high fire hazard zones? Those are things that are talked about in the legislator all the time now.

CHESTER BRITT, ARELLANO ASSOCIATES: Yeah. That's great input, Marcia. That's the kind of stuff we're looking for actually. Yeah.

Okay. We're just going around the room.

ENRIQUE ARANDA, SOLEDAD ENRICHMENT ACTION: Yes. Enrique with SEA. Thank you Chester. Katrina, I think we've come a long way and I'm very happy to see this whole design process as a participatory and a special. It makes it easier to talk about.

And initially we talked about special consideration to geography adverse impact. And what I mean specifically is the intersectionality of race and class, equity and parody. And to be more specific, black communities are always adversely impacted in the Los Angeles county. We talked about maybe making inventory adverse impact. Looking at the work of academics, hot spots, super environmental justice. So just mobile and stationary source of pollution.

How that could be mapped out and how that could be -- not just modified but considered as an important factor as we go forward. Looking at verse impact and look at hot spots. And, eventually, maybe we can cross tab some of these studies that have already been done to really continue this process.

Again, it really seems like it's a cool design process participatory and it's engaging a community. And it's refreshing to be part of this process going forward.

FRANK LOPEZ, SOCALGAS: Enrique so one of the things that I was thinking about is we have these maps of the -- these potential quarters, right? Would it be beneficial to you and others to have these routes mapped over.

For example, we are doing an environmental justice, we know where these communities are located. Would it be helpful to layer this over so you can see that cross section of the facilities over some of these communities? But at the same time study so we can see the air quality benefits can be utilized as well.

Would that be helpful for you?

ENRIQUE ARANDA, SOLEDAD ENRICHMENT ACTION: Frank, right on. Those overlays are so important, really consider.

FRANK LOPEZ, SOCALGAS: Okay. Good to know.

CID PINEDO, MEXICAN AMERICAN OPPORTUNITY FOUNDATION: Mine is a process comment. It's natural that when you see a map to automatically say where am I in it. And so the only thing is if you're going to show us a map, you have existing corridors. So I'm hearing that we don't have anything identified, but it's a long existing corridor that we already know where it is.

And so the map is what's throwing us all off because we're putting on our day-job hat and then also where-we-live hat. And the immediate question is how does this impact me and us and our work. Does that make sense?

CHESTER BRITT, ARELLANO ASSOCIATES: It does make sense, yeah.

Roy?

ROY VAN DE HOEK, DEFEND BALLONA WETLANDS: Roy Robert Van De Hoek, Defend Ballona Wetlands. I'm interested in the state and federal VIR, VIS. This is called preliminary. So you haven't started -- this is like thinking in advance of what you're going to be doing for those two environmental impact evaluations.

KATRINA REGAN, SOCALGAS: Yeah.

ROY VAN DE HOEK, DEFEND BALLONA WETLANDS: Okay. And then why is the San Joaquin Valley route being thought of as a spot because it's very rural in farming. And there's Bakersfield and it looks like the north end is, like, near Coalinga, maybe, which is an oil field area; but also farming and water contamination and the farmlands issue and water is going to be used and hydrogen production.

So why -- what are your thinking of wanting to have that be a spot verses one of the two routes that seem to be going out -- one of them towards Palm Springs. The Colorado river boundary. And I'm not quite understanding why there might be two paralog green routes near the Lake Mead -- you know, the tri-state boundary area of Arizona, Nevada, California. And I can see that one setting towards Las Vegas, but it's all coming down to Los Angeles. So explain please.

KATRINA REGAN, SOCALGAS: Absolutely. Thank you so much, Roy. I think that kind of gets to the heart of what we're trying to do here, right. So we're looking at those areas that have the highest potential for production of that clean renewal hydrogen. Hydrogen produced via electrolysis. And those areas are typically areas that are in -- there's more space. And we know in LA and the areas that we live, there's less land availability.

So it's more likely that that production of hydrogen is going to happen outside of the highly concentrated highly populated areas like Los Angeles. And all of these routes that we considered, they access those areas. So that would be one of the reasons that route you see that goes up to the San Joaquin Valley does though.

I think this slide here is also a really important one to consider because you start looking at where Arch is through their work and the efforts that they're engaged on. They've identified those various different folks who are already looking at creating hydrogen production facilities. And so our route corridors that were evaluated do consider that. And we are considering that throughout the process what ARCHES has been able to identify.

ROY VAN DE HOEK, DEFEND BALLONA WETLANDS: Thank you, Katrina. So San Joaquin Valley route looks like it's almost on the footprint for I-5. Is it, like, you're going to have the gas line running along the Interstate 5 or the equita for both?

KATRINA REGAN, SOCALGAS: Yeah. The specific routing that we have will be further refined in subsequent phases. So right now we really started off considering where our existing rights-of-way are. So they are quite close to the 5 in some areas, but we will be doing a much more refined analysis for the segment and the routes that are preferred and being moved forward with.

ROY VAN DE HOEK, DEFEND BALLONA WETLANDS: I like the idea of it. If we're going to have hydrogen, that it follow I-5. It's already public land, and it's already impacted by the north, south. And you have a huge space between the north and south route of the Interstate 5.

So you can put it right down the middle and it would allow all your crews for maintenance. And you'd have everybody with their iPhones -- if anybody is getting into mischief with the pipelines -- you know, that it could report this. And it would minimize going through the significant endangered species areas in that area -- the San Joaquin Kit fox and several rare native plants.

I'm familiar with that area in particular, and I have concerns about any of the places that it's crossing; federal lands and making sure that we really protect our open spaces and have not yet another transmission lines.

I'm not a fan of the US Forest Service. They're part of the agriculture and they consider themselves multiple use, so they're ready to green light anything you wanted to and run all kinds of stuff through our forest and lands and sacred indigenous peoples' areas.

And, so, thank you.

HYEPIN IM, FAITH AND COMMUNITY EMPOWERMENT: Good morning, again. Actually, Hyepin, President of Faith and Community Empowerment. So I just want to first, I guess, second what everyone else was saying.

So when I look at the map, it's the same question that comes to mind as I'm not exactly sure where these locations are -- potentially, I could maybe pull up a Google map as well -- so I would like clarity.

The second piece is that I did hear that you were looking at your existing infrastructure and corridors. And so again, the same concern about, you know, in the past, usually underserved communities of color have been disproportionally impacted. So, you know, in terms of your criteria that could lead to just again, the same old story of underserved communities, perhaps also being disproportionally impacted especially with the safety concerns that are there.

And so, you know, you've mentioned another criteria which was where's there more space. I think it will be helpful to perhaps layout what are some of what the additional criteria. I'm not sure you're explicit in your presentation. And then also again, being a community member but I think laying that out would be very helpful.

And then also again, as a community member, coming into this space and not being as knowledgeable, I think again what are the things that a community member should be concerned about. Even like the danger of hydrogen, like, what does that mean? Those kind of things could be helpful; of just listing out the potential benefits slash the risks so that community members could engage and ask more intentional questions as well. So thank you.

KATRINA REGAN, SOCALGAS: Great comments. Thank you very much. And I hear you, I know that the map's at a higher level are definitely a little bit more difficult to see exactly where you follow on them, so I can appreciate that.

For the features that we have identified here for evaluation in this process in the preliminary report, you will get detailed definitions of what each of these are. I think some of them here we may have summarized a little bit but then they're broken out into subsequent detail in the preliminary finding report.

We also -- I do want to make sure that we're all comfortable and aware that we don't know yet; the exact location of the preferred route. That's something that will be really further refined in these two. We'll be selecting several preferred routes in phase one and those will be published in our final draft report at the end of phase one along with the maps of those routes.

HYEPIN IM, FAITH AND COMMUNITY EMPOWERMENT: So just to be -- for clarity, so here under engineering, are these the criteria that you guys are looking at? Is, like, adverse soil condition; is that correct?

KATRINA REGAN, SOCALGAS: It will be, like, we're looking at class location one, two, three, and four. We have a single line that says class location.

HYEPIN IM, FAITH AND COMMUNITY EMPOWERMENT: Okay. I don't even know what class location is, but I know that it's not your job to explain right now. But perhaps I think -- and maybe I wasn't paying attention enough -- but to say here, you know, as we're considering, here are some of the things that we are evaluating or considering; but, like, open space terrain, I don't necessarily see it listed here.

And so I'm thinking again for many community groups, they're going to say why our community, right? And so to say well one of the needed criteria is open space or terrain for these very reasons could be at least something to offset potential future objections or concerns; or at least to address that.

CHESTER BRITT, ARELLANO ASSOCIATES: Great input. Thank you so much.

Alex also has chatted a comment which I'll read:

"How close to existing methane pipelines are you thinking about building the hydrogen pipelines? And then, also, Angeles Link will be all new dedicated hydrogen pipelines; is that correct?"

Amy is going to go ahead and answer that.

AMY KITSON, SOCALGAS: Thank you, Alex. So I'll start with your first question regarding how close to the existing methane pipelines and that is similar to corridors. So as long as that's the initial evaluation that we're looking at for our additional corridors, so if we utilize those existing right-of-ways or franchise agreements, then they will be very close to our current natural gas pipelines.

And similar to the other comments that we've gotten, if they're routed differently, that's to determined. And then as far -- we'll be following our existing pipeline right-of-ways. So there isn't -- I can't give you an exact --

KATRINA REGAN, SOCALGAS: The distance between hydrogen pipelines and substructure utilities that's something we'll be refining and further really dialing with the modes and safety standards that exist through NFPA and organizations who set those codes and regulations.

CHESTER BRITT, ARELLANO ASSOCIATES: And then the second part Amy was just confirming that they'll all be new dedicated hydrogen pipelines; is that correct?

AMY KITSON, SOCALGAS: Yeah, that's correct.

CHESTER BRITT, ARELLANO ASSOCIATES: Okay. Andrea from Food and Water Watch, I believe you also raised your hand online. If you could unmute yourself. Andrea Williams.

ANDREA WILLIAMS, SOUTHSIDE COALITION OF COMMUNITY HEALTH CENTERS: Hi, it's Andrea Williams from the Southside Coalition of Community Health Center. I was just curious about the map and if certain corridors are removed that are not chosen for the pipelines, would those areas still have access to the hydrogen gas if they need it? Or is it going to be that it's available where the pipelines are?

Because I think it's important to also include -- you know, people need to know too that you won't have access when there's areas who really don't want the pipelines in certain areas if they're not going to have access to hydrogen gas for whatever reason if they weren't needed in that area.

KATRINA REGAN, SOCALGAS: Well the areas that we considered and we moved forward with. We would intend to pursue open acts that's common carrier hydrogen lines, so they do allow for connection for those who want to use the pipelines and take hydrogen as an off-taker.

I think that the evaluation is something we'll be considering as we move forward and kind of looking at where the highest areas of concentrated potential off-take will be and then we'll be further refining that in phase two as well. So continuing to stay up-to-date with that information.

CHESTER BRITT, ARELLANO ASSOCIATES: We have a few more in person, and then we're going to move on to the next topic. But I just want to remind you if you're online and you want to chat a comment, if we don't get to it, we'll certainly circle back with you directly and make sure you have your answer. And in person, same thing. If you want to chat something down and we don't get a chance to answer it today in person while we're doing this verbally, we can also circle back with you.

But Jessy, you've had your card raised. We want to go with you.

JESSY SHELTON, CALIFORNIA GREENWORKS: Hi, Jessy with California Greenworks. So that was a lot in one presentation but it was fantastic, so I thank you for all the questions and answering everything.

We also use CalEnviroScreen, so overlaying that will be helpful just to kind of see, but I understand as it's preliminary. Like, having this kind of wider map that isn't as detailed I think at least for me has been kind of helpful to see the general scope of things. But also as you kind of narrowed down routes, I'm assuming that you'll have possibly a few that will make sense and having a pros and con list if that's possible of the -- and seeing what's the feasibility studies look like.

Mainly in the -- where my mind is kind of going is, like, endangered species and what's going to be further out into the more not as populated area of California. I know that's been some issues with different projects and such. But also as you find -- you narrow down the routes, is there anything in place through these areas where you set up the pipeline but any kind of beautification along with that where Greenworks does planting trees in underserved areas.

We use CalEnviroScreen for that. So if you're thinking about that, are you also going to be working with groups like the CBOs or do you have that in place? Or is that kind of in question yet. Thank you.

FRANK LOPEZ, SOCALGAS: The simple answer is absolutely yes. As we get to a preferred route, we will definitely be developing a community benefits plan that will be informed by the communities along those corridors. So to address some of the issues that you just spoke about -- and actually, I believe later today we're going to have a couple slides talking about the process on how we're going to develop the community plan.

But, absolutely, along those corridors are official investments to enhance those communities to mitigate measures; all of that stuff being part of the community benefits plan and we'll go over it later today.

CHESTER BRITT, ARELLANO ASSOCIATES: Alright. Thelmy, I think you had your card raised.

THELMY ALVAREZ, WATTS LABOR COMMUNITY ACTION COMMITTEE: I do. Good morning everybody. Thelmy Alvarez, Watts Labor and Community Action Committee. My question is actually specific to this map that's on the screen right now. So there's different sized circles for the different production hubs, and my first question is do those reflect the size of the production hubs?

And then my second question is Los Angeles is a huge metropolis so if we're looking possibly at some of the smaller circles or smaller hubs would that increase potentially the production of those sites and what kind of effect will the communities live near those production sites have based on the need for Los Angeles.

And, yeah, I just wanted to ask those questions because I think it's important not to just think about our needs here in Los Angeles -- obviously protecting our communities here, but also those communities that are going to be facing at the forefront of the production.

KATRINA REGAN, SOCALGAS: Thank you. So the information shared here, specifically the blue circles, that is information that we received directly from ARCHES. I believe it's on their published fact sheet. So you can see that information, it's publicly available.

We do not have information as specific to the exact quantities of production that are intended at those different sites. So it's difficult for me to say that they won't change or they may be scaled in terms of size and the sizes of the facility -- exactly what that's going to look like.

AMY KITSON, SOCALGAS: And ARCHES has community benefits meetings and community meetings. They're biweekly on Thursdays. I can give you that information if you were curious about the ARCHES process and getting involved in that as well. So I can get you all that info.

THELMY ALVAREZ, WATTS LABOR COMMUNITY ACTION COMMITTEE: That would be really helpful. The last question I had related to this is would there be a difference in safety based on the length of the pipeline? So if we're closer using production sites that are closer to us, does that actually create more safety rather than having the hydrogen travel a longer distance to get to us.

KATRINA REGAN, SOCALGAS: So Angeles Link is only the transportation portion of the system that you're seeing here. I do just wanted to make that note, SoCalGas is not producing hydrogen. The sizes here of the different circles are intended to show generally the scale and the size of the production is envisioned by ARCHES.

In terms of safety, we will be following all of the safety standards and protocol regardless of the length and the mileage of the pipeline. Safety is a core value at SoCalGas, and we really do take it very seriously.

As we will talk a little bit about it later today, we have a safety study where we explore what safety means in terms of both design and workforce and the public. So we're really excited to share that with you and hopefully provide more details on safety.

CHESTER BRITT, ARELLANO ASSOCIATES: All right. Thank you, Katrina.

KENTA ESTRADA-DARLEY, COALITION FOR RESPONSIBLE COMMUNITY DEVELOPMENT: Kenta Estrada-Darley with Coalition for Responsible Community Development. I feel like everyone is waiting for the big reveal but it comes in installments so thanks for the information. I think seeing kind of like a close up on the Los Angeles region is one of the things we're all waiting on, right. Because we want to see kind of how this is going to impact folks at home -- to the comment earlier -- and kind of, like, where in the urban area that's going to travel through and the communities that may impact. Understanding that's going to come later, I won't say any other comments around that piece.

But I think just focusing on the questions here, like, the community benefits piece is one of the things that community groups are most interested in, right. That translates into jobs, health impacts, environmental impacts, and also small business opportunities. I don't think that's something we've spoken about at great lengths. We've spoken about jobs. Good jobs that create family sustaining wages opportunities but small business procurement opportunities creating economic wealth and opportunities that way. I think all of those things are going to come later but just wanting to highlight all those pieces again, and how important that is to this entire process and really understanding how that gets put together and opportunities for real folks in these communities to get into these type of pathways in the green economy.

And just trying to understand a little better with ARCHES, right. I think I missed one of the meetings but this is a huge piece. So the investment with the California hydrogen hub with ARCHES, how is that going to coincide and impact -- or coincide with the planning? Because that seems like a key piece hydrogen production. I don't know if there's already locations scoped out for that, but that's a pretty sizeable investment from the Biden Administration in that piece so could you speak a little bit to ARCHES and the California hydrogen hub.

KATRINA REGAN, SOCALGAS: So we were very excited to hear the news that California had been awarded the $1.2 billion dollars. Our understanding is that ARCHES is still under negotiations with the DOE for exactly which projects within that application we'll receive funding and how that funding will be disbursed. So when we have those kinds of updates available to share with you, we will do so.

FRANK LOPEZ, SOCALGAS: Just to clarify, Kenta. You'll notice there's two circles here; there's a dark blue and a light blue. The dark blue -- so this is the information that ARCHES released, right. When they announced that they got the award from DOE. So these are actual ARCHES's projects.

The dark blue are the place where they're intending to produce hydrogen. The lighter blue are the places that need hydrogen. Our facilities are the one's who are assessing the green corridors. So just want to kind of conceptualized that and make sure that was clear for everyone.

CHESTER BRITT, ARELLANO ASSOCIATES: So very healthy discussion. I just want to remind you this is not your only opportunity. Today's presentation was just a preview. You are going to get the actual study when it's completed, and you'll have four weeks to review it and give us actual detailed comments. As you heard, that study will have a lot of more detailed information in it that you can then take a look at.

To make sure we're on our agenda, we're going to do a quick little break here for three minutes to make sure you guys have water or coffee.

We have one more comment. And then I also just want to give you a preview because we're kind of -- that was such a healthy conversation, we'll probably do lunch. And then maybe make it, like, a working lunch. So we'll do the CBOSG updates during lunch. Maybe 15 minutes after you guys get your food and get situated, we'll go back to that to keep us on agenda. But I do want to make sure we hear from everyone whose put their placard up.

And Andre, it looks like you had your hand up so lets go to you.

ANDRE HALLOWAY, SOCALGAS: Andre Holloway, SoCalGas. This is a infrastructure question. I was just wondering, will they'll be converting the current gas pipelines to hydrogen? How is that going to work, and who will get those jobs? Would that be going to underserved communities, or we know anything yet?

KATRINA REGAN, SOCALGAS: So at this point we're assessing the instillation of all new pipeline for Angeles Link. And the jobs is something that's absolutely going to come up and we are already looking into what that looks like in terms of existing workforce and certain grounding workforce as well.

So in phase one, we do have a workforce study that Chanice will talk a little bit about later. And it's something we want to learn more about.

CHESTER BRITT, ARELLANO ASSOCIATES: It's actually on our agenda for this afternoon, so it will be coming up.

So we're going to take a three minute break. So if you need to grab some water or coffee, please do that. And then we'll restart our next presentation.

(Break)

CHESTER BRITT, ARELLANO ASSOCIATES: So the next part of our agenda, we're going to talk about the plan for applicable safety requirements. Chanice Allen is the Project Manager for SoCalGas, and she's going to make the presentation. And then we'll have an exercise right before lunch. Go ahead.

CHANICE ALLEN, SoCalGas: Great. Thank you. Good morning, everyone. I know we're already into March, but this is the first that we're gathering. I still hope everyone's new year is going well. And thank you again for your time being here today online and in person with us.

So before we jump into the actual updates on the safety study, I would like to share a little experience about a time where I realize that even with being well intentioned with safety messaging, sometimes how it's received or perceived may be something totally different. And case in point is that I'd like to think that I do decent with my exercise and I've learned to take long walks, especially before having to present in front of a whole bunch of people. And so with that I actually have a ongoing weekly walk around Cal State Dominguez Hills every Wednesday at 5:00 a.m. -- yes, 5:00 a.m., with our ladies from Carson and Compton community.

And so, actually, we've been doing this for about seven years and awhile back along the route, one of the ladies have pointed out a pipeline marker. And so, well, actually, she called it a yellow stick and she saw that it had SoCalGas logo on it. And she knew I worked for SoCalGas. So she was like, "Chanice, what is that yellow stick for?" And so I knew living in Compton for 15 years and now I'm living in Carson, I'm pretty well aware of where all the pipeline markings are for SoCalGas and knew the reason.

And I basically told her that this indicates that there's a pipeline in the area and that's a contact information on there is to provide awareness so that people know in case of an emergency with a contact. But then she also pointed across the sidewalk where we were walking to another pipeline marker and she said, "Was that SoCalGas too?" And I looked and realize I actually haven't seen it before because it was kind of low, almost angled. And I looked at it and I was like, "No. That's actually another pipeline marker for another oil company out of Carson." Cause we know there's different refineries so it probably came from there.

But I told her, I said, "Good question," because if it's hard to read and you just see yellow, you think everything and anything is probably all the same. And so other ladies in the group, they never paid attention to it. So I remember joking that, "Yeah. You guys are not paying attention to the pipeline markers but everyone knows where the coyote signs are." Because there's tons of coyotes in Carson. And so we just went on -- that's right. And they're actually quite friendly too.

And so we proceeded on with our walk and our normal gossip. And so the point I'm bringing this up is that even though pipeline operators, we all have the same safety requirements and communications that are supposed to be out there. The bottom line is, how is it being received or perceived. How is the safety messaging coming across. So the ladies in our group really didn't know, right, until I shared some information with them.

So as I talk through the safety requirements and how today it may apply to Angeles Link today, I definitely welcome feedback and hearing from you as far as how safety requirements, messaging, how that's being communicated; whether or not you think it's effective. And looking forward to your feedback.

PRESENTATION 2 BY CHANICE ALLEN

The actual study for Angeles Link, it's

called the plan for applicable safety requirements. And the purpose of this study is to evaluate safety concerns as it may apply to the Angeles Link project. Safety is our primary consideration starting from the planning, the engineering, and design process through the execution of construction and long-term operation and maintenance. And our safety focus is always on public safety, infrastructure safety, employee safety, and contract of safety. And as part of the study, we address the safety considerations and what that can be.

So on the slide here, we know -- I understand if you remember from the DMV's presentation about hydrogen, that it's the widest element in the universe and the smallest molecule with the widest flammability range. Therefore, we know to make sure to plant, to incorporate hydrogen and safety requirements, codes and standards to utilize hydrogen, and compatible material and implement compatible specification and also incorporate the latest construction techniques.

When considering operation and maintenance activities, we plan to enhance our well established leak program and procedures that apply to hydrogen activities. And then for regular and maintenance compliance for all safety regulations, that's going to include leak detection monitoring and conducting regularly scheduled leakage surveys to mitigate potential leaks. Other design considerations such as minimizing pipeline changes in the direction across a fault zone; utilizing advance monitoring technology which we'll talk about a little later; and applying effective communication plans which comes across in public awareness plan but help us to mitigate at risk associative with natural disasters or even external events when it comes to third-party damages.

We would also implement education and training for hydrogen. Which is essential along with a well developed public awareness program to mitigate safety issues to -- as far as resulting from any employees or contractors, first responders; even the public responding and reacting to situations in a suitable manner. So the key safety considerations that are reflected on this slide for SoCalGas on top of my everyday and our day-to-day activities. How we mitigate these considerations today for our natural gas infrastructure will be similar to how we would mitigate the risk for hydrogen infrastructure.

There are numerous codes and standards as you can see here in this illustration. And as maybe applicable to those transporting gas pipeline, that's going to be natural gas and for hydrogen. SoCalGas is familiar with actively and implements many of these codes and standards in connection with our existing natural gas transportation system. And then certain code standards and best practices including the pipeline that has these materials, administrations, regulations equally applies to the transportation of hydrogen.

So the illustration that you see, in a nutshell, the bottom is the solid foundation for our federal regulations. The orange represents our state regulations. And then the grey and then the light green illustrates our industry codes and our standards. So I know that's a lot and that can be some very heavy reading to look through. Just know as far as what does that mean to you, that means that we should be doing our due diligence, what's necessary to identify the codes and standards and best practices that may be applicable to Angles Link.

I spoke about the federal regulations such as the pipeline and hazardous material safety administration. Being one of the main components for a solid foundation and for safety requirements, when it comes to transmission pipeline, design, and infrastructure. Also, the American Society of Mechanical Engineers is one of the main highlights and best practices and standards that the hydrogen industry utilizes as a guiding standard for hydrogen facilities.

Our existing SoCalGas natural operations and maintenance procedures provides a basis for evaluating hydrogen specific requirements. It has been identified that many of OMN tasks will be structured similarly to hydrogen as they are for natural gas. So what this means is for a leak detection equipment, that can be permanently fixed or portable. Like this is a Hydrogen H2 personal detection sensor I have on me. So after lunch -- it's also a CO2 monitor, if it goes off someone has to be on that.

And then for -- as far as other drones and air leak detection, utilizing helicopters, we know that there are detection equipment already out there for hydrogen. For inline inspections, for pipelines, we spoke before -- we discussed a little bit about PEGs, and the intent is for tools. This is actually a cleaning tool or brush tool. But the intentions for our pipeline integrity program it's for us to identify any anomalies or test the integrity of our pipelines. We know today that there are already companies in pipeline operators for hydrogen that utilize PEGs in order to test the integrity of their pipeline, and that could be productive today as well as in the future.

There have also been several studies related to odorization of hydrogen. Once that study performed by DMV, who actually came out here and provided a hydrogen one-on-one education. They in partner with certification and inspection company, tested various types of odorants with various samples and mixtures of natural gas and including 100% percent hydrogen sample. And the results of the study concluded that the mixture of natural gas and hydrogen and pure hydrogen can be sufficiently odorized with existing odorants.

One of the main odorants for consideration is known as THT, Tetrahydrothiophene. And it has been identified to be compatible with pure hydrogen. So as today, there are many miles of hydrogen pipeline already being constructed and operated for decades. There are many existing safety requirements already in place. And for pure hydrogen, those operational activities are being managed safety today.

On to the Public Awareness Program. So SoCalGas's existing Public Awareness Program helps protect public safety and property through improved public awareness and in compliance with our federal regulations. This also includes our American Petroleum Institute 1162 which is an industry standard that provides guidance and recommendations to pipeline operators for the development and implementation of the enhance Public Awareness Program. So as you see on the slide, the program is pretty robust. The whole intention is to be able to share information about these established programs and communicate the information in many ways with the intention to enhance the safety through increase public awareness and knowledge, reduce third-party damages to pipelines and facilities, and provide better understanding of pipeline emergency response.

And we have a table over here representing some of the information that shares the Public Awareness Program that gives you some representation. This is the yellow stick that my friend was calling on the route. But what I like to point out is where there's opportunities for part of that communication to be more effective. Typically you will see out in the field is usually all in English as far as the communications for the emergency response information. In this case, you'll see that it is bilingual so that it's more effective in making sure that we're reaching audience that are being impacted in the community that we serve.

Also, if you see, there are brochures that are sent out to buildings or facilities that are 1,000 feet of our transmission high pressure distribution line. And that information I'll go a little bit further into but I wanted to point that out. And feel free to check out the demonstrations.

So this slide is representation of those sites of materials that are out for the Public Awareness Programs. SoCalGas has -- this is, like I said, an example of a brochure that has gone out. And it's for -- it goes go to properties within 1,000 ft of a natural gas transmission line. The brochure is intended to educate customers, effected public, permanent public officials, municipal staff, and any other person engaged in excavation related activities.

The sign here is a good outline of all the different colors that may be associated with pipeline markers that you may see out in the communities. The specific details on what information is conveyed in the product descriptions would differ depending on the gas transported. So again, you'll see here on this slide as it points out, the yellow is for gas and oil. And hence, the yellow stick.

And so SoCalGas will leverage the existing Public Awareness Program that is in compliance with a federal regulations and the industry standards. But also leverage opportunity to make necessary modifications to the program by, you know, piece and point with providing bilingual language on the signs and communications. So a review of SoCalGas Standards and Evaluations was conducted to identify potential updates and new processes that can be paraded with the introduction of 100% percent clean renewable hydrogen system. What this means is that our standards and procedures that we outline and therefore our workforce to be able to safely comply and be able to conduct their workforce task. They will be able to have that direction based off of the changes and modifications that may be needed due to the differences and the properties associated with hydrogen as well as any potential task or operational activities that may need to be modified. Through our ongoing collaboration with the Center for hydrogen safety, we are referencing their hydrogen tools portal, H2, for listings of incidents and lessons learned which involve pressure relief devices, piping, and compressor. And so that too, those lessons learned can be incorporated in our procedures and also in our safety and communications to our workforce. And additionally, we've been listing the hydrogen expert panel expertise to review our Angeles Link safety study.

So at the end of the draft, the findings, along with the reviews from the community based organizations, the hydrogen safety panel will also be reviewing. So overall, our standards and specifications sheets are the building blocks of SoCalGas and identifying the gaps due to the evaluation that we have been conducting as well part of this study. This will enable us to be proactive and efficient in preparing planning for the next steps of this project.

In summary, the safety study preliminary findings supports what outlined and there are also the studies that points to that. The guidelines is one of the safest way to transport energy products. This evaluation and this study also identifies the safety requirements ranging from materials selection, pipeline designs, to monitoring an emergency response protocols, to former comprehensive plan work to mitigate risk association -- associated with hydrogen transport. And there are ultimately the evaluation confirms that SoCalGas has an existing framework that we can build upon which include 100% percent hydrogen and be able to operate and maintain it safely.

I look forward to being able to receive your feedback. But for now, I'm going to pass the torch to -- no pun intended -- to Larry Andrews our Director of Emergency Operations and Strategy.

LARRY ANDREWS, SoCalGas: And as Chanice mentioned, Larry Andrews, I'm with SoCalGas. I'm the Director of Strategy and Operations Emergency

Management. And as you've heard from all my colleagues a little bit about the engineering, the development of the project; and then Chanice outlined some of the things that we're already doing, I wanted to give you a deeper dive into how we respond to actual emergencies. So before I get started, I want to walk you through the three slides.

And the way I presented this is kind of our response kind of cycle and what that looks like. And then I'll kind of break down how we assemble information to be pro-active as well as reactive and then assimilate that out to the different communities. And it really starts with alignment with our public partners -- police, fire, and other state agencies and public officials. So before I begin, just to kind of outline, we do follow the FEMA's standards for instant reconstruct of the system, also the national incident system for the federal government. We use a lot of the same elements that they do.

Through the last several years, as everybody seen, we've gone through some very significant impacts in the state. Started with wildfire from years ago right into a pandemic. And then as everybody has seen of last year, significant weather storms that have impacted various areas. So when we look at how we evolved with out current energy, we're looking at how we evolved with emergency response. So collectively, FEMA kind of outlines four categories which is mitigate, recover, assess. And so one of the areas -- the couple of areas we really want to focus on is really how do we predict and detect and then learn because that's really what we're talking about here.

There's things that we have not seen before, all the different agencies and we're all learning to do that. So incorporating that and overall cycle will make us more effective. And what does that look like and how are we doing that. We're doing that in the initial three areas. Which is our customer contact center. This is the department that's 24/7 that takes all customer inquiries. Whether it's regular concerns, everyday work to, "Hey I think I have a gas leak. Or I smell gas and I need help." And we'll deploy resources out for that. The second area that we do, that is our dispatch. Which is the group that displays the resources, but also takes intake from first responders.

So there's a dedicated line for just first responders. It's a non public number that the 911 first responders get directly to out dispatch and say, "We have a problem here, and we need your help right away," and then we will deploy out. And then lastly, the third areas are system operators. This is the group that really balances the gas system to make sure we're providing safe reliable gas to our customers. And then they're monitoring that for any abnormalities and if there are, then they'll deploy resources out to correct that.

The more recent thing that we've implemented that is really starting to kind of change the way we look at things is we do have a 24 hour watch guest under my organization which is a team that's on 24/7. And really what they're looking for is things that aren't a problem yet. So incoming weather, wildfires, and anything that can potentially be an issues to our employees, our infrastructure, or the public. And then we can convey that information with our other key partners.

And because we no longer have to wait for an emergency to happen to react, we now have data and analytics and capabilities that are going to allow us to take it one step further. And why is this important? Because as our energy market and what we're using for energies changing, we as emergency responders need to be in a important position to also change with that. And that's how we collectively come together. They're now in a more integrated approach, so what we can assemble appropriate information and then put that together, get the right resources and the right folks deployed out to respond and mitigate those before that can potentially happen.

And then together through some of our programs Chanice mentioned first responder -- I'm sorry the public awareness which also has a first responder education component. So it's really coordinating with first responders and emerging events and emerging things that are a problem that we could be seeing and how do we want to mitigate them. So it's very important to share this practices. And when I say first responders used to get an idea our service territories about 24,000 square miles so we have about 23 different agencies that we coordinate under my organization.

And we partner not just with the emergency management group, but we have a partner with operations, our regional public affairs group. And we're not just sharing information brochures, we're actually now doing workshops. Hands-on twisting, turning, pulling; what does this look like so we can have collaborative conversation. And then we've extensively integrated with our EOC in other county coordinators, that way we're able to push information with them as well as get information so we can be sending in the right folks and the right people to get the right information. And why are those two first things important? Because it rightly leads right into the community outreach by being online with public partners pushing out this information so we can try to reduce confusion.

One thing we've all learned through these series of disasters and things that we've all been challenged with, communications is one of the things that continuously needs to have work and it kind of touches back on my initial slide, the learning. We're always constantly learning how to do things better, how to get it more efficiently. And that's why these types of events here are so important. Because we don't know what we don't know and we haven't seen the things we haven't so again just really wanted to have a kinder higher level outline. More tactically what we're doing and how we're evolving things to make the community safer.

And then in turn by making the community safer allows our public partners -- especially police and fire that are in the trenches to really be able to tactfully and strategically know where to go for help. So again just a couple slides that I wanted to outline, some of the things we're doing while we're turning the time back for Thursday questions.

ALMA MARQUEZ, LEE ANDREWS GROUP: Okay. Thank you Larry and Chanice for that great presentation. So our next exercise, we're taking it up a bit. We actually have a walk to wall activity. We have four questions that are also in your folder it's the plan requirements. The questions are here and they're up there. And we passed out some post-its so that you can go around and respond to those questions. And then we'll go around and respond to those questions and then I'll greet some of them just to save us time.

And then we also have the culinary students that I believe are almost close to -- oh, they're ready. They're ready to go to start plating us. So a couple of things going on, we're going to do the walk to walls but also the students here at Trach-Tech will be serving us for this afternoon's lunch. And I just want to go ahead and say thank you so much to the students here, if you had some of that freshly baked granola this morning, it was fabulous. Everything has been so good so we're very much grateful for all the work that you do. And I'm sure we'll be visiting all the restaurants you'll be working at because I'm sure it's going to be fabulous.

Feel free to stand up and get some lunch.

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PRESENTATION 2 COMMENTS

BRYAN BARNETT, SOCALGAS: Brian Barnett, SoCalGas. My question is for Chanice, also with the workforce. I was wondering as far as surveying goes, are you guys looking into another piece of equipment for hydrogen on top of the methane or is it going to be refined in something that's incorporated with both gases because that's a lot stuff that we carry.

CHANICE ALLEN, SOCALGAS: That's a great question, Brian. Yes, there's actually already existing equipment that we're researching and testing inhouse at SoCalGas. So we'll be able to leverage some of the existing equipment that will potentially be able to detect up to 100% hydrogen. And then there are also additional equipment that's actually outlined specifically in the safety study that talks to whether, again, like I said, there's personal equipment that you can use.

Or -- you're speaking about the RMLD -- that type of technology that will be able to have manufacturers that are looking into modernizing that equipment. And then phase two, there will be continue refinement and evaluation of those technologies.

CHESTER BRITT, ARELLANO ASSOCIATES: Does anyone else have any thoughts before we keep going.

THELMY ALVAREZ, WATTS LABOR COMMUNITY ACTION COMMITTEE: I feel impressed to, like, not ask very many questions because I feel like this session has been a lot of, "We'll find out in phase two. We're going to tell you later. We're not there yet." But one of the things that we would like to see when you talk about, like, potential materials that will be used for these pipelines are what the analysis of different materials?

What is the common industry -- well maybe there's not a common industry standard because it's so new -- but we want to see those kinds of things because a lot of us, I think, were affected by the explosion that we saw. The natural gas tanker in Wilmington which is right down the street from our organization. And our communities are really frightened by that kind of scenario.

It's really, really challenging to say, "There's going to be a hydrogen gas pipeline. Don't worry. It's going to be as safe as we can, as we will be." We want to know the hows and the what's as well. Thank you.

KATRINA REGAN, SOCALGAS: Thank you so much. Great question. So materials are absolutely something that are part of the mechanisms that can be put in place to help safeguard, assets, and people. We will be exploring those materials that are appropriate based on various different codes including ASME, B3112, and others.

Those materials will be starting with a feasibility analysis in phase one. So keeping things -- still looking at what we need to be considering further and then in phase two we will definitely be exploring those materials and doing material selection. And, so, thank you.

ROY VAN DE HOEK, DEFEND BALLONA WETLANDS: Okay. Roy here, hello. For Chanice, did I pronounce your name correctly? You answered my odorization question, but I didn't catch the scientific name of the -- you said it real fast of the odor chemical.

CHANICE ALLEN, SOCALGAS: THC. It's Techa Biopy.

ROY VAN DE HOEK, DEFEND BALLONA WETLANDS: Okay. And then you have any signs up anywhere where those faults -- earthquake faults that are crossing in these lines? Do you put signs up? Or do you just have a danger sign that says, "Danger. Gas line here." With anything that specific --

CHANICE ALLEN, SOCALGAS: Not that I'm aware of. We don't have specific signs right at that location.

ROY VAN DE HOEK, DEFEND BALLONA WETLANDS: You should do that.

CHANICE ALLEN, SOCALGAS: I will take note. Thank you.

CHESTER BRITT, ARELLANO ASSOCIATES: Thank you.

MARCIA HANSCOM, BALLONA WETLANDS INSTITUTE: It's unclear still, and maybe it's still unclear to you. If the hydrogen when it -- I can't remember those words you used. When it arrives, there's an arrival spot. The squares or rectangles -- if you're going to be storing that hydrogen, like, underground like you do with the methane gas or not.

But I can tell you that, I mean, one of the things that we learned from Aliso Canyon, there were dozens of firefighters, first responders who came when Aliso Canyon blew. And dozens of them sued, I think, SoCalGas and the city because they were told it was safe going in and a lot of them got cancer and a lot of bad illnesses.

And part of what we learned from that was that there were more than 200 chemicals. The county told us later, County Health, more than 200 chemicals are used to inject and extract the gas there. But no one would tell anybody what the chemicals were. So we know a few of them because the air management district reports, but my point is how will we -- one of the things I'd like to ask in this whole process is that if you're going to be storing the hydrogen, you know, making sure that there's transparency about what the chemicals are so the first responders and others can be safe.

FRANK LOPEZ, SOCALGAS: Thanks for that comment, Marcia. I just want to clarify that storage is part of one of our studies, right. Which study is that particular? Is it part of out routing?

KATRINA REGAN, SOCALGAS: It's part of our pipeline sizing study.

FRANK LOPEZ, SOCALGAS: So we'll have additional information on that. In terms of -- oh, you were asking a question about storage, right. About the storage of hydrogen. So I just want to acknowledge that storage is part of our feasibility study and that it's going to be a separate study that we'll share information about but we will address that to you. And then I want to reiterate what Larry's presentation was about which is about coordinating with first responders which we take very seriously.

As he mentioned, in partnership with public affairs and emergency management, we do join trainings. I imagine that that's part of this exercise as we update our standards and our training that we'll need to do more joint training with first responders. So we have facilities where we could do this stuff like Situation City where we actually go and look at pipelines and do joint exercises with them.

And we also do a lot of -- I think we're actually required to do trainings with first responders on a -- is it a yearly basis, Larry? Where we actually have to go with them and do instruction around our facilities and working with natural gas infrastructure.

LARRY ANDREWS, SOCALGAS: Yeah. Every storage field that we have goes through an annual drill was part of the requirements. And we do invite firefighters to be present for those drills and exercises and share information and look at all the different things the facility has so we can make sure that they have the appropriate information should anything happen at the facility that they have that knowledge coming in.

CHANICE ALLEN, SOCALGAS: Actually, I'd like to add to that. So there's the Community Right to Know Act and so that's under the California Health and Safety Code and under that act the information regarding hazardous materials is disclosed in the hazardous materials business plan facilities. There's a specific threshold and that information is actually recorded through the fire department -- local fire department and the state. So that information is available publicly.

MARCIA HANSCOM, BALLONA WETLANDS INSTITUTE: Well maybe you can direct me to where to find that now because we've always been told that it was an -- oh, what's the term. It's a term of art that businesses uses a lot --

CHANICE ALLEN, SOCALGAS: Material safety data sheet?

MARCIA HANSCOM, BALLONA WETLANDS INSTITUTE: No. It's some kind of -- then it's a secret. Company secret. And, you know, in terms of what is used and it would be great if we did have some transparency and knew where to go to look for that information.

KATRINA REGAN, SOCALGAS: Thank you.

CHESTER BRITT, ARELLANO ASSOCIATES: I think I see one other person over here.

ELLA CAVLIN, PESA: This also might be a little bit early to say it but I was thinking about how to disseminate this information to communities and just people that are living, regular people. As important as I agree it is to be really transparent about the chemicals that are there, I think really formulating your messaging of safety to the communities you're talking to and making sure it's digestible because I know like the second I start hearing all types of chemicals I'm -- I don't know what's going on. But I think finding ways to make sure that it's digestible for whoever you're talking about. Language as well, like, in other languages. Depending on the communities you're going to.

And another suggestion I had is maybe, like -- again, this might be a little to early -- but maybe training the fire fighters that you're talking to how to train communities and maybe schools. Like, I go back to I know what to do in a fire, I know what to do during an earthquake because I learned it when I was in elementary school. So maybe, you know, most kids are at school. So they can learn it in a really age appropriate way and bringing it home because parents are at work. They got other things they're thinking about.

So if you're able to have, like, fun fire fighters teach about what to do if you smell this or you see that or you see that then they can bring it home and make sure what their family knows what's up. That was just a suggestion.

FRANK LOPEZ, SOCALGAS: That's a great suggestion. And I think there's also one area where I think that CBO's like yourselves can actually help us too because you have a lot of credibility with allot of our customers and the communities that you serve. This exercise in itself is kind of one of those ways where we try and share information with you on some technical things and try to learn how to better communicate it.

I mean, we do this as other projects so your feedback helps and how we deliver the information. But I would like to, in the future, partner with CBO's to help get out this information as well and holding public workshops, town halls, other ways of delivering information through multiple channels not just through the utility itself.

LARRY ANDREWS, SOCALGAS: Frank, I just want to piggyback on that. Yeah, I agree. There's a lot of opportunity. We partner up with the fire department all the time. We do a lot community based stuff through Frank's organization and really getting more into that, you know, hands-on type interaction so people can take the education.

And we really do need the help to get that messaging out and it's not just hydrogen specific. It's all disaster specific because we have things that we're always trying to mitigate against so definitely would love to see that.

CHESTER BRITT, ARELLANO ASSOCIATES: All right. Jessy, I think I see your placard.

JESSY SHELTON, CALIFORNIA GREENWORKS: Jessy with Greenworks. To piggyback what Ella was saying, I also wrote on there that we have the community meetings and such for stuff like this to kind of tell the community about what's going on. But also with like partnering with schools for, like, what they smell and such like that and with anything, you know, as they're walking to school and what they can do, but also social media yeah.

I know that's kind of, like, no duh but I know from where I from in the valley there's like a community emergency response team and putting all their stuff on Instagram and Tik Tok of just, like, little things of what you can do is such a huge help.

JESSY SHELTON, CALIFORNIA GREENWORKS: Absolutely.

ROY VAN DE HOEK, DEFEND BALLONA WETLANDS: Based on what Ella and Marcia just said, I was listening to your presentation and I wonder if we're using the real correct when we say "hydrogen gas." We're saying the name of the chemical hydrogen gas. In the way back meetings, I would say lets not say natural gas anymore let's methane gas. And maybe now I'm thinking lets put an asterisk next to that methane word. Saying that there's other chemicals with methane in it so that it's more informative for the public because natural is sort of a persuasive word to make us feel calm and it' not really saying what it is.

Methane is what it really is. We're saying hydrogen gas to be consistent and for the precedent, now, it's just a good time to start using the word methane instead of natural. It's not natural. It was natural when it's in the ground but then humans take it out and move it in the corridors, change it, pump it below the ground, extract it. It's really, by then, completely synthetic and manmade changed.

JESSY SHELTON, CALIFORNIA GREENWORKS: So does anyone have anything to offer for the CBOSG updates. No. So we're going to go ahead and move on to the preliminary workforce planning and training evaluation presentation. I want to make sure that we've tried to stay on track with out time. We want to respect everyone's time, we're supposed to be done at 2:00 so if we can go to that slide.

PRESENTATION 3 COMMENTS

JESSY SHELTON, CALIFORNIA GREENWORKS: Any questions for Amaree.

KENTA ESTRADA-DARLEY, COALITION FOR RESPONSIBLE COMMUNITY DEVELOPMENT: Alright. Kenta

Estrada-Darley with Coalition for Responsible Community Development. So not a question. Just wanted to commend you all. Thank you for the presentation. No offense to the other presenters, but this was the best part. Absolutely why we're here. I think there's so many opportunities for expanding work like this, right, and part of the community benefits piece of Angeles Link but just, you know, partnering with SoCalGas in general.

Amaree, we didn't get to connect last week, but lets definitely connect. There's groups in the room like Reimagine LA, SEA, YMCA that work with community. Getting folks into these career pathways. So whatever we can do to support these and expand models like that, these are the type of jobs we're talking about. Jobs with family sustaining wages, 25 years career, right? Infrastructure development is only going to continue with booming in the LA area. So if these are the pathways, we want to get community members into it. But thank you and congrats.

CHESTER BRITT, ARELLANO ASSOCIATES: Thank you for that comment. I see a couple others. Ella.

ELLA CAVLIN, PESA: Hi. Ella from Pesa, again. Thank you for sharing. It's great to hear how much you love your job. It's awesome when you love your job.

I have a question for Amaree. Where do you guys recruit? Because I have students leaving high school and sometimes thinking about trades as an option; and what age group do you normally enroll; and where do you recruit if I ever wanted to refer anybody.

AMAREE EL JAMII, JTM ACADEMY: When was Covid again? Whenever that was, that caused us to go online. So we started teaching on Zoom. So now we recruit from anywhere, right, because our classes are remote. We meet up once a month in person to do some hands on training and in Mr. Halloway's backyard in Compton.

But other than that, we're on Zoom. We can connect, and we can get some of your folks into the class and anyone else who's interested in connecting with us and trying to get some folks that you know inside of your communities, engaged. We actually can get them connected. Yes.

CHESTER BRITT, ARELLANO ASSOCIATES: Anyone else.

RASHAD RUCKER-TRAPP, REIMAGINE LA: I would also reiterate the kind words that everyone said. I think it's fabulous what you guys are doing, and I commend your success and your continue success. And, of course, we want to partner in any way possible. Even if it is with the outreach. You mentioned Instagram and social media. So what is that hook so we can also, you know, I would love to share on our social media platform what you guys do as well. So if you guys can share that hook and begin sharing.

AMAREE EL JAMII, JTM ACADEMY: @JTM_Academy. You can find us on Instagram, Facebook, Twitter.

FRANK LOPEZ, SOCALGAS: Just thank you for sharing your success story. As Kenta mentioned, I know there are other organizations that do similar work, so if you want to share that information with us, we can share it to the broader group. And then I also want to do a shameless plug for SoCalGas's scholarship program which the application is opened right now.

We actually offer scholarships for students that are going to trade schools and community colleges. The application closes on March 19th, so make sure to share that information out there too. We still need applicants so we have money to give especially those going into trades, please let us know. We'll share that information with you.

(Break)

GROUP SESSION

ALMA MARQUEZ, LEE ANDREWS GROUP: Lets go ahead and start with our Zoom folks. Lets start with

Isaac's group. Okay. So we'll go ahead and have -- if you guy's are ready. Lets have Michael go ahead and report out on his group.

JESSY SHELTON, CALIFORNIA GREENWORKS: This is Jessy from Greenworks. For the first question, how could we collaborate with other CBO's, stakeholders for effective training and education programs. So we said partnering with schools, focussing on STEM.

Either, like, elementary schools through college. Develop interactive information group like a Q and A, just make it more digestible and interactive and fun. Incentivize and collaboration. Perspective building. Knowing your audience and, like, kind of speaking a language to bridge the gap. Piggy backing off current programs like child development.

Collaborate with a broad range of CBO's. And Greenworks has -- I was saying that Greenworks has, like, our group, we have allot of community outreach stuff so for SoCalGas to come to events like that and kind of -- we already have the community there, it would be relatively easy. Do you want me to go through -- can I move to the second question? Okay cool.

The second question, so incentivize other services and being more transparent about the cons of the pipeline. Just, kind of, setting everything out on the table. Accessibility and where the workers are coming from. Be upfront about the cost and hidden cost and the threshold.

And then the last, if you have prior experience in the workforce development, what strategies have proven successful. Incentives was really a big one. Transparency and representation on gender, age, and race. And then collaborations with stakeholders. Flexibility. Once the workforce -- they have jobs, to kind of follow through with that. Not just, like, we have a job and then we're done.

ALMA MARQUEZ, LEE ANDREWS GROUP: Thank you Jessy.

And we're going to go ahead and move to Kevin's group.

KEVIN WEIR: Hi, everyone. My name is Kevin. I'm with the Angeles Link Outreach Team. So for the first question, we talked about reaching out to students because that's the best way to go. Working with the organizations that already worked with local high schools or local elementary schools. And making sure that we're giving this information accessibly and illustrating that through different visuals where it can easily be digest. And they can take that back home and share that information.

We also spoke about resource fairs so we can speak with different entities in the other CBO groups that also might have the same questions or also will be sharing different information on this. We talked about reaching out to local communication organizations that have, like, their niche communities. So not everyone gets the same information from the same source so we were looking at maybe working with other media that are able to spread the information and be more easy to accessible communities that watch those certain entities.

And for this second question, we focused on getting people back into the workforce. So people that have been previously incarcerated, we've learned that it's hard for them to come back, and it's hard for them to get a job that pays liberal wages. So we wanted to focus on having that incarceration to education program where they can come in and have the necessary training, have the necessary developments, and have the ability to work in this field and work in this practice.

The next one was setting up some key performance indicators to measure the impact that we're doing for environmental justice and disadvantage communities. We want to make sure that we're using the data and we're comparing that data on a weekly basis, monthly, or on a yearly basis to see what needs to be more developed and what needs to be more developed and what needs to be more focused on because we can learn a lot from different data points as well.

And for our last question, we wanted to focus on reducing barriers to employments. So as I mentioned before with the incarceration, we wanted to make sure that we were making this accessible and we were reaching out to all different types of languages so that we're able to able to spread this information and get everyone the experience that they need for the workforce development.

We talked about representation. So, you know, seeing -- we see pictures of people working in, you know, building hydrogen pipeline; or there's also a woman being represented; or they're also -- they're from this city is being represented. So we wanted to focus on that as well.

And we also spoke about career development. Like, career development teachers that work in career centers and high schools and local schools; even at colleges so that we're able to work with them. Let them know more about this type of industry and also make it more accessible and have that ability for people to learn more about this as well.

ALMA MARQUEZ, LEE ANDREWS GROUP: Thank you, Kevin.

And our third group, Alyssa.

ALYSSA MARTINEZ: Some of my group had to take off so I'll be reporting mostly about what we talked about.

Enrique, for question one, how we could collaborate with you and other CBO's for hydrogen safety. Enrique brought a cool program -- or method to community organizing and information which I think we talked about in the past before as well. But using it as a way to share information about hydrogen and as a method to demystifying hydrogen in disadvantage communities and environmental communities. And then also engaging opportunities or as previously called disadvantage use in effective training education programs for hydrogen.

And then for the second question, what factor should SoCalGas take into account on establishing workforce initiatives. We spoke about engaging the youth and educating them in different renewable energy sources, not just hydrogen, but also the benefits of solar and how all these factors come together to help the environment holistically. Hoping that -- making the more inclusive of the youth and creating lasting partnerships where the CBO's have more decision making power whereas just having one organization kind of be the one to hold all the power and make all the decisions. So really giving CBO's a voice in those project labor agreements.

And then making meeting places diverse. So Marcia brought up an idea of having community meetings at gardens at different places where people feel comfortable and it makes it more interesting. We talked about how the youth are very adaptable, they're very resilient. And so taking advantage of that. And we will be sharing information about education and training programs. And also how SoCalGas can invest in educational curriculums in K-12 schools. Like, wood shop and then electric classes.

Jerry brought up how they partner with hub cities to help identify students that are currently in school and then helping them get jobs at the YMCA. So implementing that kind of structure to higher school board about hydrogen lookout. So that's kind of our thing.

Roy do you want to add anything.

ROY VAN DE HOEK, DEFEND BALLONA WETLANDS: Come to focussing about youth, you know, and the YMCA and which area and then Enrique with Soledad

Organization. And I mentioned that the youth are really intelligent. I mean, junior high, high school, young adults are pretty smart and they're into the language. You can see they're advocating for solar and wind.

So if you're only going to do a program that's focused on hydrogen employment or training, you're not giving them the full realm. And since hydrogen may only be a temporary thing, as a bridge -- a transition to solar and wind, don't you want to have the youth get the training in hydrogen solar wind? The whole realm of things so that it can be very adaptable in their careers, and it would then make the gas company look better too because it would be an acknowledgement that they're looking towards the future. And then Marcia chimed in saying well that's what the conversation with youth is called. JUST. Just for justice, just for transition.

ALMA MARQUEZ, LEE ANDREWS GROUP: Thank you, Roy.

So we're going to move on with our Zoom groups. So we have two more to report out. So let's go ahead and start with Nancy's group. Someone or yourself can report out. If there's something different that has not been mentioned, to save us a little bit of time, please share.

NANCY VERDUZCO: Yes. Hello, everybody. So I would like to welcome Hyepin to provide our recap here. We had a lot of great comments and I think her comments are really great. So if you're comfortable Hyepin, please go ahead and recap our conversation. If not I can do that.

HYEPIN IM, FAITH AND COMMUNITY EMPOWERMENT: I wasn't expecting that. Okay, I see the first one. I guess part of the -- one was the first step to disclose where the various chemical compounds in the hydrogen and how it's, you know, best for safety reasons. So just education in itself and how the leakage can be monitored and so anything around that should be education as well.

And also again two months of impact and not just looking at each item in isolation as well. And then, lets see, I also mentioned about ongoing sustained participation. There should be, actually, compensation for the organizations like a one shot deal. I think probably most of us can do. But if it's something that's supposed to be ongoing sustaining, that should be considered.

Also, there should be incentives for participants. I would think that, again, you know, if you say come and say, "Come and learn about hydrogen," I don't know how many people would actually show up, right. And so again, I think that's something that's important. There's some long term health impacts, again, for workers as well. And again, even though this is about safety, I think it should also explain the benefit and the purpose of the hydrogen and all the surrounding reasons for that as well.

And please, if there's others who want to add, you can please do. I already mentioned about what would attract people to come into the session. I would say using ethnic media universal outreach does not reach underserved communities. And so in language, translation, materials for training; not just outreach. So again, multiple languages.

I think earlier testimonies of the participants in the Urban League program I think shows how important it is to have more of a holistic program where assistance, guidance, hand holding are all done in a holistic way to support them from the beginning of their journey to the end. And so again, if you do just universal, you will get the low hanging fruits. But if you are targeting underserved communities, there needs to be more than intentionality as well. Yes, universal doesn't work. I think, again, with the testimonies of the participants, it shows that part of it is really about leadership training that is incorporated into and support and mentorship as well.

If there's anything else that I missed, please elaborate.

ALMA MARQUEZ, LEE ANDREWS GROUP: Well we have one more group left, and then we're going to move on to the next part of the agenda. So with that, someone from our fifth group. Isaac.

ISAAC MARTINEZ: Hi. Hello. So I'll be reporting out. So many of these answers here were also very similar and further carried on to the answers of the other groups.

So for the first question here, we've also got how can SoCalGas collaborate with CBOs to develop effective training education programs. So we've also got diversifying community outreach plans. This would also be considered into small community meetings; such as town hall styles. Different communication plans for how people can get information on workforce initiatives. Where can they get parted, and where can they find this information out.

For question two, what factors should be considered. Many of these were in relation to diversifying community outreach such as their access to technology. Prioritizing unrepresented groups. Integration at all tiers to workforce development initiatives. This also includes leadership to ensure outcome efficiency. And another one was for establishing additional support systems for people to get connected with workforce initiatives.

For question three, we've got a key outreach plans to diversify participant programs such as developing alternative outreach programs to get people connected. And as well as partnerships and collaborations with organizations and of variant populations. A great example, this was to help previously incarcerated individuals into workforce programs.

And that was all. Thank you.

ALMA MARQUEZ, LEE ANDREWS GROUP: Thank you, Isaac.

And thank you everyone for participating in this breakout session. It seems like there was very similar themes of diversity and inclusion and getting the word out and collaborations, incentives; all common themes here. So it seems like we have some like-minded individuals so that's great to hear.

And again, this is all going to be saved and recorded and sent over to you after today's meeting as well as the walk the wall activity. We'll definitely make sure to send everything out to you. So I just want to thank you again for your participation.

I know it's been a long day, and we're almost at the end. So please bare with us as we continue with our next part of our agenda which is the introduction of the community benefits plan. And with that, we have my partner here to my right, Frank Lopez who is our Regional Public Affairs Director for SoCalGas, who will be going through this agenda.

PRESENTATION 3 COMMENTS

MARCIA HANSCOM, BALLONA WETLANDS INSTITUTE: Just wondering, does that mean that before June, we will actually know where if where in our communities these places will be?

EMILY GRANT, SOCALGAS: No. So we're asking for -- we're just -- put your thinking cap on for June about what we can be doing. This is more about the process and the planning portion for identifying those community benefits. And if you have any ideas on the best way to brainstorm that as a group; do we like the small group sessions? Do we want to have a larger conversation amongst all of us? A high hybrid of the two. How do we want to start doing that?

MARCIA HANSCOM, BALLONA WETLANDS INSTITUTE: The reason why I ask that, I mean every community is different. Do you have any idea when we will know?

EMILY GRANT, SOCALGAS: Well I think, Marcia, you're asking the perfect type of question for what we want to tackle in June. That's a very smart consideration and when we need to take into account. So those are exactly the types of things that we need to start documenting and thinking about and how do we want to tackle that. What's the best way for SoCalGas to approach that that really to the term benefits the community. We want to make sure we're not missing anything. So I think you're exactly on the right track with the type of exercise we want to complete. Thank you for that we appreciate it.

So as usual, you can all E-mail me, call, text. As we've said from the beginning, that if you have ideas on the best way that we can start having this conversation, I think banking on your past experiences is kind of where we're starting. So that would be very helpful if you can come with that.

ALMA MARQUEZ, LEE ANDREWS GROUP: Okay. And I believe that is the end of our meeting. So thank you very much.

(The session concluded at 2:00 p.m.)

HEARING REPORTER'S CERTIFICATE

I, Christina L. Rodriguez, Hearing Reporter in and for the State of California, do hereby certify:

That the foregoing transcript of proceedings was taken before me at the time and place set forth, that the testimony and proceedings were reported stenographically by me and later transcribed by computer-aided transcription under my direction and supervision, that the foregoing is a true record of the testimony and proceedings taken at that time.

I further certify that I am in no way interested in the outcome of said action.

I have hereunto subscribed my name this March 18, 2024.

Hearing Reporter

CHRISTINA L. RODRIGUEZ

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FRANK LOPEZ
PEARL HSU
CHANICE ALLEN
KATRINA REGAN
YURI FREEDMAN

ATTENDEE LIST (CONTINUED):

AMY KITSON

LARRY ANDREWS

CHESTER BRITT: Let's get started with our meeting. So I want to welcome everyone to -- I don't know which number this is, but it's been, I think, about a year since we've originally got together. I think it was in March of 2023 that we first had our first meeting. So you guys have great endurance.

Ernie, good to see you again. You're still here. Your hair is a little longer, but you're looking the same, so that's good.

Let's go ahead and do our safety moment to get us started. Armando, I think you're going to get us started is our tradition. SoCalGas always does a safety moment, so we're going to start with that.

ARMANDO TORRES: Yes. Thank you before, Chester. Before I jump into the safety moment, I just want to very quickly go over our evacuation procedure, if needed. We all see the two exits in front of me, probably behind the majority of you. Our plan will be to exit through one of these two exits, make an immediate left, and then you will see the exit signs leading you out of the facility. The muster point will be in the back corner of the parking lot here, which is the northwest corner. Hopefully that is not information that any of us need, but in the event that we do, now we have it.

So I would also like to start by just doing a quick introduction of myself, as I am new to the AngelesLink team. So as Chester mentioned, my name is Armando Torres. I am the regulatory and policy manager for AngelesLink. I have now been with the team for about two months, but I do have about 24 years experience with Southern California Gas Company from operations to information technology, system integrity, emergency management and, finally, joining the AngelesLink team, and I'm happy to be here with you all today.

So -- oh, sorry. I got a little bit more. Awkward pause. Trying to build some anticipation here. So my safety message for today is actually seasonal, and it has to do with the upcoming Daylight Saving Time change that we will all experience this upcoming Sunday.

And, typically, when you hear a safety message related to Daylight Savings Times, they are in relation to reminders, maybe a reminder to change the batteries in your smoke detectors or carbon monoxide testers or maybe doing some certification for your fire extinguishers, and these are all very valuable tips, and I encourage you all to do that.

However, my safety message is more in relation to personal safety. And I wanted to highlight four key areas affected by the shift in Daylight Savings Time, and those four areas are your mood, your appetite, your cognitive function, and the increased risk of heart attacks and strokes.

First, the change in time can significantly impact our mood. The loss of an hour's sleep may seem minor, but it can disrupt our sleep cycles leading to hormonal imbalance. This disruption can cause feelings of depression, anxiety, increased irritability, and mental exhaustion.

The anxious mood not only makes it difficult to fall asleep, but can also lead to a vicious cycle of sleep deprivation. Second, our appetite; the adjustment to Daylight Savings Time can confuse our body's internal clock, affecting the hormones Ghrelin and leptin, which regulate hunger.

Sleep deprivation can cause the hormones to send mixed signals leading to increased cravings and overeating. It's a subtle change that can have a significant impact on our dietary habits.

Third, cognitive impacts; research from the Journal of Applied Psychology highlight a stark reality that the Monday following a shift to Daylight Savings time sees a noticeable increase in workplace injuries and severity of the injuries.

Moreover, studies have shown a spike in traffic accidents on this day attributed to tiredness and a decreased alertness. Our memory, performance, and concentration skills take a hit, emphasizing the need for heightened awareness during this period.

And then lastly and, perhaps, the most alarmingly is an increase in the health risks. A study recently published in the British Medical Journal reveals a 24 percent increase in the risk of heart attacks the Monday after we spring forward. Additionally, there's an 8 percent increase in ischemic strokes during this time. These statistics are a sobering reminder of the physical toll the time change can exert on our bodies.

In light of these findings, it's necessary that we take proactive steps to mitigate these risks. Prioritizing sleep, maintaining a healthy diet, practicing mindfulness to manage stress, and being extra cautious on the road can all contribute to a smoother transition into Daylight Savings Time. As we adjust our clocks, let's also adjust our habits and routines to prioritize our health and safety.

By being aware and prepared, we can ensure the transition into Daylight Savings Time is as seamless and safe as possible for ourselves and for our communities. Thank you.

CHESTER BRITT: Thank you. I think I'm going to take that Monday off and sit by my school after that discussion. It's interesting to know those facts; right?

I think I skipped over my normal introduction, so I'll just go back to that. My name is Chester Britt. Most of you know me. I'm the PAG facilitator. I also have with me Alma Marquez, who is with Lee Andrews group. We had our CBOSG meeting yesterday, which was terrific, and she helps facilitate these groups with me as well.

Also, some housekeeping items; this meeting is recorded, both audio and video. We also have a court reporter who will be transcribing the meeting. We would ask that you please announce yourself. This is a different room. The audio settings are a little bit different. So please speak directly into the microphone when we pass it to you if you have something to say so that the people online can hear you.

And if you're online, you'll need to unmute yourself when we call on you so that we can hear you in person here in our room. We would also encourage you to turn on your cameras if you're online so that we can see you. We have large format TVs here in our room. So if you are speaking online, we would love the benefit of having to see your lovely face. So if you could do that, that would be great.

You can also feel free to use the Zoom chat feature. We are tracking that as we're doing our meeting. You always have the opportunity to chat anything you would like, and we'll be capturing that in our meeting documents as well.

If you would like to speak, you would just need to raise your hand on the Zoom call so that we can see that you're interested in speaking, and then when the appropriate time comes, we'll call on you. We'll be able to unmute your mic, and you'll need to do the same, and then we can hear you in our meeting.

So with that, I'm going to go ahead now and go to -- I believe it's the land acknowledgment with Alma, who is going to do that.

ALMA MARQUEZ: Yes. Good morning, everyone. And welcome PAG members to this morning's meeting. It's great to see a lot of you that have been coming throughout the years. So thanks again for your support on this wonderful project. Our land acknowledgement this morning is we want to acknowledge the indigenous peoples on whose ancestral land we gather of the diverse and vibrant communities of Tongva, Tataviam, Toronto Keys (phonetic spelling) and Chumash people, who for generations have cared for these lands and make their home here today. We honor and pay our deepest respect to their elders and descendants, past, present, and emerging as they continue their enduring stewardship of these lands and waters for generations to come.

We acknowledge our collective responsibility and commitment to elevating the stories, culture, and community of the original caretakers of this region and are grateful for the opportunity to live and work on these ancestral lands. We celebrate the resilience, strength, and unwavering spirit of indigenous peoples and are dedicated to creating collaborative, accountable, and respectful relationships with indigenous nations and local tribal governments. Thank you.

CHESTER BRITT: All right. Thank you. So now we're going to do our roll call just quickly. We have a few people here in person, but we also have quite a few online, so we'll start in person, and I'll turn it over to Frank to my right.

FRANK LOPEZ: Hey, good morning, everyone. Frank Lopez, Director of Regional Public Affairs for SoCalGas.

AMY KITSON: Good morning. Amy Kitson Director of AngelesLink, Engineering and Technology.

KATRINA REGAN: Good morning. I'm

Katrina Regan. I'm the Engineering and Technology Development Manager for AngelesLink.

CHANICE ALLEN: Good morning. I'm Chanice Allen, Engineering and Technology Project Manager for AngelesLink, SoCalGas.

YURI FREEDMAN: Good morning. I'm Yuri Freedman, Senior Director of Business Development, SoCalGas.

LARRY ANDREWS: Larry Andrews, Director of Emergency Management for SoCalGas.

ERNEST SHAW: (Inaudible.)

I'm Ernie Shaw.

UNIDENTIFIED SPEAKER: (Inaudible introduction.)

NORMAN PEDERSEN: Norman Pedersen, Southern California Generation Coalition.

ANTHONY D'AQUILA: Good morning. My name is Anthony D'aquila. I'm with the city of Burbank.

CHARLEY WILSON: Charley Wilson, Southern California Water Coalition. I feel like I'm at a congressional hearing.

DENNIS BURKE: Dennis Burke, Energy Services Officer of city of Long Beach.

HEATHER HAMILTON: Hello, everyone.

Heather Hamilton, Long Beach Utilities. I'm an analyst, Gas Business Services Bureau.

JILL TRACY: Hi. Good morning, everybody. Jill Tracy, AngelesLink Senior Director of Regulatory and Policy and for SoCalGas. Thank you.

EMILY GRANT: Good morning. Emily Grant, Outreach Manager with AngelesLink.

CHESTER BRITT: All right. Now we're going to go to the folks online. I'm going to call your name, and when I do, if you could unmute yourself, we'll do the same, and then we should be able to hear you, and you can introduce yourself. So the first person I see is Aaron Stockwell.

AARON STOCKWELL: Good morning, everybody. Aaron Stockwell with California State Pipe Trades Council.

CHESTER BRITT: Welcome. Okay. I see Arthur Fisher.

ARTHUR FISHER: Good morning, everybody. Arthur Fisher with the Public Advocates office.

CHESTER BRITT: All right. I see a Arun Raju.

ARUN RAJU: Good morning, everyone.

Arun Raju with city of Riverside.

CHESTER BRITT: All right. Benjamin Tang.

BENJAMIN TANG: Good morning. This is Benjamin Tang with Public Advocates Office.

CHESTER BRITT: All right. Charles Guss.

CHARLES GUSS: Good morning. This is Charles Guss. I am Senior Asset Manager for the Southern California Public Power Authority. Thank you.

CHESTER BRITT: Thank you. Christopher Arroyo.

CHRISTOPHER ARROYO: Good morning, everyone. Christopher Arroyo. I'm a hydrogen analyst at the CPUC.

CHESTER BRITT: All right. Jesse Vismonte.

JESSE VISMONTE: Hi. Good morning, everyone. Jesse Vismonte with LADWP's Power System Planning Division.

CHESTER BRITT: Welcome. Joon Hun Seong.

JOON HUN SEONG: Hi, everyone. This is Joon Hun Seong from Environmental Defense Fund.

CHESTER BRITT: Lorraine Paskett.

LORRAINE PASKETT: Good morning. Lorraine Paskett, Air Products.

CHESTER BRITT: Marybel Batjer.

MARYBEL BATJER: It's Marybel Batjer. Good morning. California Strategies.

CHESTER BRITT: I apologize for that, Marybel.

MARYBEL BATJER: No problem.

CHESTER BRITT: Matthew Taul.

MATTHEW TAUL: Matthew Taul, Public Advocates Office.

CHESTER BRITT: And Maryam.

MARYAM HAJBABAEI: Good morning. Maryam Hajbabaei, South Coast Air Quality Management District. I'm a -- (inaudible) -- supervisor with -- (inaudible.) Thank you.

CHESTER BRITT: Thank you. Miles Heller.

MILES HELLER: Miles Heller with Air Products.

CHESTER BRITT: Welcome. Pete Budden. Pete, are you there? All right. Sara --

PETE BUDDEN: Pete Budden with Natural Resources Defense Council. Sorry about that.

CHESTER BRITT: All right. Welcome. Rizaldo Aldas.

RIZALDO ALDAS: Hi. Good morning. Rizaldo Aldas with California Energy Commission, Renewable Energy Division.

CHESTER BRITT: Sara Gersen.

SARA GERSEN: Good morning. Sara Gersen representing Sierra Club.

CHESTER BRITT: Welcome.

Sarah Wiltfong.

SARAH WILTFONG: Hi. Sarah Wiltfong with the Los Angeles County Business Federation.

CHESTER BRITT: Sasha Cole.

SASHA COLE: Hi. Sasha Cole with CPUC, hydrogen analyst.

CHESTER BRITT: Welcome.

Theo Caretto.

THEO CARETTO: Good morning. Theo Caretto with Communities for a Better Environment.

CHESTER BRITT: Good to hear you from. Tyson Siegele.

TYSON SIEGELE: Tyson Siegele. Today I'm representing UCAN, the Utility Consumers' Action Network.

CHESTER BRITT: All right. I am going to apologize before I even try this name, but it's V-a-s-i-l-e-i-o-s.

VASILEIOS PAPAPOSTOLOU: Good morning, everyone. Vasileios Papapostolou, South Coast AQMD Technology, special manager.

CHESTER BRITT: Welcome. Looks like Xinhe Le.

XINHE LE: Good morning. This is Xinhe Le also with LADWP. Thank you.

CHESTER BRITT: Welcome. I think that might be everyone. If I did not call on you, if you could raise your hand, then we can let you introduce yourself; otherwise, I think I got everyone. There's quite a few people online.

So thank you for all attending. So we're going to go ahead now and just keep going on our agenda. Before I introduce Frank, let me just quickly go through our agenda for today. I mentioned we do have food in the back. We did our safety moment, land acknowledgment, and roll call.

Frank, in a moment, is going to do our welcome from SoCalGas. We are going to then go into our different discussion items. The first one is the process review and preview of preliminary findings for the preliminary routing and configuration analysis; that will be followed by our discussion.

We'll then also talk about the plan for applicable safety requirements, another member discussion, and then we'll have lunch, and then we will go into workforce planning and training evaluation with another member discussion. We'll wrap everything up by having an introduction to community benefits plan development. We'll talk about our calendar and next steps, and then we'll adjourn.

And then for those of you who are interested in person, we do have the opportunity to do the Long Beach Airport tour, which we'll explain at the end of our meeting how you guys can participate in that. It's supposed to be fantastic.

So if you are here and you haven't thought about that, I would highly encourage that you give that a consideration. So with that, I'm going to turn it over to Frank, who is going to do the SoCalGas welcome.

FRANK LOPEZ: Thank you, Chester. I'm Frank Lopez. I am Director of Regional Public

Affairs for SoCalGas. I think most of you know me. For those of you who don't, I actually was involved in the development of the PAG and CBO process and kind of putting the structure together.

I've attended some meetings in person, watched some remotely, but I want to just get an opportunity to reintroduce myself because I'm going to actually be taking over the PAG and CBO responsibilities for my colleague, Jill Tracy, our Senior Director, who many of you know. Jill is actually transitioning into a new job.

So I want to thank her for all of the work that she's done, you know, all the blood, sweat, and tears that's gone into the CBOSG and the PAG. Wish Jill all the best, and I wanted to just take a moment to just acknowledge her for her hard work. Thank you, Jill.

You know, this is, I believe -- this is our 21st meeting, Emily? 21st meeting; right? Our first quarterly PAG meeting of the year. I want to thank all of you for all of the time and effort that you've put into this process.

I know that it is a lot of work. I was just thinking about all of the hours that has gone into preparing for these meetings, to participate in the meetings, to review the materials, to submit your comments, and wanted to just let you know that our project and our process is a lot better as a result of your contributions to it, so thank you for that.

We also had a really, really good CBO stakeholder group meeting yesterday over at L.A. Trade Tech. We had a fantastic turnout. We had 24 of the 30 members attend in person. I think it was our biggest turnout that I can remember. It kind of reminded me of that initial kickoff that we had over AltaSea. It was really good to see everyone in person. I know we've spent a lot of time together virtually, but it's always nice to connect with individuals and make for a really good discussion, so I want to acknowledge all of you who drove to be here in person and thank you for taking time to commute here and encourage all of you who are watching online, if you get an opportunity to join us for another PAG meeting in person, I think it does make a difference when you are here in person. It does give an opportunity for folks to connect and form relationships outside of this process. So thank all of you for that.

I also just want to mention that, you know, we're kind of -- as we're starting to think into 2024 -- obviously, this is the first quarterly meeting, and we have a couple of others as we start to kind of wind down the phase one, and we have some important information that we're going to be covering today.

I think some of these topics are some of the topics that our PAG members CBOSG members mentioned to us as being some of the most important, so I'm really looking forward to the discussion and the feedback that we're going to get. And with that, I just want to thank you all again and looking forward to a great meeting.

So back to you, Chester.

CHESTER BRITT: All right. Thank you, Frank. So now I'm going to introduce Katrina Regan. She's the Engineering and Technology Development Manager. She's going to be giving us a presentation on routing and configuration.

KATRINA REGAN: Hello, everyone. So great to be here today to talk with you about this important piece of our phase one studies. So today you're going to see a preview of our preliminary findings for the routing configuration work that we've done in phase one.

And as you may imagine, this is an important component of the phase one studies, so we're excited to share with you today. Since we kicked off phase one in January 2023, there have been significant developments, most notably the creation of a regional clean hydrogen hub, via the successful efforts of ARCHES' application to the DOE. And today you'll see a little bit more about our work with ARCHES as well.

We'll begin by revisiting the core objectives that drive this study. So as you saw in our description and technical approach that you commented on, the goal of this feasibility study was to start with a broad perspective, really focusing on a range of potential options.

And as we integrate a variety of other data coming from the other studies and from this study itself, we can start to identify and consider several preferred routes for our hydrogen pipeline, and this allows us to leverage potential while also understanding things like the communities, terrain, and environmental factors.

So today you'll see a preview of our process for this evaluation, and we'll also be sharing the potential corridors that we began with for the evaluation and what we're considering at and what we're looking at throughout the process.

And I do want to remind you that the evaluations are still underway. And while we'll be sharing maps today, which I know everyone is very interested in seeing, no preferred route has been selected. Preferred routes will be identified in the draft routing report, which will be shared with you.

And phase two of AngelesLink would consist of identified one preferred option and conducting refined design, engineering, and environmental studies for the proposed system. So following our discussion today, you'll receive the preliminary findings.

It will detail the assumptions that guided our evaluation process, the corridors included in the evaluation, why, and the notable features that we're currently in the process of identifying.

We welcome your comments, insights, and feedback, and it's very important to make sure that this is a collaborative process to help ensure thorough decisionmaking.

All right. So on this slide here, so this routing evaluation, it included the assessment of many important features, as you can see them listed here, and these include social, environmental, and engineering.

The goal was to understand different factors that could apply to different route options. And the preliminary findings report will include a comprehensive list of these different features, as well as how they were defined in our work.

As you may recall from previous discussions, Pivot served as the primary third-party cloud-based application which we used to map these geospatial features. And during the evaluation of various pipeline corridors, we broke up the corridors into segments to allow for more manageable analysis.

As you'll see in the maps presented today, we start with a really broad range, which we narrow down and we'll be narrowing down at the conclusion of the study. So while our focus remained at a high level during this exploratory stage, you know, we did ensure that particular emphasis was placed on minimizing impacts on environmental and social content, including DAC and species habitats and, where feasible, avoiding it, while considering spatial factors for engineering, design, and construction.

We recognize that detailed refinement is something that will occur in subsequent phases. So when we look at maps today, please keep that in mind. They are high level still, and we will be continuing to refine analysis.

Another key consideration here is environmental justice. So Justice-40 is an important national initiative that seeks to deliver 40 percent of the benefits of certain federal investments to disadvantaged communities that face burdens that are related to climate change.

And information that we collect through this work here will help support our contributions and provide a foundation for our community benefits plan, which Frank will speak a little bit about later. In the draft report that will be issued at the conclusion of the study, you will see quantitatively how these features that are shown here apply to the various pipeline corridors that were evaluated.

The potential routes will be included in the draft report and will consider community impacts, access to production, demand, cost, and more. And we'll discuss that a little bit later in the presentation as well.

So as we've said, in initially setting up the foundation for our routing evaluation, we cast a very broad net and aim to focus our attention immediately on areas most suitable for placement of a hydrogen pipeline in Central and Southern California.

To do this, we start with a wide range of different data collections from federally recognized datasets and other publicly available information. First, we'll talk about the energy corridors on federal land, which you see here. To improve energy delivery, we know that multiple government agencies are working together to establish these coordinated networks on federal lands throughout the U.S.

And so these would be agency preferred citing locations for infrastructure that includes hydrogen pipelines and would provide industry and the public with greater certainty in infrastructure planning, while also protecting the environment.

Specifically Section 368 of the Energy Policy Act of 2005, which directed the secretaries of agriculture, commerce, defense, energy, and the interior to designate corridors for this energy infrastructure.

Moving forward, we'll discuss the Alternative Fuels Data Center or AFDC. This is another government collaboration between the Department of Energy this time and the Department of Transportation. So maps developed with data from the Federal Highway Administration and AFDC itself supporting plans to make it easier and more efficient for access to alternative fuels like hydrogen were also considered.

And the National Pipeline Mapping System or NPMS, this is another dataset and this one contains the locations of information, the locations of and information about gas transmission pipelines and another assets that are under the jurisdiction of PHMSA, Pipeline and Hazardous Material Safety Administration.

In this dataset, you may be familiar

with. It's used by government officials, pipeline operators, and the general public for a variety of different tasks that include emergency response, smart growth planning, infrastructure and environmental protections.

I should note here, too, that the NPMS does include SoCalGas transmission pipeline assets as well. And, finally, our efforts extended to joining ARCHES and to becoming a partner in support of their development of a clean regional hydrogen hub.

We support deep decarbonization of the California economy, and we, therefore, look to align our corridor sighting and our evaluation with the great work that ARCHES has been engaged on.

And as you'll see, both production and off-take sites identified by ARCHES align with the areas we evaluated, and that just further underscores the harmony between the efforts that SoCalGas is engaged on with AngelesLink and the state's strategic vision for progress for decarbonizing California.

All right. So SoCalGas owns and operates over 100,000 miles of pipeline that's been established over the last 150 years. This illustration that you see before you is a smaller subset of these pipelines categorized as transmission lines. These lines are typically characterized by higher pressure and larger diameter, and they play a role in facilitating gas movement over large distances across our service territory.

The SoCalGas natural pipeline system is therefore larger than the map you see here. But leveraging these existing transmission corridors means that the land has already undergone prior disturbance, potentially streamlining the permitting process and reducing environmental impact.

In phase one, we also will be publishing maps as part of our Nock (phonetic spelling) study to illustrate potential air quality benefits from AngelesLink for the communities near these corridors. And that was something that we discussed yesterday with our CBO groups as well.

Okay. So here's the first visualization of all the corridors being evaluated by the phase one studies overlaid with our existing SoCalGas transmission system. So as you may be able to tell here, 75 percent of the corridors assessed overlap with existing SoCalGas assets and align closely with the corridors that we highlighted in the federal energy -- energy quarter area we discussed in a couple slides before.

So on first glance, I want to acknowledge that this appears very broad, and it is. When we started our evaluation process, we looked to evaluate a wide range of routes that we intend to narrow down to a set of preferred routes at the conclusion of the study.

So as Neil shared back in January, proposed routes are currently estimated to be up to 450 miles in length, and we really seek to take clean renewable hydrogen from where it's being produced to end-users in Central and Southern California, including L.A. Basin and the areas of highest potential concentrated demand.

The evaluation that we've been conducting in phase one spanned multiple counties, and that includes counties of Orange, Riverside, San Bernardino, L.A., Kern, and Kings. Now, some of the corridors here that you see may ring a bell because they do include a variety of different routes that were initially researched within the spec reports.

And the intention here was to build upon that foundation but tailor the approach more specifically to the objectives of AngelesLink and to the state as we weave in new information from the other phase one studies. So notably here, not every quarter identified will be pursued for AngelesLink.

At the conclusion of phase one, we will present several preferred routes in the draft report. And so today, our goal and our aim is to provide insight into that evaluation process and that underpins the other various studies here.

So as we evaluate these corridors, we are integrating material and information from the other phase one studies that are currently in flight. So this illustration offers insight into that interconnectivity.

So, for example here, you can see how the areas that we've identified for clean renewable hydrogen production within the production study, you can see how the existing pipeline corridors act as a unifying element and can continue to do that between all of the information we seek from other studies like production, environmental, and demand.

And we can clearly integrate data here to evaluate the system pathways from multiple angles. So the integration is the basis for which pathways for the most promised in both the short term and the long term.

So, again, while we're evaluating a wide variety of corridors right now, the goal of our next phase is to really pursue a preferred route. So we've cast a wide net here to explore multiple options, accommodate multiple elements that support development and optimization, and that gives us the ability to more carefully consider potential impacts on communities, the environmental, as well as system operations.

And the intent of this illustration is again to show that while SoCalGas is not producing hydrogen, incorporating multiple studies together throughout this process and using the same platform really provides an optimal basis for comprehensive analysis.

So last year when the DOE awarded California 1.2 billion toward the creation of a regional clean hydrogen hub, ARCHES published this fact sheet, which you see here, which you may be familiar with. The illustrated map presents approximate locations and sizes of -- excuse me -- the production and off-take sites identified by ARCHES for inclusion in the application to the DOE.

And so here we can see the overlap between the corridors that were assessed for hydrogen feasibility in phase one and those ARCHES identified production and off-take sites. This analysis holds significance importance because aligning the great work done by ARCHES and the state's decarbonization objectives is integral to our analysis.

It's essential to look at the locations of projects identified by ARCHES so that AngelesLink only further supports advancing the hydrogen economy and accessing its associated benefits.

SoCalGas was grateful for the opportunity to submit several proposed segments within the ARCHES evaluation process, and we're excited to announce that some of these were chosen for the application. So while ARCHES and the DOE are still in negotiations, we're eager to hear the results of their conversations later this year and we'll share with you.

But collaborative partnerships like this really are indispensable in our collective effort to achieve California's clean fuels goals as soon as possible.

So we've discussed these different pieces now. And on this slide, we can really start to see how the layers begin to converge, how this evaluation happens. And here you can see the corridors that are being evaluated for feasibility alongside those areas identified in the production study, as well as the production and off-take sites that are part of the ARCHES hub.

This side offers a comprehensive visualization and starts bringing all of the different pieces together, all of the elements that we've just discussed into a single view, and it gives you a look at the process that we're in the midst of. We hope to apply layers such as the CalEnviroScreen to this as well.

So as we've discussed and, again, it's important to note that in the draft and final report for the study, several preferred routes will be presented, and today the study is still at a broad evaluation stage. So your comments and feedback are absolutely welcome and necessary.

All right. So we've discussed where we started and the process that we've gone through to determine what was considered. I now will talk a little bit about the evaluation process. So there are a wide variety of different and important information that's being collected within this study and the others.

We looked at the features the study's collecting earlier. And integrating this information will allow for evaluation and identification of several preferred routes at the end of phase one based on the potential.

So building a thorough and data-based understanding about the different various elements of the different routes really creates insight into what should be evaluated further, the opportunities they present, and what additional benefits can be achieved.

It's important to note, too, since we kicked off phase one in January 2023, there have been significant developments, as we've touched on; again, most notably the creation of a regional clean hydrogen hub. And our study will continue forward to finish the analysis that we set out to complete, and we'll also be incorporating new information and your input and feedback as it's received.

And so as envisioned in our work, AngelesLink could transport clean renewable hydrogen from regional third-party production storage sites to end-users and extend across approximately 450 miles.

As we've been analyzing this work, AngelesLink, the pipeline, the infrastructure, we've been looking at a range of pressures between 200 and 1200 PSI, pounds per square inch. The technical components of our engineering design will be further explored within the draft report of our pipeline sizing and design study, which will be released later this year.

Next I'd like to share some illustrations of a few conceptual examples of what a preferred route may look like, but just with the reminder that we are still in the process of evaluation, and routes are still at a very high level.

So I'm going to go through two

conceptual examples here. This is the first one. So these slides here represent examples of potential routes with the goal of moving forward, moving hydrogen from where it's being produced to the L.A. Basin and the highest areas of concentrated demand, while also considering resiliency and reliability as well as environmental and social impacts.

So on these slides, you can see the two segments that ARCHES included in their application to the DOE from SoCalGas. One is in the San Joaquin Valley, and one is near Lancaster. While ARCHES is the deal, we are still in negotiations on funding. We're excited to share updates we receive with you later this year.

These routes present a variety of different opportunities to connect to other potential hydrogen networks and storage while creating opportunities for access to production potential and pathways to move hydrogen to areas of more concentrated demand within predominantly existing rights of way.

In phase one, we initially studied a very wide area. We broadly considered how to bring hydrogen into the L.A. Basin from different production areas, and at the end of our study, we'll identify those corridors with the most potential for further pursuit and refinement.

Next steps: So as we've said before, the objectives of the phase one study for routing, configuration, and analysis is to identify and recommend several preferred routes for the AngelesLink pipeline system, looking for those with the most potential to deliver value with the least impact while understanding things like terrain and environmental requirements.

We're very excited about the DOE work and the work that ARCHES is doing with the DOE. And following our discussion, you'll receive the preliminary findings report that details the information we've discussed today.

In the draft report, which we'll be sharing a little bit later this year, toward the end of phase one, maps and underlying findings and data will be provided that illustrate potential pipeline corridors, and these will be preliminary in nature still, I want to assure you, so there will still be an opportunity at that point to provide feedback, make adjustments, and address or minimize impact.

In phase two, the research will be refined and even more detail will be added. Now, we'll be expanding our outreach, which I think Frank will talk a little bit more about, and we'll look to complete further refinement of the system, its components, and an identified route.

So we expect it to be a very dynamic process and continuing -- I mean, this is our 21st meeting, so we are very engaged, and that's why it's so vital to us to get your collaboration and feedback now at this early stage.

And the goal remains consistent; right? We would like to chart a pipeline route that is efficient, it's sustainable, and it's harmonious with the environment and communities. So thank you.

CHESTER BRITT: Thank you. That was quite a presentation. So I'm sure that the PAG members are eager to ask questions, so now is your opportunity.

Her presentation really covered a lot of information. Obviously, it talked about the process that they went through to look at the different corridors that showed you the corridor considerations, evaluation criteria, conceptual routes, and next steps.

So who would like to go first? Is there anyone online? Okay. Theo, you've raised your hand, so we'll go to you. If you would unmute your microphone, we should be able to hear you. If you could please announce yourself and your organization for the court reporter. Thank you.

THEO CARETTO: Hi. Yeah, Theo Caretto, Communities for a Better Environment. Katrina, one of the items that you mentioned the study would consider is environmental justice.

And so I was just curious what SoCalGas's definition of environmental justice is and how that is being taken into account. And then I have two additional questions, but I'll stop with that first one.

FRANK LOPEZ: Hey, Theo. This is Frank Lopez, Director of Regional Public Affairs. So I don't think that SoCalGas has a definition. I think we refer to the way that the state of California has identified environmental justice communities, right, looking obviously at the CalEnviroScreen and their definition.

For me personally, you know, I identify

an environmental justice community as an organization that has been disproportionately impacted by pollution and faces socioeconomic disadvantages relative to other communities, but I think as part of our analysis, I think we'll end up using the CalEnviroScreen definition. Correct?

KATRINA REGAN: Yes. Thank you, Frank. So we are using disadvantaged communities and CalEnviroScreen as part of our features and routing analysis.

I believe environmental justice -- environmental social justice is also discussed in one of our other studies, the environmental detail and detailed report in environmental social justice.

CHESTER BRITT: Theo, were you going to ask some follow-up questions?

THEO CARETTO: Yeah. Thank you. And then I guess I'm curious to hear a little bit more -- I don't know if maybe this will just be covered in the actual report once we have that copy of that, but to the extent that this looked at data available from PHMSA and the current regulations available from PHMSA, did SoCalGas identify any ways in which the PHMSA gas pipeline regulations are, I guess, out of date or fail to address concerns that have to do with moving hydrogen specifically?

KATRINA REGAN: Thank you for that question. We do look in the safety study that we'll talk about shortly about the various regulations that we're looking at, including PHMSA, and the other best practices that are available for hydrogen, and Chanice will be speaking on that, right, in the safety presentation shortly after.

CHESTER BRITT: Theo, any more? All right. Well, if -- go ahead. I see you're muted, so --

THEO CARETTO: Sorry. Yeah. It's difficult to mute and unmute. But that's all for now. Thanks.

CHESTER BRITT: Okay. Great. Thank you. I'm going to go to in person, and then we'll go back to some people online. Norm Pedersen, you have your placard raised.

NORMAN PEDERSEN: Thank you, Chester. Norman Pedersen, SCGC. Thank you, Katrina, for that presentation. You covered a lot very rapidly. I'm not sure I got all of it. I'd like to start by asking about your slides 19 and 20. These were the conceptual examples 1 and 2.

There it is, I think. 19 -- there's 20. It looks like the only difference is really a loop and slide in the conceptual example 2 that would connect -- connect the routes coming from the border to the central part of the SoCalGas service territory.

What's the difference between 1 and 2, as you would summarize it?

KATRINA REGAN: Okay. Yeah. Great question, Norm. Thank you. So the base map that underlays this doesn't change between the two slides, right, and that base map with all of the different options, that's illustrative of all of the options that we considered as we started the study.

And then as we move through the various other phase one studies and we integrate information, we'll be pulling it together to apply it to the different pieces. And in this illustration here, the difference is just that you noted. It's a different pathway into L.A. Basin, so really just illustrating that as we go through this, that's what we'll be looking at are the different pathways to move from the outer edges of the system into L.A. Basin. Does that help?

NORMAN PEDERSEN: Yes. And then going to the earlier -- if I can just ask one more question, and then we'll move to some other people. The slides where you had the brown tinted area, production areas, and then you had the blue bubble showing production areas, there's not much correlation, it doesn't look like, between the brown areas and the blue bubbles.

What are the characteristics of the brown areas, and what are the characteristics of the blue bubble areas, which I guess are -- you labeled them ARCHES off-take sites. Can you just talk about the characteristics of the brown tinted areas and the blue production bubbles?

KATRINA REGAN: Absolutely. And thank you. There is a lot of content on that slide, so I'm glad we're going to take a step back. So first of all, let's talk about the ARCHES fact sheet. So this is an illustration that ARCHES produced last year some time.

And taking this information and from the map, we translated the colors here, so you can see it enlarged on the right-hand side of the screen. Those bubbles, the blue ones, there are two different shades there, and they represent those sites that ARCHES has identified for production and off-take and have been included, I believe, in their application efforts with the DOE. So that's what those bubbles represent. So those are sites that were identified through the work that ARCHES has been doing.

The yellow or brown areas, these polygons here you see on the map, these are areas that we've identified through the great work in our production study. That's part of the phase one efforts.

That study will be published also later this year, and that study aims to identify -- or one of the aims is to identify where production for clean renewable hydrogen could occur in California, and that's what these polygons on the map illustrate, where that production could occur.

NORMAN PEDERSON: Thank you.

CHESTER BRITT: You know, I have a follow-up question, Katrina. You have bubbles that are all along the green lines and even the pale yellow polygons.

Is the AngelesLink envisioned as a true

point A to point B where point A is production only and point B is the end of the line, or is there the potential of having production feeding into the system throughout the line?

KATRINA REGAN: Yeah, I think that it does -- it does both to short answer your question, Chester. I think we envision there being access opportunities for production along the line and opportunities for off-take and delivery along the line as well.

CHESTER BRITT: That might feed into a little bit of your question, Norm. Okay. We have a couple more people online that have their hand raised. Let's go to Sara Gersen. And, yeah, we'll come back to someone in the room. We'll go back and forth. Yep.

Sara, go ahead and unmute your microphone, and we should be able to hear you. Introduce yourself for the court reporter, please.

SARA GERSEN: Good morning. Sara Gersen for Sierra Club. My question is also about this slide, so you can leave it up. I notice that several of the routes go to the California border, and three of the four routes that go to the California border are not linking up with production zones at their far end, which makes me infer that these potential routes would be relying on production zones out of state.

So to the extent that's true and if you could confirm if it is, it'd be great to have an understanding about in your study what assumptions you're making about other pipeline out of state existing to bring in production, who would be building those pipelines, on what timeline you, know, just, like, the source of any and all assumptions you're making on out-of-state infrastructure would be great.

KATRINA REGAN: Yeah. So I'm happy to answer that. Thank you. Great question. So the routes that you see there that really go toward the border that, as you pointed out, they don't necessarily have any ARCHES identified production sites nearby them, we did keep those within the evaluation, as they do present opportunities for pathways to -- out of potential access to storage opportunities out of state or potential access to out-of-state pipeline networks.

We are not making assumptions around who may own and operate those facilities. We are making design assumptions for the hydraulic modeling of those routes for different pressures at the border for intake into those pipes, but really those that were intended to allow us to do a comprehensive evaluation of all of the pathways that exist within Central and Southern California using the federal maps that we discussed earlier as well as our existing rights of way.

CHESTER BRITT: And just to reiterate the point you made, these light green lines that are highlighted are the ones that you evaluated, so we're not necessarily proposing that those would be the routes. Those are just the routes that you considered as part of the overall look at what's going on.

KATRINA REGAN: Exactly.

CHESTER BRITT: I want to go to Dennis now in person. If you could ask your question. We need someone to give you a mic so they can hear you online. Where is the yellow one? That one seemed to work, Kevin. They can't hear him online. Yeah. Thank you.

DENNIS BURKE: Yeah, just does any of this involve blending hydrogen with the natural gas supply? Just individual products, projects, and the new pipes are kind of, like, parallel with the corridors you have highlighted in green; correct?

KATRINA REGAN: Yeah, so great question. So AngelesLink as envisioned is to transport 100 percent hydrogen, so that's what our phase one studies are focused on. Great question. Thank you.

CHESTER BRITT: Oh, yeah. We just would like for you all to state your name for the court reporter, too, just in the future. That was Dennis Burke. All right. We're going to go to Arthur Fisher. Arthur, you're online. You have your hand raised. Please unmute yourself and introduce yourself, and we should be able to hear you.

ARTHUR FISHER: Good morning. It's Iain Fisher from Public Advocates Office. Can I ask you to go back a couple of slides to the long list of environmental criteria you're assessing? I just want to kind of -- that's it. Thank you.

So you mentioned in this list of engineering high consequence areas. What it looks like to me at this point is you're assessing co-location of a hydrogen line with existing natural gas lines, at least in 75 percent of the cases. How are you assessing that co-risk or assessing that within the actual evaluation? So, you know, you're going to have natural gas right next to hydrogen. What does that look like? What are the risks? How are you assessing that? How are you evaluating that, I guess?

KATRINA REGAN: Great question. So as we evaluated this -- all of the different various corridors, we really started off focusing on our exiting rights of way, but we are still keeping our evaluation at a high level, and we do know that we will be refining these routes further.

I think that your question around co-location and distance proximity between hydrogen pipelines and any other substructure is very important and following the codes and standards and regulations to ensure that our infrastructure and facilities are installed and then maintained safely is absolutely something that we'll be exploring. I think that that exact evaluation will occur during that refinement process for the preferred route. So I hope that answers your question.

ARTHUR FISHER: Partly. To the extent that that's what you would do, yes, but not really. What I'm trying to suggest -- what I would suggest is you need to start looking at routes that are not co-located or that are in other corridors.

The 368 corridors are half a mile wide, a mile wide at most, in most instances, and there's a lot of infrastructure in them already. There's transmission lines in them. There's pipelines in them. There's oil, gas pipelines in them, so they could be potentially pretty crowded.

Do you have any impression on where you might have any constraints as far as that's concerned?

KATRINA REGAN: Yeah, assessing the space within the right of ways is something that is crucial and will be something that we perform as part of that refinement analysis. But thank you for your comments.

ARTHUR FISHER: So my -- so there's two comments on that, and I'll finish. If you're going to have a constraint, you need to know about it as soon as possible, and we need to about it as soon as possible because you're going to have to reroute that side of the corridor.

If you're rerouting outside your

existing rights of way, that has a lot of implications. I don't need to point that out, obviously. So I strongly recommend looking into a much broader range of corridors than you've already looked at.

I think this is inadequate, number one. Number two, if you're going to come in for a CPC and the commission, you're going to need a range of alternatives that will all be equally analyzed. That will be a requirement for the -- I know under the word of CEQA, that is not a requirement, but how the commission does CEQA, it would be a requirement.

Also, if you're going for NEPA, which you're going to do if you're going to use a 368 corridor, you're going to have to have multiple -- multiple alternatives analyzed equally, and so I'm not hearing that from you at this point in time, which concerns me, so those are my observations at this point. Okay.

KATRINA REGAN: Thank you. Yeah, I do want to say one more thing, and that is just for phase one, and I think everyone should keep this in mind, that we're really looking to identify a whole variety of different features among and across the different 16 studies.

So our right-of-away analysis is part of that work overall, so looking to identify those areas with the highest potential for things like production and also areas for potential for things like demand and connecting those areas is really important and critical, especially just as we begin our analysis and determine a foundation for our subsequent refinement.

We do also have an alternatives analysis that's being completed as part of those initial 16 studies as well, so we're eager to share that information later this year as well.

ARTHUR FISHER: Understood. And I appreciate that. I'm not seeing the variety of alternatives in his routing study that I would expect to see if you're just staying in own existing corridors. That's my concern. Okay.

CHESTER BRITT: Thank you, Arthur. We're going to go back in person. Ernie, you have your placard raised. If you could ask your question. Need to give him a microphone.

ERNEST SHAW: Oh, cool. All right. What's up -- oh, this is super loud. President, Ernie Shaw, Utility Workers of 483, transmission and storage. You know, it's funny because -- just more of a comment, but, you know, looking on the map right there, just seeing how wide it is and how long and how huge, right, like, our transmission lines run throughout our territories, you know, from the, you know, Needles, Blythe, you know, Mexicali borders, all the way to up north, stuff like Fresno County and along the coast, just something to keep in mind, all of that pipeline that runs through, you know, our -- my members currently, myself included, right, because I do both jobs, but we patrol -- constantly patrol, survey, evaluate, reevaluate from class locations and, you know, do damage prevention for third parties with located mark every day, every month, no harm, no foul.

And we're going to get into it later, I think, but we even pig our lines for, you know, any kind of anomalies and stuff like that constantly, so that way if anything comes up, we're there to get on top of it, identify it, fix it, do what we got to do.

So this gives me kind of hope seeing all these information here with the engineering, environmental, and social. Like, wow, this is bigger than I thought it was. But so far, so good. No injuries, no deaths, nothing like that. We're successful as we can be. So eager to kind of get jumped on this, so thank you.

CHESTER BRITT: Thank you. All right. Theo Caretto, I think you have your hand raised again unless you didn't lower it from the last time, but I believe you re-raised your hand. Go ahead.

THEO CARETTO: Hi. Yeah, Theo Caretto, Communities for a Better Environment. I wanted to ask about -- we have a bunch of different permutations of pipelines here -- what steps SoCalGas has taken to engage with the folks that live along those pipeline routes and how that engagement is being handled at this stage?

FRANK LOPEZ: Theo, this is Frank Lopez. Thank you for your question. So as you know, we have a community-based organization stakeholder group that meets separately from this group, and they get all of the information that we present at this PAG.

So they -- yesterday they also saw these maps and got the same type of presentation that we're presenting today. So we're primarily engaging them.

You know, when we started this process, we didn't have any proposed routes, so we tried to cast as wide of a net as possible in terms of the type of organizations and the communities that they serve.

As we move into a phase two, obviously, you know, we're going to start to narrow down the routes and have a better sense of where these hydrogen corridors will be located, and we're starting to think about what a more refined, community-based organization stakeholder process would look like, which would mean engaging those communities, right? Obviously, the municipalities along those corridors and other civic and policymakers along those corridors to engage and provide and put in the process.

So just like we would on the engineering, we're going to do the same thing on the community engagement piece, which will be more refined, more local, and get more community input along the corridors as part of phase two.

CHESTER BRITT: All right. Tyson, I see your hand raised. If you could unmute yourself.

TYSON SIEGELE: Hi. Tyson Siegele representing the Utility Consumers' Action Network. I had a couple of questions here. The first question is the question of what demand has to do with the routing studies. Is the forecast demand, the demand from the demand study something that featured prominently in the design of these particular routes?

CHESTER BRITT: Yuri, is this a question for you?

YURI FREEDMAN: Good morning, Tyson. Thank you for the question. This is Yuri Freedman, SoCalGas. Pipelines overall may be various -- (inaudible) -- connect supply and demand. In this particular case, as I know we've explained, Los Angeles Basin is a very large center of demand for clean hydrogen, as it is the center of demand for energy here now today; and, therefore, we are developing the pipeline that are going to serve this going load, specifically with eloped the pipeline surface mode, specifically with an eye to sectors, which I know was mentioned before, its power generation and transportation.

And while we have not gone in full depth in analyzing the geography of this demand, we are trying to make sure that the pipeline connects all these areas with abundant potential of hydrogen, clean and renewable hydrogen production with those demand centers. I'm hoping that's helpful.

TYSON SIEGELE: I'm trying to figure out if these are specifically just routes or if they are routes that are based on a particular demand. If, for instance, these are based on a specific demand, for instance, demand that is proposed in the demand study, how does that affect these routes? Are they specific to a particular demand? If the demand was higher, would there be different routes? If the demand was lower, would there be different routes?

YURI FREEDMAN: It's a good question. And I don't think there's a direct correlation between the demand level or what we'll call pipeline throughput. And the routing options, ultimately, what we're trying to make sure is we can serve demand that will come from power plants of Los Angeles Department of Water and Power, as well as the transportation that is very heavily driven by the activities in the port, in the ports.

So ultimately, if you look at that map that Katrina showed, I think that the various routes ultimately determinate in the greater L.A. area, so I don't think you'll see significant distinction listed on to the point here where we can say that there will be significant distinction between routes if demand ends up being higher or lower.

TYSON SIEGELE: So, for instance, if demand were higher, then would there be bigger pipelines, or would there be additional pipelines to additional production centers?

Is there a -- one of the other questions, I guess, is the production centers themselves. My understanding is that clean hydrogen production locations have not been finalized, and that's what I understood from this presentation as well.

Is it possibly premature to be looking at pipeline configurations at all when we don't know where the production is going to occur?

YURI FREEDMAN: Well, a lot -- Norm I see a question. Should I answer?

NORMAN PEDERSEN: I don't have a question so much as I have -- this is

Norman Pedersen, SCGC. It seems to me that Tyson is somewhat misconstruing Katrina's presentation.

And, Katrina, I would like you to check my description of your presentation to see if it's actually what you intended to present.

As I understood Katrina's presentation, it's driven primarily by potential areas of production. It's basically agnostic with regard to demand, which is going to be generally in the Los Angeles Metro area.

So Tyson's question, it's a good question if you would imagine Katrina going beyond her presentation to the central core of the SoCalGas service territory, but Katrina wasn't, I don't think, going there.

You were looking solely at potential areas of production, and you're basically agnostic with regard to those as well. You don't know exactly what those will be.

Is that accurate, Katrina, or could you clarify?

KATRINA REGAN: Thank you, Norm. So in our routing study, we really sought to determine first what areas should even be considered because we are in a feasibility stage and then present those pathways so that we can also use that information and integrate it into other studies.

Identifying where these pathways are helps us to, you know, kind of look at what is around those in terms of production and demand, but then also we allow that information to feed where these routes are as well.

So it is a really iterative process between the routing study and other studies. So things like demand volume or production volume, assumptions around those may be developed within our pipeline sizing study to help us determine what kinds of diameters we need to consider to move forward with and pay attention to.

So the qualitative work here is really important, and the quantitative work is equally as important, but it is more assumption based.

CHESTER BRITT: So, Tyson, I don't want to leave you if you have any follow-up thoughts, but we have a few more people that have their hand raised, too, so...

TYSON SIEGELE: I think that covers what I was -- what I was interested in. Thank you so much.

CHESTER BRITT: All right. Thank you.

Theo, I think your hand is raised again.

THEO CARETTO: Hi. Yeah, this is Theo Caretto, Communities for a Better Environment. I guess I just want to ask the same question again, which is what has been done to include the communities along these proposed pipeline routes? And I'm aware of the CBO group, and I want to know, I guess, specifically are there communities in the CBO group that represent areas along each of these pipeline routes? And what has been done by SoCalGas to ensure that all of the information being shared in this space and the CBO space is getting to the folks that could potentially be impacted by this project?

FRANK LOPEZ: Yeah, thanks, Theo. So, you know, as I mentioned when we started this process, we didn't know where these routes could be located, but we did know that we intended to serve the L.A. Basin, so that's where we would primarily focus. And that's why if you see the CBOSG composition, it's mainly a lot of organizations that operate in the Los Angeles Basin.

Now, this map that we have up, you can see it goes through most of the transmissions. So in this state, it would be very difficult to engage all of the communities along these corridors. And it's also possible that some of these corridors won't advance and won't be identified, right. So I think that's why I mentioned, you know, our outreach is really going to follow the engineering on this.

You know, we're going to continue to meet with the CBOSG because we know for sure that this facility will end up in -- at least one of these will end up in the L.A. Basin, but as we start to get more refined engineering information about routes and where those routes are located, then we will start to reach out to those communities and start to engage them.

And, obviously, we would like to engage them as part of the CBOSG, but we're not constrained by that, too. I mean, we operate in, you know, all of Central -- most of Central and all of Southern California, and so we do have the ability to engage with them and brief them outside of the process as well, and we intend to do that as well.

THEO CARETTO: So just to clarify, has any outreach been done along each of these proposed routes? I mean, I know that we didn't have as much clarity as we have now earlier on, but these maps being shared now are permutations of potential routes that have been shared previously, and so there was, to some not insignificant extent, pathways of pipelines identified by SoCalGas, and so I want to know if outreach has been done along those pathways yet or if all of that is being deferred to a later stage.

FRANK LOPEZ: No, not all of it. I mean, we've been informing communities that we are proposing to build an AngelesLink project, right. They're aware of this information.

Prior to this process starting, we had public webinars where we disclosed the specs that is in all of these routes, so there is information circulating out there. Obviously, we just got these maps now, right, so you're seeing them for the first time. The CBOSG is seeing them for the first time, and we can definitely use this moving forward to engage communities outside of this process, if needed, or even include them into this process, if that makes sense.

So I don't want to say that we're going to defer all outreach. You know, our outreach will follow the engineering, but, for sure, at the end of this phase one process, I think our goal is to get one or two preferred routes, right, and then as part of a phase two, we would do that 30 percent engineering.

And by that point, we would for sure know where these routes would be located, and we'll have a community-based, you know, stakeholder input process to ensure that all of the communities along those corridors have a voice at the table and provide input on the engineering as well, so this is going to be an iterative process, just like it is on the engineering. It will be the same on the community stakeholder engagement. We're not going to defer it and do it at the end. We'll do it throughout the entire process from beginning to end.

CHESTER BRITT: All right. Thank you, Theo. We're going to go back in person. Mike Galvin.

FRANK LOPEZ: I'm sorry. Just one last thing. I want to -- if you have recommendations on organizations that you would like us to consider to engage, by all means, you can share those to us. You know, we're happy to brief anyone who is interested in this project. So if you have those suggestions, you can just send them to me. Thank you.

CHESTER BRITT: Mike.

MICHAEL GALVIN: Mike Galvin, Port of from L.A. I just had a question about the demand side terminus of the pipelines. And this all conceptual. I understand that. But what is the interface there with the marketplace? I understand it could be a power plant, but with the rest of the marketplace, how does the pipeline then distribute from there?

Is that thought about at this point, or is there any thought process in speaking to different potential off-takers to figure out what the best way to align with what the pipeline off-take?

YURI FREEDMAN: Mike, thank you for the question. I think that, again, on a sector level, that is going to be interplay of power generation transportation that ultimately are two sectors, which together, in our estimate, account for the vast majority of the throughput on the pipeline.

So importantly, to look at the footprint, on the one hand. We are trying to make sure we can deliver to Scattergood and other plants. On the other hand, we are trying to make sure that they are going to deliver to ports, including Port of L.A., Port of Long Beach.

We have not yet fully done what I call last-mile analysis, which is to say what we do not have is the map of this distribution network, which is to say how it's going to play out. And it's probably going to be, to some degree, complex because, as you know very well, various off-takers may choose to receive the hydrogen in different forms. Power plants will likely want gaseous hydrogen, whereas many transportation customers may want their hydrogen liquid.

So there's a whole layer of analysis, which we are looking forward to doing phase two, which is going to help us understand what is the lowest cost configuration, which will allow to serve this diverse needs. There's also very interesting pattern of demand where we expect transportation demand to be somewhat tradable or consistent over time whereas power generation will be probably nothing but.

And so we are going to figure out how to make sure that we have substantial, you know, ability to deliver power generators what they need on that critical day. And so that's work in front of us to be done. But, again, there is no question at Port of Los Angeles and Long Beach is going to be the absolute kernel of demand there, and we are going to work closely with, frankly, your -- you and your customers to make sure that it works for them.

MICHAEL GALVIN: Just a followup. So -- but as these segments are theoretically built over time, there will be a need for some other bridge, right, to get it down to the ports? So there will be some facility at the terminus of these pipeline segments that will create that bridge as future plans come about later on down the road?

YURI FREEDMAN: Yeah, you're exactly right. That's exactly what we envision. We just have not yet developed it to the degree where we can show you the fully flushed out technical aspects of that.

MICHAEL GALVIN: Okay. Thank you.

CHESTER BRITT: Thank you. All right. Great discussion. We have two more people online we're going to go to, and then we're going to wrap up this section because we do need to keep moving on our agenda. I just want to remind you that you have the opportunity to chat a question that we'll document.

If you didn't get an opportunity today to ask all of your questions, you can always call us or write us or e-mail us, and we will follow up with you specifically.

So we're going to go to Sara Gersen. If she can unmute herself, we should be able to hear you.

SARA GERSEN: Hi. Sara Gersen again, Sierra Club. If I understood the presentation correctly, you mention that the existence of disadvantaged communities along the different routes would be a factor in taking a preferred route.

What I didn't understand is the role of the disadvantaged communities on the various routes and your decisionmaking process, because I could imagine two different scenarios, right. On the one hand, you might say, oh, this route goes through a DAC that is on the scale in favor of sighting this pipeline in the DAC because wouldn't it be wonderful if this disadvantaged community could access this clean hydrogen, or, on the other hand, I could imagine the scenario where you recognize that routing a new hydrogen pipeline through a DAC comes with a lot of risk, a lot of harmful impacts potentially, and so you might say that is a thumb on the scale against the route through a DAC. And I'd appreciate if you could tell me which one it is in your decisionmaking process.

KATRINA REGAN: Thank you so much, Sara. We are still at the really early stages of this evaluation, and these feasibility studies are important to allow us to help collect the information and build a strong foundation.

I would be eager to see more of kind of what you're thinking of and would love to have your thoughts in writing. Perhaps, you have some suggestions for us for the best way to make this consideration.

FRANK LOPEZ: Yeah, and if I can just add to that, too, you know, we haven't identified a route, but for sure we're going to incorporate environmental justice as part of the decisionmaking. That's why we're performing that environmental justice analysis. That will be an important factor for us.

And, you know, at some point, we're going to take these facilities, and we're going to layer them over, you know, in CalEnviroScreen communities and try to identify how they overlap, right, and also try to map out some of the benefits associated, so we're going to factor all of that information into our decisionmaking.

But to Katrina's point, if you have suggestions on how we should be approaching this, you know, I welcome those.

CHESTER BRITT: All right. Thank you. Arthur Fisher.

ARTHUR FISHER: Hi again. Arthur Fisher, Cal Advocates. I'm hearing two or three words being used interchangeably here at this point.

Can you please provide me with definitions of corridor routes and rights of way and when in the process you would anticipate having nailed down each of those particular aspect of the design? Thanks.

KATRINA REGAN: Thank you. I think we can provide those to you and follow up.

ARTHUR FISHER: Including timing within

the kind of process, the whole -- for all the phases?

KATRINA REGAN: Yes. I believe we can do that. Just clarify, too, you're looking for corridors, routes, and right of way?

ARTHUR FISHER: Yeah. That's what I'm asking because there's -- they're being used interchangeably at the moment or at least that's how I'm hearing it. Very important we actually identify what they mean and when you would expect to have defined each one adequately to present to people.

KATRINA REGAN: Absolutely. Thank you. We can definitely provide that.

ARTHUR FISHER: Thanks.

CHESTER BRITT: Good question, Arthur. Tyson, you're the last one, and then we're going to move on. So if you could ask your question, we should be able to hear you.

TYSON SIEGELE: Hi. Tyson Siegele with the Utility Consumers' Action Network. So when I was listening to the explanation on the last mile and that last mile work still needs to happen, one of the pieces that comes to mind is that there is a lot of uncertainty in who is going to take service. For instance, in the L.A. 100 study completed by NREL and others, the -- there's analysis that says, well, it's quite possible that LADWP will self-produce its own hydrogen, which makes sense. LADWP has water. It has power. All it really needs is electrolyzers and storage. So the -- and that's one option that was reviewed in the L.A. 100 study.

So I guess the question is what happens if LADWP and others, for instance, the ports, the airports, they each decide, well, you know, we're going to go ahead and produce our own hydrogen, and then will that have a significant impact on what this study looks like?

Will this study shift more toward a hub-type of situation where everything is produced in Los Angeles and SoCalGas provides piping simply from production site to production site within the L.A. Basin? Will that create a significant effect?

And one of the reasons also I bring this up is that there's a lot of data showing that municipal utilities, like LADWP, have just a much lower cost structure, and they produce electricity, for instance, at much lower costs than Semper utilities do.

That's something that's pretty well known. And so it's, I guess, surprising that LADWP is looked at as a -- as sort of an anchor customer for this particular pipeline project when there seems to be a lot of reason to believe that hydrogen can be produced and may be produced by these off-takers without the need of SoCalGas at all.

YURI FREEDMAN: Thank you for the question. I think there's been a lot packed into that, so I'll try to unpack it a little bit, and if I miss something, please correct me, Tyson.

I will start from saying that the Los Angeles Department of Water and Power has demonstrated their interest in third-party proposals to produce hydrogen couple of years ago when they requested the proposals.

I have not seen any data suggesting that the interest has waned. In fact, I would think that as Scattergood decision has been made, that interest in hydrogen increase, and I know that they are in the process of their strategic long term resource plan. We are looking forward to seeing the outcome of that analysis.

I definitely will leave it to them to decide whether to get involved in hydrogen production or not. I will say that if you look at the volumes -- and, again, becomes the question of scale -- if you add what the range, which goes to a wide range of demand for power generation and the range of what the demand from transportation would materialize, the amounts of hydrogen that would be required to supply that quantity would likely have to be produced reasonably far away from the lot center for the simple reason that's where large parcels of contiguous land can be found.

That's also where the solar quality is higher. So that's just the nature of the production of hydrogen at scale, and that necessitates the infrastructure to bring it from supply areas to demand areas.

So in some sense, regardless of who is going to be producing hydrogen, it is a fact that is going to be need to be transported at those levels of magnitude over fairly long distances. And, again, that's what we have been looking at within the production study and all powered in the past.

I think I've touched upon the majority of what you brought up. If there's anything I left out, please comment.

CHESTER BRITT: Yeah, we're going to go ahead and move forward to keep ourselves on the agenda. We do have one more person in -- one more person in person who has a question who we're going to take, and then we're going to move forward with Chanice's presentation.

ANTHONY D'AQUILA: Good morning. My name is Anthony D'aquila. I'm with the city of Burbank, and I have actually two questions that I'll ask. You can answer in any order.

If you had your wishes and you could pick one of the routes regardless what route, I'm curious to know what the timeline is. 2045 is not that far away. So best case scenario, no sooner than what date would the pipes be ready to deliver the first molecule of hydrogen? That's question one.

And the second one is when will SoCalGas identify which power plants within the L.A. Basin? I think we've heard Scattergood more than once, but what other power plants?

I represent Burbank, of course, which

owns and operates a power plant, 300 megawatts, and owned by Southern California Public Power Authority. It's 300 megawatts. We're looking towards Hydrogen. I think we're eight to ten miles from Scattergood.

We're kind of trying to figure out is that pipe -- and somebody asked about distribution system -- that last eight miles. It's not one mile, but eight miles, ten miles. How do we figure out whether that plant is on the plan or not?

KATRINA REGAN: So the -- let's go with your second question first. So when would you know whether or not City of Burbank would be able to take power from this? Okay. So in our phase two, we will be doing more refinement around demand and the exact last mile delivery, as Yuri said, so I think that there's still some flexibility in terms of the exact off-take.

There's also still determinations that need to be made around, you know, that last mile delivery exactly and how that looks and how that's formed around this pipeline structure, so --

YURI FREEDMAN: Yeah, thank you, Katrina. I would just say that ultimately this pipeline, like any other pipeline, is built to serve customers. So you're a potential customer. Thank you. We are going to work with you very closely to make sure that we can do all we can to deliver the lowest cost product because that is ultimately the purpose of power asset.

KATRINA REGAN: And then your second question was around timing; right? So great question. So there's obviously a lot of legwork that needs to be done still to finalize our routes and to finalize both production and off-take side. I believe that for those segments that are identified by the work that we're doing with ARCHES, we're targeting 2030 for operation and then for the --

FRANK LOPEZ: I think it's too soon --

KATRINA REGAN: Yeah.

(Speaking simultaneously.)

FRANK LOPEZ: -- right? It depends on feasibility studies and additional analysis.

ANTHONY D'AQUILA: Yeah, I think we just need to coordinate because I'm not aware of any power plants that could run off a hundred percent hydrogen. So as we're doing our planning of retrofitting, rebuilding, reconstructing, we need to work at the same parallel path as you to get to the finish line.

And if we don't have an idea of when that timeline is and it's not somewhat firm, you may have a pipe, but you might have a power plant, and you'll be mixing at that point, 20, 30 percent mixture rather than a hundred percent.

CHESTER BRITT: That's why we're glad that you're here, Anthony. Exactly.

KATRINA REGAN: Please feel free to reach out to us.

CHESTER BRITT: All right. Great discussion. Again, if you have further thoughts, please send those to Emily, and we'll collect those and get back to you with detailed information.

Chanice Allen is the Engineering Project Manager for SoCalGas, and she's going to make a presentation before lunch on safety requirements. I'm going to hand the clicker over to her and let her make her presentation.

CHANICE ALLEN: Thank you. Good morning, everyone. I'd like to think this is the first time that I'm speaking to safety at the PAG meeting. I've been to majority of the PAG meetings. I met mostly everyone, but just to give you a little bit more formal background on myself, I've been working for SoCalGas for about 20 years, and my initial stint was a short stint, but it was as a represented employee as a meter reader, but I've been able to utilize my civil engineering degree to work through and support quite a few operations within the company starting off with gas operations in our service centers, hazardous materials operations.

I've also supported projects for our pipeline integrity management programs, our pipeline safety enhancement plans. And more recently, I was the project execution manager for our leak abatement program for Senate Bill 371 and now have had the privilege of being able to support the AngelesLink project leading the safety and workforce efforts.

So starting off with safety, the title of the AngelesLink safety study is actually the plan for applicable safety requirements, and the purpose of this study is to evaluate safety concerns as they may apply to the AngelesLink project.

Safety is the primary consideration for

AngelesLink starting from the planning and engineering design that Katrina spoke of, that whole process, and through the execution of constructing and testing and long term operation maintenance.

That safety focus is founded on our four pillars, which is our public, our employees, our infrastructure, and our contractors. We understand hydrogen is the lightest element in the universe and the smallest molecule with the widest flammability range. Therefore, we plan to incorporate hydrogen safety requirements, codes and standards to utilize hydrogen compatible materials, implement compatible welding specifications and incorporate the latest construction techniques to mitigate potential material and equipment failures.

When considering operation and maintenance activities, we plan to enhance our well established leak abatement program and procedures to apply for towards our hydrogen activities and for regular maintenance and compliance with all safety regulations, including leak detection, monitoring and conducting regularly scheduled leakage surveys.

Design considerations such as minimizing the pipeline changes in the direction across the fault zone or utilizing advanced monitoring technologies and applying effective communication plans mitigates the risk associated with natural disasters or external events like Ernie mentioned, such as third-party damages.

We would implement education and training for hydrogen, which is very essential, along with a well developed public awareness program to mitigate safety issues resulting from any employees, contractors, first responders, or the public responding or reacting to situations in a suitable manner.

These safety considerations that are highlighted on this slide for SoCalGas are top of mind every day and ingrained in our day-to-day activities. How we mitigate these considerations today for our natural gas infrastructure would be similar to how we mitigate risk for hydrogen infrastructure.

There are numerous existing codes and specifications and standards, and regulatory requirements are applicable to transporting gas by pipeline. SoCalGas is very familiar with and actively implements many of these codes and standards in connection with this existing natural gas transportation system.

Certain codes and standards and best practices, including the pipeline and Hazardous Materials Administration regulations equally apply to the transportation of hydrogen as well.

The building blocks of the safety framework are illustrated here. This simple triangle outlines that as far as PHMSA is concerned -- I know that was mentioned -- that's the foundation associated with the federal regulations. The orange represents the state regulations. And the gray and the green represents the industry codes and standards associated with hydrogen.

Why should all these regulations, codes, and standards matter? This represents the due diligence that is necessary to identify the codes and standards and best practices that may be applicable to AngelesLink and to support safely designing, constructing, operating, and maintaining hydrogen infrastructure.

I spoke about the federal regulations such as the pipeline Hazardous Materials and

Safety Administration as being one of the main components for a solid foundation for safety requirements when it comes to transmission pipeline design and construction considerations.

The American Society of Mechanical Engineers, specifically 31.12, is also a guiding standard for hydrogen facilities that will require pipe material and welding specifications and other typical construction activities specific to hydrogen.

Existing SoCalGas natural gas operations and maintenance procedures provide a basis for evaluating hydrogen specific requirements. It has been identified that many of these R and M tasks will be structured similarly for hydrogen as they are for natural gas.

This means that leak detection equipment, which can be either permanently fixed or portable -- I have some demonstration or demo tools. This is actually a real H2 sensor that will be utilized as personal production equipment.

Even aerial equipment, such as drones, can be utilized and are available for hydrogen detection. Inline inspections, which I forgot to put in my plug, we have a pig associated with our inline inspections where we assess the integrity of our pipelines. Feel free to check out the demo and ask any questions.

Through those use of those smart pigs, we help to identify the pipeline integrity issues that could result in pipeline failures. We already do this and know for our inline inspections -- I'm sorry -- for our inline inspection of hydrogen pipelines that they are possible and they exist today. There are already hydrogen pipeline operators that pig or inspect their pipelines on a day-to-day basis.

There have been several studies related to the odorization of hydrogen. Once the study performed by DNV and a certified and licensed company where they essentially had a panel that was exposed to different samples of odorant, and several questions were asked regarding the odor and the familiarity of the smell.

The results of the study concluded that the mixtures of natural gas and hydrogen and pure hydrogen can be sufficiently odorized with existing odorants. Per the studies and discussions conducted, the odorant knows as THT, TetraHydroThiophene, has been identified to be compatible with a pure hydrogen system. Generally, odorization of a hundred percent hydrogen gas appears to be achievable.

Due to there already being miles of existing hydrogen pipeline being constructed and operated daily and for the past few decades, there are many existing requirements related to hydrogen and pure hydrogen operational activities that are managed safely today.

SoCalGas existing public awareness program helps protect public safety and property through improved public awareness and then compliance with federal regulations, specifically 49 CFR, 192.616.

The public awareness actually is where the American Petroleum Institute 1162 is incorporated by reference into the PHMSA regulation, and that is an industry standard that provides guidance and recommendations to pipeline operators for the development and implementation of enhanced public awareness programs.

What this means is our public awareness plan is developed to reach the audience you see listed here on the slide. We share information about these established programs that are outlined, and we communicate the information in many ways with the intention to enhance safety through increased public awareness and knowledge, reduce third-party damages, and provide better understanding of pipeline emergency response.

API 1162 does not distinguish between natural gas and hydrogen gas. Therefore, the content of our public awareness program would be modified when referring to a hydrogen pipeline versus a natural gas pipeline.

So to give you a little bit more example of our public awareness program, this slide is an example of the community brochure that is mailed out to properties within a thousand feet of a transmission pipeline. This is to inform and educate about the prevention and recognition of gas pipeline emergencies.

This type of procedure is used to educate customers, affected public, permit public officials and municipal staff and persons engaged in excavation-related activities.

The specific details on what information is conveyed and the product descriptions would differ depending on the type of gas that is being transported. An example of a key difference is the use of pipeline markers along a pipeline route. Again, American Petroleum index -- sorry - Institute 1162 has prescriptive language for the, use, size, lettering, and market information.

The existing SoCalGas line markers indicate natural gases being transported through the pipeline; therefore, for a hundred percent clean renewable hydrogen pipeline. SoCalGas would create line markers to indicate hydrogen gases being transported through the pipeline.

As you can see in the slide, there is representation of the different colors associated with utilities that they use for their pipeline markers. I have a pipeline marker here today just to show you as far as representation of the contact information is bilingual to make sure that the language is appropriate for the communities that the communication is for. And, ideally, it would be in compliance with the regulations and would be associated with communicating that for a hydrogen pipeline.

A review of SoCalGas standards and specification sheets identify potential updates and new processes to be created with an introduction of 100 percent clean renewable hydrogen system. This has been a big component of our safety study and our evaluation because it's key that we assess where there are potential gaps where we would need to transition our procedures that are associated with natural gas and how that would correlate to a hydrogen infrastructure.

Through our ongoing collaboration with the Center for Hydrogen Safety, we have been referencing the hydrogen tools portal for listings of incidents and lessons learned, which involve pressure-release devices, piping incidents, compression equipment, to learn and potentially incorporate that within our standards as well.

Furthermore, we've enlisted the Hydrogen Safety Panel's expertise to review our AngelesLink safety study. There are safety standards, specifications, and our protocols are the building blocks of our company, and identifying the gaps through this evaluation that we're conducting early on in this process will enable us to be proactive and efficient in preparing and planning for the next steps of the project.

In summary, the safety study

preliminary findings support what PHMSA has communicated and what many other studies point to, and that is that pipelines are one of the safest ways to transport energy products. They identify safety requirements ranging from the material selection and pipeline design to monitoring emergency response protocols, which we'll talk about a little bit further, form a comprehensive framework to mitigate risk associated with hydrogen transportation.

SoCalGas has an existing framework that we plan to build upon to include 100 percent hydrogen transport to ensure application of our safety requirements.

We look forward to hearing more of your feedback. I will pass the baton on to our Director of Emergency Response and Strategy, Larry Andrews.

LARRY ANDREWS: Great. As Chanice said, my name is Larry Andrews. I'm the Director of Emergency Management for SoCalGas. And I'm going to walk you through three slides that kind of outline where we've gone for SoCalGas and the emergency management world, kind of how we're leveraging data and technology to be more proactive and less reactive and then how we're then taking that information from across all enterprises and how we're communicating that to the pubic, because at the end of the day, what really resonates with key response is having solid communications with our public partners so that information will be shared with the public.

So with that, before I get into it, I understand there's a lot of different ways we can respond to emergencies. Relative for us, we do follow our foundation is driven by FEMA, the Federal Response Management Agency, as well as NIMS, which is the National Incident Management System, and what we use is we use the incident command structure, also known as ICS.

Generally speaking, the framework on a response kind of covers four key areas, which is mitigation, preparedness response, and recovery. The slide I have that represents here is kind of some evolutions in which we've done to evolve how we look at emergency management response.

As we are transitioning our energy, we are also transitioning on how we respond, and really we're looking at better ways to integrate our operational group so we can better coordinate to share information internally so that internal information becomes better for our public partners so we can collectively come together, respond, and support the public.

A couple of the key areas I really want to kind of point out is really looking at the prediction and the detection and learning. So one thing that's been really great about advancing technology, we're able to analyze data to make better decisionmaking to understand things before they happen.

And as a result of that, that allows us to respond much quicker. It allows us to get our operating folks out in the field quicker to understand the potential risks and make decisions. And so, you know, the question is, well, how is that any different than what you've been doing before?

In the three -- the four areas that I'll show you kind of outlines that, and this is all going to centralize into location. The company has made a significant investment in our facilities. And on the next slide, you'll kind of see; this picture here is a representation of what our new EOC center will look like, and where that really becomes important is, you know, we have three primary areas in the past where we coordinate, which is our customer contact center. That's where our customers can report any concerns. They might be smelling gas. And then they'll then defer that to our dispatch group, who will deploy resources.

Second is our dispatch organization where not only do they deploy resources, but they take all the incoming calls from first responders, so we have dedicated phone number for first responder. It's a nonpublic phone number that police and fire can call when they are needing our services.

And then we have our system operator, which is looking and monitoring the system for any potential anomalies. And when they see things going out of specifications, they'll reach out to Ernie's team and other operating groups to deploy out there to assess what's going on to determine if there's anything going on.

The one, the last item, the watch desk is the one I want to point out. That's a significant investment from the company to represent the drive where we're going with safety and operationalizing emergency management. That's a group that's under my organization that is 24/7. They're a group looking for potential risks to our service territory.

And what I mean by that is whether it's pending wildfires, recent weather events; anything that could potentially be a problem, they're looking and analyzing that from key data points, whether that's stuff from dispatch, the contact center, or the system operator or things that are pending on social media.

We have algorithms now that we're looking at that we can start to investigate and see if there's a potential risk, and then we'll reach out to operations or one of the other three components to see if there's some validity in that and do we need to go out and respond?

As a result of this watch desk that we've really evolved, there's been a couple instances where we've seen hillside challenges with the recent rain. And as a result of that, we were actually able to reach out to our local districts because we saw stuff on the news where, hey, three houses might be sliding down this hill, and we don't have a call yet because there's no utility impact yet. But why are we waiting for those house to fall? Why don't we proactively go out there? And we did.

We proactively reached out to our district. They met with the local first responders, and they were able to make some decisions in the isolated service to those homes. And as a result of that, there was no impact to the community. There was no need to then go into full-fledged response mode, so really looking at how we mitigate that risk.

And then lastly, I'll kind of share this, is through these efforts, you know, we are also -- as Chanice mentioned, we do have a very substantial public awareness, which is part of our first-responder education. So we do meet with the first responder, police and fire annually, and we share best practices, not just about pipeline, not just about commodity, but also about any other emerging challenges they might be having.

So that could be anywhere from, you know, cars crashing into homes, right? It's a big thing right now because of distracted driving. You know, and then we share that information to best educate them, as well as seeing the things that they're seeing, so it best educates us, and we can share that with our operating groups.

And then our county, EOC, we're really being proactive in working with them more extensively because we really want to make sure that that information that we're sharing is the right information because the last thing we want to do is send out conflicting information to the public. That creates concerns, so we really want to focus on that. We've done a really good job.

We've had -- you know, obviously, again, we've had significant rainstorms. We've been integrated with Ventura County, L.A. County, San Bernardino County, L.A., EOC, and a lot of others, too, as well, just making sure they have the most relevant information and then us identifying any potential impacts that they want to be aware of that we can be working on.

And then lastly, community outreach. We work extensively hand in hand with Frank Lopez's team with the regional public affairs to make sure that we're elected and public officials are up to speed. The challenge that we have and we'll continue to have, because there's always opportunity for improvement, is we can't beat social media.

Anybody with a You-Tube account and a cell phone can post it much faster than we are, but we are strengthening those relationships to understand so we can validate information, so that way we're sharing it with the public and trying to be more proactive.

We've done a fairly good job with our public partners reactively, but really focusing on that more, you know, preparedness and being ahead of things. So with that, just kind of wanted to run you through some of the things that we've been working on in the background that a lot of people don't see, but we're really excited about the new facility we're going to get and really having that dedicated group that brings all this information together so we can get it reported out and be helpful in those responses. So that's all I have.

CHESTER BRITT: That was a lot. Anthony, you have your card up, or is that from the last time? Oh, darn it. I thought we had it. We are ready for questions, Norm, so you can be the first one.

(Norman Pedersen is inaudible.)

LARRY ANDREWS: That is my

understanding, yes, that it would be a coordinated effort where it would be the same system operator that does the gas would do the hydrogen as well, too.

(Norman Pedersen is inaudible.)

CHESTER BRITT: We just need to turn your mic, on Norm. I don't think it's actually on. Yeah. We can hear you, but online, I don't think they can hear you. There we go.

NORMAN PEDERSEN: Norman Pedersen, SCGC.

CHESTER BRITT: And could you just repeat your question just for the court reporter, even though Larry already answered it, the first question.

NORMAN PEDERSEN: Oh, my first question was will the system operator for the hydrogen system -- the dedicated hydrogen system be the same as for the gas system? And, Larry, I think you said your understanding is yes.

KATRINA REGAN: Yes. I think there's definitely some room, as you said, for economies and, yeah, aligning. That is something that we are still looking into further to really refine and make sure that we're in compliance with everything Chanice has been working to put together within that safety study.

NORMAN PEDERSEN: Thanks, Katrina. And then, secondly, this is my introduction to the Center for Hydrogen Safety. What is the Center for Hydrogen Safety? Where is it? Who created it? What is it?

CHANICE ALLEN: There we go. So the American Institute of Chemical Engineers, that organization has framed the framework, along with the Department of Energy, to create a panel of experts, the hydrogen safety panel.

And the Center for Hydrogen Safety, just to make sure I get the right defining organization from the website, it's a global nonprofit dedicated to promoting hydrogen safety and best practices worldwide by supporting and promoting the safe handling and use of hydrogen across applications in the energy transition and providing a common communication platform with a global scope to ensure safety information, guidance, and expertise that's available to all stakeholders.

NORMAN PEDERSEN: So it's a virtual organization? It's not something like the North

American Energy Standards Board that has an office in Houston, Texas? It's -- it's --

CHANICE ALLEN: No. It's not virtual. It's founded. There is an actual organization. And the American Institute of Chemical Engineers supports that organization. And, also, there are branches associated with the Department of Energy associated with the --

NORMAN PEDERSEN: So in Washington D.C.?

CHANICE ALLEN: Yes.

NORMAN PEDERSEN: Thank you.

FRANK LOPEZ: As you can imagine, Norm, this is a topic of interest -- of national interest, right? We're not the only company that's interested in delivering hydrogen so there are other companies that are interested, and I imagine that there --

CHANICE ALLEN: We're not the only ones that -- the Center for Hydrogen and Safety is world-renowned as far as the breadth of their support and their expertise in providing guidance to the hydrogen economy as a whole.

CHESTER BRITT: Ernie, I think you have your card up.

ERNEST SHAW: Thank you, Chester. I do. Ernie Shaw, president of Utility Workers of America, Transmission and Storage, Local 483. So, yeah, I mean, you know, I got a comment and then a question to follow, but if I can kind of also shed some light on some of the safety guidelines and first responders, you know, stuff.

You know, my members are on call. We do have on-call requirements that cover, you know, 24/7, right, week to week. So if there's anything that happens and they're in the vicinity, they are ready to go within half an hour.

So the likelihood of, like I said, anything get passed up, it's just unlikely because they are always ready to work. They live for it, so -- but we do have a good on-call system that we follow that works for everybody. And, also, even when we're not on call during our regular shifts, certain catastrophes or even events that take place, like, I'll name the Castaic fire that happened a couple years ago.

It was over by the 5 freeway between what -- was it Temple -- and I forgot what -- like, you know, Hughes or Parker or whatever, right, but if you're familiar with that area --

you know, myself, I was a part of that, right, and a couple other guys that were working.

We heard that there was fire kind of in the vicinity where our lines and 25 was and 85, so right away we spread over there as fast as we could to kind of monitor it and kind of see the direction of it, where it was going, and the character of it.

And as soon as we saw, like, okay, yeah, it's creeping towards our lines, that's when we kind of sounded the alarm, and everybody kind of went onboard, right, and was kind of prepared for that as far as the other municipalities as well that were affected and so on and so forth.

And throughout the night, right, it was a good thing we were on -- you know, working and stuff like that because, you know, a leak had occurred, and we were there to kind of remedy and fix it and be onsite and be ready and available for that.

So, like I said, we're constantly vigilant, there, ready. And even mudslides that occur after the rains, we do storm patrol subsequently, you know, during and after just to make sure that there's nothing funky going on in the hills and stuff like that and our right of ways ans where we might be affected, so just something to kind of, like, shed some light and kind of add some kind of, like, security to.

We're all in good hands out there to the extent of Local 483. Just want to say that. And even, like, on the internal side, right, of our storage operations, our storage field, we have our operators that are on shift rotating 12-hour shifts.

So anything that goes on with any alarms or anything with the equipment or any of the wells, I mean, they're there ready to remedy and be onsite, so just something to think about.

And I guess my question that I had is I saw on your first slide with all the little pyramid of everything kind of dropping down, which is pretty cool, I didn't see it on there, and maybe I'm not too familiar with codes and, you know, everything else, but will PHMSA's Mega Rule be in conjunction with that ASME 31.12, or is that somewhere in the middle there that I'm not seeing with the CFR and stuff like that?

CHANICE ALLEN: The Mega Rule 31.12 -- so AMSE 31.12 is not incorporated by reference into the PHMSA regulation; however, that's how we see it in the industry of best practice that will still apply to AngelesLink. The Mega Rule still applies in general for pipeline infrastructure.

CHESTER BRITT: Thank you. Charley Wilson.

CHARLEY WILSON: Question for Larry. For fear of, you know, standing in front of lunch, but also obvious, you sort of touched on it a little bit in your comments, but to assure the pubic, right, of appropriate safety measures and appropriate response, you talked a little bit about the forecasting and repositioning and anticipation of what could happen based on a variety of data points.

How frequently today do you pre-open your EOC, and do you see that as becoming sort of a regular occurrence based upon data points, particularly adding something like this to the portfolio?

LARRY ANDREWS: Appreciate the question. Good question. It depends on the significance of it, right. So, obviously, as the framework is the complexity event. So as it becomes more complex, we have no -- we are more conservative in opening our EOC and from the perspective of at least monitor mode because it signifies, hey, we got enough going on here where maybe it's not your hair's on fire, right? But there's enough going on that we could end up that in a day, two days, three days.

And I keep touching back on the storms, but that's a perfect example. You know, a lot of our counties and EOC's were activated as a result of that. Some of them were able to deactivate.

One of the things, again, we're continuing to learn, well, you know, we're still evaluating stuff, so there's land movement, so that could happen a couple days from now, even though -- because the land is really saturated. So we chose to keep our EOC activated at monitor mode because we thought it was the prudent thing to do because it does -- as Ernie mentioned, we have a lot -- we have a very robust on-call system.

And so that signifies for folks, like, hey, we still got some activity going on. Be on the lookout and be ready should you get that phone call. And really what's, you know, I want people to take away from this is it doesn't matter what commodity we're delivering. Those practices stay the same.

Now, we might need to incrementally adjust some of our tactics on our policies and procedures because of the commodity, but at the end of the day, we are very set to -- through this evolution of how we look at emergency management, we're in position to accept the transition and energy as well too. That's the important part. So hopefully that answers the question.

CHESTER BRITT: All right. I don't see anyone online. Would anyone online like to ask a question? Well, having seen none, I think we are getting to the point where it's lunchtime. So it's about ten after, five after 12:00. I think we're going to reconvene at 12:45.

So for you who are in person, I think lunch is outside that door. Oh, should we do 12:30? All right. So there's a consensus we're going to do 12:30. So if you're online, please reconvene at 12:30, and we'll get started then. If you're in person, please grab your food, and we'll start the second half of our presentation after lunch. Thank you so much.

(Whereupon, a lunch recess was held.)

CHESTER BRITT: We're also going to have Chanice give that part of the presentation, so I'm going to turn it over to her, and she can begin that presentation. Do you have the clicker, Chanice? If not, we need to get you the clicker. Sounds like my house. It's always missing at my house, too.

CHANICE ALLEN: All right. Good afternoon. Hopefully everyone's bellies are full from lunch. And so hopefully then you won't fall asleep on me. So I'll try to make this painless. We'll be talking today about the workforce and planning and training evaluation study, but I would like to add that the importance of preparing our workforce for the clean energy transition has really resonated with me because I grew up with my dad actually working hard at his trade job starting off as an apprentice at a steel mill. He also was a station laborer at a nuclear power plant, and he completed his career as a journeyman electrician.

And so when I say "career," because learning a trade can lead to a long fulfilling career path that not only supports families but communities, that's what I've been keeping in mind as I've been evaluating and working through the preliminary workforce evaluation study.

The priority is to focus on what action needs to take place to support the existing workforce and emerging workforce and the hydrogen skills and training necessary to adapt to the energy transition so that everyone has the opportunity to be able to have a fulfilling career.

The objective of the workforce planning and training evaluation study is to evaluate construction practices and operations and maintenance protocols as it applies to a hundred percent clean renewable hydrogen infrastructure and workforce needs for the AngelesLink project.

Federal requirements from the pipeline and Hazards Materials Safety Administration, as well as state requirements from the California Public Utilities Commission, provides a basis for establishing the training programs and workforce planning.

As mentioned for the safety study, applying those regulatory drivers and best practices as the basis and evaluating our eternal standards, protocols, and our specifications enables us to identify potential updates to operating tasks and, if appropriate, job classifications that would be needed.

Additionally, we are assessing our existing SoCalGas facilities and technologies in comparison to what that may look like for hydrogen infrastructure to see where they potentially may need to be modifications.

How do these changes translate into action for us in preparing the workforce? As the result of the pipeline routing and design study that Katrina had spoke to earlier, as those results are available and then the evaluation of the potential changes associated with our procedures and our facilities and technology, even our human resources changes are completed, then the planning, which is the process of analyzing and forecasting workforce supply and demand and identifying any opportunities for updates will be our next steps.

This information will help develop the workforce in stages to educate and train individuals to meet the needs of the job requirements and also structure how we safely comply with planning, constructing, maintaining a hydrogen infrastructure.

As mentioned in the safety study, the review of company standard specifications and protocols to identify updates are needed was based on their regulations and codes and standards that establishes the necessary tasks to meet the requirements for hydrogen pipeline safety and the associated training programs.

This can be utilized for our workforce planning. For unskilled workforce, whether it's a field position or technical staff position, identifying skill requirements for hydrogen infrastructure is necessary and allows for comparison with existing skill sets. And by comparing these skill sets, we allow SoCalGas to properly plan to address any potential gaps.

For our workers in the workforce overall, estimating the number of workers required at different stages of construction and to support our routine operation and maintenance is important to structure the appropriate training and accommodate the growing demand for these hydrogen jobs.

And then for the workforce that need to be prepared, and that would apply to what's appropriate for the tools that would be needed to be used on hydrogen assets and the regulatory requirements and best practices that drive the pipeline operator qualifications, which, in turn, translates to specific training necessary for operations personnel.

These considerations are top of mind, not only for SoCalGas, but actually everyone involved in the energy transition. It's critical to understand and anticipate the skills needed for the hydrogen and safety -- hydrogen industry overall and to plan a path towards a hydrogen-ready workforce.

The methodology for resource planning for both constructing AngelesLink project and operating the infrastructure will consist of utilizing business data that measures and describes work volumes, work activities, and labor costs in both time and money.

The resource planning will be focused primarily on the pipeline, which, of course, is needed to transport the gas, and the corporation stations, which are needed to maintain the flow and pressure of gas.

As the pipeline configuration is

completed in the location of third party hydrogen production sites and facility locations are developed, we will address the effective use and scheduling of internal and external resources to build out these facilities.

Staffing models will be utilized and be compared to our existing gas system, and utilizing standard construction project resourcing data will form what the workforce staging may look like, and that includes providing an estimate of jobs that would be created for AngelesLink.

Forecasting how any workers are needed for a construction project, how many employees our organization needs to maintain the new infrastructure, where it needs them and what roles they will fill is a critical step in creating training programs to onboard clean energy workers.

Essentially, this evaluation would also help drive more accurate external recruitment efforts to ensure that we have a diverse workforce. To jump start the workforce planning and developing process, knowledge sharing would be a key factor. We know that sharing information is essential in closing the knowledge gap between the hydrogen industry, the government, unions, and especially our communities.

We see sharing information at three levels; awareness, education, and training, awareness at a very high level, providing general facts to keep people informed, education, providing some organized curriculum to provide people with knowledge for comprehension and training -- specific training focused on teaching skill sets.

As part of our study, we will be identifying sources that we'll be able to provide these level of information to extend these avenues for our workforce internally and externally and as well as for the communities.

Data from these preliminary routing and design study will help determine what operational standards and operator qualifications may be necessary not only to build out, but operate and maintain this new infrastructure.

This information, in return, will set the stage for proactive planning to build out the workforce. And how will we be promoting these jobs? We will be providing that awareness, education, and training in a great -- in a manner that will start to drive interest and to inform people, such as the CBO and TAG meetings so they are informed of these opportunities.

This will attract new people but also provide opportunities for the existing oil and gas workers that already have skills that transfer naturally to renewable energy positions.

Essentially matching the skill sets today and upskilling where necessary for new clean renewable hydrogen jobs in the future is our primary focus as we're building the hydrogen job pathways to foster clean energy growth.

I would like to share how SoCalGas is supporting and promoting education and training programs to equip existing and new workers with the necessary skills to fulfill a wide range of jobs in the renewable hydrogen economy.

SoCalGas has been eagerly participating, collaborating, and initiating the development and progression for education and training programs that will address our industry specific needs and be tailored to building job pathways.

Not only do we continue to leverage our existing workforce partnerships to identify opportunities in the future to integrate hydrogen curriculum and skills training, but actually lead by example by establishing new partnerships specific to hydrogen development.

Our partnership with DNV and Enbridge is within the industry, and within that partnership we have initiated a joint industry project to help develop a conceptual hydrogen certification pathway to educate a range of personnel.

So this will be all job positions classifications across from whether it's a project manager, a pipeline tech, to an environmental analyst or a safety professional. For H2EDGE, SoCalGas has joined the Hydrogen Education for Decarbonized Global Economy. That's what H2EDGE stands for.

It is an initiative to advance emerging hydrogen workforce by developing newly trained personnel and enabling the existing workforce to migrate into the hydrogen field. This coordination will allow us to develop workforce readiness and information around training, education, and recruitment of qualify people.

AltaSea, which many of you may remember, that was one of our first PAGs and CBO venues and events, and we can continue to have a partnership with AltaSea where we're collaborating with them to develop certificate programs for the local community colleges in order to coordinate learning engagement activities associates with hydrogen and also incorporate our elementary and high school students as well.

SoCalGas is committed to meeting our community needs, and our PAG and CBO meetings are a reflection of those opportunities for us to listen, to understand, and collaborate with everyone in supporting the development and employment of our local workers for future in the hydrogen industry for these next steps as far as continuing development and collaborating with ensuring our training and our workforce are being able to receive and have those opportunities for those new skill sets and upscaling workforce.

I look forward to hearing your feedback where there may be other potential opportunities. Thank you.

KATRINA REGAN: Thank you.

CHESTER BRITT: Norm, I love it. We always need somebody to go first, and you're it. So thank you.

NORMAN PEDERSON: Thank you, Chester. Norman Pederson, SCGC. Chanice, I'm sensing kind of a disconnect between the discussion we had before lunch and this discussion. The discussion we had before lunch was about safety, and you went through the PHMSA regulations. And, you know, we heard from Larry about how, you know, gas operations will be handling -- current gas operation handling the new hydrogen pipeline, the dedicated hydrogen pipeline.

But now when you're going through workforce, you're making it sound like, oh, a very different skill set is going to be required of the people who are going to be working on the hydrogen pipeline.

I don't know. It may be a question for Ernie. Aren't you guys ready to go?

CHANICE ALLEN: Ernie, before you speak, I can go ahead and add -- let me make sure I clarify. No, that is not the case. So if the perception was that it was going to be completely new skill set that needs to be -- we're enhancing the skill sets that we have already established through the framework for our regulatory requirements for PHMSA, which already is associated with our training requirements and operator qualifications.

So that's what I'm elaborating on is that we'll be enhancing those skill sets to customize it to the specific needs of hydrogen because it does have different properties than natural gas that we have to take into account.

NORMAN PEDERSEN: I guess I'm having trouble imagining what those are.

CHANICE ALLEN: Maybe Ernie can clarify.

ERNESTO SHAW: Ernie Shaw, President of Utility Workers, Local 483, Transmission and Storage. So, yeah, I can kind of see, like, maybe where this is going on the presentation. And thank you for that.

The answer to your question is yes, hell, yes, my members are ready to go right now today, but, you know, perhaps it might be, like, something along the lines of something we don't know, like, we want to enhance with our welding procedures, right, you know -- and even, like, the some of the throughput that goes in and out, how to adjust that, right, some of my instrument specialists just to make sure that if it's too much, that it might, for lack of a better term, degrade the pipe even more. We don't want to do that.

So I definitely see that as an advantage to say, like, okay, what do we know and what do we don't know and how can we capitalize on that. So -- and if there's anything we don't know, yeah, let's take advantage and work together to, you know, keep everything great and safe and moving forward. Thank you again.

NORMAN PEDERSEN: Thank you.

CHESTER BRITT: Thank you, Norm. Anyone else have any thoughts about workforce training? I would encourage you if you're online and you haven't spoken to -- this is your opportunity. There's not a waiting line. Looking for your input.

I mean, I guess one of the thoughts that occurs to me just as a facilitator is that as much as we would like to say hydrogen is a known commodity and it's been around for a long time, I think we can also say that it's an emerging industry, and certainly transmitting it through a pipeline of this size would be kind of a first; right?

So I think that's where, you know, we need to look at, obviously, the protocols that are in place now, but we also need to understand and acknowledge that there's going to be new things with hydrogen that are not the same as natural gas that have to be identified and addressed.

NORMAN PEDERSEN: We have hydrogen -- this is Norman Pedersen, SCGC. We have hydrogen pipelines right now. The air products are pipelines. For example, I don't see Lorraine Paskett's name up on the list, but if Lorraine were here, she'd probably be telling us, yeah, we have operating pipelines, and it's well known operating hydrogen pipelines, well known the ways in which the same.

The ways in which they are different from gas pipelines -- and I guess I was asking you, Chanice, about it, what more would be needed for the workforce? I was thinking about well, what's been the experience with the pipelines that we have already in operation in the U.S. and around the world.

KATRINA REGAN: Thank you, Norm. I think that she laid it out really well. There's a lot of synergy there between the two, and it's a matter of making sure that there are codes and standards as they apply specifically to hydrogen are reflected in the training and the skills to make sure that those operators and workers on the asset themselves are able to distinguish and act in a way that's appropriate for the exact fuel that is being moved, so it's very slight nuance there, but it is worth looking into.

ERNESTO SHAW: Once again, President, Ernie Shaw, Utility Workers of America, Local 483, Transmission and Storage. So another thing that I want to kind of point out as well with some of these workforce and enhancements and stuff like that -- I know we really didn't get too much into it, but, like, some of the pigging that you see there right on the table right there, that's a foam pig. Do you guys know what that is or not?

Don't confuse that with a Nerf ball, right? It's not light by any means. It doesn't feel, like, foamy. It's just material, and it's used to disengage some properties inside the pipeline, kind of like a brush, right, clean it as the first initial run.

But, you know, like, how does hydrogen pick their pipelines; right, and maintain it and look for anomalies, any obscursions (sic) to excavate and repair and/or maintain, and maybe those are different from natural gas; right?

And I'm eager to learn that method, and that way, you know, we'll be ready to kind of run our own show when we're pigging stuff and, you know, keeping our pipeline safe and my workforce working, right, clean union jobs, as we say.

So there's that aspect. And then another thing I wanted to mention -- and I don't know, maybe this might tie in or not, but this is actually following up with the -- I think her name is Sara Gersen with Sierra Club.

She had mentioned disadvantaged communities, right? Now, not to say that this pipeline comes in and -- in the disadvantaged community, right, if you have direct flow of workforce coming through, but it would be an opportunity for those that are qualified to be able to, you know, apply and throw their name in the hat and learn a new skill and trade to be able to be a part of something, you know, great and huge, right, moving forward.

Case in point, I'll say it again. Like, on the map, it showed, I think, some highlighted areas, you know, Blythe, right, to the port. That's where I grew up, Blythe, California, whoop, whoop. Don't go there. It's not worth it. You'll get stuck. You'll never leave.

But, you know, some of us folks that work there now currently in the compressor station, I grew up with, I went to high school with, and, you know, I kind of know.

So, for me, I say 43 encourages that, right, for disadvantaged communities to be able to take part in the potential to have that opportunity to have a job and learn something greater and be a part of that and also be a stark alternative for an energy resource.

You know, like, my grandmother lives out there by herself. I mean, if she was all electric, I mean, she can't cook a turkey in the oven like that, right, so she has something to supplement that with and cool, right? So just something to think about, right, but just wanted to mention that. That's all I got. Thank you.

CHESTER BRITT: Thank you. Anyone else? All right. Well, I don't see anyone online as well, so we're going to go ahead and keep going on our agenda then. The next item is to introduce the community benefits plan and what we're doing to develop that.

Frank, I think this is you. You need the clicker.

FRANK LOPEZ: Frank Lopez, SoCalGas. So we're not presenting today on our community benefits plan, but we wanted to kind of lay some of the groundwork of how we're approaching community benefits and start to see the conversation for a future presentation.

Before we get into it, I do want to turn it over to Emily, though, for the first slide just to kind of give a quick overview. Okay. Did we take it out? Okay. Let me get to the slide. Sorry. Okay then. We'll skip that. Back to me.

So as can you imagine, we still haven't identified a route, right. We have several routes. And once we do get to a route, obviously, we're going to want to engage the communities along those route, as Theo mentioned, right, to make sure that we have robust community input and engagement with the process on, you know, the type of community benefits that they would like to see.

We've identified these topics here on the right through our CBO process and through other stakeholder input on the issues that are important to them. We're looking at developing a community benefits plan with kind of three pillars. One is obviously the Justice 40 Initiative. This is an executive order, I think, from the White House that requires that disadvantaged communities benefit from 40 percent of the benefits from these types of projects. So that's something that we'll consider.

And then as ARCHES -- I think ARCHES has also released a community benefits plan as well, and they require that 1 percent of the total cost of projects be allocated for community benefits. And then, obviously, we're going to love to get community input from those communities along those corridors. So those are the kind of three pillars that will inform our community benefits plan.

And then just in terms of the process, you know, this is a really large infrastructure project that will traverse multiple communities. And even when we get down to a route, it will be hard to make sure that we get community input from all of the stakeholders along those corridors and other stakeholders that have a vested interest in the outcome of that project.

So I wanted to just kind of float this idea to those who are interested in this topic to start thinking about, you know, what are the best practices for infrastructure providers who do this? I'm assuming in the water, this is probably a lot of good practices on the water system as well, right? Large pipelines that traverse multiple communities.

How do you ensure adequate representation in that process, right? What are some best practices for community benefits? What are some of the things that we should be avoiding, strategies that have worked very well, and just kind of open to creative thinking on how to approach this work given the framework that we laid out.

So that's all I have there. I'm happy to take any questions. Obviously, we're going to have a presentation on this at a subsequent meeting, but I just kind of wanted to share with you our approach and thinking on community benefits for that presentation.

Emily, anything else you want to add to this?

EMILY GRANT: No. I think you covered it, Frank. Just that we'll be tackling this with the CBOSG group in a little bit more -- a little more in depth with them, as obviously they would be the ones to speak to what works for community benefits, and so that will be a large portion of our meeting with them, going over the process by which they want to see that happen.

NORMAN PEDERSEN: Norman Pedersen, SCGC. What are community benefits? What are you talking about when you talk about community benefits? Like, a new recreation center? What are you talking about?

EMILY GRANT: It could be beautification in the area, in which we do construction projects. It could be labor agreements for workforce. It could be a variety of different things. So those are the topics that we want to approach because, really, we see it as a partnership with our current community base stakeholders, so we want to hear from them rather than us telling them what they think they should be considering.

We want to hear from them what's important to them in those communities. And one thing we've heard, too, from ARCHES in particular is that, you know, every area, every city, every town is different, and so those benefits are going to change depending on the needs of that local community. So we're going to do our best to really engage stakeholders at the local level to find out what it is they're looking for for the community.

FRANK LOPEZ: I think that's one area that we could also benefit from input, right? What are the categories and types of community benefits? Emily mentioned some. It could be workforce development. It could be investment in the local businesses, doing workforce training, right? Making sure that on our procurement side, we're going from small business -- investing that money in small businesses. So there are a wide range of community benefits and obviously helping inform by the communities along those corridors, but if folks have ideas on categories and best practices on the types of community benefits and approach, we would welcome that.

EMILY GRANT: Yeah, local procurement has been a big one. I'm glad you brought that up. That's been one that the community group has referenced a couple times now. So in June, we'll break up into small groups. I think we're considering breaking them up by sector so they can take their particular areas of expertise and start to offer us exactly what you're asking for, Norm, kind of bulleted approaches that we can be taking to community benefits.

CHESTER BRITT: Dennis, you had your card up.

DENNIS BURKE: Yeah. This goes back to the workers in training. I believe right now -- I could be wrong -- that city of Long Beach, a lot of the requirements for our construction guys are provided through SoCalGas. With hydrogen being more specialized or probably more training needed, are you guys planning on keeping Long Beach in the loop if these training programs do become available or --

CHANICE ALLEN: Yes. As far as our existing partnerships and collaborations that we have, that will continue to be ongoing and incorporated any new hydrogen training skill sets or curriculum.

FRANK LOPEZ: And, Chanice, I think you mentioned earlier about industry partnerships, and

I think that's one of the reasons why, right? So that as we disseminate information to the industry for benefit of other organizations and companies that are interested in the curriculum and the information. Is that correct?

CHANICE ALLEN: Yes.

FRANK LOPEZ: Thank you.

EMILY GRANT: Okay. Great. So we're going to move into next steps. So, obviously, you still have the water leakage, GHG, and NOx preliminary findings on the living library right now. So we'll be taking that feedback up until Friday, March 29th. If you have any questions about that, let us know.

As usual, you can e-mail that feedback. And writing is always best over to insignia. We'd appreciate that. We'll have the meeting materials from today posted to the living library soon. And other than that, we hope to let you know when our next meeting date is sooner rather than later, so stay tuned for that. I think that's it.

CHESTER BRITT: I think we have someone raise their hand, actually, and then we can go back to Norm. But, Theo Caretto, I think you raised your hand, sp we'll take your comment or question.

THEO CARETTO: Hi. Thanks. Theo Caretto, Communities for a Better Environment. I just -- I wanted to ask whether there's specificity on when these standards by which the community benefits plan will be developed are expected to be put together.

FRANK LOPEZ: Theo, this is Frank. Can you clarify, what do you mean by "standards"?

THEO CARETTO: So I guess you discussed that there is a community benefits plan being worked on, and it's being informed by several different sources like Justice 40 and ARCHES, as well as the CBO group, and so I'm asking when the decision on how that process will look will be finalized, when the process -- the process being the process through which community benefits plan -- the community benefits plan is arrived at.

FRANK LOPEZ: Yes, so I foresee that -- let me take a step back. So the full-blown kind of community benefits plan won't happen until later, right, until we actually have a route and proposed project, but I think what we're going to be focusing on is what is the framework, right? What is the approach and the process that we'll take? That's why we're soliciting feedback from the CBOs, right. How should we be approaching this? What are the categories of potential investments.

And also the timing, right. Like, oftentimes, sometimes community benefits are deployed when a project is ready for construction, but if you know you're going to be on a particular route, are there community benefits that can happen prior?

I think these are all the things that we're open to thinking about, our approaches as we move into subsequent phases. So I envision that that will happen as part of phase one, that initial thinking, and have at least a framework by the end of phase one on what the approach on the community benefits plan will be as we move into phase two. Does that answer your question?

THEO CARETTO: Yeah. That answers my question. I guess I just wanted to back and highlight that if organizations that are going to be subject to this plan negotiation aren't actually, I guess, act in this early stage about how the plan should work, it kind of puts them at disadvantage versus the folks who are being engaged right now, you know, these community organizations and the folks here who are not necessarily based all on the pipeline route.

FRANK LOPEZ: Yeah. Absolutely. That's why I wouldn't want to negotiate on now. At least if we have a framework, we have an idea of how to approach this going into those subsequent phases, I think we'll be in a better position. I want to wait to get to that point to start laying that groundwork.

CHESTER BRITT: Tyson, I believe your hand is raised.

TYSON SIEGELE: Hello. Tyson Siegele with Utility Consumers' Action Network. When I am thinking about community benefits, there are two things that I think about; the cost of energy and the -- and how clean the energy is, and so those are two things that I hope are kept in mind when the overall -- the overall concerns are addressed there.

In the previous meeting, I had mentioned the three pillars of clean hydrogen, and I wanted to raise that again because that really truly does provide a community benefit, and it is -- it's been studied. There are several studies that were in a link that I provided during the last meeting that showed that if the three pillars are not used, then you're going to have substantially dirtier energy than what you would with the three pillars.

Some studies show that there is -- it would be more beneficial just to continue using natural gas instead of switching over to hydrogen if the three pillars are not used.

Last meeting I was asking has SoCalGas committed to the three pillars at this point, and at that point, there was not a -- there was not a response in terms of specifically on the three pillars. I would be interested in hearing if SoCalGas has updated that position at this point.

YURI FREEDMAN: I can take that. And I'll start by saying that I know we mentioned this more than once, but it's worth reiterating the point that SoCalGas has not been planning and it's not intending to be a producer of hydrogen.

We are going to provide infrastructure that's going to enable transporting clean renewable hydrogen from production ares to the demand centers. That said, we are very well aware that the city of Los Angeles is interested in green hydrogen. And we honor and appreciate that commitment, but you also must be aware that the commission asked us to explore the broader spectrum of options, which they termed as clean renewable hydrogen, and we're happy to provide the references which exist in federal real with regards to what this entails.

I'll just leave it there because, as you know very well, the discussion about the three pillars, additionality, and time matching are continuing. The guidance from treasury is to be issued, and, again, I'll end up with what I started. We, as an infrastructure company, are committed to transport this clean renewable hydrogen from where it's going to get produced to where it's going to be needed.

TYSON SIEGELE: That makes sense. What I would request is that SoCalGas consider adopting a requirement for its infrastructure that only hydrogen that adheres to the three pillars of clean renewable hydrogen is transported.

And the reason I ask for that is -- and I think the community is interested in having lower cost energy, is interested in having cleaner energy, and neither of those things will be accomplished if the three pillars are not -- are not adopted.

YURI FREEDMAN: Appreciate the comment, Tyson. As I mentioned, we always are working under the guidelines laid out in the decision by the commission, but we appreciate your point. Thank you.

CHESTER BRITT: All right. Anyone else in person? Okay. I want to give Olga an opportunity to introduce the tour. Where is Olga? Is she here? Oh, she's outside?

Yes, Norm. We're at the end of our agenda, so --

NORMAN PEDERSEN: Okay, well --

CHESTER BRITT: You have the mic.

NORMAN PEDERSEN: Norman Pedersen, SCGC. The commission approved funding for phase one. Where does SoCalGas stand with its expenditures for phase one at this point? What do you see as -- when do you see the end of phase one occurring? And at one of the previous meetings, you said you were planning a phase two application. When will we be seeing the phase two application?

FRANK LOPEZ: In terms of our spending

on phase one, I don't have that number readily available. I'm sure that's something that we can look into, yeah, and follow up. Amy just told me we're on track for our budget, though, so we can follow up with you on that one.

On phase one ending, I think -- Katrina, what --

KATRINA REGAN: Yeah, end of Q3, early Q4, Norm. The end of Q3 or early Q4 of this year, the end.

FRANK LOPEZ: And then for phase two, for those who attended the workshop -- our last workshop where Neil spoke, he kind of gave a quick overview what we're thinking for phase two. We don't have a date yet of when we plan to file that, but we did make a commitment that when we do know more information about what that effort will entail, we would follow up and provide an opportunity for folks to be aware of that filing in advance of the filing itself.

NORMAN PEDERSEN: Is it still your intent -- Norman Pedersen, SCGC. Is it still SoCalGas's intent to file the application for phase two prior to the end of phase one so that there would be a possibility that the commission would issue a decision so that it would be a relatively seamless execution of work?

KATRINA REGAN: Yeah, and part of that, Norm, is we're trying to be in alignment with ARCHES that we spoke of earlier today and their timeline because the timeline for ARCHES is quite aggressive. They would like something -- all of their projects to be in place and constructed by 2030. And so we're trying to maintain alignment with that, as well as continue on with the phase -- the other part of phase two, the AngelesLink.

CHESTER BRITT: Any more questions, Norm?

NORMAN PEDERSEN: Is it possible for you to elaborate on that? If you move backwards from ARCHES' goal of 2030? And I take it that you mean that would be DOE's goal; correct?

KATRINA REGAN: Correct.

FRANK LOPEZ: And we don't want to get ahead of the team that's working on that, so I think what we'll do is better -- when we have more information and we're ready to present it, we'll follow up and we'll schedule an opportunity to provide this group with an update on the phase two filing.

NORM PEDERSEN: Fair enough. Thank you, Frank.

CHESTER BRITT: All right. I don't see anyone else with their hand raised online. So did Olga come in? Is she available? Okay. Olga -- I was just telling Olga I'm going to give her a chance to present. I don't think she believed me.

But Olga is one of the SoCalGas staff that has helped us facilitate the tour option today, so I just wanted to give her the opportunity to explain what the tour is and how you can participate.

(Olga gives tour explanation).

CHESTER BRITT: So thank you guys so much for attending in person. We had a really good meeting, I think, with lots of good input. Again, don't forgot there is other opportunities to give us input in between meetings. So you can always reach out to Emily and SoCalGas, and we will follow up with you, but, again, thank you so much, and have a safe trip back home.

(Whereupon, the meeting adjourned.)

REPORTER'S CERTIFICATE

STATE OF CALIFORNIA)
COUNTY OF LOS ANGELES) ss.

I, Ariela Kelley, CSR No. 13167, in and for the State of California, do hereby certify:

That I was requested to transcribe from the live videoconference of this meeting;

That said meeting was taken down by me in shorthand, and thereafter reduced to typewriting under my direction, and the same is a true, correct, and complete transcript of said proceedings;

I further certify that I am not interested in the event of the action.

Witness my hand this 13th day of March, 2024.

Ariela Kelley

Ariela Kelley, CSR 13167
Certified Shorthand
Reporter for the
State of California

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REGAL COURT REPORTING

APPENDIX 6 – CBOSG MEETING MATERIALS

CBOSG
QUARTERLY MEETING AGENDA
10:00 AM – 2:00 PM

- Arrival and Breakfast
- SoCalGas Safety Moment, Land Acknowledgement & Roll Call
- LATTC Welcome
- SoCalGas Welcome from President Maryam Brown
- Process Review and Preview of Preliminary Findings: Routing and Configuration Analysis
    - Member Discussion + Worksheet w/ Guiding Questions
- Preview of Preliminary Findings Safety & Emergency Response
    - Member Discussion + Walk the Walls Activity
- LUNCH – Thank you students of LATTC
- CBOSG Updates
- Preview of Preliminary Findings: Workforce Planning and Training Evaluation & Workforce Partnerships
    - Small Groups: Workforce Planning and Development
- Introduction to Community Benefits Plan Development
- Calendar/Next Steps/Adjourn

March 4, 2024
10:00 a.m – 2:00 p.m.

ANGELES LINK

Community Based Organization Stakeholder Group (CBOSG)

March Q1 Quarterly Meeting

Warm welcome to our participants!
We will be starting shortly after 10:00 a.m.
to make sure everyone is present in-person and online.

SoCalGas

WELCOME FROM OUR FACILITATORS

ANGELES LINK

ALMA MARQUEZ
Vice President Gov. Relations
Lee Andrews Group
CBOSG Lead

CHESTER BRITT
Executive Vice President
Arellano Associates
PAG Lead

SoCalGas

HOUSEKEEPING:

This meeting will be recorded (video and audio), and a court reporter will be transcribing the meeting. Please announce yourself before you speak

Zoom microphones are muted by the host to eliminate background noise. You will need to unmute your microphone when called on to speak. *For both in-person and on-line participants please speak directly into the microphone to ensure everyone can hear*

We encourage you to turn on your cameras so we can better engage with you

Please feel free to use the Zoom chat to provide input and ask questions throughout the meeting

If you would like to speak, please use the "Raise Hand" button at the bottom of the Zoom screen

Wireless microphones will be passed to those speakers attending in person

ANGELES LINK

SoCalGas

AGENDA

- Arrival and Continental Breakfast
- SoCalGas Safety Moment, Land Acknowledgement & Roll Call
- LATTC Welcome
- SoCalGas Welcome from President Maryam Brown
- Process Review and Preview of Preliminary Findings: Preliminary Routing/Configuration Analysis
  - Member Discussion
- Preview of Preliminary Findings: Plan for Applicable Safety Requirements
  - Activity: Walk the Walls
- Lunch
- CBOSG Updates
- Preview of Preliminary Findings: Workforce Planning and Training Evaluation
  - Activity: Breakout Session
- Introduction to Community Benefits Plan Development
- Calendar/Next Steps
- Adjourn

SoCalGas

SOCALGAS SAFETY MOMENT

ANGELES
LINK

ARMANDO TORREZ
Regulatory and Policy Manager
SoCalGas

SoCalGas

LAND ACKNOWLEDGEMENT & ROLL CALL

LOS ANGELES TRADE TECH WELCOME

ANGELES LINK

DR. MARCIA WILSON

Vice Dean of Academic Affairs

LA Trade Technical College

SoCalGas

SOCALGAS WELCOME

ANGELES LINK

MARYAM BROWN
President
SoCalGas

SoCalGas

PROCESS REVIEW AND PREVIEW OF PRELIMINARY FINDINGS: ROUTING/CONFIGURATION ANALYSIS

ANGELES LINK

KATRINA REGAN
Engineering & Technology
Development Manager

SoCalGas

Preliminary Routing & Configuration

» Phase 1 Objectives

- Consider existing pipeline rights-of-way, franchise rights, and designated federal energy corridors
- Connect identified areas of hydrogen production and demand
- Identify several preferred routing alternatives for the hydrogen system

» System Evaluation

- Overall pipeline corridors assessed based on similar geographic, environmental, constructability, and community factors
- Various production and demand locations considered

» Pipeline Corridor Evaluation

- Pipeline corridors divided into "segments" to evaluate engineering, environmental, and social criteria

ANGELES LINK

SoCalGas

Segment Evaluation – Feature Glossary

Engineering

Adverse Soil Conditions
Class Location
Existing SoCalGas Right of Way
Fault Areas
High Consequence Areas
Mainline Valve
Overhead/Underground Utilities
Physical Conflict
Pipeline Constructability
Railroad/Road Crossings
Route Length
Sloped Terrain
Trenchless Crossings

Environmental

Coastal Zones
Conservation Areas
Cultural & Tribal Resources
Endangered/Threatened Species
Floodplains
Landfills & Hazardous Waste Sites
Stream Crossings
Wetlands

Social

Disadvantaged Communities
Land Use
Military Facility/Property
NRHP Historic Locations
Pasture/Agricultural Land
Proximity to Buildings
Public & Recreational Areas
Special Circumstances

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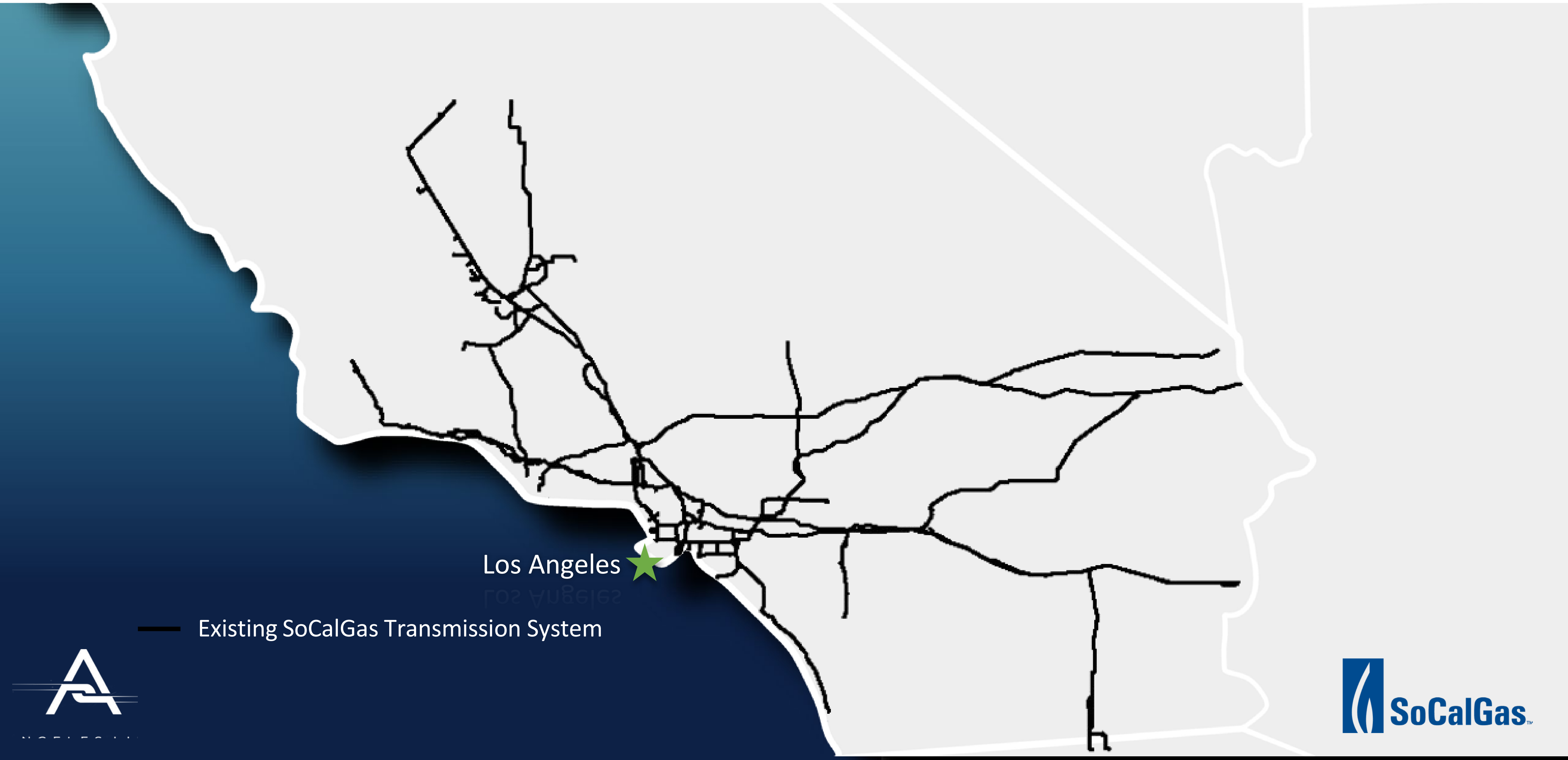
SoCalGas

Preliminary Routing Considerations

- » Federal Corridors
  - Department of Energy/BLM/Forest Service
    - – Energy Corridors on Federal Lands
  - Dept. of Energy and Dept. of Transportation
    - – Alternative Fuels Data Center
  - National Pipeline Mapping System (NPMS) by PHMSA
- » SoCalGas Existing Infrastructure
- » Alliance for Renewable Clean Hydrogen Energy Systems (ARCHES) Initiatives

Existing SoCalGas Natural Gas Transmission System



Existing SoCalGas Natural Gas Transmission System & Corridors Under Evaluation

These renderings show evaluated conceptual corridors for the Angeles Link project.

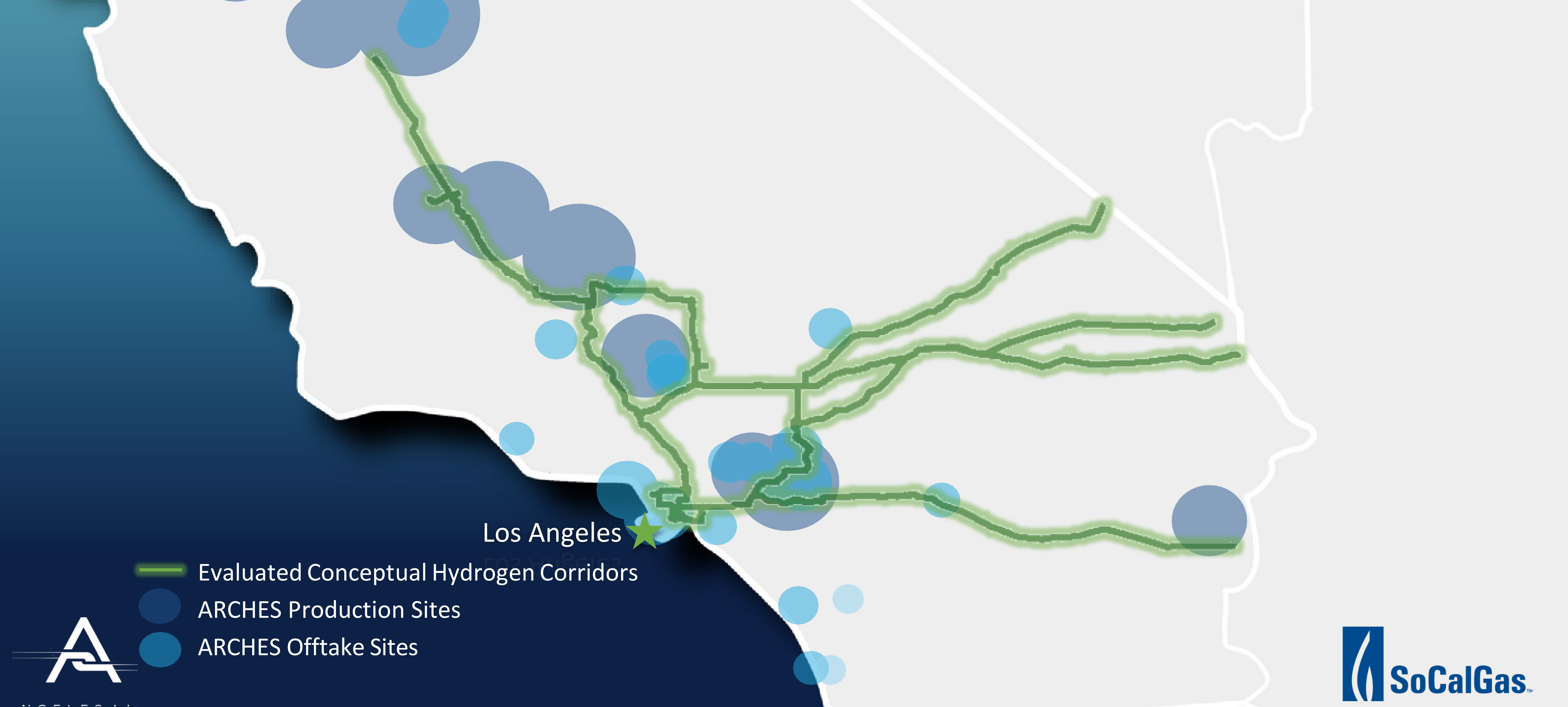
SoCalGas™

Corridors Under Evaluation

These renderings show evaluated conceptual corridors for the Angeles Link project.

Corridors Under Evaluation

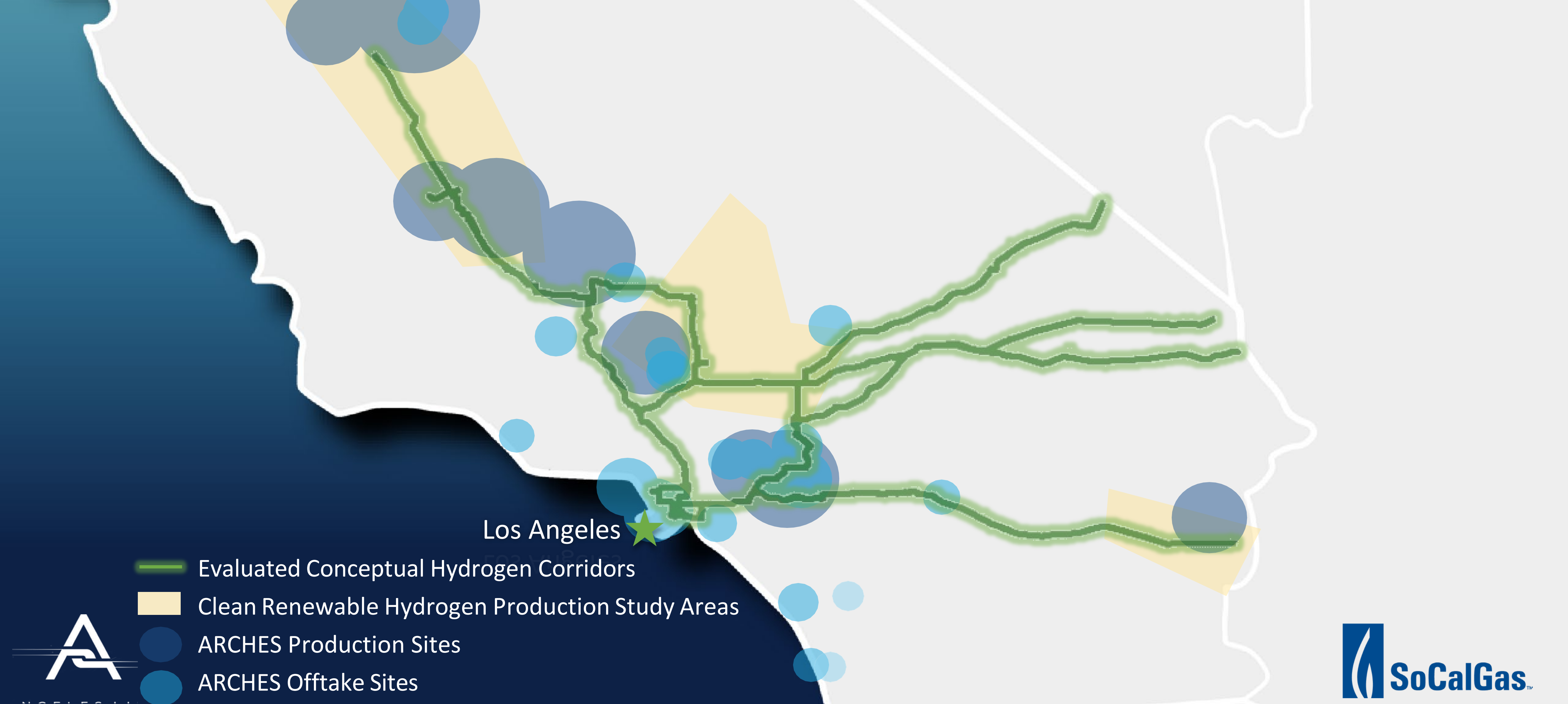
These renderings show evaluated conceptual corridors for the Angeles Link project.



ARCHES Map Derived From ARCHES Fact Sheet, October 2023

Corridors Under Evaluation

These renderings show evaluated conceptual corridors for the Angeles Link project.



ARCHES Map Derived From ARCHES Fact Sheet, October 2023

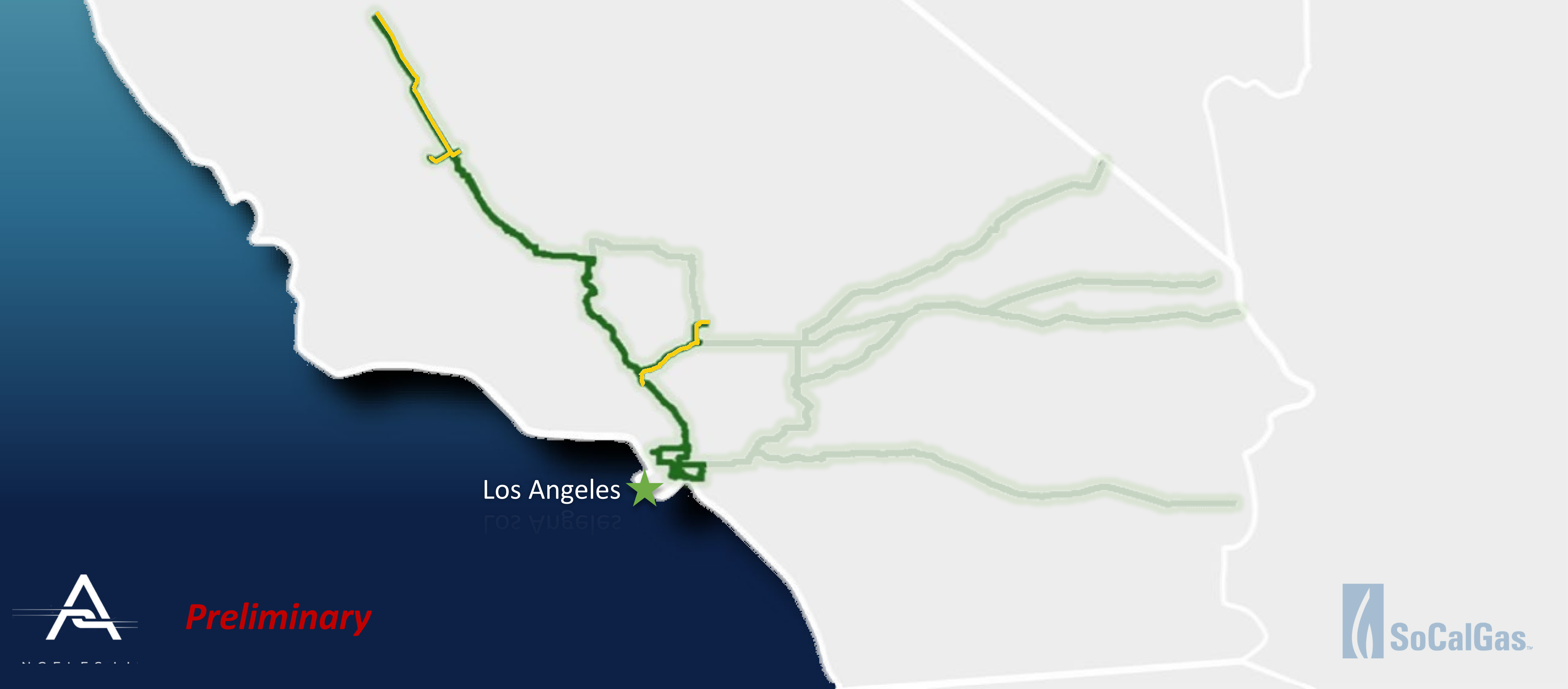
Evaluation Components

Phase 1 Approach: Evaluation of a wide range of routes and corridors that can be narrowed down to a set of preferred routes based on a variety of elements.

- Production
- Demand
- Environmental
- Project Cost
- Resiliency & Reliability
- Land Considerations (ROW/Franchise)
- Route Features (Social, Engineering, Environmental)
- Other Large-Scale California Infrastructure Projects

Conceptual Example 1 of 2

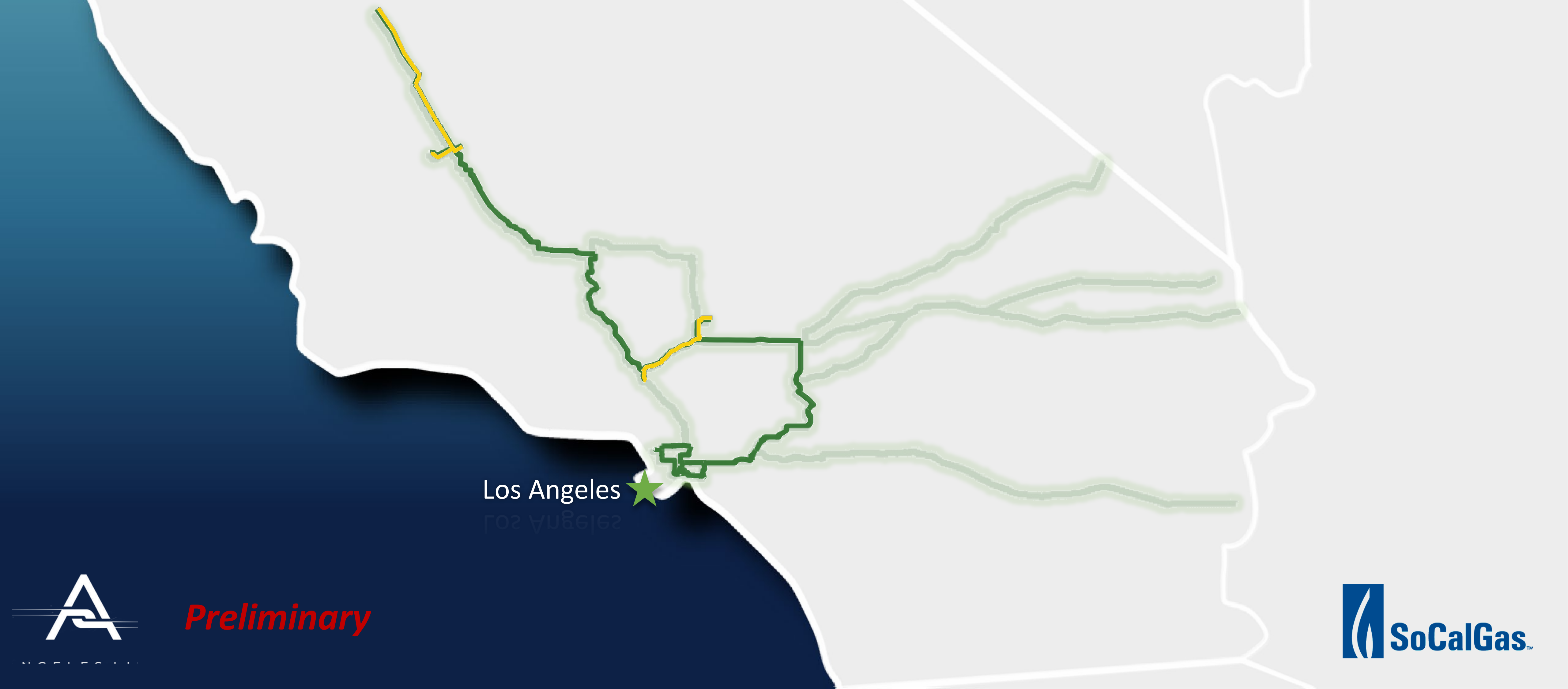
These renderings show conceptual examples that may be evaluated for the Angeles Link project.
Potential Angeles Link routes are still to be determined and analyzed for feasibility including hydraulics, engineering, etc.



Preliminary

Conceptual Example 2 of 2

These renderings show conceptual examples that may be evaluated for the Angeles Link project.
Potential Angeles Link routes are still to be determined and analyzed for feasibility including hydraulics, engineering, etc.



Preliminary

SoCalGas

Next Steps

- Phase 1 Routing Study is still underway and is expected to include:
  - Comprehensive Research & Analysis
  - Connect identified areas of hydrogen production & demand throughout the Central and Southern California area
  - Pipeline Corridor Evaluation
- Various configurations are still under evaluation
- The Pipeline Routing/Configuration Study is expected to be completed and shared in Q3 2024
- Phase 2 will determine a preferred route

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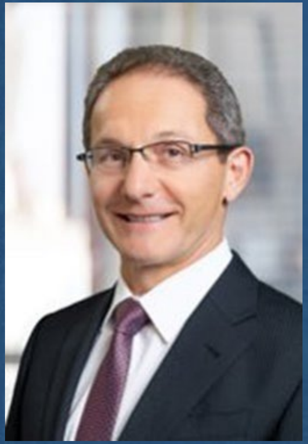
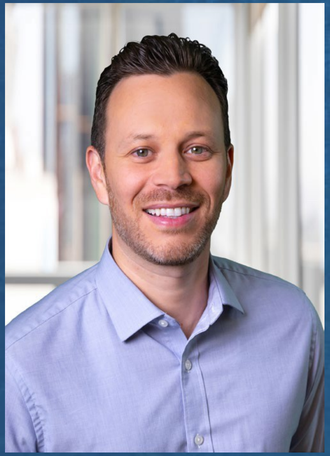


YURI FREEDMAN
Senior Director
Business Development

AMY KITSON
Angeles Link Director
Engineering & Technology



FRANK LOPEZ
Regional Public Affairs
Director

MEMBER DISCUSSION:
PRELIMINARY ROUTING/CONFIGURATION ANALYSIS

- Please announce your name and speak directly into the microphone
- Be concise and focus on discussion topics
- Verbal comments are not the only way to provide input, feel free to type a chat
- We are accepting written input after this meeting if we run short on time, or you think of things later

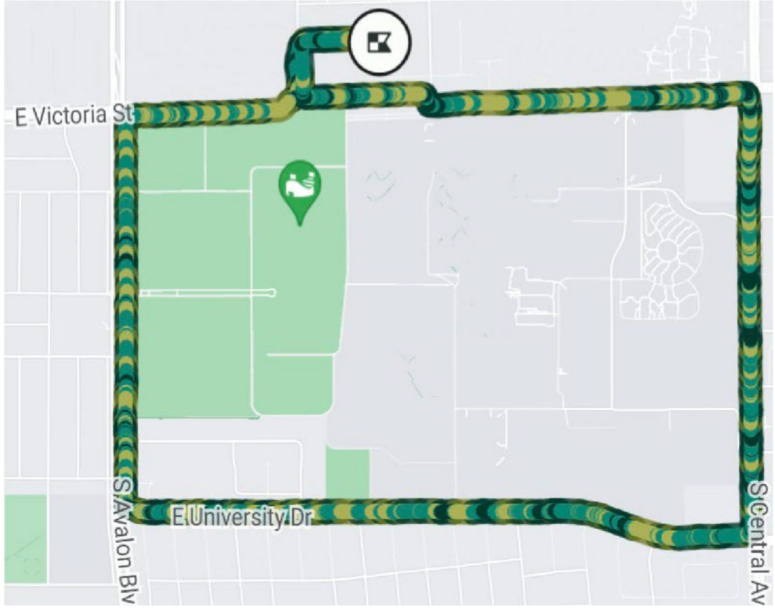
PREVIEW OF PRELIMINARY FINDINGS: PLAN FOR APPLICABLE SAFETY REQUIREMENTS

CHANICE ALLEN
Engineering Project Manager
SoCalGas

WALKING ROUTE - PIPELINE MARKERS

E Artesia Blvd

E Alberton



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KEY SAFETY CONSIDERATIONS

Failures & Embrittlement

- Material
- Equipment

Operations and Maintenance

- Surveys
- Leakage Detection
- Monitoring

Natural Disasters & Events

- Earthquakes
- Third-party Damage
- Physical & Cyber Security

Operations

- Workforce
- Contractors
- Emergency Responders
- Public

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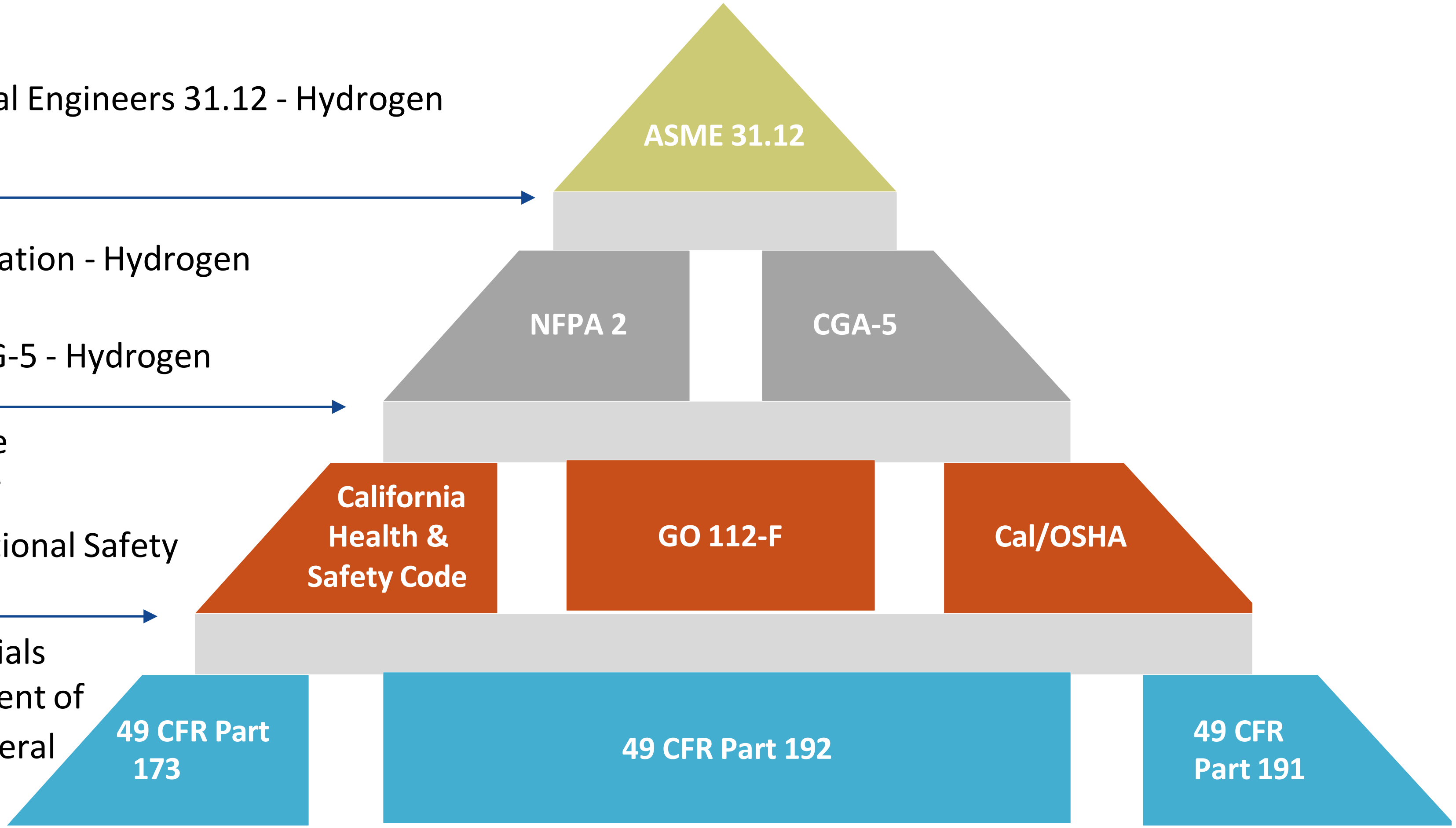
PLAN FOR APPLICABLE SAFETY REQUIREMENTS

- American Society of Mechanical Engineers 31.12 - Hydrogen Piping and Pipelines

- National Fire Protection Association - Hydrogen Technologies Code
- Compressed Gas Association G-5 - Hydrogen

- California Health & Safety Code
- CPUC General Order No. 112-F
- Cal/OSHA - Division of Occupational Safety and Health

- Pipeline and Hazardous Materials Safety Administration, Department of Transportation – 49 Code of Federal Regulations.



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DESIGN, CONSTRUCTION, OPERATION & MAINTENANCE

Design & Construction

Design considerations will apply code ASME 31.12 specifically for hydrogen piping and pipeline

Material selection and compatibility will be critical in the safe design and operation for pure hydrogen

Proven welding procedures and technologies used in other industries that are currently using pure hydrogen

Operation & Maintenance

Leak detection equipment is available and can be utilized for hydrogen detection

In-line inspection (ILI) of hydrogen pipelines is feasible

Studies show odorization of pure hydrogen gas is feasible

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PUBLIC AWARENESS PLAN

Public Awareness Program

Safety	Pipeline Safety Resource	API 1162

Audience
- Public
- Emergency planning and response officials
- Public officials and governing councils
- Excavators

Program
- Pipeline purpose and reliability
- Hazard awareness and prevention measures
- Leak recognition and response
- Emergency preparedness communications
- Damage prevention
- Pipeline locations

Communication Method
- Bill inserts
- News release
- Advertising
- Brochures
- Direct mail
- Email
- Safety website
- Meetings

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PUBLIC

REPRESENTATION OF BROCHURE DISTRIBUTED TO THE PUBLIC

Keep the CommunitySafe

Contact 811 Before You Dig – It's Free!

If you plan to install a fence, plant a tree or dig for any reason, protect your family, neighbors and the pipelines near you by following these safety steps:

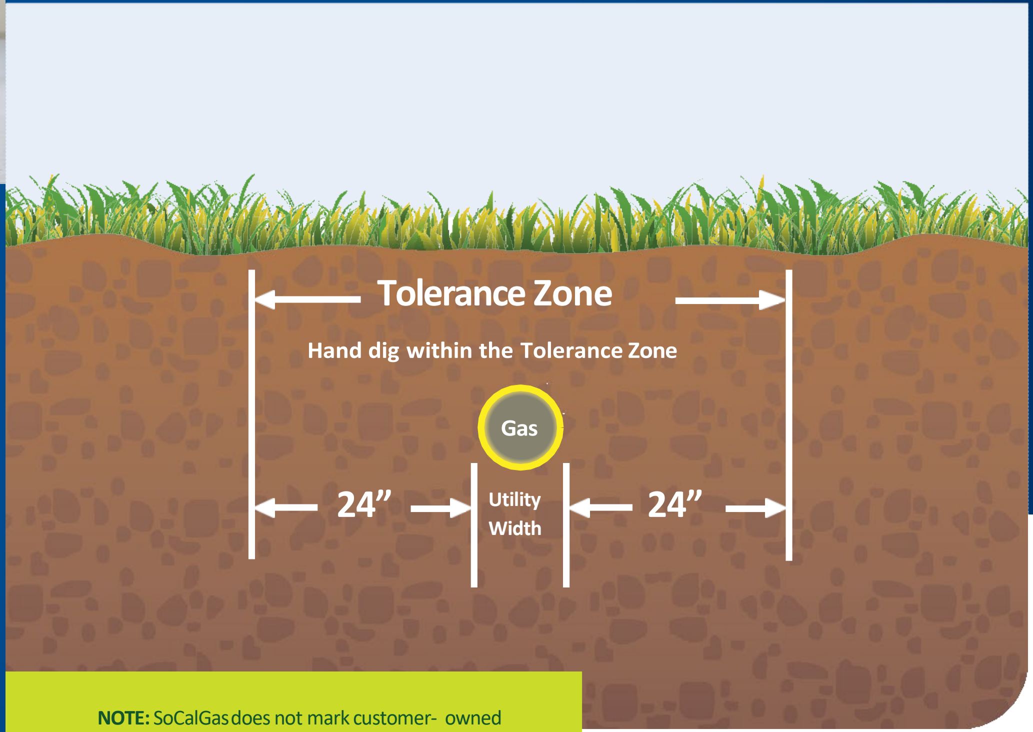
Mark Out your proposed project area in white paint or provide other suitable markings.

Contact 811 at **california811.org** or dial **811**, to submit a location request at least two business days before digging. SoCalGas will be contacted, as well asother local utility owners, to mark the location of all utility-owned lines for free.

Check utility responses to your 811 ticket by visiting **DigAlert.org** or **USANorth.org**.

For more details, visit socalgas.com/811.

Use Only Hand Tools within 24 inches on each side of marked utility lines to carefully expose the exact locations of ~~all~~ lines.



NOTE: SoCalGas does not mark customer- owned natural gas lines, which typically run from the meter to natural gas equipment. Tolocate and mark customer-owned lines contacta qualified pipe-locating professional.

ANGELES LINK

SoCalGas

PUBLIC

REPRESENTATION OF BROCHURE DISTRIBUTED TO THE PUBLIC

Locate Pipelines Near You

Most pipelines are buried underground. Pipeline markers identify the approximate locations of major pipelines and include our emergency number. Markers do not indicate the depth or number of pipelines in the area. You can view the approximate locations of major natural gas pipelines at **socalgas.com/Map** or on the National Pipeline Mapping System (NPMS) website at **npms.phmsa.dot.gov**.

These maps only indicate the general location of pipelines and should never be used as a substitute for contacting 811 at least two working days before digging.

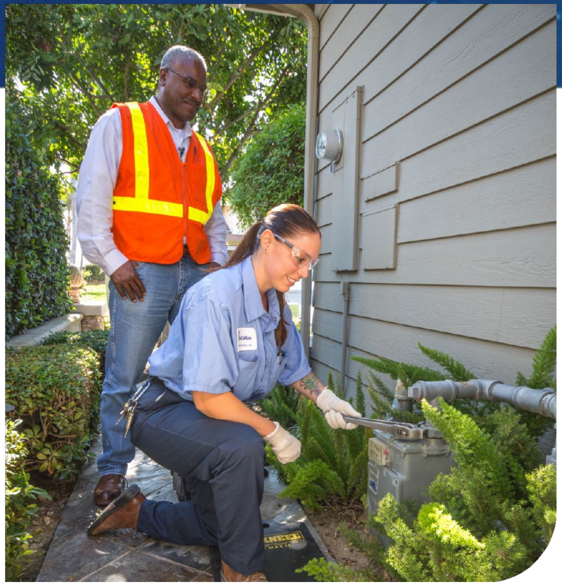
Pipeline Markings & What They Mean

High-visibility markers, like the one below, mark the general location of major pipeline routes.

Contact **811** if you need accurate pipeline location marked.

Utilities Color Codes

- **Red:** Electric
- **Yellow:** Gas, oil, steam
- **Orange:** Communications
- **Blue:** Water
- **Purple:** Reclaimed Water
- **Green:** Sewer
- **Pink:** Temporary Markings
- **White:** Proposed Excavation



Pipeline Maintenance And Your Safety

SoCalGas pipelines deliver natural gas to approximately 22 million residential and business customers. We routinely patrol, test, repair and replace our natural gas pipelines. Our employees also undergo ongoing technical training and testing. We monitor natural gas for quality and add a distinctive odor to aid in the detection of leaks. We also maintain an ongoing relationship with emergency response officials in order to prepare for and respond to any pipeline emergency. For more information on our integrity management plan outline, visit **socalgas.com/PipelineSafety.**

Important Contact Information

Report a pipeline emergency
1-800-427-2200 or 911

Hearing Impaired, call TDD/TTY
1-800-252-0259

Asistencía en español 1-800-342-4545

Contact 811:
Visit **california811.org**
or call 811

For safety information:
socalgas.com/BeSafe

Para información de seguridad en español:
socalgas.com/Seguridad

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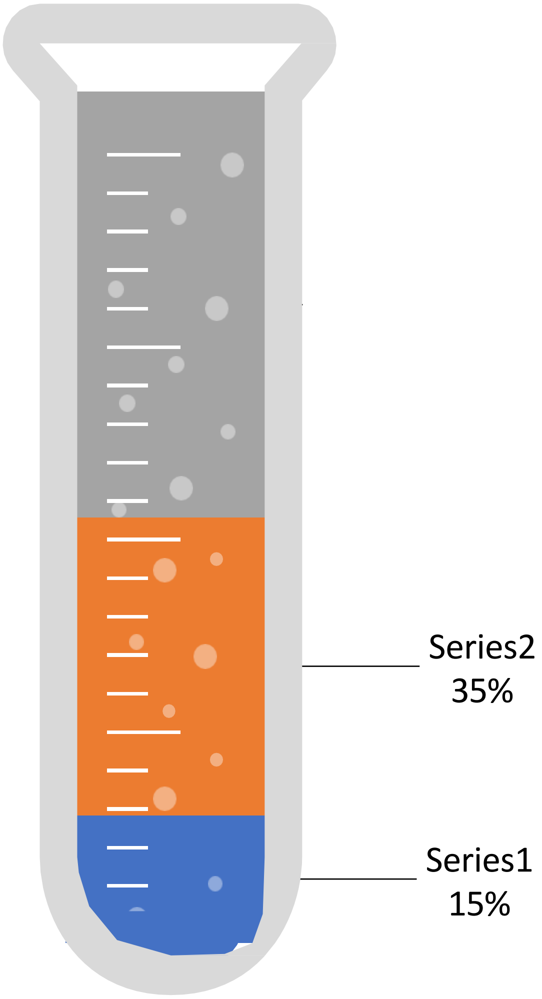
THIRD-PARTY STANDARDS REVIEW EVALUATION AND PROGRESS

- **Reviewed ~1600 existing specification, standards, and protocols (SSPs)**
  - ~500 SSPs may apply to hydrogen infrastructure and subject to potential modifications
  - ~200 potential new SSPs
- **Developing SCG Standards and material specifications around hydrogen**
  - Created eight standards and ten material specification sheets for H2 and hydrogen blends
- **Center for Hydrogen Safety**
  - On-going collaboration with the Hydrogen Safety Panel for an expert third-party review of our Angeles Link Safety Study

CENTER FOR Hydrogen SAFETY
Connecting a Global Community



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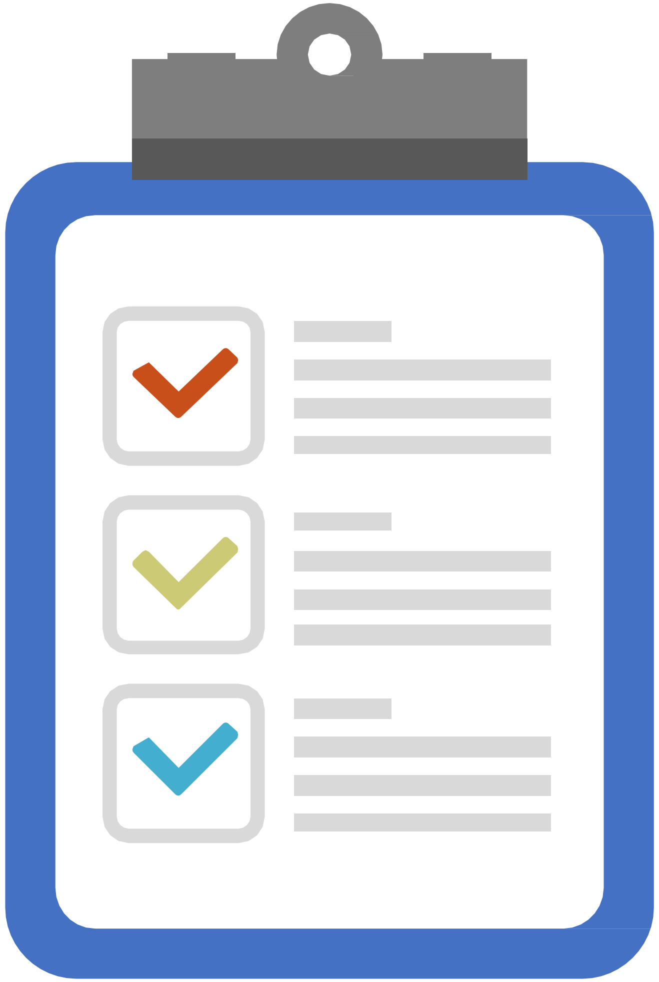
CONCLUSION



1. Pipelines are the safest method of transporting large volumes of gas over long distances
2. A comprehensive framework of safety requirements can mitigate hydrogen transport risks
3. SoCalGas has an existing safety framework that can be built upon to include 100% hydrogen transport

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PIPELINE SAFETY: EMERGENCY RESPONSE & MONITORING

ANGELES
LINK

LARRY ANDREWS
Director – Emergency Strategy & Operations
SoCalGas

EMERGENCY MANAGEMENT: MONITORING AND RESPONSE

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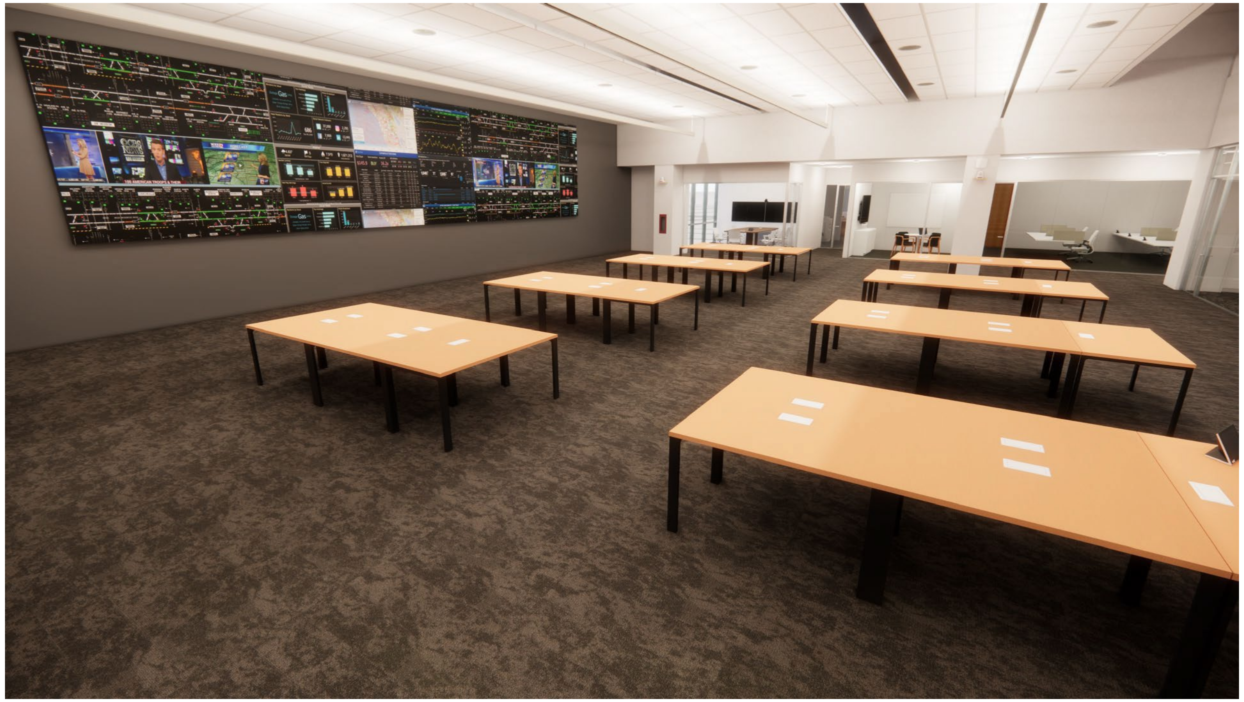
EMERGENCY MANAGEMENT: MONITORING AND RESPONSE

- Customer Contact Center
- Dispatch
- System Operator
- Watch Desk 24/7



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IMPORTANT INFORMATION FOR FIRST RESPONDERS

- First Responder Education
- EOC/ County Coordinators
- Community Outreach

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WALK THE WALLS ACTIVITY
PREVIEW OF PRELIMINARY FINDINGS:
PLAN FOR APPLICABLE SAFETY REQUIREMENTS

- Please walk around the room to the easel boards with guiding questions
- Utilize post-it notes to offer feedback on each question
- If you have any questions, we encourage you to ask our presenters
- We are accepting input after this meeting if we run short on time or you think of things later

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LUNCH - THANK YOU STUDENTS OF LATTC

ANGELES
LINK

CBOSG UPDATES

- Please announce your name and speak directly into the microphone
- Be concise and focus on discussion topics
- Verbal comments are not the only way to provide input, feel free to type a chat

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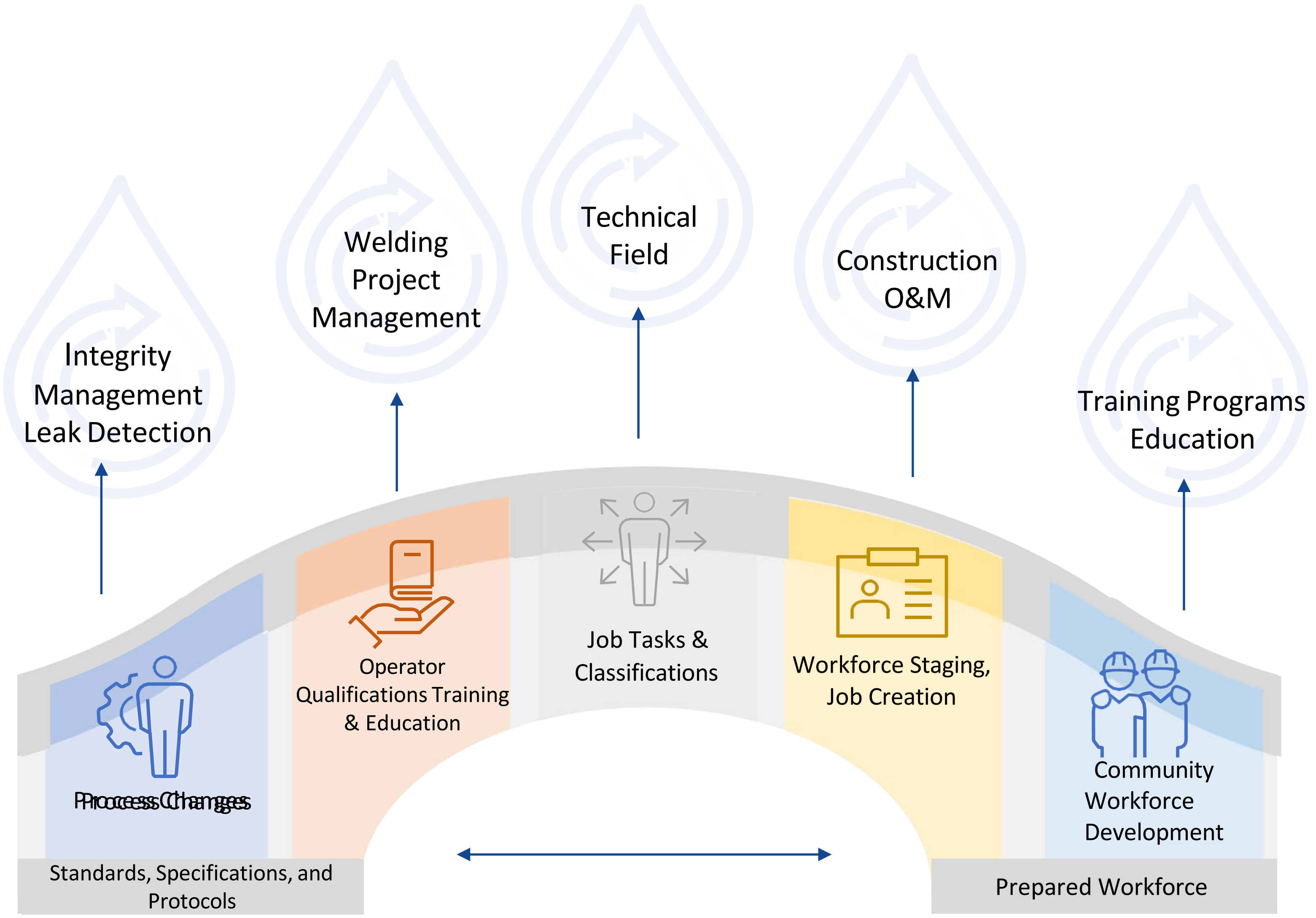
PREVIEW OF PRELIMINARY FINDINGS: WORKFORCE PLANNING AND TRAINING EVALUATION

ANGELES LINK

CHANICE ALLEN
Engineering Project Manager
SoCalGas

SoCalGas

BRIDGING THE GAP



ANGELES LINK

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WORKFORCE NATURAL GAS/HYDROGEN TRANSITION

Natural Gas

Before

- Technology – Management systems unique to natural gas
- Operation Procedures – Demonstrate compliance with regulatory requirements and reflect industry best practices
- Human Resources – Management and represented employees

Hydrogen

After

- Technology – Potential increase in capacity, scale and customization specific to hydrogen
- Operation Procedures – Demonstrate compliance with regulatory requirements and reflect industry best practices with potential modifications
- Human Resources – Potential for separate job tasks and classifications or combined tasks

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SOCALGAS PROGRESS IN HYDROGEN SAFETY TRAINING AND EDUCATION DEVELOPMENT

- **Industry Leading Joint Industry Partnership with DNV and Enbridge**
  - Developing a training program which includes fundamental hydrogen safety curriculum in addition to process engineering and field operations training
  - Currently in Phase 2 – Course Development
- **Nationwide Industry and Academia Partnership**
  - Developing newly trained personnel, and enabling the existing workforce in the four key technical pillars that form the basis for the hydrogen industry: production, delivery, storage, and end-use with safety as a foundation woven throughout
  - Local university partnership coming soon
- **AltaSea Supporting Partner**
  - Providing industry knowledge in partnership with AltaSea working together with LA Harbor College in developing a Marine Hydrogen Certification program for regional workforce training
  - In addition to the Los Angeles Unified School District (including Inglewood and Lawndale), 15 + community-based organizations work with AltaSea including: Boys and Girls Clubs of the LA Harbor, Santa Monica College, Wilmington's Strength Based Community Change (SBCC), and the Watts Entrepreneur Education Center

DNV

H2EDGE

AltaSea AT THE PORT OF LOS ANGELES

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WORKFORCE PARTNERSHIPS

Construction Career Academy

Pre-Apprenticeship Careers Pathways for Women

SoCal Veterans First Program

- 28 SCG hires
- Latino/Hispanic
- Black/African American

- 5 stipends
- Latino/Hispanic
- Black/African American
- Asian American

- 4 SCG hires
- Latino/Hispanic
- Black/African American

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WORKFORCE PARTNERSHIPS: LA URBAN LEAGUE

ANGELES
LINK

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BREAKOUT SESSIONS:
PREVIEW OF PRELIMINARY FINDINGS:
WORKFORCE PLANNING AND TRAINING EVALUATION

- To create an enriching discussion, we will breakout into groups of 3-4 members
- In-person and online members will be able to participate
- There will be one scribe per group
- Be concise and focus on discussion topics
- Feel free to utilize the post-it notes throughout the meeting to provide additional feedback on any topic

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MEMBER REPORT OUT:
PREVIEW OF PRELIMINARY FINDINGS:
WORKFORCE PLANNING AND TRAINING EVALUATION

- A representative from each group will share the discussions and outcomes from their breakout session
- In-person and online members will be able to participate
- Be concise and focus on discussion topics
- Feel free to utilize the post-it notes throughout the meeting to provide additional feedback on any topic

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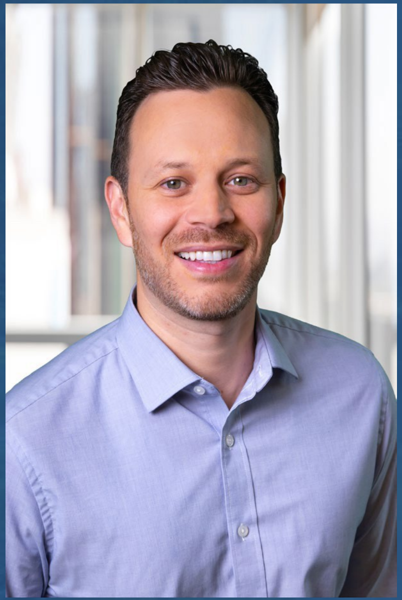
INTRODUCTION TO COMMUNITY BENEFITS PLAN

ANGELES LINK



FRANK LOPEZ
Regional Public Affairs
Director
SoCalGas

SoCalGas

CBOSG MEETING TIMELINE

SEPTEMBER 2023

Hydrogen Overview/ Community Engagement Planning/Air Emissions 101

OCTOBER 2023

ARCHES Introduction/ Technical Approach to Workforce Development and Routing /Project Alternatives and Options

DECEMBER 2023

Preliminary Findings of Nox & GHG Studies/ Demand/Transition to Hydrogen

MARCH 2024

Workforce Planning & Training Evaluation/ Safety & Emergency Response/Preview of Preliminary Findings of Routing & Configuration Analysis

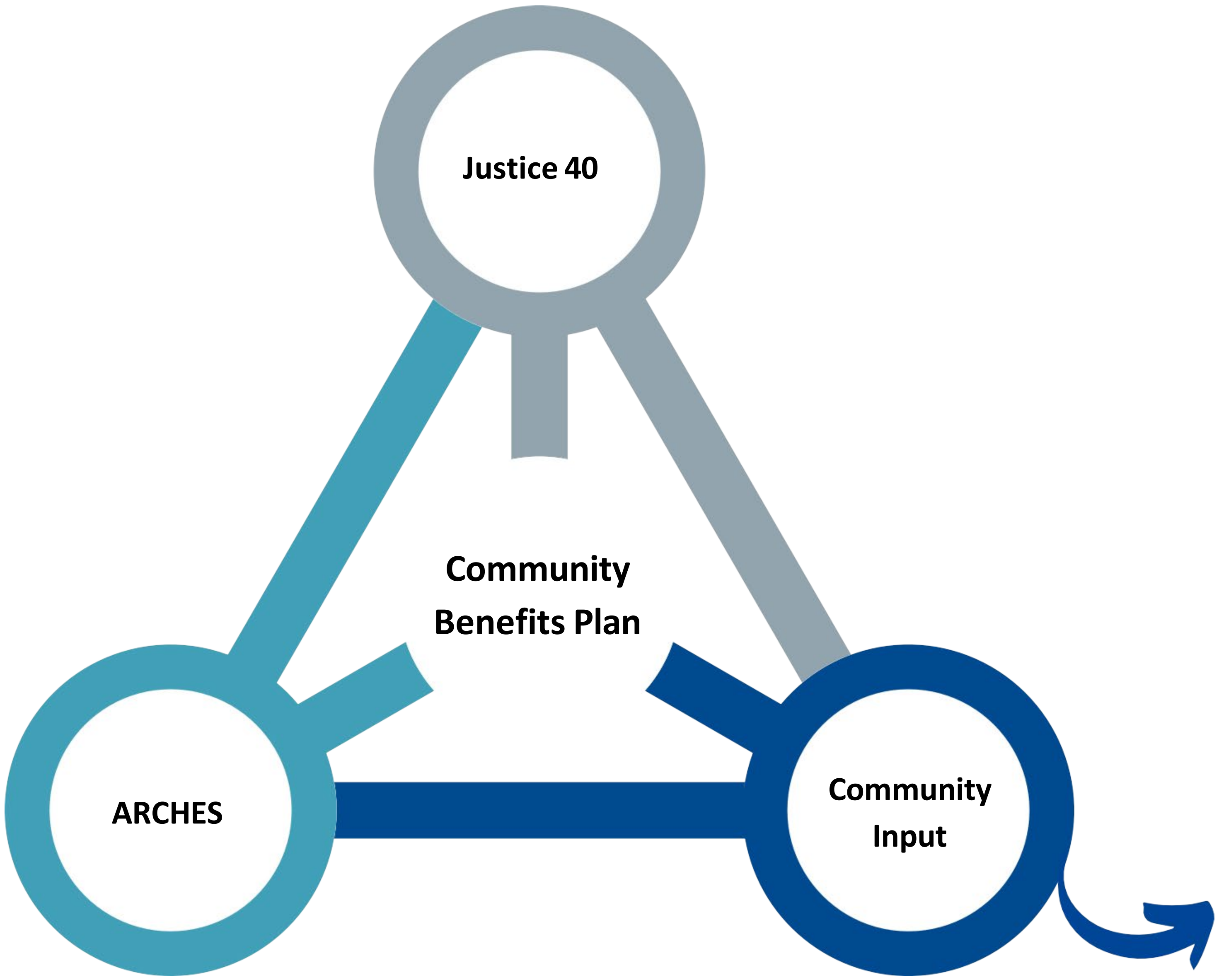
KEY PRIORITIES

- Health
- Environmental Justice
- Workforce
- Safety
- Cost / affordability

KEY FEEDBACK THEMES

- Engaging diverse communities
- Inclusive workforce development
- Transparency about safety and local impacts
- Collaborating with community-based organizations
- Invest in community initiatives

CRITERIA



Topics

- Education
- Economic and Workforce Development
- Health and Safety
- Diversity, Equity, and Inclusion
- Environmental/ Environmental Justice

PROCESS & NEXT STEPS

Here are some guidinging questio,ns for us t,o co,nsider during the **EXPLORE** plhase:

1. Have you be,en involved in designing a CBP for a large-scalie infrastru cture project?
2. can you provide exampl,es or best practices of strategies that have worked?
3. What strategies hav,e not worked?
4. Are therie any other creative ideas/ solutions?

NEXT STEPS

- The Water, Leakage, GHG Emissions Evaluation, and NOx preliminary findings were posted on the Living Library on Tuesday, February 27 and will be open for feedback until Friday, March 29
  - CBO Feedback: ALP1_Study_CBO_Feedback@insigniaenv.com
- Today's presentation and meeting recording will be available soon on the living library
  - Microsoft now requires two-step verification to access the living library. If you have any difficulties accessing the library, please let us know
- If you have questions or comments, please submit them in writing at your next convenience

ANGELES LINK

THANK YOU FOR YOUR PARTICIPATION

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ROUTING SUMMARY

The presentation explains the preliminary considerations and criteria used to evaluate the possible preferred routes for the Angeles Link project. This section explains how these routes were evaluated, and provides next steps in the routing process.

KEY FINDINGS

Criteria Glossary:

Engineering

- Fault areas
- Route length
- Adverse soil conditions, etc.

Environmental

- Coastal zones
- Conservation areas
- Cultural & tribal resources, etc.

Social

- Disadvantaged communities
- Industrial land
- Public and recreational areas, etc.

Key considerations:

- Federal corridors
- Existing SoCalGas Right-of-Way
- ARCHES initiatives

GUIDING QUESTIONS

1. Can you provide feedback on the process SoCalGas has undertaken to evaluate existing utility corridors for the proposed pipeline?
2. What impacts do you foresee for the communities along the proposed corridors, and what responses would you recommend to SoCalGas?
3. What kind of community benefits does your organization expect from the proposed pipeline?
4. What environmental factors and procedures should SoCalGas consider during the production and operation of the proposed pipeline?

KEY TAKEAWAYS

1. The routes and information shared reflect considerations and criteria for selecting possible preferred routes, these routes are not final.

2. Engineering, environmental, and social factors were considered during the preliminary routing process.

SAFETY AND EMERGENCY RESPONSE

PLAN FOR APPLICABLE SAFETY REQUIREMENTS

This section covers key safety considerations, emphasizing the importance of planning for applicable safety requirements throughout the project lifecycle. It addresses design, construction, operation, and maintenance phases, stressing the need for safety protocols at each stage. The presentation also outlines a public awareness plan aimed at disseminating critical safety information to stakeholders and the wider community.

PIPELINE SAFETY SCENARIO

This section covers three key topics: emergency management monitoring and response, emergency management preparedness and training, and crucial information for first responders. It provides insights into effective strategies for monitoring emergencies and responding promptly to mitigate risks. Emphasizing the significance of preparedness measures and training protocols to equip first responders with the necessary skills and knowledge to handle diverse emergency scenarios efficiently.

PLAN FOR APPLICABLE SAFETY REQUIREMENTS

GUIDING QUESTIONS

1. What strategies does your organization employ to disseminate critical safety information to stakeholders and the wider community?
2. How can SoCalGas effectively communicate critical safety information to stakeholders and the broader community?
3. Can you share examples of successful initiatives where your organization effectively responded to emergencies and mitigated risks, and what lessons were learned from these experiences?
4. What additional safety and risk mitigation strategies do you believe SoCalGas should consider?

KEY TAKEAWAYS

1. 100% hydrogen can be safely transported by pipeline if requirements are adhered to.

2. A comprehensive framework of safety requirements can mitigate hydrogen transport risks.

3. SoCalGas has an existing safety framework that can be built upon to include 100% hydrogen transport.

WORKFORCE PLANNING AND DEVELOPMENT

SUMMARY

This presentation addresses a multifaceted and integrated approach to closing resource gaps in efforts to support a prepared and equitable workforce. It outlines relevant jobs related to the construction and maintenance of the project and explores the major fields transition from natural gas to hydrogen. The presentation also explores current workforce programs that could be used as a model as well as developing training and educational programs that focus on hydrogen education and workforce development.

GUIDING QUESTIONS

1. How can we collaborate with you and other CBOs and stakeholders to develop effective training and education programs for hydrogen safety?
2. What factors should SoCalGas take into account when establishing hydrogen workforce initiatives to ensure fair and equitable outcomes for environmental justice and disadvantaged communities?
3. If you have prior experience in workforce development, what strategies have proven successful in partnerships, and where do you see room for improvement?

KEY TAKEAWAYS

1. The workforce transition from natural gas to hydrogen involves adapting technology, operational procedures, and human resources management.

2. Construction, operations and maintenance of the pipeline would employe a wide range of professions.

3. The transition to hydrogen energy relies on investment in workforce development and training programs.

APPENDIX 7 – PAG MEETING MATERIALS

WELCOME PAG MEMBERS

Welcome, Housekeeping & Rollcall

ARCHES Update

Preview of Water Resources Evaluation

Member Discussion: Water Resources Evaluation

Break

Preview of Hydrogen Leakage Assessment

Update: GHG and NOx

Member Discussion: Hydrogen Leakage Assessment

Next Steps/Upcoming Meetings

Adjourn

February 15, 2024
10:00 a.m. – 12:00 p.m.

ANGELES LINK

Planning Advisory Group (PAG)
February Workshop

Warm welcome to our participants!
We will be starting at 10:00 a.m.
to make sure everyone is present.

SoCalGas

WELCOME FROM OUR FACILITATOR

ANGELES LINK

CHESTER BRITT

Executive Vice President

Arellano Associates

PAG Lead

SoCalGas

HOUSEKEEPING:

This meeting will be recorded (video and audio), and a court reporter will be transcribing the meeting. Please announce yourself before you speak

Zoom microphones are muted by the host to eliminate background noise. You will need to unmute your microphone when called on to speak. *For both in-person and on-line participants please speak directly into the microphone to ensure everyone can hear*

We encourage you to turn on your cameras so we can better engage with you

Please feel free to use the Zoom chat to provide input and ask questions throughout the meeting

If you would like to speak, please use the "Raise Hand" button at the bottom of the Zoom screen

Wireless microphones will be passed to those speakers attending in person

AGENDA

- Arrival and Continental Breakfast
- Roll Call
- Opening Remarks & ARCHES Update
- Water Resources Evaluation
  - Member Discussion
- Break
- Hydrogen Leakage Assessment
  - Update: GHG and NOx
  - Member Discussion
- Next Steps/Upcoming Meetings
- Adjourn

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ROLL CALL

SoCalGas

OPENING REMARKS & ARCHES UPDATE

ANGELES LINK

NEIL NAVIN
Chief Clean Fuels Officer
SoCalGas

SoCalGas

PREVIEW OF WATER RESOURCES EVALUATION

ANGELES LINK

JILL TRACY
Senior Director
Regulatory & Policy

BRENDA EELLS
Principal
Environmental Planning
Renewable Energy Infrastructure
Rincon

SoCalGas

WATER AVAILABILITY STUDY INTRODUCTION

Imagery provided by Esri and its licensors © 2023.

- Purpose of study is to identify and characterize potential water supply sources needed to support third-party production of clean renewable hydrogen that Angeles Link could then convey
- Study area generally defined by the boundaries of SoCalGas's service territory and includes selection of potential sources outside the territory, e.g.:
  - Wastewater treatment facilities in San Joaquin Valley
  - Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) program, also located in San Joaquin Valley
  - Other sources may be identified in the future

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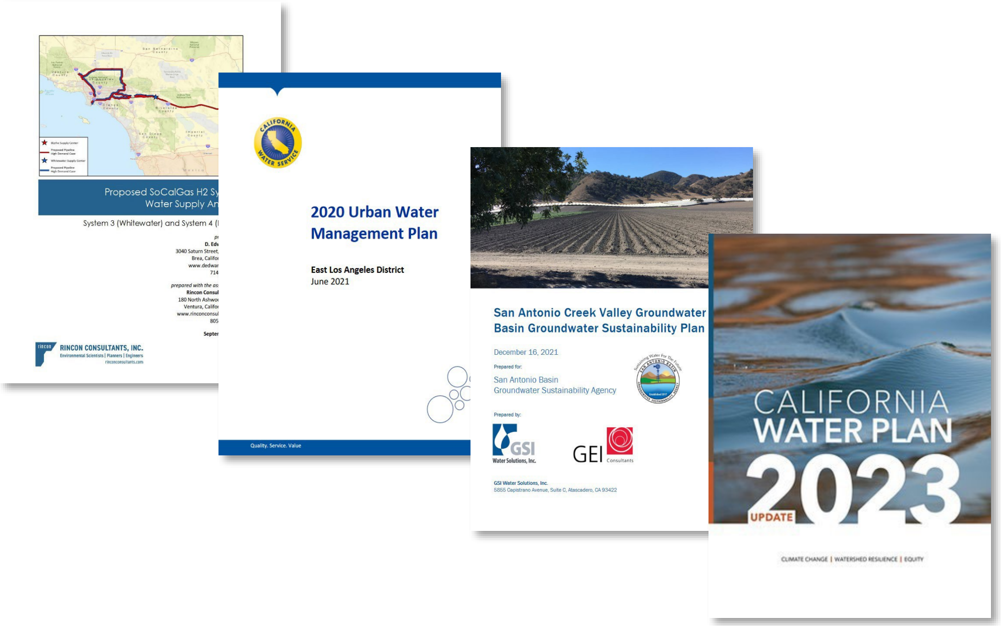
STUDY APPROACH

- Approach includes a review of existing technical documents, including:
  - 2021 SPEC Water Study
  - Urban Water Management Plans
  - Groundwater Sustainability Plans
  - California Water Plan
  - Other Existing Studies



- Information sharing and initial inquiries with select water agencies and regional water suppliers within study area:
  - Metropolitan Water District of Southern California (Metropolitan)
  - Los Angeles Department of Water and Power (LADWP)
  - Orange County Sanitation District (OC-San)
  - Santa Ana Watershed Protection Authority (SAWPA)

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WATER SUPPLY MANAGEMENT

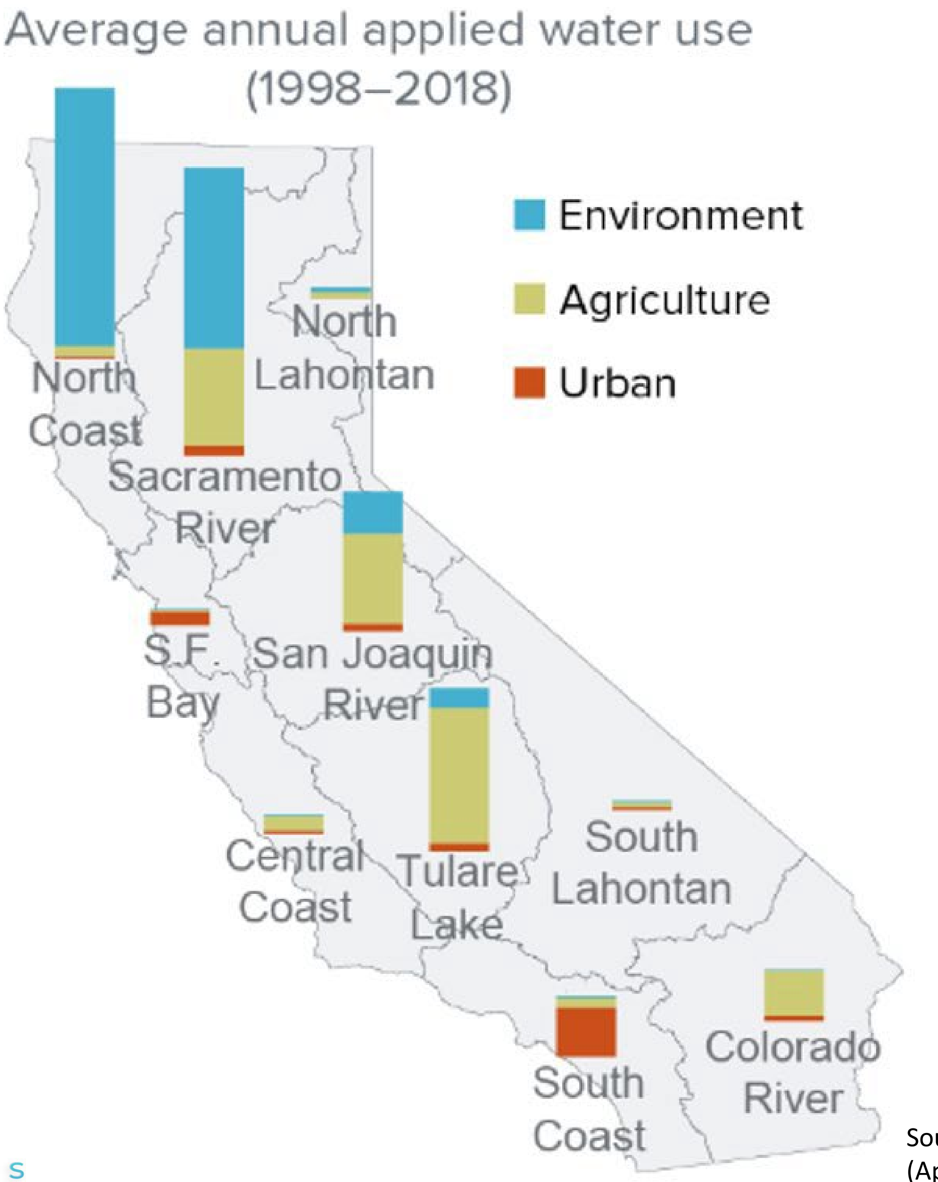
- Involves multiple regulatory agencies governed by complex laws and regulations
- Affected by seasonal and annual fluctuations and California's diverse water needs
- Managed across three main sectors: urban, agricultural, and environmental
- Shifting water demands and obligations may change over time as uses for water in the state evolve

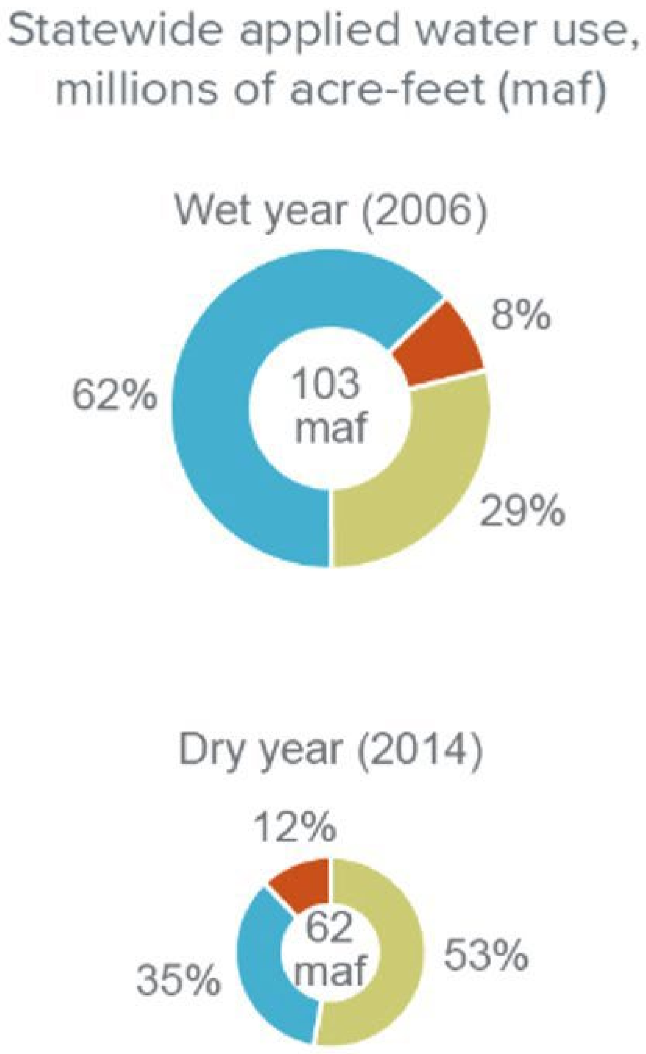
Average Annual Applied Water Use, 1998-2018

Use Type	Dry Year (AFY)	Wet Year (AFY)
Urban	7,000,000	8,000,000
Agriculture	33,000,000	30,000,000
Environment	22,000,000	65,000,000
Total	**62,000,000**	**103,000,000**

Source: Public Policy Institute of California, Fact Sheet – Waster Use in California (April 2023), https://www.ppic.org/wp-content/uploads/jtf-water-use.pdf.

AVERAGE ANNUAL APPLIED WATER USE: 1998-2018





Source: Public Policy Institute of California, Fact Sheet – Waster Use in California (April 2023), https://www.ppic.org/wp-content/uploads/jtf-water-use.pdf.

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WATER NEEDS FOR PRODUCERS TO MEET HYDROGEN DEMAND

- Phase One Demand Study projects demand for clean renewable hydrogen across SoCalGas's Service territory through 2045 to be approximately 1.9 MMT/year under a conservative scenario to 5.9 MMT/year under an ambitious scenario
- Dividing water needs for production by total applied water in state shows that water required for third-party production to meet that projected demand across SoCalGas's service territory comprises a small percentage of California's total water usage each year as set forth below

Estimated Water Needs for Hydrogen Producers to Meet Demand Across SoCalGas's Service Territory Compared to Statewide Applied Water Rates

Demand Scenario	Demand (Million Metric Tons/Year)	Water Needs[1] (AF/Y[2])	Dry Year Applied Water (62 Million AF/Y)	Wet Year Applied Water (103 Million AF/Y)
Conservative	1.9	21,311	0.03%	0.02%
Ambitious	5.9	66,175	0.11%	0.06%

1. Water demand estimates are based on average estimates analyzing potential supply sources of various water qualities.
2. Acre feet per year

Source: Public Policy Institute of California, Fact Sheet – Waster Use in California (April 2023), https://www.ppic.org/wp-content/uploads/jtf-water-use.pdf.

ANGELES LINK

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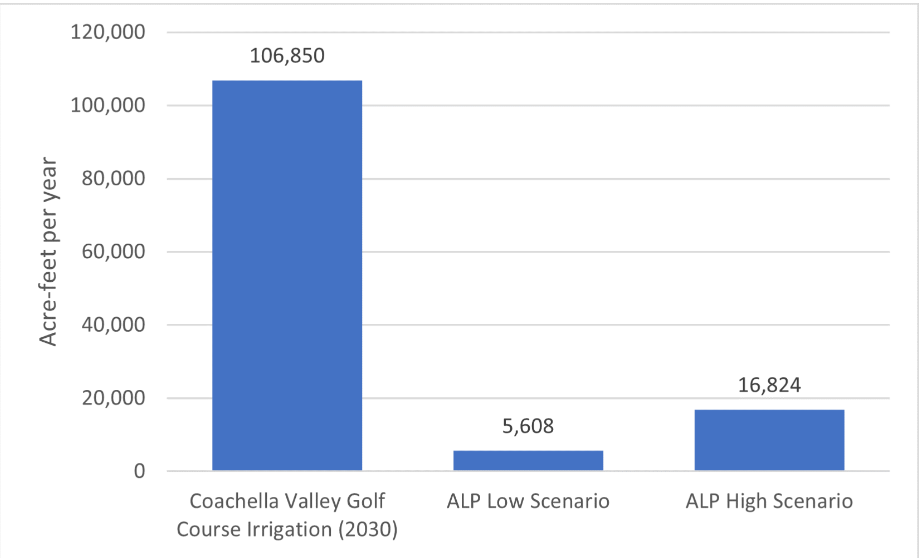
WATER NEEDS FOR HYDROGEN TRANSPORTED BY ANGELES LINK

- Angeles Link proposes to transport a portion of projected H2 demand across SoCalGas's service territory. Complementary to the scenarios used in other studies, water study evaluated range of throughput
- Dividing (1) water needs for production of a portion of projected H2 demand that Angeles Link would transport by (2) total applied water in state shows that water needed for third-party producers to meet that portion of projected demand represents less than 1/100 to 3/100 of one percent of California's total water usage each year

Estimated Water Needs Compared to Statewide Applied Water Rates

Angeles Link Throughput	Portion of Demand (MMT/year)	Water Needs[1] (AF/Y[2])	Dry Year Applied Water (62 Million AF/Y)	Wet Year Applied Water (103 Million AF/Y)
Low scenario	0.5	5,608	0.01%	< 0.01%
High scenario	1.5	16,824	0.03%	0.02%

1. Water demand estimates are based on average estimates analyzing potential supply sources of various water qualities.
2. Acre feet per year



Source: Public Policy Institute of California, Fact Sheet – Waster Use in California (April 2023), https://www.ppic.org/wp-content/uploads/jtf-water-use.pdf.

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POTENTIAL WATER SOURCE TYPES

Source Type	Overview
Imported Surface Water	• Source: includes water from State Water Project, Central Valley Project, and Colorado River • Potential to tap into surface water from existing rights holders
Treated Wastewater (Recycled water)	• Source: municipal wastewater, sewage that is highly treated and disinfected at wastewater treatment facilities • Potential supply from treated wastewater discharged from facilities without plans for reuse
Groundwater	• •Source: groundwater which may be managed by local agencies under the Sustainable Groundwater Management Act (SGMA) or Court appointed Watermasters • Potential opportunities as a supply source in low priority basins, adjudicated areas, or groundwater "banks" depending on site-specific conditions and other demands
Agricultural Industry Water	• Source: agricultural field drainage, surface water runoff, and subsurface drainage; agricultural wash water or process water used to remove soil and debris before distribution • Ability to capture and reuse field drainage water or process water before treatment
Brine Line Flows	• Source: brine lines remove salts and contaminants from specific watershed areas to preserve local resource quality • Potential supply from brine line flows planned for discharge that could be diverted and treated
Advanced Water Treatment Concentrate	• Source: waste flow from facilities that treat recycled water for further water quality treatment. • Potential supply from concentrate not currently reused or planned for beneficial reuse that could be treated.
Oil & Gas Industry Water	• Source: refinery offset water from reduced or halted refinery operations; produced water, extracted along with oil and gas during pumping • Potential supply sources if water not currently reused or planned for beneficial reuse could be acquired
Inland Brackish Groundwater	• Source: arises from natural (geology and soils) and manmade sources (discharges from treatment plants and agricultural runoff) • Potential supply sources could undergo treatment to address water quality concerns and management issues
Dry Weather Flows	• Source: non-precipitation flows accumulating in municipal storm sewer systems during dry weather conditions • Potential source from flows not reused or planned for beneficial use
Urban Stormwater Capture and Reuse	• Source: capture of stormwater runoff before reaching discharge outlets during precipitation events • Potential source explored with agencies to assess future availability or develop new capture projects

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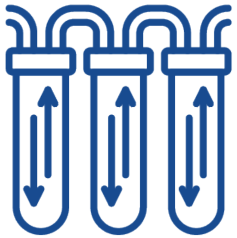
WATER TREATMENT OVERVIEW

- Water sources need treatment to a certain quality before being fed to electrolyzers
- Treatment of source water to ultrapure water requires two main steps:

1

Pretreatment removes the bulk of:

- Solids
- Salts
- Organics
- Microorganisms



2

Polishing to Ultrapure Water

Polishing typically involves removing impurities present in low concentrations and difficult to remove including:

- Conductivity (ion contents)
- Hardness
- Total Organic Carbon
- Silica

WATER ACQUISITION

- Water supply for clean renewable hydrogen development may potentially be acquired through several different mechanisms:

Acquisition Mechanism	Overview
Exchange agreements	• Acquire water through water seller that provides an amount of surplus water to a buyer in a certain area, and buyer provides a replacement supply in the same amount in the seller's service area • Exchange agreement may involve water from State Water Project, or from groundwater banking
Local water agencies	• Purchase of supply from local water agencies drawing on locally available supplies, sustainably managed groundwater, developed water such as treated wastewater, or surplus from wet weather years • Potential to partner with local agencies to develop new supply sources for mutual benefit (e.g., collecting and treating waste streams)
Water markets	• Acquire water through markets. For example, purchase from adjudicated groundwater basins or purchase wet weather surplus flows from State Water Project contractors
Land purchase with water rights	• Purchase land with certain attached water rights that would allow use of water for reasonable and beneficial purposes

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WATER AVAILABILITY STUDY KEY FINDINGS:

- Water required for the portion of hydrogen production that Angeles Link could transportis a small percentage of California's total water usage each year
- Water study supports third-party hydrogen production that would be delivered by Angeles Link
  - Multiple water supply sources to meet water demand for the clean renewable hydrogen that Angeles Link could transport identified
  - Numerous water source types may meet water demand
    - Examples include surface water, treated wastewater, brine line flows, urban stormwater capture/rescue, oil & gas industry water, and inland brackish water
  - Existing and new water supply sources as well as acquisition can be used to meet water demand
    - Examples include exchange agreements, local water agencies, water markets and land purchase with water rights
  - Shifting water demands and obligations may present opportunities for new water supply development
- The menu of water sources that feed specific production projects can be further evaluated and developedon a case-by-case basis as more details on specific projects develop

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MEMBER DISCUSSION:
WATER RESOURCES EVALUATION

- Please announce your name and speak directly into the microphone
- Be concise and focus on discussion topics
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- We are accepting written input after this meeting if we run short on time, or you think of things later

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BREAK

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PREVIEW OF HYDROGEN LEAKAGE ASSESSMENT

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DARRELL JOHNSON
SoCalGas Manager
Environmental
Services

SoCalGas

INTRODUCTION

- As required by CPUC Decision 22-12-055 OP 6(g) the Hydrogen Leakage Assessment:
  - Evaluates potential for hydrogen leakage associated with new infrastructure
    - Hydrogen Production
    - Hydrogen Compression
    - Hydrogen Storage (Aboveground and Underground)
    - Hydrogen Transmission
  - Evaluates opportunities to minimize or mitigate hydrogen leakage
- Volumetric estimates for leakage are not presented since detailed infrastructure information was not available

TECHNICAL APPROACH

>> Review of technical information including:

Studies from research-based academic institutions

- Columbia Unh1,ersity
- University of W\{'oming
- Fraz,er-Nash Consultancy (private organizartion)

Regulatory requirements from federal and state agencies

- US EPA
- US DOE
- PHMSA
- CARB
- CEC

Literature, presentations, and data from other entities and agencies

- NREL
- EDF
- JRC

Manufacturers of technological advancements to measure or minimize leakage

- Aerodyne
- Fukuda
- POC Machines

METHODOLOGY

- Two primary leakage estimation methodologies were identified:

1

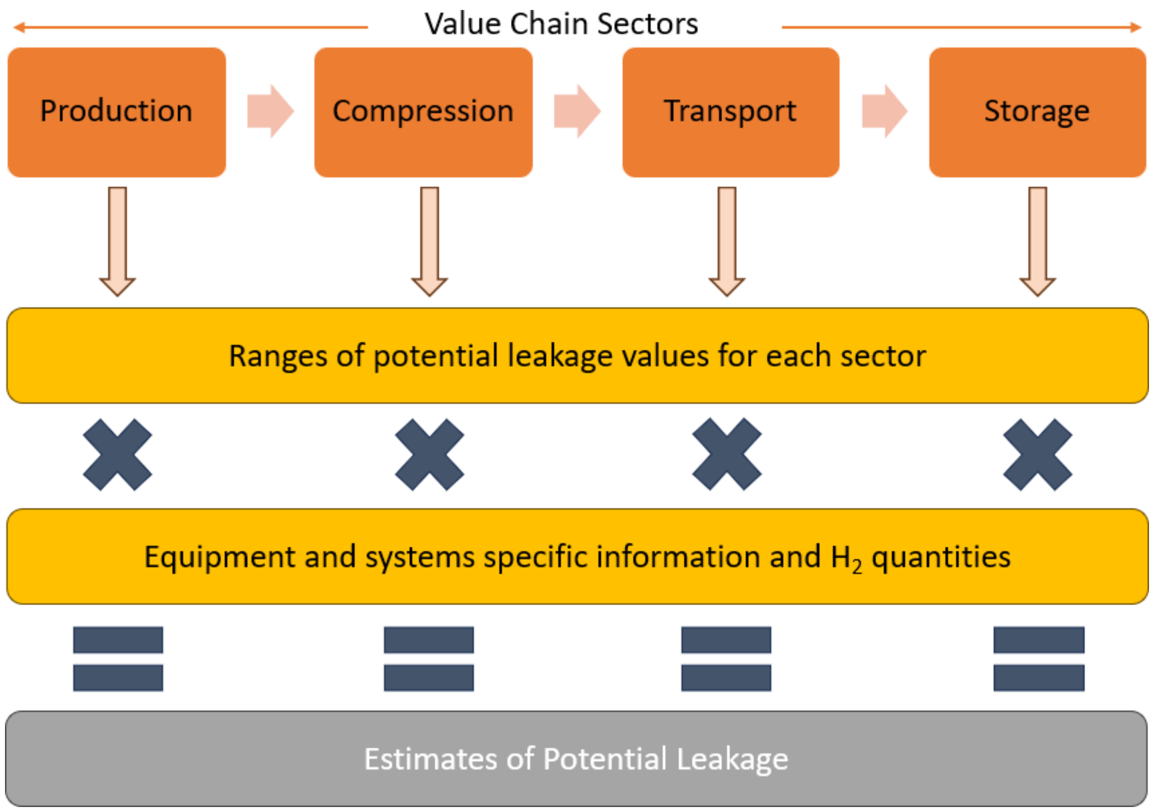
Total Value Chain Approach
(Top-down)

- Provides component leakage ranges summarized from literature reviews

2

Component-count Level Approach (Bottom-up)

- Relies on project-specific and detailed equipment, process, and component counts



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LEAK DETECTION TECHNOLOGIES

Technology	Leak Detection Range
Aerodyne Analyzer	10 ppb
Semiconductor Sensors	0.5 ppm to 5,000 ppm
Highly Sensitive Single-Crystalline Silicon Thermopiles Sensors	1 ppm to 20,000 ppm
Electrochemical Sensors	10 ppm and greater
Catalytic Combustion Sensors	1,000 ppm and greater
Detection Tapes	1,000 ppm and greater

SUMMARY OF UNCONTROLLED LEAKAGE RATES IN LITERATURE

Component	Values	Details	Data Source
Production	0.0001%, 0.03%, 0.1%, 0.2%, 0.24%, 0.25%, 0.5%, 0.52%, 4%, 4%	0.0001% associated with SMR. 0.2% estimate is the current understanding of losses during electrolysis. Losses are generally due to hydrogen and oxygen crossover through the membrane and to the dryer regeneration process	Harrison & Peters, (2013) Frazer-Nash (2022), Arrigoni and Diaz (2022), Cooper et al., (2022)
Compression	0.14%, 0.27%	Lower and upper limits, estimated using natural gas as a proxy with relative leak rates based on physical property differences	Cooper et al., (2022)
Aboveground Storage	2.77%, 6.52%	2.77% has a 50% confidence level (2-days) 6.25% has 99% confidence level (30-days)	Frazer-Nash (2022)
Underground Storage	0.02%, 0.06%	Salt cavern leakage rates are predicted to be very low with leakage primarily from surface plant during maintenance or emergency venting	Cooper et al. (2022) Frazer-Nash, (2022)
Transmission	0.02%, 0.04%, 0.06%, 0.1%, 0.2%, 0.4%, 0.48%	0.1% estimate for new pipelines dedicated to transport of hydrogen using global energy system model and global atmospheric model. Global energy system simulation model TIMER was used to develop a set of diverging scenarios.	Panfilov, 2015. US DOE targets, (2022) , Frazer-Nash (2022), Cooper et al. (2022) Arrigoni & Diaz, (2022), Van Ruijven et al., 2011

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OPPORTUNITIES TO MINIMIZE LEAKAGE

Opportunity	Estimated Reduction Potential	Data Source
Design and Engineering	**Up to 100%**	
• Compressors: Leakage capture and return mechanism with vapor control system	95% or greater	Frazer-Nash (2022), EPA Natural Gas STAR (2023)
• Pipelines: Welded connections and leak tight valves	Up to 100%	Arrigoni et al (2022), Frazer-Nash (2022)
Operations	**Not quantified at this time**	
Maintenance and Repair (Leak detection and repair program for valves, flanges, connections, etc.)	**89% to 96%**	Arrigoni et al (2022) CSU Fullerton (2012) PG&E (2016)

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RELATIONSHIP TO GREENHOUSE GAS ASSESSMENT

- GHG assessment considers potential climate impacts from hydrogen leakage
- Certain third-party literature identified that potential climate impacts may be caused by:
  - Reduction in available hydroxyl radicals to react with methane, potentially prolonging methane's lifetime in the atmosphere
  - Increased tropospheric concentrations of ozone
  - Increased concentrations of water vapor

Summary of GWP* 20 and GWP 100 Estimates for Hydrogen			
GWP100 Range of Estimates	GWP20 Range of Estimates	Date of Article	Article Authors
5 +/- 1	---	January 2020	R. G. Derwent, et al
3.3 +/- 1.4	---	August 2021	R.A. Field, R.G. Derwent
12.8 +/- 5.2	40.1 +/- 24.1	November 2022	D. Hauglustaine, et al
8 +/- 2	---	March 2023	R. G. Derwent
11.6 +/- 2.8	37.3 +/- 15.1	June 2023	M. Sand et al
11.5 +/- 6	34.8 +/- 19	October 2023	N. J. Warwick,. et al

*GWP = Global Warming Potential

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NOx & GHG UPDATE

- Preliminary findings from Demand Study evaluated demand across SoCalGas service territory
  - Preliminary findings were then applied to Angeles Link as detailed below

Assessments Update

Demand Scenario	Projected Hydrogen Demand (million MT/yr)		NOx Reductions in 2045 (tpy)		GHG Reductions in 2045 (million MT/yr)	
	Total	Angeles Link	Overall Demand	Angeles Link	Overall Demand	Angeles Link
Conservative	1.9	0.5	13,732	3,763	16.7	4.5
Moderate	3.2	1	17,003	5,292	24.9	7.8
Ambitious	5.9	1.5	20,271	5,141	35.7	9.0

MEMBER DISCUSSION: HYDROGEN LEAKAGE ASSESSMENT

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CLOSING REMARKS

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ANDY CARRASCO
Vice President, Communications,
Local Government and
Community Affairs
SoCalGas

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NEXT STEPS

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- The feedback window on the Demand Study Draft Report will close on February 23, 2024.
- Today's presentation and meeting recording will be available soon on the living library.
  - Microsoft now requires two-step verification to access the living library. If you have any difficulties accessing the library, please let us know.
- If your questions or comments were not answered today verbally, please submit them in writing at your next convenience.
- Please join us for the Q1 Quarterly Meeting on March 5, 2024. Additional details coming soon.

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THANK YOU FOR YOUR PARTICIPATION

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PAG QUARTERLY MEETING AGENDA

- Arrival and Breakfast
- SoCalGas Safety Moment, Land Acknowledgement & Roll Call
- SoCalGas Welcome
- Process Review and Preview of Preliminary Findings: Routing and Configuration Analysis
    - Member Discussion
- Preview of Preliminary Findings: Plan for Applicable Safety Requirements
    - Member Discussion
- LUNCH
- Preview of Preliminary Findings: Workforce Planning and Training Evaluation
    - Member Discussion
- Introduction to Community Benefits Plan Development
- Calendar/Next Steps/Adjourn
- Long Beach Airport Tour

March 5, 2024
10:00 a.m. – 1:30 p.m.

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Planning Advisory Group (PAG)

March Q1 Quarterly Meeting

Warm welcome to our participants!
We will be starting at 10:00 a.m.
to make sure everyone is present.

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WELCOME FROM OUR FACILITATOR

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CHESTER BRITT
Executive Vice President
Arellano Associates
PAG Lead

ALMA MARQUEZ
Vice President Gov. Relations
Lee Andrews Group
CBOSG Lead

SoCalGas

HOUSEKEEPING:

- This meeting will be recorded (video and audio), and a court reporter will be transcribing the meeting. Please announce yourself before you speak
- Zoom microphones are muted by the host to eliminate background noise. You will need to unmute your microphone when called on to speak. *For both in-person and on-line participants please speak directly into the microphone to ensure everyone can hear*
- We encourage you to turn on your cameras so we can better engage with you
- Please feel free to use the Zoom chat to provide input and ask questions throughout the meeting
- If you would like to speak, please use the "Raise Hand" button at the bottom of the Zoom screen
- Wireless microphones will be passed to those speakers attending in person

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AGENDA

- Arrival and Continental Breakfast
- SoCalGas Safety Moment, Land Acknowledgement & Roll Call
- SoCalGas Welcome
- Process Review and Preview of Preliminary Findings: Preliminary Routing/ Configuration Analysis
  - Member Discussion
- Preview of Preliminary Findings: Plan for Applicable Safety Requirements
  - Member Discussion
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SOCALGAS SAFETY MOMENT

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ARMANDO TORREZ
Regulatory and Policy Manager
SoCalGas

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LAND ACKNOWLEDGEMENT & ROLL CALL

SOCALGAS WELCOME

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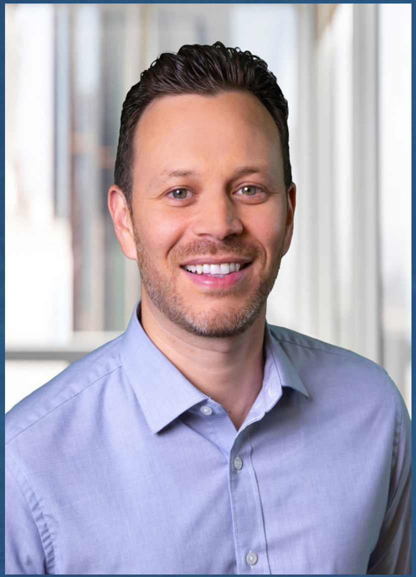

FRANK LOPEZ
Regional Public Affairs Director

SoCalGas

PROCESS REVIEW AND PREVIEW OF PRELIMINARY FINDINGS: ROUTING/CONFIGURATION ANALYSIS

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KATRINA REGAN
Engineering & Technology Development Manager

SoCalGas

Preliminary Routing & Configuration

- Phase 1 Objectives
  - Consider existing pipeline rights-of-way, franchise rights, and designated federal energy corridors
  - Connect identified areas of hydrogen production and demand
  - Identify several preferred routing alternatives for the hydrogen system
- System Evaluation
  - Overall pipeline corridors assessed based on similar geographic, environmental, constructability, and community factors
  - Various production and demand locations considered
- Pipeline Corridor Evaluation
  - Pipeline corridors divided into “segments” to evaluate engineering, environmental, and social criteria

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Segment Evaluation – Feature Glossary

Engineering

Adverse Soil Conditions
Class Location
Existing SoCalGas Right of Way
Fault Areas
High Consequence Areas
Mainline Valve
Overhead/Underground Utilities
Physical Conflict
Pipeline Constructability
Railroad/Road Crossings
Route Length
Sloped Terrain
Trenchless Crossings

Environmental

Coastal Zones
Conservation Areas
Cultural & Tribal Resources
Endangered/Threatened Species
Floodplains
Landfills & Hazardous Waste Sites
Stream Crossings
Wetlands

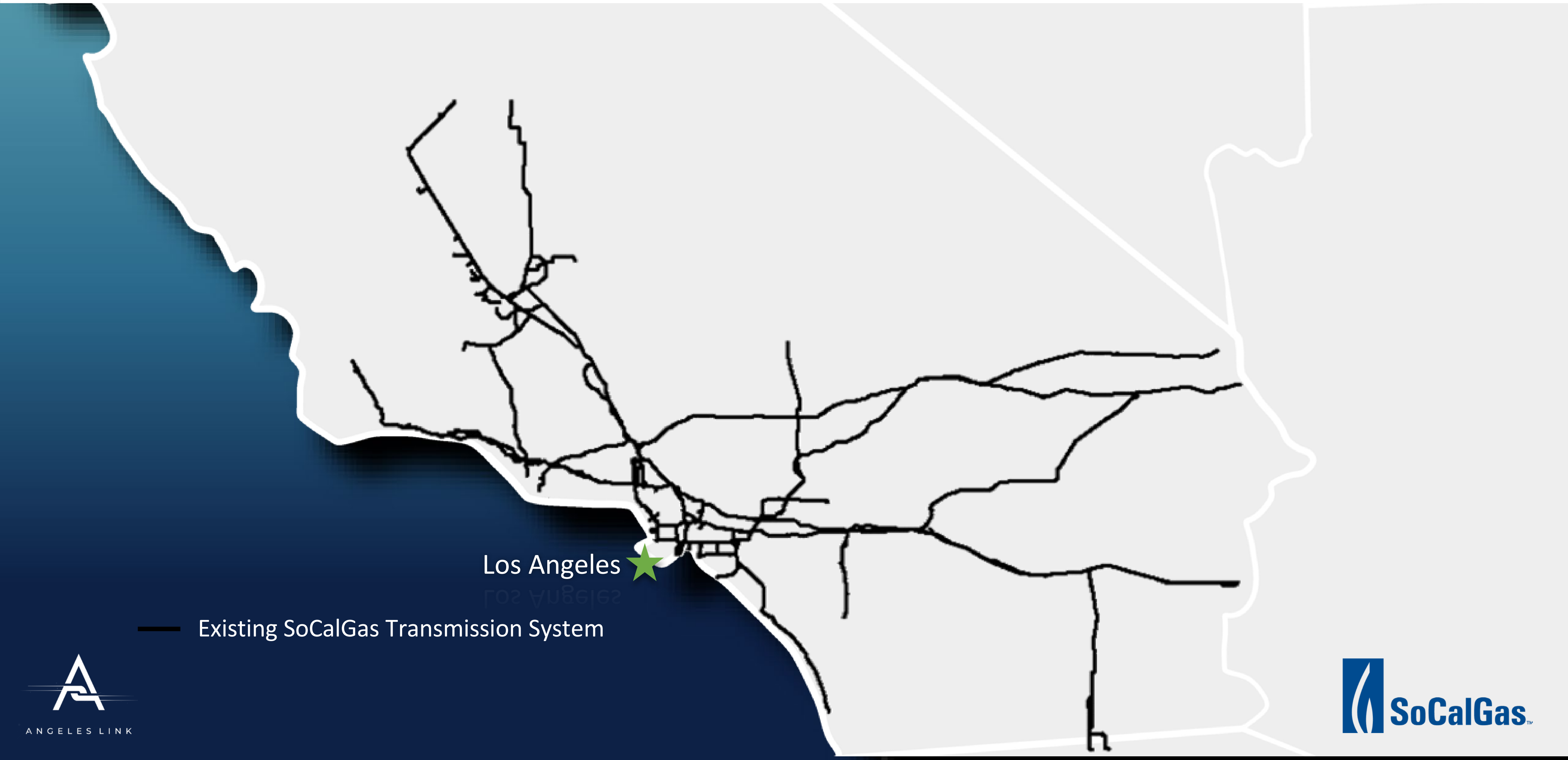
Social

Disadvantaged Communities
Land Use
Military Facility/Property
NRHP Historic Locations
Pasture/Agricultural Land
Proximity to Buildings
Public & Recreational Areas
Special Circumstances

Preliminary Routing Considerations

- Federal Corridors
  - Department of Energy/BLM/Forest Service
    - Energy Corridors on Federal Lands
  - Dept. of Energy and Dept. of Transportation
    - Alternative Fuels Data Center
  - National Pipeline Mapping System (NPMS) by PHMSA
- SoCalGas Existing Infrastructure
- Alliance for Renewable Clean Hydrogen Energy Systems (ARCHES) Initiatives

Existing SoCalGas Natural Gas Transmission System



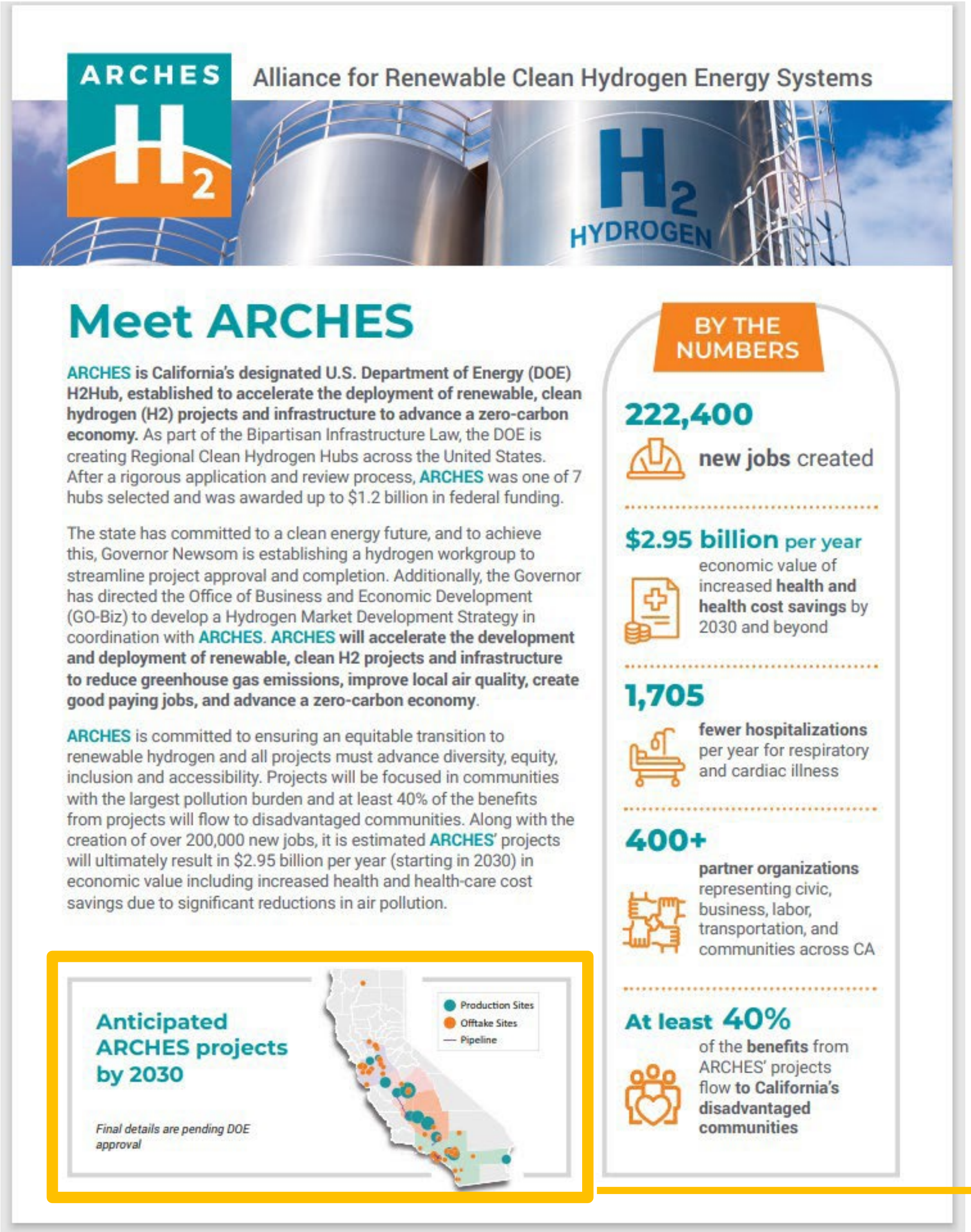
Existing SoCalGas Natural Gas Transmission System & Corridors Under Evaluation

These renderings show evaluated conceptual corridors for the Angeles Link project.

Corridors Under Evaluation

These renderings show evaluated conceptual corridors for the Angeles Link project.

ARCHES



ARCHES H2

Alliance for Renewable Clean Hydrogen Energy Systems

H2 HYDROGEN

Meet ARCHES

ARCHES **is California's designated U.S. Department of Energy (DOE) H2Hub, established to accelerate the deployment of renewable, clean hydrogen (H2) projects and infrastructure to advance a zero-carbon economy.** As part of the Bipartisan Infrastructure Law, the DOE is creating Regional Clean Hydrogen Hubs across the United States. After a rigorous application and review process, ARCHES was one of 7 hubs selected and was awarded up to $1.2 billion in federal funding.

The state has committed to a clean energy future, and to achieve this, Governor Newsom is establishing a hydrogen workgroup to streamline project approval and completion. Additionally, the Governor has directed the Office of Business and Economic Development (GO-Biz) to develop a Hydrogen Market Development Strategy in coordination with ARCHES. **ARCHES will accelerate the development and deployment of renewable, clean H2 projects and infrastructure to reduce greenhouse gas emissions, improve local air quality, create good paying jobs, and advance a zero-carbon economy.**

ARCHES is committed to ensuring an equitable transition to renewable hydrogen and all projects must advance diversity, equity, inclusion and accessibility. Projects will be focused in communities with the largest pollution burden and at least 40% of the benefits from projects will flow to disadvantaged communities. Along with the creation of over 200,000 new jobs, it is estimated ARCHES' projects will ultimately result in $2.95 billion per year (starting in 2030) in economic value including increased health and health-care cost savings due to significant reductions in air pollution.

BY THE NUMBERS

222,400 new jobs created

$2.95 billion per year economic value of increased **health and health cost savings** by 2030 and beyond

1,705 **fewer hospitalizations** per year for respiratory and cardiac illness

400+ **partner organizations** representing civic, business, labor, transportation, and communities across CA

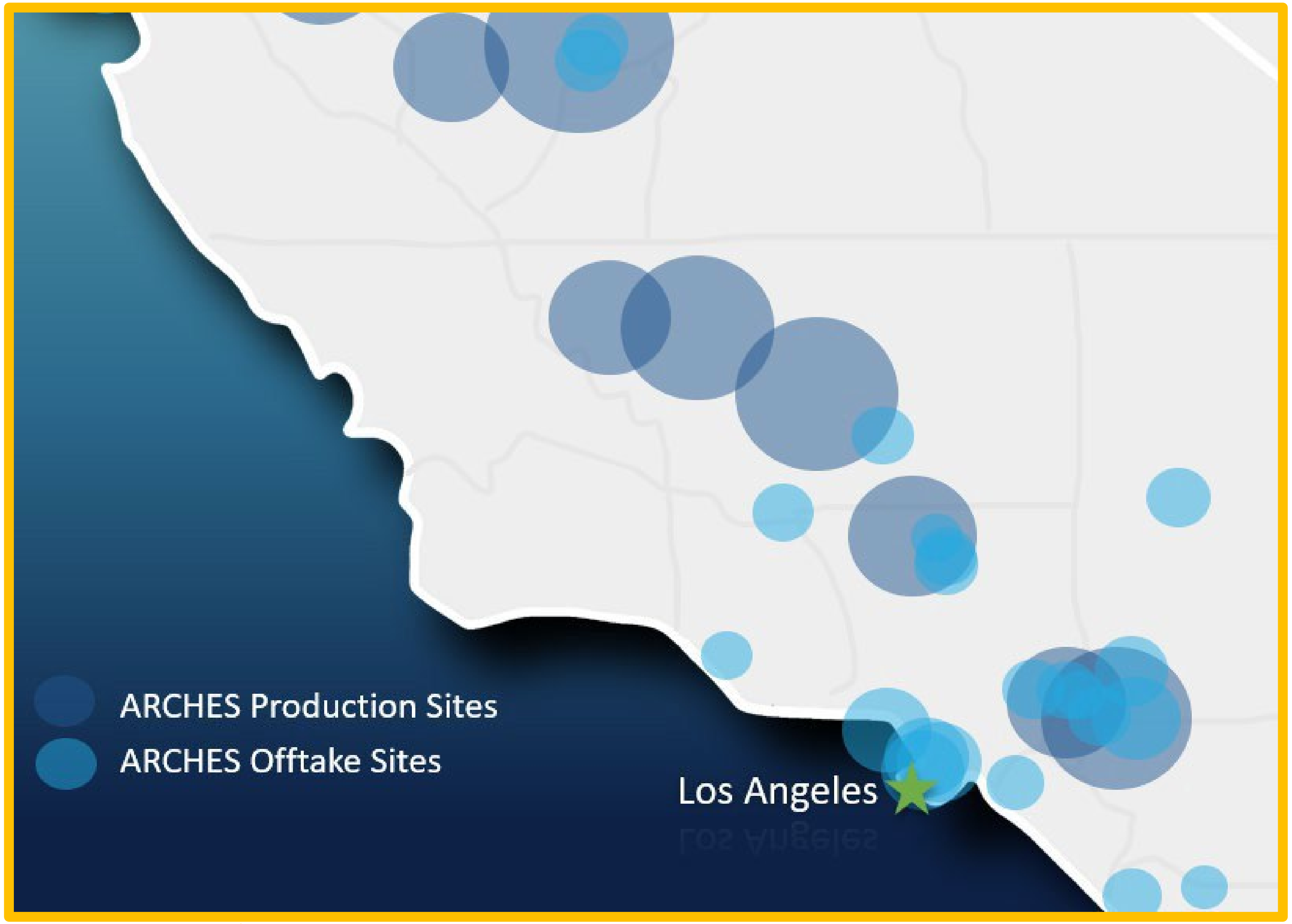
At least 40% of the **benefits** from ARCHES' projects flow **to California's disadvantaged communities**

Anticipated ARCHES projects by 2030

Production Sites
Offtake Sites
Pipeline

Final details are pending DOE approval

ARCHES Fact Sheet, October 2023



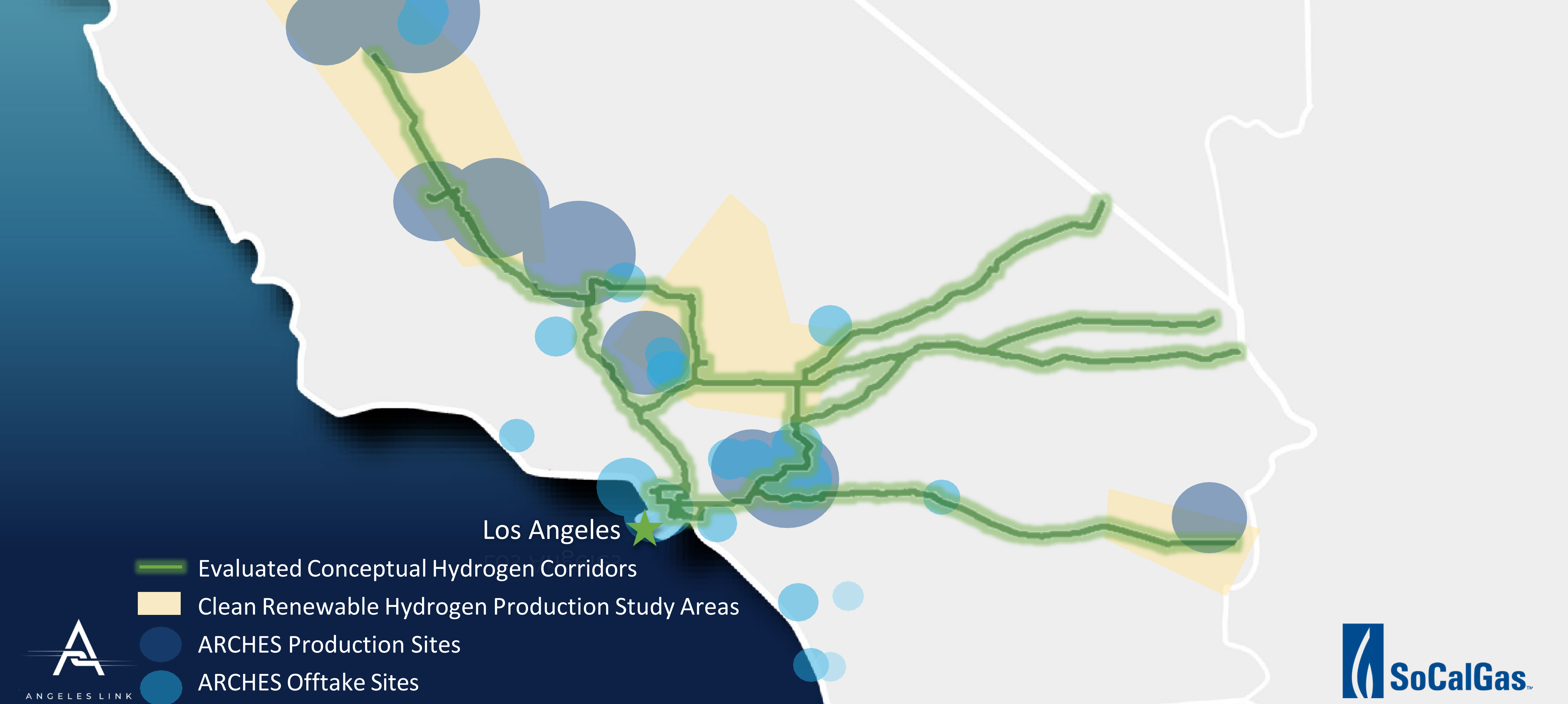
Corridors Under Evaluation

These renderings show evaluated conceptual corridors for the Angeles Link project.

ARCHES Map Derived From ARCHES Fact Sheet, October 2023

Corridors Under Evaluation

These renderings show evaluated conceptual corridors for the Angeles Link project.



ARCHES Map Derived From ARCHES Fact Sheet, October 2023

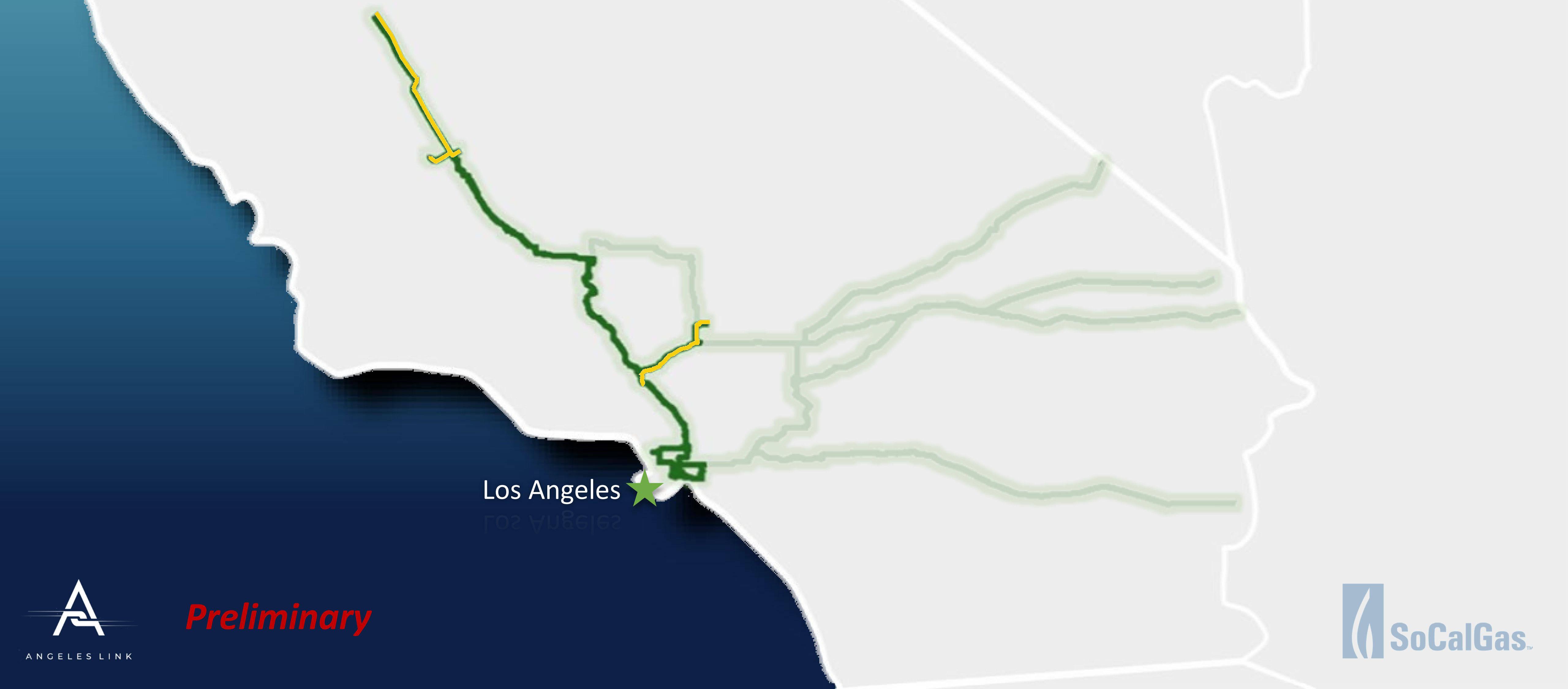
Evaluation Components

Phase 1 Approach: Evaluation of a wide range of routes and corridors that can be narrowed down to a set of preferred routes based on a variety of elements.

- Production
- Demand
- Environmental
- Project Cost
- Resiliency & Reliability
- Land Considerations (ROW/Franchise)
- Route Features (Social, Engineering, Environmental)
- Other Large-Scale California Infrastructure Projects

Conceptual Example 1 of 2

These renderings show conceptual examples that may be evaluated for the Angeles Link project.
Potential Angeles Link routes are still to be determined and analyzed for feasibility including hydraulics, engineering, etc.



Preliminary

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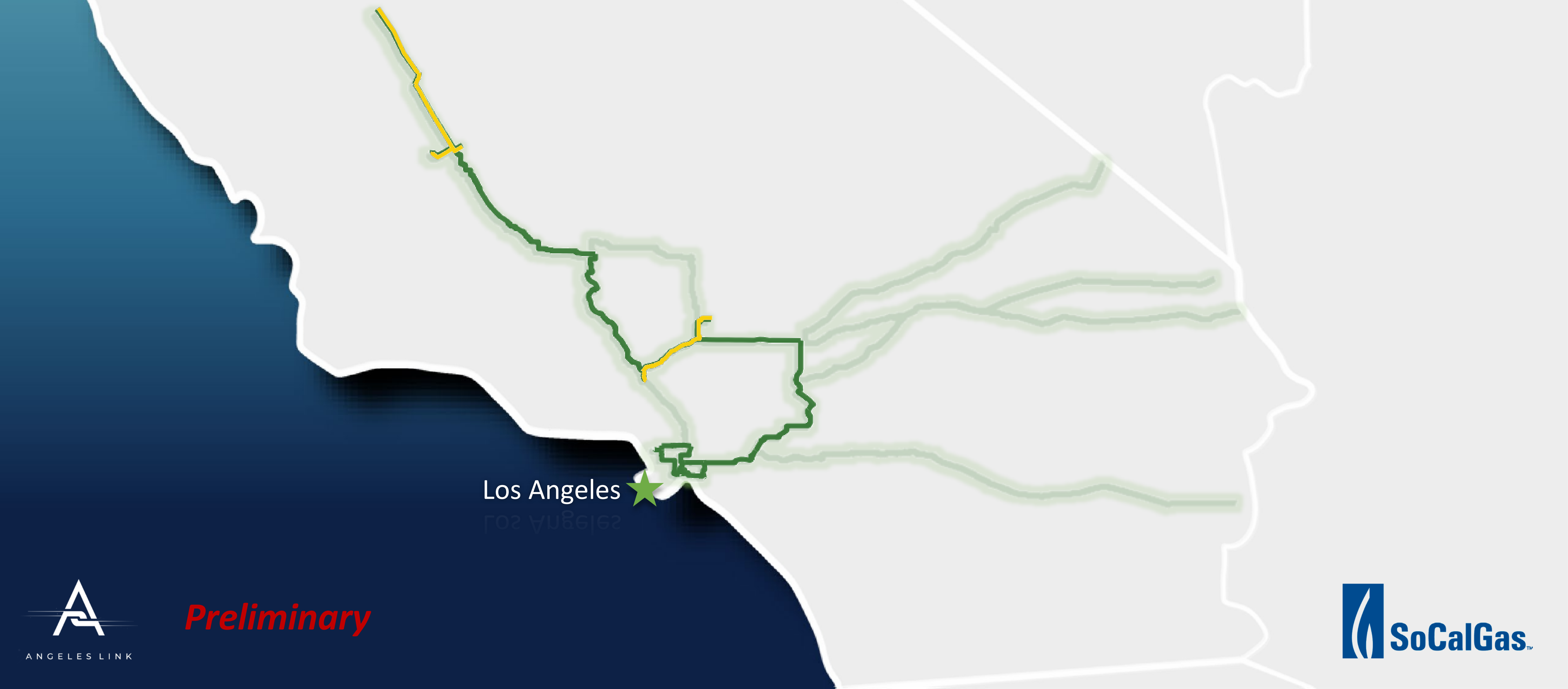
Conceptual Example 2 of 2

These renderings show conceptual examples that may be evaluated for the Angeles Link project.
Potential Angeles Link routes are still to be determined and analyzed for feasibility including hydraulics, engineering, etc.



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Preliminary

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Next Steps

- Phase 1 Routing Study is still underway and is expected to include:
  - Comprehensive Research & Analysis
  - Connect identified areas of hydrogen production & demand throughout the Central and Southern California area
  - Pipeline Corridor Evaluation
- Various configurations are still under evaluation
- The Pipeline Routing/Configuration Study is expected to be completed and shared in Q3 2024
- Phase 2 will determine a preferred route

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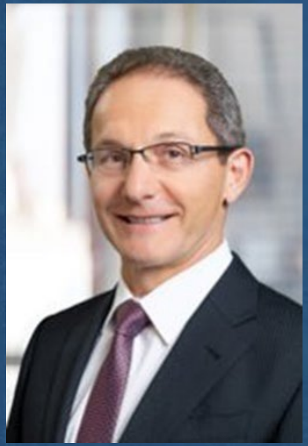
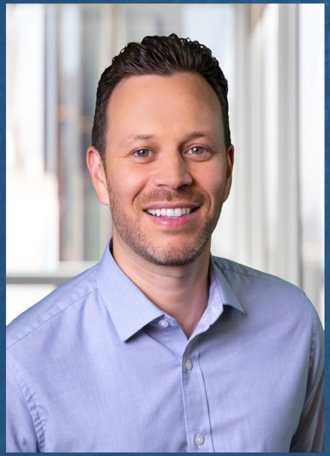


YURI FREEDMAN
Senior Director
Business Development

AMY KITSON
Angeles Link Director
Engineering & Technology



FRANK LOPEZ
Regional Public Affairs
Director

ANGELES LINK

MEMBER DISCUSSION:
PRELIMINARY ROUTING/CONFIGURATION ANALYSIS

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PREVIEW OF PRELIMINARY FINDINGS: PLAN FOR APPLICABLE SAFETY REQUIREMENTS

ANGELES LINK

CHANICE ALLEN
Engineering Project Manager
SoCalGas

SoCalGas

KEY SAFETY CONSIDERATIONS

Failures & Embrittlement

- Material
- Equipment

Operations and Maintenance

- Surveys
- Leakage Detection
- Monitoring

Natural Disasters & Events

- Earthquakes
- Third-party Damage
- Physical & Cyber Security

Operations

- Workforce
- Contractors
- Emergency Responders
- Public

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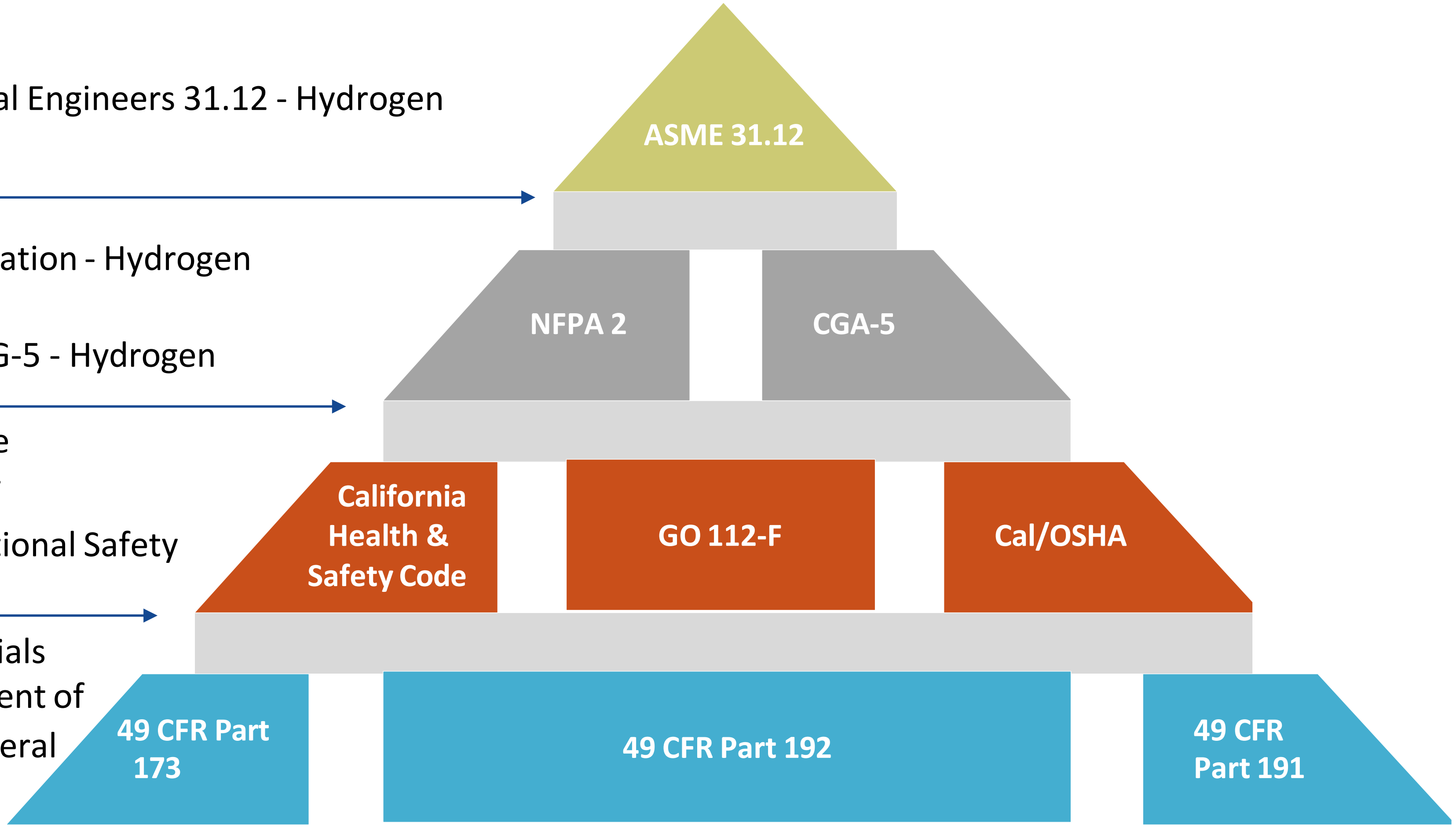
PLAN FOR APPLICABLE SAFETY REQUIREMENTS

- American Society of Mechanical Engineers 31.12 - Hydrogen Piping and Pipelines

- National Fire Protection Association - Hydrogen Technologies Code
- Compressed Gas Association G-5 - Hydrogen

- California Health & Safety Code
- CPUC General Order No. 112-F
- Cal/OSHA - Division of Occupational Safety and Health

- Pipeline and Hazardous Materials Safety Administration, Department of Transportation – 49 Code of Federal Regulations.



DESIGN, CONSTRUCTION, OPERATION & MAINTENANCE

Design & Construction

Design considerations will apply code ASME 31.12 specifically for hydrogen piping and pipeline

Material selection and compatibility will be critical in the safe design and operation for pure hydrogen

Proven welding procedures and technologies used in other industries that are currently using pure hydrogen

Operation & Maintenance

Leak detection equipment is available and can be utilized for hydrogen detection

In-line inspection (ILI) of hydrogen pipelines is feasible

Studies show odorization of pure hydrogen gas is feasible

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PUBLIC AWARENESS PLAN

Public Awareness Program

Safety	Pipeline Safety Resource	API 1162

Audience

- Public
- Emergency planning and response officials
- Public officials and governing councils
- Excavators

Program

- Pipeline purpose and reliability
- Hazard awareness and prevention measures
- Leak recognition and response
- Emergency preparedness communications
- Damage prevention
- Pipeline locations

Communication Method

- Bill inserts
- News release
- Advertising
- Brochures
- Direct mail
- Email
- Safety website
- Meetings

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PUBLIC

REPRESENTATION OF BROCHURE DISTRIBUTED TO THE PUBLIC

Keep the CommunitySafe

Contact 811 Before You Dig – It's Free!

If you plan to install a fence, plant a tree or dig for any reason, protect your family, neighbors and the pipelines near you by following these safety steps:

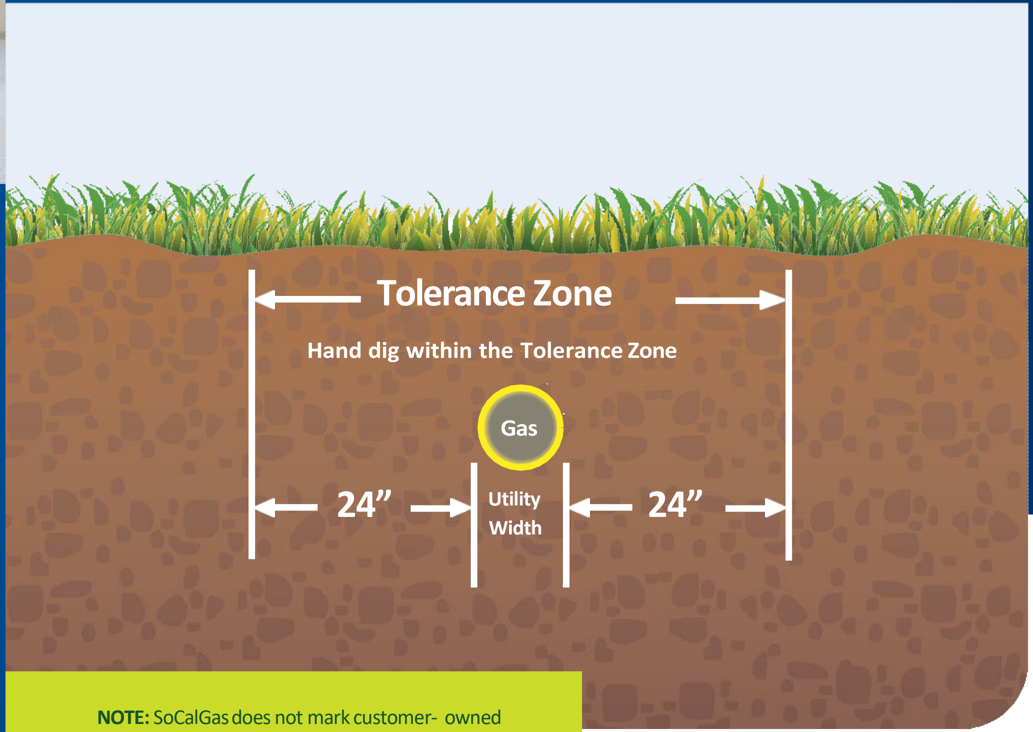
Mark Out your proposed project area in white paint or provide other suitable markings.

Contact 811 at **california811.org** or dial **811**, to submit a location request at least two business days before digging. SoCalGas will be contacted, as well as other local utility owners, to mark the location of all utility-owned lines forfree.

Check utility responses to your 811 ticket by visiting **DigAlert.org** or **USANorth.org**.

For more details, visit socalgas.com/811.

Use Only Hand Tools within 24 inches on each side of marked utility lines to carefully expose the exact locations of ~~all~~ lines.



NOTE: SoCalGas does not mark customer- owned natural gas lines, which typically run from the meter to natural gas equipment. Tolocate and mark customer-owned lines contacta qualified pipe-locating professional.

ANGELES LINK

SoCalGas

PUBLIC

REPRESENTATION OF BROCHURE DISTRIBUTED TO THE PUBLIC

Locate Pipelines Near You

Most pipelines are buried underground. Pipeline markers identify the approximate locations of major pipelines and include our emergency number. Markers do not indicate the depth or number of pipelines in the area. You can view the approximate locations of major natural gas pipelines at **socalgas.com/Map** or on the National Pipeline Mapping System (NPMS) website at **npms.phmsa.dot.gov**.

These maps only indicate the general location of pipelines and should never be used as a substitute for contacting 811 at least two working days before digging.

Pipeline Markings & What They Mean

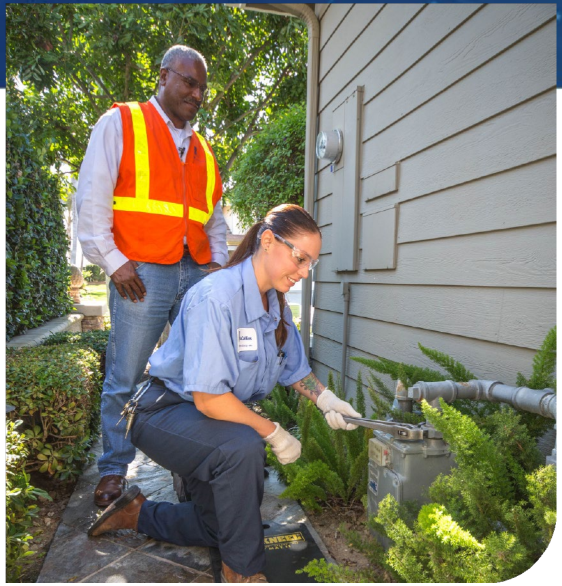
High-visibility markers, like the one below, mark the general location of major pipeline routes.

Contact **811** if you need accurate pipeline location marked.

Utilities Color Codes

- **Red:** Electric
- **Yellow:** Gas, oil, steam
- **Orange:** Communications
- **Blue:** Water
- **Purple:** Reclaimed Water
- **Green:** Sewer
- **Pink:** Temporary Markings
- **White:** Proposed Excavation

ANGELES LINK



Pipeline Maintenance And Your Safety

SoCalGas pipelines deliver natural gas to approximately 22 million residential and business customers. We routinely patrol, test, repair and replace our natural gas pipelines. Our employees also undergo ongoing technical training and testing. We monitor natural gas for quality and add a distinctive odor to aid in the detection of leaks. We also maintain an ongoing relationship with emergency response officials in order to prepare for and respond to any pipeline emergency. For more information on our integrity management plan outline, visit **socalgas.com/PipelineSafety.**

Important Contact Information

Report a pipeline emergency
1-800-427-2200 or 911

Hearing Impaired, call TDD/TTY
1-800-252-0259

Asistencía en español 1-800-342-4545

Contact 811:
Visit **california811.org**
or call 811

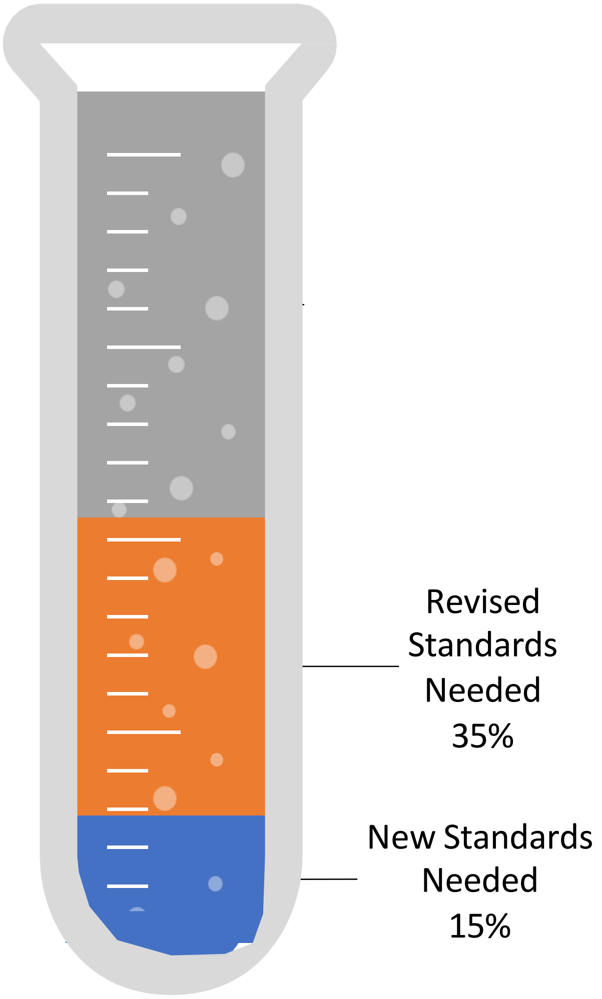
For safety information:
socalgas.com/BeSafe

Para información de seguridad en español:
socalgas.com/Seguridad

SoCalGas

THIRD-PARTY STANDARDS REVIEW EVALUATION AND PROGRESS

- **Reviewed ~1600 existing specification, standards, and protocols (SSPs)**
  - ~500 SSPs may apply to hydrogen infrastructure and subject to potential modifications
  - ~200 potential new SSPs
- **Developing SCG Standards and material specifications around hydrogen**
  - Created eight standards and ten material specification sheets for H2 and hydrogen blends
- **Center for Hydrogen Safety**
  - On-going collaboration with the Hydrogen Safety Panel for an expert third-party review of our Angeles Link Safety Study



CONCLUSION

1. Pipelines are the safest method of transporting large volumes of gas over long distances
2. A comprehensive framework of safety requirements can mitigate hydrogen transport risks
3. SoCalGas has an existing safety framework that can be built upon to include 100% hydrogen transport

ANGELES LINK

SoCalGas

PIPELINE SAFETY: EMERGENCY RESPONSE & MONITORING

ANGELES LINK

LARRY ANDREWS
Director – Emergency Strategy & Operations
SoCalGas

SoCalGas

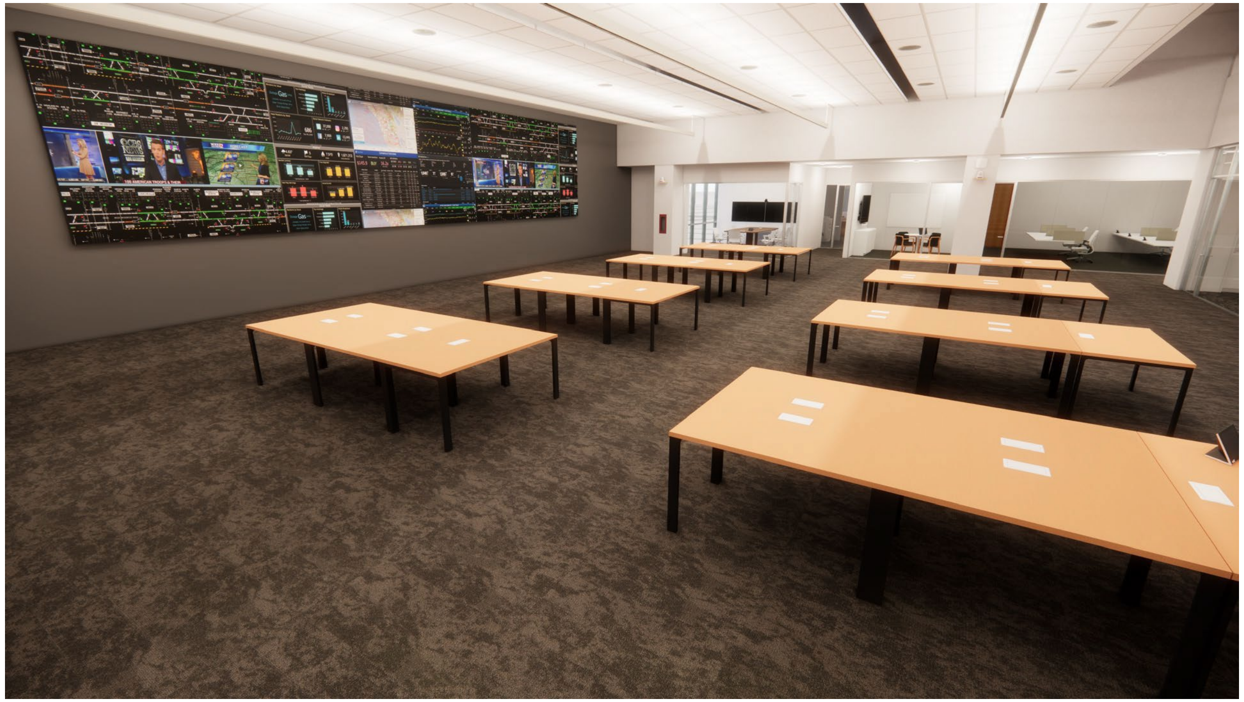
EMERGENCY MANAGEMENT: MONITORING AND RESPONSE

ANGELES LINK

SoCalGas

EMERGENCY MANAGEMENT: MONITORING AND RESPONSE

- Customer Contact Center
- Dispatch
- System Operator
- Watch Desk 24/7



ANGELES LINK

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IMPORTANT INFORMATION FOR FIRST RESPONDERS

- First Responder Education
- EOC/ County Coordinators
- Community Outreach

ANGELES LINK

MEMBER DISCUSSION:
PREVIEW OF PRELIMINARY FINDINGS:
PLAN FOR APPLICABLE SAFETY REQUIREMENTS

ANGELES LINK

- Please announce your name and speak directly into the microphone
- Be concise and focus on discussion topics
- Verbal comments are not the only way to provide input, feel free to type a chat
- We are accepting written input after this meeting if we run short on time, or you think of things later

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LUNCH

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PREVIEW OF PRELIMINARY FINDINGS: WORKFORCE PLANNING AND TRAINING EVALUATION

ANGELES LINK

CHANICE ALLEN
Engineering Project Manager
SoCalGas

SoCalGas

WORKFORCE PLANNING & TRAINING EVALUATION

Workforce Action

- Planning
- Development
- Management

Change Management

- Standards, Protocols, Specifications
- Facilities/Technologies
- Job Tasks/Classification

Regulatory Drivers

- Operations & Maintenance
- Operator Qualifications
- Training

ANGELES LINK

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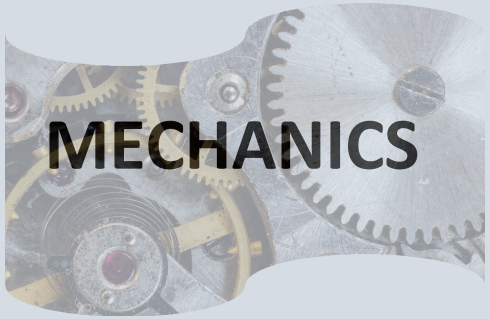
WORKFORCE PLANNING & TRAINING CONSIDERATIONS

- Identify skill requirements, specifically qualifications required for various roles involved in hydrogen pipeline construction and pipeline operations.
- Workforce training for safety and regulatory compliance.
- Identify gaps in the required skills within the existing workforce.

- Determine workforce size to estimate the number of resources needed.
- Continuous monitoring and adaptation for workforce management.



- Education and training given to the project management and operations workforce for material and component selection.
- Operator qualifications to provide appropriate training and awareness to operations personnel.
- Training programs to enhance existing workforce skills and/or prepare new workforce for hydrogen related work.

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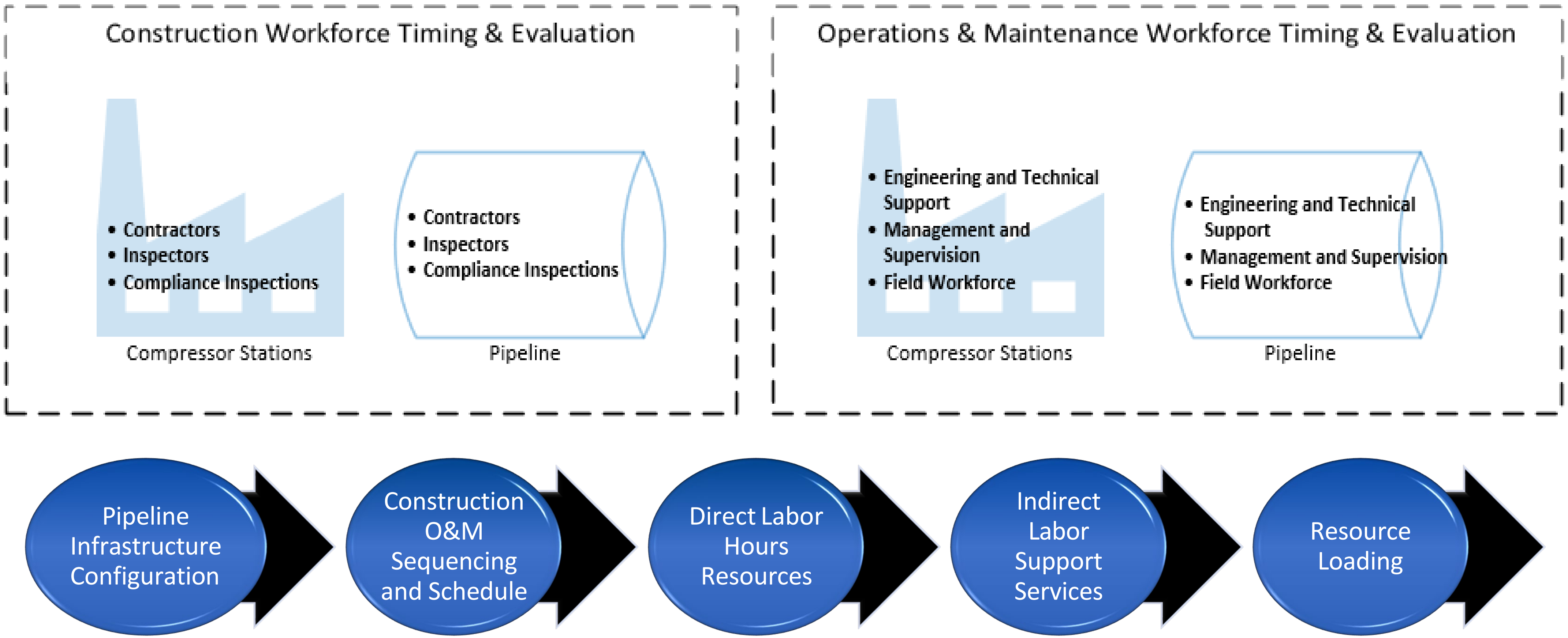
WORKFORCE METHODOLOGY/FORECASTING

Workforce Staging Timing & Evaluation



ANGELES LINK

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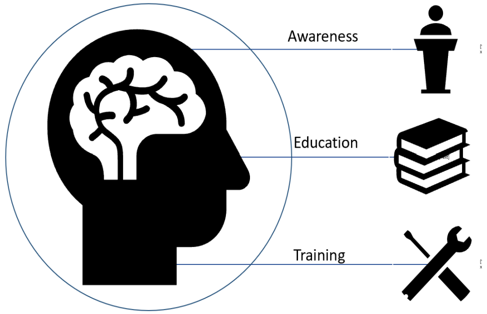
WORKFORCE DEVELOPMENT

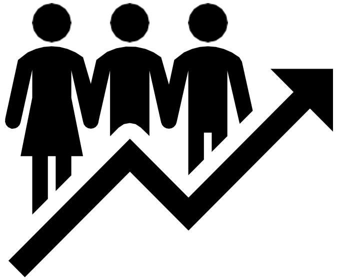
Sharing Knowledge

Collaborate with industry, government, unions, and local communities on workforce initiatives



Workforce Planning

Utilize resourcing data to plan for hydrogen industry workforce needs; new skilled and upskilled workers



Build Hydrogen Job Pathways

Support workforce centers, universities/trade schools, and skills/training programs

ANGELES LINK

SoCalGas

SOCALGAS PROGRESS IN HYDROGEN SAFETY TRAINING & EDUCATION DEVELOPMENT

- **Industry Leading Joint Industry Partnership with DNV and Enbridge**
  - Developing a training program which includes fundamental hydrogen safety curriculum in addition to process engineering and field operations training
  - Currently in Phase 2 – Course Development
- **Nationwide Industry and Academia Partnership**
  - Developing newly trained personnel, and enabling the existing workforce in the four key technical pillars that form the basis for the hydrogen industry: production, delivery, storage, and end-use with safety as a foundation woven throughout
  - Local university partnership coming soon
- **AltaSea Supporting Partner**
  - Providing industry knowledge in partnership with AltaSea working together with LA Harbor College in developing a Marine Hydrogen Certification program for regional workforce training
  - In addition to the Los Angeles Unified School District (including Inglewood and Lawndale), 15 + community-based organizations work with AltaSea including: Boys and Girls Clubs of the LA Harbor, Santa Monica College, Wilmington's Strength Based Community Change (SBCC), and the Watts Entrepreneur Education Center

DNV

H_2EDGE

AltaSea
AT THE PORT OF LOS ANGELES

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MEMBER DISCUSSION:
PREVIEW OF PRELIMINARY FINDINGS:
WORKFORCE PLANNING AND TRAINING EVALUATION

- Please announce your name and speak directly into the microphone
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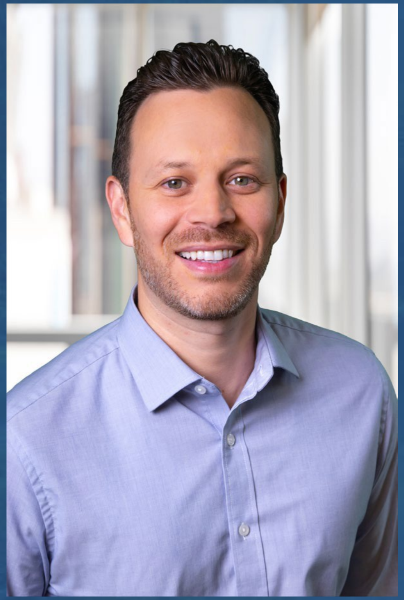
INTRODUCTION TO COMMUNITY BENEFITS PLAN

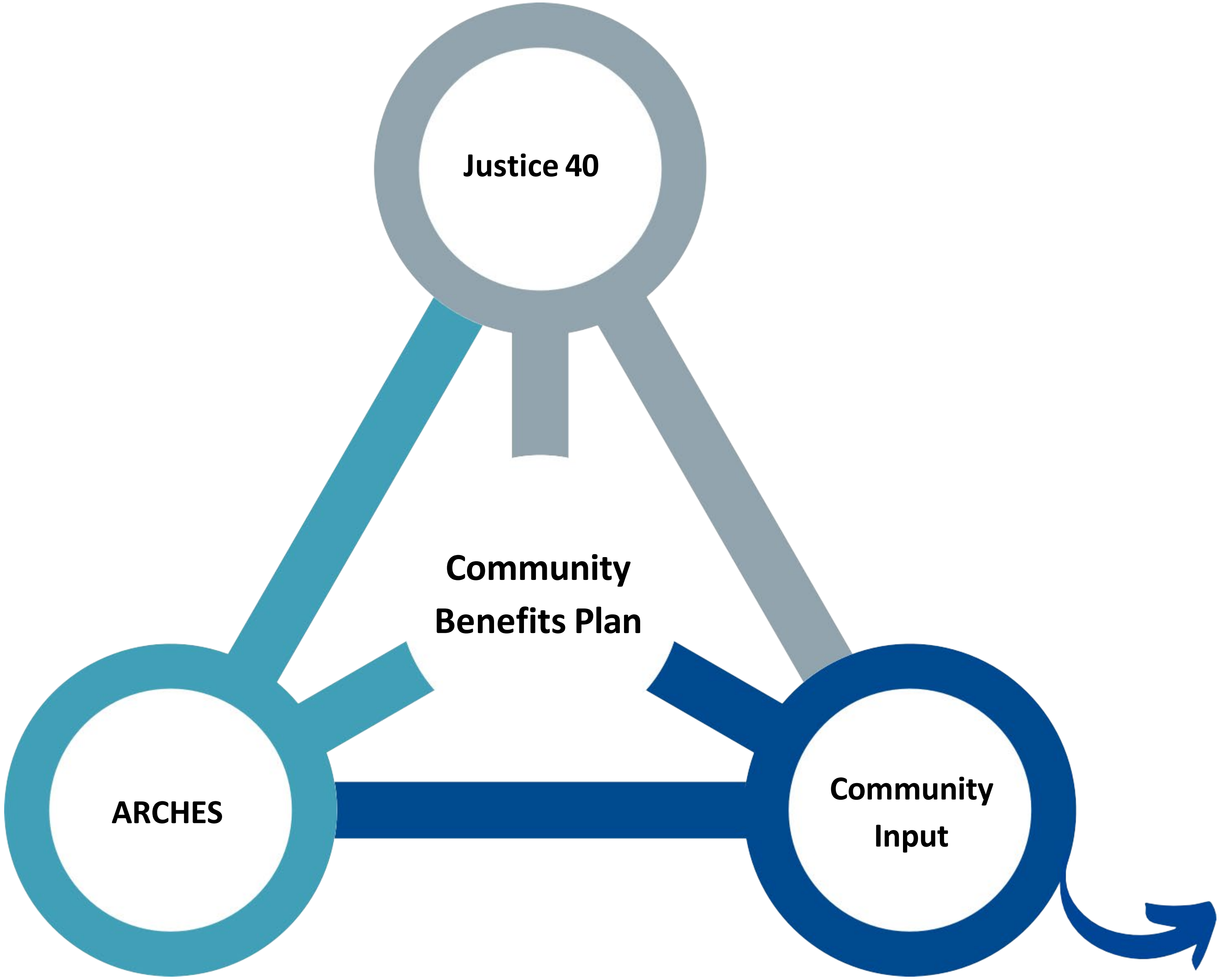
ANGELES LINK



Frank Lopez
Regional Public Affairs
Director
SoCalGas

SoCalGas

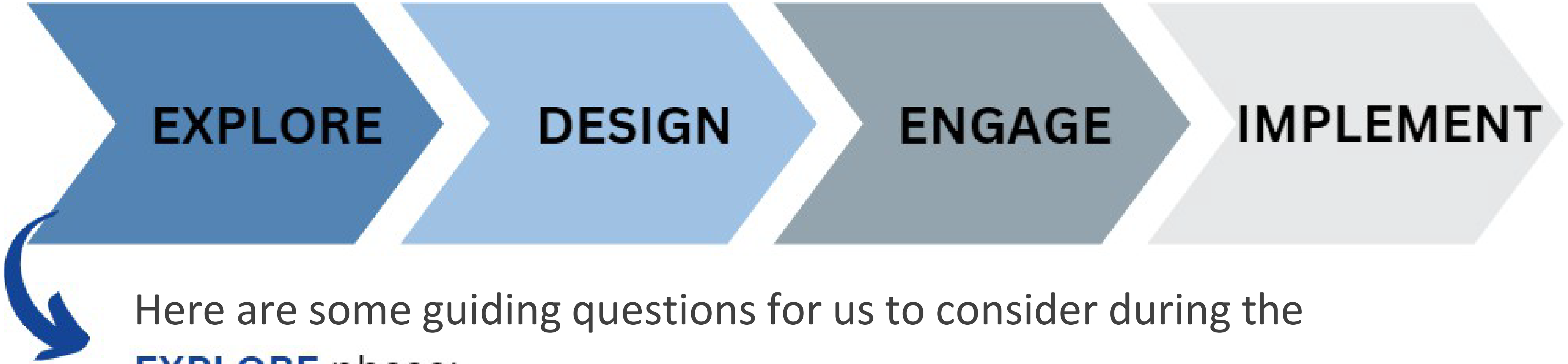
CRITERIA



Topics

- Education
- Economic and Workforce Development
- Health and Safety
- Diversity, Equity, and Inclusion
- Environmental/ Environmental Justice

PROCESS & NEXT STEPS



Here are some guiding questions for us to consider during the **EXPLORE** phase:

1. Have you been involved in designing a CBP for a large-scale infrastructure project?
2. Can you provide examples or best practices of strategies that have worked?
3. What strategies have not worked?
4. Are there any other creative ideas/ solutions?

NEXT STEPS

ANGELES LINK

- The Water, Leakage, GHG Emissions Evaluation, and NOx preliminary findings were posted on the Living Library on Tuesday, February 27 and will be open for feedback until Friday, March 29
  - PAG Feedback: ALP1_Study_PAG_feedback@insigniaenv.com
- Today's presentation and meeting recording will be available soon on the living library
  - Microsoft now requires two-step verification to access the living library. If you have any difficulties accessing the library, please let us know
- If you have questions or comments, please submit them in writing at your next convenience

SoCalGas

L ACH AIRPORT TOUR
THANK YOU FOR YOUR PARTICIPATION
Storm Water and Best Management Practices
Southern California Gas Company® proudly states this landscape captures tens of thousands of gallons of potentially hazardous runoff and is Ocean Friendly. Here's how it works:
• Rain is captured on the roof with drains, grates and gutters
• The runoff then is transported throughout the landscape by perforated pipes in gravel filled trenches, eliminating standing water
• The pipes eventually lead the water to dry streambeds where much of it will sit and infiltrate
• To minimize erosion, excessive and possibly damaging runoff from large storms is directed to overflow drains that quickly transport it to the storm drain system
SoCalGas

APPENDIX 8 – LINK TO PAG AND CBOSG MEETING RECORDINGS

PAG Recordings

February 15th, 2024 – PAG 2/15/24 February Workshop Meeting

March 5th, 2024 – PAG 3/05/24 March Quarterly Meeting

CBOSG Recordings

March 4th, 2024 – CBOSG 3/04/24 March Quarterly Meeting

APPENDIX 9 – SUMMARY OF CBO STAKEHOLDER MEETING

CBOSG MARCH QUARTERLY MEETING SUMMARY

3/04/2024 CBOSG Q1 March Quarterly Meeting (10:00AM – 2:00PM)

Attendee Report: 16 in-person attendees; 10 virtual attendees (3/04); 21 CBOs represented
Link to full attendance: 3.04.24 CBOSG Attendee List.xlsx

Topics for discussion: Preview of Preliminary Findings for Routing, Safety, Workforce Development, and an introduction to Community Benefits Plan

Link to full presentation: CBOSG March Q1 Quarterly Meeting

Feedback Themes:

- CBOs priorities of interest included environmental and health impacts, environmental justice, engaging disadvantaged communities including multi-lingual outreach and support, and diverse representation in workforce programs, providing education and training programs that are adaptable, transparency, and long-term support for people entering and currently in the workforce.

    - During the Preview of Routing Preliminary Findings and Routing Process discussion the following themes emerged:
        - CBOs requested more detail in the preliminary routing maps, including jurisdictions, school proximity, and overlays that includes health and environmental impacts to disadvantaged communities
        - Community benefits including education and training programs, mitigation opportunities, and beautification were also discussed during this session
        - Requests were made to understand more about Alliance for Renewable Clean Hydrogen Energy Systems (ARCHES)
    - During the Preview of Safety Preliminary Findings discussion the following themes emerged:
        - Inquiries on the types of materials that will be used for the pipelines, seeking transparency about their safety standards and an understanding of industry norms for hydrogen infrastructure
        - Emphasis the need for clear, digestible information regarding pipeline safety that can be easily understood by the community. Suggestions include communication strategies, language considerations, and educational programs for different community groups, including schools
        - Concern about the readiness and additional burdens on the workforce
        - Importance of training and preparing first responders
    - Following the safety discussion, CBOSG members participated in a "Walk the Walls" activity to answer the following questions:
        - What strategies does your organization employ to disseminate critical safety information to stakeholders and the wider community?
        - How can SoCalGas effectively communicate critical safety information to stakeholders and the broader community?
        - Can you share examples of successful initiatives where your organization effectively responded to emergencies and mitigated risks?
        - What additional safety and risk mitigation strategies do you believe SoCalGas should consider?
    - The following themes emerged:
        - Using various social media platforms, NextDoor, Facebook, WhatsApp, Instagram, Local Weekly
        - Disseminate information using newsletters, text messages, townhall meetings, local broadcasts, radio, and podcasts
        - Diverse outreach approaches, including a multilingual and multi-generational approach with age-appropriate explanations
        - Create lesson plans for teachers/ education programs
        - Community needs assessments
        - Partner with organizations and other entities already engaged with the community
    - During the Preview of Preliminary Findings for Workforce Development discussion the following themes emerged:

        - There was a commendation for the presentation by JTM Academy and graduates, highlighting its importance and potential for expanding such initiatives
        - Curiosity about recruitment strategies and age groups targeted by the workforce programs
        - The desire for collaboration between SoCalGas, training academies, and CBOs was clear to maximize and ensure that opportunities are presented to those who need them most
    - Following the workforce discussion the CBO members broke up into small groups and answered the following questions:
        - How can we collaborate with you and other CBOs and stakeholders to develop effective training and education programs for hydrogen safety?
        - What factors should SoCalGas consider when establishing hydrogen workforce initiatives to ensure fair and equitable outcomes for environmental justice and disadvantaged communities?
        - If you have prior experience in workforce development, what strategies have proven successful in partnerships, and where do you see room for improvement?
    - The following themes emerged:
        - Community collaboration and partnerships
        - Diversified recruitment and outreach
        - Transparency and comprehensive information
        - Incentives and support systems
        - Representation and inclusion
        - Continuous improvement and adaptability
        - Educational investment and career development

Highlights:

- Graduates from the JTM Academy's partnership through the LA Urban Legue presented on their experience training with JTM and getting hired at SoCalGas
- The preliminary "EXPLORE" stage of the Community Benefits Plan was previewed at this meeting

Next Steps:

- During the June Quarterly Meeting, the CBOSG will further discuss best practices for Community Benefits Planning, prioritizing:
    - Workforce and Education
    - Cost and Economic Development
    - Safety and Health
    - Environmental Justice/Environmental Social Justice
- The group was asked to come prepared to answer the following questions:
    - Have you been involved in designing a CBP for a large-scale infrastructure project?
    - Can you provide examples or best practices of strategies that have worked?
    - What strategies have not worked?
    - Are there any other creative ideas/solutions?
- Feedback on the NOx and GHG studies are due March 29th, 2024, at 5:00 pm.

APPENDIX 10 – SUMMARY OF PAG MEETINGS, INCLUDING ATTENDEE ROSTERS

SoCalGas Angeles Link
Planning Advisory Group (PAG)
PAG February Workshop Summary

2/15 PAG February Workshop (10:00AM-12:00PM)
Energy Resource Center, Downey, CA & Zoom

I. Attendee Report

- 2/15: 1 in-person & 23 virtual attendees.

Please refer to Attachments A for a complete list of attendees.

II. Purpose

- Provide an update on ARHCES
- Provide information and solicit input from PAG members on the following topics:
    - Preview of Water Resources Evaluation
    - Preview of Hydrogen Leakage Assessment, including an update on GHG and NOx

III. Presentation Highlights and Feedback Themes

- **Preview of Water Resources Evaluation:** The presentation focused on the water availability study, which is used to identify the potential water supply sources needed to support clean, renewable hydrogen. The study considered various water supply sources, estimated water needs to meet hydrogen demand, and highlighted the importance of engaging with water supply agencies to navigate California's complex regulatory landscape.
    - Feedback Themes:
        - Suggestion to include the energy budget for different water purification methods in the water study to help understand the net benefits of hydrogen production.
        - Request for clarification on whether the water study is based on the quantity of hydrogen that is listed in the Draft Demand Study.
        - Question on whether the water study for the Angeles Link project accounted for both the net and gross water demands, emphasizing the significance of gross water needs in regions facing water scarcity, even if recycled back into fresh supplies.
        - Question on whether the study calculated how much diesel and gasoline might be offset from transportation usage.
        - Emphasis on the importance of accurately determining costs prior to submitting to the CPUC. Inquiry about the inclusion of embedded energy costs in water treatment and conveyance for different sources in the Angeles Link project.

    - Suggestion to enhance the study by considering the importance of forecasting changes in conveyance, water rights, and conservation requirements and noting the potential doubling of water costs per acre-foot, which impacts the affordability equation.

- **Preview of Hydrogen Leakage Assessment:** The presentation provided a high-level preview of the hydrogen leakage assessment which evaluates potential for leakage associated with new infrastructure and evaluates mitigation opportunities. The presentation also provided a NOx and GHG update which showed preliminary findings from the Demand Study applied to Angeles Link.
  - <u>Feedback Themes:</u>
    - General appreciation for the update on NOx and GHG.
    - Suggestion to include recent studies on global warming potential for the leakage assessment.
    - Concerns leakage on EJ communities. Request for the assessment to consider leakage of other fossil gases in the study, such as biogas or ethanol.
    - Request for clarification on parameters for the .01% estimate for new pipelines.
    - Suggestion to assess nonpipeline alternatives.
    - Suggestion to break down GHG and NOx reductions by sector to understand what is driving the reductions.
    - Request for clarification on the production methods assumed for leakage emissions.

SoCalGas Angeles Link
Planning Advisory Group (PAG)
PAG March Q1 Quarterly Meeting Summary

3/5 PAG Q1 Quarterly Meeting (10:00AM-2:00PM)
Long Beach Airport Mariott, Long Beach, CA & Zoom

I. Attendee Report

- 03/05: 7 in-person & 23 virtual PAG attendees.

Please refer to Attachments A for a complete list of attendees.

II. Purpose

- Provide information and solicit input from PAG members on the following topics:
  - Process Review and Preview of Preliminary Findings: Routing and Configuration Analysis
  - Preview of Preliminary Findings: Plan for Applicable Safety Requirements
  - Preview of Preliminary Findings: Workforce Planning and Training
  - Introduction to Community Benefits Plan Development

III. Presentation Highlights and Feedback Themes

- **Process Review and Preview of Preliminary Findings: Routing and Configuration Analysis:** The presentation focused on a preview of routing and configuration work based on studies found in phase one. The presentation outlined how various data sources and evaluation components have helped identify and consider several potential hydrogen routes. While considering pipeline routes, the study also considered communities, terrains, and environmental factors. The presentation shared two maps with potential hydrogen pipeline route choices and production and offtake sites from ARCHES.
  - Feedback Themes:
    - Request for SoCalGas' definition of environmental justice and how Angeles Link is taking environmental justice into account.
    - Questions on whether SoCalGas has reviewed the data and regulations from PHMSA to identify concerns of transporting hydrogen.
    - Request for further explanation of the differences between the two conceptual map examples.
    - Request for further inquiries on the characteristics of the blue ARCHES bubbles and yellow regions shown on the map.
    - Regarding the "Corridors under Evaluation" slide, questions on whether the routes closest to the CA border without a production site will receive connections to out-of-state production/networks.
    - Inquiries on whether routes will include hydrogen mixing with natural gas.

    - Question on how the project assesses the risks of transporting hydrogen alongside existing natural gas networks (routes).
    - Suggestion to identify routes that are not co-located with existing natural gas networks.
    - Concerns on whether existing routes are too crowded due to existing pipeline infrastructure in the same area.
    - Comment on current constraints on how the project needs to identify other potential routes to avoid having to reroute outside the existing right-of-way.
    - Concerns that the project does not identify multiple alternative routes equally for NEPA and CEQA evaluation under the CPUC.
    - Comment on excitement about starting work on the pipeline work and maintenance.
    - Question on what steps the project has taken to engage the communities who live along pipeline routes and how engagement is being handled at this stage [of the project].
    - Question on whether the Demand Study had any influence on the routes that were being shown.
    - Question on whether outreach has been conducted to communities living alongside the routes previously or if there will be outreach in the future.
    - Inquiry on whether offtake sites will only distribute to power stations or different potential offtakers.
    - Request for clarification on definitions for corridor, route and right-of-way in terms of the project phase.
    - Questions on the timeline of when the pipeline will be ready.
    - Inquiry on what power plants will receive/ be a part of the distribution system.

- **Preview of Preliminary Findings: Plan for Applicable Safety Requirements:** The presentation focused on key safety considerations, highlighting existing regulations, codes, and standards applicable to hydrogen transportation, as well as SoCalGas' efforts to adapt its procedures and protocols for hydrogen transport. The presentation also discusses collaboration with industry experts and ongoing evaluations to identify and address potential gaps in safety protocols. It concluded by providing an overview of the integration of operational groups and the centralization of information to improve internal coordination and communication with public partners.
  - <u>Feedback Themes:</u>
    - Question on whether the hydrogen system operator would be the same for the gas system.
    - Clarification on what is the Center for Hydrogen Safety.
    - Comment from union representative on how their workers are called and are ready when a problem has occurred.
    - Question on whether the mega rule will also apply to the ASME 31.12.

- **Preview of Preliminary Findings: Workforce Planning and Training:** The presentation emphasized the need to support both the existing and emerging workforce with the necessary skills and training for the hydrogen industry. The presentation discussed assessing existing facilities and technologies for potential modifications and identifying skill requirements and job classifications for hydrogen infrastructure. It also highlighted the need for knowledge sharing and promoting job opportunities within the hydrogen industry, including initiatives to develop education and training programs tailored to building job pathways.
    - Feedback Themes:
        - Request for clarification between the safety and workforce presentations.
        - Clarification on existing hydrogen pipeline transportation and workforce planning.
        - Comment on the eagerness to learn and develop a workforce training program.

- **Introduction to Community Benefits Plan Development:** The presentation focused on the importance of robust community engagement and input to ensure that the plan addresses the needs and priorities of affected communities. Examples include beautification projects, workforce development programs, local procurement initiatives, and small business investments.
    - Feedback Themes:
        - Request for clarification on the definition of community benefits.
        - Question regarding workforce training: whether SoCalGas will notify City of Long Beach when hydrogen training becomes available.
        - Inquiry on when SoCalGas will share the community benefits plan.
        - Request for SoCalGas to consider adopting a requirement for hydrogen to adhere to the three pillars of clean hydrogen.
        - Questions regarding when Phase One ends and when Phase Two application will be available.