

# SoCalGas and AQMD

Webinar



Natural Gas for High Horsepower Engine

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# LNG consist

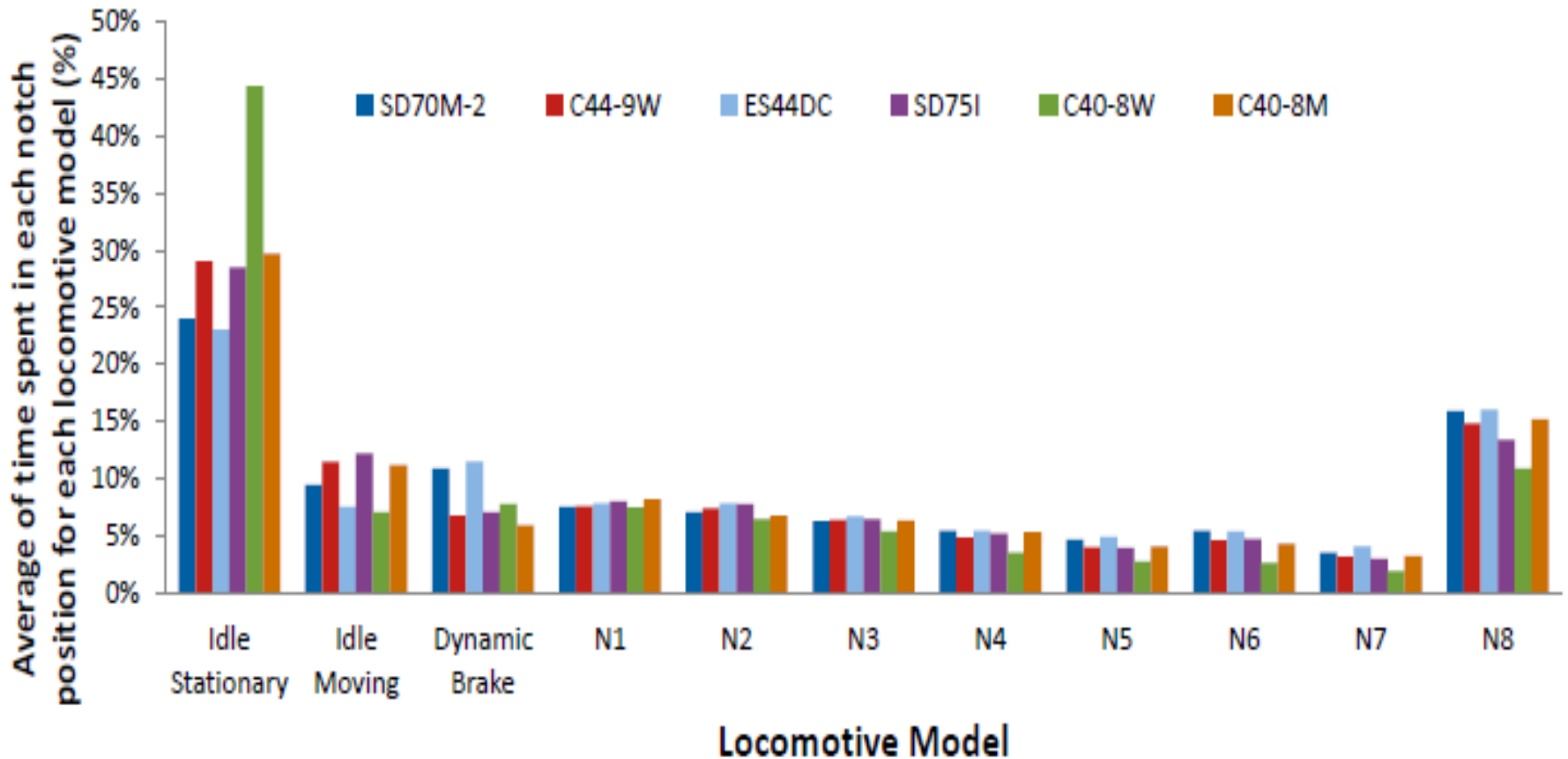
## Trial test on main line



# Locomotive Usage

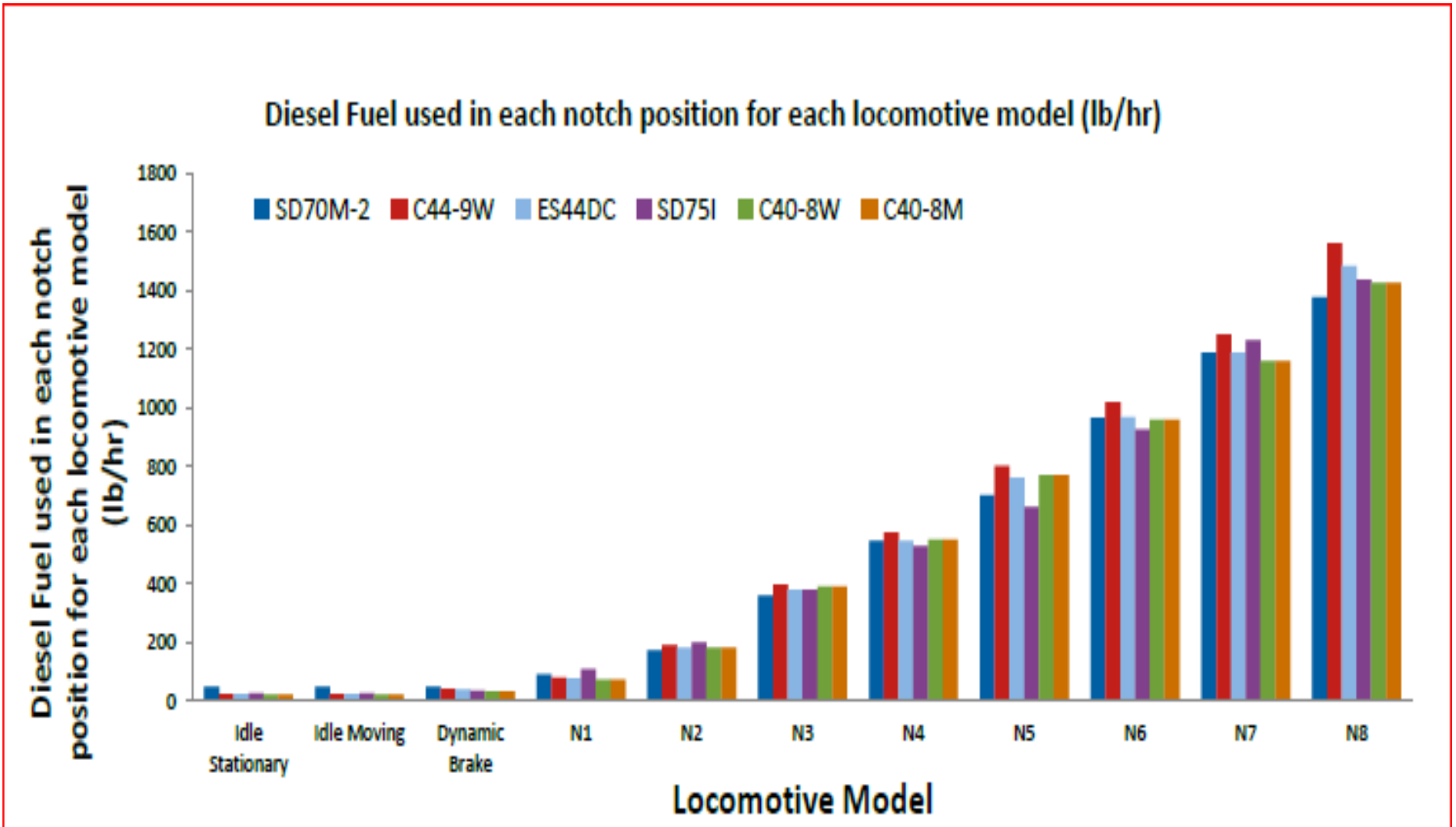


Average of time spent in each notch position for each locomotive model (%)



# Fuel usage

Main line





# Engine



- Locomotive fleet is a mix ( different HP and manufacturers)
- Average fuel consumption on main line



# Engine



- What are the technologies
- Key effects and performance
- Performance profile
  - Power, fuel consumption, emissions, cleanliness of the gas, substitution rate
- Ability to operate at high power rating
- Gas conversion via retro-fit
- Gas quality consideration (methane, propane, butane )



# Engine substitution

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- Two technical approaches:
  - High Pressure Direct Injection
  - Low Pressure (port or direct injection)
- Various type of injections
  - Existing system, modified injectors, pilot injectors, etc.



# Locomotive substitution



- Target of 85 % rate of substitution, have to look at a 95 % of diesel substitution at higher notch
- Substitution is linked to load profile; therefore impact on the conversion of the fleet, higher load usage more cost effective conversion
- Identify technology that will deliver a > 95 % fuel substitution rate
- Retrofit locomotives with high load operating profile



# Tender



LNG tank car tender provides highest range even when shared between two locomotives

CNG requires one tender per locomotive

Summary of Tender Car Concepts (Selection)

	Concept Name	Specs <sup>1</sup>	Range <sup>2</sup> Gas 85/15	Est. cost per unit	Time to Fuel	Locos Powered
	LNG Tank Car	25.5k gal 0-150 psi -263° F	2,200 mi	\$0.9 M	35 min @ 700 gpm	2 locos per tender
	LNG Intermodal 53'	12.5k gal 0-150 psi -263° F	2,200 mi	\$0.6 M	18 min @ 700 gpm	1 loco per tender
	CNG Tank Car	24.0k gal 3,600 psi 60° F	1,600 mi	\$1.0 M	144 min @ 5,000 scfm 60 min @ 12,000 scfm	1 loco per tender
	CNG Intermodal (FPC)	16.4k gal 3,600 psi 60° F	1,100 mi	\$1.0 M	96 min @ 5,000 scfm 40 min @ 12,000 scfm	1 loco per tender



# Tender



- Method of transferring
- Type, size, location of compressors pumps
- Location and size of heat exchanger, pressure regulator
- Cooling components
- Complexity of systems



# Tender consideration

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- Range (volume of tank)
- Output power
- System mass
- Costs development / conversion , operational (fuel)
- Plant and Infrastructure, maintenance and breakdown
- Emissions and waste
- Controllability ,fuel flow and distribution on-board
- Fuel safety collision/rupture safety, exhaust fire / explosion
- Fuel storage self pressurization
- Gas / cryo link between loco and tender
- Contamination of fuel at refuel
- Gradient effects on fuel flow (fuel slosh) use baffles & have gasification on loco, rather than tender , Icing up of fuel lines
- Use of Commercial Off-The-Shelf (COTS) components
- Readiness levels of technology / manufacturing /
- Failure of tender coupling, thermal cycling / fatigue life, vibration (at cold)
- Adequate grounding; static build-up

# Refuelling efficiency



- Time to fill (less than 30 minutes)
- Sizing of the fuel system
- Gas supply pressure available
- Number of nozzles
- Cost of the systems



# Safety



- Compressed gas at a minimum distance from locomotive
- Safety of the tank
- Safety at the refuelling



# Business Case

Key factors to consider



- Engine hardware and performance requirements
- Tender and options
- Refuelling and safety impacts
- Cost of capital to replace the fleet
- Implementation

# Key challenges



## Finding the proper trade-offs



### Business Case Optimization Workshops

- Assess/optimize infrastructure tradeoffs: storage vs. compression; buffer stock; etc.
- Define bus. case for targeted supply hubs
- LNG - Make vs. buy; further CNG investigation
- Conversion ramp up timing validation
- Regulatory approval support

### Tender Supplier Selection and Sourcing

- Define component group for sourcing
- Assess universe of suppliers
- Define selection criteria and conduct RFQ
- Down-select to targeted design partners and commodity suppliers

### Natural Gas Fuel Option Implementation

- Tender vehicle program management
- Supplier interface, production & launch support
- Tender design review; identification of design and cost optimization opportunities
- Locomotive supplier interface/collaboration

### Tender Program Delivery

- Location selection, sizing, and layout
- Define storage, compression, refrigeration; fuel flow rate needs; assess trade-offs
- Railyard equipment sourcing
- Refuel and maintenance process optimization

### Coordination of Supply Hub Development