



Near-Zero Emissions Natural Gas Engines

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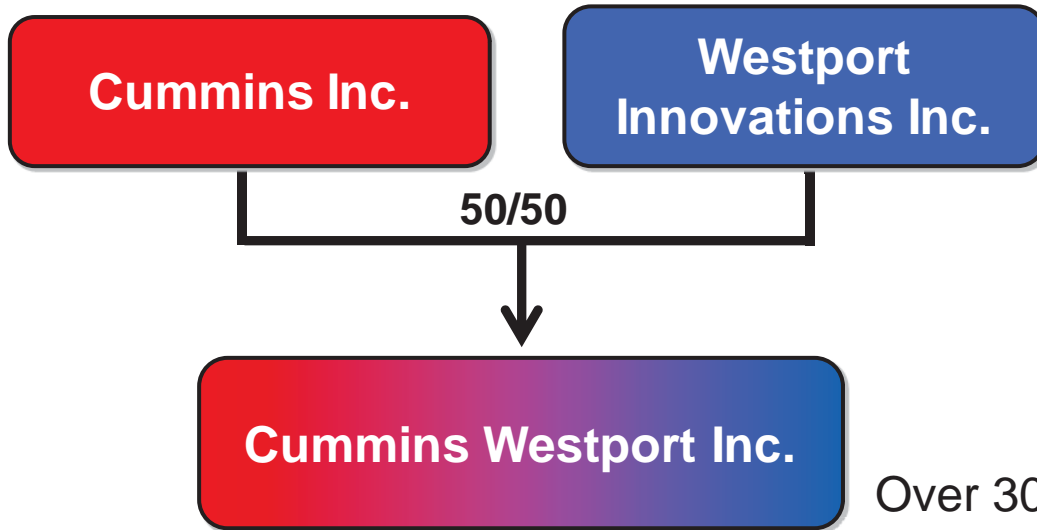
Director, Product & Market Planning

Explore Every Alternative.

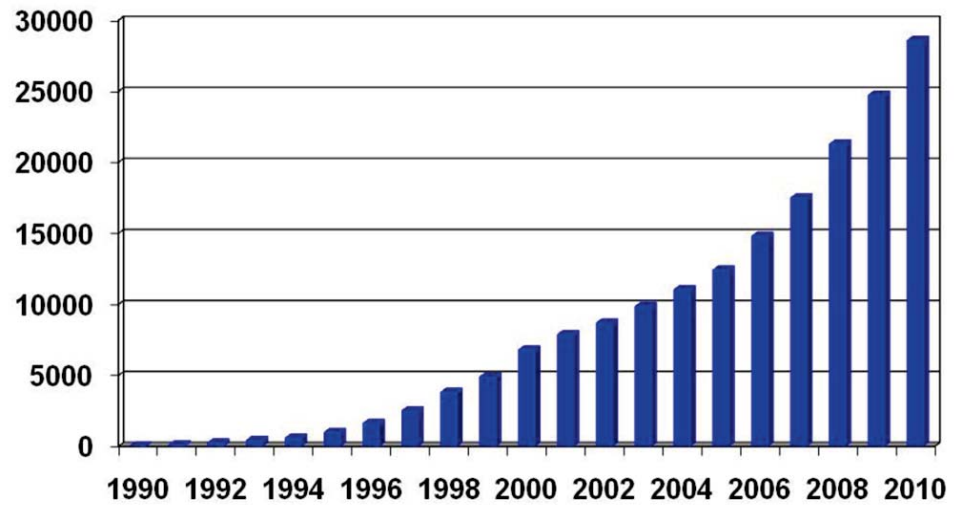
Agenda

- Cummins Westport Overview
- Current Emissions Profile
- Near-Zero Emissions Potential

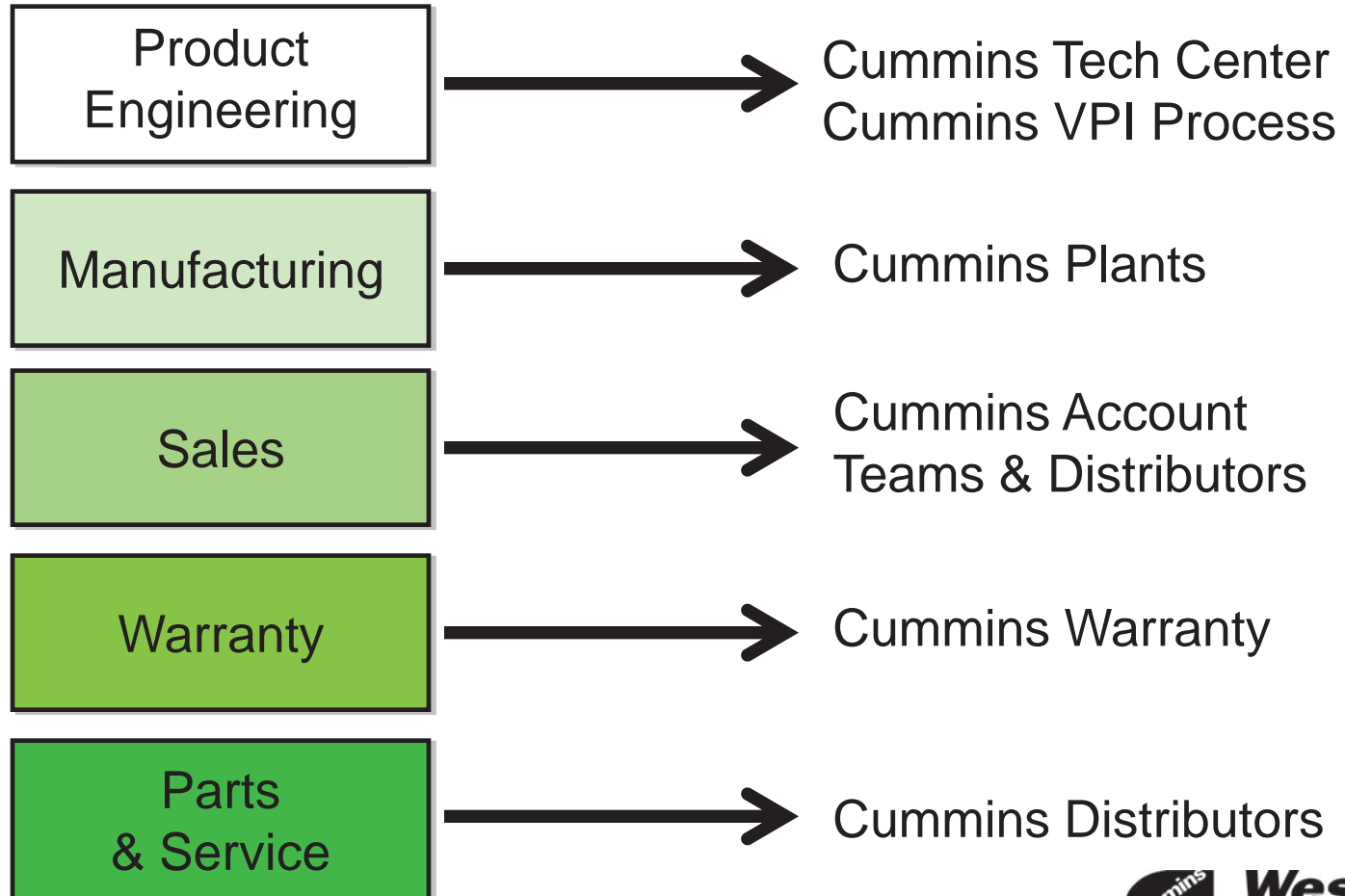
Corporate Overview



Over 30,000 Engines Delivered To Date

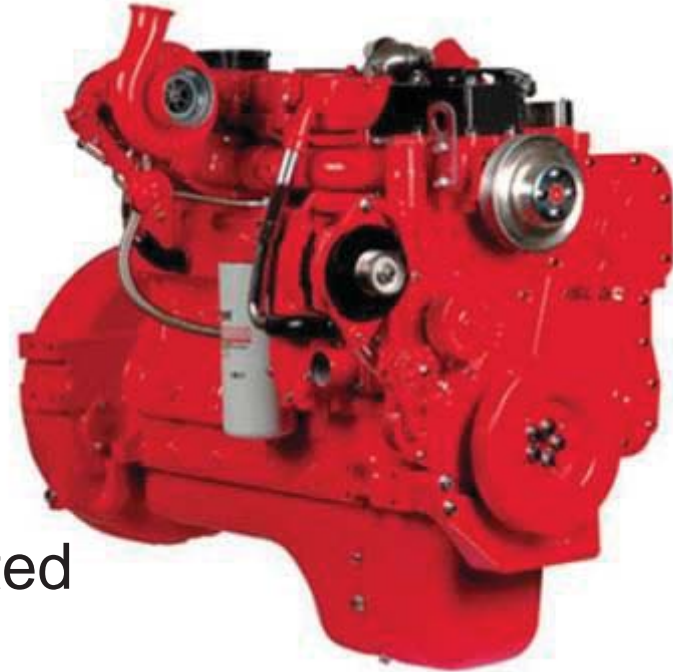


Cummins Westport: Fully integrated within Cummins. We are Cummins' automotive natural gas engine company.



ISL G

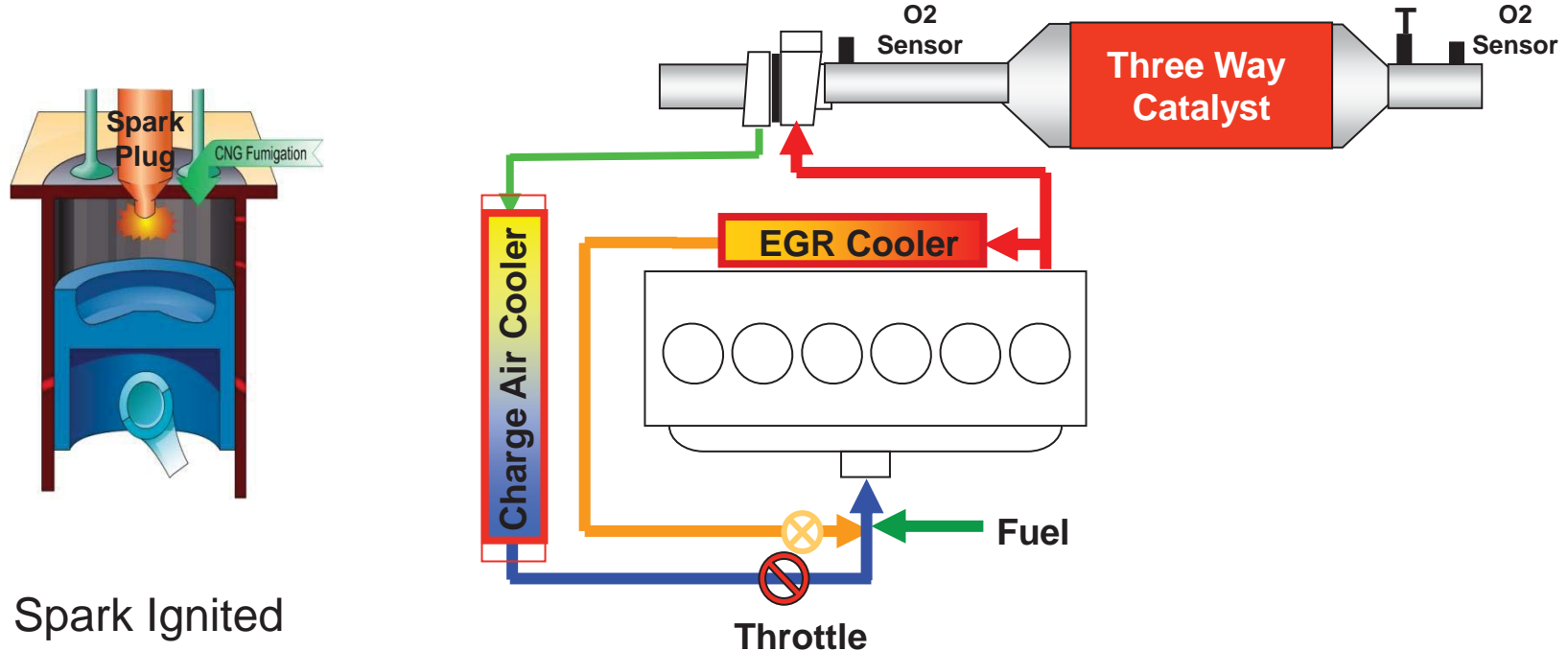
- 8.9 Litre (540 cu. In.)
- In line 6 cylinder
- Spark Ignition
- Peak Rating:
 - 320 hp, 1000 lb-ft
- Three Way Catalyst Aftertreatment
- Manufactured & tested as a dedicated natural gas engine in Cummins Engine Plant - Rocky Mount, North Carolina
- First engine in North America certified to 2010 EPA/CARB standards (2007)
- Broad OEM availability
 - Trucks & buses



ISL G



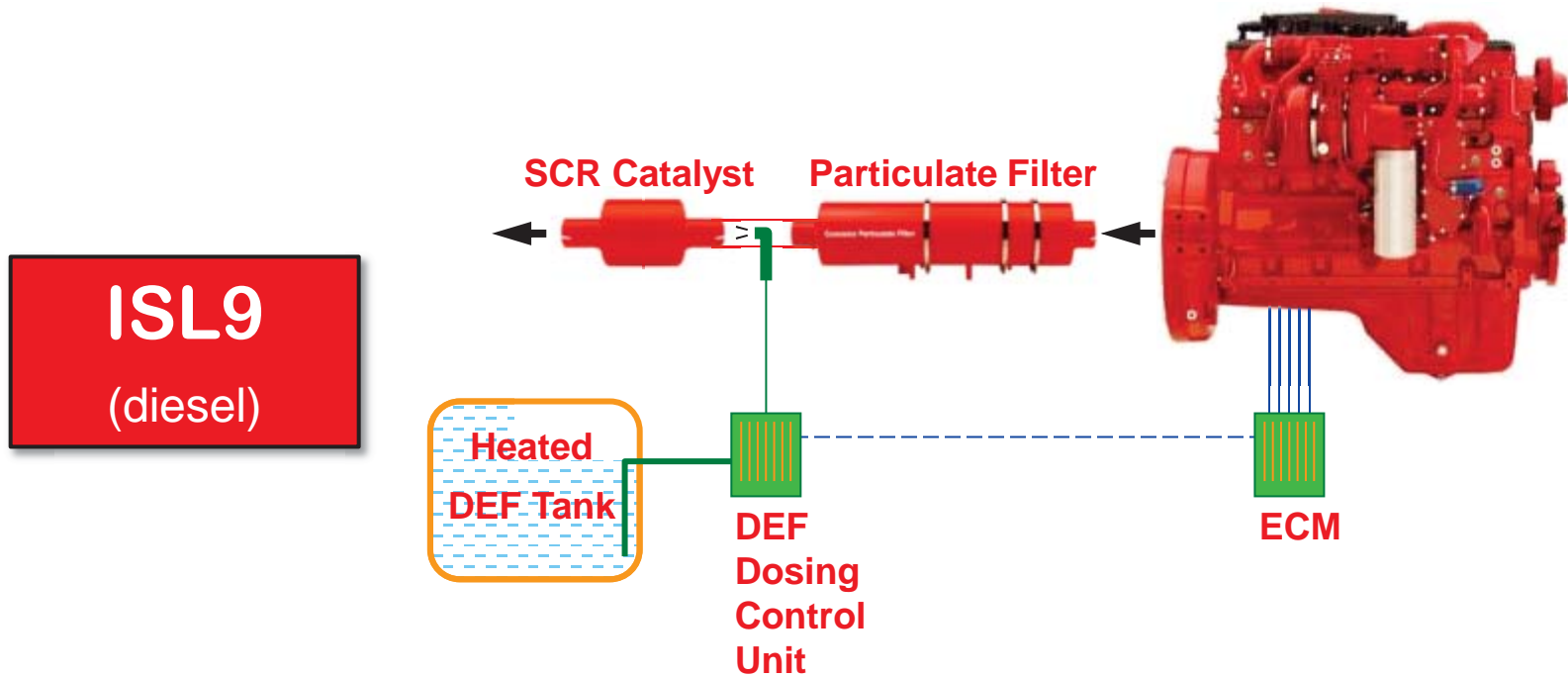
ISL G Engine Architecture



Spark Ignited

- Based on Cummins ISL9 diesel engine platform
 - Over 80% parts commonality

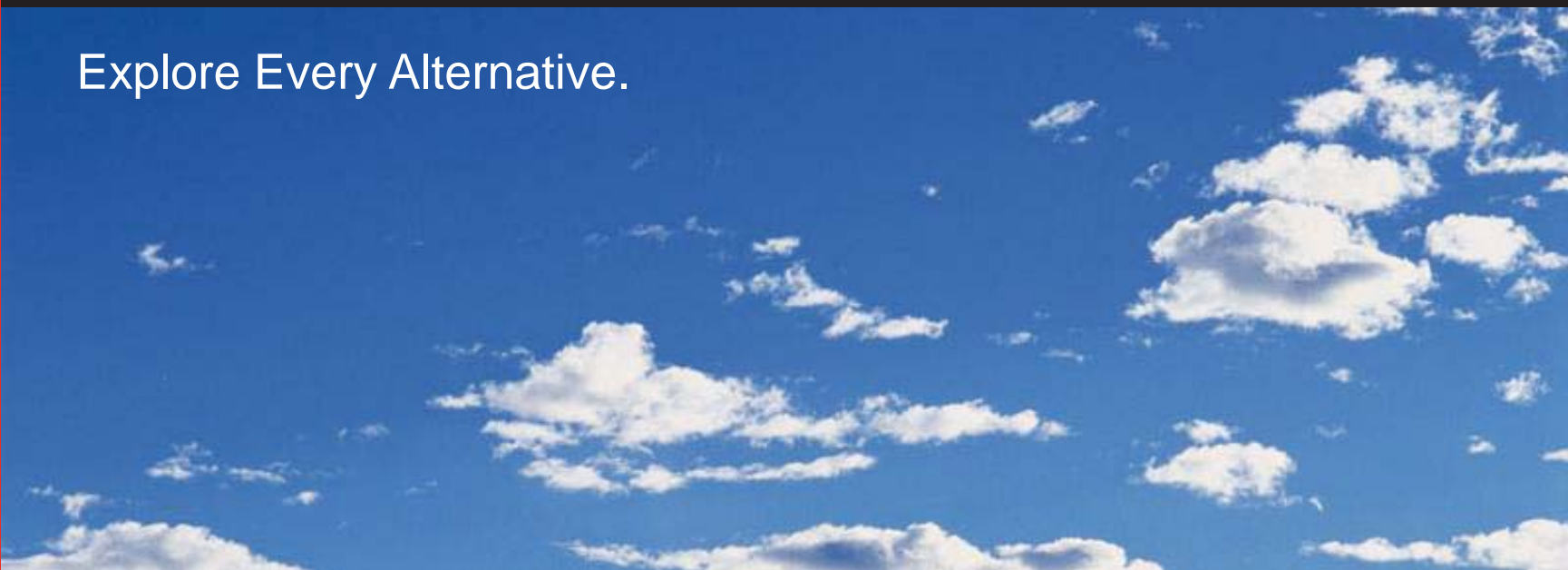
Aftertreatment Comparison





ISL G Current Emissions Profile

Explore Every Alternative.



CARB Executive Order



ISL G is below 2010 NOx and PM regulations

	NMHC		NOx		CO		PM	
	FTP	EURO	FTP	EURO	FTP	EURO	FTP	EURO
STD	0.14	0.14	0.20	0.20	15.5	15.5	0.01	0.01
CERT	0.06	0.06	0.13	0.01	9.8	8.0	0.002	0.001

- Cummins Westport is focused on NOx & PM
 - PM is 80% below the standard
 - NOx is 35% below the standard

Greenhouse Gas Emissions (GHGs)

- Natural gas offers significant GHG benefits on a “full fuel cycle” or “well-to-wheels” basis
 - GHG profile varies as a function of fuel source, path to market, CNG vs. LNG
- ARB Low Carbon Fuel Standard analysis¹

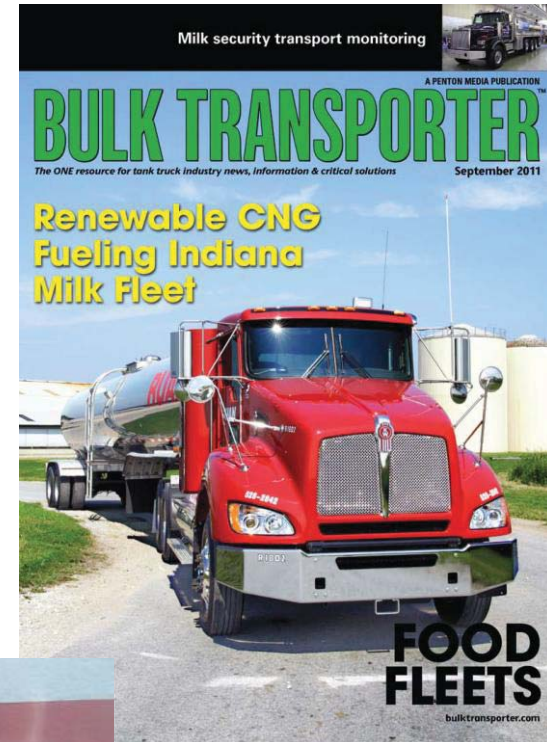
Fuel	Fuel Pathway	WTW Emissions (g CO2e/MJ)	% GHG Reduction vs. ULSD
ULSD	California ULSD	94.7	-
Conventional Natural Gas Pathways			
CNG	North America NG	68.0	28.2%
LNG	North America NG	83.1	12.3%
Renewable Natural Gas Pathways			
CNG	Landfill Gas	11.3	88.1%
CNG	Dairy Digester Biogas	13.5	85.8%
LNG	Landfill Gas	26.3	72.2%
LNG	Dairy Digester Biogas	28.5	69.9%

1. Cummins Westport analysis of ARB LCFS data, <http://www.arb.ca.gov/fuels/lcfs/lcfs.htm>



Renewable Natural Gas Improves GHG Profile

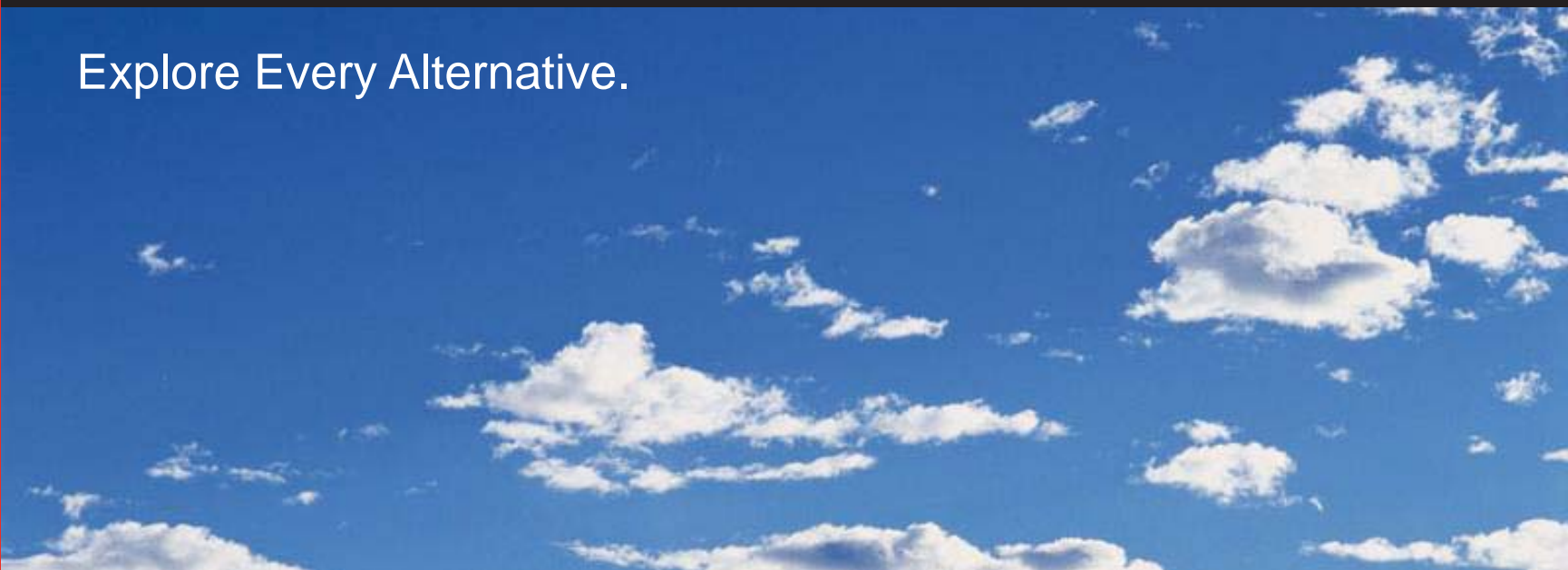
- ISL G can operate on renewable natural gas (aka biomethane) blends, including 100% biomethane
- ISL G engines are in operation with renewable natural gas from landfills & dairy farms





ISL G Near-Zero NOx Program

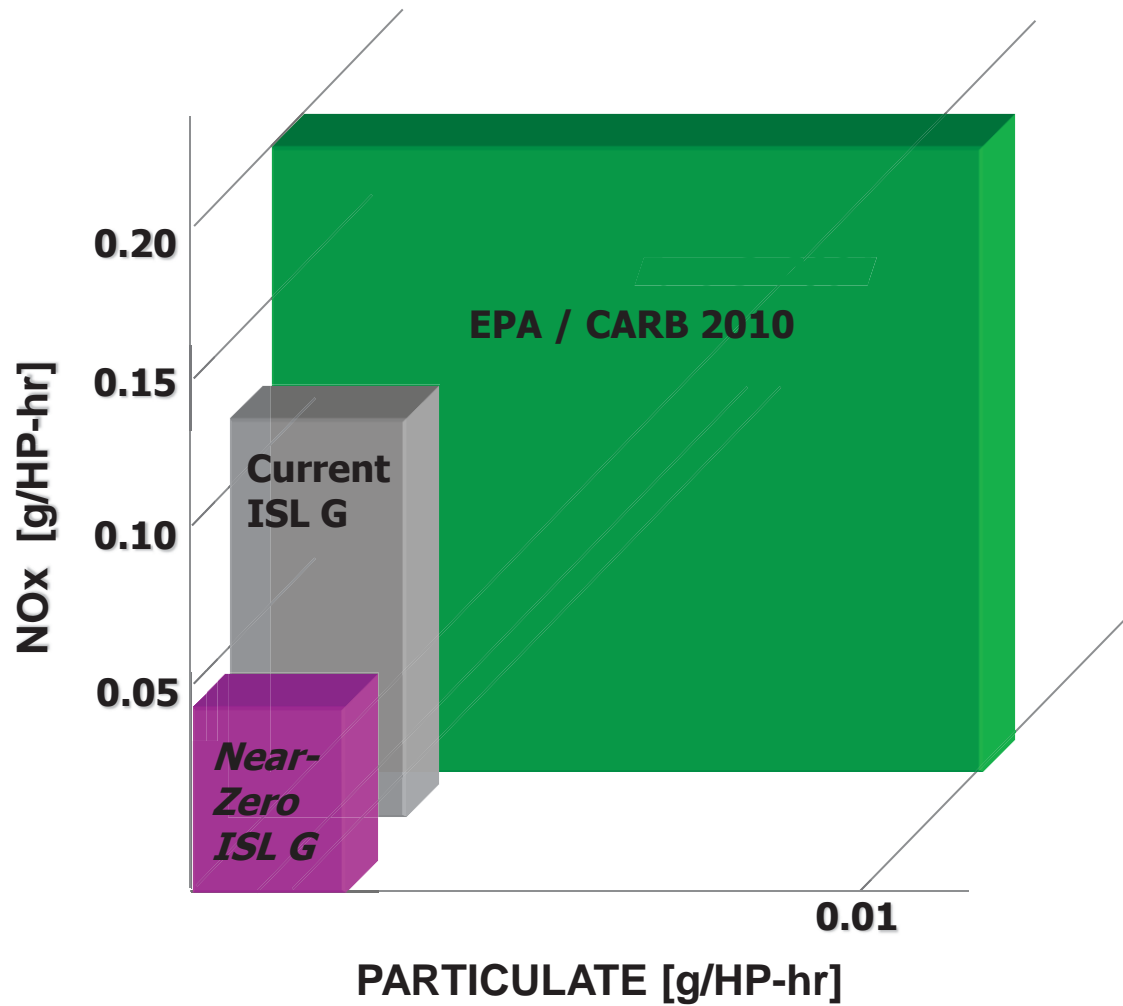
Explore Every Alternative.



Near-Zero Emissions Natural Gas Engine

- Cummins Westport plans to further develop ISL G for near-zero emissions while maintaining current architecture
- Near-zero emission efforts are focused on NOx
 - PM emissions already near-zero
 - Additional work required to achieve < 0.05 g/bhp-hr NOx
- NOx reduction opportunities
 - Cold-cycle emissions
 - Near-zero NOx has been demonstrated over hot cycles
 - Transient emissions
 - Optimize control system for low NOx during transient events
 - Emissions variability (engine to engine, test to test)

Near-Zero NOx Internal Combustion Engine



Technology & Product Development Process

- Technology development prepares new technologies for product development
- Technology development precedes product development
 - Begins with a Market or Product need/potential
 - Typically laboratory-based R&D, using prototype hardware, to demonstrate proof of concept
- Product development takes laboratory research findings and develops them for commercial availability
 - Component and engine design for high-volume manufacture
 - Extensive component / system validation to demonstrate performance, reliability and durability, including field testing
 - Emission certification

Near-Zero NOx Development

- Near-zero NOx technology development currently underway
 - Focused on catalyst design and engine control strategies
 - Target is < 0.05 g/hp-hr NOx
- Product development is expected to follow in 2 to 3 years
 - Market research required to define which product(s) and vehicle application(s) are best suited to near-zero emission products
 - Product development process includes extensive field testing
 - Product development concludes with emission certification & commercial launch following field test

Conclusion

- Cummins Westport is committed to ongoing development that optimizes the environmental profile of natural gas engines to meet market requirements
- Near-zero NOx emissions are believed to be achievable with current natural gas engine & aftertreatment architecture
- Near-zero NOx technology development is underway on the ISL G platform, targeting < 0.05 g/bhp-hr
- Pending successful technology development & market demand, anticipate commercial availability within 3 to 5 years

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Every Alternative. Natural Gas Engines.

Cummins Westport (CWI) integrates robust diesel components into heavy-duty engines specifically designed for alternative fuels to offer performance, fuel economy and quiet & clean operation. CWI's vision is to be the world's leading provider of natural gas engines that deliver the most economic solution for all bus and truck customers. Low emissions, economic benefits, reliable performance—you can depend on Cummins Westport.

Here's why interest is growing in natural gas as a vehicle fuel:

lower fuel costs • reduced dependence on foreign oil • reduced emissions

CWI engines are available factory direct from [leading truck and bus manufacturers](#).

Industry News

[Fair Oaks Farms leases 42 CNG-powered trucks provided by PacLease](#)

Fair Oaks Farms and Paccar Leasing Company (PacLease) have entered into a full-service lease agreement for 42 new Kenworth T440 tractors powered by Cummins Westport ISL-G compressed natural gas (CNG) engines.

[McNeilus CNG Refuse Trucks Power Up Texas](#)

McNeilus Companies, Inc., an Oshkosh Corporation (NYSE: OSK) company, announced today it has sold its first CNG automated refuse truck in Texas and other CNG refuse trucks as the interest for alternative fueled refuse vehicles continues to

