

Natural Gas Engines

What's the Natural Gas Value Proposition?

Natural Gas as a Transportation Fuel



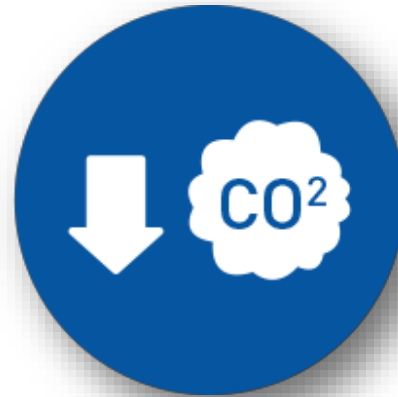
ECONOMICS

- Historically ~8:1+ price advantage Btu basis
- Long-term price stability
- Long-term price outlook
- No costly emissions control systems



ABUNDANCE

- U.S. #1 natural gas producer in the world
- 100+ years of affordable reserves
- Basins provide increased access to markets
- Production can grow rapidly with demand



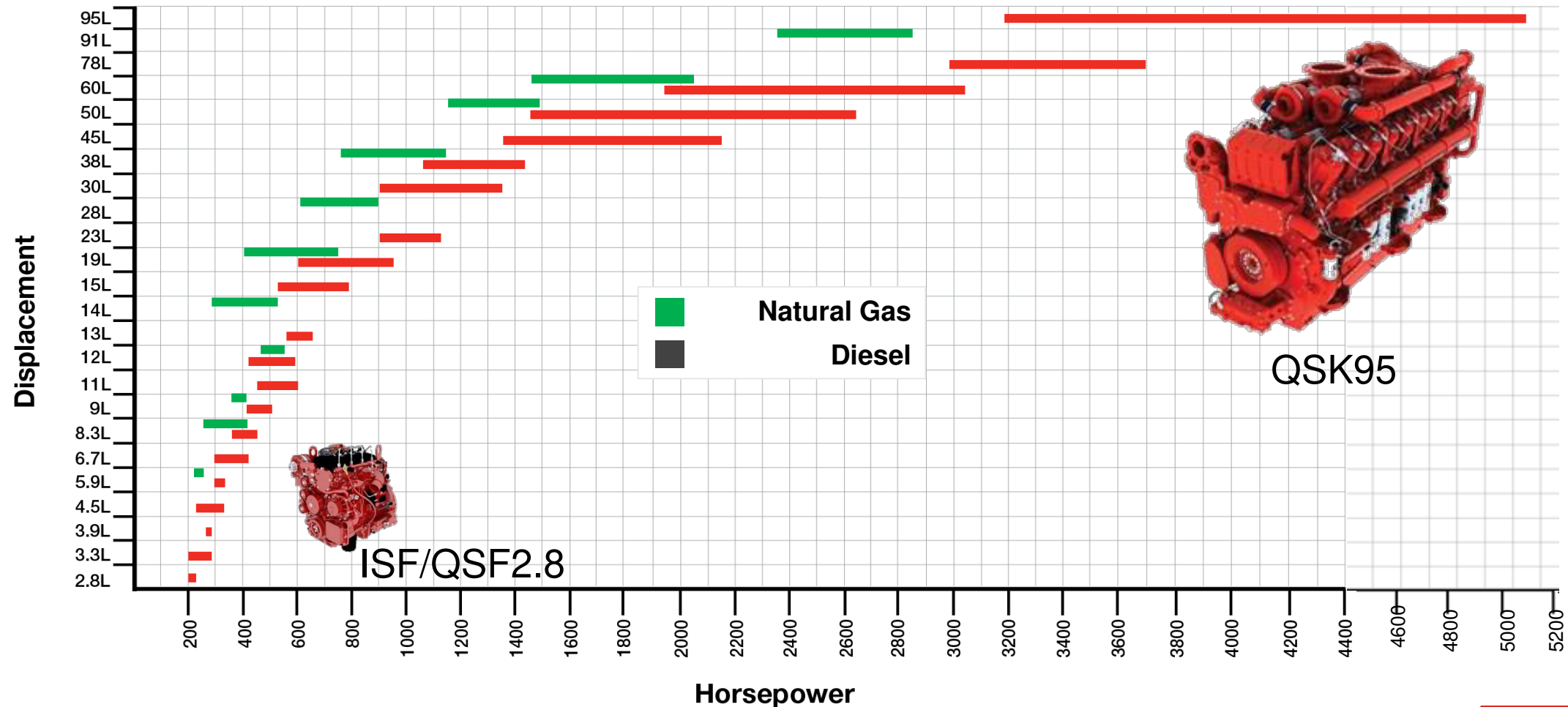
ENVIRONMENTAL

- 27% lower CO2 emissions than petroleum
- 13 – 17% lower WTW GHG emissions
- Lower in-use NOx emissions
- Lower PM emissions
- Quieter engines



Cummins Broad Product Range

A major expansion of the range since the late 1990s, with twice the number of engine platforms covering 49 to 5100 horsepower



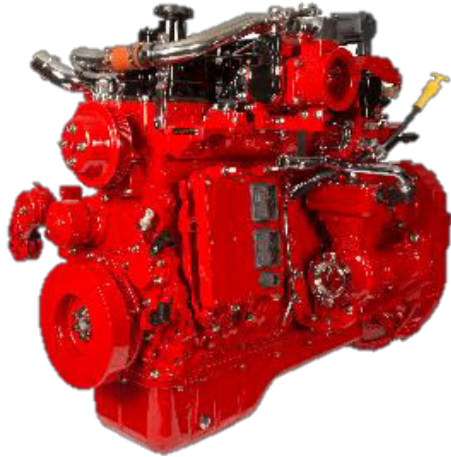
Cummins Westport, Inc.

On Highway Heavy Duty Engines Designed Specifically for Alternative Fuels

- *Based on Reliable Cummins Engine Platforms*
- *Common parts and design provide heavy duty performance*
- *Engineered and Optimized Specifically for Alternative Fuel*
- *Continued improvement in reliability and cost of ownership*
- *Service Support through the Global Cummins Distributor network*



2019 North America Product Line



Coming in 2020
.02 NOx!

B6.7N™

6.7L

Peak Rating: 240 hp / 560 lb-ft torque
33,000 lb. GVW

School bus/MD Truck/Shuttle
bus/Sweeper/Yard spotter

EPA/ARB Low NOx
0.1 g/bhp-hr (50% reduction)



L9N™

8.9L

Peak Rating: 320 hp / 1000 lb-ft torque
66,000 lb. GVW

Refuse/Transit/Regional P&D
Truck/Mixers

EPA/ARB Near Zero NOx
0.02 g/bhp-hr (90% Reduction)



ISX12N™

11.9L

Peak Rating: 400 hp / 1450 lb-ft torque
80,000 lb. GVW

Regional Haul Truck/Tractor/Refuse

EPA/ARB Near Zero NOx
0.02 g/bhp-hr (90% Reduction)

Features:

	ISX12N™	L9N™	B6.7N™
Emission Certification	EPA/CARB Near Zero (NZ) 0.02 g NOx	EPA/CARB Near Zero (NZ) 0.02 g NOx	EPA/CARB Optional Low NOx 0.1 g NOx
NOx Reduction to 2017 EPA	90%	90%	50%
OBD	2019	2018	2018
CCV	YES	YES	YES
TWC	<ul style="list-style-type: none"> • Increase in size (TBA) • One piece design • Mid bed O2/Temp Sensor • OEM Harness 	<ul style="list-style-type: none"> • Same size as '17 ISL G NZ • One piece design • Mid bed O2/Temp Sensor • OEM Harness 	<ul style="list-style-type: none"> • Same size as '17 ISB6.7 G • One piece design • Mid bed O2/Temp Sensor • OEM Harness
Product Changes	<ul style="list-style-type: none"> • New fuel system improves performance and reduces parts content • On-engine electric CCV filter with 2 CCP sensors • CM2380 ECM • 500 kbaud datalink • New wiring harness • New 2380 ICM 	<ul style="list-style-type: none"> • Steel Pistons • New Liners • Improved Ring Pack • New Valve Seat Material • New Oil Cooler • Improved Piston Cooling • Additional crankcase pressure sensor • New CM2380 ECM • 500 kbaud datalink • New wiring harness • New Ignition Control Module 	<ul style="list-style-type: none"> • Additional crankcase pressure sensor • New CM2380 ECM • 500 kbaud datalink • New wiring harness • New Ignition Control Module

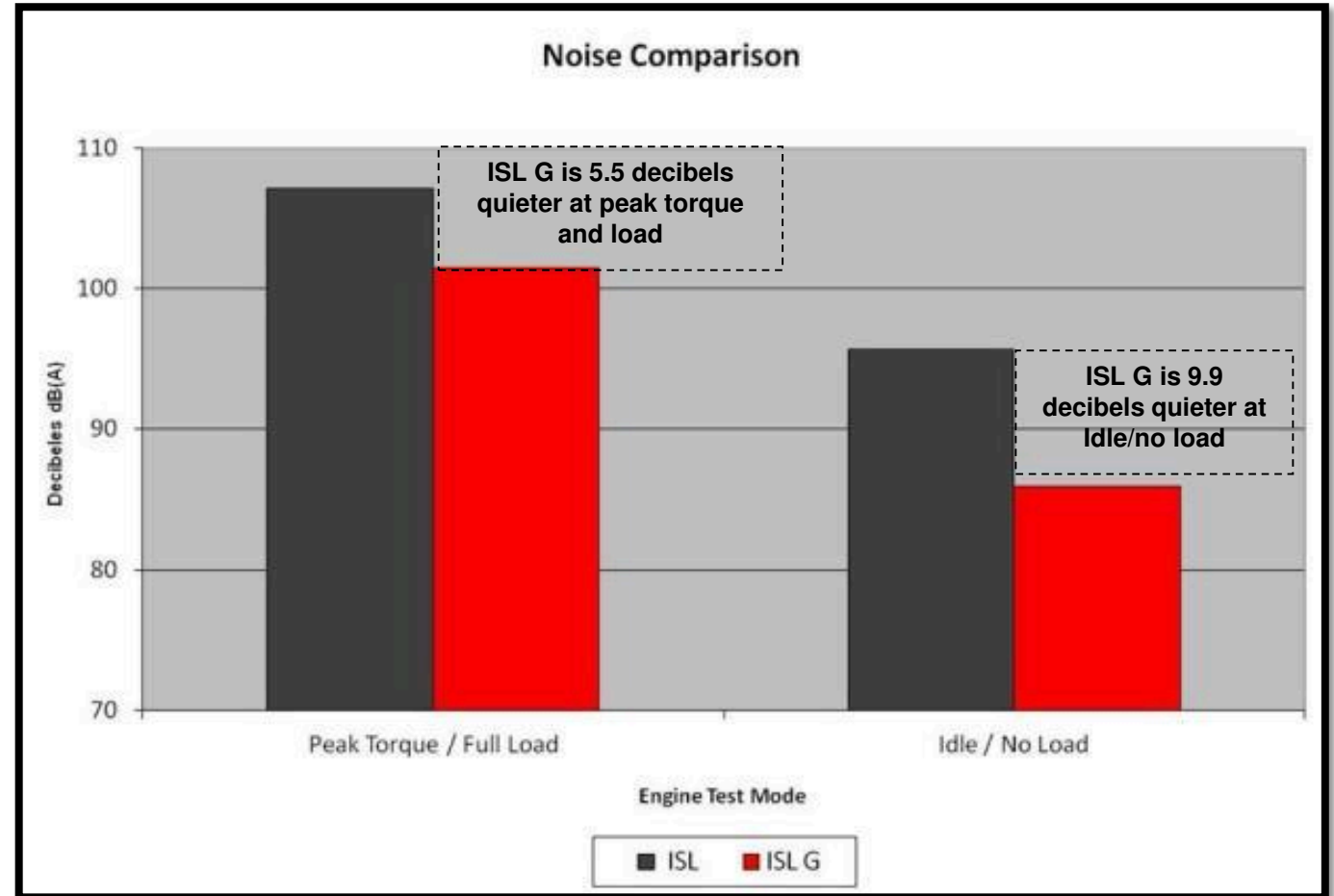
Maintenance & Fluid Free Exhaust Treatment | Three-Way Catalyst



- Similar to catalyst on gasoline passenger cars
- Packaged as a muffler with vertical or horizontal mount
- Weighs ~100 pounds
- Benefits:
 - More reliable, no downtime
 - Maintenance-free, no filters to clean or replace
 - No active regeneration required
 - No SCR fluid or maintenance or costs

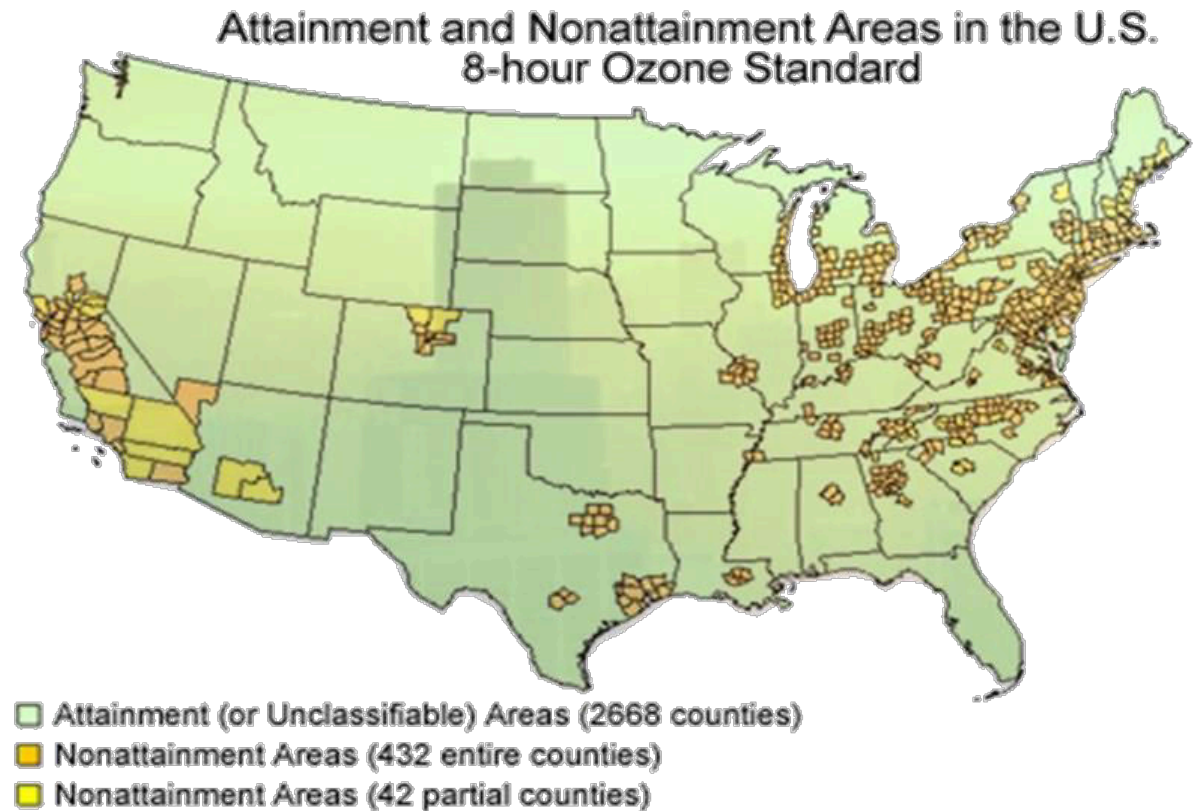
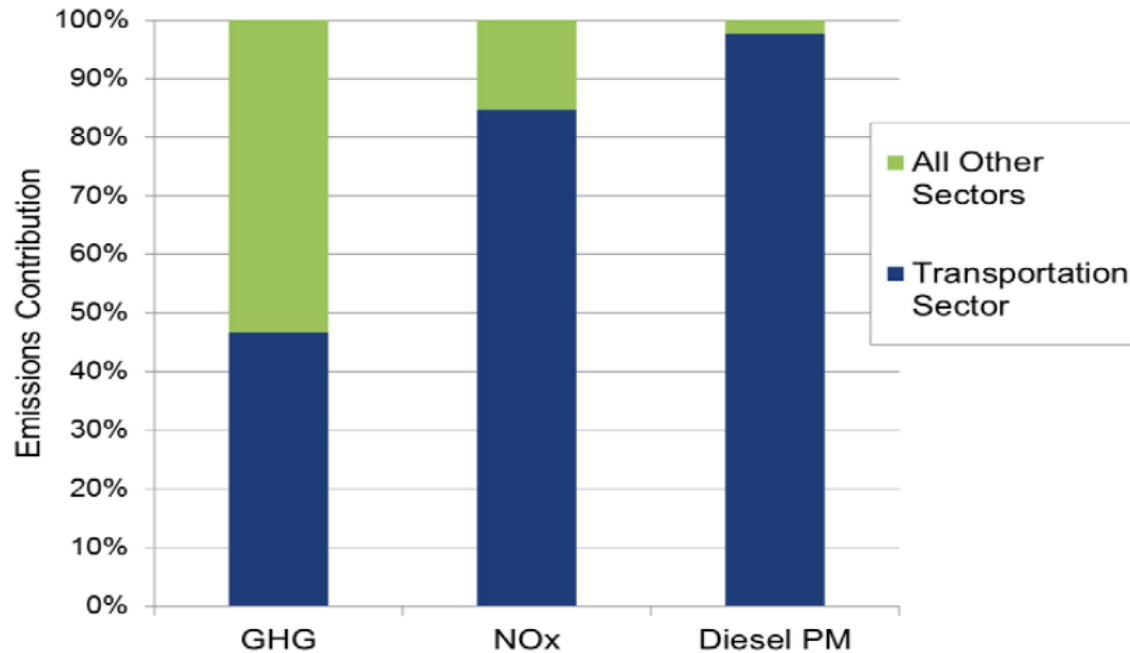
Quiet Operation

- Spark ignition provides quiet operation
- Communities notice the natural gas noise advantage.
- **ONE** Diesel engine idling is louder than **10** natural gas engines idling together



Why is Near Zero needed ?

Figure 2-1: Emissions Contribution from Mobile Sources



Counties Designated by EPA as Non-Attainment

EXTREME

- Los Angeles-South Coast Air Basin, CA
- San Joaquin Valley, CA

SEVERE 15

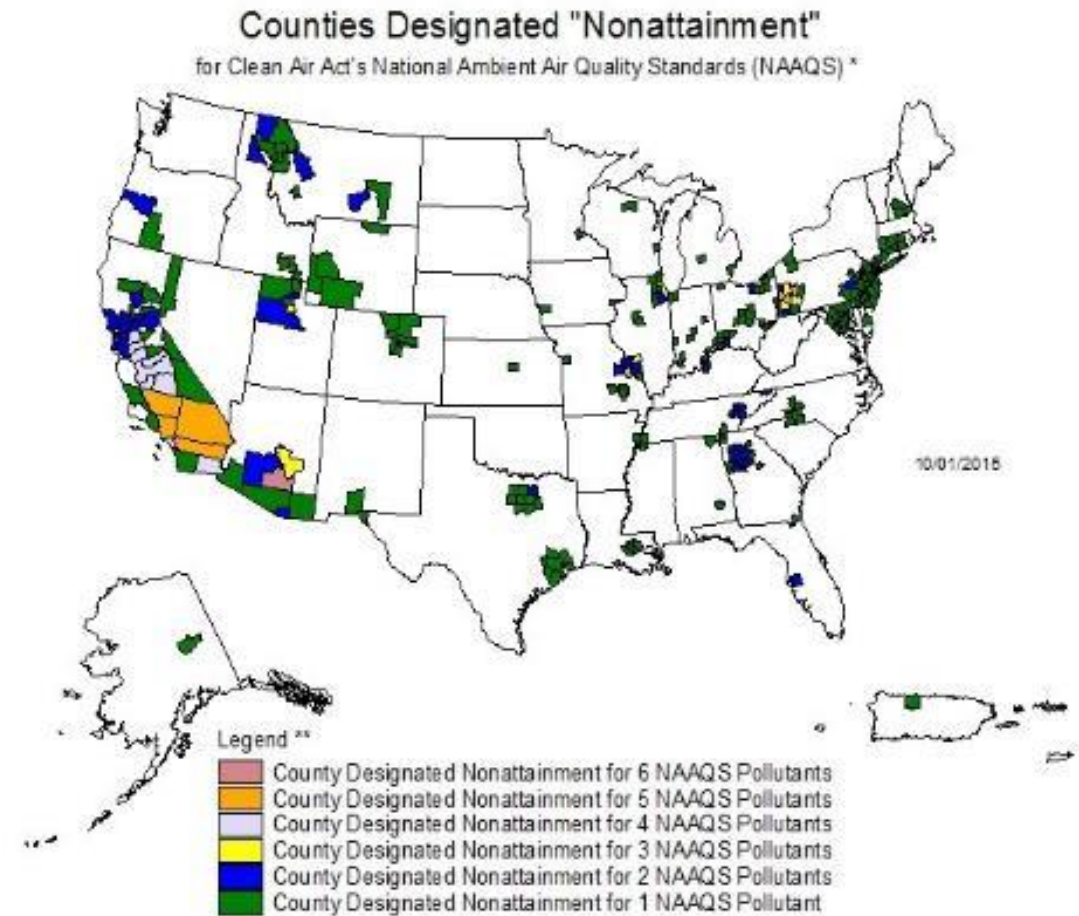
- Los Angeles-San Bernardino Counties, CA
- Riverside Co, (Coachella Valley), CA
- Sacramento Metro, CA

SERIOUS

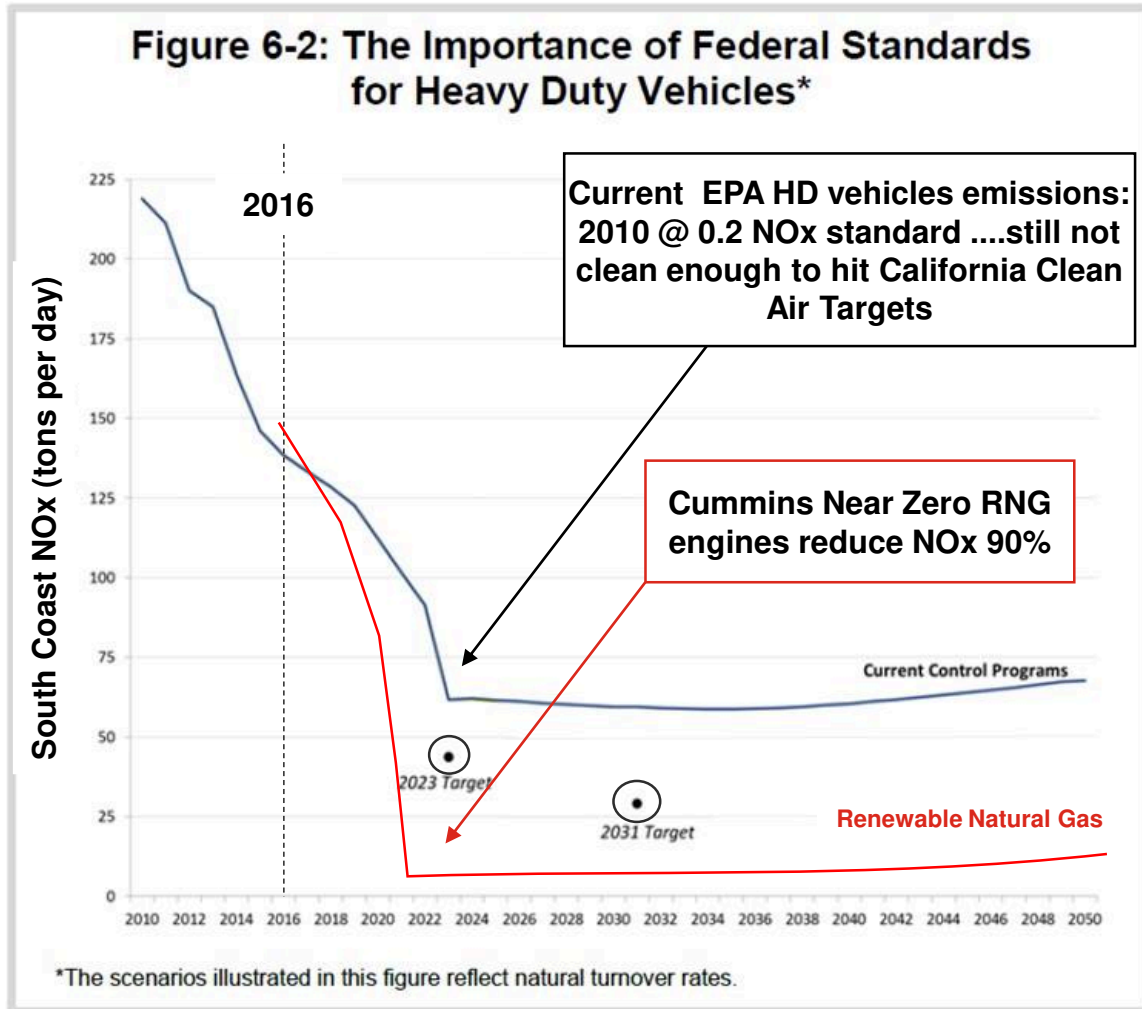
- Porter County, IN
- Lake County, IN

MODERATE

- Floyd County, IN
- Clark County, IN



The Importance of Federal Standards for HD Vehicles



- Cummins Near Zero RNG Engines are commercially available today moving goods with this technology will reduce corporate GHG liabilities immediately.

California Optional Low Emissions Tiers

Low NOx

- 0.1 g/bhp-hr
- 0.05 g/bhp-hr
- 0.02 g/bhp-hr

Near Zero Emissions

- 0.02 g/bhp-hr NOx
 - *90% reduction from current standard of 0.2 g/bhp-hr*

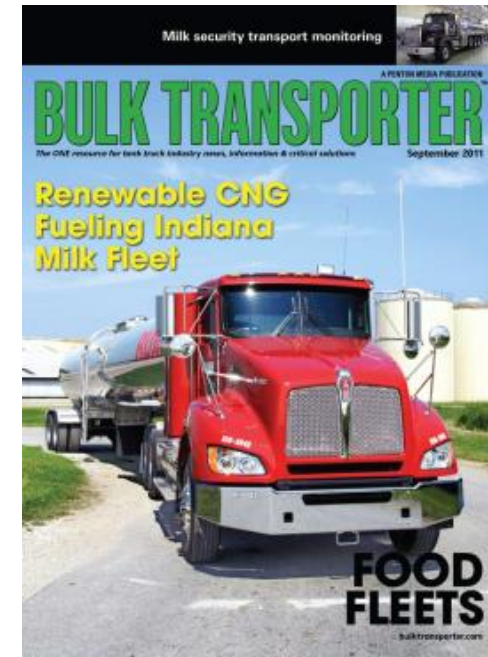
Zero Emissions

- No tailpipe emissions
 - *Regardless of how low (NOx, PM, GHG, etc.)*

CEC* has defined this certified Near Zero emission level as equivalent to a 100% battery truck using electricity from a modern combined cycle natural gas power plant.

Renewable Natural Gas Improves GHG Profile

- Landfill gas and biogas that has been processed to “pipeline quality” is **RNG**
- CWI engines can operate on up to 100% **RNG** and are currently in operation with RNG from landfills (landfill gas) & dairy farms (biogas)
- RNG from some sources produces a negative carbon intensity – or sub-zero GHG emissions



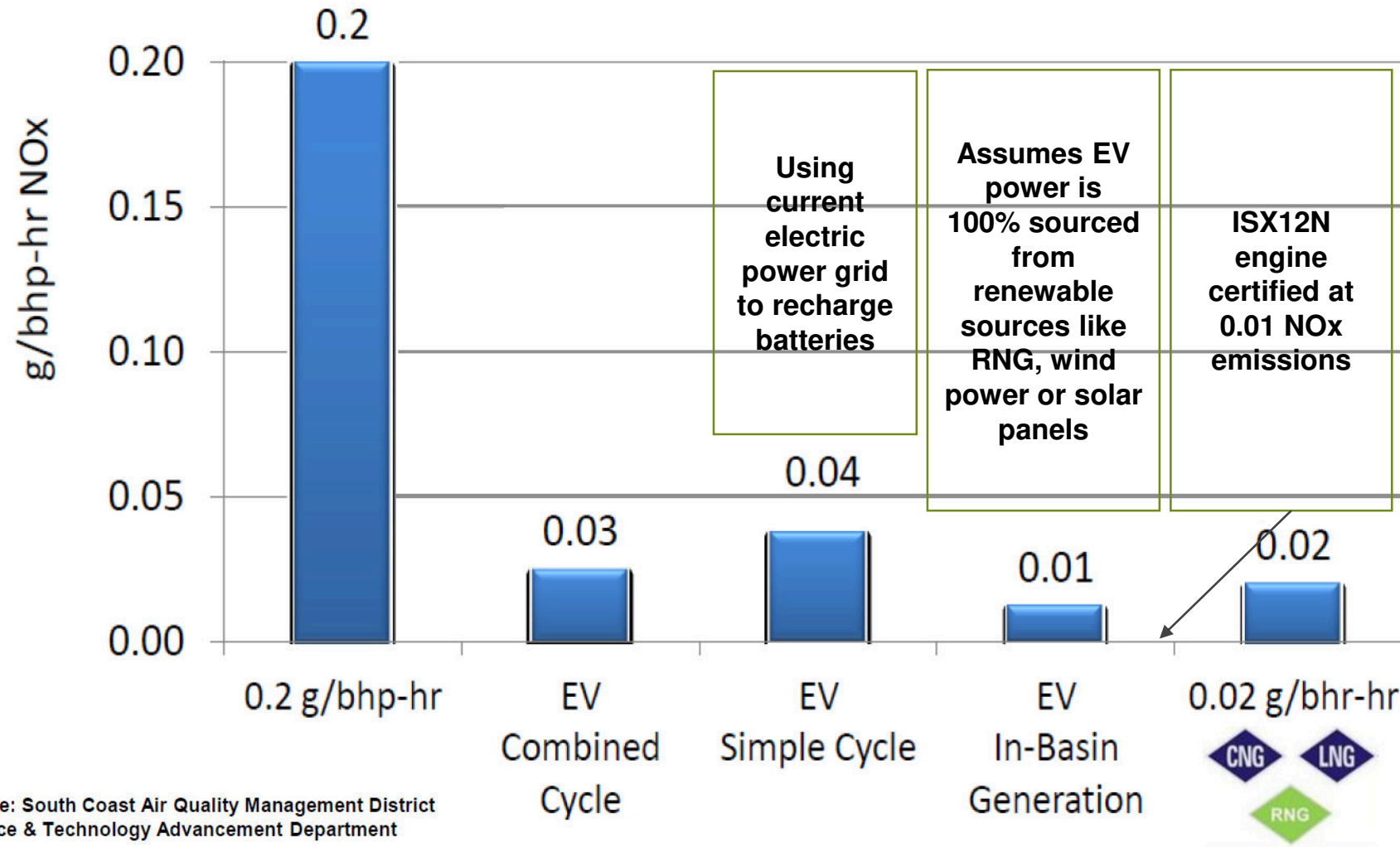
Why Renewable Natural Gas Engine Technology?



Environmental Durability

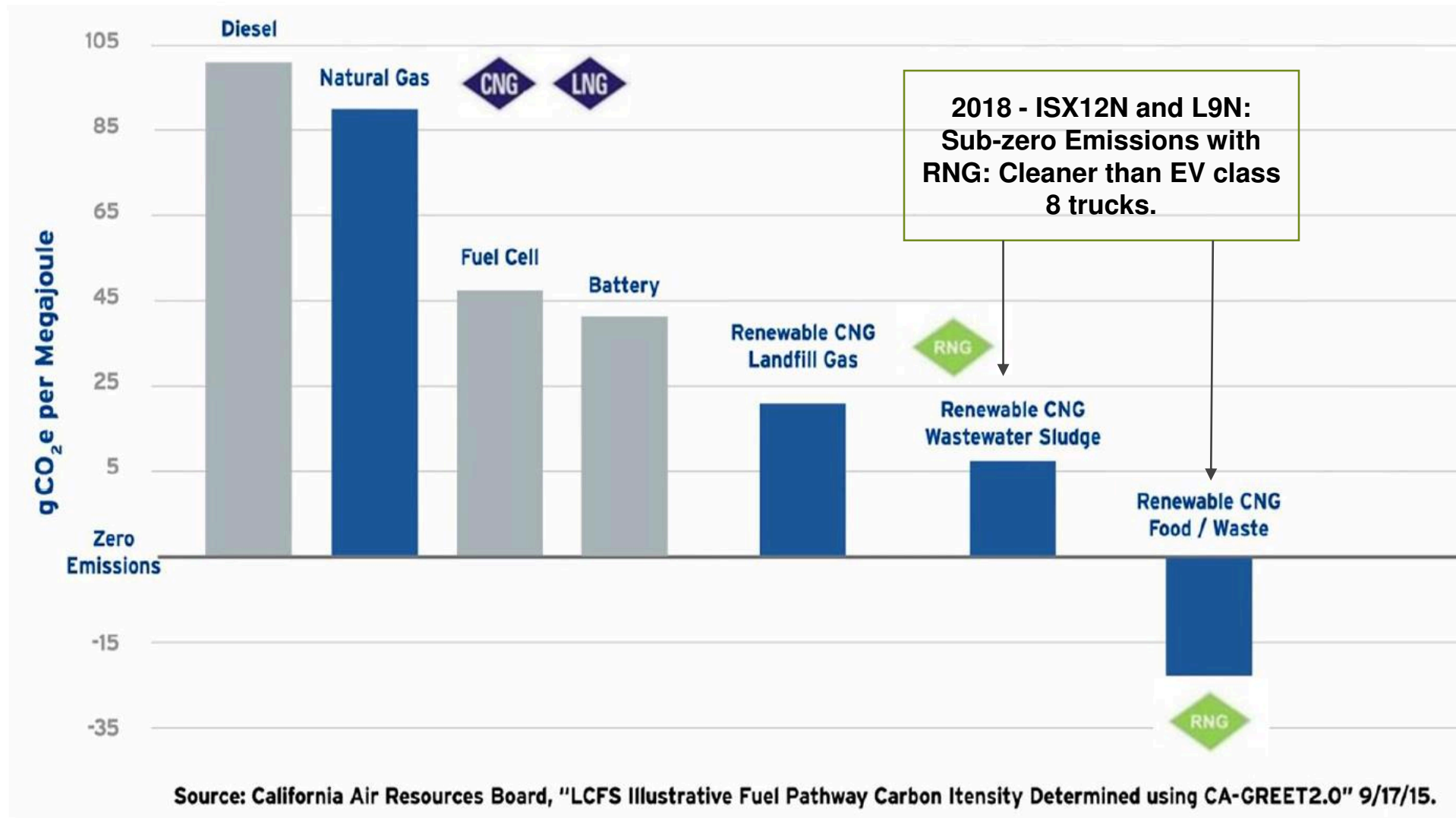
- NOx is reduced by 90% below standard
- PM is reduced 90% below standard
- Renewable NG reduces Global Warming GHG emissions to Near Zero
 - Landfill source (GREET1_2016 and CA GREET2.0)
 - Up to 97% reduction in CO2
 - Up to 80% reduction in WTW GHG

Electric Equivalent NOx



Source: South Coast Air Quality Management District
Science & Technology Advancement Department

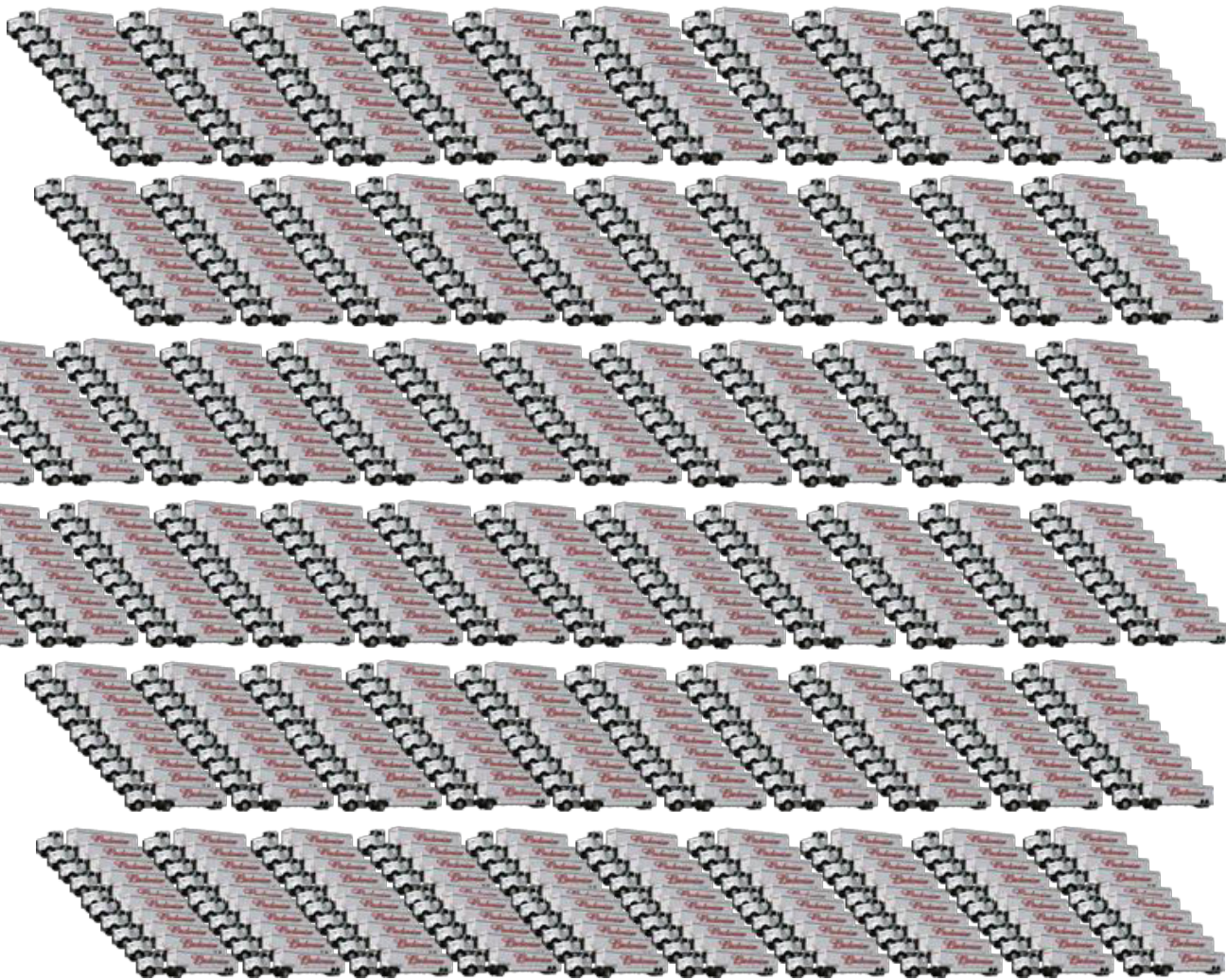
Sub-zero Carbon Intensity



Heavy Duty Truck/Bus Emissions Reduction Impact - NOx



=



	1985	1990	1991	2000	2010
NOx (g/hp-hr)	10.8	6	5	4	0.2
PM (g/hp-hr)	0.59	0.59	0.25	0.05	0.01

0.01

1080

Natural Gas Playbook

CWIplaybook.com


- Online Natural Gas Playbook with tips and tools to help customers with the successful adoption of natural gas into truck, refuse, school bus, and transit applications.
- Featuring a Well-to-Wheel GHG emissions calculator and a Payback calculator.
- Organized into 5 sections to guide customers:
 1. Assess
 2. Specify
 3. Prepare
 4. Implement
 5. Operate & Maintain
- “Print to PDF” feature allow users to create their own Playbook of reference material.




Natural Gas Playbook Emissions Calculator

RESULTS

Region	US Typical
GHG Specification/Model	REET1_2016
Annual Total WTW GHG (CO ₂ eq) Savings with NGVs (Metric Tonnes per year)	5,893.3
% Reduction Relative to Current Vehicle Fleet	80.4%
Truck Equivalent GHG Avoided by Converting to NGV	20.1
# of Near Zero Gas Trucks it Would Take to Generate GHG of Current Fleet	127.4
Tailpipe NOx Emissions Reduction with NGV	90%

 PRINT/PDF THIS PAGE

CWI ENGINE SELECTED
ISX12N



GHG Engine Emission Calculator

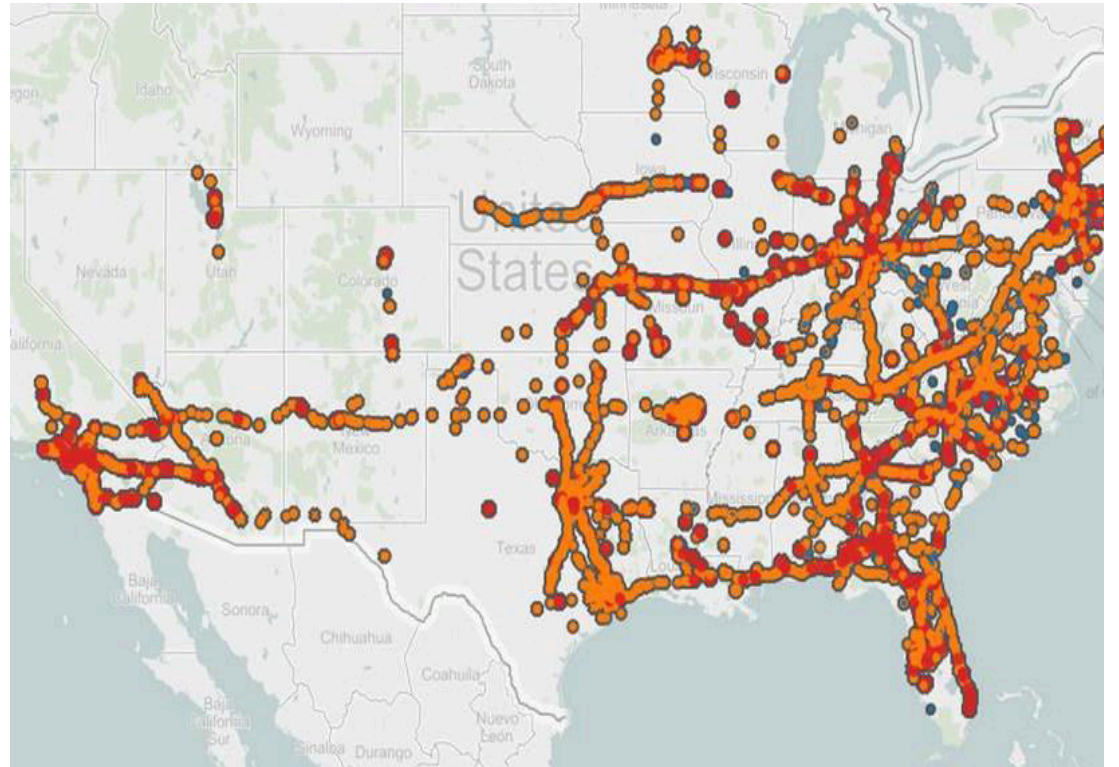
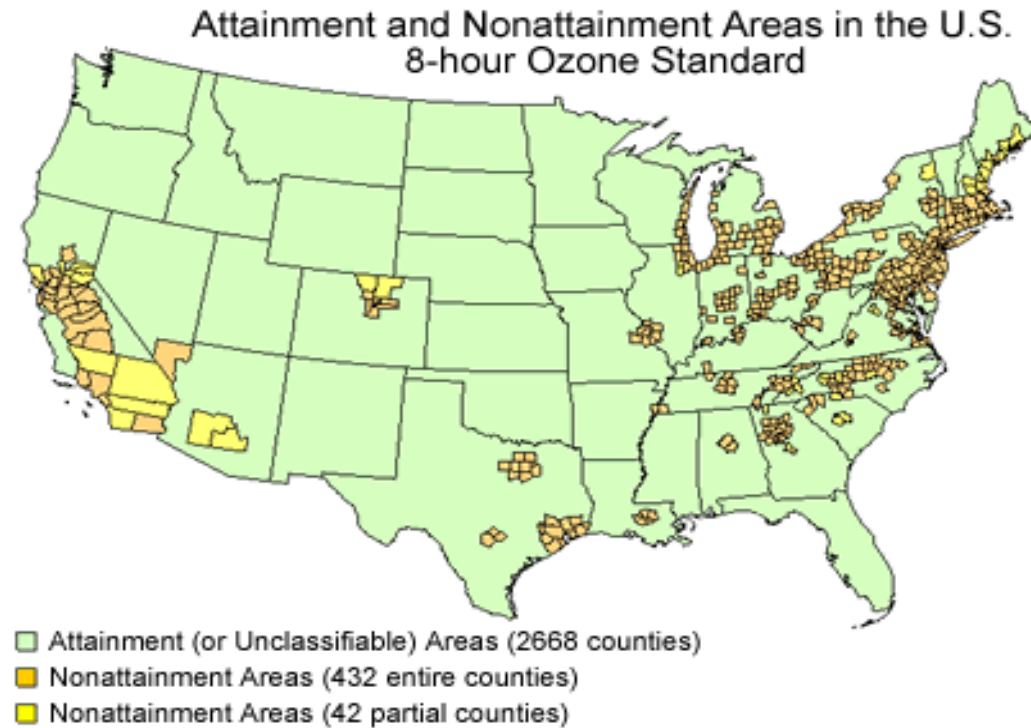
Region	US Typical
GHG Specification/Model	REET1_2016
Application	Heavy Duty Truck
Model Year / Vintage	2013
# Vehicles to Replace	1000
Vehicle Fuel Economy and Distance	100000 Miles @ 7MPG
Fuel Type	CNG
Use RNG	YES

Results

Annual Total WTW GHG (CO ₂ eq) Savings with NGVs (Metric Tonnes per year)	156,131.2
% Reduction Relative to Current Vehicle Fleet	79.8%
Current vehicle equivalent GHG avoided by converting to NGV	797.5
# of Near Zero vehicles it would take to generate GHG of current fleet	4,939.3
Tailpipe NO _x Emissions Reduction with NGV	90%
CWI Engine Model Selected	ISX12N

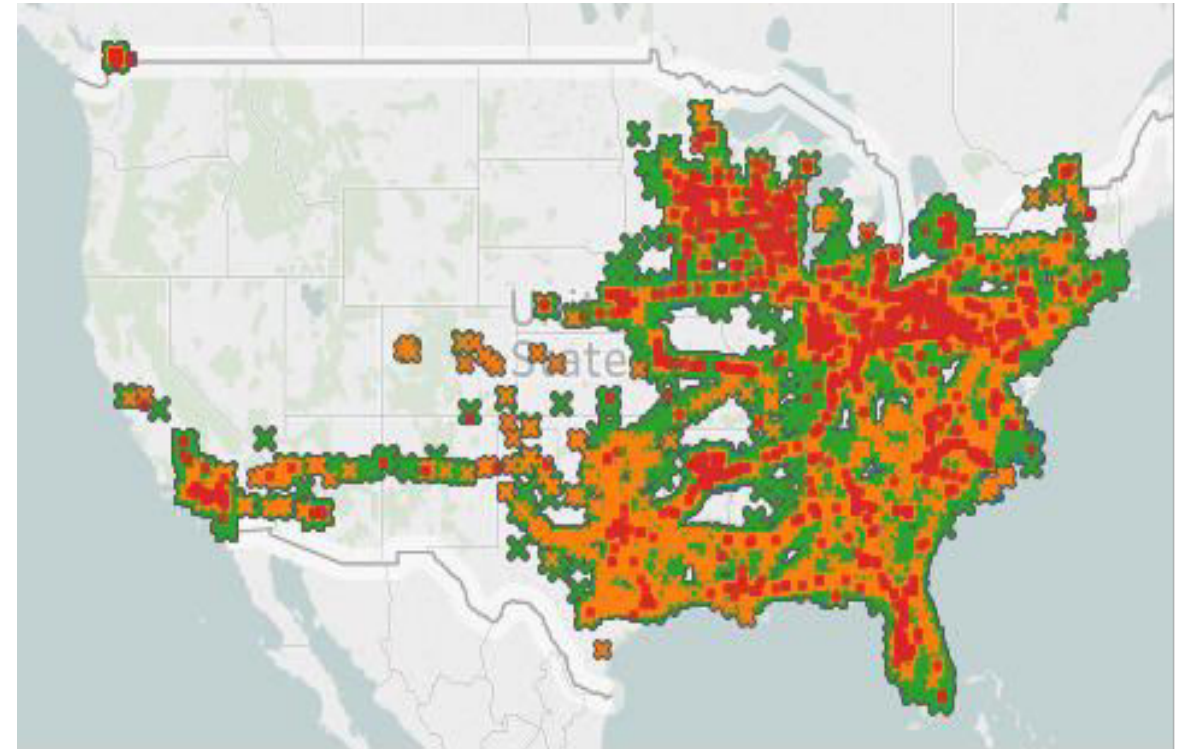
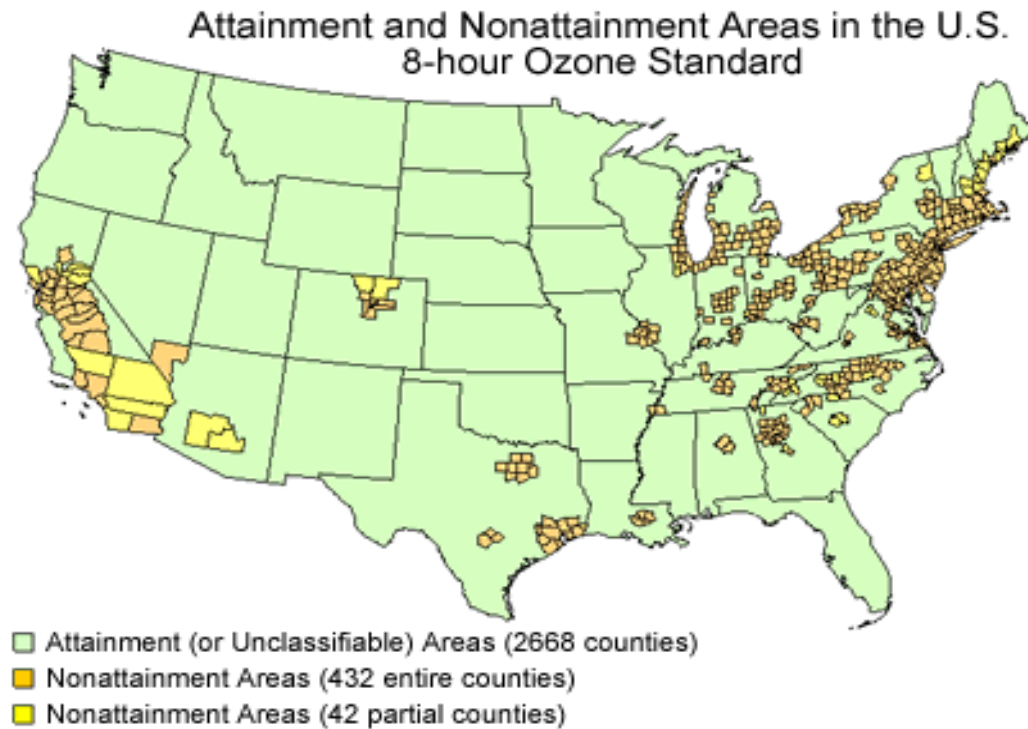
ISX12 G Engines in Motion

2015

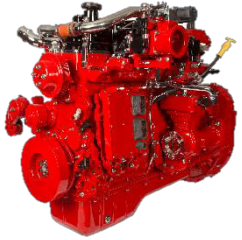


ISX12 G Engines in Motion

2018



2019 OEM Availability



B6.7N™



L9N™



ISX12N™



Benefits:

- **Maintenance & Fluid Free Exhaust Treatment** – same as your automobiles, no fluids, no regeneration downtime, no cleaning or replacing exhaust treatment filters
- **Environmental** – Cleanest, most cost effective commercial goods movement power available in the world today and for the foreseeable future, GHG credits transfer to shipper
- **Low Engine Exhaust Emissions** – NG engines broadly accepted by state regulators and agencies with significant funding incentives in many states.
- **Economics** – lower cost per mile than any other technologies operating in return to base or urban applications.

Moving Goods with Natural Gas Engines

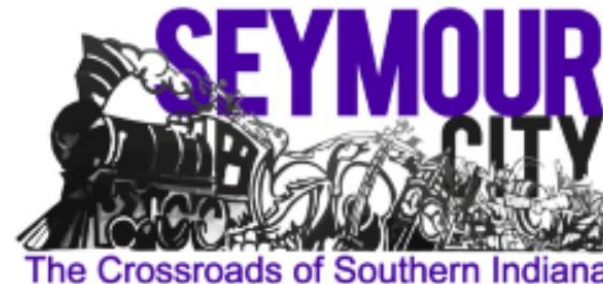


Moving ~~Goods~~ with Natural Gas Engines

INDIANA



transpo



Thank You!

- For more information:
Bill Boyce
East Regional Manager
(330) 720-9785
or
bill.boyce@cummins.com
- Or visit
www.cumminswestport.com

