

# LNG Bunkering & Rail Opportunities

**Erik Neandross**

October 19, 2016 - San Diego, CA



Natural Gas Vehicle Technology Forum 2016 Meeting

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PURPOSE: US DOE Clean Cities NGV Technology Forum – Oct. 19, 2016

# GNA Overview

- North America's Leading Full Service Alternative Fuel Vehicle Consulting Firm
- Southern California & NYC
- Founded Dec. 1993
- Diverse Staff of 35
  1. Technical Team
  2. Programs
  3. Public Affairs
  4. Events & Marketing



# GNA: Heavy-Duty Commercial Transport



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# What We Do



## Fleet Planning Analysis

Evaluate the best clean technology options for your fleet operations.



## Fuel Procurement & Infrastructure Development

Ensure fueling is cost-effective, reliable, and safe.



## Maintenance Facility Modifications

Maintain your fleet safely and cost effectively.



## Market Analysis & Development

Identify market barriers and opportunities for your product.



## Government & Public Affairs

Reach the stakeholders and decision-makers who matter.



## Creative Marketing Services

Stand out from the competition.



## Regulatory Compliance

Stay ahead of evolving regulatory requirements.



## Grant Writing & Funding Procurement

Secure and manage grants and incentives.



## New Vehicle & Engine Certification

Forge a path toward commercialization.



## Event Production

Engage directly with your target audience.



## Education & Training

Gain more information before launching your project.



## Investor Guidance

Gain on-the-ground insight for your clean tech investment.

# Heavy-Duty NGV Deployment





# GNA HHP NG Projects



# GNA LNG Import / Export





# GNA LNG Import / Export



# Stakeholder Engagement





# Engagement, Education & Training

- LNG 101 & Familiarity
- Safety Demonstrations
- LNG Safety & Handling
- Permitting Officials
- Fire Department
- First Responders
- Community Outreach
- All Project Personnel







# Proposed LNG Export Terminals

## LNG Export Terminal in Canada: Operating & Planned



16

Source: FERC, API, RBC Capital Markets

# LNG Export Terminals: Current Status

- Long term permitting and approval process
  - Competitive global market
  - Slowed global demand for energy (especially in Asia)
  - Very few approved
  - Very few LNG export terminals will be constructed
- *Long term, stable and low prices for North American natural gas customers*





# Small Scale Domestic LNG Production



# Small Scale Domestic LNG Production



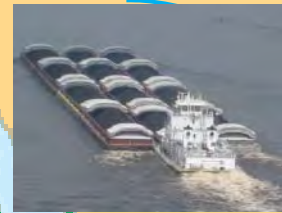
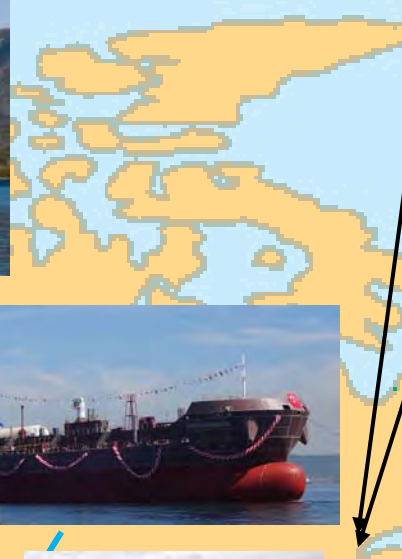


# Growing HHP Market for LNG





# Tremendous Growth of LNG Marine in N.A.



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# Harvey Gulf LNG Project

1. Harvey Energy: 1 year 6 months
2. Harvey Power: 1 year
3. Harvey Liberty: 6 months

**1,117 days of total operation**



Statistics from Wartsila presentation; HHP Summit 2016

# Harvey Gulf LNG Project

February, 2015 – January 2016

- 89 Truck-to-Vessel Transfers
- 850,000 gallons transferred



Statistics from Wartsila presentation; HHP Summit 2016



# Harvey Gulf LNG Project



## January, 2016 – Present

- 157 Truck-to-Tank Transfers
- 1,500,000 gallons transferred
- 47 Tank-to-Vessel Transfers
- 1,455,000 gallons transferred

Statistics & photo from Wartsila presentation; HHP Summit 2016



# Harvey Gulf LNG Project





# Harvey Gulf LNG Project

- ATB/articulated tug barge vessel for bunkering liquefied natural gas
  - Load / discharge rate of 600 cubic meters (nearly 160,000 gallons) per hour
- ABS Approval in Principle (AiP) and U.S. Coast Guard design base approval
- 3,996 cubic meters (> 1 million gallons) total storage capacity



Statistics from Wartsila presentation; HHP Summit 2016



# TOTE LNG Marine Project

- Isla Bella operational since October 2015
- Sister ship Perla del Caribe entered service Feb 2016





# TOTE LNG Marine Project

- Have loaded over 720 trailer loads of LNG as of October 1, 2016
- Requirement is to load about 250,000 LNG gallons in 5 hours while simultaneously discharging and loading container cargo



Statistics from TOTE presentation; HHP Summit 2016

# TOTE LNG Bunkering

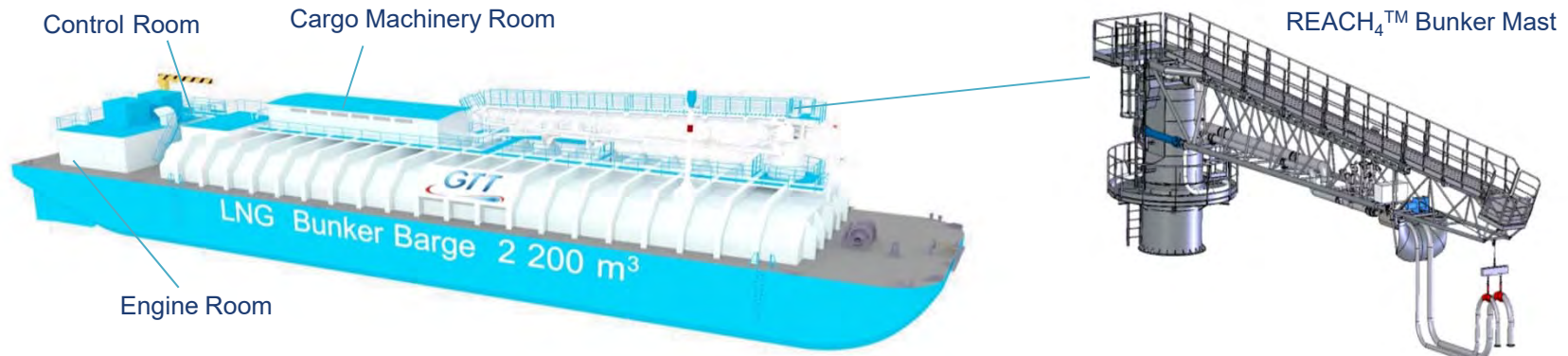




# TOTE LNG Bunkering



# TOTE LNG Bunkering



- Keel Laid September 9, 2015
- Enters service in JAX 2017 when plant commissioned
- Dimensions 232' L x 49' B x 16' D Jones Act
  - US Flag vessel
  - Built in US
  - Owned by US citizens
  - Manned by US mariners





# Small Scale Domestic LNG Production





# Small Scale Domestic LNG Production





# BC Ferries LNG Project





# BC Ferries LNG Project





# Seaspan LNG Project



# Groupe Desgagnés LNG Project





# Carnival Cruise Lines LNG Commitment





# Next Generation of LNG Bunkering

## An innovation in the LNG bunkering market

Potential customers include container ships, coastal vessels, and ferries.

**FEATURES:** Cutting-edge shipping design and technology with a special loading arm for ship-to-ship transfers and sub-cooling unit to keep LNG at sub atmospheric pressure.

**CAPACITY:**  
6,500 cubic metres

**LENGTH:** ~120 metres

 Co-financed by the European Union  
Connecting Europe Facility

Copyright of Shell LNG Marketing and Trading

The new vessel will be built by STX Offshore & Shipbuilding. It will be based at the port of Rotterdam in the Netherlands, and will load from the new LNG break bulk terminal and jetty to be constructed by the Gas Access to Europe (Gate) terminal. It will also be sea-going and, therefore, able to bunker customers at other locations.





# LNG for Freight Locomotives





# LNG for Freight Locomotives





# LNG for Freight Locomotives

28,000 Gallon Tank Car Style LNG Fuel Tender



11,000 Gallon ISO Container Style LNG Fuel Tender

# Rail Transport of LNG

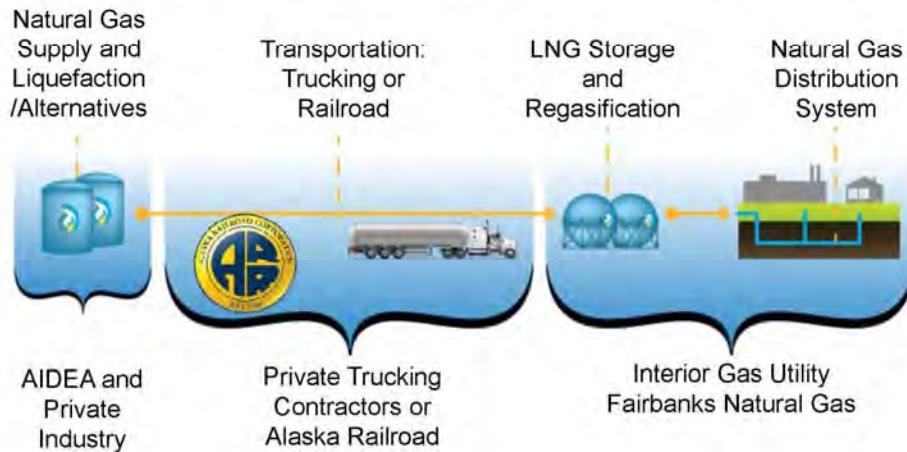




# Alaskan Interior Energy Project

- 350 miles Anchorage to Fairbanks
- 11 hours 45 minutes by train
- Cost to average home in Fairbanks is 8100/year - \$675/month
- Four times the national average

## INTERIOR ENERGY PROJECT FULL SUPPLY CHAIN FOCUS





# HHP Summit – Oct. 11 – 13; Chicago

MENU



October 11-13, 2016  
Chicago - McCormick Place

Natural Gas for  
POWER GENERATION

REGISTER ▶

EXHIBIT ▶



## Value Registration Is Open ▶

Save through October 7 and join us in Chicago.


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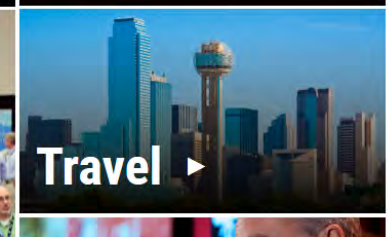
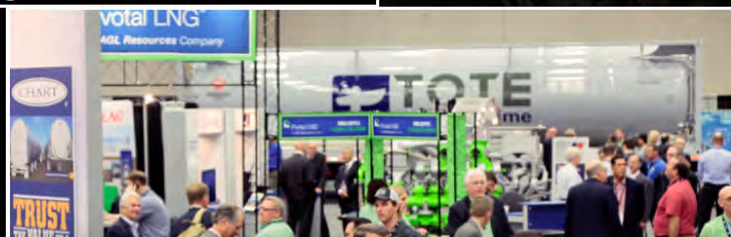
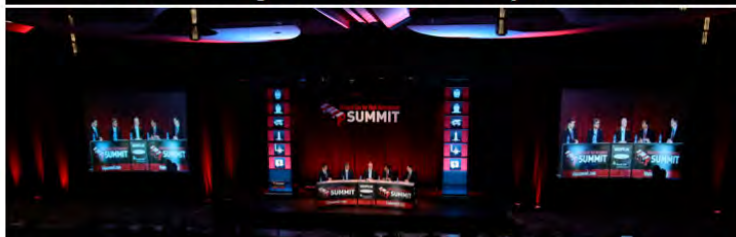
See the growing list of natural gas industry leaders sponsoring the show.



### Event Overview ▶

"You can meet with other peers who are actually doing what you want to do and find real partners for your next project."

– CSX Transportation



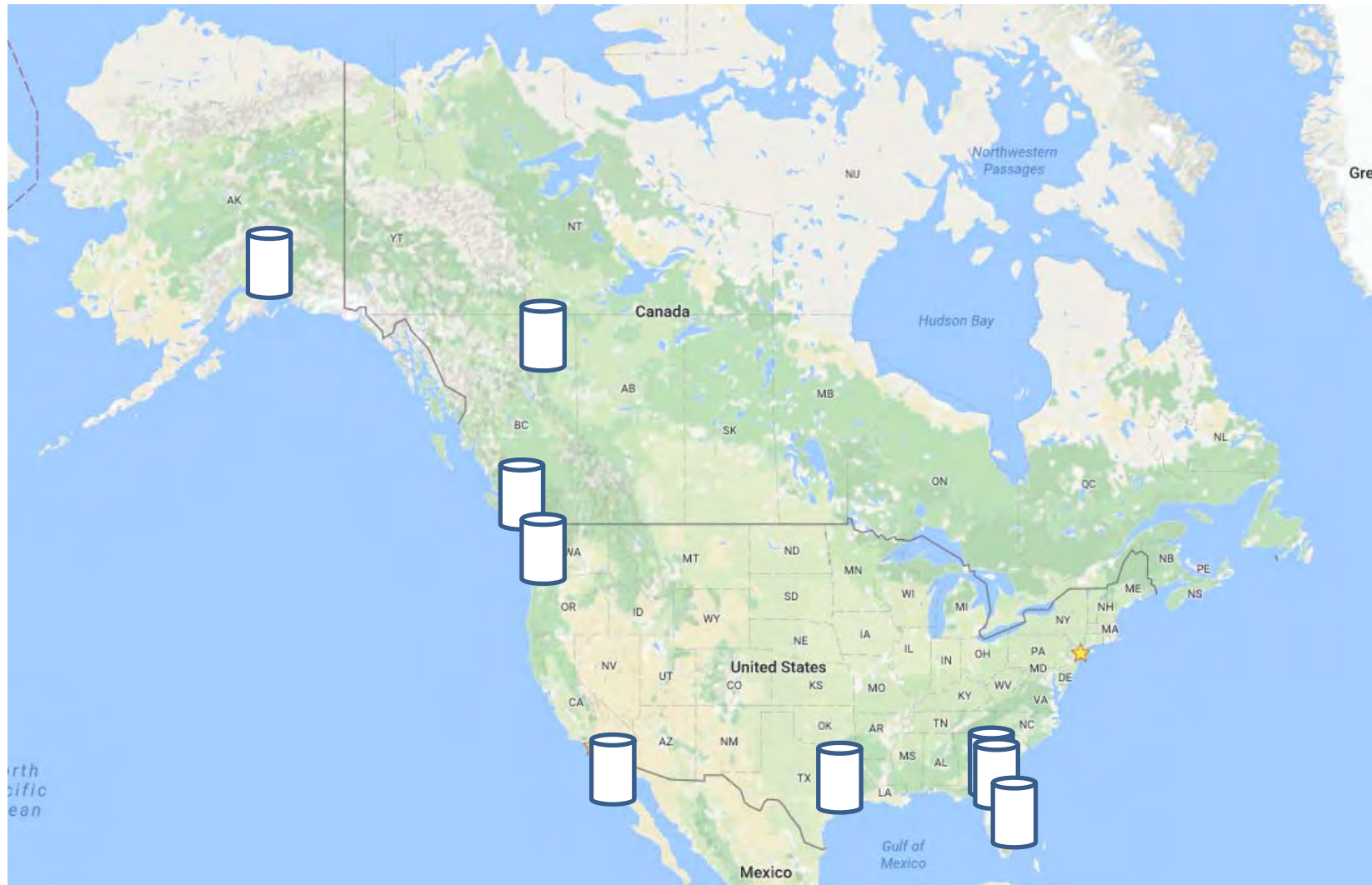
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# New & Expanded LNG Fuel Supply

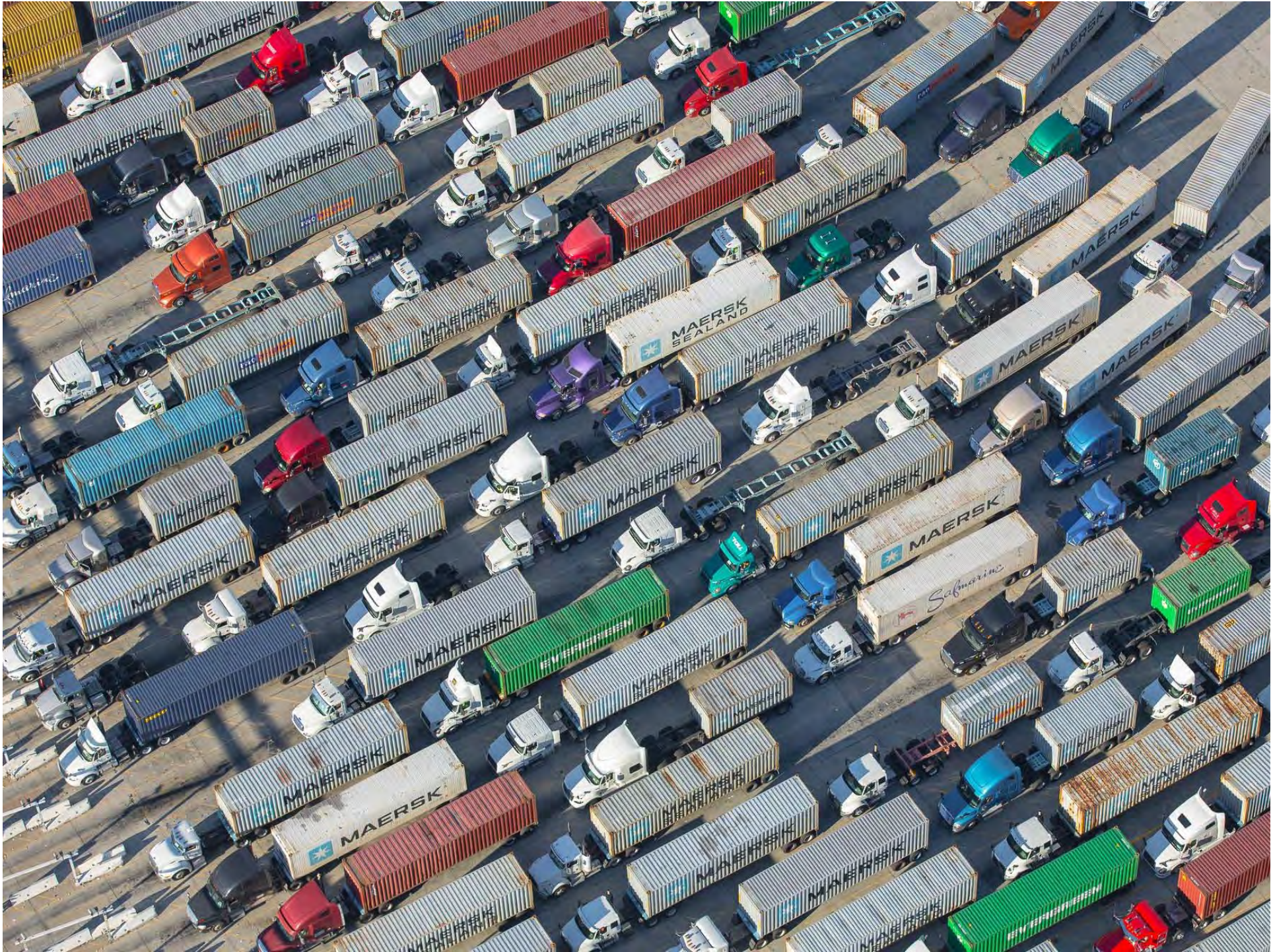


# Opportunities for LNG Marine & Rail

## **SUMMARY – Marine and Rail and other HHP sectors**

- Strong environmental and economic factors will continue to drive these markets
  - Carbon markets and carbon pricing
  - IMO decision on fuel oil sulfur limit: 3.50% to 0.50% on Jan. 1, 2020 or Jan. 1, 2025 (current limit of 0.10% in ECA zones)
- Growing LNG fuel supply will further facilitate market development, but a lot more is needed...
- Key regulatory issues remain (AAR/FRA tender car spec; USCG approvals, etc.)
- Further engine technology development work needed to achieve lower emissions
- Opportunity for renewable natural gas?





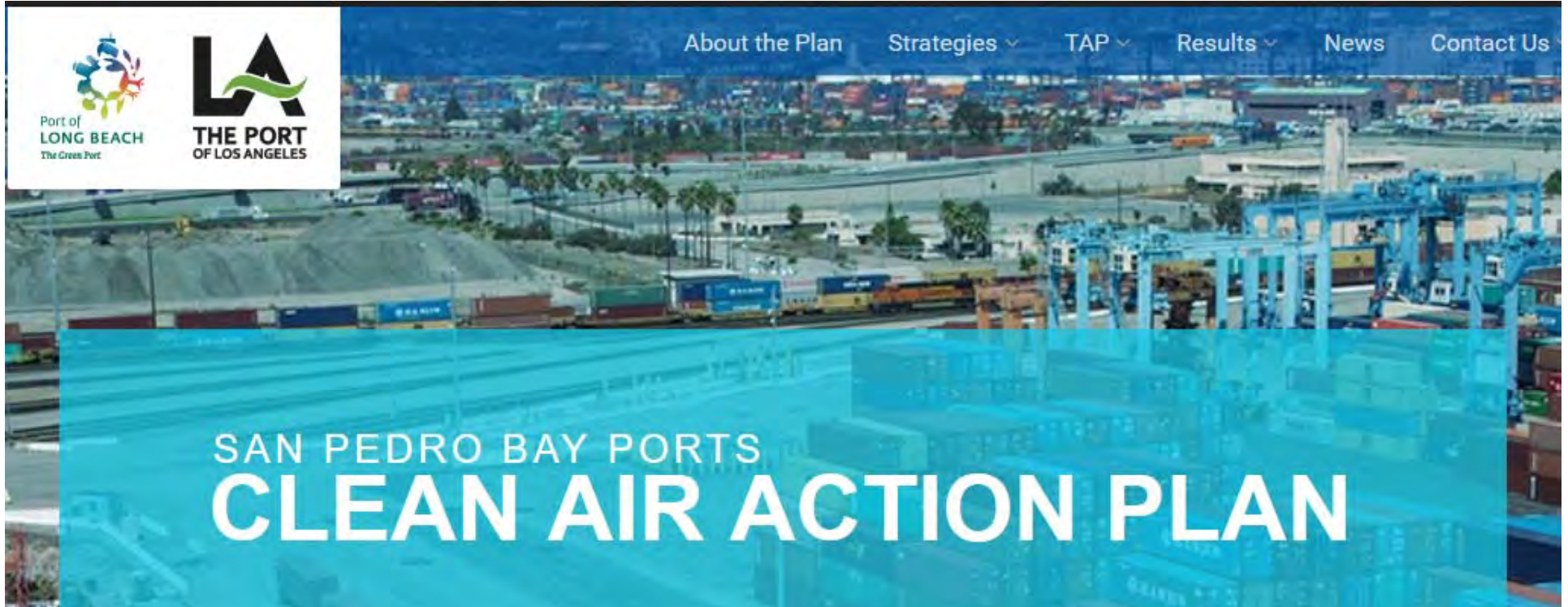


# GNA Case Study: Cal Cartage





# San Pedro Bay Ports Clean Truck Program



# NOx & GHG from Drayage Trucks

Table ES.2: 2015 Maritime Industry-related Emissions by Category

Category	PM <sub>10</sub> tons	PM <sub>2.5</sub> tons	DPM tons	NO <sub>x</sub> tons	SO <sub>x</sub> tons	CO tons	HC tons	CO <sub>2e</sub> tonnes
Ocean-going vessels	74.7	69.4	59.3	3,779.7	124.6	320.7	146.2	248,431
Harbor craft	30.5	28.1	30.5	825.5	0.7	487.4	80.9	61,013
Cargo handling equipment	9.1	8.5	7.2	557.3	1.8	760.3	84.9	170,710
Locomotives	30.2	27.5	30.2	819.0	0.8	194.3	45.8	68,432
Heavy-duty vehicles	8.3	8.0	7.7	1,895.9	4.2	134.6	36.2	381,737
<b>Total</b>	<b>152.9</b>	<b>141.4</b>	<b>134.9</b>	<b>7,877.3</b>	<b>132.1</b>	<b>1,897.3</b>	<b>394.0</b>	<b>930,324</b>

DB ID:457

Source: Port of Los Angeles 2015 Air Emissions Inventory



# Ultra-Low NOx HD Trucks



# Cummins Westport Product Lineup

## Low-NOx Heavy-Duty NG Engines

### ISL-G NZ (9L)

Now CARB & EPA CERTIFIED to  
90% below existing standard



*Deployment Begins*

### ISB-G (7L)

To be CARB & EPA CERTIFIED to  
50% below existing standard



### ISX-G NZ (12L)

To be CARB & EPA CERTIFIED to  
90% below existing standard



*Deployment Begins*

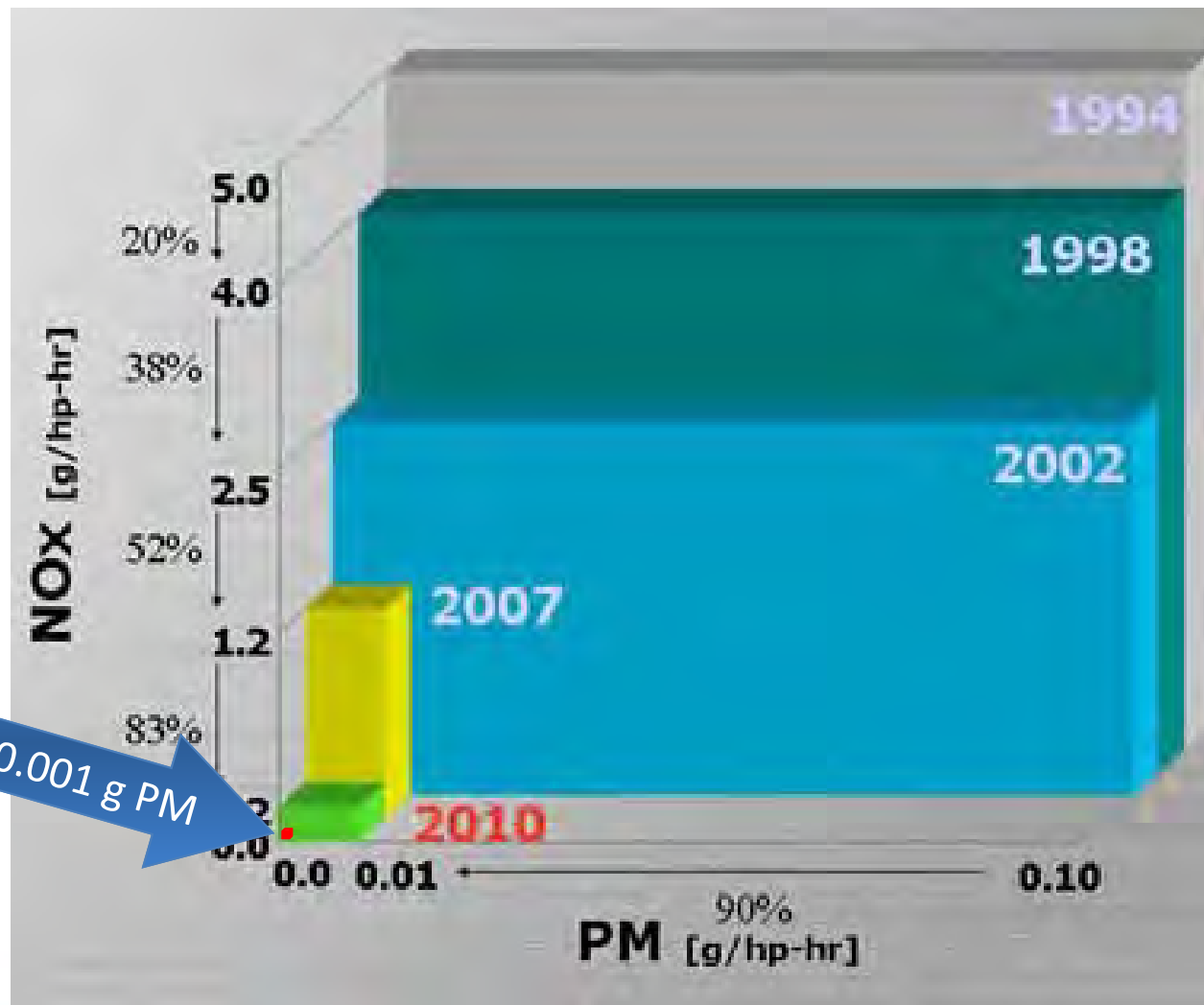
-----2016-----

-----2017-----

-----2018-----



# HD 0.02g NOx Natural Gas Engines



# Near Zero Emission Technology

## **“NEAR ZERO EMISSION”**

- 0.02 g/bhp-hr NOx
- Same as a battery electric truck plugged into a brand new modern combined cycle natural gas power plant in Southern California (i.e. “power plant equivalent”)

## **“ZERO EMISSION EQUIVALENT”**

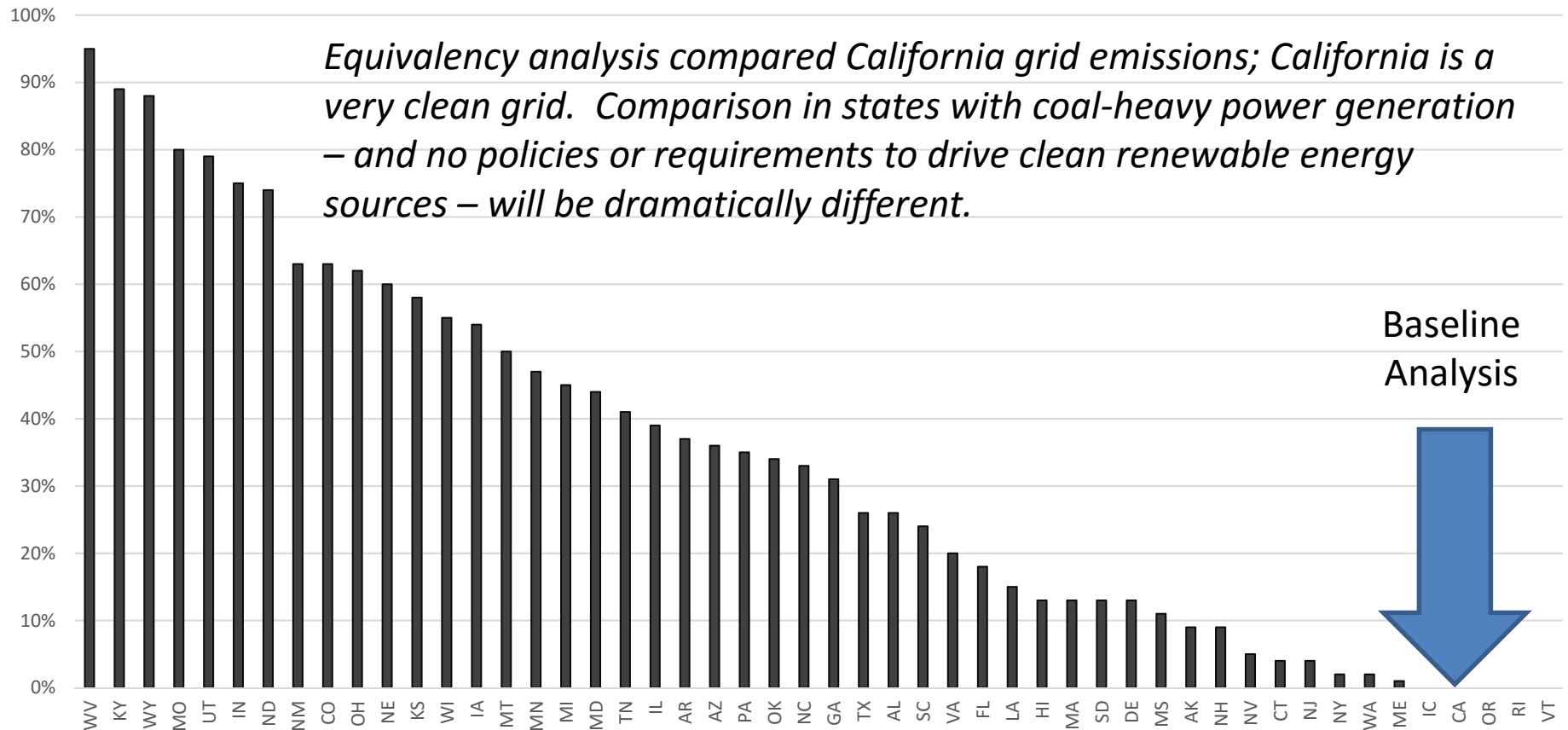
- 0.07 g/bhp-hr NOx
- Same as a battery electric truck plugged into the California grid (~30% carbon free, very clean)
- What about other states with coal heavy power grids?





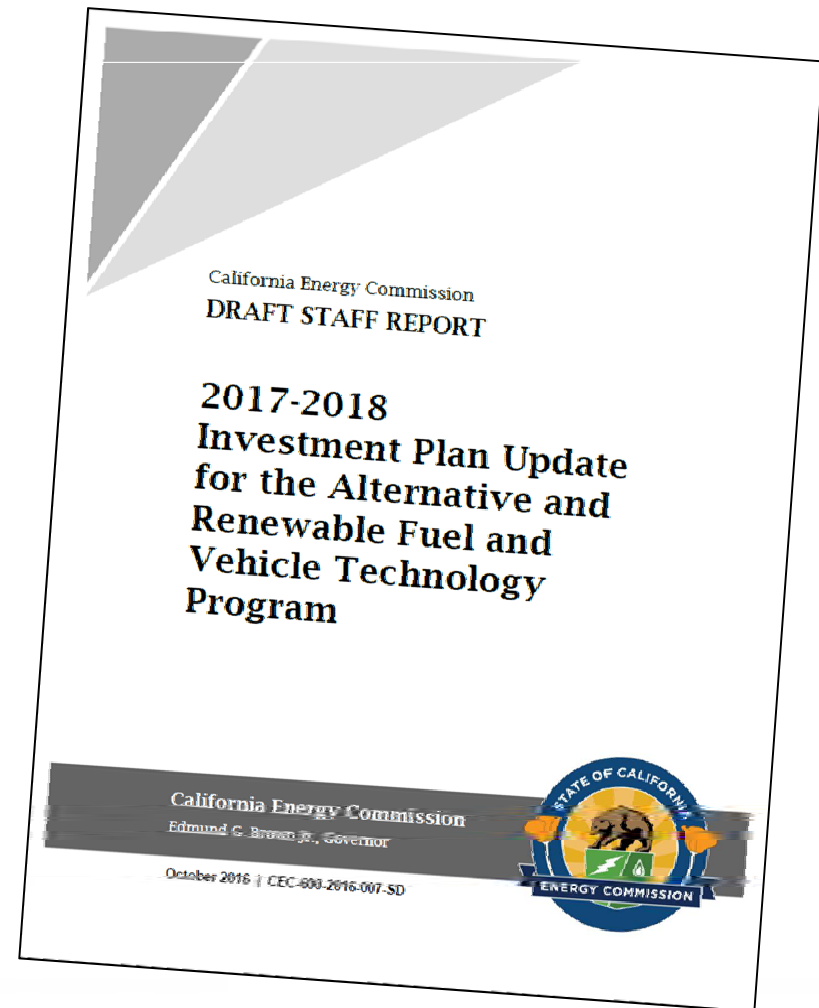
# Grid Cleanliness – Needs to Consider National Grid

## Percent Coal-Fire Generation by State



# Near Zero Emission Technology

*Growing recognition by air quality and energy agencies that ultra-low NOx heavy-duty technologies can provide real and immediate benefits, long before other technologies are commercially available to the market and can meet the full range of duty cycles required by the HD sector.*





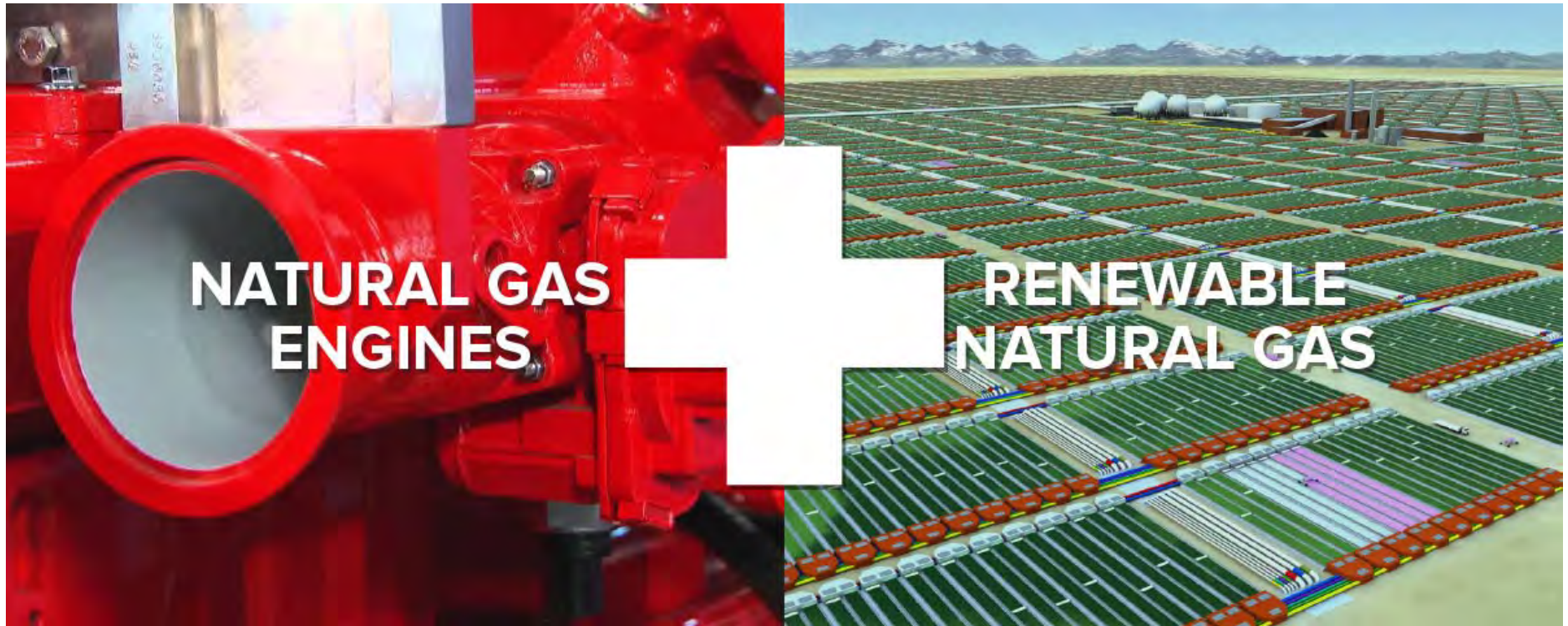
# Near Zero Emission Technology

Emerging technologies are also expected to transform the needs and opportunities for ARFVTP funding in coming years. Natural gas engines and emission control technologies that achieve the ARB optional low oxides of nitrogen (NO<sub>x</sub>) emission standard are now commercially available, and, when combined with biomethane fuel, can reduce the life-cycle emissions of medium- and heavy-duty vehicles to levels near or equal to those of zero emission electric vehicles. Nonpropulsion technologies, such as intelligent transportation systems for freight movement, may also provide an opportunity to reduce petroleum use as well as GHG and criteria pollutant emissions. Energy Commission staff will continue to monitor new opportunities and incorporate them into the ARFVTP investment plan update and solicitations when appropriate.

## **2017-2018 Investment Plan Update**

Assembly Bill 1314 (Wieckowski, Chapter 487, Statutes of 2011) reduced the scope of the annual ARFVTP investment plan to an update. The update builds on the work of

# Game Changing Opportunity



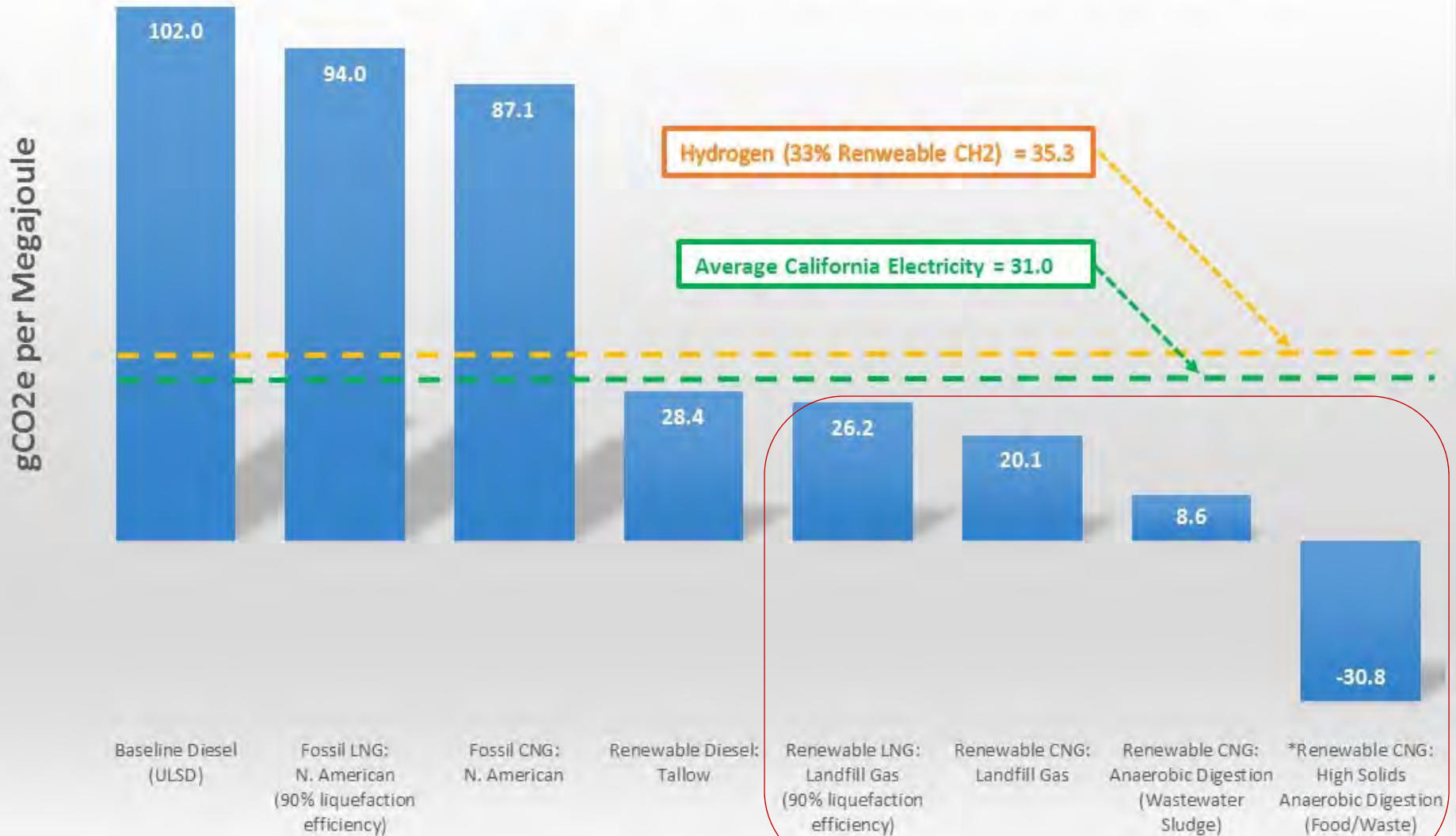


# Sources of Low Carbon RNG

- Landfills
- Organic Waste Digestion
- Dairy Waste
- Waste Water Treatment Plants



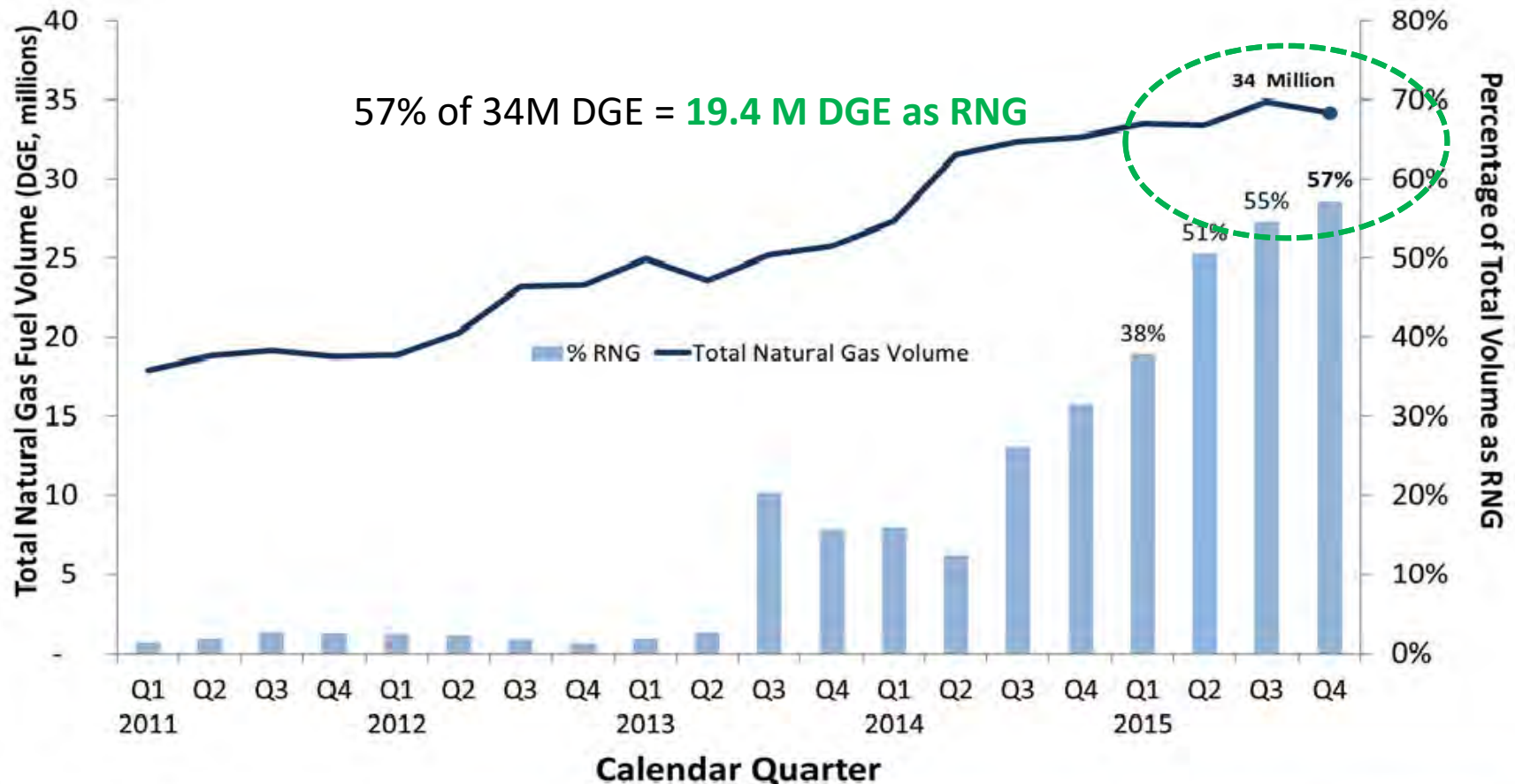
## EER-Adjusted Carbon Intensity Values (Illustrative Only - ARB November 2015, CA-GREET 2.0)



Source: California Air Resources Board, "LCFS Illustrative Fuel Pathway Carbon Intensity Determined using CA-GREET2.0," discussion presented by staff on 9/17/15, except\*, which is from "CA-GREET 1.8b versus 2.0 CI Comparison Table," 4/15/15.



# RNG in the California LCFS



Source: ARB LCFS Quarterly Data. Available at [http://www.arb.ca.gov/fuels/lcfs/dashboard/quarterlysummary/media\\_request\\_041516.xlsx](http://www.arb.ca.gov/fuels/lcfs/dashboard/quarterlysummary/media_request_041516.xlsx)

- **Black line:** total NG volume (millions of DGE) reported under CA's LCFS program
- **Blue bars:** percentage that was RNG
- **Take-away:** well over half (57%) was RNG in latest reporting (Q4, 2015)

# Investment in Low Carbon RNG





# Game Changer White Paper

- Released May 2016
- Documents Zero Emission Opportunity
  - Ultra Low NOx HD Engines
  - Renewable Natural Gas
- Opportunity for:
  - Air Quality Improvement and Federal Attainment
  - Economic Development
  - Climate Change Mitigation

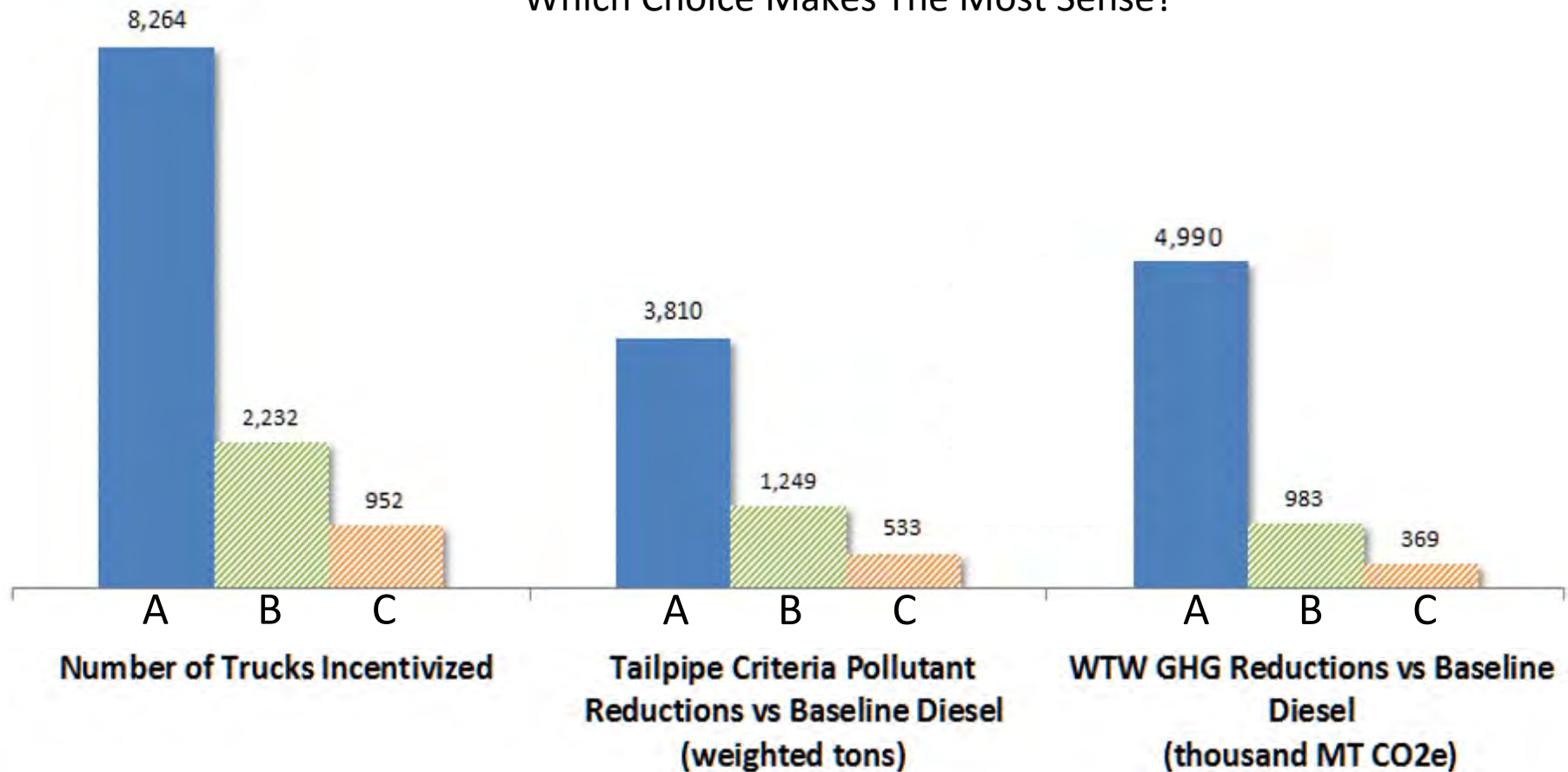
Report available for download:

[http://www.gladstein.org/gna\\_whitepapers/game-changer-next-generation-heavy-duty-natural-gas-engines-fueled-by-renewable-natural-gas/](http://www.gladstein.org/gna_whitepapers/game-changer-next-generation-heavy-duty-natural-gas-engines-fueled-by-renewable-natural-gas/)



# Here Are Some Choices For Cleaning The Air

For the same level of investment, we can pick option A, B or C...  
Which Choice Makes The Most Sense?



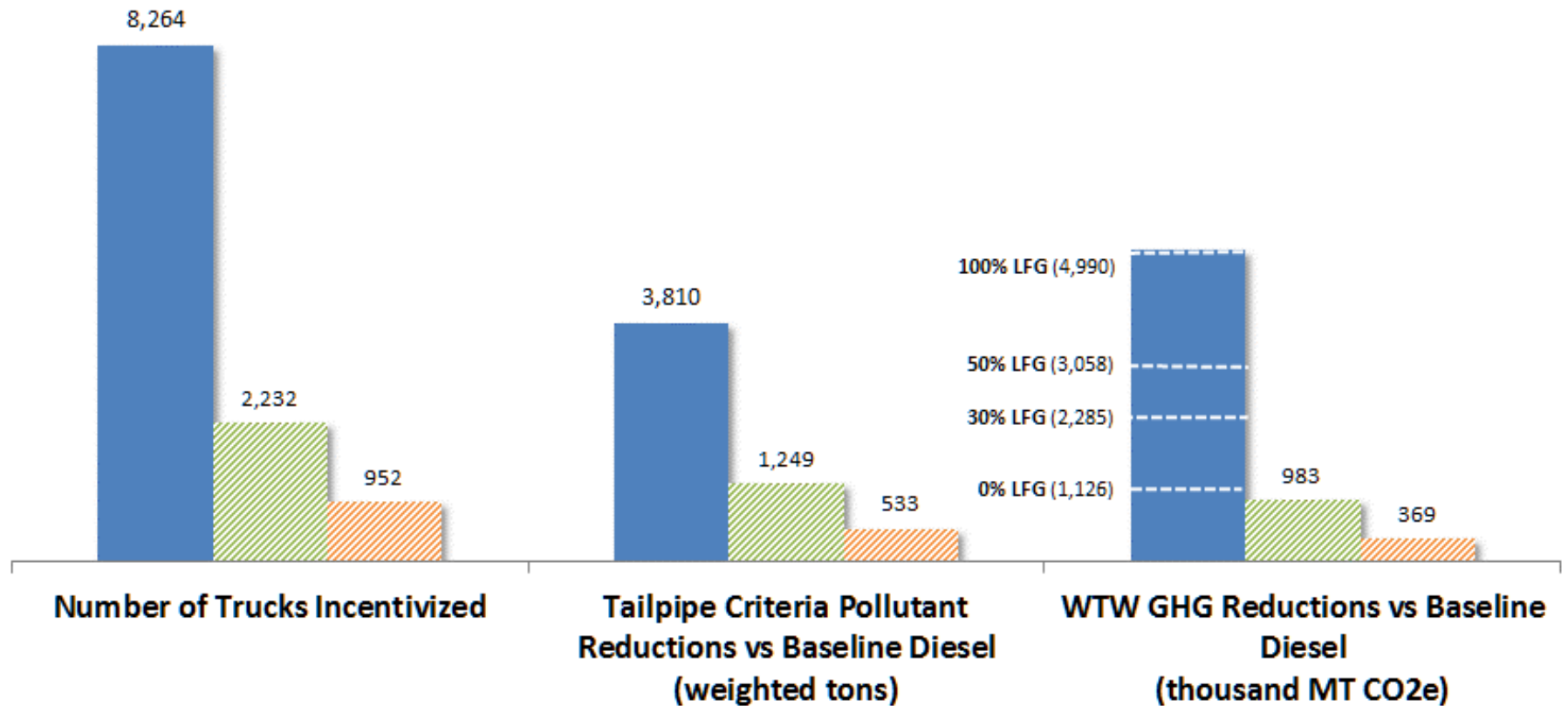


# Short Haul Truck Incentives

## What does \$500 million buy?

■ CNG NZ - LFG
▨ EV Ca Grid
▨ FCV - 33% RH2

*Commercially available in 2016*    *Not yet commercially available in short haul applications*



Incentive amounts based on incremental purchase cost of advanced heavy-duty short haul trucks over baseline diesel truck

Based on emissions and vehicle activity data from CARB EMFAC 2014

Weighted emissions =  $NOx + 20 * PM10 + ROG$

GHG emissions based on illustrative fuel pathways calculated by ARB Staff using CA-GREET 2.0

Cost effectiveness uses Moyer program capital recover factors based on typical retention period of first owner

Analysis done by Ramboll/Environ for LACMTA – CARB currently evaluating

# Cost Effectiveness 2015 – 2055 (\$/ton)

		LNOx + RNG	ELECTRIC BUS		FUEL CELL BUS	
			Depot Charge	Depot & In-route	SMR	ELECTR
Compared to Baseline	Cost Increase (NPV \$ million)	\$161.3	\$2,154.9	\$1,224.5	\$1,420.7	\$1,992.4
	GHG Reduction (million tons)	11.4	8.3	8.4	3.3	6.7
	In-basin NO <sub>x</sub> Reduction (tons x 000)	2.7	2.9	2.9	0.1	2.5
Cost Effectiveness (\$/ton) <sup>1</sup>	GHG	\$14	\$259	\$146	\$432	\$296
	IB NO <sub>x</sub>	\$59,000	\$755,000	\$427,000	\$20 mill	\$795,000

<sup>1</sup> Assumes that 100% of cost increase attributed to each pollutant



# In Use NG Emissions Very Compelling

**UCR** | College of Engineering- Center for Environmental Research & Technology

## Description

Modal NO<sub>x</sub> with ambient bag correction

Dilute bag NO<sub>x</sub> with ambient bag correction

Raw NO<sub>x</sub> no ambient bag correction

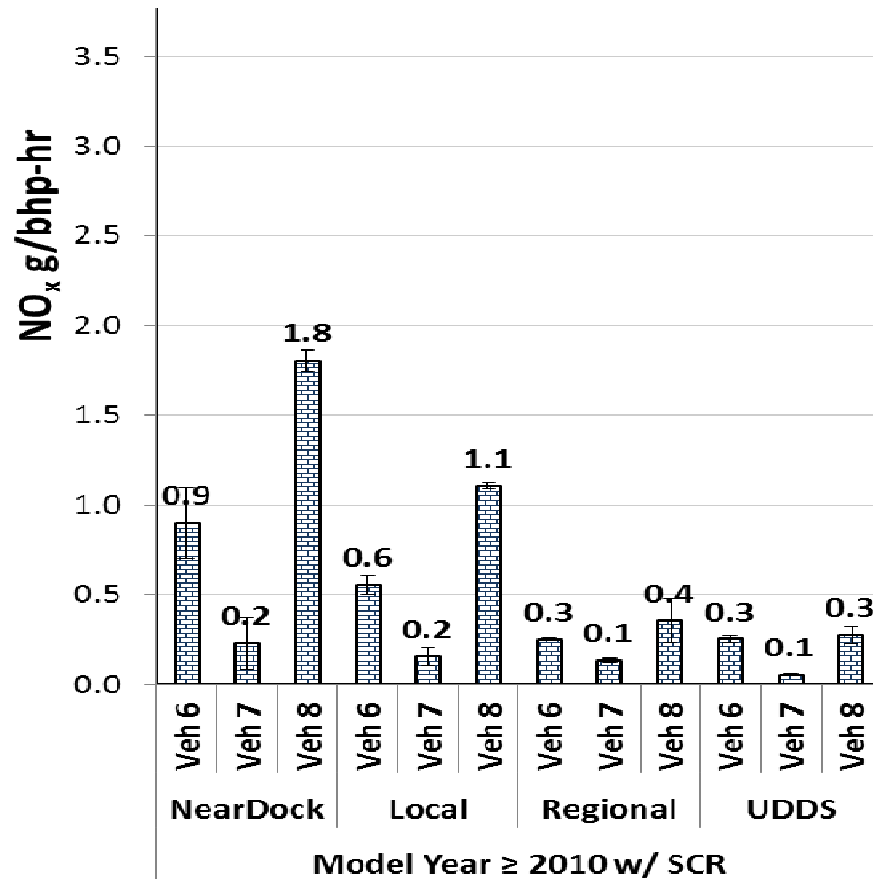
Modal dilute NO<sub>x</sub> with ambient real time correction

Trace analyzer dilute bag with trace ambient bag correction



MY 2012 Diesel w/ SCR

# In Use NG Emissions Very Compelling



- NO<sub>x</sub> levels from the baseline 2012 diesel with SCR in a drayage duty cycle, with high NO<sub>x</sub> in nearly all modes.



MY 2012 Diesel w/ SCR

Chart / data from UCR CE-CERT presentation



# In Use NG Emissions Very Compelling

- **NG engines showing in-use emissions below their certification level, particularly at low speeds (i.e. drayage truck duty cycle)**
- Diesel engine testing showing results that are the exact opposite (i.e. higher than cert level when operating in a drayage duty cycle, by a factor of 3x).
- CWI NZ technology (cert level 0.02g NO<sub>x</sub>) showing **in-use results at 0.002 g NO<sub>x</sub>** (tested using 5 different methodologies).
- **“As the duty cycle decreased on the ISL G NZ engine (i.e., the load-speed got lower), so did the NO<sub>x</sub> emissions.** This is due to the nature of the stoichiometric NG engine and there way catalyst after-treatment. This is the opposite of the diesel engine.”
- **The most important results show that NG NZ engines are actually better in real-world use, especially in duty cycles that are very challenging for diesel trucks (low-speed, low-load). This makes NG a “golden solution” for drayage and refuse type applications, and also very promising for line haul trucks.**
- Key issue is long-term emissions performance after 10,000 miles

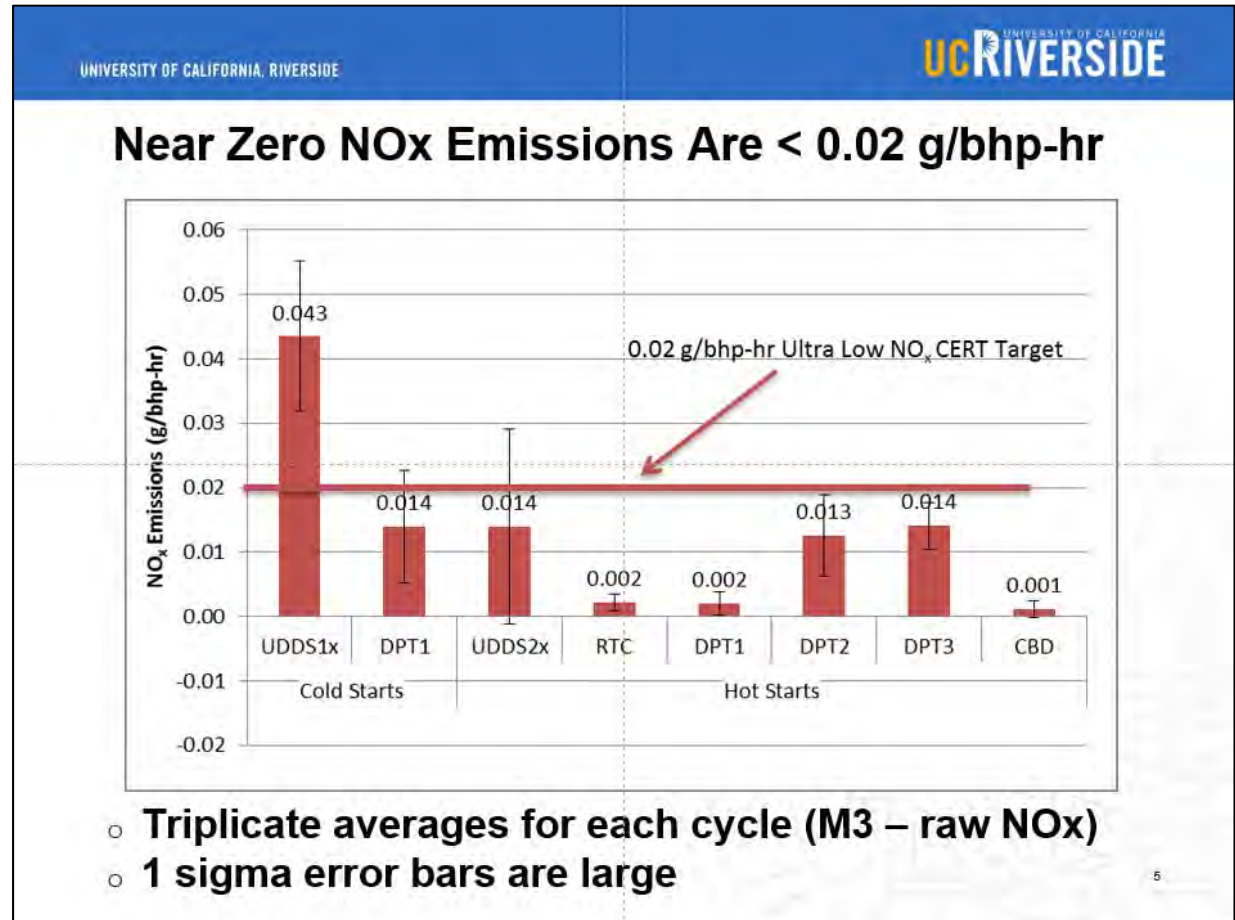
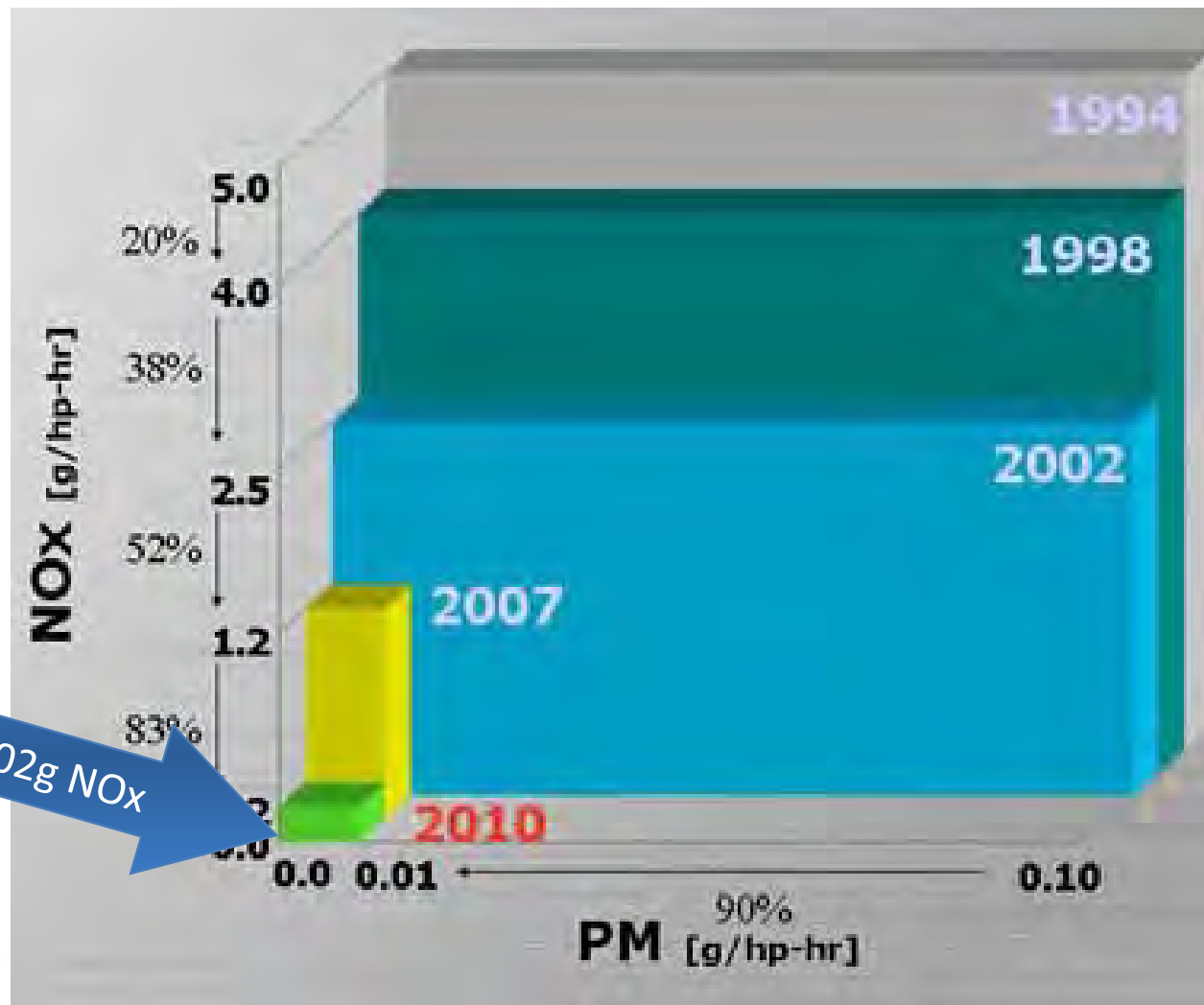


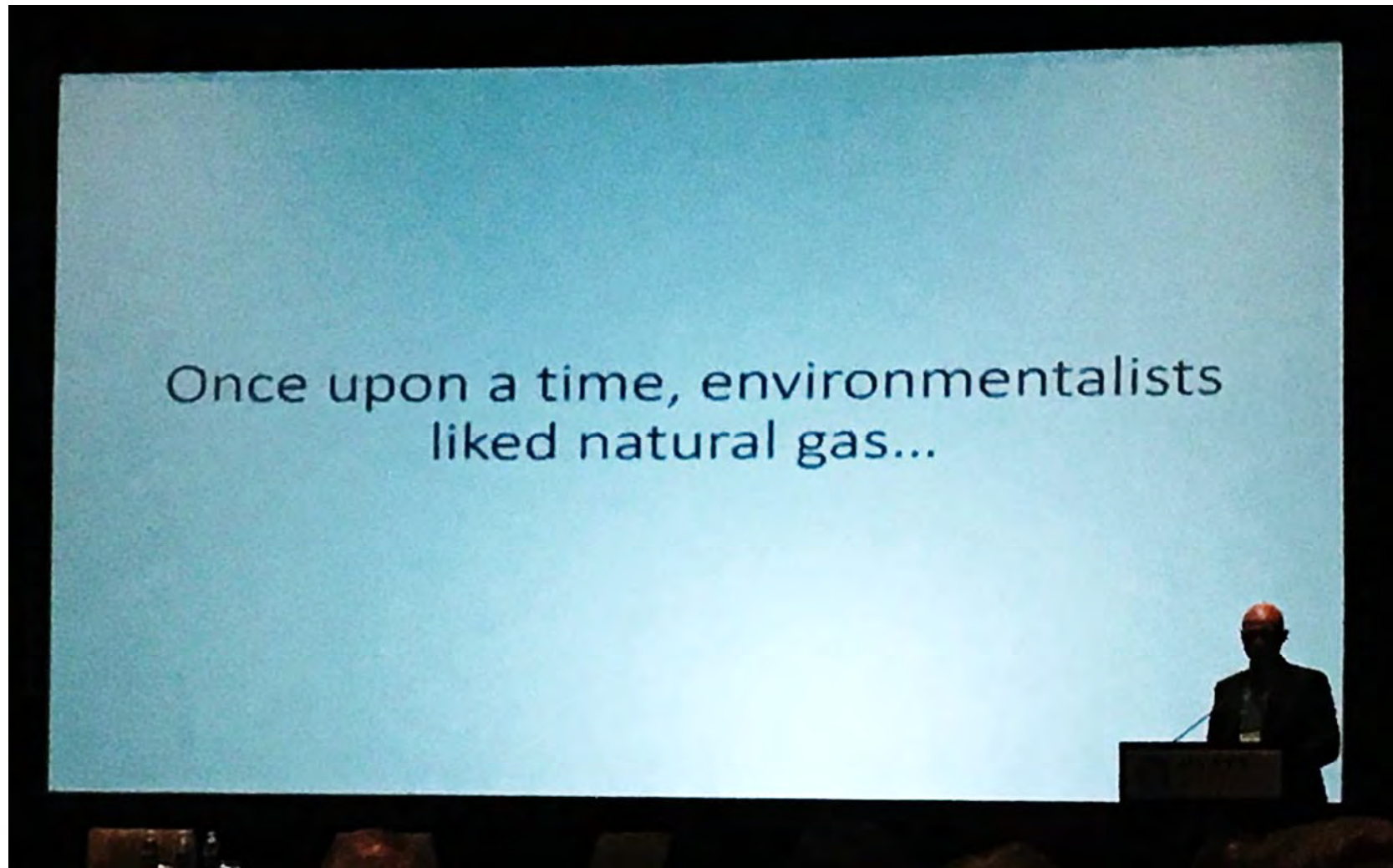
Chart / data from UCR CE-CERT

# In Use Emissions 99% Lower than EPA10!

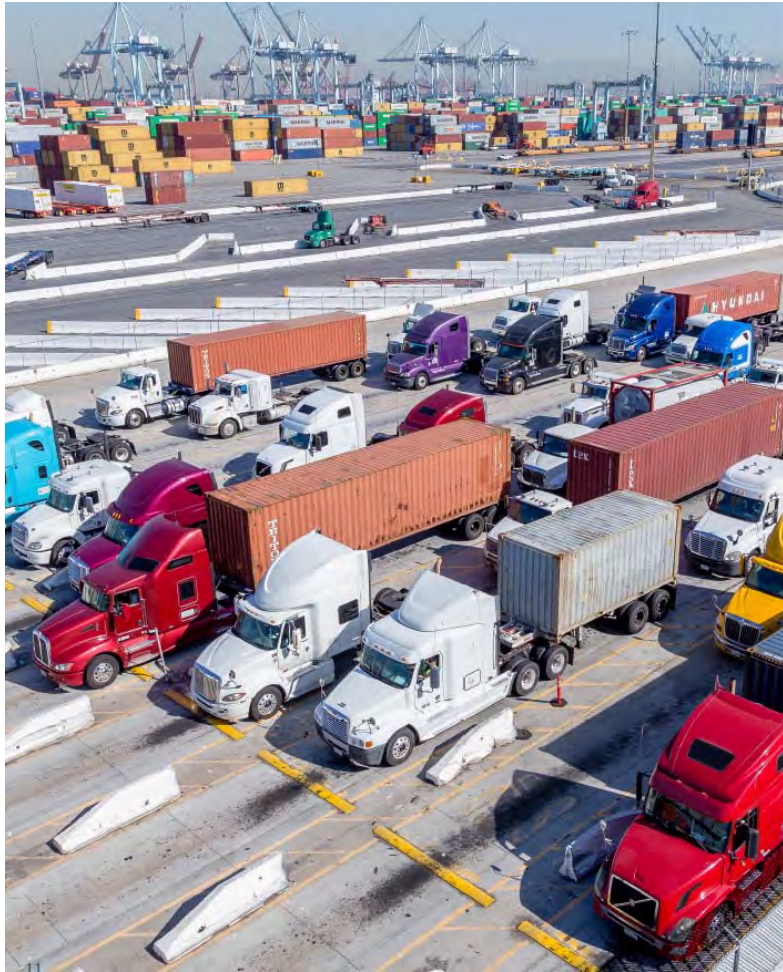




# Natural Gas...Yesterday's Solution?



# Tremendous Opportunity for Air Quality



Natural Gas Trucks  
Offer the Best and Most  
Immediate Opportunity  
to Eliminate Emissions  
From Port Drayage  
Trucks in North America





**THANK YOU!**

**Erik Neandross**

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