

**CLEAN CITIES NATURAL GAS STAKEHOLDERS SUBGROUP
OF HOUSTON-GALVESTON CLEAN CITIES COALITION STAKEHOLDERS**

MEETING NOTES

Thursday, June 14, 2016 – 11:00 A.M.

Houston-Galveston Area Council of Governments
3555 Timmons Lane, Suite 120, Houston, Texas 77027

On June 14, 2016, the Houston-Galveston Clean Cities Coalition (HGCCC) hosted a meeting of the Greater Houston Natural Gas Vehicle Alliance (NGVA) at the Houston-Galveston Area Council (H-GAC) offices. This meeting also served as a meeting of the HGCCC Natural Gas Stakeholders.

At this meeting, there were a pair of speakers. First, Jorge Gonzales of Cummins Westport Inc. presented information about his company's new ISL G Near Zero CNG engine. Second, Andrew DeCandis of H-GAC presented information about the new Interactive Alternate Fuels Finder and recruited volunteers to beta test the new map. Finally, the meeting ended with reports and discussion about CNG issues from NGVA members.

Cummins Westport
The Natural Choice

Near Zero Emissions

ISL G NEAR ZERO

CNG LNC LNG

Why Lower NOx Emissions?

- High temperature engine combustion produces NO_x
- Via complex reaction with sunlight NO_x leads to NO₂
- This Conversion leads to ground level ozone formation
- Reactive hydrocarbons can speed the conversion process
- Natural Gas hydrocarbons are less reactive than diesel
- In most urban areas lower engine related NO_x will reduce ground level ozone

NOx is not Just a Southern California Issue

Attainment and Nonattainment Areas in the U.S. 8-hour Ozone Standard

Attainment (or Unclassifiable) Areas (2668 counties)
 Nonattainment Areas (432 entire counties)
 Nonattainment Areas (42 partial counties)

California NOx Improvement.

- California's poor PM and Ozone air quality is pushing government to take significant steps for NOx improvement
 - Fund technology development and demonstration
 - Offer end-user incentives to offset incremental vehicle costs, customers will request product!

Additional Reductions Needed

- Health impacts still significant
- Localized impacts still remain
- Near and long term reductions still needed for air quality and SIP

If the entire on-road fleet complies with 2010 NO_x standards:

- SIACGS for PM and Ozone will still be exceeded
- NOx creates Ozone
- NOx contributes to secondary formation of PM (nitrate)

How California (ARB) Plans to Get There

- Already a 98% NOx reduction with current standards comparing 1985 to 2010 EPA
- Now ARB has established three optional low NOx emissions standards
 - 0.02 g - "Near Zero" NOx emissions, 90% reduction in NOx from current (2010) standards

ARB 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.

Introducing Cummins Westport's Path to Lower Emissions

Near Zero Emissions Natural Gas Engine

- CWI has been working on a project supported by the SCAQMD, CEC & SoCal Gas to develop technology that would reduce NOx emissions to below the 0.02 g/bhp-hr "Near Zero" level
- In 2014, CWI completed laboratory-based R&D, using prototype hardware, testing the ISL G for near-zero emissions while maintaining current architecture
- 2015 work included
 - Component and engine design for high volume manufacture
 - Extensive component / system validation to demonstrate performance, reliability and durability, including field testing in California
 - Emissions certification
- 2016 Production begins

Emissions Criteria	Reduction	Near Zero
Particulate Matter (PM)	> 90% below EPA standards	✓
Nitrogen Oxides (NOx)	> 90% below EPA standards	✓
Engine-related Methane (CH ₄)	> 90% reduction (on-dock and tailpipe)	✓
Greenhouse Gases (CO ₂ equivalent)	> 90% reduction (technology pathway for further reduction in 2019/2020)	✓

EPA and California ARB Certifications

ISL G

Current ISL G certification

- PM is 80% below the EPA standard
- NOx is 35% below the standard

Pollutant	EPA		CA		EPA		CA	
	FTL	EURO	FTL	EURO	FTL	EURO	FTL	EURO
PM	0.21	0.21	0.02	0.02	15.0	15.0	0.04	0.04
NOx	0.21	0.20	0.04	0.04	1.1	1.1	0.71	0.70

ISL G Near Zero certification

- PM is 90% below the EPA standard
- NOx is 50% below the NZ standard!
- CO₂ is 16% below NZ Standard!

Pollutant	EPA		NZ		EPA		NZ	
	FTL	EURO	FTL	EURO	FTL	EURO	FTL	EURO
PM	0.21	0.21	0.02	0.02	15.0	15.0	0.04	0.04
NOx	0.21	0.20	0.04	0.04	1.1	1.1	0.71	0.70

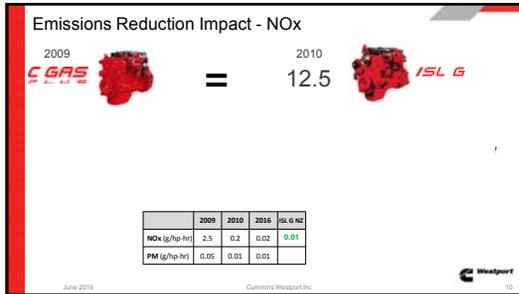
Figure 6-2: The Importance of Federal Standards for Heavy Duty Vehicles*

Current control programs drive all HD vehicles to 2010 0.2 NOx standard by 2023... rapid progress but still not enough to hit Clean Air targets

A NZ NGV advocacy program overlay could reduce NOx 50% below current controls (around 60 extra tons per day)

NZ NGV Advocacy

- NOx is 50% below STD
- PM is 90% below STD
- CO₂ is 16% below STD
- RNG compatibility enables GHG emission reduction to near zero levels as well (landfills, dairies, waste water streams, etc.)
- NZ is ready now... how clean do you want to be and how fast?



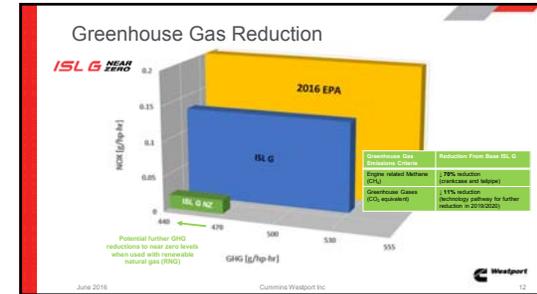
Greenhouse Gas

- Greenhouse gases are essential to maintaining the temperature of the Earth as they reduce the loss of heat into space and help control global temperatures through the greenhouse effect
- Increased emissions of greenhouse gases can cause global warming.
- Carbon Emissions are gaining in importance by government and industry
- Carbon dioxide, methane, nitrous oxide and three groups of fluorinated gases (sulfur hexafluoride HFCs, and PFCs) are the major greenhouse gases.

Natural gas is a low carbon fuel.

From GREET 4, 2015	CNG	LNG	Diesel	Gasoline
Fuel Carbon Content per Unit of Energy (gCO ₂ /MJ)	96.3	95.6	74.9	72.7
CNG compared to Petroleum			25% lower	22% lower

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Use Renewable Natural Gas

- The use of renewable natural gas as a fuel reduces greenhouse gas emissions
- Biogas is a mixture of methane and other gases produced from the natural decomposition of organic materials in landfills, composting or agriculture.
- Purifying biogas to "pipeline quality" produces Renewable Natural Gas (RNG) or biomethane that is a pipeline-quality natural gas substitute.
- Converting the methane that leaks from landfills or other sources to biomethane fuel has significant greenhouse gas emissions reduction benefits.
- In addition, there is a 100% displacement of fossil fuels as RNG is a renewable resource.

Biogas based fuel (RNG) improves GHG reduction

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Renewable Natural Gas (RNG) Improves GHG Profile

- Landfill gas and biogas that has been processed to "pipeline quality" is **RNG**
- ISL G can operate on up to 100% RNG or as it sometimes called, biomethane.
- ISL G / ISX12 G engines are currently in operation with renewable natural gas from landfills (landfill gas) & dairy farms (biogas)

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Greenhouse Gas Reduction from RNG?

gpm/kilometer	Extraction	Processing	Fueling, Transportation and Storage	Vehicle Operation	C in End Use Fuel from CO ₂ in Air (RMG)	Total	Change
Natural Gas (CNG)	124.7	118.4	58.4	1290.7	0	1592.2	-11.1%
Natural Gas (CNG) / ISL G #22	124.7	118.4	58.4	1214.7	0	1516.1	-15.5%
Renewable Natural Gas (CNG - Landfill)	0	31.7	45.3	1214.7	-1141.4	193.6	-89.2%
Diesel	103.2	328.1	9.3	1352.2	0	1792.8	Baseline

Source: GHG Emissions for Cleaner Natural Gas Baseline - Q1, Genesis Feb 2016

- Baseline ISL G natural gas reduces GHG WTW emissions by 11%
- ISL G Near Zero improves WTW GHG reduction to 15%
- Use of RNG with ISL G Near Zero improves GHG reduction to 89%
 - For every 50,000 miles save 128 metric tons of CO₂

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Greenhouse gas (CO₂) Measured in Metric Tons

One Metric Ton of CO₂ = 4 tractor trailers full

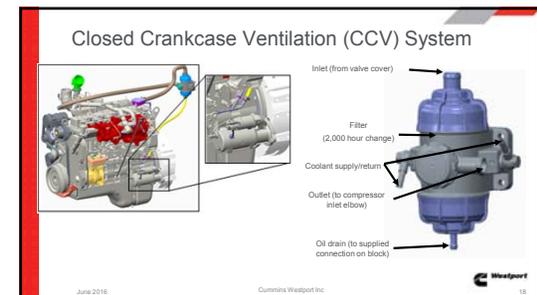
One ISL G Near Zero running RNG removes 512 trailers full of CO₂ per year

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ISL G NEAR ZERO

- Base ISL G engine design is the same
 - Engine will be factory built at Cummins Rocky Mount Engine Plant
 - Ratings, warranty and operational / maintenance procedures will be the same
 - No change in technician service certification requirements
- Closed Crankcase Ventilation (CCV) will be added to engine
 - CCV system reduces engine related methane emissions by 70%
 - CCV filter change required at 2,000 hours
- Three Way Catalyst will change to meet next level emissions
 - Remains maintenance free
 - Larger size catalyst with addition sensor added
 - New substrate composition for durability and emission performance

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ISL G NEAR ZERO Summary

- Cummins Westport has certified the ISL G Near Zero (NZ) NOx with EPA and California ARB for Bus and Truck applications
- Field testing is in progress in transit and refuse applications.
- ISL G NZ NOx engines will be factory built and available in 2016 for new Bus and Truck installations as well as for repowers of existing natural gas vehicles.
 - There are no plans for retrofit kits for existing engines
- Zero Emission technology at conventional propulsion system values!



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Why ISL G Near Zero vs Current ISL G?

- ISL G Near Zero has 90% lower NOx and 9% better GHG profile
 - Lowest emission mid range engine in North America
 - 10 - ISL G Near Zero engine NOx emissions equal one ISL G
 - Tenfold decrease in emissions for new and existing fleets
- ISL G Near Zero is better qualified for Non Attainment funding
 - Cleanest ICE technology available.
- ISL G Near Zero features all the latest engineering improvements from the ISL G
 - Natural gas fleets looking to replace existing natural gas vehicles or engines will notice a dramatic improvement in reliability an uptime performance
- ISL G Near Zero affords fleets the opportunity to market "Near Zero" emissions.
- ISL G Near Zero is the "go forward" product for CWI
 - OBD in 2018 will obsolete base ISL G

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Near Zero Product Plan – Feb 2016

(Certified to ARB Near Zero NOx standard - 0.02 gm/bhp-hr.)

Engine	2016	2017	2018	2019
ISB6.7 G	Available	Available	Development Program Not Funded	Development Program Not Funded
ISB6.7 G	Available	Available	Development Program Not Funded	Development Program Not Funded
ISL G	Available	Available	Available	Available
ISL G	Available	Available	Available	Available
ISX12 G	Available	Available	Available	Available

Legend: Available (Green), Not Available (Cross-hatched)

* ISB6.7 G will be certified at launch to California ARB optional Low NOx (0.1 gm/bhp-hr.)
 Near Zero development funding for the ISB6.7 G has not been secured – no ISB6.7 G NZ in plan without funding
 ISX12 G NZ will be available in 2018
 Base ISL G and ISX12 G engines are not available post 2017 (not OBD compliant)

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OEM Availability

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OEM Availability

	OEM	ISL G	ISX12 G	OEM	ISL G	ISB6.7 G
Conventional Truck	Freightliner	Yes	Yes	El Dorado	Yes	Pending
	International	Yes	-	Gillig	Yes	-
	Kenworth	Yes	Yes	New Flyer	Yes	-
	Mack	-	Yes	Nova	Yes	-
	Peterbilt	Yes	Yes	Blue Bird	Yes	-
Refuse Truck	Volvo	Yes	Yes	IC Bus	-	-
	Western Star	-	-	Thomas Built	Yes	Yes
	Autocar	Yes	Yes			
Coach	Crane Carrier	Yes	-			
	Mack	Yes	-			
	Peterbilt	Yes	Yes			
	MCI	-	Yes			

ISL G NZ Availability Pending OEM orders

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More information... www.cumminswestport.com



- Natural Gas Academy: great source of information about NG, technology, vehicles
- Series of instructional videos, including engine walk-arounds and service & driver training videos
- Engine information – specs, features, maintenance intervals
- Product Brochures & Bulletins available for download

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Cummins Westport Regional Managers



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Thank You



Jeff Campbell,
 Director, Marketing
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Ixhc#Ilgghu

Houston-Galveston Area Council
June 14, 2016

Andrew DeCandis, Air Quality Planner



2

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- Allow users to find alternative fuels in a Houston-specific format
- Facilitate networking between potential fleets and vendor partners
- Help to match future supply with current demand



3

Dorz #Kvhuv#wr #Ilgg#Dw#Ixhov

- Publically accessible map
- Allows users to find information about a variety of fuels as well as facility info




4

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- Allows users to suggest:
 - Changes to existing facilities that may have new or incorrect information
 - Inform H-GAC and other users of new facilities that are in development.




5

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- Allows users to suggest locations where alt fuel stations will be helpful
- H-GAC staff will follow up with requester and convey interest to suppliers




6

Ghp rqvudwlrq



7

P rylqj#Iruz dug

- Complete and publish basic map with interactivity
- Add additional data to map to help fuel providers with locating new stations
 - Pipeline information and other sources
 - Fleet concentrations



8

Z kdwa#rx#Fdq#Gr

- Be a Beta Tester
- Make Suggestions
- Offer Data
 - Fleet
 - Infrastructure



9

- <http://tr266.hgac.net/flexviewers/AlternateFuels/>

