

Will Truckers Ditch Diesel for Natural Gas?

- Great Lakes Maritime Research Institute
- June 19th, 2012
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Agenda

- What is driving the business?
- LNG / CNG technology.
- Correct Application

Agenda

**What is driving the
business?**

Market Segmentation

DIFFERENTIATED TECHNOLOGY

LD



forklifts



passenger cars



light-duty trucks



MD



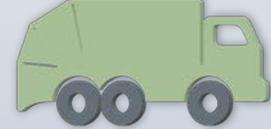
delivery vans



school / shuttle buses



transit buses / motorcoaches



wastehaulers



vocational trucks



HD



heavy vocational trucks



heavy-duty long-haul trucks



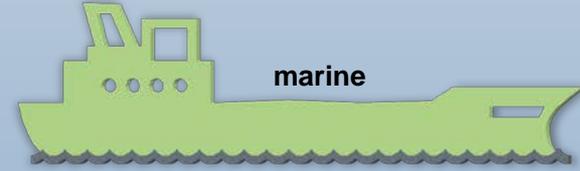
HHP



rail



mining (resource extraction)



marine

*



cryogenic fuel storage, delivery and transportation



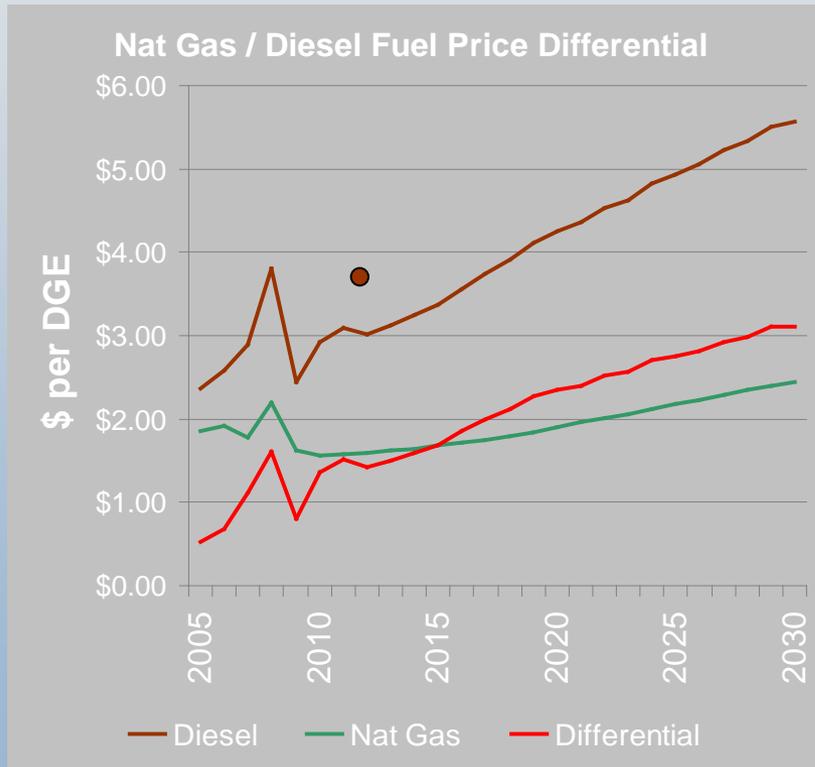
Natural Gas and Transportation

- **Economics** – Lifecycle operating cost superiority over diesel
- **Performance** – same horsepower, torque & fuel economy as base diesel
- **Emissions** – ~25% GHGe reduction; EPA/CARB 2010 certified
- **Energy security/ volatility**– domestic natural gas

Energy Game Changer: Domestic Natural Gas

Forecast: Delivered Energy Prices for Diesel & Natural Gas Transportation Fuels, 2010-2035

2008 Equivalent U.S. Dollars Per Gallon Equivalent



Source U.S. Energy Information Administration, Annual Energy Outlook 2010

Gas Shale Plays are an Industry Changing Breakthrough



North America Resource Estimates

- 2,119 Tcf of Total Resource
- 95+ Year Supply at 75 Bcf/d
- 70+ Year Supply at 100 Bcf/d

Source International Gas Union, October 2009

GX ANNUAL FUEL SAVINGS ESTIMATOR (STANDARD)

ANNUAL FUEL CONSUMPTION (values in DEG [diesel equivalent gallons] per year per truck)

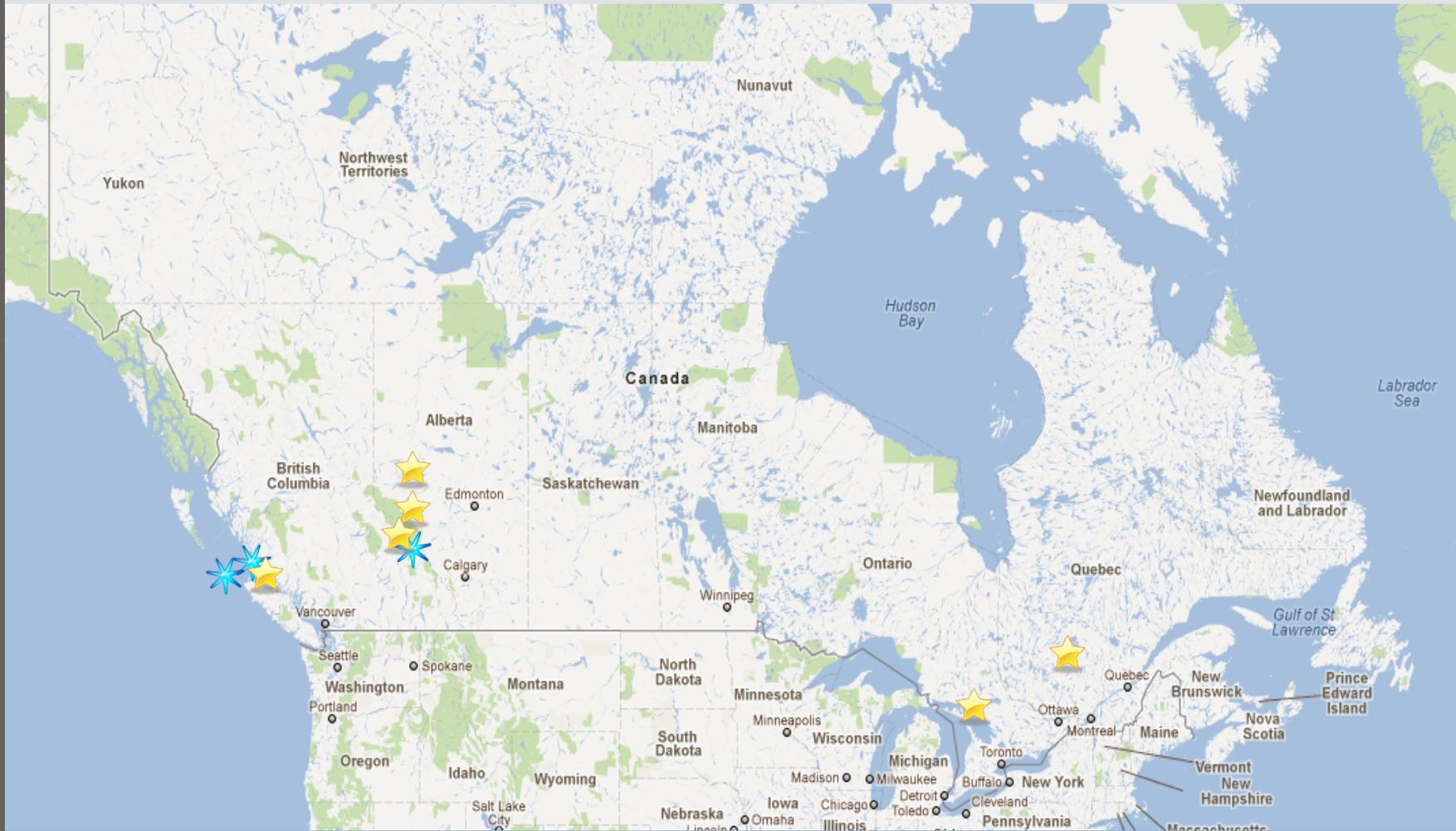
Fuel Economy (miles per DEG)	Annual Mileage (miles per year)							
	25,000	50,000	75,000	100,000	125,000	150,000	175,000	200,000
3.5	7,143	14,286	21,429	28,571	35,714	42,857	50,000	57,143
4.0	6,250	12,500	18,750	25,000	31,250	37,500	43,750	50,000
4.5	5,556	11,111	16,667	22,222	27,778	33,333	38,889	44,444
5.0	5,000	10,000	15,000	20,000	25,000	30,000	35,000	40,000
5.5	4,545	9,091	13,636	18,182	22,727	27,273	31,818	36,364
6.0	4,167	8,333	12,500	16,667	20,833	25,000	29,167	33,333
6.5	3,846	7,692	11,538	15,385	19,231	23,077	26,923	30,769
7.0	3,571	7,143	10,714	14,286	17,857	21,429	25,000	28,571
7.5	3,333	6,667	10,000	13,333	16,667	20,000	23,333	26,667
8.0	3,125	6,250	9,375	12,500	15,625	18,750	21,875	25,000

These tables provide a quick estimate of the potential fuel saving achieved by a single GX powered vehicle as a result of the differential price between LNG and diesel, based on the vehicle's fuel economy, annual mileage and resulting annual fuel consumption.

ANNUAL FUEL SAVINGS (values in dollars per year per truck)

Fuel Price Differential (\$ per DEG)	Annual Fuel Consumption (DEG per year)											
	5,000	10,000	15,000	20,000	25,000	30,000	35,000	40,000	45,000	50,000	55,000	60,000
\$0.25	\$1,250	\$2,500	\$3,750	\$5,000	\$6,250	\$7,500	\$8,750	\$10,000	\$11,250	\$12,500	\$13,750	\$15,000
\$0.50	\$2,500	\$5,000	\$7,500	\$10,000	\$12,500	\$15,000	\$17,500	\$20,000	\$22,500	\$25,000	\$27,500	\$30,000
\$0.75	\$3,750	\$7,500	\$11,250	\$15,000	\$18,750	\$22,500	\$26,250	\$30,000	\$33,750	\$37,500	\$41,250	\$45,000
\$1.00	\$5,000	\$10,000	\$15,000	\$20,000	\$25,000	\$30,000	\$35,000	\$40,000	\$45,000	\$50,000	\$55,000	\$60,000
\$1.25	\$6,250	\$12,500	\$18,750	\$25,000	\$31,250	\$37,500	\$43,750	\$50,000	\$56,250	\$62,500	\$68,750	\$75,000
\$1.50	\$7,500	\$15,000	\$22,500	\$30,000	\$37,500	\$45,000	\$52,500	\$60,000	\$67,500	\$75,000	\$82,500	\$90,000
\$1.75	\$8,750	\$17,500	\$26,250	\$35,000	\$43,750	\$52,500	\$61,250	\$70,000	\$78,750	\$87,500	\$96,250	\$105,000
\$2.00	\$10,000	\$20,000	\$30,000	\$40,000	\$50,000	\$60,000	\$70,000	\$80,000	\$90,000	\$100,000	\$110,000	\$120,000
\$2.25	\$11,250	\$22,500	\$33,750	\$45,000	\$56,250	\$67,500	\$78,750	\$90,000	\$101,250	\$112,500	\$123,750	\$135,000
\$2.50	\$12,500	\$25,000	\$37,500	\$50,000	\$62,500	\$75,000	\$87,500	\$100,000	\$112,500	\$125,000	\$137,500	\$150,000
\$2.75	\$13,750	\$27,500	\$41,250	\$55,000	\$68,750	\$82,500	\$96,250	\$110,000	\$123,750	\$137,500	\$151,250	\$165,000
\$3.00	\$15,000	\$30,000	\$45,000	\$60,000	\$75,000	\$90,000	\$105,000	\$120,000	\$135,000	\$150,000	\$165,000	\$180,000

LNG Infrastructure Canada



Agenda

LNG / CNG HD technology.

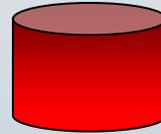
Volume and Range Comparison

Diesel



Volume Per 100

mi



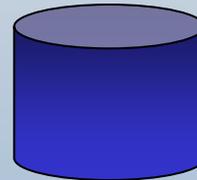
15 Gal.

Approximate
Range Per 100
Gallons



650 mi

LNG

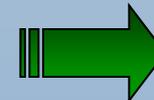


28 Gal.



380 mi

CNG



170 mi

* Estimate based on 6.5 mpg diesel, and same efficiency for NG vehicle

LNG vs. CNG

- Re-fuelling time
 - LNG tanks are re-fuelled at 40gpm = 3-4 minutes/tank
 - Fuelling times same as diesel
 - Fast fill CNG takes as much as 5 x longer
- Portability
 - Mobile LNG units can be relocated anywhere to meet customers needs
- LNG not limited by pipeline constraints
 - CNG stations need to be situated at large interstate/intrastate pipelines



ISL G



8.9 Litre (540 cu. In.)
In line 6 cylinder
Charge Air Cooled (CAC)
Spark ignition

Ratings:

HP-250-320 hp

Torque: 660-1000 lb-ft

2010 EPA and CARB certified

Manufactured by Cummins in

Cummins Engine Plant- Rocky Mount, North Carolina

Over 6,000 in service.



OR



Westport™ HD

14.9 Litre
In line 6 cylinder
High Pressure Direct Injection (HF)
Compression Ignition
SCR Aftertreatment

Ratings:

HP-400-475 hp

Torque: 1450 -1750 lb-ft

2010 EPA and CARB certified

Based on Cummins 2009 ISX eng

Engine conversion by Westport at

Westport Assembly Center, Delta, BC

Over 300 in service.



All classes of the vehicle market

Light Duty (1-5 litres)



Westport™ LD

Medium Duty (5.6-9 litres)



Westport

Heavy Duty (11-16 litres)



Westport™ HD

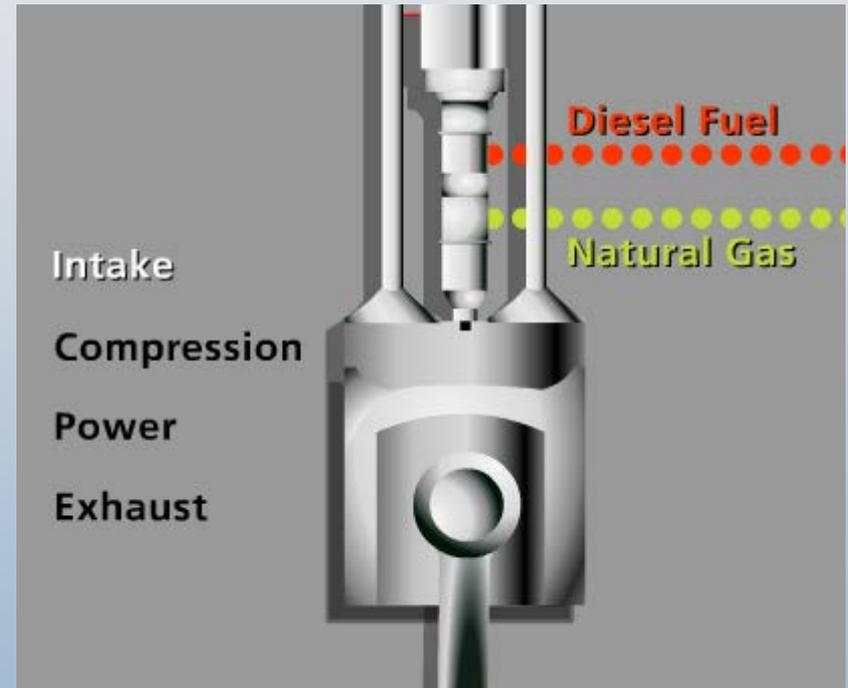
High Horsepower (>16 litres)



Class-leading emissions performance while maintaining equal horsepower, torque, and efficiency to a diesel/petrol-fueled engine

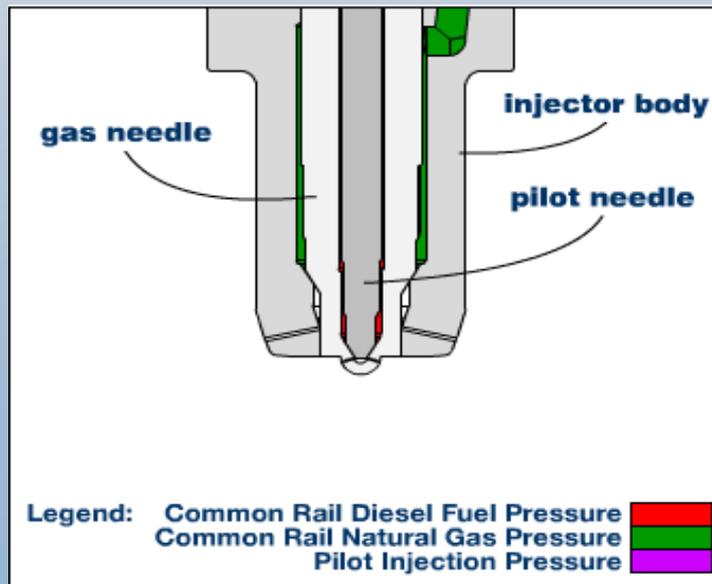
Westport™ HD HPDI Technology

- Pilot diesel injected just prior to natural gas to provide energy for auto-ignition of gas injection
- Natural gas injected at high pressure at end of compression stroke (no pre-mixed air/fuel)
- Low diesel usage under all conditions
- Diesel Engine Performance remains
 - Same high power and torque
 - Same or higher efficiency
- Robust combustion over wide range of fuel composition (no premixed air/fuel so no chance of detonation)



Westport™ HD HPDI Fuel Injector

- Common-rail style injector
- Directly replaces diesel injector
- Capable of independently injecting diesel and gas at up to 300 bar (4500 psi) injection pressure
- Diesel used as an ignition source, actuation fluid, lubricant, and coolant



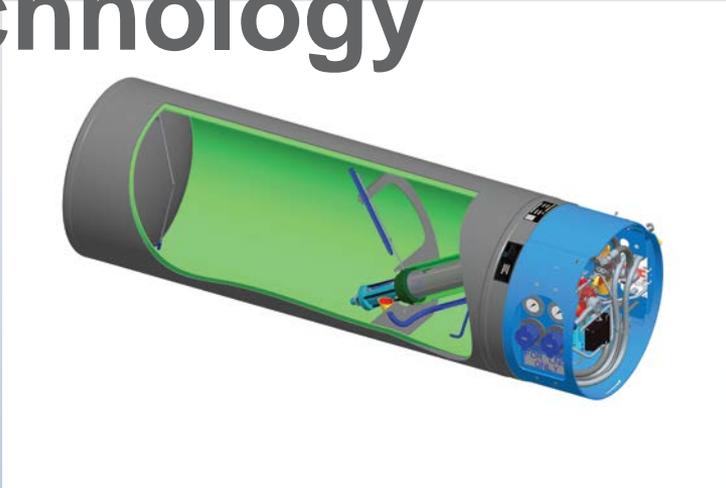
Diesel

HPDI



Westport Tank Technology

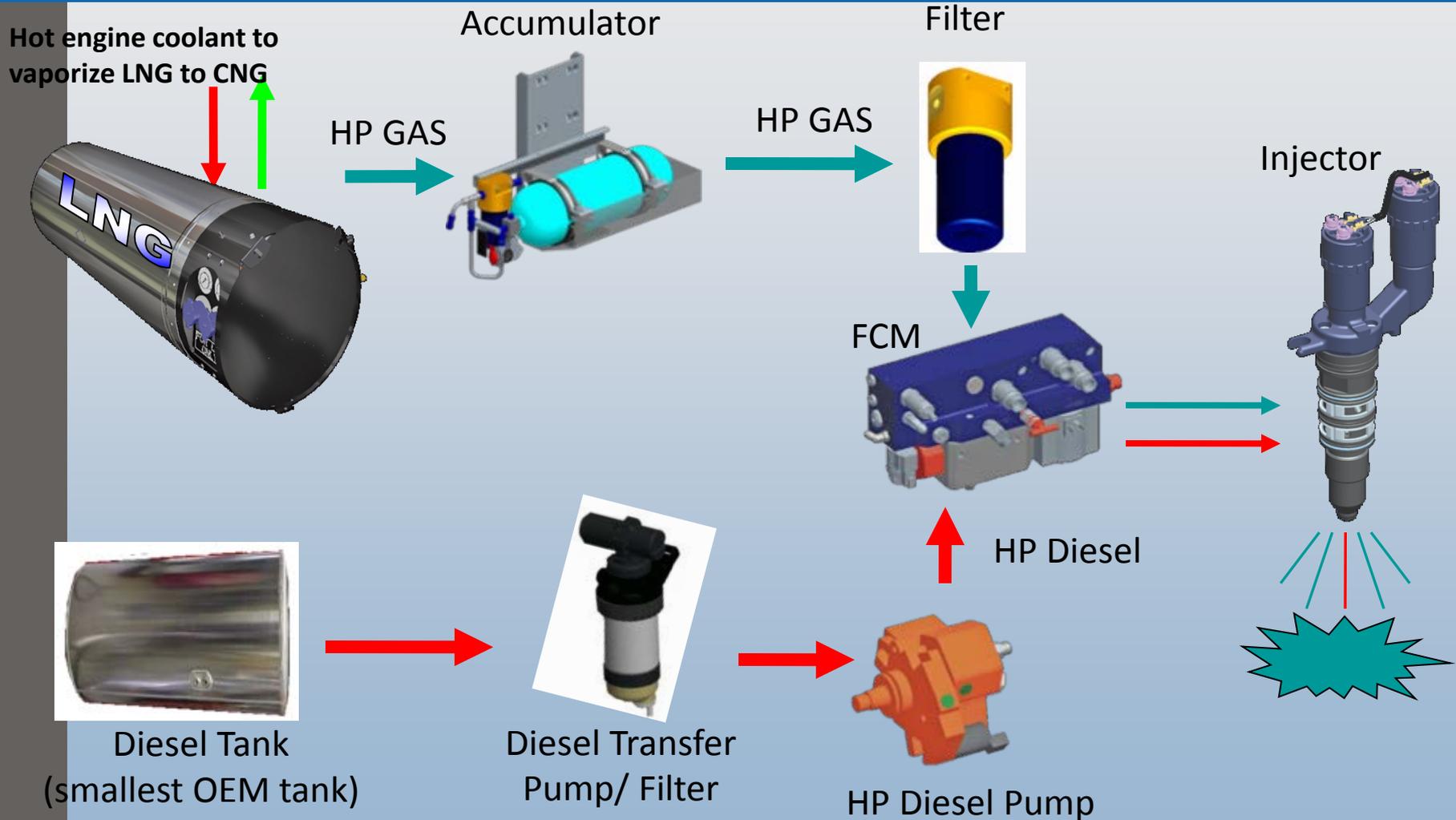
- Works like a “Thermos”
 - Dual wall 3.5mm T304 SS
 - Insulated by a vacuum and cryogenic insulation materials
 - Internal hydraulic LNG pump



- Can have 1 or 2 fuel tanks per vehicle

	70 gal	100 gal	120 gal
Diesel Gallon Equivalent :	31 DGE	44 DGE	54 DGE
Total weight (full of LNG, incl. brackets & piping) :	844 lbs	1056 lbs	1200 lbs
Range at 5.5mpg US :	170 miles	245 miles	300 miles

Westport™ HD Westport HPDI – Operations





Agenda

Applications

- Loads > 100,000 lbs
- High fuel consumption 5.4 MPG
- High annual miles 120,000 plus
- Dedicated routes
- Main transportation corridors
- Range 250 to 500 miles one way
- Engine > 400 HP, > 1500 lb-ft.
- Trade cycle > 5 years
- PACCAR customer
- Dealer network engaged in natural gas



Applicable Vocations

- Most HD applications are suited to Westport GX LNG System
 - 1450 – 1750 ft-lbs of torque
 - 400 – 475 hp

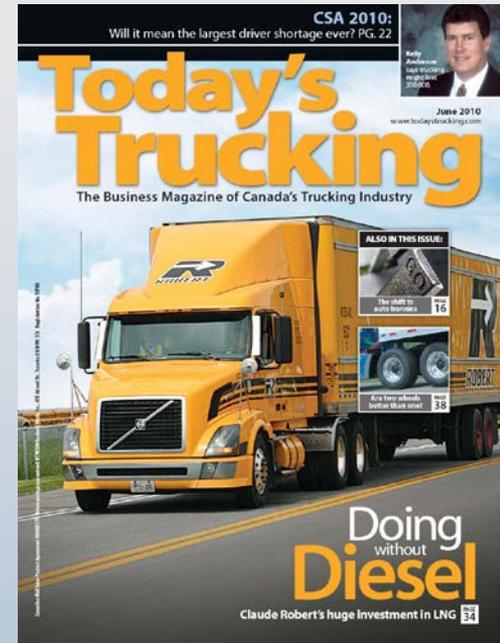


- Customized chassis integration to suit:

Roll Off Trucks	✓
Heavy Haul	✓
Refuse Transfer	✓
Water Trucks	✓
Flat Bed Haul	✓
Dump Truck	✓
Freight Haul	✓
Derrick Rigs	✓
Bulk Haul	✓

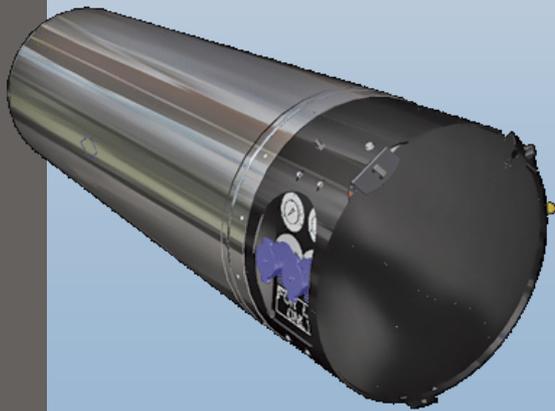
Application

- Transport Robert: 180 LNG Peterbilts
- Vedder Transport: 50 LNG Peterbilts
- UPS: 48 LNG Kenworths
- Heckmann: 200 LNG Peterbilts
- Ryder: over 200 LNG trucks





LNG Safety



Thank You

