



**EVERY
ALTERNATIVE.**

The Engine/Energy Transition to Tomorrow

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Cummins Westport Inc.
January 24, 2008

New Appointment



Vice President
Of
Big Decisions

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Fred & Myrtle

And the

Helicopter

Ride

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What is changing ?

- Higher vehicle pricing for new technology
- Higher cost of Ultra Low Sulfur diesel fuel
- SCR for 2010 -- cost implications
- The shifting economics of diesel operation
- Concern about Green House Gases

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What are your alternatives?



- Get out your checkbook
- Conserve diesel fuel however you can
- Change vehicle specifications
- Bus and Truck specs for fuel economy
- Consider other alternatives
- Manage better

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Question



When was the first
Diesel Truck sold in
the United States?

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Why Diesel?

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THE CUMMINS DIESEL
*"Twice as Far for
Half as Much"*

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Consider an Alternative to Diesel Fuel

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- Cost
- Performance
- Emission reduction trade-offs
- Infrastructure and fuel availability
- Impact on engine components

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Alternative Fuel Options

- Fuels
 - Biodiesel
 - Di-Methyl Ether (DME)
 - Ethanol
 - Methanol
 - Gas to liquid
 - Coal to liquid
 - Water/diesel emulsions
 - Ethanol/diesel emulsions
 - Natural Gas (CNG / LNG)
 - Propane
 - Hydrogen
 - Hythane (NG + H)
 - Biofuels (non-biodiesel ester)
- Criteria
 - Availability
 - Chemistry
 - Efficiency
 - Emissions
 - Infrastructure
 - Price
 - Safety

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Alternative Fuel Properties

Characteristics	Diesel	Biodiesel	MeOH	EtOH	NG	LPG
Structure	$C_{18}H_{36}$	$C_{18}H_{35}O_2$	CH_3OH	C_2H_5OH	CH_4	C_3H_8
Cetane No.	40+	40+	10	10	--	5
Octane No.	--	--	95	95	120	95
Energy (LHV)						
btu/gal(x1000)	128	119	57	76	85(LNG)	84
btu/cu. ft					1000(CNG)	
Energy Storage (relative vol.)	1	1.1	2.3	1.7	1.7 (LNG) 3.7 (CNG)	1.6

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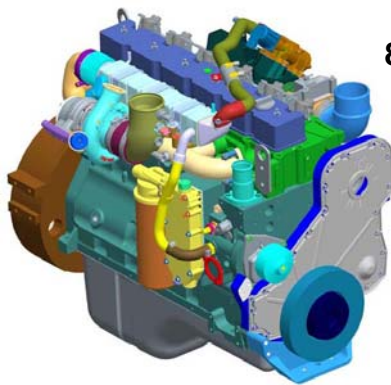
What about natural gas ?



- Cleaner burning than diesel
- Abundant supply in North America
- Engine efficiency improving over diesel
- Renewable fuel – LFG to LNG
- Can be less expensive to operate than diesel
- Latest technology engines available

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ISL G – Next Generation Natural Gas Engine



8.9 litre Stoichiometric EGR engine:

- Lowest emissions
 - **0.20 g/bhp-hr NOx**
 - **0.01 g/bhp-hr PM**
- Higher efficiency
- Diesel-like reliability & durability
- Improved performance - Higher clutch engagement torque
- 250-320 Ratings
- Increasing OEM Availability
- Fourth generation

ISL G

Launched June, 2007

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2007 ISL G Benefits

- Meets 2010 Emission Standards
- More fuel efficient
- No exhaust system related maintenance costs
- Improved clutch engagement torque (+34%)
- 80% of design based upon diesel engine platform
- Uses a renewable fuel found in North America
- Substantial GHG Reductions

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ISL G Applications/OEMs

REFUSE



URBAN TRANSIT



VOCATIONAL



FUTURE



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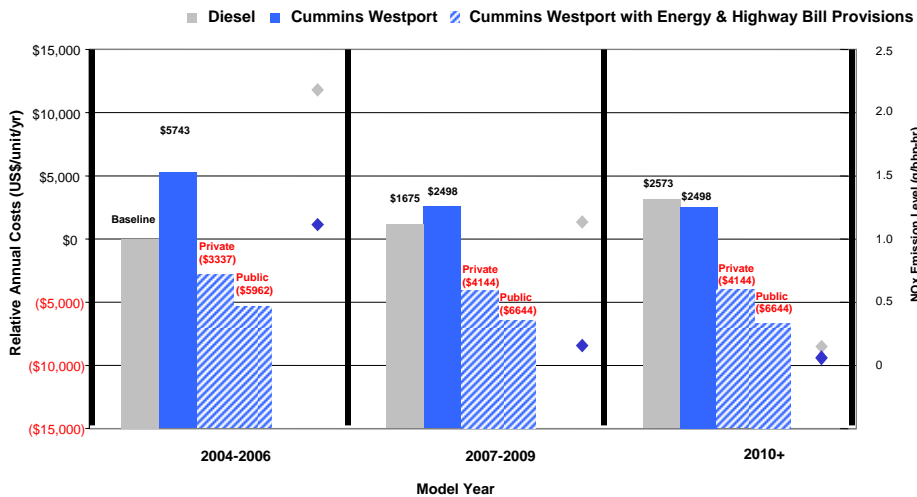
What about the cost of change?




- Standard CWI LCC model default assumption set
 - Not whole vehicle cost
 - Incremental natural gas related capital, and engine, fuel system, detection maintenance
 - Also includes capital and maintenance required for fuel infrastructure, and maintenance facilities
- \$1 Million facility modifications for both refuse and transit
- 50 truck fleet refuse and 70 bus fleet transit - actual property-southern US
- Urban Bus analysis assumes CNG
- Refuse analysis assumes LNG Fuel Prices:
 - Diesel Fuel (refuse): \$2.30 / gallon (\$0.05 added for ULSD)
 - Diesel Fuel (urban bus): \$2.20 / gallon (\$0.05 added for ULSD)
 - Liquid Natural Gas (refuse): \$1.72 DGE (prior to application of Highway Bill excise tax credit)
 - \$675,000 LNG infrastructure capital not included in fuel price but included in model
 - Natural Gas (transit): \$1.70 DGE (prior to application of Highway Bill excise tax credit)
 - Includes commodity, O&M, electricity and \$2 Million station 80% FTA funded
- Assume that Highway/Energy Bill tax credit flows fully & completely to end-user
 - Actual impact on end-user TBD
- Assume Energy Bill credit applies to net incremental cost after FTA funding (83%) is applied (Urban Bus only)
- Maximum \$12,000 Energy Bill Credit to OEM for Hybrid (no Highway Bill credits)
- Assume that Energy & Highway Bill provisions remain in effect beyond 2010
- Diesel Electric Hybrid fuel economy benefit assumed to be 20%, based on recent projections from fleets (e.g. Ottawa)




LCC Analysis - Refuse Collection






Diesel / NG Pathways to 2010

<u>Diesel</u>	<u>Natural Gas</u>
<ul style="list-style-type: none"> <input checked="" type="checkbox"/> ULSD <input checked="" type="checkbox"/> Active Diesel Particulate Filters <input checked="" type="checkbox"/> CEGR (ISC/ISL) <input checked="" type="checkbox"/> NOx Adsorber or SCR <ul style="list-style-type: none"> <input checked="" type="checkbox"/> SCR more efficient but a liquid that will be regulated and taxed <input checked="" type="checkbox"/> Crank Case Ventilation (CV) '07 <input checked="" type="checkbox"/> Lube Oil <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Will require new, low ash oil <input checked="" type="checkbox"/> New Oil Filters 	<ul style="list-style-type: none"> <input checked="" type="checkbox"/> No change- CNG or LNG capable <input checked="" type="checkbox"/> Replace Oxicat with Three Way Catalyst <input checked="" type="checkbox"/> Add- CEGR (ISL G) <input checked="" type="checkbox"/> No NOx adsorber required <input checked="" type="checkbox"/> No CV required-reduced maintenance vs. LBSI <input checked="" type="checkbox"/> No Change- Low Ash Oil in use today <ul style="list-style-type: none"> <input checked="" type="checkbox"/> CES20074 <input checked="" type="checkbox"/> Fleetguard Filter
<p>=</p> <p>1.2 NOx + 0.01 PM in 2007</p> <p>0.2 NOx + 0.01 PM in 2010</p>	<p>=</p> <p>0.2 NOx + 0.01 PM in 2007</p>







Why Natural Gas Engines for Buses & Trucks?

Emissions Leadership

- ISL G is the only Urban Bus and Truck engine that met 2010 EPA Emissions at launch in 2007



<h4>Emerging Economic Benefits</h4> <ul style="list-style-type: none"> • Continuous reliability improvement • ISL G Improved Efficiency • Greatest benefits in high fuel use applications 	<h4>Energy Security</h4> <ul style="list-style-type: none"> • Reduced reliance on imported oil • Lower fuel costs • Pathway to hydrogen
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Remember

Change is Inevitable

Except from a Vending Machine

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