Cummins Westport Inc. (CWI)

- Cummins Westport is a joint venture company established in 2001
  - 50% - Cummins Inc. - world’s largest builder of commercial diesels
  - 50% - Westport Innovations Inc. - world leader in gaseous fuel engine technology
- CWI offers 6 to 12 liter alternative fuel automotive engines. (CNG, LNG, RNG)
- Engines are manufactured by Cummins with over 80% parts commonality as the diesel platform
- Parts, warranty, service and training support through the Cummins Sales and Service network
- Over 70,000 engines delivered worldwide
Continued Emission Leading Performance

C Gas Plus
First engine 2004 EPA Certified
1.8 g/bhp-hr. NOx
Lean Burn Combustion

ISL G
First HD engine certified 2010 EPA/ARB
0.2 g/bhp-hr. NOx
SEGR Combustion

ISX12 G
HD Truck engine certified EPA/ARB
0.2 g/bhp-hr. NOx
SEGR Combustion

ISB6.7 G
Mid range engine certified EPA/ARB
0.15 g/bhp-hr. NOx
SEGR Combustion

ISX12N
First engine Certified Near Zero ARB
0.02 g/bhp NOx
SEGR Combustion

HD OBD
0.02 g/bhp NOx
SEGR Combustion

Particulate Matter (PM)
All CWI engines have met the 2010 EPA/ARB Particulate Matter (PM) standard (0.01 g/bhp-hr.) with a catalyst since 2001

2002 2007 2013 2016 2016 2018
Why Lower Emissions?

- Many of the largest US cities are not meeting Clean Air Act standards, including most larger cities in California.
- The focus is NOx reduction which will reduce ground level ozone in most urban areas.
- California ARB has defined new NOx standards to reduce emissions.

<table>
<thead>
<tr>
<th>NOx Standard</th>
<th>NOx (g/bhp-hr)</th>
<th>Engine</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010 Standard</td>
<td>0.2</td>
<td>Diesel, ISL G</td>
</tr>
<tr>
<td>CA Optional Low-NOx</td>
<td>0.1</td>
<td>B6.7N</td>
</tr>
<tr>
<td>CA Optional Low-NOx</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>CA Optional Low-NOx (Near Zero)</td>
<td>0.02</td>
<td>L9N, ISX12N</td>
</tr>
</tbody>
</table>

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.
Emission Reduction Impact

<table>
<thead>
<tr>
<th>Year</th>
<th>NOx (g/hp-hr)</th>
<th>PM (g/hp-hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>10.8</td>
<td>0.59</td>
</tr>
<tr>
<td>1990</td>
<td>6</td>
<td>0.59</td>
</tr>
<tr>
<td>1991</td>
<td>5</td>
<td>0.25</td>
</tr>
<tr>
<td>2000</td>
<td>4</td>
<td>0.05</td>
</tr>
<tr>
<td>2010</td>
<td>0.2</td>
<td>0.01</td>
</tr>
</tbody>
</table>

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### Greenhouse Gas Reduction

<table>
<thead>
<tr>
<th>Greenhouse Gas Emissions Criteria</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine related Methane (CH₄)</td>
<td>↓ 70% reduction (crankcase and tailpipe)</td>
</tr>
<tr>
<td>Greenhouse Gases (CO₂ equivalent)</td>
<td>↓ 9% reduction (technology pathway for further reduction in 2019/2020)</td>
</tr>
</tbody>
</table>

Potential further GHG reductions to near zero levels when used with renewable natural gas (RNG)
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
Transit Agency Case Study: NOx Reduction

Current Fleet: 125 2007 and newer (0.2 NOx) and 75 Pre-2007 (2.2 and 4.0 NOx)

These 200 buses collectively run approximately 6,000,000 miles and produce 349,384 lbs NOx per year

- **Replace 25 2.2 – 4.0 NOx pre-2007 buses with ISLG NZ**
  - **Step 1: 129,601 lb reduction**

- **Midlife repower 30 0.2 NOx 2011 buses with ISL G NZ**
  - **Step 2: 9,376 lb reduction**

- **Replace 50 2.2 NOx pre-2007 buses with L9N**
  - **Step 3: 176,801 lb reduction**

Total Reduction: 315,161 lbs
New Fleet NOx/year: 34,224 lbs
90% Reduction in NOx

- **Midlife repower remaining 95 0.2 NOx buses with L9N**
  - **Step 4: 27,736 lb reduction**

New Fleet NOx/year: 6,488 lbs
98% Reduction in NOx

Recommendation for future emissions reductions:

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Transit Agency Case Study: RNG and GHG

- In 2015, the agency changed to using 100% RNG
- Cut GHG emissions by 62%
- With LCFS credits, decreased their fuel costs by 26%

RNG cuts emissions by 62%
Transit Agency Case Study: Summary

98% reduction in NOx by changing to Near Zero engines

62% reduction in GHG by changing to renewable natural gas

All of this completed with:

- No changes to infrastructure
  - No real estate costs
- No changes to operational tasks
  - No range limitations
  - No mid-day re-fueling
  - Any bus can run any route

Minimal Incremental Costs
2018 North America Product Line

6.7L
Peak Rating: 240 hp
560 lb-ft torque
33,000 lb. GVW
School bus/Shuttle bus
EPA/ARB Low NOx
0.1 g/bhp-hr (50% reduction)

8.9L
Peak Rating: 320 hp
1000 lb-ft torque
66,000 lb. GVW
Transit Bus
EPA/ARB Near Zero NOx
0.02 g/bhp-hr (90% Reduction)

11.9L
Peak Rating: 400 hp
1450 lb-ft torque
80,000 lb. GVW
Coach Bus
EPA/ARB Near Zero NOx - 0.02 g/bhp-hr (90% Reduction)
Key Product Attributes

- 4 cycle, spark ignited, in-line 6 cylinder, turbocharged, CAC
- Displacement - 8.9 Litre (540 cu. In.)
- Certified to CARB Optional Low NOx 0.02g Standard (ISL G NZ introduced in 2016)
- Exceeds 2017 EPA GHG requirements
- **2018 On-board Diagnostic (OBD) compliant**
- Dedicated 100% natural gas engine
- Peak rating: 320 hp, 1000 lb-ft
- Maintenance free Three Way Catalyst aftertreatment
- Up to 66,000 lb GVW
Changes for 2018

<table>
<thead>
<tr>
<th>Engine</th>
<th>NOx Certification</th>
<th>OBD</th>
</tr>
</thead>
<tbody>
<tr>
<td>B6.7N</td>
<td>0.1 Low NOx</td>
<td>HD OBD for optimal emissions performance</td>
</tr>
<tr>
<td>L9N</td>
<td>0.02 Near Zero</td>
<td></td>
</tr>
<tr>
<td>ISX12N</td>
<td>0.02 Near Zero</td>
<td></td>
</tr>
</tbody>
</table>

Product Changes:
- ECM
- ICM
- Wiring harness
- Crankcase pressure sensor
- Steel Pistons

Catalyst Changes:
- One piece design
- L9N catalyst size similar to ISL G
- Mid-catalyst O2/Temp Sensor
End Customer Impact

- No changes to power ratings, fuel economy or range from current products. Meets the demand for all transit routes
- Continued high durability with minimal engine changes for MY2018
  - Product improvements introduced on the ISL G will be carried over to the L9N - steel pistons, tube EGR cooler, 3-piece exhaust manifold, as well as a new ECM and ICM
- Same Base Warranty and Extended Coverage options
- Maintenance free Three Way Catalyst aftertreatment
  - Similar in size to ISL G. Allows for easy repower to lower emissions
- Technician certification requirement is same as current products
- Lowest cost Near Zero emissions alternative
NG Playbook

- [www.cwiplaybook.com](http://www.cwiplaybook.com)
- Helps customers assess the natural gas opportunity and successfully incorporate natural gas powered trucks and buses into their fleet operation.
  - Helps identify fleet opportunities with natural gas
  - Provides technical product information
  - Addressed questions/concerns about purchasing and operating NG engines
  - GHG Emissions Calculator
  - Diesel v. NG Payback Calculator

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More information on natural gas engines
Features the Natural Gas Academy, a series of instructional videos
Designed to provide a general overview of operating a natural gas fleet whether it is compressed (CNG) or liquefied (LNG)
ISX12 G and ISL G engine walk around, service and driver training videos
Summary

▪ ISL G Near Zero is in production today with several hundred already successfully operating on the road.
▪ Successful repowers of the ISL G to ISL G Near Zero have been completed. Repowers even easier with the L9N and new catalyst.
▪ The L9N will incorporate all recent ISL G product updates
▪ Near Zero emissions is considered equivalent to a 100% BEB using electricity from a modern natural gas power plant

Mature. Reliable. Affordable. Ready Now
THANK YOU

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Please come visit us in our booth during the Expo and join us Thursday for the Evening Reception at the Mission Inn Hotel