Reduction of particle emission from diesel vehicles (Public Transport and Freight) Alternatives for Mexico City

Sustainable Solutions for Powering Transit Buses

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Mexico City
September 26th, 2016
Agenda

- Cummins in Public Transit Bus Market
- Solutions Portfolio
- A Portfolio Approach to Clean Propulsion
Cummins Bus Engine Business Facts

97 Years of experience in the engine business

Transporting 2B+ passengers daily

Powering buses in Mexico since 1965

Engines shipped to over 140 countries

#1 Bus engine supplier in the world

Unparalleled Global Support Network 190+ countries

Focus on Sustainability, Uptime & TCO

1/4 Of the world’s bus needs served in 2015
## Bus Market Megatrends

<table>
<thead>
<tr>
<th>Urbanization</th>
<th>Alt Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public transit solutions to combat urban clogging</td>
<td>Sustainability has taken center-stage</td>
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</table>

<table>
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<tr>
<th>Connectivity</th>
<th>Export</th>
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<td>Real Time Fleet and Route Management.</td>
<td>Exports across regions by both developed and emerging market players</td>
</tr>
</tbody>
</table>
Cummins Global Transit Bus Initiative

Environmental Sustainability

Lower Total Cost of Ownership

Improved Uptime

Focus is close partnership with customers to understand their business and optimize our products for their specific applications and duty cycles. Scope includes optimized calibrations, product tailoring with improved power and torque, mild-hybrid technologies, integrated powertrains and an expanded lineup of alternative-energy products.
- Reduction of pollutants
  - Close to 99% reduction with more stringent emission standards
- EPA 2010 technology
  - Offers additional reduction of NOx compared to Euro VI
Diesel Start / Stop

- Optimized for Bus Duty Cycle
- Proven durability
  - Over 4M Start/Stop events accumulated
  - 680 Start/Stop units in service
- Proven reduction in fuel consumption and CO2 emissions
- 30-40% reduction in NOx emission
- Improved passenger and pedestrian comfort
- Flexible architecture to meet customer and operator needs
- Short payback period
Diesel Hybrid

- Mainstream product in NA and Europe
- Engine downsizing
  - B4.5 Euro 6 powering double decker bus
- Two systems
  - Engine is a back up for electric system
- Long route capability
- No infrastructure investment required
**Economics**
- NG price less than diesel
  - However payback impacted
    - Fuel price differential
    - Fuel Usage
- NG vehicle premiums justified by fuel savings

**Energy Policy**
- Reduced crude oil imports
  - Abundant supply of NG
  - Ability to use renewable bio-methane sources
- Global oil production impacting economics of fuel pricing

**Environment**
- Adopting fleets increasing access to “green minded” customers, edge in niche markets
- Meets or exceeds GHG emission reductions
Near Zero Natural Gas

- Ability to meet Near Zero Emissions
  - ARB requires to certify at 0.02
    - Near Zero ISL G is certified to 0.01
    - 90% reduction from current EPA of 0.2 g/bhp-hr
- Low emission internal combustion technology
  - Competitive with electric, hybrids, and fuel cells
- Based on current ISL G architecture
- Maintenance free aftertreatment
  - 3-way catalyst
Near Zero - How Much NOx is Reduced?

One 1985 engine emits the same NOx as **1080** ISL G Near Zero engines.

<table>
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<tr>
<th>Emissions year</th>
<th>NOx Standard g/bhp-hr.</th>
<th>Equivalent Number of Vehicles</th>
</tr>
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<tbody>
<tr>
<td>Base = 1985</td>
<td>10.8</td>
<td>1</td>
</tr>
<tr>
<td>2010</td>
<td>0.2</td>
<td>54</td>
</tr>
<tr>
<td>2016</td>
<td>0.02</td>
<td>540</td>
</tr>
<tr>
<td>ISL G Near Zero</td>
<td>0.01</td>
<td>1080</td>
</tr>
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</table>
Electrification

- Not the future, a reality today
- Wide-spread interest at transit authorities
  - Urban pollution is primary driver of interest
- Battery technology has developed but still relatively new
  - Electric buses are still highly reliant on government funding
- Must consider TCO in a different way
- Duty cycle/route analysis must be complete to determine impact on fleet
A Portfolio Approach to Clean Propulsion

A Program of SmartChoice
What Do You Value Most In Your Solution? Choose Your Key Enablers.

<table>
<thead>
<tr>
<th>Life of Bus</th>
<th>Clean Air</th>
<th>Low Maintenance</th>
<th>New Technology</th>
<th>In Route or Depot Ability</th>
</tr>
</thead>
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<tr>
<td>Lower Initial</td>
<td></td>
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<tr>
<td>Investment</td>
<td>$</td>
<td>Emission</td>
<td>Cummins</td>
<td>Connectivity</td>
</tr>
<tr>
<td>Mileage Range</td>
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<td>Lower Nox</td>
<td>Uptime</td>
<td>TCO</td>
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<td></td>
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<td></td>
<td>Infrastructure</td>
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- Lower Initial Investment
- Emission Standards
- Cummins
- Connectivity
- Mileage Range
- Lower Nox
- Uptime
- TCO
- Infrastructure

What do you value most in your solution?
Smart Efficiency

Fuel Economy
Operating Costs
Performance

The Right Momentum