Near Zero Emission Propane Autogas Engines
Roush at a Glance

- Michigan-based
- Privately held
- Founded in 1976
- Over 3,700 employees
- Over 2.8 million sq. ft. office/development space

**Primary activities:**
- Engineering
- Testing
- Prototype Development
- Manufacturing
- Motorsports Management
ROUSH CleanTech

- Founded in 2010.
- Dedicated to developing quality alternative fuel solutions.
- Propane autogas focus.
- EPA and CARB certification.
- Platform customization to suit customer needs.
- Reduces operating costs, carbon footprint.
- OEM support through Ford and BPN dealers.
- Creating opportunities for partner companies.
- Using American fuel and American technology.
Units in Operation

<table>
<thead>
<tr>
<th>Year</th>
<th>Units Introduced</th>
<th>Total Accumulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>459</td>
<td>459</td>
</tr>
<tr>
<td>2011</td>
<td>1151</td>
<td>598</td>
</tr>
<tr>
<td>2012</td>
<td>1554</td>
<td>1,752</td>
</tr>
<tr>
<td>2013</td>
<td>2739</td>
<td>4,591</td>
</tr>
<tr>
<td>2014</td>
<td>2704</td>
<td>7,295</td>
</tr>
<tr>
<td>2015</td>
<td>2508</td>
<td>9,803</td>
</tr>
<tr>
<td>2016</td>
<td>2350</td>
<td>12,153</td>
</tr>
<tr>
<td>2017</td>
<td>17352</td>
<td>20,104</td>
</tr>
</tbody>
</table>
Our Scorecard

- Over 18,000 Vehicles on the Road
- Accumulated Over 400 Million Miles
- Over 750 School Districts
- Over 600 Million Gallons of Propane

800.59.ROUSH ROUSHcleantech.com
Propane Autogas Product Lineup

- Medium duty Ford trucks, chassis cabs, cutaways, and stripped chassis; and Blue Bird Type A and C school bus.
- Factory Ford warranty maintained.
- No loss of HP / torque / towing capacity.
- Serviceable with existing diagnostic equipment.
- EPA & CARB Certified.
ULTRA LOW NOₓ EMISSIONS
ARB is encouraging all Manufacturers of Record (MORs) to overachieve on the NOx standard to support smog reduction.

ARB has issued alternative standards at 0.1, 0.05 and 0.02g/bhp-hr for NOx.

The recent VW settlement also includes funding that supports NOx reductions across all 50 states that off sets the increase in NOx caused by their diesel emissions.
Achievement of Ultra Low NOx starts with a high quality production engine

At ROUSH CleanTech, we start with:

- Ford 6.8L V10 3V Spark Ignition
- Used by Ford in all HD Vehicle applications
- F 450/550 Chassis Cab
- F 650/750 Chassis Cab
- F 53/59 Stripped Chassis
- 320 HP/460 Lbs. Ft
- Close to 2 Million in operation
- Started production in 1997
- For gasoline, meets or exceeds all emissions standards presently through 2017.
June 7th 2017 ROUSH CleanTech announces achievement of very low NOx with the 6.8L V10 Engine.

- For the 2017 MY RCT LPG Blue Bird Buses and applicable Ford Truck upfits are now certified to 0.05 g/bhp-hr NOx.

- This is achieved with no extra hardware or increased variable cost.

<table>
<thead>
<tr>
<th></th>
<th>CO</th>
<th>CO2</th>
<th>NOx</th>
<th>NMHC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Useful Life STD</td>
<td>14.4</td>
<td>627</td>
<td>0.05</td>
<td>0.140</td>
</tr>
<tr>
<td>Actual Cert Level</td>
<td>2.7</td>
<td>614</td>
<td>0.03</td>
<td>0.04</td>
</tr>
</tbody>
</table>

- The low NOx levels were achieved through careful, significant calibration changes and a CSSR (cold start spark retard) approach.
## Standard Changes for NOx

<table>
<thead>
<tr>
<th>Vehicle Model Year</th>
<th>NO\textsubscript{x} Standard (in g/bhp-hr)</th>
<th>ROUSH CleanTech 6.8L V10 3V propane engine (certified to NO\textsubscript{x} level of .05 g bhp-hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>4</td>
<td>99% cleaner</td>
</tr>
<tr>
<td>2002</td>
<td>2.5</td>
<td>98% cleaner</td>
</tr>
<tr>
<td>2007</td>
<td>1.2</td>
<td>95% cleaner</td>
</tr>
<tr>
<td>2010 - current</td>
<td>0.2</td>
<td>75% cleaner</td>
</tr>
</tbody>
</table>
STUDENT TRANSPORTATION
A Growing Trend

10,000 SCHOOL BUSES

QUALIFIED VEHICLE MODIFIER

OVER 750 SCHOOL DISTRICTS

800.59.ROUSH ROUSHcleantech.com
FOOD & BEVERAGE
PUBLIC TRANSIT
WHERE ARE WE HEADED.....
Propane is 28% more cost effective at reducing NOx than CNG
Propane is 33% more cost effective at reducing NOx than diesel
Propane is 71% more cost effective at reducing NOx than electric

2016 version of AFLEET. School bus comparison using Arkansas average pricing. Assumptions include replacing a 2007 model year diesel school bus with a 2019 model year propane, diesel, electric or CNG school bus. Also assumes a 15 year average service life and 12,600 miles travelled annually.
Certification versus Reality?

Certification versus Reality?

A report released by the University of California Riverside’s College of Engineering and Center for Environmental Research and Technology (CE-CERT) found that new ultra-low NOx natural gas heavy-duty vehicles met and exceeded their certification standards during a full range of duty cycles. The finding is in stark contrast to previously released CE-CERT data of heavy-duty diesel trucks that emitted higher levels of NOx than their certification standards in the same duty cycles. With the near-zero emission factors demonstrated for natural gas vehicles, it is expected that these vehicles could play an important role in providing much-needed emissions reductions required for the South Coast Air Basin and California to reach federal air quality attainment standards.

Key Facts:

- The current EPA NOx emission standard is 0.2 g/bhp-hr.
- The cleanest heavy-duty diesel engine available today is certified at 0.3 g/bhp-hr.
- The cleanest heavy-duty natural gas engine available today is certified by CARB at 0.02 g/bhp-hr, 95% cleaner than the EPA NOx emission standard.

Natural gas vehicles emitted lower NOx:
The ISL G natural gas engine emitted lower NOx emissions than its EPA certification standard. Emissions decreased as the duty cycles decreased (i.e., slower speeds, idling, stop-and-go traffic, etc.).

Diesel vehicles emit up to 4x higher NOx:
2010 diesel engines with SCR emitted up to 4 times higher NOx emissions than its EPA certification standard. Emissions increased as the duty cycles decreased.

Natural gas vehicles emitted lower NOx:
The ISL G natural gas engine emitted lower NOx emissions than its EPA certification standard. Emissions decreased as the duty cycles decreased (i.e., slower speeds, idling, stop-and-go traffic, etc.).

Diesel vehicles emit up to 4x higher NOx:
2010 diesel engines with SCR emitted up to 4 times higher NOx emissions than its EPA certification standard. Emissions increased as the duty cycles decreased.
Blue Bird Vision Propane
The Most Cost-Effective Solution to Reduce NOx Emissions from School Buses

School buses transport 25 million children across the U.S. to and from school each year. Because of the stop-and-go driving conditions, diesel buses emit increased exhaust emissions filled with tiny soot particles and toxic gases. Using the Volkswagen Environmental Mitigation Trust (EMT) to fund propane buses enables states to meaningfully reduce this harmful exposure, which benefits our nation’s children.

**Standard Argonne AFLEET Emissions Outputs**

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Purchase Price</th>
<th>NOx Reduced</th>
<th>$/lb</th>
<th>Cost Effectiveness vs. Propane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propane</td>
<td>$95,000</td>
<td>537.0</td>
<td>$177</td>
<td></td>
</tr>
<tr>
<td>Diesel</td>
<td>$90,000</td>
<td>330.5</td>
<td>$272</td>
<td>-35%</td>
</tr>
<tr>
<td>Electric</td>
<td>$300,000</td>
<td>593.4</td>
<td>$506</td>
<td>-65%</td>
</tr>
</tbody>
</table>

**Argonne AFLEET 2017 w Diesel In-Use Multipliers**

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Purchase Price</th>
<th>NOx Reduced</th>
<th>$/lb</th>
<th>Cost Effectiveness vs. Propane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propane</td>
<td>$95,000</td>
<td>893.7</td>
<td>$106</td>
<td></td>
</tr>
<tr>
<td>Diesel</td>
<td>$90,000</td>
<td>67.7</td>
<td>$1,330</td>
<td>-92%</td>
</tr>
<tr>
<td>Electric</td>
<td>$300,000</td>
<td>1,119.0</td>
<td>$268</td>
<td>-60%</td>
</tr>
</tbody>
</table>

*Vehicle purchase price may vary by state. Calculations assume the full cost to deploy the cleanest commercially available Type C buses for each fuel type based on emission calculations from the 2017 AFLEET Tool with diesel In-use adjustment.

2017 AFLEET Changes
WHY?

- Significant cost per mile reduction vs diesel based on lower fuel and maintenance costs
- Low cost of infrastructure
- Ample supply
- Cleaner
- Domestic
- Evidence manual grows
- Path to renewable propane

*Best NOx reduction per dollar spent in the class 4-7 market*
THANK YOU

800.59.ROUSH
ROUSHcleantech.com

Chelsea Jenkins
Director of Government Affairs

734.812.1965
Chelsea.Jenkins@roush.com