



# Near Zero Emission Propane Autogas Engines



**800.59.ROUSH**

**ROUSHcleantech.com**

# 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**<sup>®</sup>

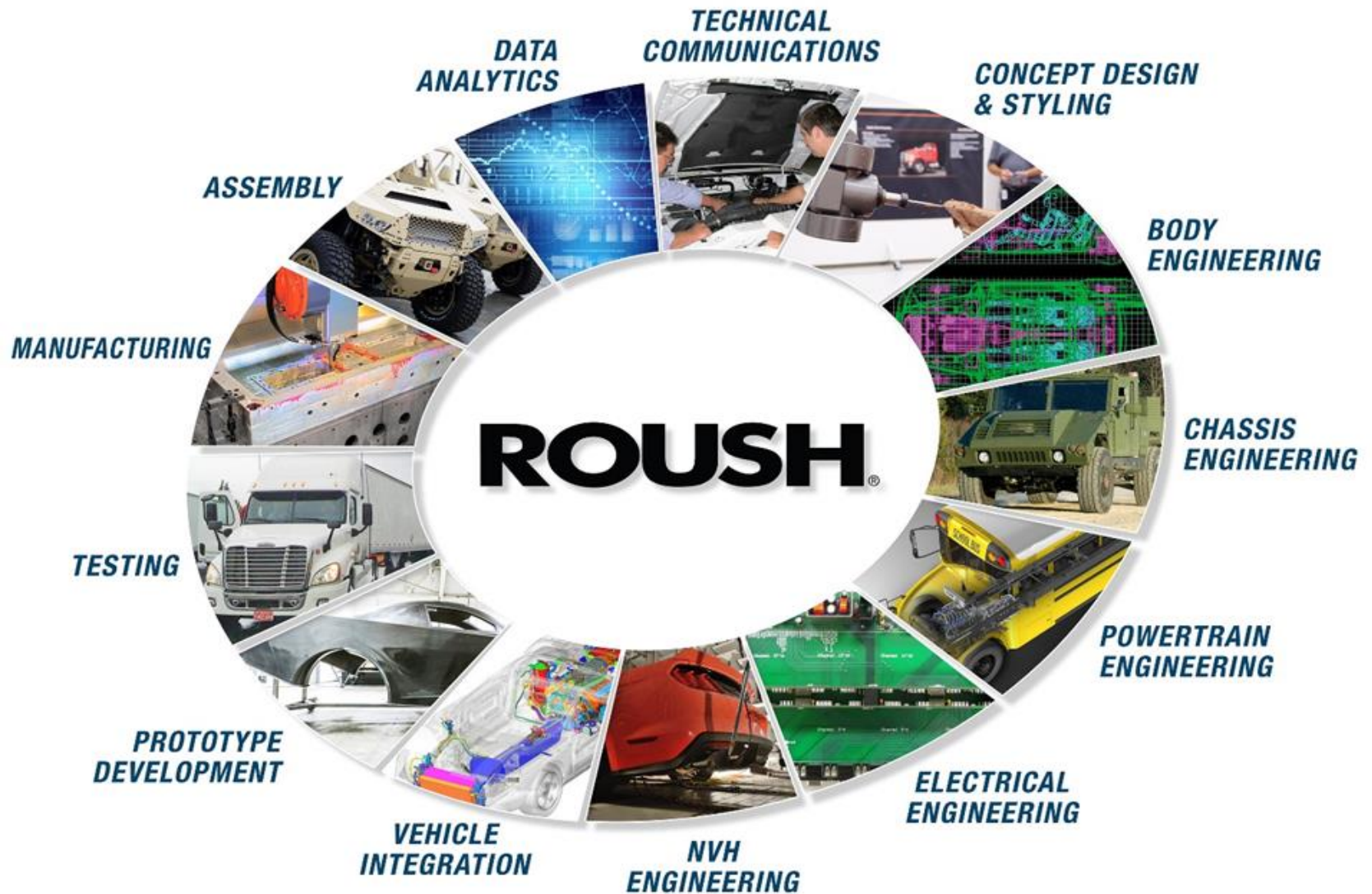
**ROUSH FENWAY**  
RACING



**ROUSH**<sup>®</sup>  
CLEANTECH



# Single Source Partner

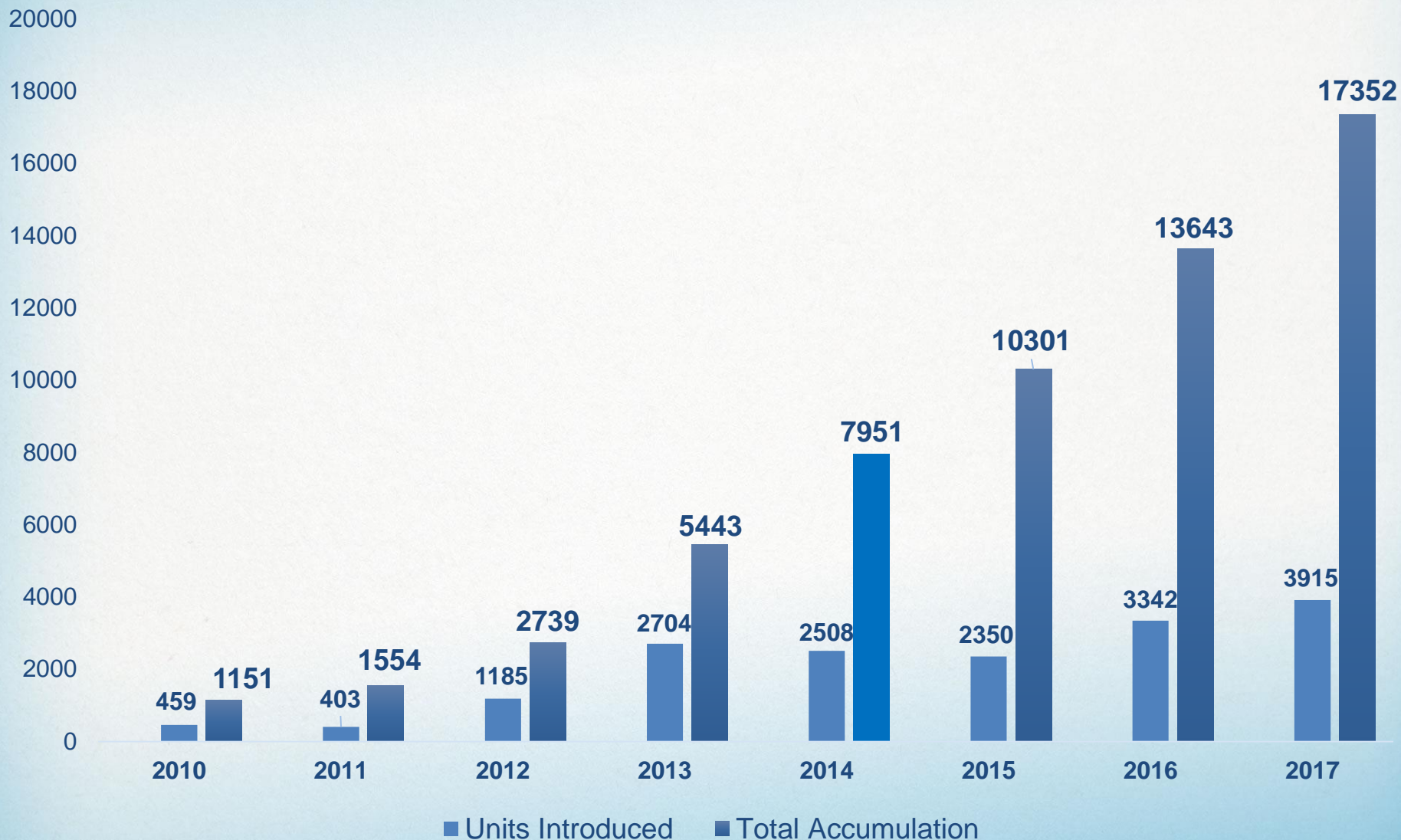




- Founded in 2010.
- Dedicated to developing quality alternative fuel solutions.
- Propane autogas focus.
- EPA and CARB certification.
- Platform customization to suit customer needs.
- Reduces operating costs, carbon footprint.
- OEM support through Ford and BPN dealers.
- Creating opportunities for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



# Units in Operation





OVER

**18,000**

VEHICLES ON  
THE ROAD

ACCUMULATED  
OVER

**400**

MILLION MILES

OVER

**750**

SCHOOL  
DISTRICTS

OVER **600** MILLION GALLONS OF PROPANE



# 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.



Ford F-53 / F-59

Ford E-450

Ford F-450/550

Ford F-650/750

Blue Bird Vision

Micro Bird G5



# ULTRA LOW NO<sub>x</sub> EMISSIONS



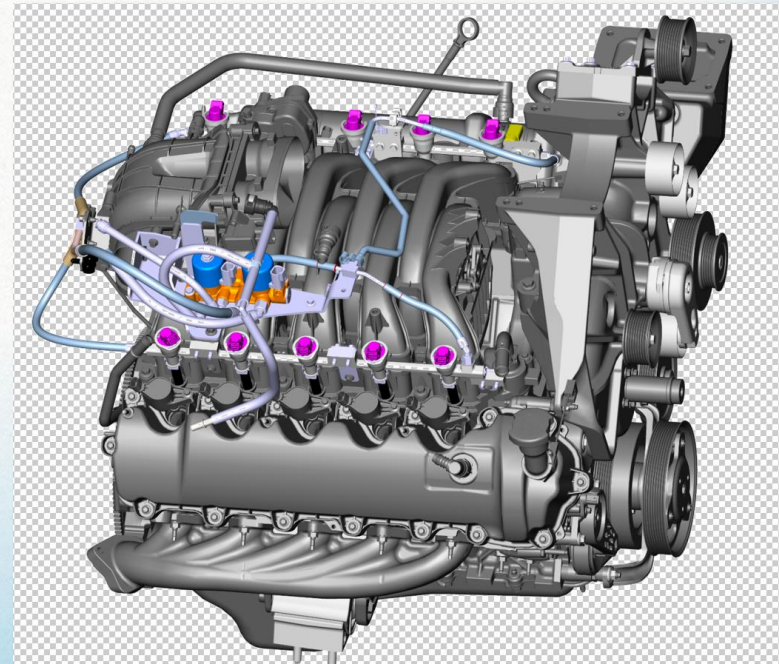
## Drive for Reduced NOx

- 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.





## RCT Status of Low NOx





June 7<sup>th</sup> 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**.

|                      | CO   | CO2 | NOx  | NMHC  |
|----------------------|------|-----|------|-------|
| Full Useful Life STD | 14.4 | 627 | 0.05 | 0.140 |
| Actual Cert Level    | 2.7  | 614 | 0.03 | 0.04  |

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

# Standard Changes for NOx

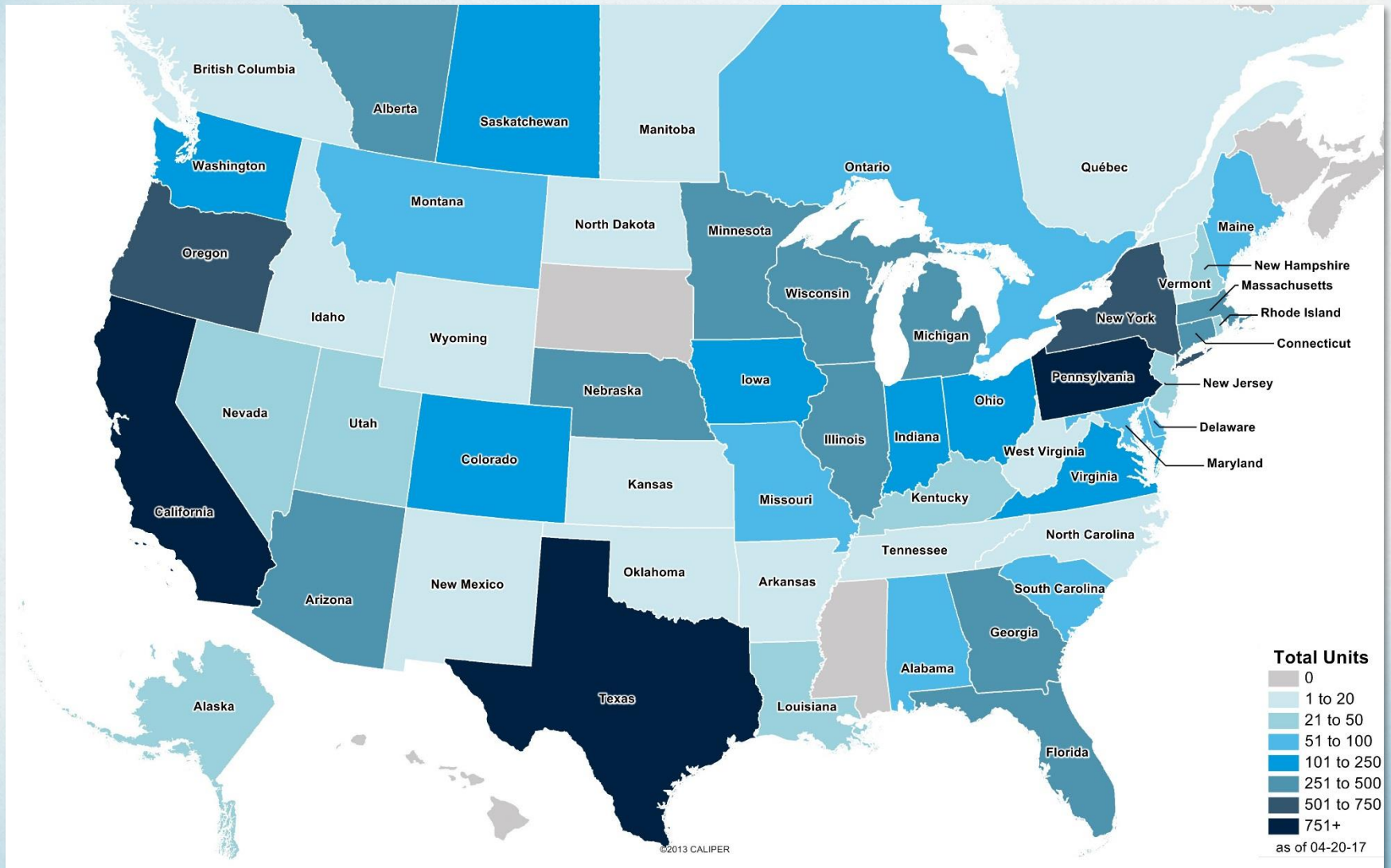
| Vehicle Model Year | NO <sub>x</sub> Standard (in g/bhp-hr)   | ROUSH CleanTech<br>6.8L V10 3V propane engine<br>(certified to NO <sub>x</sub> level of .05 g bhp-hr) |
|--------------------|--|---|
| 1998               | 4<br>     | 99% cleaner   |
| 2002               | 2.5<br>   | 98% cleaner   |
| 2007               | 1.2<br>   | 95% cleaner   |
| 2010 - current     | 0.2<br> | 75% cleaner   |





# STUDENT TRANSPORTATION

# Propane School Bus Deployments





# A Growing Trend

10,000

SCHOOL  
BUSES



OVER  
750

SCHOOL  
DISTRICTS





# FOOD & BEVERAGE





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U.S. DOT 665959  
GVW 19,500







# PUBLIC TRANSIT



Metropolitan Transit System

3102

MTS

MANUFACTURED BY  
FIELD TRANSIT  
CORPORATION  
2000 10000





WHERE ARE WE HEADED.....



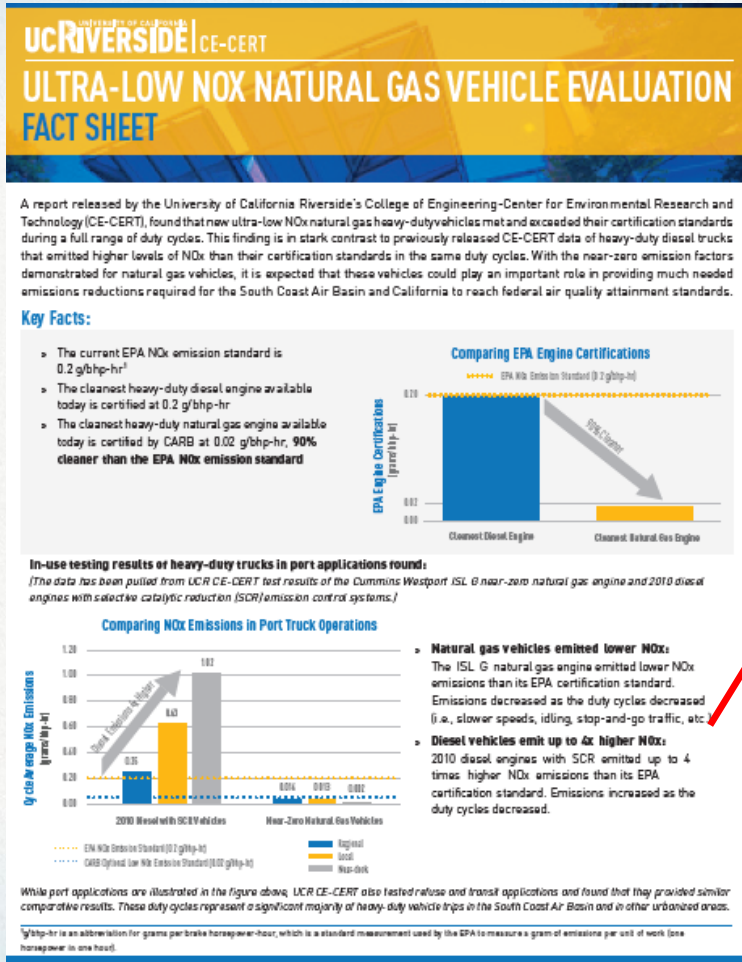
# 2016 AFLEET Emissions Tool

| Standard Argonne AFLEET Emissions Outputs |                |             |        |                                |
|---|----------------|-------------|--------|--------------------------------|
| Fuel                                      | Purchase Price | NOx Reduced | \$/lb  | Cost Effectiveness vs. Propane |
| Propane                                   | \$ 93,000      | 537.0       | \$ 173 |                                |
| Diesel                                    | \$ 85,000      | 330.5       | \$ 257 | -33%                           |
| Electric                                  | \$ 350,000     | 593.4       | \$ 590 | -71%                           |
| CNG                                       | \$ 125,000     | 518.3       | \$ 241 | -28%                           |

- 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?



- » **Natural gas vehicles emitted lower NOx:**  
The ISL 9 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.



### PROPANE

Purchase price: \$95,000  
NOx reduced: 894 lbs.  
**Cost per pound of NOx reduced: \$106**



### DIESEL

Purchase price: \$90,000  
NOx reduced: 67 lbs.  
**Cost per pound of NOx reduced: \$1,330**



### ELECTRIC

Purchase price: \$300,000  
NOx reduced: 1,119 lbs.  
**Cost per pound of NOx reduced: \$268**

**92%**

more cost-effective  
than diesel school buses

**60%**

more cost-effective  
than electric school buses



\*Vehicle purchase prices 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 AVL AFLEET tool with diesel in-use adjustment.



**750+**

School transportation  
fleets in operation

**10,000+**

School buses in  
service across  
North America

# 2017 AFLEET Changes

## Standard Argonne AFLEET Emissions Outputs

| Fuel     | Purchase Price | NOx Reduced | \$/lb  | Cost Effectiveness vs. Propane |
|----------|----------------|-------------|--------|--------------------------------|
| Propane  | \$ 95,000      | 537.0       | \$ 177 |                                |
| Diesel   | \$ 90,000      | 330.5       | \$ 272 | -35%                           |
| Electric | \$ 300,000     | 593.4       | \$ 506 | -65%                           |

## Argonne AFLEET 2017 w Diesel In-Use Multipliers

| Fuel     | Purchase Price | NOx Reduced | \$/lb    | Cost Effectiveness vs. Propane |
|----------|----------------|-------------|----------|--------------------------------|
| Propane  | \$ 95,000      | 893.7       | \$ 106   |                                |
| Diesel   | \$ 90,000      | 67.7        | \$ 1,330 | -92%                           |
| Electric | \$ 300,000     | 1,119.0     | \$ 268   | -60%                           |

- 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 NO<sub>x</sub> reduction per dollar spent in the class 4-7 market***





# THANK YOU

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