NC STATE UNIVERSITY

SUSTAINABLE FLEET TECHNOLOGY

VIRTUAL CONFERENCE 2020

Session 3: Gaseous Fuels Trends & Applications

August 12, 2020

NC CLEAN ENERGY TECHNOLOGY CENTER

STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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SUSTAINABLE FLEET TECHNOLOGY
VIRTUAL CONFERENCE 2020

Next Series Dates & Topics:

August 19: The Green Garage Contest Details & Application Review

August 26: The Evolving World of Telematics: Real-Time Information for Fleet Performance

September 09: Green Fleet Award Winners 2020 Announcement

September 23: Best Practices & Lesson Learned in Charging Infrastructure Deployment

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Format

- Q&A at the end
- Submit questions and comments to “Panelists”
- Scheduled for 2:00p-3:30p
- Slide handout
- Recording

NC STATE UNIVERSITY

Gaseous Fuels Trends And Applications
August 12, 2020

2:00-2:05 **Rick Sapienza, NC Clean Energy Technology Center**—Welcome & Introduction

2:05-2:15 **Steve Whaley, PERC**—Overview and Applications of Propane Autogas

2:15-2:23 **Lisa McAbee, McAbee Trucking**--LPG Application Story: Lessons, Benefits & Results

2:23-2:31 **Herb Mullen, Inter-County Public Transport**—LPG Application Story: Lessons, Benefits & Results

2:31-2:40 **Ed Hoffman, Alliance AutoGas**—Autogas Infrastructure Considerations

2:40-2:48 **Sherrie Merrow, NGVAmerica**—Natural Gas/Renewable Natural Gas Solutions Now!

2:48-2:58 **Michael McDonald, UPS**—Natural Gas Application Story UPS' Rolling Laboratory

2:58-3:08 **Brian Beltran, Waste Management**—Natural Gas Application Story for the Refuse Industry

3:08-3:15 **Matt Gold, Hyliion**—Emerging Technology the Hyliion Hypertruck ERX

3:15-3:30+ **Q&A**

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STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Rick Sapienza
resapienza@ncsu.edu
Phone: 919-515-2788

- **Clean Transportation Program Director NC Clean Energy Technology Center at NC State University**
- **8 years with NC State**
- **30+ years experience including General Motors, Draper Lab and Great Lakes Pulp & Fibre in both engineering and business management roles**

NC CLEAN ENERGY TECHNOLOGY CENTER

STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Steve Whaley
stephen.whaley@propane.com
864-606-2290

- Director of Autogas Business Development for the Propane Education & Research Council
- More 25 years experience working with both natural gas and propane solutions for public and private fleets
- Previous experience with Whaley Clean Transportations Consulting, Agility Fuel Systems, Roush Clean Tech and Blossman Propane

PROPANE
CLEAN AMERICAN ENERGY®

Propane Autogas:
Trends and Applications

Sustainable Fleet Technology 2020 Conference

Stephen Whaley

Director of Autogas Business Development
Stephen.Whaley@propane.com

864-606-2290

Successful Alternative Energy Adoption

What Makes an Alternative Energy Adoption Successful?

- There is a reduction in emissions over the lifecycle of the energy used in the vehicle without increasing cost or losing efficiency.
- Total cost-of-ownership reduction or a return on investment long before the end of the vehicle lifecycle.
- The vehicle performs as well or better than the original fuel without compromising range.
- There must be a high volume supply of energy domestically sourced.

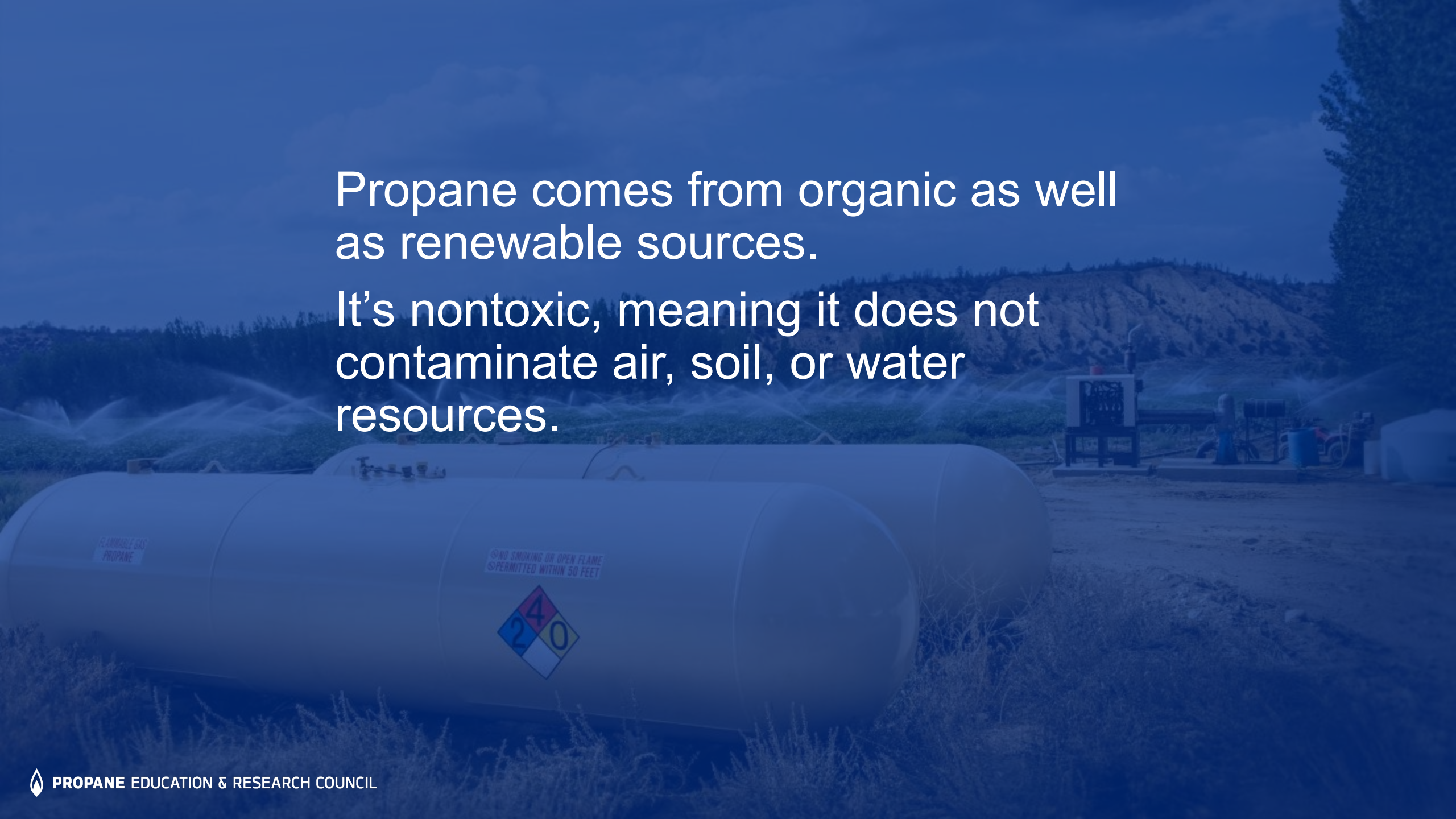
How Does Autogas Fit Into The Conversation?

- Propane autogas is the most cost-effective energy source to reduce NOx emissions.
- Propane autogas provides the lowest total cost-of-ownership of any fueled vehicle.
- Propane autogas offers comparable or improved performance without compromising range.
- Propane production in the U.S. was 28 billion gallons in 2019, nine billion used domestically and 19 billion gallons were exported.

WHAT IS PROPANE?

- Affordable, Clean, American-Made Fuel
  - C3H8
  - Byproduct of natural gas processing.
  - 100% Domestic
  - Commonly used for space and water heating, cooking, and as engine fuel.

- Using Propane
  - 48 million Households
  - 900,000 Farms
  - 600,000 Forklifts
  - 25,000 Commercial Mowers



Propane comes from organic as well as renewable sources.

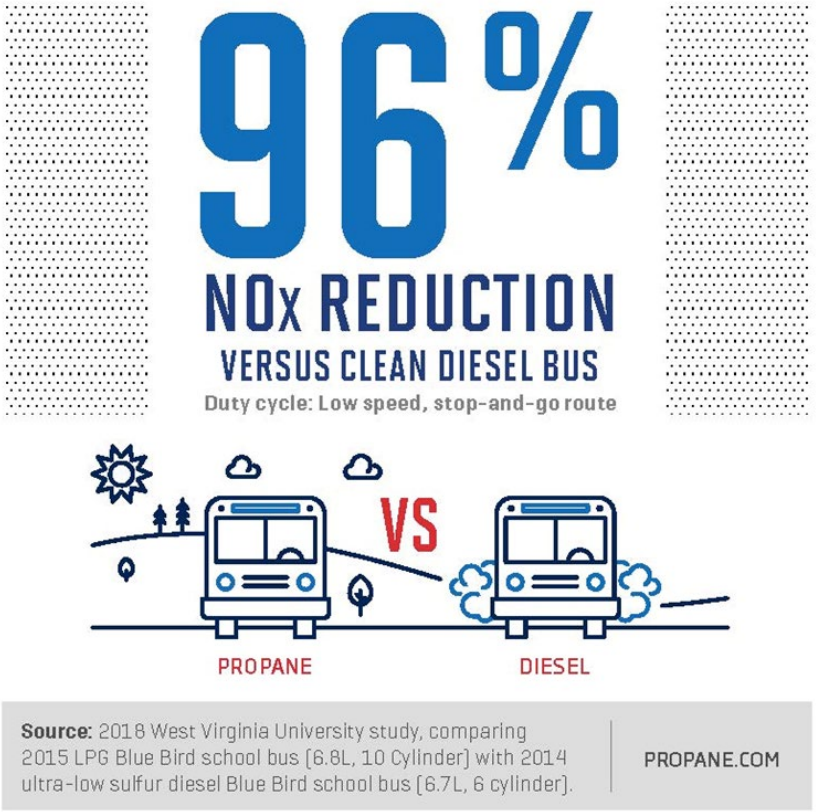
It’s nontoxic, meaning it does not contaminate air, soil, or water resources.

WHY FLEETS CHOOSE PROPANE AUTOGAS

Total Cost-of-Ownership
Lower Emissions
Reduce Noise
Less Maintenance/Increased Uptime
Improve Corporate Image
Employee Morale/Driver Retention

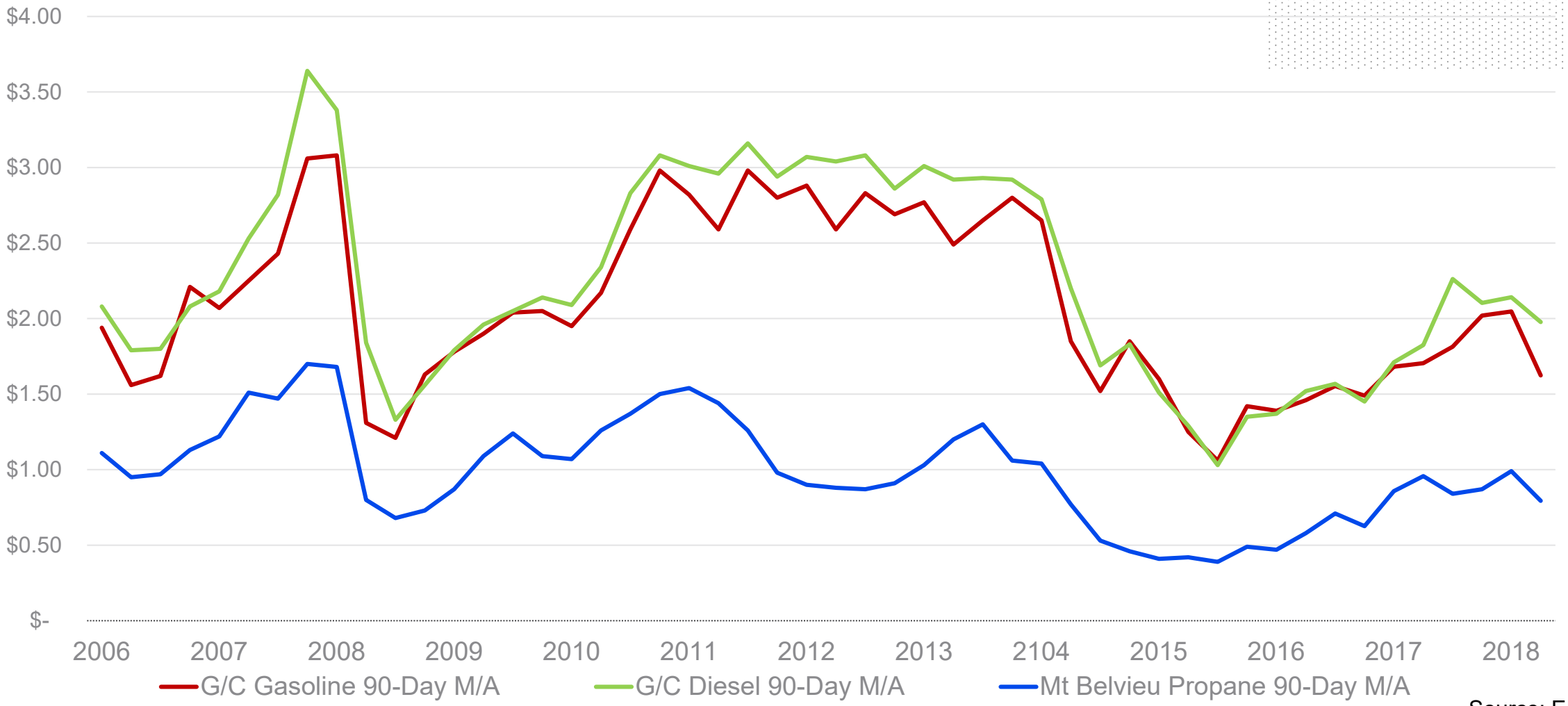
Path to Zero Emissions

- Particulate Matter
  - Virtually zero
  - Zero with renewable propane
- NOX
  - 96% reduction from best in class diesel
  - Certifying to .02, operating at 0.01, full duty cycle
- GHG
  - New technologies 25% reduction from next best technology



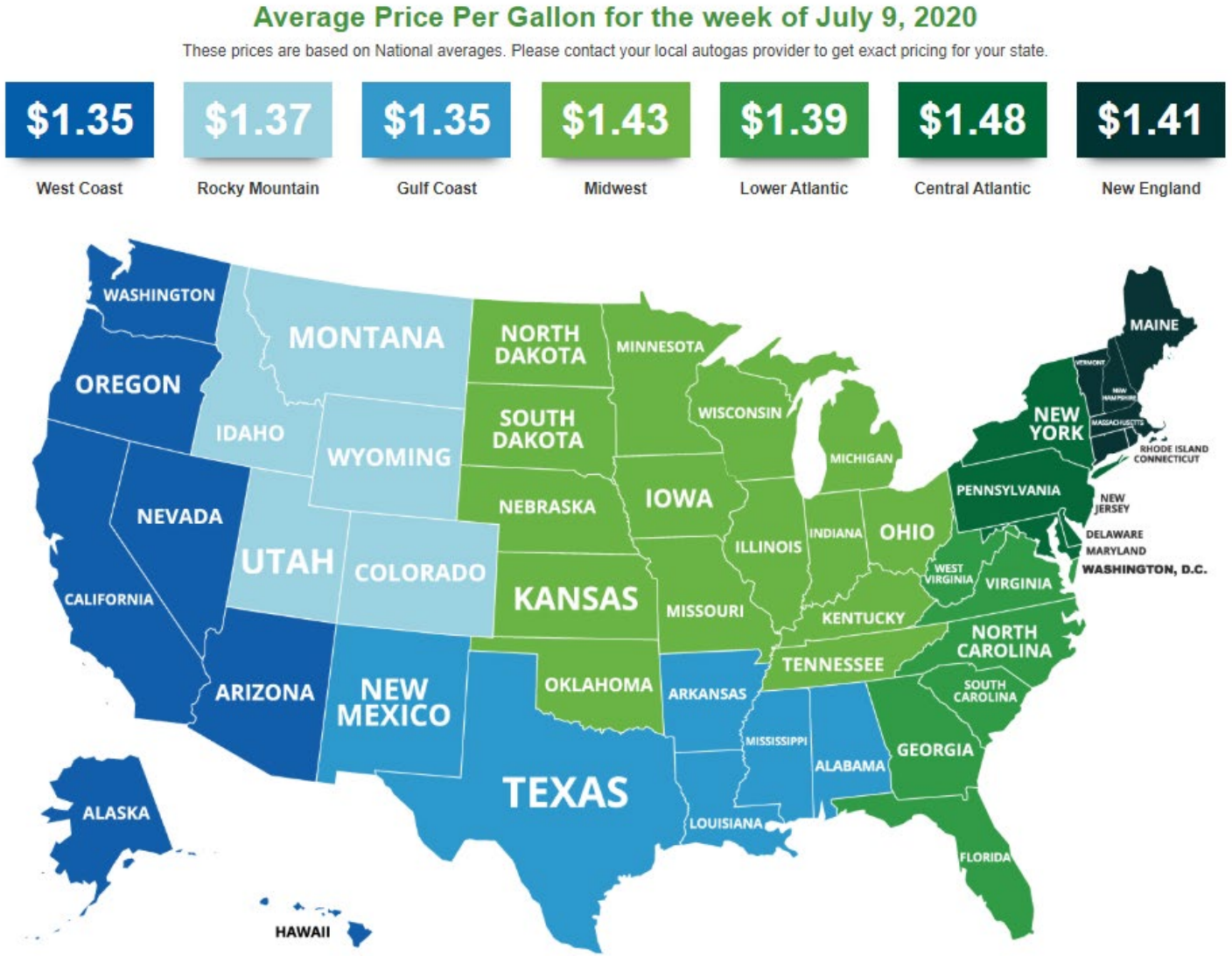
Fuel & Maintenance Cost Reductions

US ENERGY PRICE COMPARISON 2006 – 2018



Source: EIA.gov

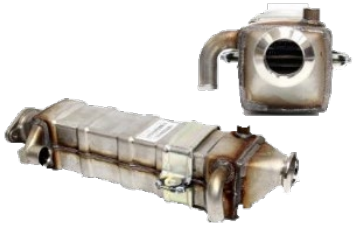
Today's Propane Autogas



Increased Inventory

- Propane eliminates the need for DEF and the possibility of putting the wrong fluid in a tank

The Diesel We Know Today











Engine Components: Diesel

Cummins ISB 6.7L

Part	Quantity	Price	Total
NOx Sensor	1	$480.00	$480.00
NOx Sensor	1	$560.00	$560.00
Pressure Sensor	1	$140.00	$140.00
Doser Injector	1	$290.00	$290.00
Catalyst Assembly w/ DPF	1	$10,554.11	$10,554.11
Temperature Sensor	1	$78.90	$78.90
Temperature Sensor	2	$84.90	$169.80
Turbo	1	$2,731.20	$2,731.20
Injector	6	$755.56	$4,533.36
EGR Valve	1	$590.15	$590.15
EGR Cooler	1	$923.72	$923.72

Total
$21,051.24

Preventative Maintenance

Ford V10
Gas and Propane
7 Quarts

Various Engines
Diesel
17 – 30 Quarts

Preventative Maintenance

Ford 6.8L V10

Part	Quantity	Price	Total	
Element Air Cleaner	1	$15.75	$15.75	Total $70.94
Oil Spin On Filter	1	$4.11	$4.11	
Element, PSR, 510 Filter	1	$24.90	$24.90	
Mobil Special 5W-20	7	$3.74	$26.18	

Cummins ISB 6.7L

Part	Quantity	Price	Total	
Oil Filter	1	$13.75	$13.75	Total $277.15
Fuel Spin-On Filter	1	$37.90	$37.90	
Power Steering Spin Filter	1	$9.86	$9.86	
Fuel Filter	1	$20.53	$20.53	
Allison Control Filter	1	$8.49	$8.49	
Mobil Fleet 15W-40	18	$2.59	$46.62	
Cleaner, Air Element	1	$140.00	$140.00	

Current Autogas Vehicle Offerings


SCHOOL BUS


Jean


SANDY SPRINGS
FIRE-RESCUE


0
PROPANE


911


Powered by
Clean
Propane

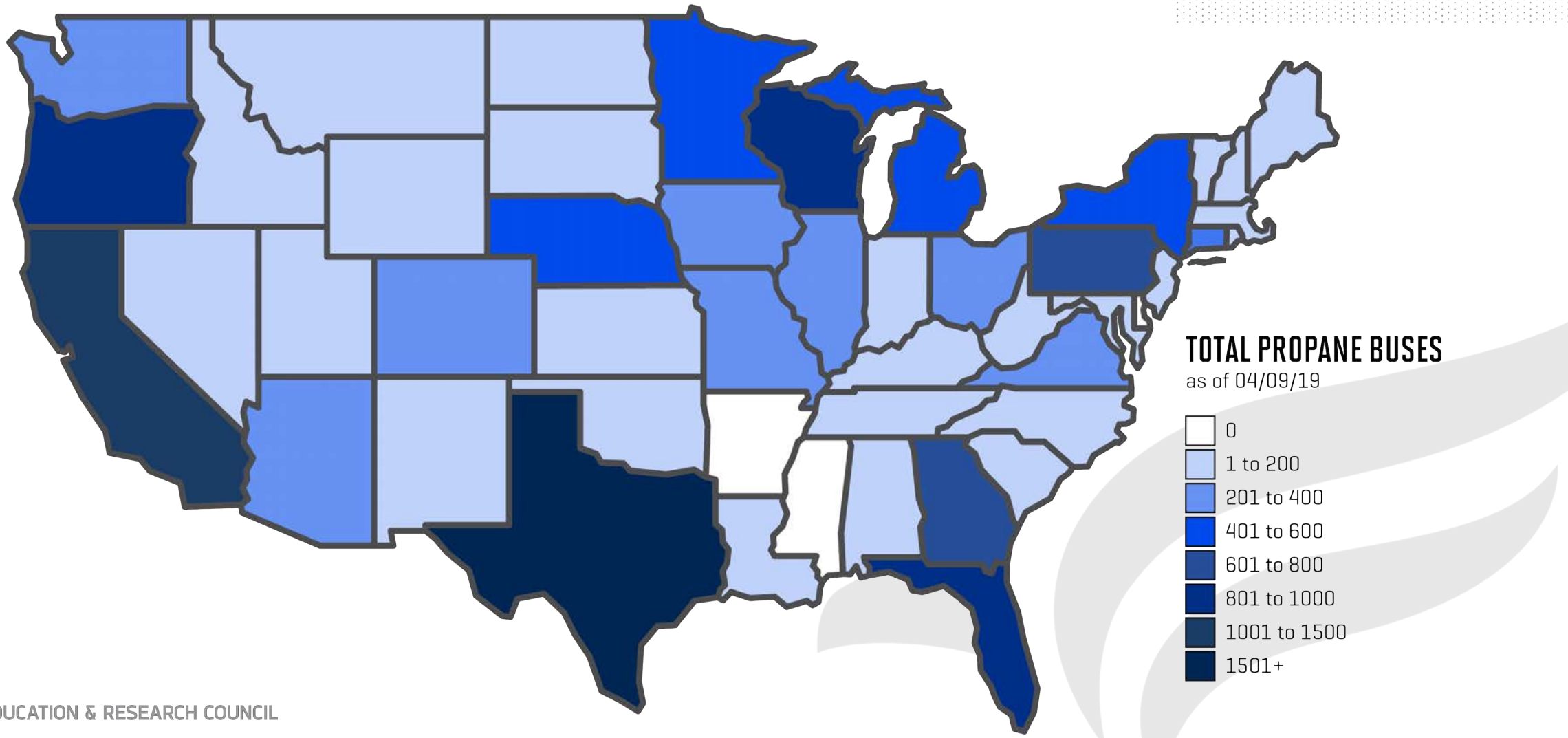

SCHOOL BUS
SCHOOL BUS
R415
STOP


SCHOOL BUS


SCHOOL BUS


SCHOOL BUS

Propane School Bus Deployments



SNAPSHOT OF PROPANE AUTOGAS SCHOOL BUS MARKET

1,250,00+
STUDENTS TRANSPORTED
DAILY

14 STATES WITH

500+ BUSES

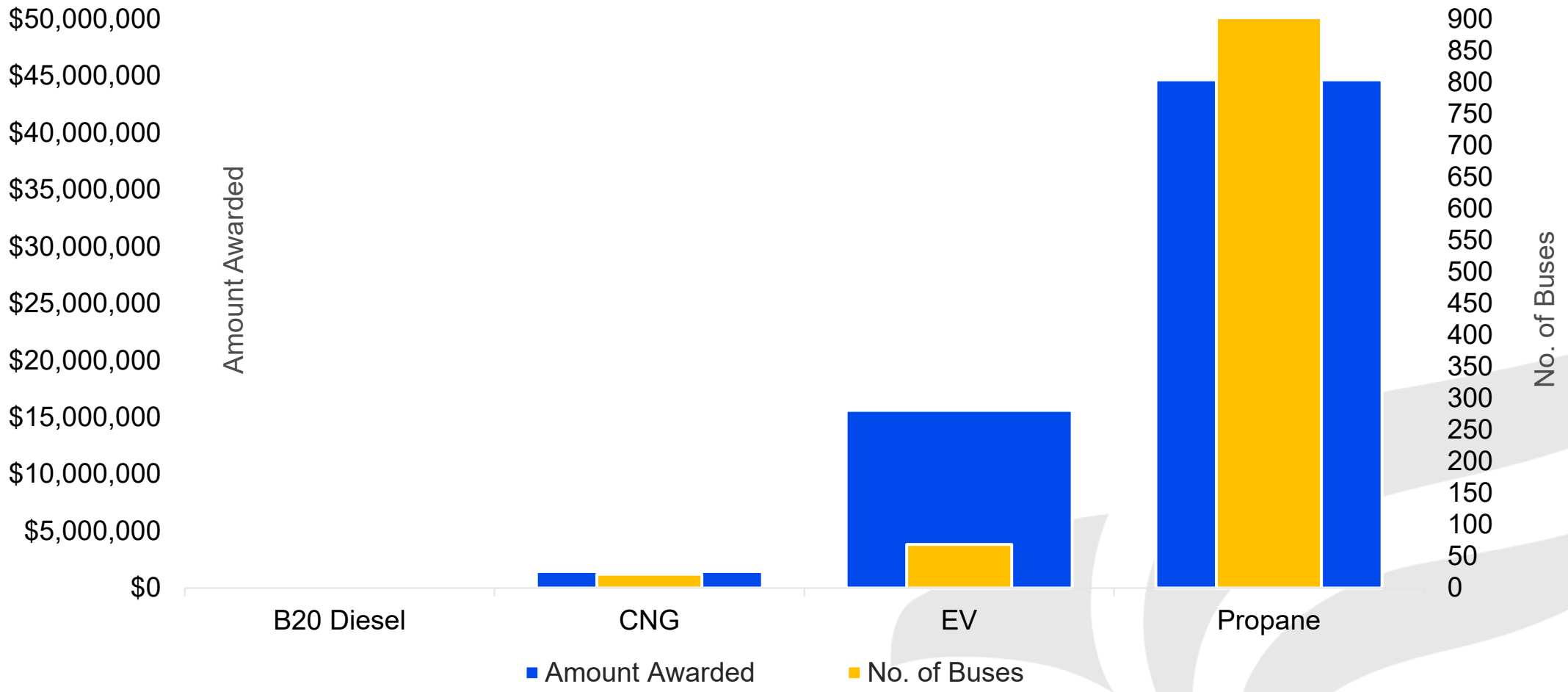
1,000 DISTRICTS & CONTRACTORS OPERATE PROPANE AUTOGAS BUSES

20,000+
PROPANE AUTOGAS BUSES
ON THE ROAD

Similarly Equipped Blue Bird Type C Bus

Diesel, Cummins, ISB, 6.7L	$98,500.00
LPG, Ford/Roush, 6.8L	$107,000.00
CNG, Ford/Roush, 6.8L	$134,000.00
Electric, Adomani,	$385,000.00

VW: School Bus Funding & No. of Buses Through July 20, 2020



Source: Propane Education & Research Council

Emerging Vehicle Markets

Top Targets For Alternative Fuel Adoptions

- Medium duty trucks.
  - Class 3-7.
- High volume fuel consumption.
  - 300 to 900+ gallons per month.
- Regional routes.
  - 75 to 300+ miles per day.

Food/Beverage

- Major companies have already validated propane autogas in this market.
  - ReadyRefresh by Nestlé Waters.
  - Schwan’s Home Delivery.

Paratransit

- 25,000 paratransit vehicles nationwide.
- 600 gallons per month average fuel consumption.
- ADA requires every county in the U.S. to provide service.

Parcel/Package

- USPS has 92,000 routes for moving mail.
  - Over 70,000 routes are performed by independent contractors.
- There are approximately 10,000 class 6-7 straight box trucks operated by USPS contractors.
- Contractors bidding on USPS routes score higher with alternative fuel vehicles.
- 1,000 gallons per month average fuel consumption.

TCO Box Truck example

Total Cost of Ownership Calculator	Class 6/7 Diesel	Class 6/7 Propane	Class 6/7 Gasoline
FUEL			
Annual Miles	60,000	60,000	60,000
Years Operated	5	5	5
Total Miles Lifetime Miles	300,000	300,000	300,000
Fuel Economy (mpg)	7	5	6
Gallons Used Annually	8,571	12,244	10,909
Gallons Used Total	42,857	61,224	54,545
Fuel Price / Gallon	$2.42	$1.39	$2.19
PREVENTATIVE MAINTENANCE			
Oil Interval	7,000	5,000	5,000
Oil Capacity (Quarts)	21	7	7
Oil Filter Cost	$9.36	$4.00	$4.00
Oil Cost Per Quart	$2.55	$2.55	$2.55
Cost Per Oil Change	$62.91	$21.85	$21.85
Lifetime Oil Change Total Cost	$2,696.14	$1,311.00	$1,311.00
Lifetime DEF Gallons	1,500	0	0
DEF Cost per Gallon	$1.89		
DEF Total Cost Over Lifetime	$2,834.99		
Fuel Filter Change Interval	15,000	50,000	15,000
Fuel Filter Cost	$12.99	$264.00	$15.00
Total Filter Changes	20	6	20
Fuel Fiter Cost Lifetime	$259.80	$1,584.00	$300.00
ACQUISITION COST			
Acquisition Cost without body	$65,000.00	$50,000.00	$50,000.00
Incremental Cost (Fuel System)	$0.00	$17,900.00	$0.00
Vehicle Rebate per Unit		$0.00	

TOTAL COST OF OWNERSHIP	Class 6/7 Diesel	Class 6/7 Propane	Class 6/7 Gasoline
Lifetime Operational Cost	**$174,504.87**	**$155,896.36**	**$171,064.55**
Lifetime Savings	0	**$18,608.51**	**$3,440.32**
Cost per Mile to Operate (CPM)	$0.37	$0.29	$0.40

Customer Information

Propane Fuel Price
$1.39

Diesel Fuel Price
$2.42

Gasoline Fuel Price
$2.19

GGE Fuel Price CNG
$0.00

Propane MPG
4.90 70%

Diesel MPG
7.00

Gasoline MPG
5.50 79%

CNG MP GGE
0.00 0%

Years Operated
5

Annual Miles per Year Truck
60,000

Incremental Cost (Propane)
$17,900.00

Rebate Per Unit (Propane)
$ -

Rebate Per Unit (CNG)
$ -


Agility
fuel solutions


ALKANE
TRUCK COMPANY


Alliance AutoGas
POWERED BY PROPANE


BLUE BIRD


C P
CAMPBELL - PARNELL


COLLINS
BUS CORPORATION


FREIGHTLINER
Custom Chassis
Driven By You


Greenkraft Inc
The Green Automotive Future


ICOM
NORTH AMERICA
Alternative Fuel Systems


ISUZU
Commercial Truck of America, Inc.


PSI
POWER SOLUTIONS
INTERNATIONAL


ROUSH
CLEANTECH


Thomas
BUILT BUSES
Because every mile matters.℠


Westport
Here and Now.

OEM Propane Options

- Light & medium duty Ford trucks & vans, school bus.
- Factory Ford warranty maintained.
- No loss of HP / torque / towing capacity.
- Serviceable with existing diagnostic equipment.
- EPA & CARB Certified.

ROUSH® CLEANTECH


Ford F-53 / F-59


Ford E-350/450

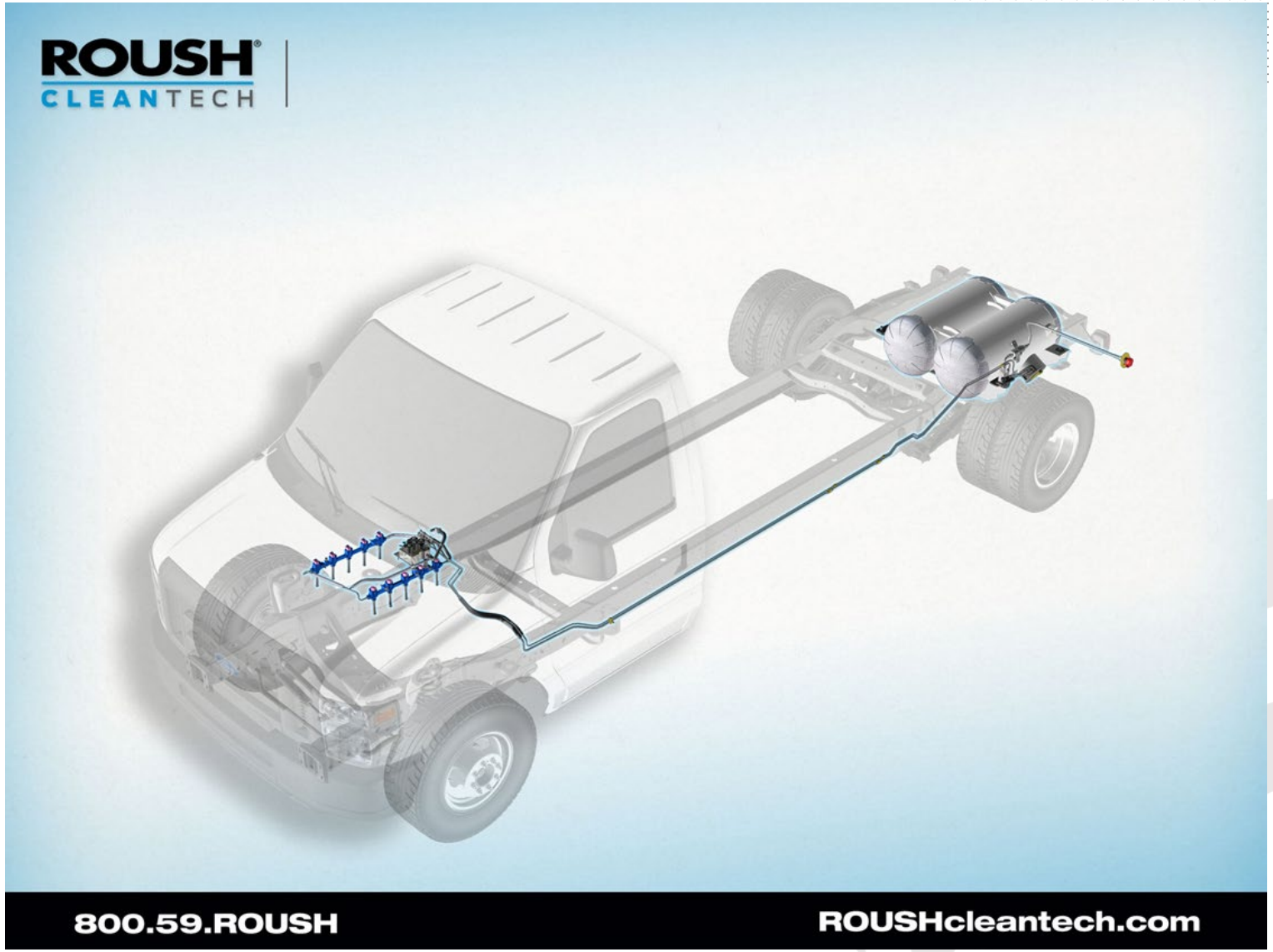

Ford F-450/550


Ford F-650/750

Blue Bird Vision

Micro Bird G5

Small Profile System Compared to Electric



OEM Propane Options

- Updated and improved to increase reliability.
- The entire powertrain is sold, warranted, and supported by Freightliner Custom Chassis.

Greenkraft Inc
The Green Automotive Future

Long Awaited Alternative Fuel Trucks Are Now Available!

CHOOSE YOUR FUEL!

Greenkraft offers trucks in Classes 4 to 7

14,500, 16,500, 17,950, 19,500, 26,000 & 33,000 GVW

BIG SAVINGS ON FUEL

NO DIESEL NO DPF NO DOC NO SCR NO UREA

FEATURES

- Panoramic view
- Heavy duty chassis
- Increased turning radius
- Air brakes
- Available in CNG, LPG & gasoline
- More hauling
- Less servicing
- Warranty 100,000 miles
- GM 8.0 liter engine with Allison 2300 RDS transmission
- Roomy interior
- High tech dashboard
- Near zero emissions certified
- Qualifies for government incentives

Please contact us for more details: sales@greenkraftinc.com | 714-545-7777

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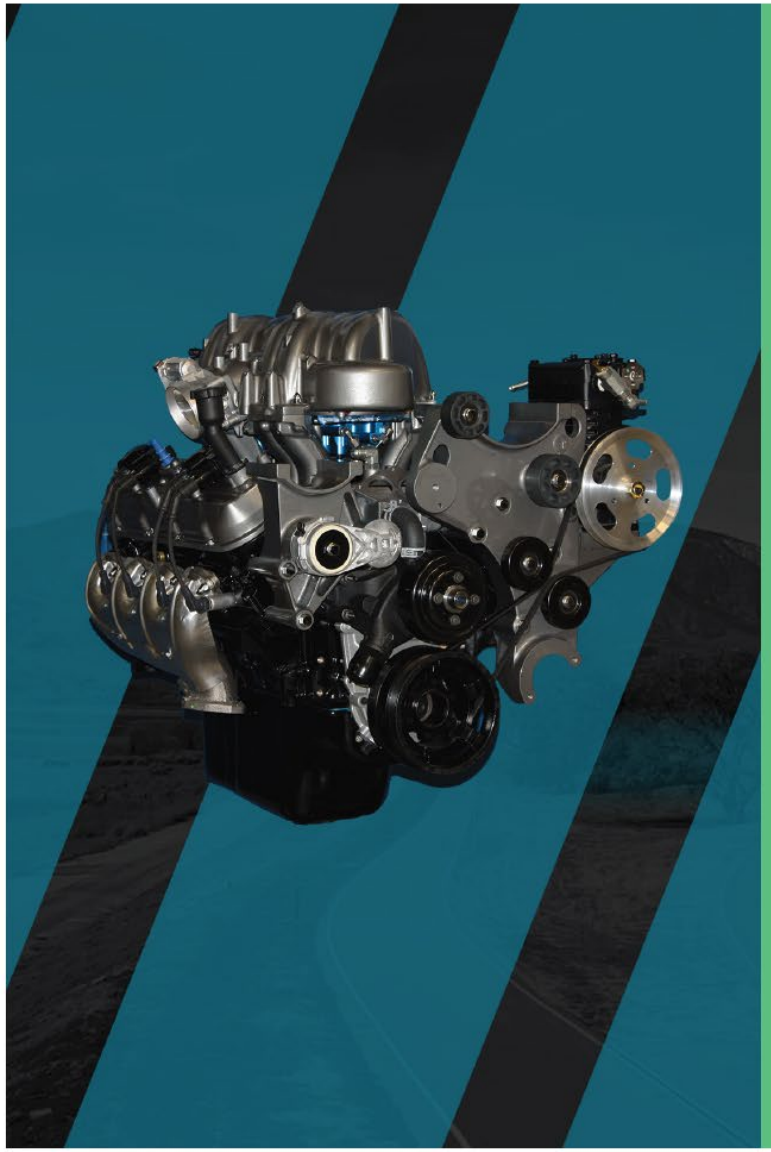
Agility®
fuel solutions

GM 8.0L Propane Engine Powered by Agility



Innovation

The only dedicated propane genuine GM 8.0L engine available in the market

Improved fuel efficiency with patented Agility Liquid Propane Injection (LPI)® fuel system

Improved durability and reduced friction with roller rockers

Improved positive crankcase ventilation baffle reduces oil consumption

NEW reverse torque calibration ensures power is available even when backing up a slope

Redesigned lower intake manifold for improved gasket seal

Rugged tall deck cast iron long-block engine for improved durability

Full-length water jackets (non-siamesed cylinders) for improved cooling

Twelve unique front-end accessory drives able to accommodate your needs: three air conditioning options, air/hydraulic brakes, optional block heater

Industry standard J1939 engine controller compatible with existing diagnostic tools

2020 Model Year Products

Alliance AutoGas
POWERED BY PROPANE

Ford

F150
- 3.3 PFDI
- 5.0 PFDI
- 2.7/3.5 PFDI (SUMMER 20)

F250-F350
- 6.2 PFI

F450-F750
- 7.3 PFI (2021 MY)

E450
- 6.2 PFI
- 7.3 PFI (2021 MY)

TRANSIT
- 3.5 PFDI
- 3.5 ECOBOOST (FALL 20)

EXPLORER
- 3.3 PFDI

GM

SILVERADO 1500
- 5.3 DI

SILVERADO 2500/3500
- 6.6 DI

EXPRESS/SAVANA
- 6.0 PFI

FCA
FIAT CHRYSLER AUTOMOBILES

DURANGO
- 5.7 PFI

CHARGER
- 3.6 PFI

RAM
- 5.7 PFI
- 3.6 PFI (SUMMER 20)

Icom's certified Medium Duty Platforms

The Icom JTG II system is EPA Certified & CARB approved for over 1,200 2009-2019 vehicle platforms including many Ford and GM models.

The Total Solution for any Type of Fleet!

E450 - CARB approved
2016-2017

F350 F450 F550

F750

***FORD NEW 7.3L engine available Spring 2020!**
Taking orders now!

F53 F59 (BAKERY, LINEN, FEDEX TYPE BOX TRUCKS)

6.0L HD

Please confirm with Icom engine family

Chevy Cutaway
Coming soon!

ICOM Alternative Fuel Systems

CAMPBELL PARNELL AND ISUZU NPR

- Bi-Fuel conversions Pre or Post delivery
- 5 year warranty and maintenance packages available
- Plug and Play for ease of installation and service
- CP works directly with the OEM for product development
- EPA and Carb Certification

CAMPBELL-PARNELL

www.UseAltFuels.com

Off Road Applications

Propane Mowers

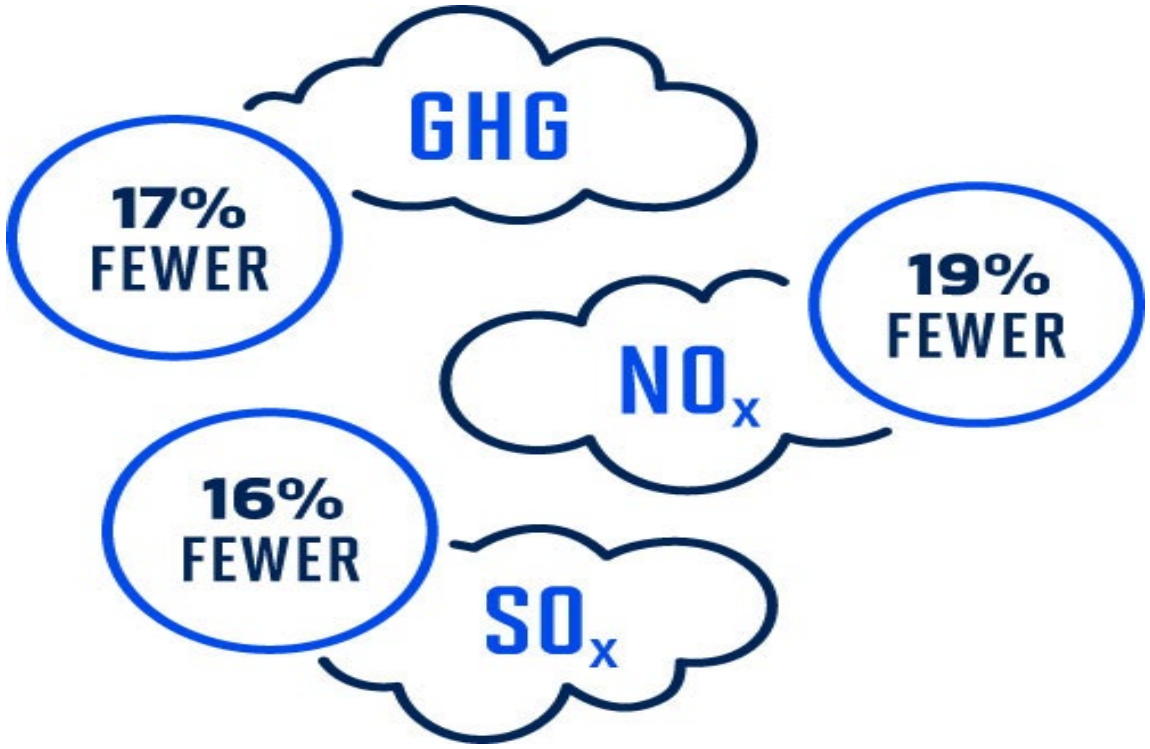
- Professional or Commercial-grade mowers
  - Zero-turn rider (ztr)
  - Walk behind
  - Stand-on
- 800 to 1,000 gallons per mower annually.
- Average of 30% fuel savings compared to gasoline.
  - 50% compared to diesel.

The Brands Farmers Know and Trust

OEM's

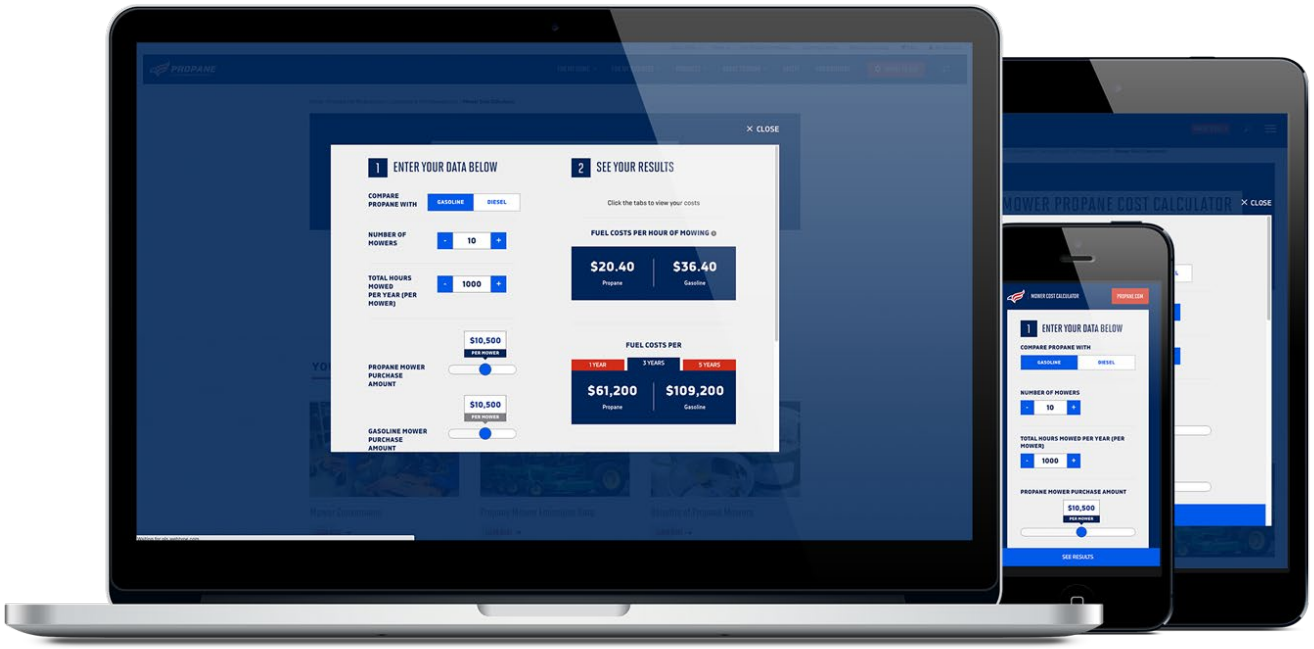
Aftermarket Conversions

Reduced Emissions



COMPARED WITH GASOLINE

Propane Mower Calculator



- Input variables specific to your fleet to determine the amount of savings propane equipment can provide your business.
- Available in tablet, smartphone and desktop applications.

propane.com/mower-calculator

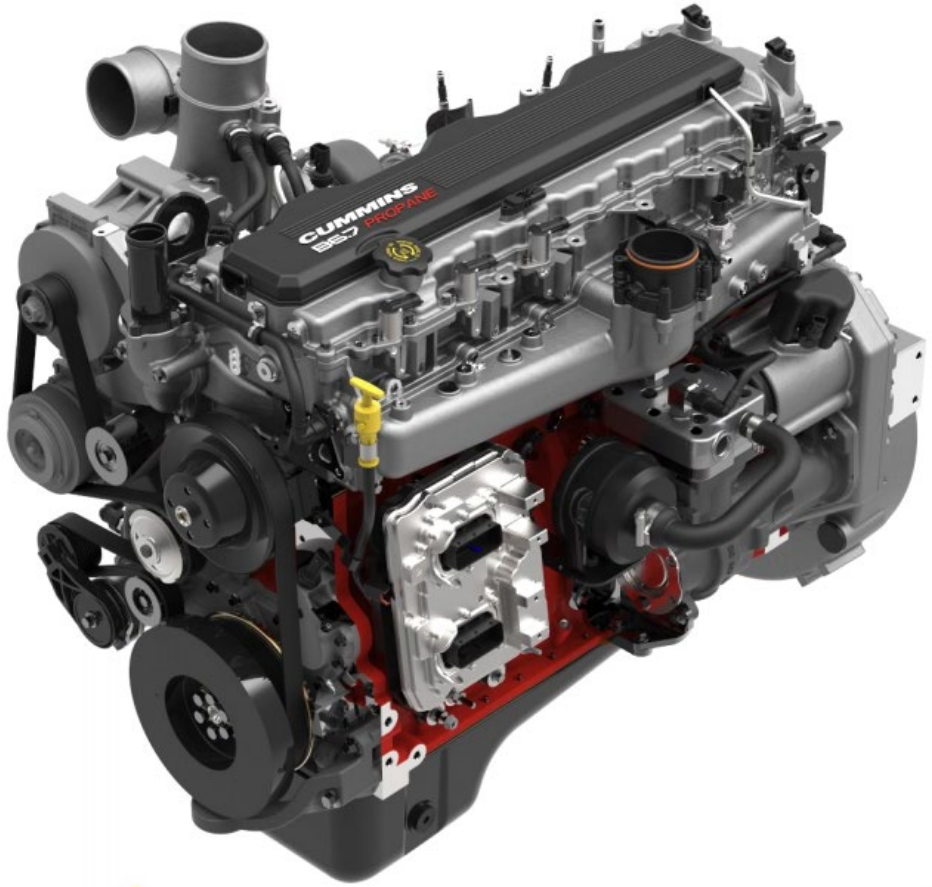
More Than Mowers

Propane is highly versatile and works hard in the field in a variety of applications:

- Utility Vehicles.
- Ride-on Blowers.
- Material Buggies.
- In-field Portable Power.

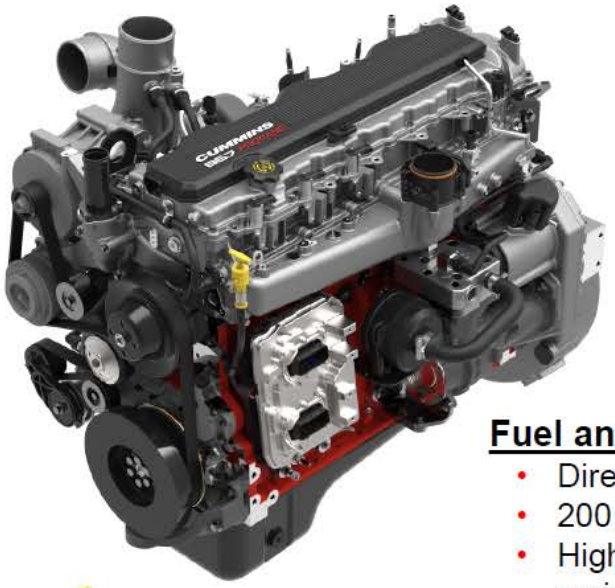
Technological Innovations

CUMMINS 6.7L PROPANE DEMONSTRATION ENGINE



B6.7 PROPANE DEMONSTRATION ENGINE ARCHITECTURE

Base Engine
- 6.7L Displacement
- 107 mm Bore x 124 mm Stroke
- 12:1 CR
- Late Intake Valve Closing cam
- 4 Head Bolt Gray Iron Block
- Dual Overhead Camshaft Valve Train
- 4 Valve Aluminum Cylinder Head
- 174 bar PCP Limit
- High Efficiency Pent Roof Combustion Chamber
- High Tumble Charge Motion Intake Ports
- Leverages B6.7 Diesel Components Where Applicable for Increased Reliability and Durability



Fuel and Ignition System
- Direct Propane Injection
- 200 bar Rail Pressure Capability
- High Pressure pump w/ recirculation
- M14 Spark Plug w/ single coil on plug inductive ignition system

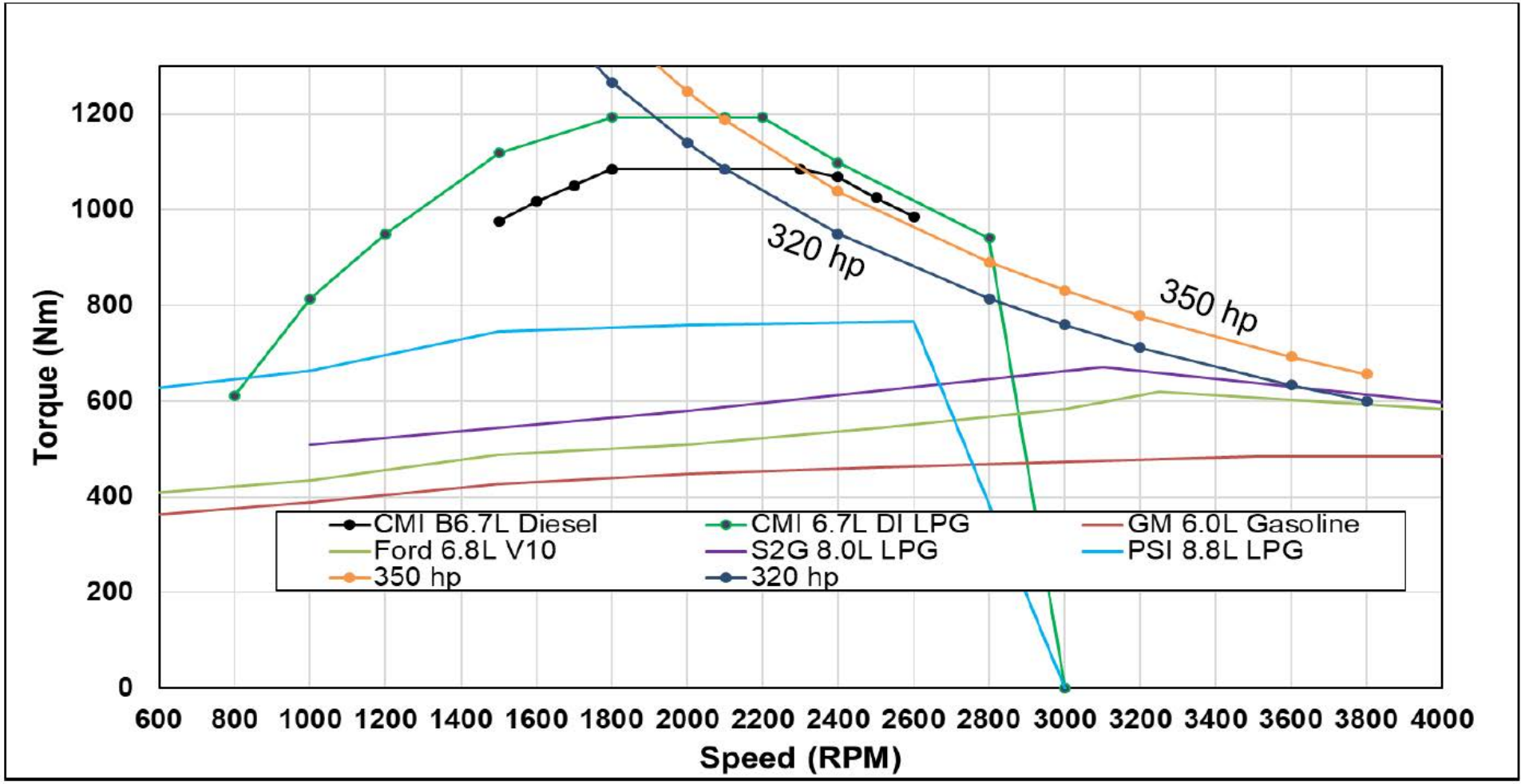
Air Handling System
- Twin Entry, Dual Scroll, Wastegate Turbocharger with Command WG

Cummins Aftertreatment System
- On-Engine Close Coupled Three Way Catalyst

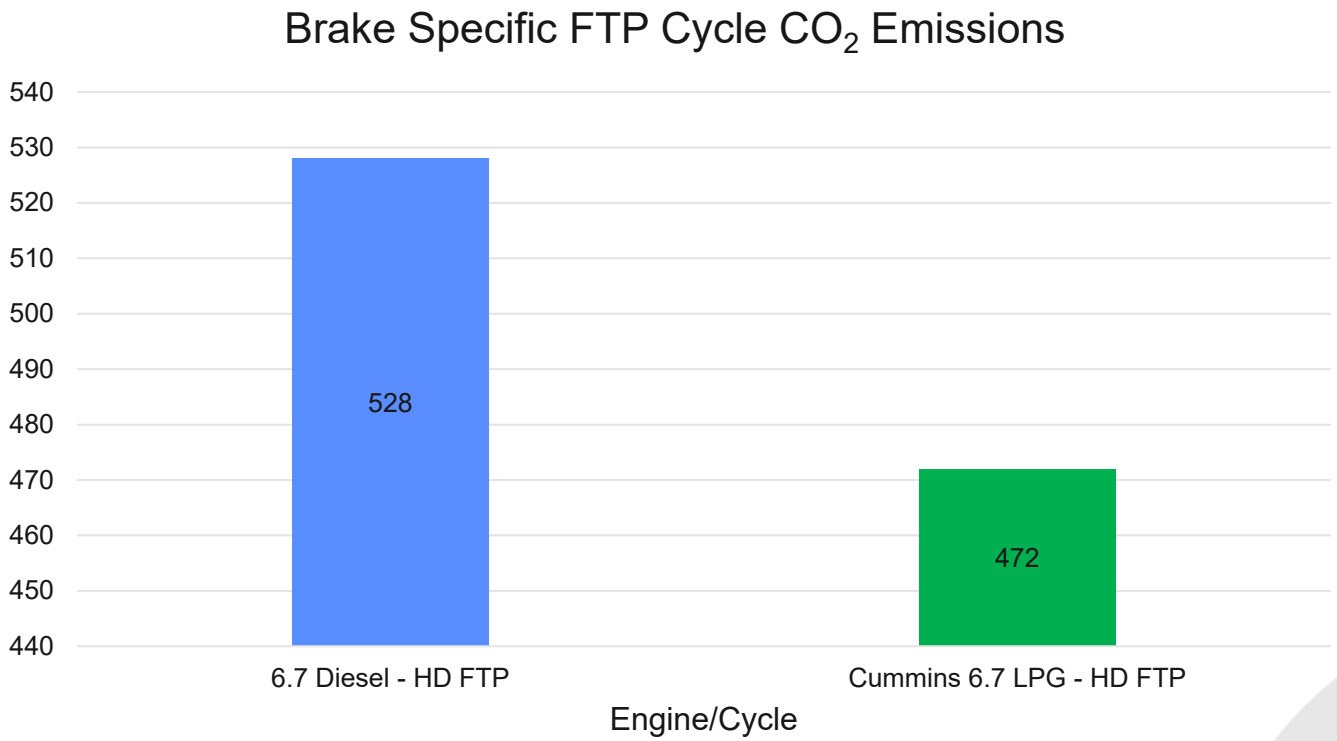
Electronics/Controls
- SI Specific ECM

Vehicle Integration
- System Weight Improved Over B6.7 Diesel
- Customer Interfaces Similar to B6.7 Diesel

TORQUE CURVE COMPARISON



GREENHOUSE GAS EMISSIONS

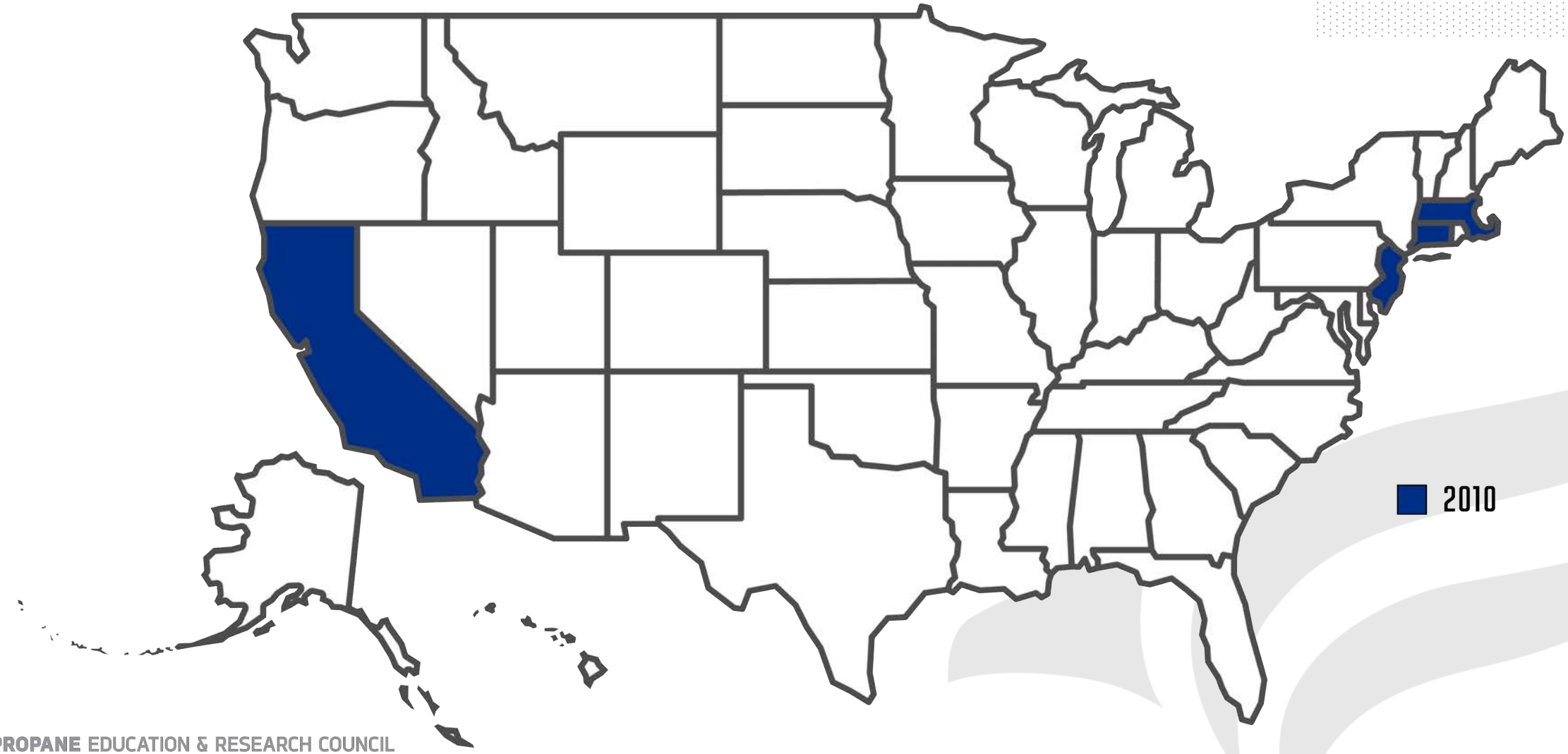


- 11.4% lower CO_2 emissions than diesel engine with similar displacement and torque curve. Similar BTE, favorable H/C ratio results in lower CO_2.

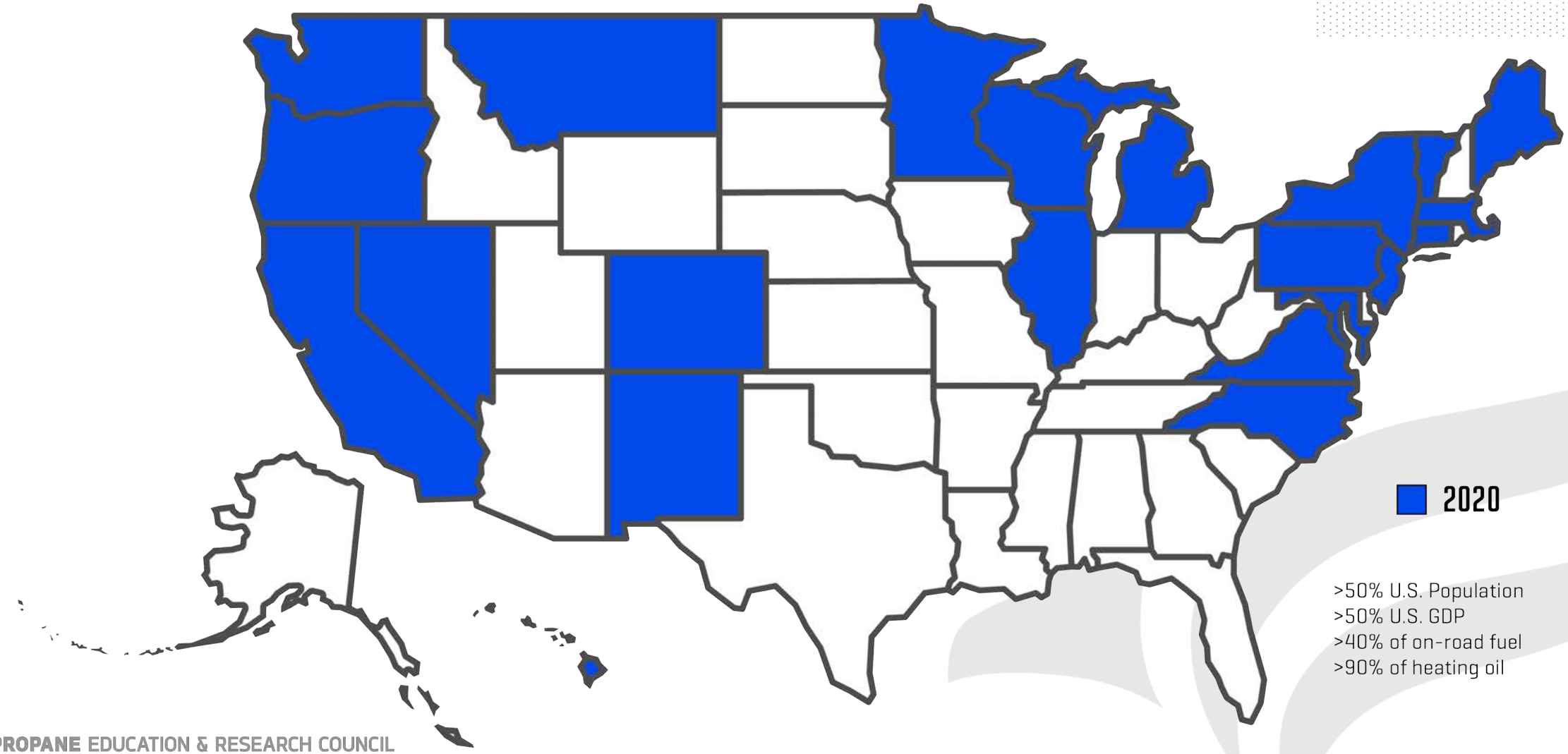
Renewable Propane

The Future of Propane Autogas

Comprehensive Carbon Goals



Comprehensive Carbon Goals

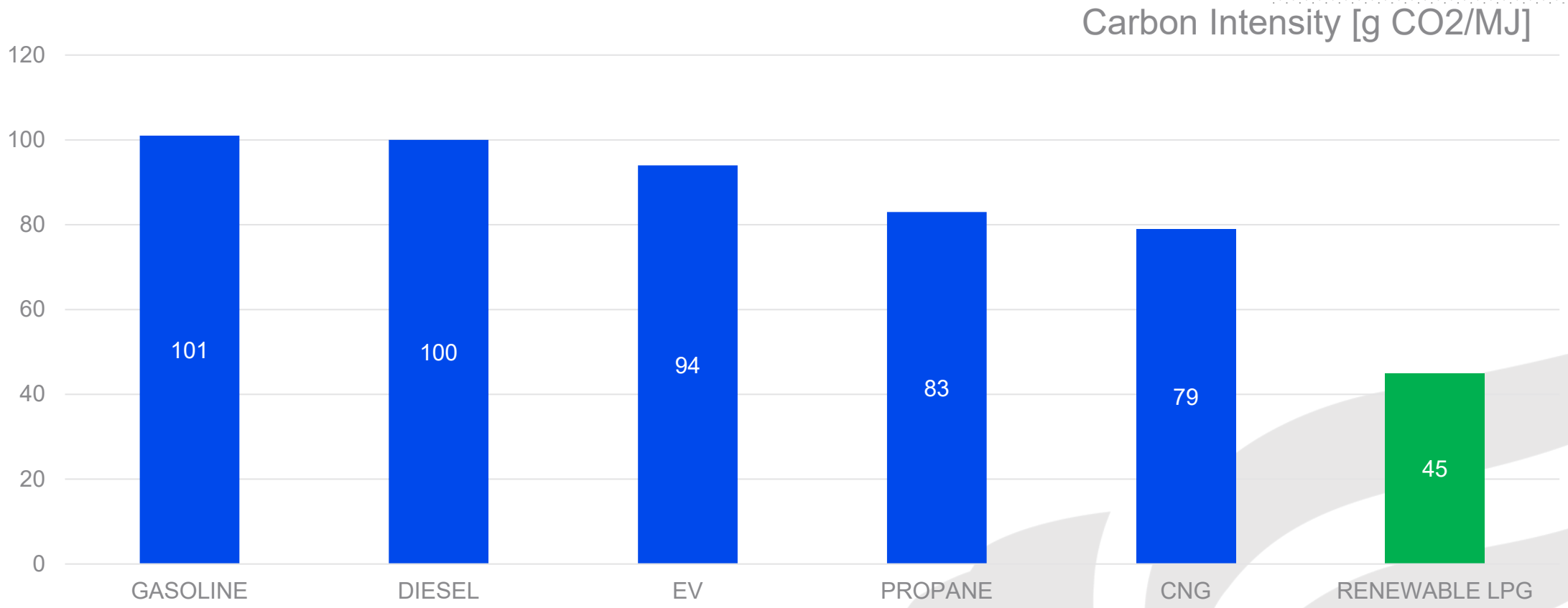


>50% U.S. Population
>50% U.S. GDP
>40% of on-road fuel
>90% of heating oil

Renewable Propane

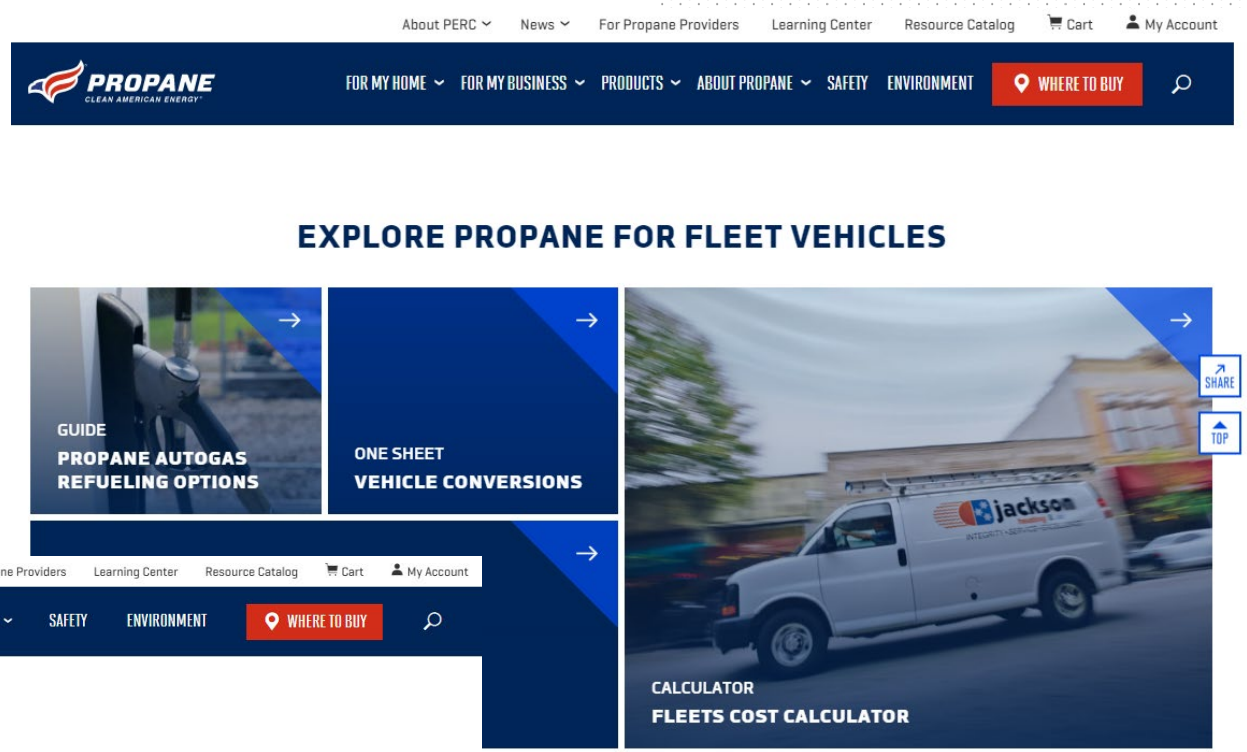
- Low carbon intensity.
- Inexpensive feedstock.
- Abundant feedstock.
- Low energy conversion.
- Final product competitively priced.

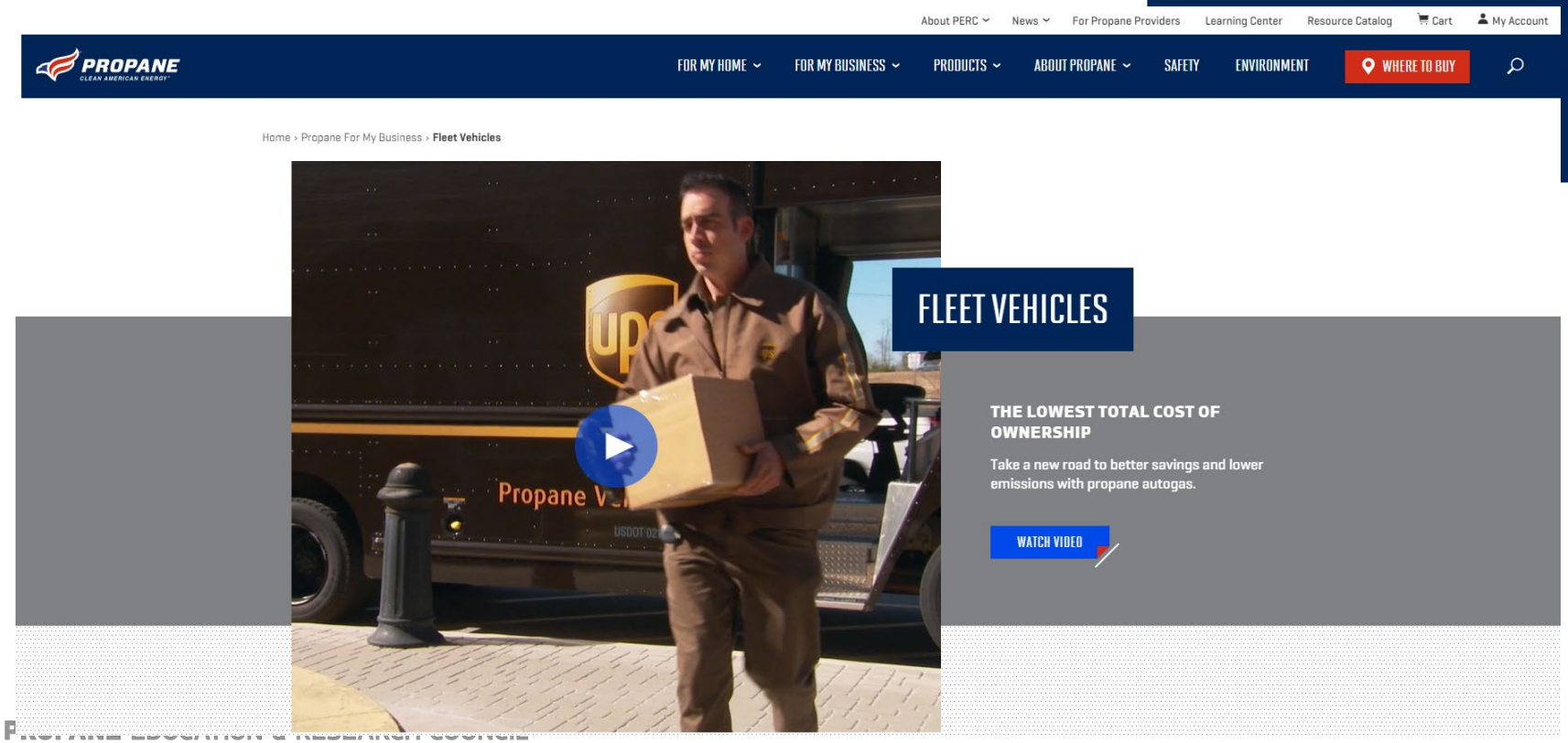
CARBON INTENSITY SCORES



Renewable Propane – Drive The Future Now

www.propane.com/for-my-business/fleet-vehicles/





STEVE WHALEY

DIRECTOR OF AUTOGAS BUSINESS DEVELOPMENT

PROPANE EDUCATION & RESEARCH COUNCIL

STEPHEN.WHALEY@PROPANE.COM

864-606-2290

Lisa McAbee
lismcb@aol.com
864-839-6974

- Vice-President of McAbee Trucking
- Contractor to United States Postal Service for parcel delivery between distribution centers in NC & SC
- Uses CNG in class 8 tractors
- Uses propane autogas in class 6-7 straight trucks

McAbee Trucking: Propane Autogas for US Postal DC Parcel Delivery

Herb Mullen
hmullen@arhs-nc.org
252-338-4477

- Director of Transportation for the Inter-County Public Transportation Authority which operates throughout 5 counties in northeast NC
- More than 20 years experience
- Service area of 1,000 sq-mi with more than 500 daily trips
- Governor's award for legislation streamlining NC funding for regional transportation
- Use and integration of technology including propane fleet conversion
- BS from Barton College in Business Management with minor in Economics

Inter-County Public Transportation Authority

Anyone Can Ride !

www.icpta.net

ALBEMARLE REGIONAL HEALTH SERVICES
Partners in Public Health

Timeline

- November 2012 - NCDOT had an alternative fuels presentation at our PTD Conference
- April 2013 - Contacted the Governor's office about getting propane conversion kits on State contract
- July 2014 - Bid was awarded
- January - 2015 vehicles were converted

Benefits of Propane

- 557A is available to all NC government programs as well as municipalities, and counties etc.
- Two of the systems listed on State Contract are Duel Fuel. If you run out of propane the system reverts back to gasoline.
- ICPTA saved an average of 44% when using autogas instead of gasoline for FY20.
- Propane can reduce greenhouse gas emissions by about 25%
- 98% of propane is American-made, which reduces our dependence on foreign oil

Fueling station

- 2000 Gallon package fueling skid $41,203
- Site work and installation $18,000

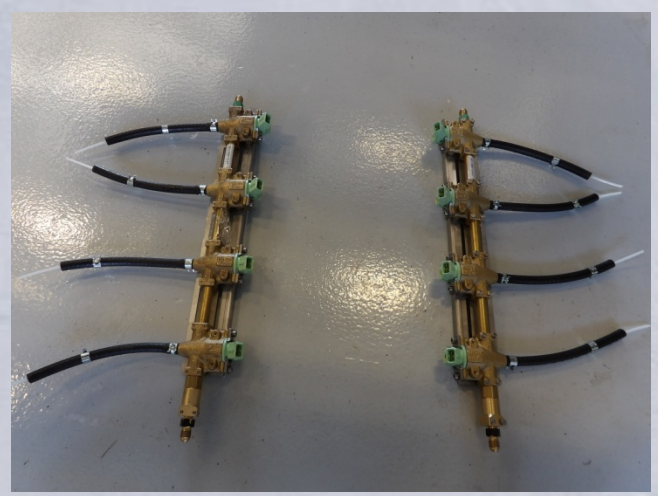
Total Project $59,203

This was a 100% local expense!!!

Cost of Conversion Kits

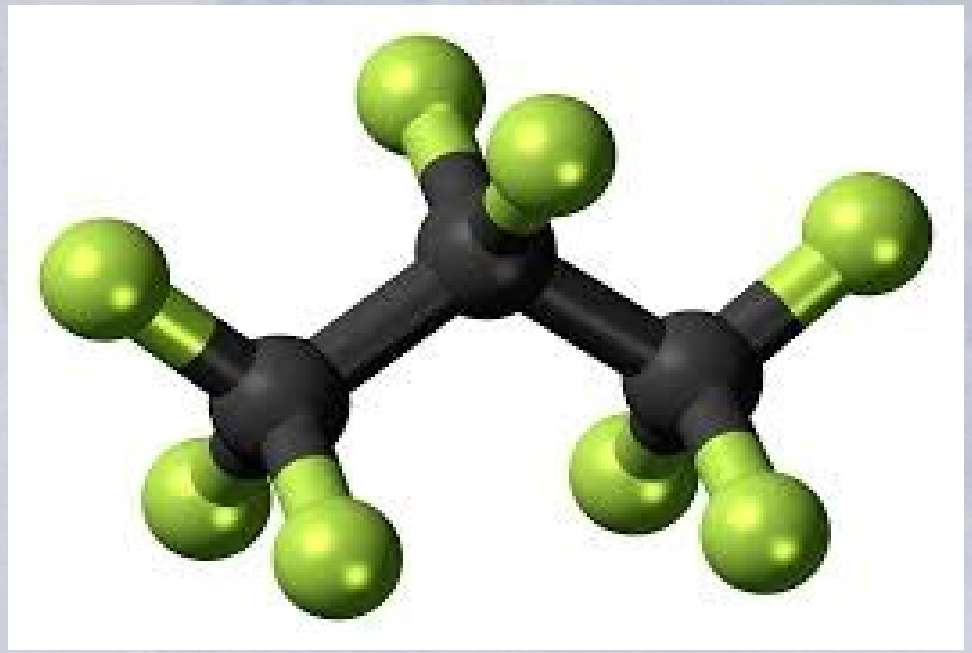
- $9,200
- ***5311 Capital will fund 90% of this cost for Public Transportation***

Propane Conversion Kits



Propane Conversion Kits Return on Investment

- $256,495 Since January 2015
- Price of propane autogas 8/11/2020 .89 per gallon



Ed Hoffman
ehoffman@blossmanservices.com
828-232-0910

- President of Blossman Services, the distribution partner for Alliance AutoGas
- More than 25 years experience industry experience
- Previous experience includes positions with Keystone Automotive, XTRA Lease, Ryder Sytems, Penske Truck Leasing and CarMax Auto Superstores
- BS in Management & Industrial Relations from Wilkes University and an MBA in Operations Management from University of Scranton

Alliance AutoGas
POWERED BY PROPANE

Gaseous Fuels: Trends and Applications

Ed Hoffman

Alliance AutoGas
POWERED BY PROPANE

Why do it?

- Save money
- Use American fuel
- Become a leader in your industry
- Provide cleaner air for your community
- Autogas is a proven solution, available right here, right now

Infrastructure, the chicken or the egg?

- No capital investment
- Driver friendly
  - Fast fill times
  - Quick Connect nozzles
- Private station offers
  - Productivity
  - Always the best price
  - Detailed data capture
- Resilient
- Scaleable

Our Systems

Alliance AutoGas offers a bifuel system, giving fleet vehicles the flexibility to run on either autogas or gasoline, eliminating range anxiety

Alliance AutoGas
POWERED BY PROPANE

Current Products

F150
- 3.3 PFDI
- 5.0 PFDI

F250-F350
- 6.2 PFI

F450-F750
- 7.3 PFI (2021 MY)

E450
- 6.2 PFI
- 7.3 PFI (2021 MY)

TRANSIT
- 3.5 PFDI

EXPLORER
- 3.3 PFDI

SILVERADO 1500
- 5.3 DI

SILVERADO 2500/3500
- 6.6 DI

EXPRESS/SAVANA
- 6.0 PFI

DURANGO
- 5.7 PFI
- 3.6 PFI (Coming Soon)

RAM
- 5.7PFI
- 3.6 PFI (Coming Soon)

CHARGER
- 3.6 PFI

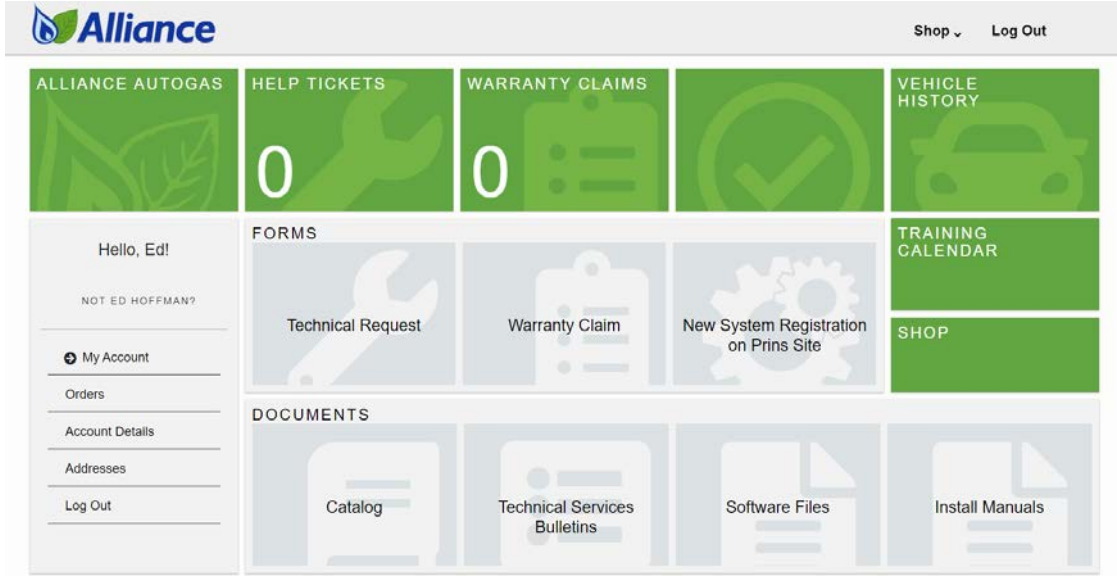
All Aftermarket "Kits" Are Not The Same

- Each vehicle platform is customized in the US for the US market
  - Full detailed install manuals for consistent installs
  - Custom brackets that guarantee proper component locations
  - Custom vehicle wiring harnesses - no bundling or nests of wires
  - Custom injection solutions
  - Pre developed no tamper calibrations (load and go)
  - Documented performance and EPA compliance

- Warranty and support
  - Alliance AutoGas warranty supplements and exceeds existing factory warranty
  - 5 Year 100,000 Miles on new units

Upfit / Service / Support

- **Upfit**
  - Easy "check the box" upfit options
  - Get delivered from your dealer
  - Utilize trusted upfitter network
- **Service**
  - Timely and proven service provider
  - Kickoff/intro call with our service support team prior to delivery
  - We identify service center targets in your area that are a good fit
- **Support**
  - Hands on training upon vehicle delivery
  - Ongoing training and technical communication



Contact Us

Info@allianceautogas.com
www.allianceautogas.com

Sherrie Merrow
SMerrow@ngvamerica.org
202-824-7360

- **Director of State Government Affairs for NGVAmerica**
- **Leads a team of more than 175 people from more than 70 member companies who focus on issues and activities related to the growth of the natural gas vehicle industry, including the VW Settlement**
- **Additional experience as an advisor to the oil & gas industry for natural gas vehicle programs**
- **BS in Computer Science from University of Wyoming and BA in Literature From Wheaton College**

NGVAMERICA

NGVAMERICA

Natural Gas Vehicles for America

SUSTAINABLE FLEET TECHNOLOGY

VIRTUAL CONFERENCE 2020

Natural Gas / Renewable Natural Gas Solutions Now!

August 12, 2020

About NGVAmerica

NGVAmerica is the national organization dedicated to the development of a growing, profitable, and sustainable marketplace for vehicles powered by natural gas and biomethane and for promoting the use of more natural gas in transportation… trucks, trash, transit, and even off-road uses like HHP marine, rail, and construction/mining applications.

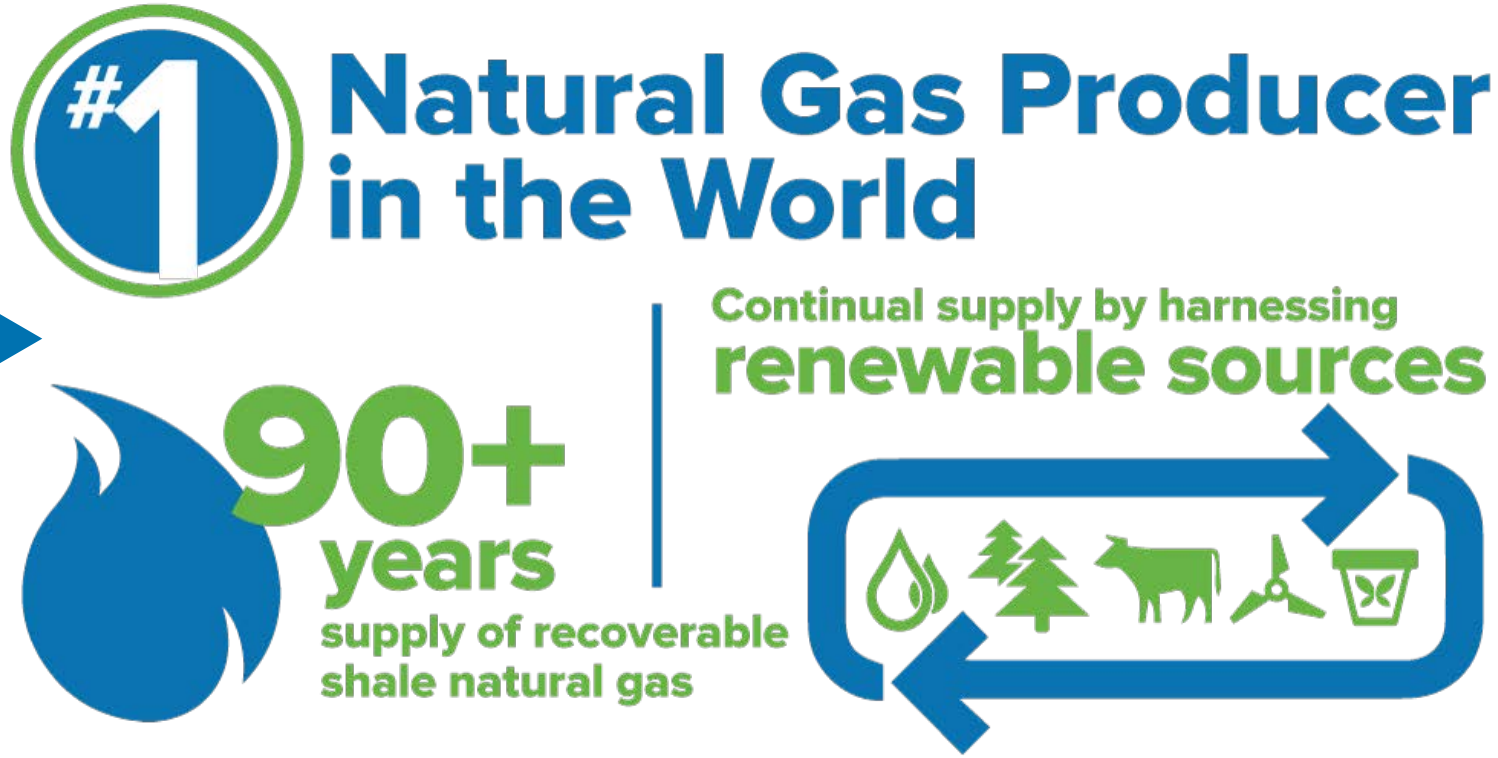
200+

NGVAmerica represents 200+ companies, LDCs, fleets, OEMS, environmental and government organizations.

NGVAMERICA

NGVAmerica Members

North America has an abundant domestic supply of clean, cost-effective natural gas



The cleanest medium- and heavy-duty truck engines in the world are powered by natural gas

- Certified in 2018 by the U.S. Environmental Protection Agency and California Air Resources Board

The Cummins Westport and Agility Ultra-Low NOx engines are certified to a 0.02 g/bhp-hr standard, which is:

- 90% cleaner than the EPA's current NOx standard
- 90% cleaner than the latest available diesel engine

Renewable natural gas (RNG) provides even greater CO_2 and greenhouse gas emission reductions

Carbon Intensity Rating of Key Transportation Fuels

Transportation Fuel	EER-Adjusted Carbon Intensity
Diesel (conventional)	102.01
Natural gas (conventional)	88.60
Hydrogen (from natural gas)	55.61
Electricity (California grid)	38.95
RNG - Landfill gas	33.89 to 65.64
RNG - Wastewater biogas	8.61 to 34.36
RNG - Food/green waste biogas	-25.48
RNG – Dairy biogas (prospective)	-303.30

Source: www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm, CARB, February 2017. Adjusted for heavy-duty truck applications.

What does this really mean?

NGVs + RNG offer the cleanest commercially available path to reduce heavy-duty vehicle emissions

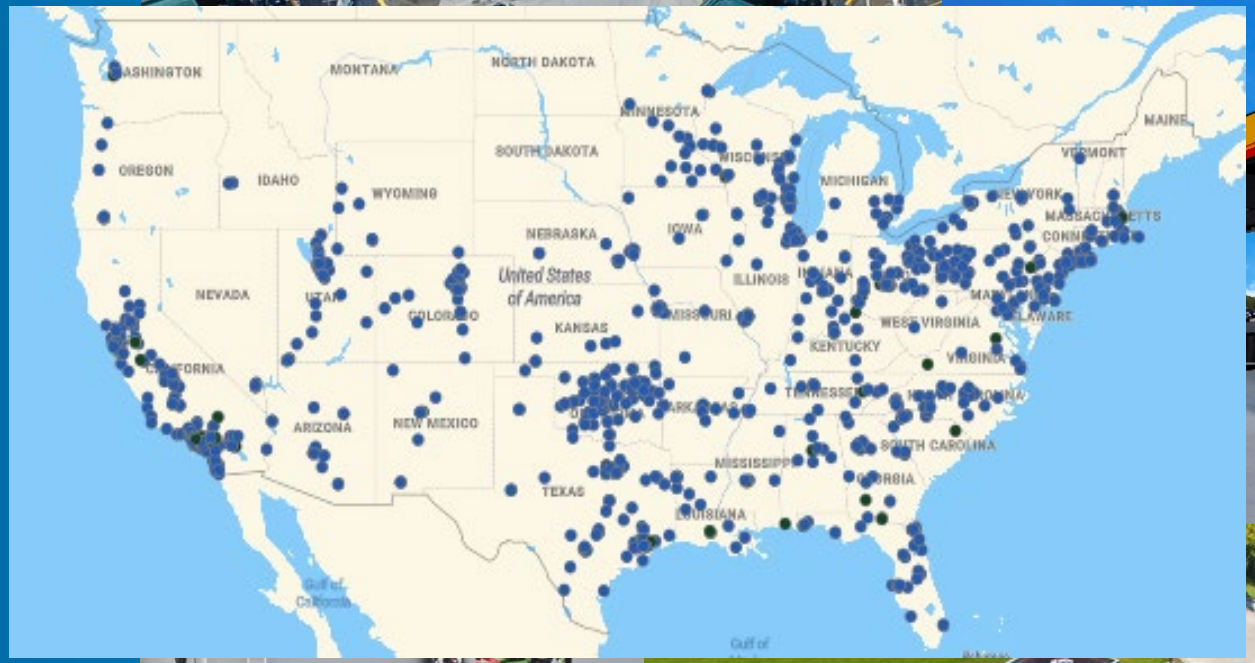
Every Medium- & Heavy-Duty and High Horsepower Application

Ready-Right-Now Technology On and Off the Road Today.

NGVAMERICA

Natural gas fuel station infrastructure is continually expanding

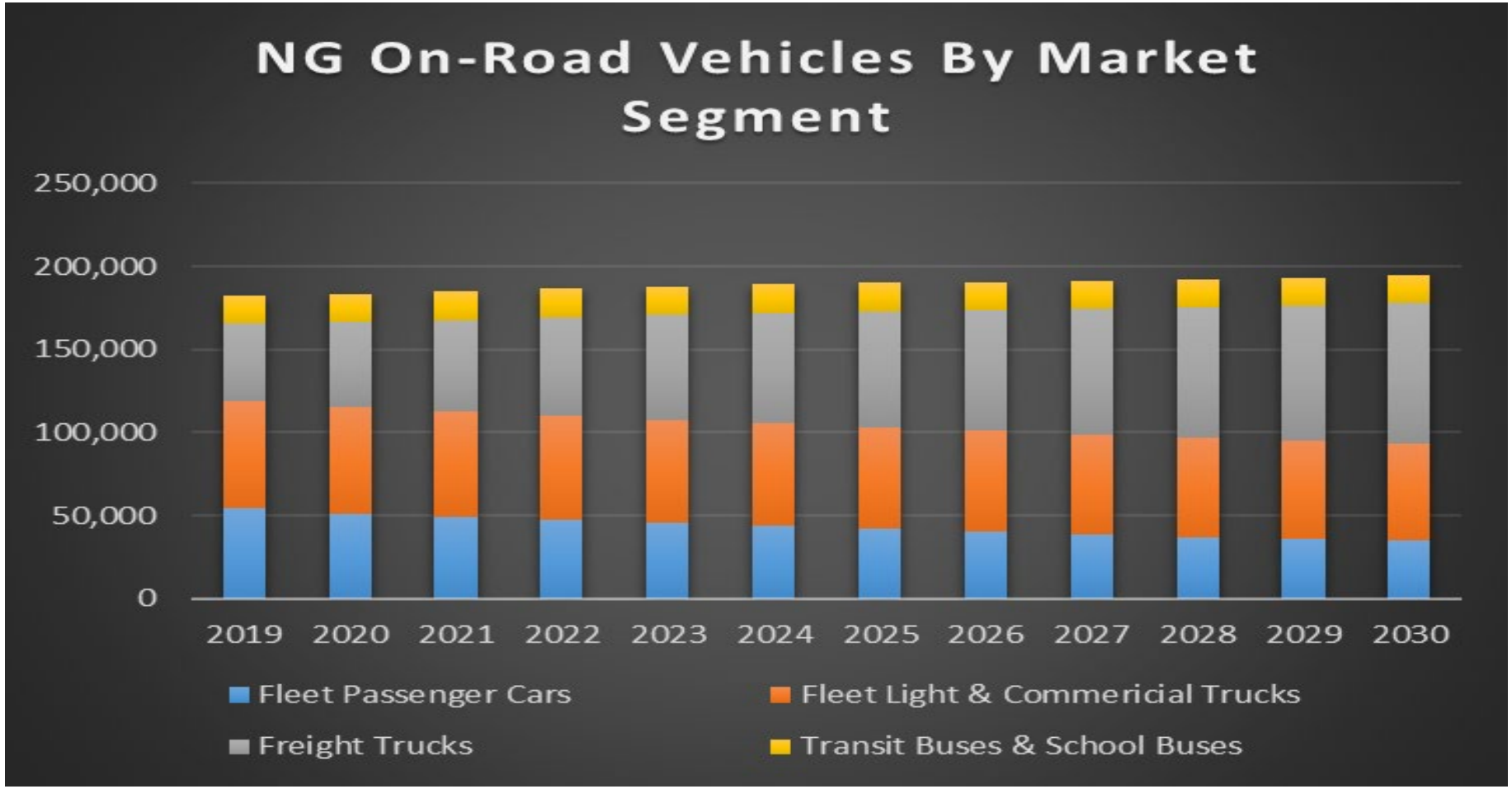
2019 Year End
1,604 CNG Stations
120 LNG Stations



Source: https://www.ngvamerica.org/fuel/

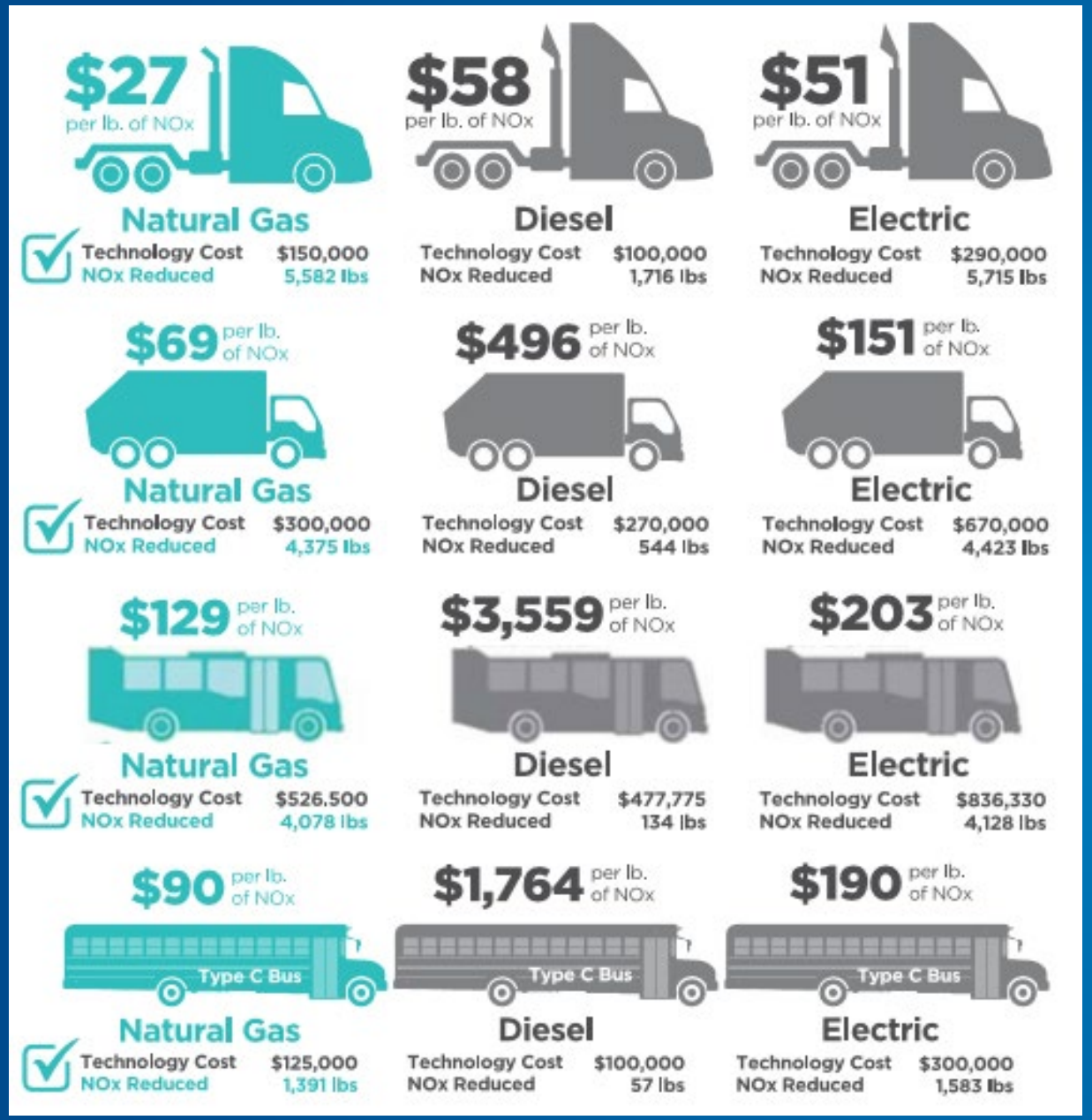
NGVAMERICA

EIA (AEO 2020) Market Forecast of NGVs On-Road



Importance of Freight Trucks

- Freight trucks account for greater than 60% of on-road fuel consumption
- Freight market size continues to grow in future outpacing other vehicle segments
- Sales as reported by EIA for freight trucks are approximately 6,000 units in 2019 but this does not include transit buses. ACT Research estimate for 2019 for Class 7 & 8 trucks was 4,100 trucks and 1,600 transit buses. CWI published data indicates 2019 sales were about 7,900 units.



NGVs Deliver the Largest & Most Cost-Effective NOx Emissions Reductions

Across All HD Applications:

- ✓ Heavy-Duty Trucks
- ✓ Refuse Trucks
- ✓ Transit Buses
- ✓ School Buses

Source: Emission comparisons are based on results using Argonne National Laboratory's HDVEC tool (https://afleet-web.es.anl.gov/hdv-emissions-calculator/) and include modeling of new low-NOx natural gas engines and the diesel in-use emissions option.

NGVAMERICA

NGVAmerica.org

Your source for all NGV industry news and information.

NGVAMERICA

NGVs deployed today benefit our lives NOW and for the future!

NGVAMERICA

NGVAMERICA

Natural Gas Vehicles for America

Contact Information

Sherrie Merrow – Director, State Government Affairs

smerrow@ngvamerica.org

Michael McDonald
mmcdonald@ups.com

- Director of Sustainability and Government Affairs for UPS
- Works with UPS' Corporate Maintenance and Engineering to integrate alternative fuels and advanced vehicle technologies into fleet operations, a.k.a. UPS' "rolling laboratory"
- One of the largest fleets in the industry with more than 10,000 vehicles that travel more than 1M miles each day

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Alternative Fuel & Advanced Technology

August 12, 2020

Introduction

- Michael McDonald
- Decision Drivers
- History LNG / CNG
- The Numbers
- Challenges
- Successes

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Sustainability Drivers

- 20% of global energy and process-related CO2 emissions come from heavy transport.
- 90% of people worldwide breathe polluted air, with many megacities exceeding safe pollutant levels several times over.
- 10% of U.S. retail sales are conducted via e-commerce.
- $5 billion is spent globally on digital commerce platforms.

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Advantage LNG

- Charged to take advantage of LNG fuel cost
- LNG had range and capacity
- Tennessee high mileage runs and LNG fuel agreement
- LNG production in Chattanooga and Birmingham
- Close to operations, transport cost worked
- Not enough range with CNG class 8

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Advantage CNG

- Years later CNG range extended with technology
- CNG had range and capacity
- Pipeline delivery preferred over tanker delivery
- CNG used in delivery trucks, no LNG system for delivery truck
- CNG cost less all in
- Note: LNG class 8 cost less than CNG class 8

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Global Alternative Fuel & Advanced Technology Vehicles

Total Vehicles (U.S. & International): 10,462

United States Fleet: 8,632
(7.9% of US Small Pkg Fleet)

- Compressed Natural Gas Vehicles: 4,893
- Liquid Natural Gas Vehicles: 1,293
- Hybrid Electric Vehicles: 669
- Electric Vehicles: 122
- Propane Vehicles: 1,176
- Hydraulic Hybrid: 76
- Electric Bikes: 6

International Small Package Fleet: 1,830
(11.3% of International Small Pkg Fleet)

- Propane Vehicles: 1,275
- Compressed Natural Gas Vehicles: 153
- Electric Vehicles: 214
- E-Bikes: 58
- Ethanol Vehicles: 79
- Liquid Natural Gas: 34
- Hybrid Electric Vehicles: 17

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UPS Investments in Alternative Fuel Market

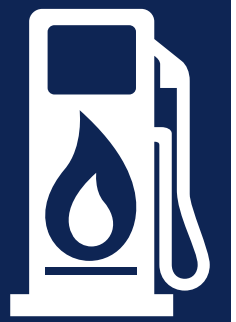
Since 2008

>$1 billion

global investment

in natural gas vehicles and fueling stations

48
CNG sites



14
LNG sites

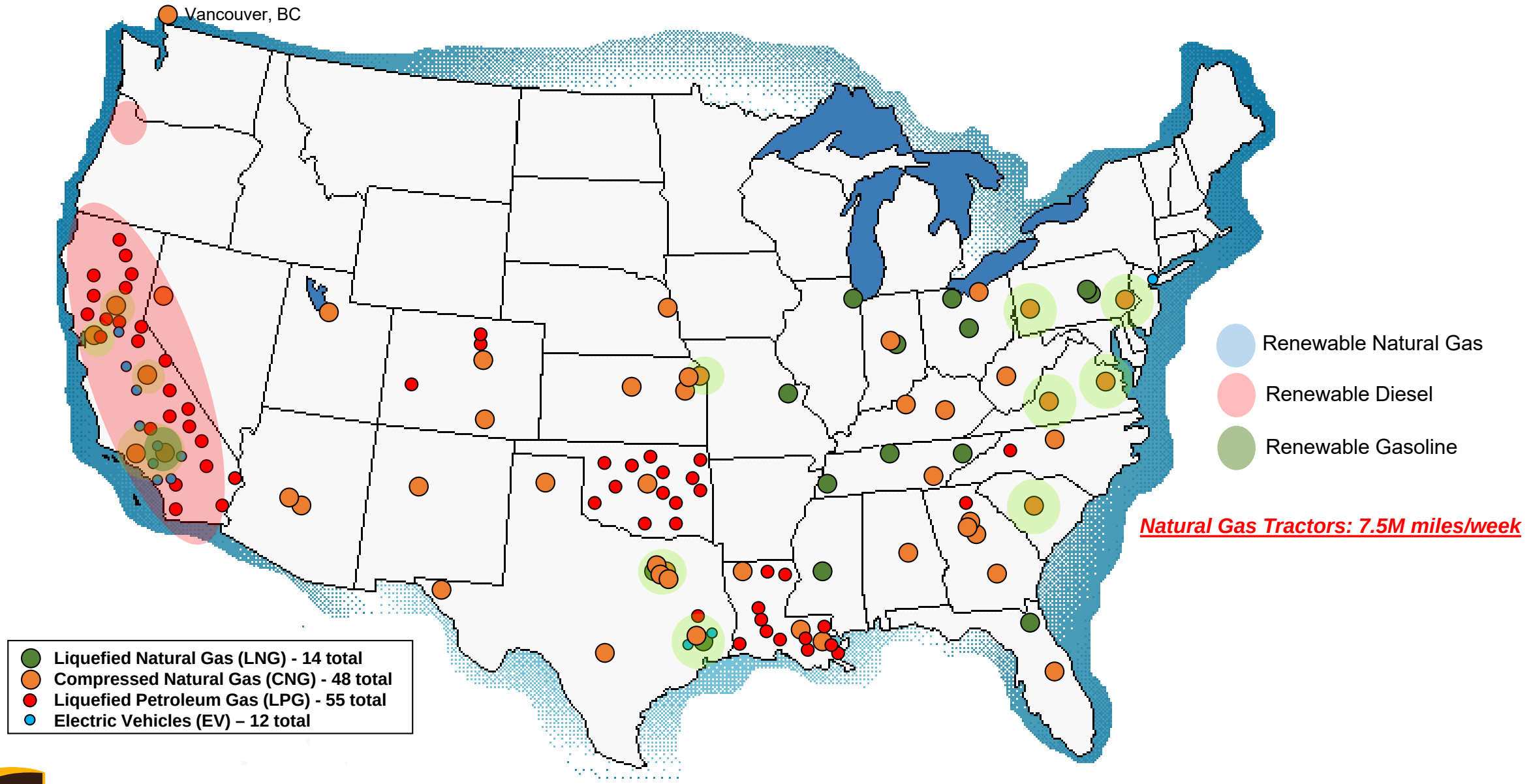
55
Propane sites

248M
combined gallons (DGE) of natural gas since 2014

28M
gallons of Renewable Natural Gas (RNG) since 2014

42M
gallons of Renewable Diesel (RD) since 2014

Alternative Fuel Station Footprint – US Domestic



Natural Gas Tractors: 7.5M miles/week

Challenges & Successes

- Technology
- Climate
- Training
- Fuel supply
- Employee response
- Quiet
- Tailpipe emissions
- Fuel cost

111

Thank you

United Parcel Service
Michael McDonald
Dir. of Sustain & Gov. Affairs

Brian Beltran
bbeltran@wm.com
864.949.5407

- South Atlantic Area Fleet Director for Waste Management
- Started WM in 2012 as Fleet Manager in Charlotte NC
- Won WM Top Shop Award in 2013 for Most Improved Shop
- 2018 recipient of prestigious Circle of Excellence Award
- Retired Chief Warrant Officer with 20 years in the US Army, served 6 combat tours in both Iraq and Afghanistan
- Defense Contractor training Iraqi Army on weapons, communication and equipment maintenance

WM Natural Gas Program Overview

Gaseous Fuels Trends and Applications Session 8.12.20

Brian Beltran
Fleet Director
Waste Management

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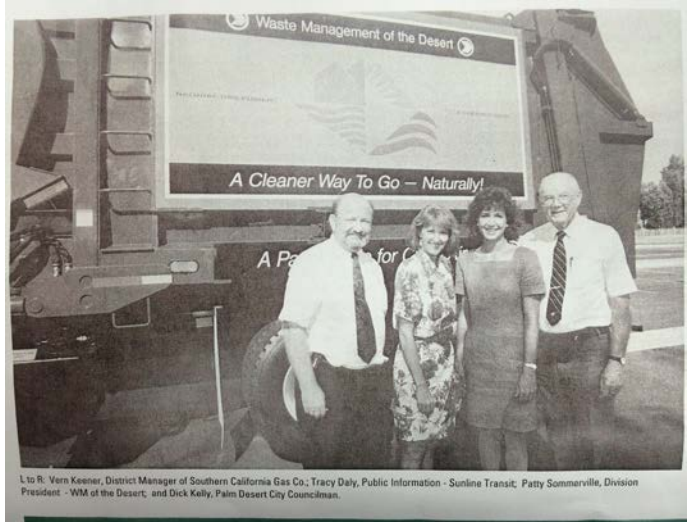
WM's Natural Gas History

- **1995** - The first 14 natural gas trucks launched in Palm Desert California.
- **1997** - 8 trucks deployed in Lancaster PA
- **2000** - 120 LNG truck project in partnership with PGE.
- **2001-2006** - 405 natural gas trucks deployed in SoCal South Coast Air district.
- ***2007*** *- WM CEO David Steiner commits to increasing fuel efficiency and reducing emissions by 15% by the year 2020.*
- **2009** - 122 natural gas trucks deployed in the City of Seattle, the largest single municipal refuse launch in US history. Trademarked
- "**C**lean **N**' **G**reen"
- **2011** - 1000 trucks in operation, Formalization of the WM CNG team, commitment to build $250MM in Stations over the next 5 years.
- **2012** - efficiency and emission goal accomplished
- **2017** - 100 stations completed and 6,000 NGV's in operation.
- **2019 Seattle renewal**



L to R: Vern Keener, District Manager of Southern California Gas Co.; Tracy Daly, Public Information - Sunline Transit; Patty Sommerville, Division President - WM of the Desert; and Dick Kelly, Palm Desert City Councilman.

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WM's Natural Gas Fleet Facts (Q1 2019)

- Natural gas vehicles: **9,790**
- NGV 2020 Year end: **10,000**
- NG fueling stations: **156**
- Stations open to public: **25**
- 2019 Greenfield Stations **35**
- **76 MM gals of Diesel** displaced in 2018

- **Over $3 Billion** invested in NGVs and infrastructure
- **3** Renewable Natural Gas (RNG) production facilities, 3 more in process.
- RNG fuels 45% of NGV Fleet, reducing GHG's by 75+%

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WM Natural Gas Program Awards

- Multiple “Green Fleet” Awards
- 2011 - NGVA, Industry Achievement Award
- 2013 - State of Washington, 5 Star Evergreen Award
- 2014 - NGV Global, International Champion Award
- 2017 - ACT Expo, The “In it for the Long Haul” Award
- 2019 – NGVA, “Exemplary NGV Industry Leadership” Award

Growth of Natural Gas Vehicles & Infrastructure

- We are transitioning large districts with over 75 trucks first and then the balance of the 425 sites that are capable.
- We have developed fueling capabilities for our smaller sites down to as few as 16 trucks. 16-6 truck sites in process.

The alternative fuel and fleet industry recognizes that natural gas will be the best option for heavy duty vehicles for the foreseeable future

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Equipment Compound – Large Site Solutions

- Routes 50 - 250
- Trucks fueled per compressor – 50 to 100
- Inlet Pressure Range 7 – 700 psi
- Flow Rate 250-1000scfm (100 – 400 DGE/hr per compressor)
- Horsepower 100 – 450
- Vendors –
  - ANGI NG600E-JGA; NG300E-JGQ (3 and 4 stage compressors)
  - Clean Energy (IMW) IMW-50 (3, 4 and 5 stage compressors)

Equipment Compound – Medium Site Solutions

- Routes 20 - 60
- Trucks fueled per compressor 20 - 60
- Inlet Pressure Range 7 – 700-psi
- Flow Rate 250-750scfm (100 – 300 DGE/hr per compressor)
- Horsepower 100 - 300
- Vendors – ANGI, Clean Energy (IMW), CMD
  - ANGI NG300E-JGQ; JGP; KB100 (3 and 4 stage compressors)
    - FleetPro Integrated skid
  - Clean Energy (IMW) IMW-50 (3, 4 and 5 stage compressors)
    - Complete CNG Integrated skid

Equipment Compound – Small Site Solutions

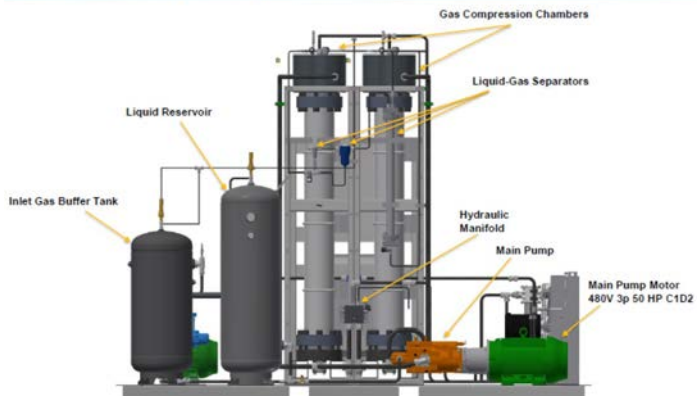
Piloting Complete CNG 2.0 in Jacksonville and Pasco FL

- Routes 15 - 30
- Trucks fueled per compressor 10 - 30
- Inlet Pressure Range 3 – 130-psi
- Flow Rate 90 – 400scfm (35 – 175 DGE/hr per compressor)
- Horsepower 75 - 150
- Vendors – ANGI, Clean Energy (IMW), CMD
  - ANGI NG300E-JGQ; JGP; KB100 (3 and 4 stage compressors)
    - FleetPro Integrated skid
  - Clean Energy (IMW) IMW-50 (3, 4 and 5 stage compressors)
    - Complete CNG 2.0 Integrated skid
  - CMD - ANGI or Sauer integrated skid
  - TruStar Energy (Sauer) - CFS Integrated modular skid

Equipment Compound – Very Small Site Solutions

Piloting Simple-Fill at Columbus and Phoenix North
Piloting Go-Flo80 in Orem

- Routes less than 15
- Trucks fueled per compressor 5 - 15
- Inlet Pressure Range 3.5 – 60
- Flow Rate 40 – 100scfm (15 – 45 DGE/hr per compressor)
- Horsepower 75 or less
- Vendors – ANGI, Onboard Dynamics, Simple Fill
  - ANGI – ANGI 75 - Under development
  - CEC Complete CNG 2.0
  - Onboard Dynamics – GoFlo CNG 80
  - Simple Fill
  - TruStar CFS 2.0 Integrated Skid



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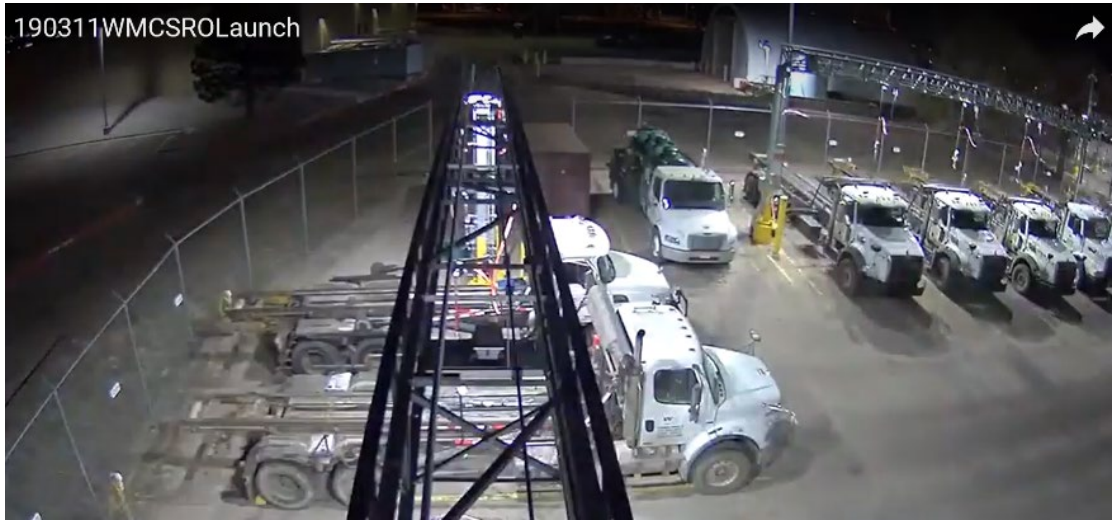
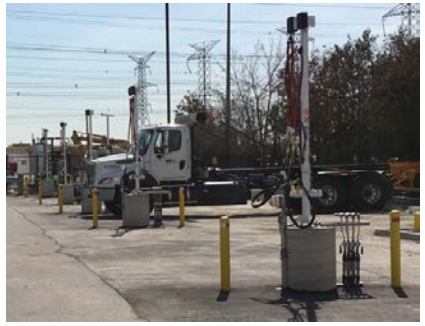
Time Fill Fueling Options

- Overhead Truss
  - Two sided fueling
  - Single sided fueling
  - Block heaters
  - Integrated LED lights
  - SDO M100 Launch
- K-Rail
  - Two sided fueling
  - Single sided fueling
- Caisson
  - Two sided fueling
  - Single sided fueling

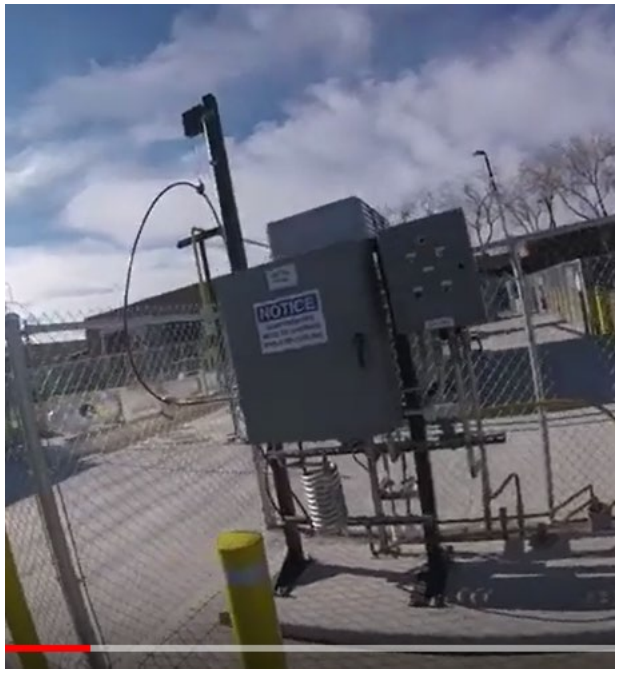




Defuel Panels

Heated defuel panels to support defueling before maintenance and emergency fueling from tube trailers

- ANGI
- Clean Energy
- Mitchell
- TruStar



WASTE MANAGEMENT

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Future of Natural Gas Vehicles & Infrastructure

- Overhead truss system with incorporated LED lighting and launch system.
- The system is modular and allows us to provide the safest possible launch of Trucks and Drivers.

New Shop Technology

Shop Safety Panel/System

Exercise safety systems

PLC programable and remote support

EANS (Email Alarm Notification System)

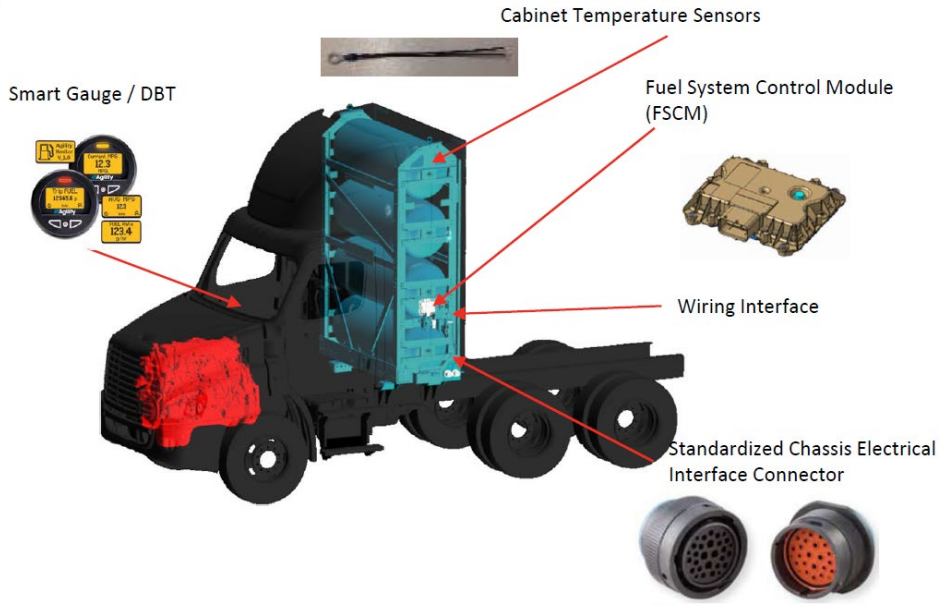
New Truck Technology

Agility Fuel Solutions Blue IQ

Fuel System Integrated Controls and Driver Management Tool

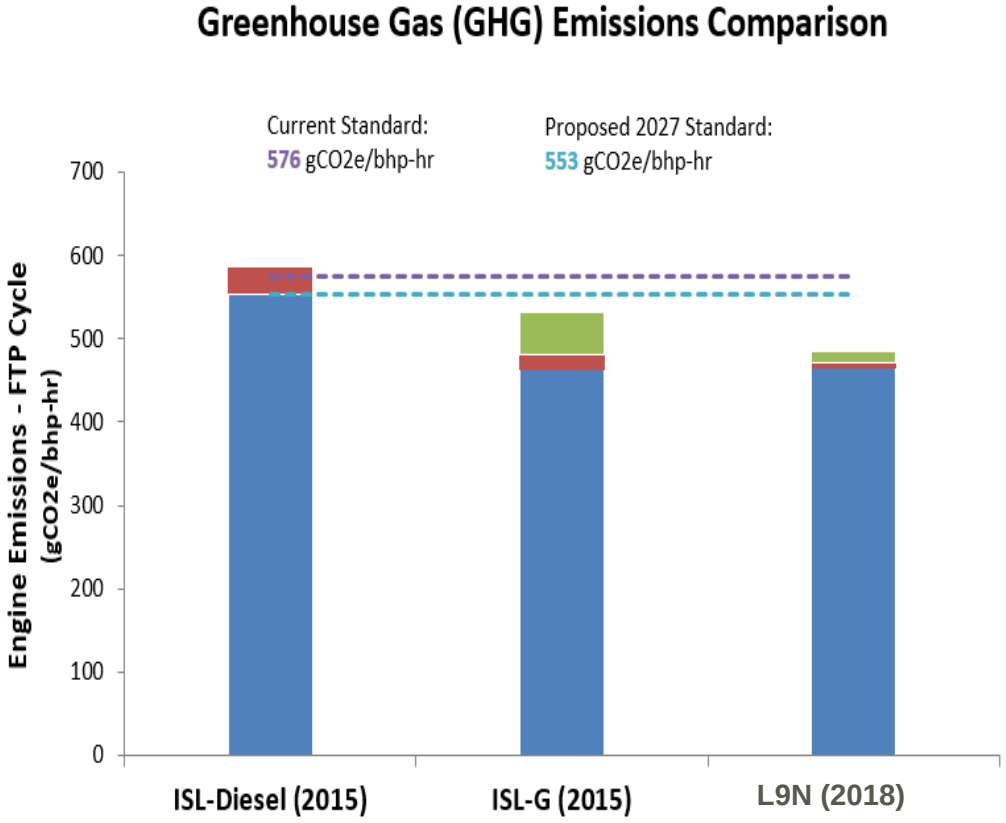
Developed jointly with Cummins

- Works with all Cummins diagnostic platforms:
  - Insite, QuickServe Online, Expert Diagnostic System
- Blue IQ Benefits
  - Smart Gauge/Driver Management Tool
    - Accurate fuel onboard
    - **Distance to Empty**
    - Acceleration Management/Fuel Economy/Allison Fuel Sense
  - Fuel Compartment Temp Sensor
    - Cold and low pressure start-up logic
    - Load Fire Detection
- **Driving competitors for same options**



Ongoing fleet improvements Cummins L9N & X12N
The best partnership of Emissions and Economics

Cummins Westport (CWI) new Near Zero (NZ) engines reduce NOx by over 90% and GHG emissions by 70% over 2015 NGVs



Source: US EPA GHG Certification data for 2015 ISL-G, 2015 ISL-Diesel, and 2016 ISL-G NZ engines for MHHD service class

Cummins L9N

- ✓ **Over 17% lower GHG emissions than 2015 diesel**
- ✓ 70% Reduction in methane emissions compared to 2015 natural gas engines
- ✓ Already 16% below the current GHG standard for MHHD engines
- ✓ ***Already 12% below the proposed 2027 GHG standard for MHHD engines***
- ✓ *Cleaner than electric if you look at "total planet impact"*
- ✓ *33.8% of electricity is produced from Natural gas #1*
- ✓ ** Only exception is where Electric grid uses a large amount of wind and hydro.*

CH4
N2O
CO2
Current Standard
Proposed 2027 Standard

✓ **# 1 Economical Green Technology**
✓ **Simplest Technology for Techs**

WASTE MANAGEMENT

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The Future

- Expand collection fleet to 15,000 NGV's
- Expand fueling infrastructure to 400 stations
- Increase internal RNG production to approximately 80 percent of collection fleet usage
- Reduce collection fleet emissions 45 percent by 2038 (versus 2010 baseline)
- After the ADS acquisition is completed WM will be the largest class 8 US DOT fleet.

The above goals are moving the company closer to a near-zero emissions collection fleet.

WASTE MANAGEMENT

THINK GREEN.®

Thank You

WASTE MANAGEMENT

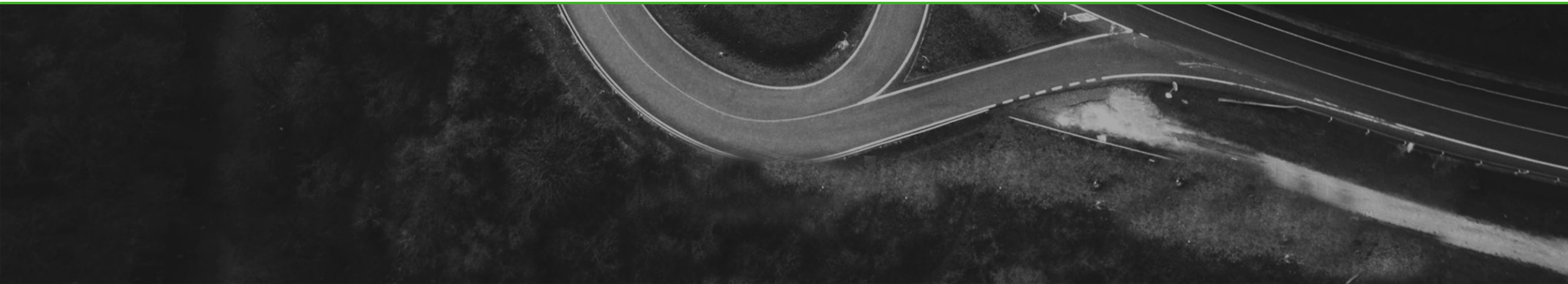
THINK GREEN.®

Matt Gold
matt.gold@hyliion.com
737-701-2366

- Director of Sales for Hyliion
- Sales account management and engineering experience in the automotive and commercial vehicle industries
- Previous experience as a sales engineer with Timken
- BS in Mechanical Engineering from Ohio State University and and MBA from Ohio University
- Former professional soccer player with MLS' Toronto FC

HYLIION

CLASS 8 ELECTRIFICATION



MISSION

Be the leading powertrain provider of electrified solutions for the commercial vehicle industry

LOWEST COST OF OWNERSHIP

NET-NEGATIVE EMISSIONS

EXISTING INFRASTRUCTURE

SUPERIOR VEHICLE PERFORMANCE

FASTEST PATH TO MARKET

HYLIION OVERVIEW

- Electric powertrain, battery systems, and software solution provider focusing on Class 8 market
- Founded 2015
- Over 2,000,000 miles proven over the road with the hybrid solution

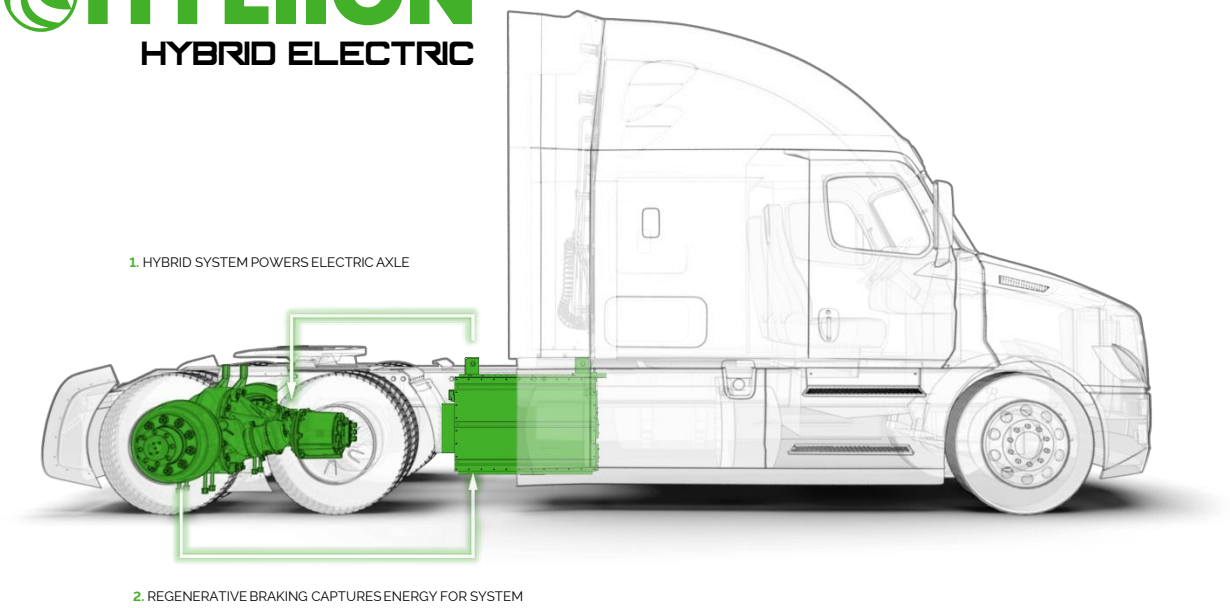
MERGER ANNOUNCEMENT

HYLIION® CLASS 8 ELECTRIFICATION | Tortoise℠ Acquisition Corp.

AGILITY PARTNERSHIP

HYLIION'S LEADING TECHNOLOGY PLATFORMS

HYLIION® HYBRID ELECTRIC



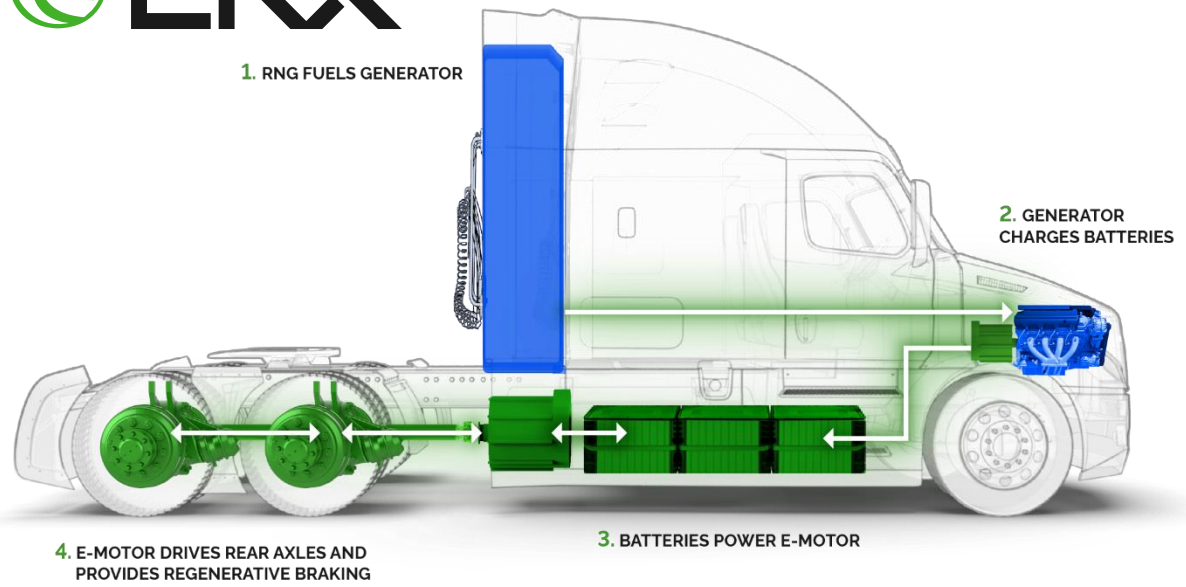
HYBRID POWERTRAIN OVERVIEW

- 5-10% fuel savings in hilly terrain
- 12+ hours in-cab climate control
- 120HP and 1,500 ft-lb of torque from e-axle

Hybrid MRSP: $29,000

New Truck:: +$14,000
(over base spec)

HYPERTRUCK™ ERX



ERX POWERTRAIN OVERVIEW

- 35% reduction in lifetime TCO
- Net-negative GHG emissions
- Over 1,000-mile range
- Up to 25 miles of EV range or 34+ hr. APU time

Powertrain MRSP: $100,000

New Truck:: ~$220,000

HYLIION Peterbilt KENWORTH FREIGHTLINER® NAVISTAR® VOLVO | OEM COMPATIBLE

HYBRID SOLUTION

HYLIION

HYBRID DIESEL

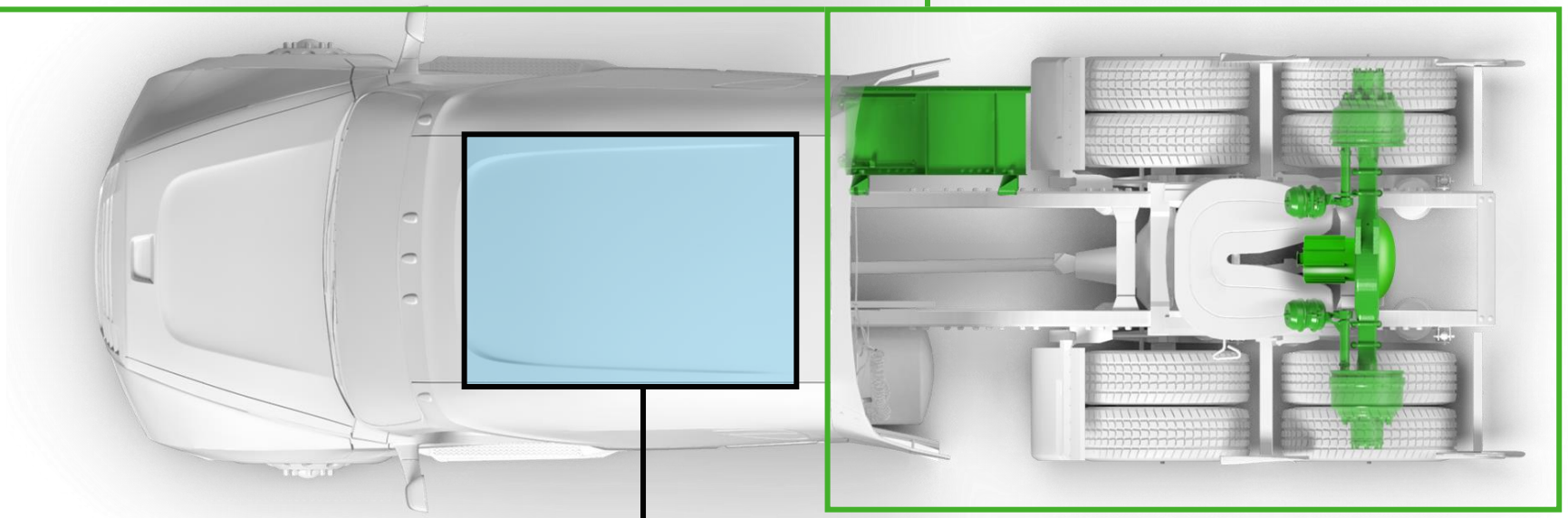
REDUCES DIESEL FUEL USE

- 5-10% fuel savings based on terrain conditions
- 120HP and up to 1,500 foot-lbs of torque
- Provides torque to reduce diesel fuel usage

HYBRID CNG

POWER ASSIST FOR HILLS

- Adds 120HP to 400HP 12L Cummins
- Faster climbs, diesel-like performance
- Safer and improved driving experience



AUXILIARY POWER UNIT

Eliminate Engine Idling

- 12+ hours of run time
- A/C with over 10,000 BTU
- In-Cab control unit
- 400-pound weight exemption

BENEFIT

Provides climate control and 'hotel' power for the entire mandatory rest period, eliminating engine idling

HYPERTRUCK ERX

HYLIION

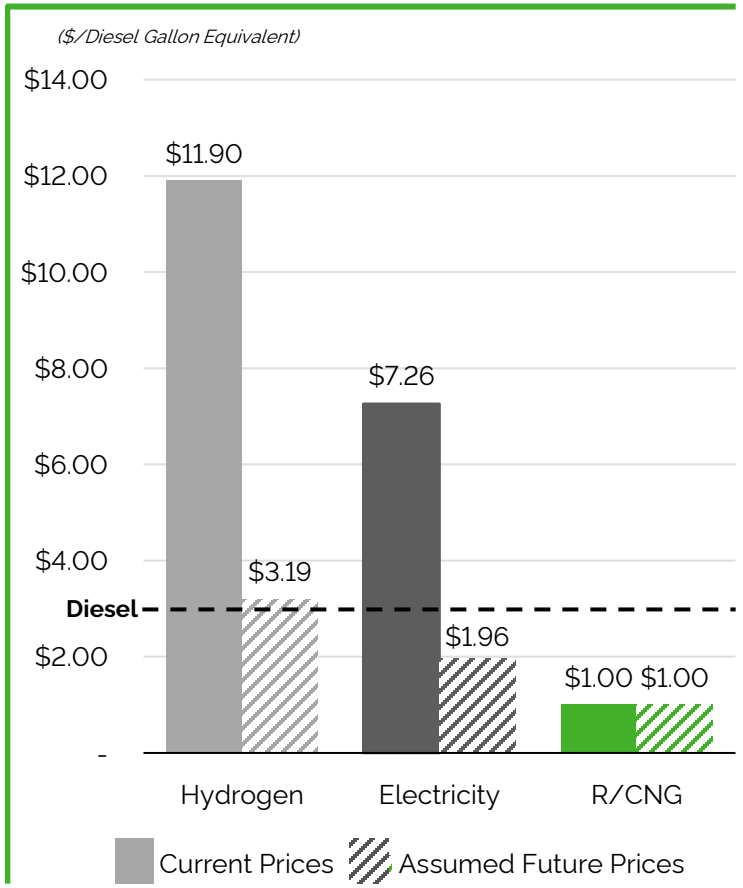
HYLIION OFFERS THE LOWEST TOTAL COST OF OWNERSHIP…

CLASS 8 SOLUTIONS




	DIESEL	FUEL-CELL ELECTRIC (FCEV)	BATTERY-ELECTRIC (BEV)	HYPERTRUCK ERX
	VOLVO / INTERNATIONAL / FREIGHTLINER / PACCAR	NIKOLA™	TESLA	HYPERTRUCK ERX
AVAILABILITY	**TODAY**	**2023+**	**2021+**	**2021**
UPFRONT VEHICLE COST	$132,600	$235,000	$200,000	$220,000
5-YEAR TOTAL FUEL COST	$283,393	$300,000	$84,000	$81,191
5-YEAR TOTAL PAYLOAD REVENUE LOST/(GAINED)	N/A	$37,500	$100,000	($25,000)
5-YEAR TOTAL COST OF OWNERSHIP	**$415,993**	**$572,500**	**$384,000**	**$276,191**
SAVINGS VS. DIESEL	**——**	**-38%**	**8%**	**34%**

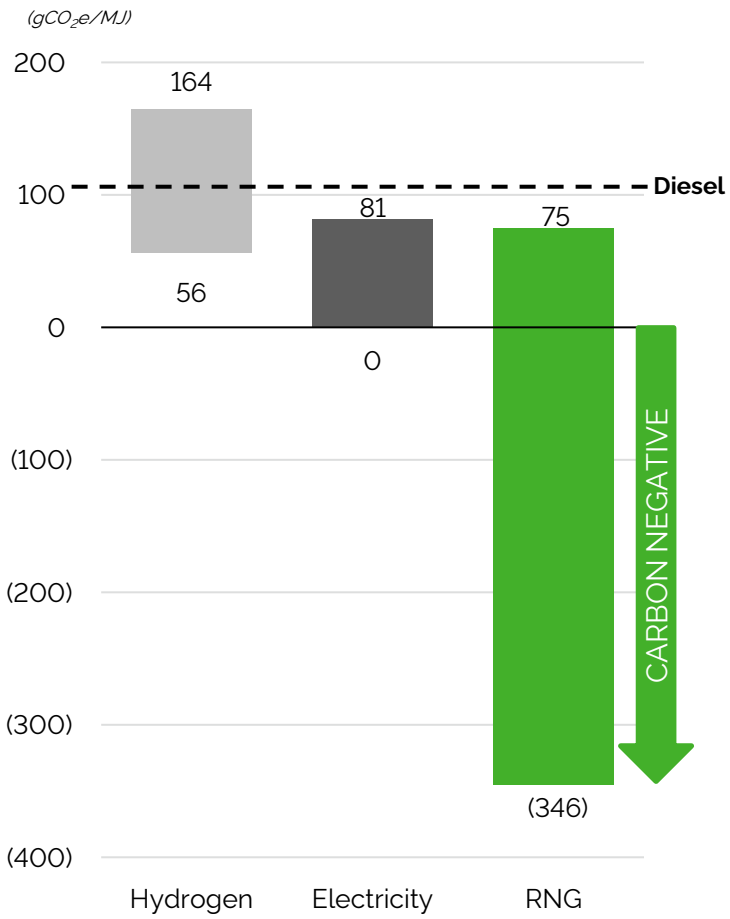
FUEL PRICES



*Tesla & Nikola payback figures are based on assumed future prices.

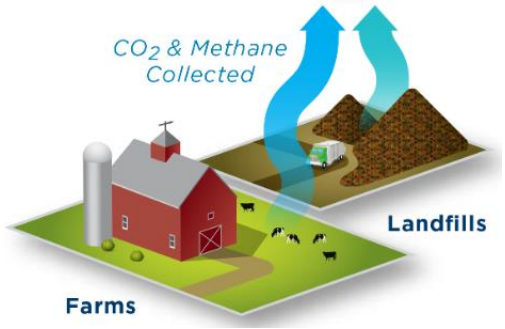
EMISSION LEVELS OF FUEL SOURCES

FUEL CARBON INTENSITY SCORES



WHAT IS RENEWABLE NATURAL GAS (RNG)

RNG is captured from dairy farms, landfills, waste treatment facilities, and others.



RNG can be purchased through gas utility channels, similar to solar/renewable energy..

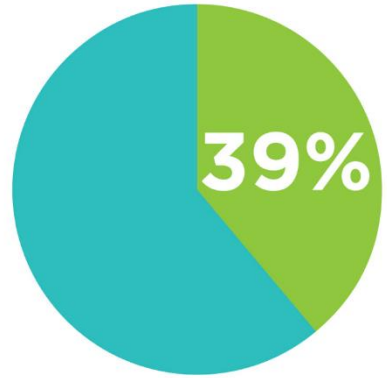
Fleets operating on RNG today:

RNG AVAILABILITY

2019 NGV Fuel Use

717 Million GGE Total

In 2019, **39%**, of all on-road fuel used in natural gas vehicles was RNG

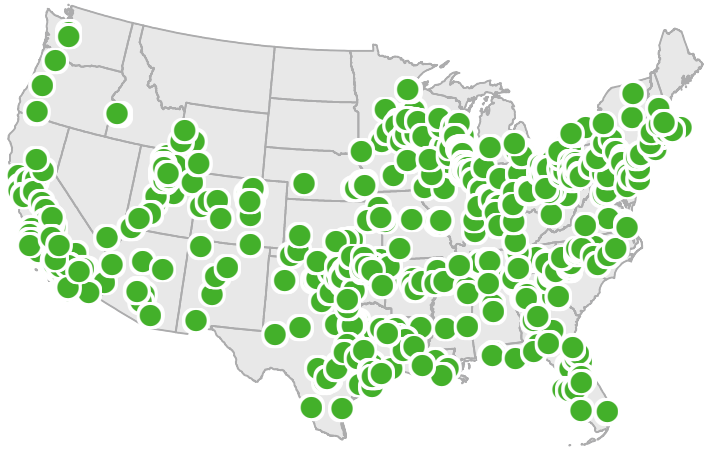


Conventional Natural Gas
440 Million GGE

Renewable Natural Gas
277 Million GGE

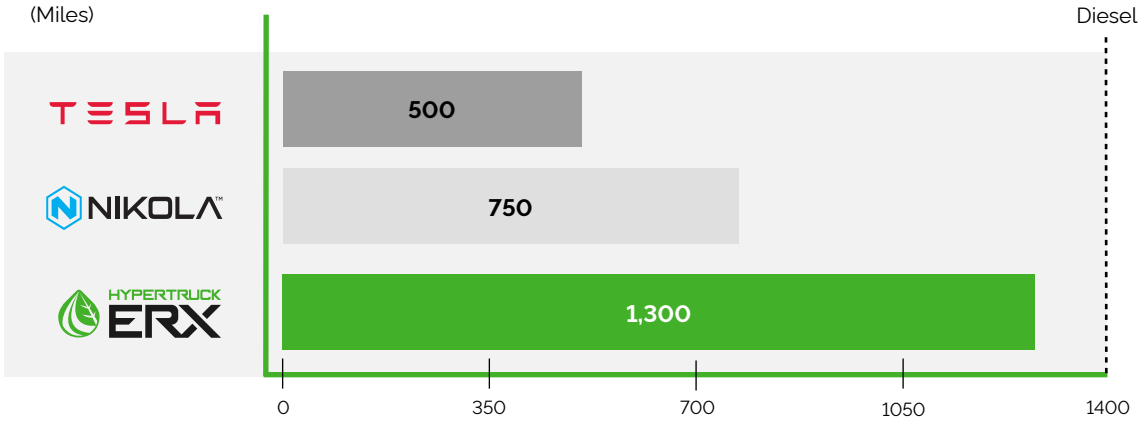
(# of Class 6-8 fueling stations in the United States

Hydrogen	Electricity	R/CNG
<10	<10	729

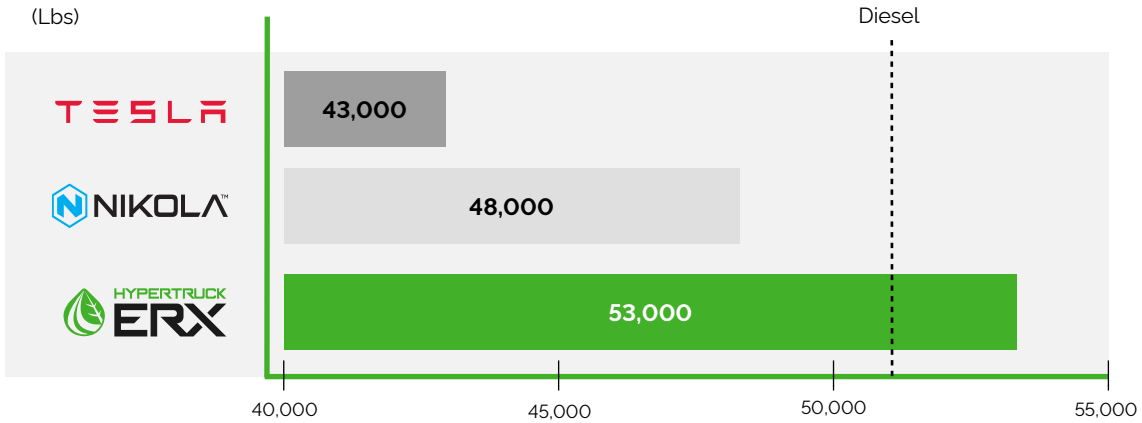


OUTPERFORMS THE COMPETITION

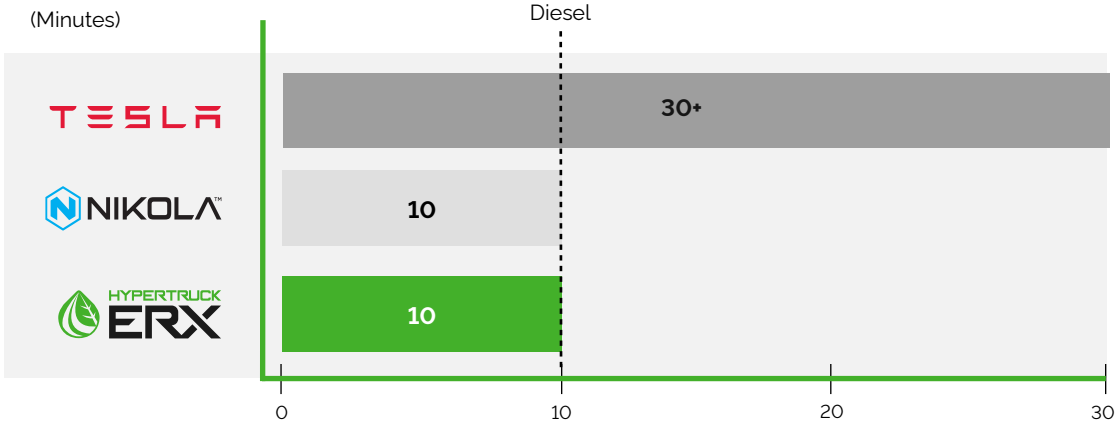
RANGE



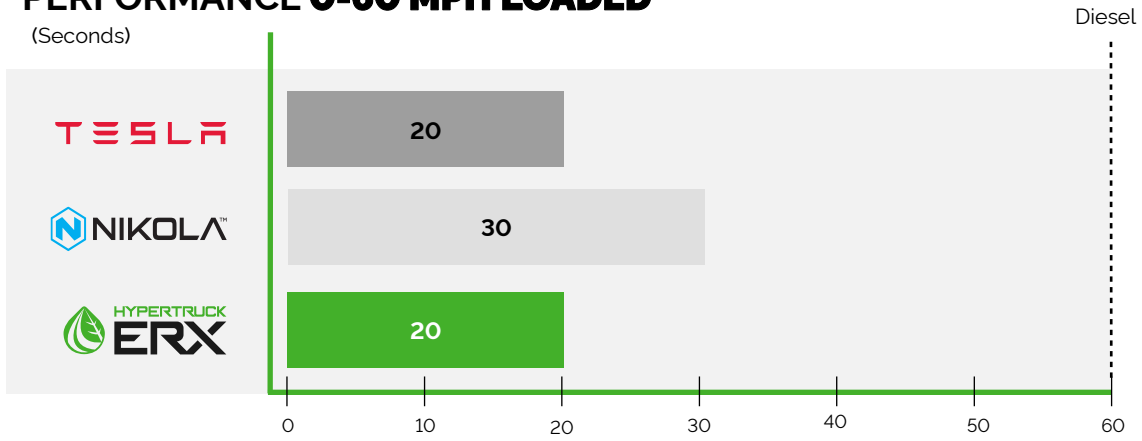
PAYLOAD CAPACITY



REFUEL OR CHARGE TIME



PERFORMANCE **0-60 MPH LOADED**



THANK YOU

HYLIION

NC STATE UNIVERSITY

SUSTAINABLE FLEET TECHNOLOGY

VIRTUAL CONFERENCE 2020

Session 3: Gaseous Fuels Trends & Applications

August 12, 2020

NC CLEAN ENERGY TECHNOLOGY CENTER

STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION