Diesel Drop-In Alternatives: Ultra-Low Sulfur, Bio-, and Renewable

February 11, 2025

MESSY MIDDLE BOOTCAMP

RUN ON LESS MESSY MIDDLE

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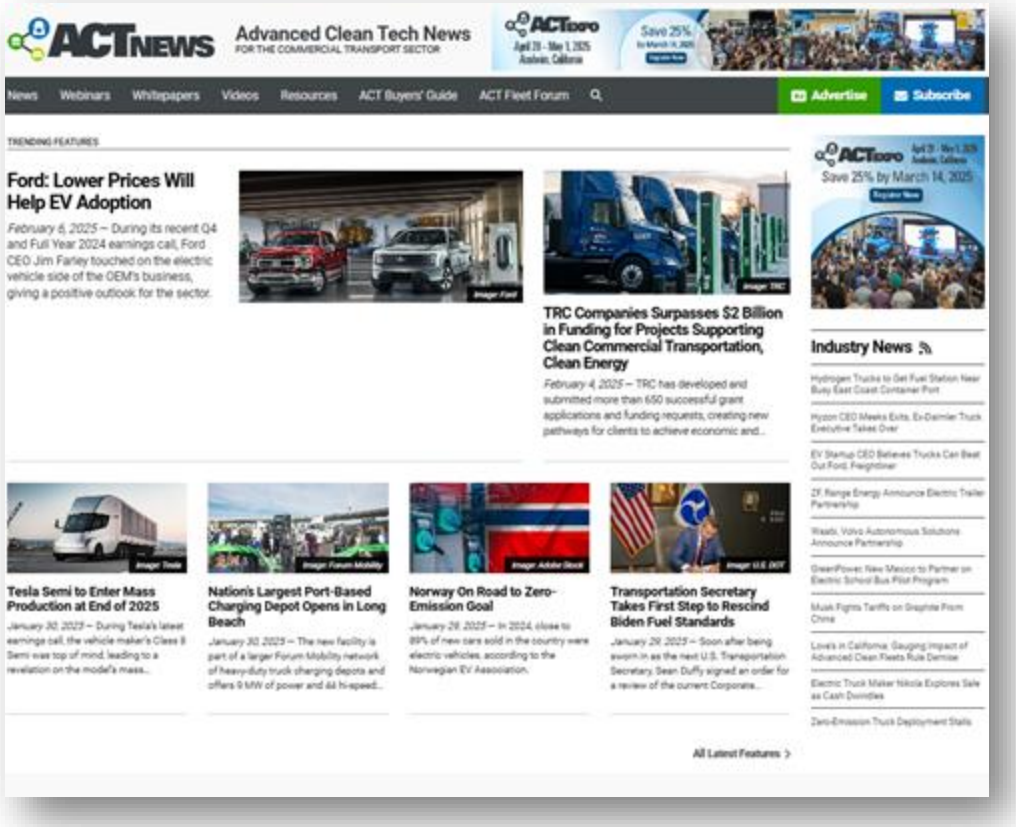

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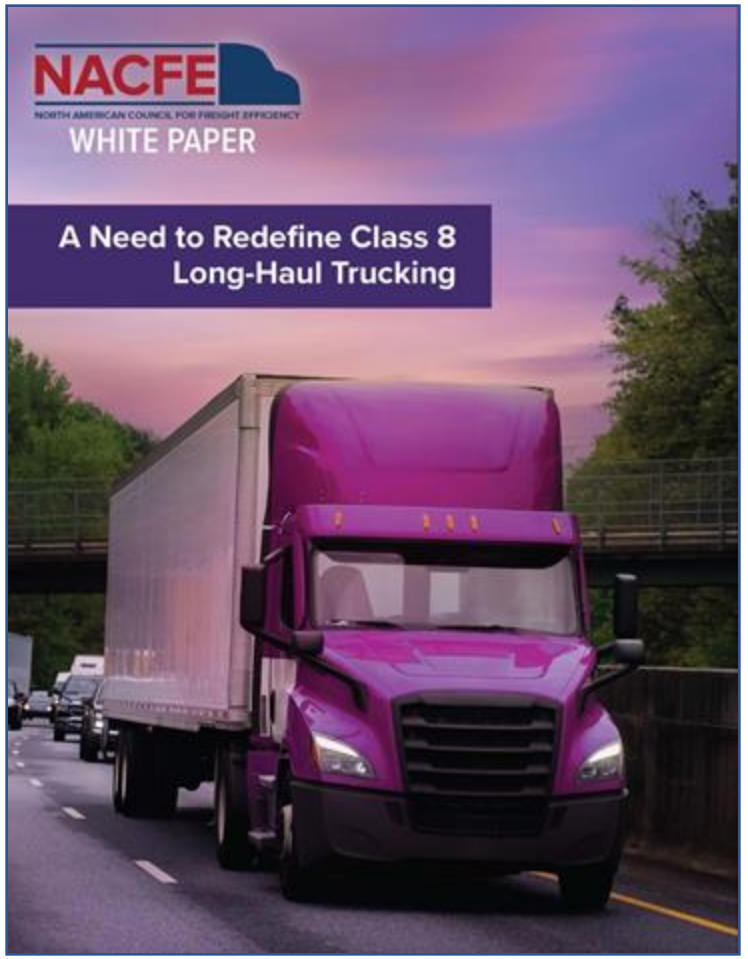
Anaheim, CA | Anaheim Convention Center

Run on Less - Messy Middle

- Class 8 truck market is not homogenous
- 65% of heavy-duty truck market is highway tractors *(ACT Research)*
- Important to standardize language and descriptions when discussing long-haul
- This report offers some definitions of long haul we will be using throughout Run on Less - Messy Middle



Access Report Here

RUN ON LESS MESSY MIDDLE

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Messy Middle Bootcamp Series

Diesel Drop-In Alternatives: Ultra-Low Sulfur, Bio-, and Renewable (February 11th)

Decarbonizing with Natural Gas (February 25th)

Future Prices & Availability of Existing Infrastructure: What's Next? (March 11th)

DIESEL AND NATURAL GAS WORKSHOP (March 25th)

The Current State of HD BEV: Technologies and Capabilities (April 8th)

Strategizing Successful HD BEV Adoption (April 27th)

Charging Depots, Networks & the Economics of Fleet (May 6th)

HD BEV WORKSHOP (May 20th)

The Production Processes of Hydrogen Fuel (June 3rd)

Moving Hydrogen from Here to There: The Distribution and Storage of Hydrogen Fuel (June 17th)

The Opportunities and Challenges of Selling Hydrogen to the Industry (July 1st)

HYDROGEN FUEL CELL WORKSHOP (July 15th)

2023 Bootcamp is still available at: https://runonless.com/electric-depot/

2025 Messy Middle Fleets

Update from The Run Planning…

Follow the Fleets, Drivers, providers, and more on:

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Quiz for Today's Session

Completing Today's Quiz:

- Go to runonless.com and click back into the session
- Click 'Take Quiz' button
- Create username and password to keep track of your progress
- Provide your name and email to enter a drawing for a Run on Less - Messy Middle swag bag

What You Should Know

Q&A

Submit your questions to the host using the Q&A box in the upper right-hand corner

Recording

A recording of today's webinar will be available on runonless.com

Technical Issues

Contact Stephane Babcock at

stephane.babcock@gladstein.org

Today's Bootcamp Speakers

Diesel Drop-In Alternatives: Ultra-Low Sulfur, Bio-, and Renewable

Scott Fenwick
Technical Director
Clean Fuels Alliance America

Andrew Gibson
Global Sector Marketing Manager Fleet & Global Brand Manager Shell Rimula
Shell

Colin Huwyler
CEO
Optimus Technologies

Jeff Seger
Clean Energy Consultant
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EPA27 Low Nox Technologies

Agenda

What is the EPA27 Low Nox rule

What problem are we trying to solve

What technologies are likely

Other regulation driving technology changes

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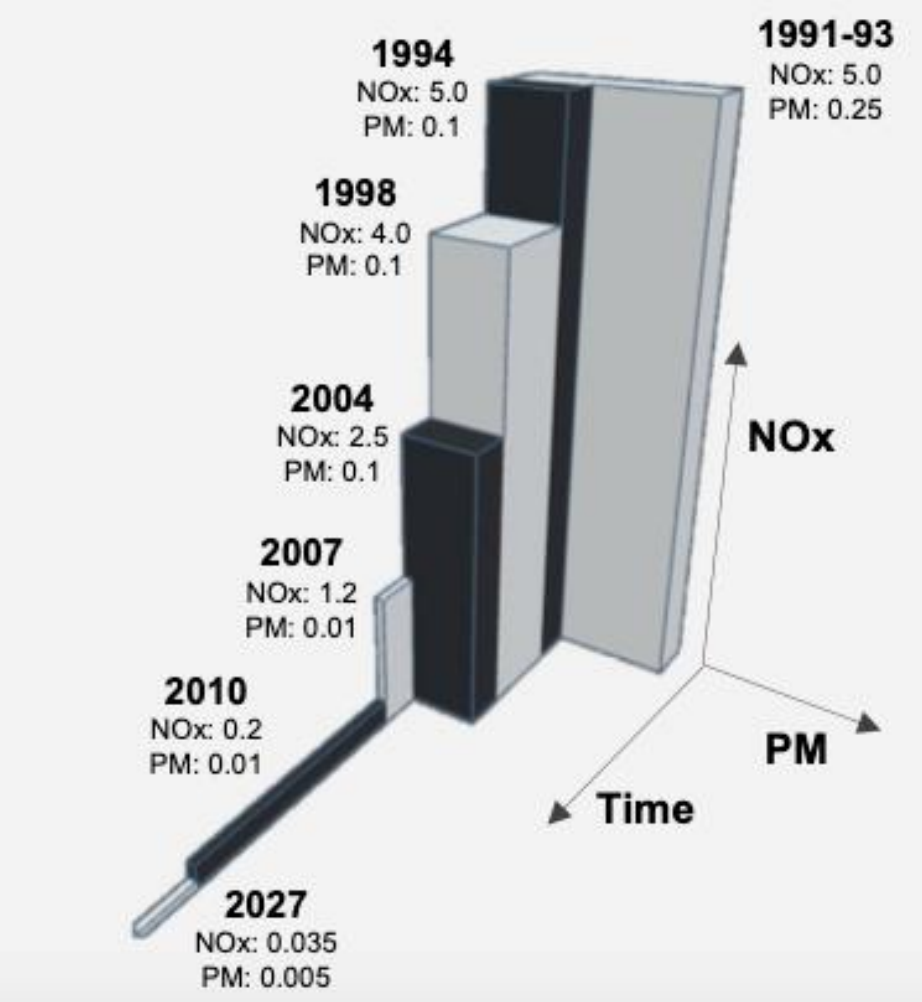
What is EPA27



Courtesy: Cummins, Inc

Largest regulatory change since 2010

NOx limits reduced from .2 to .035 g/bhp-hr

Reduction over time

- 80+% reduction since 2010
- 99+% reduction since 1994

Emissions warranty increase

- MHD: 5yr/100k to 10yr/280k miles
- HHD: 5yr/100k to 10yr/450k miles

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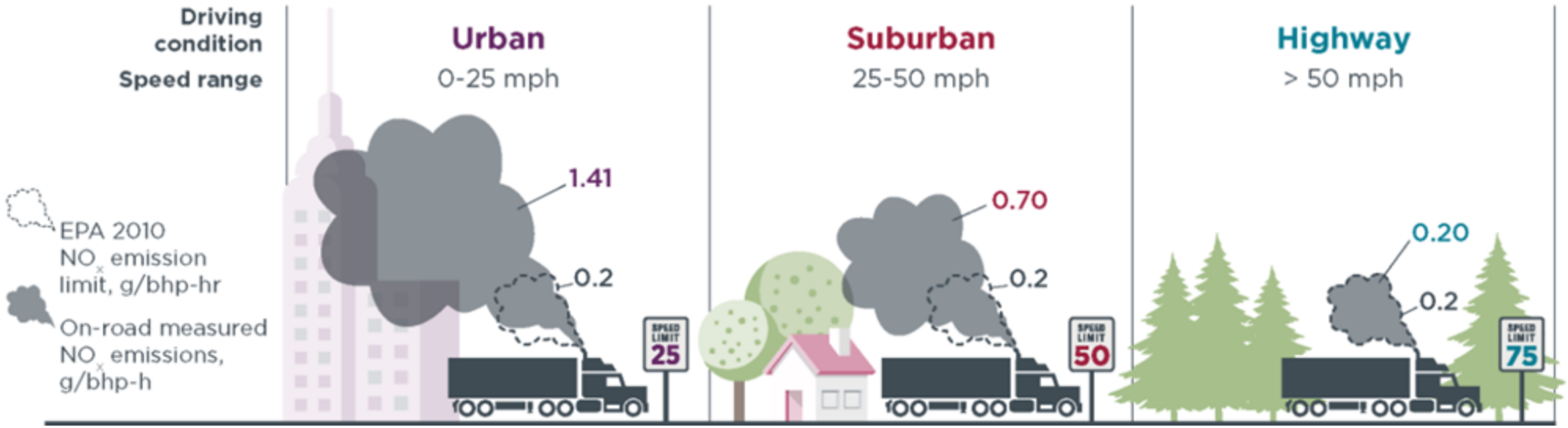
What problem are we trying to solve



Majority of NOx generated under start-up and light load

SCR efficiency is low at low temperatures

Plan of attack is to create heat at light loads

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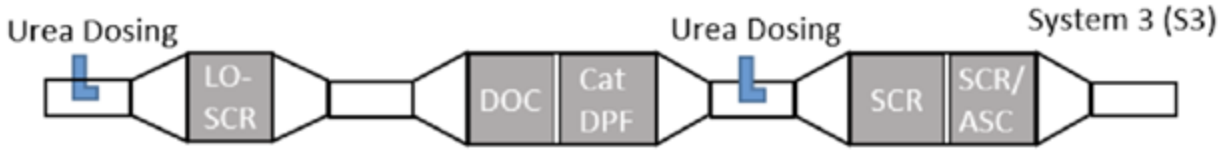
Two basic approaches



Heater(s) at the catalyst

1. Add heater(s)
2. Add some catalyst volume

Dual SCR

1. Add 2nd doser near turbo
2. Add 2nd catalyst and volume

1. *Cylinder Deactivation and Variable Valve Actuation are additional levers but not believed to be used at this time*
2. *Alternate fuels also provide low Nox (CNG, RNG, LPG, RD, etc)*

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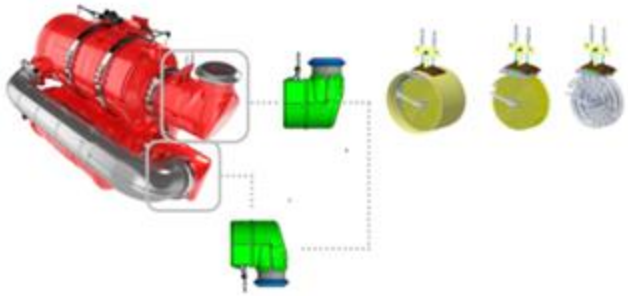
Low NOx Solutions/Architectures

Cummins



PACCAR MX

Volvo

International S13

Cummins, Volvo, PACCAR announce similar strategies

- 2010-like architecture
- 48V alternator and heater
- Volvo to use a 48 V battery

International

- Dual Dosing w/ 1st doser after turbo
- No active DPF, no EGR cooler, high Compression Ratio

Design iterations likely between now and EPA 27

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Some of the key attributes

Heater System	Dual SCR and Dual DEF Dosing
Positives 1. More traditional SCR architecture 2. Only slight increase in DEF consumption (< 1%) 3. Claimed fuel economy improvement	Positives 1. Removal of EGR cooler and simpler turbo 2. Passive regen 3. Claimed fuel economy improvement
Keep an eye on these potential impacts 1. Higher idle fuel consumption? 2. Alternator and heater reliability? 3. Expansion of 48 v system to other functions? 4. Other?	Keep an eye on these potential impacts 1. Possible change in catalyst config to meet .035? 2. 2nd doser reliability/complexity? 3. Increased DEF consumption? 4. Other?

This is not a comprehensive list of changes
It focuses on the primary technologies used for Ultra-Low Nox

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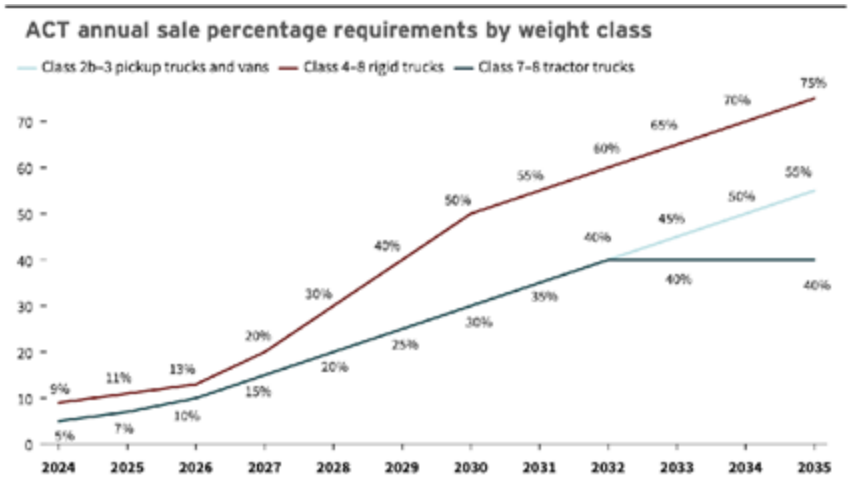
Other regulation driving technology changes

EPA Greenhouse Gas Phase 3 (CO2 Percent Reduction from Phase2)

Regulatory group	MY 2027	MY 2028	MY 2029	MY 2030	MY 2031	MY 2032
Light heavy-duty vocational	17%	22%	27%	32%	46%	60%
Medium heavy-duty vocational	13%	16%	19%	22%	31%	40%
Heavy heavy-duty vocational	–	–	13%	15%	23%	30%
Medium heavy-duty all cab and heavy heavy-duty day cab tractors	–	8%	12%	16%	28%	40%
Sleeper cab tractors	–	–	–	6%	12%	25%

CARB ACT



We also have EPA Greenhouse Gas Phase 3 and CARB ACT

These are intended to reduce CO2

Other likely changes

1. Aerodynamics, Tires, APUs, electronic parameters, etc
1. Powertrain efficiency
1. Battery Electric Vehicles
1. Fuel Cell Vehicles
1. CNG, RNG, LPG, Renewable Diesel, etc
1. Hybrids?
1. Other?

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Stay tuned for all Bootcamp sessions

We will cover all of these future technologies

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References

ICCT NOx at light loads graph: https://theicct.org/publication/current-state-of-nox-emissions-from-in-use-heavy-duty-diesel-vehicles-in-the-united-states/

SCR architecture diagrams: https://www.meca.org/wp-content/uploads/resources/MECA_2027_Low_NOx_White_Paper_FINAL.pdf

PACCAR MX: https://www.ttnews.com/articles/peterbilt-carb-mx-13-engine

Volvo: https://www.aftermarketnews.com/volvo-heavy-duty-carb-omnibus-compliant-engine/

International S13: https://www.robertstruck.com/--S13-Integrated-Powertrain?t

Greenhouse Gas Phase 3: https://theicct.org/wp-content/uploads/2024/09/ID-214-–-EPA-Phase-3_final.pdf?t

CARB ACT Mandate: https://rmi.org/understanding-californias-advanced-clean-truck-regulation/?t

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Clean Fuels ALLIANCE AMERICA

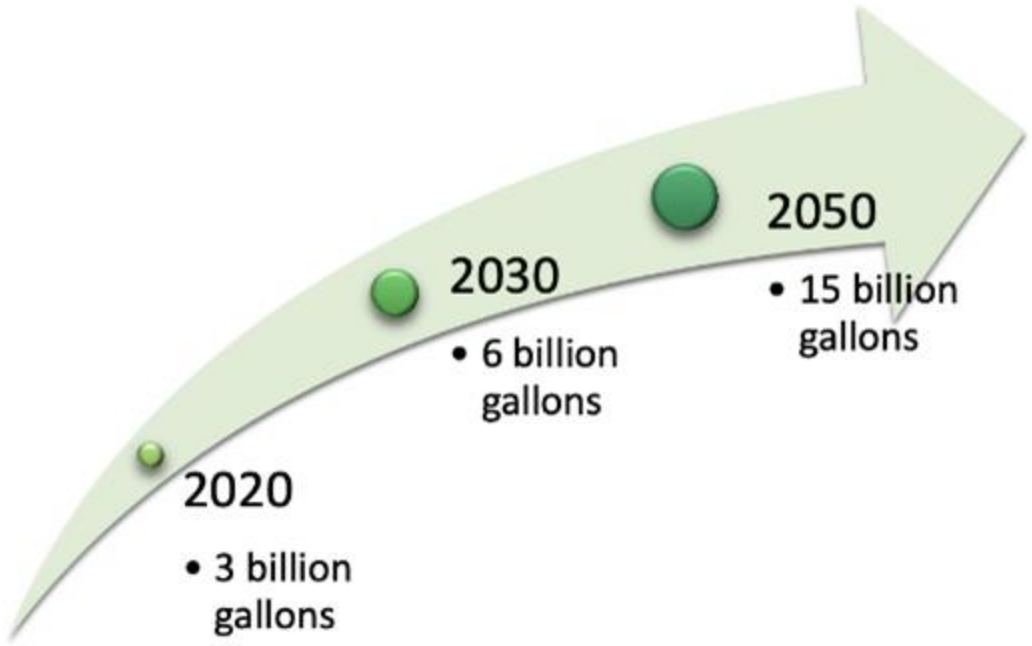
North American Council for Freight Efficiency

Run On Less – Messy Middle Bootcamp webinar

THE BENEFITS OF RENEWABLE BIOMASS-BASED DISTILLATE FUELS AND THE CHALLENGES THAT REMAIN TOWARDS DECARBONIZATION

CLEAN FUELS APPRECIATES THE SUPPORT OF OUR FARMERS AND THEIR CHECKOFFS

Clean Fuels Alliance America INDUSTRY vision



Biodiesel, renewable diesel and sustainable aviation fuel will be recognized as mainstream low-carbon fuel options with superior performance and emission characteristics. In on-road, off-road, air transportation, electricity generation and home heating applications, use ***will exceed 6 billion gallons by 2030,*** **avoiding over 50 million metric tons of CO_2** equivalent greenhouse gas emissions annually. With advancements in feedstock, use will reach ***15 billion gallons by 2050***.

Biodiesel & Renewable Diesel Today

Production

Today's domestic producers have reached over 4.6 billion gallons with more than 5.9 billion gallons of domestic production capacity online today or in development.

Feedstocks

Soybean oil makes up the largest supply of biodiesel/renewable diesel today at nearly 40%. The rest make up the balance fairly equally.

Markets

Today's markets are made of fleets, on-road and off-road diesel, as well as the expanding heating oil market.

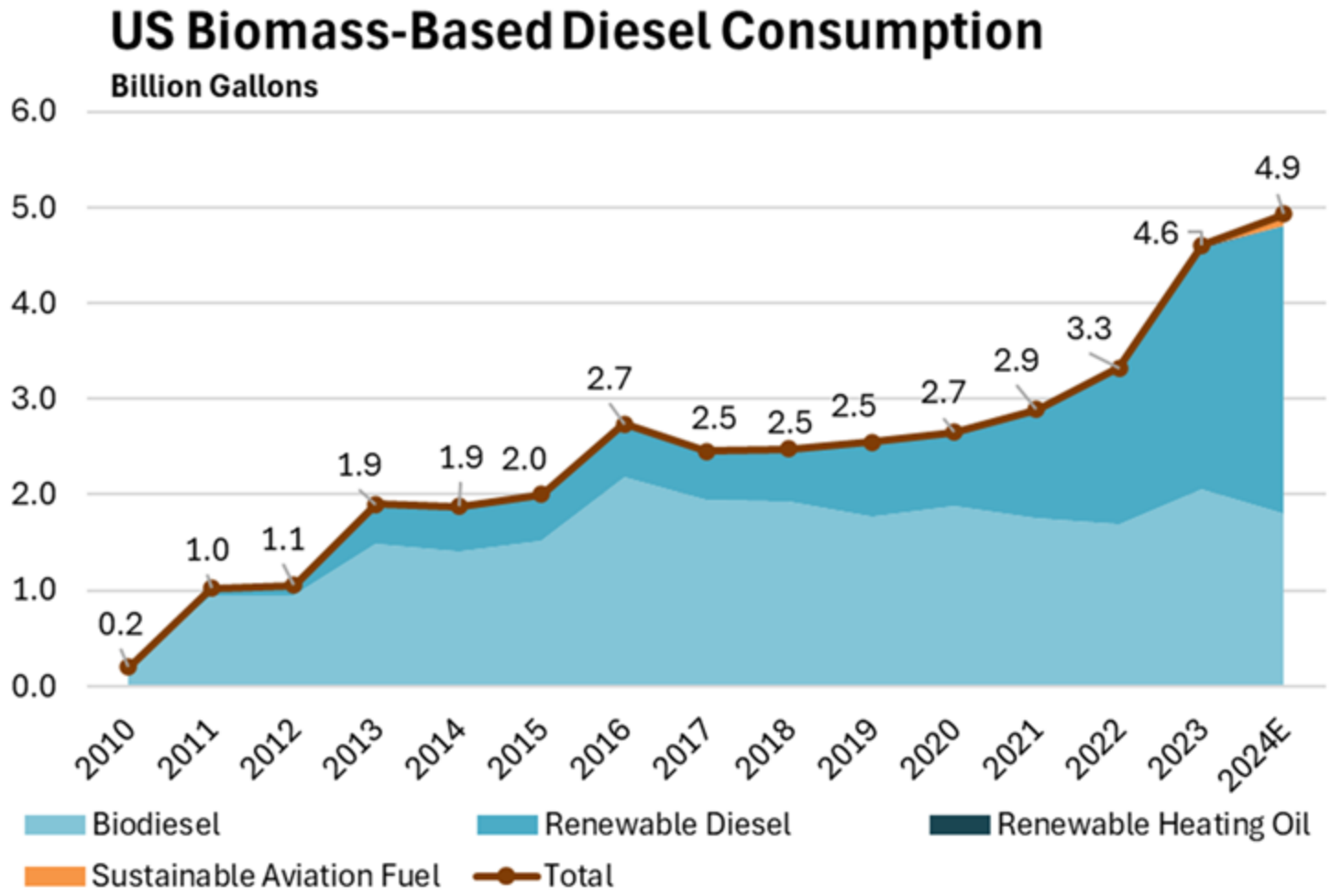
Renewable jet fuel, marine fuel and railroad applications are also emerging markets.

Policy

Combination of legislation that drives biodiesel success:

- **Renewable Fuel Standard**
- **Federal Tax Incentive**
- **Carbon Policies**
- **State Mandates and Incentives**
- USDA Higher Blend Infrastructure Incentive Program

BBD CONSUMPTION ON THE RISE



- 2023 set record at 4.6 BG consumed in US
- 2024 on pace to eclipse 2023's record
- SAF starting growth phase
  - Increased volumes expected in 2025

Source: EPA EMTS

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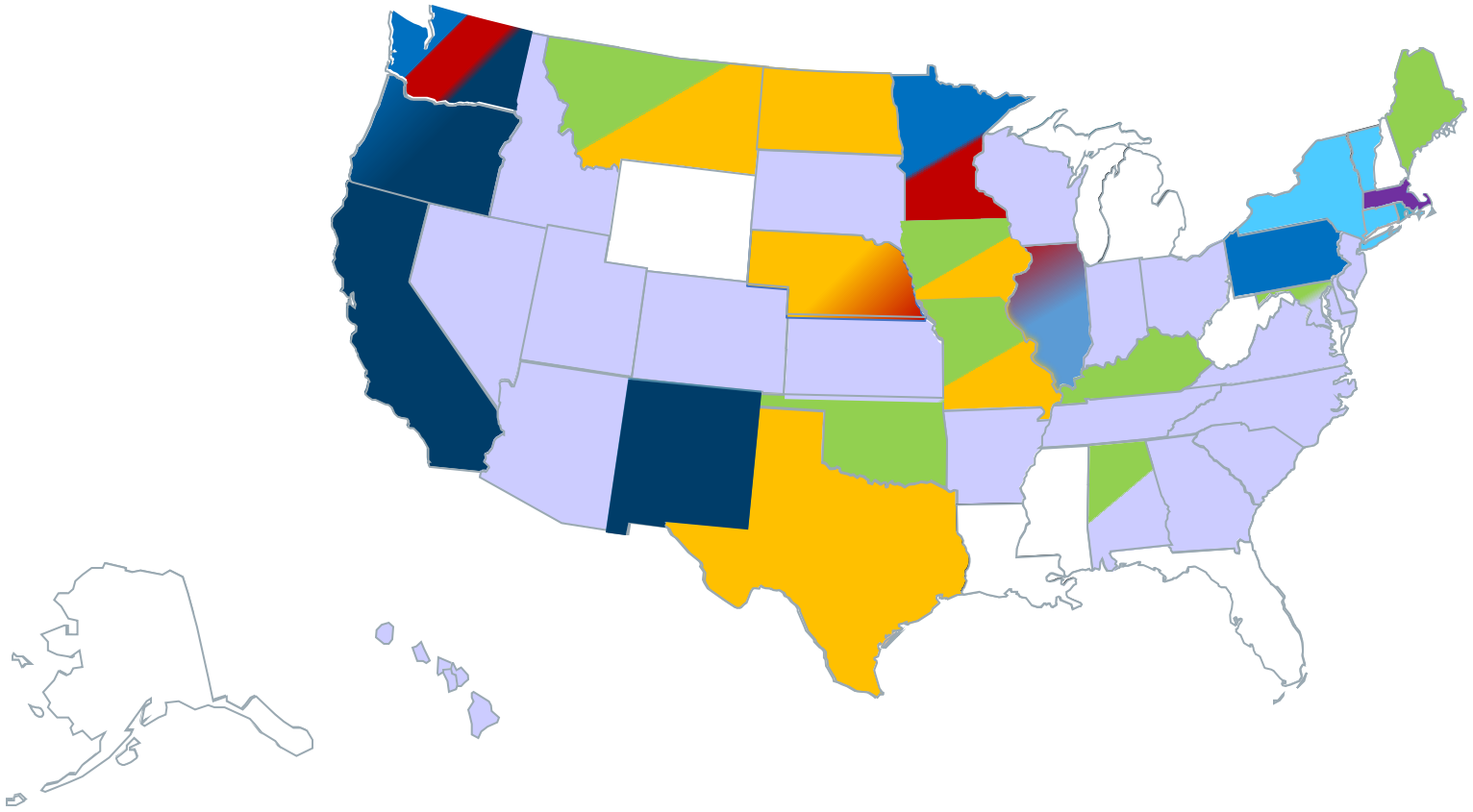
STATES WITH NOTABLE BIODIESEL POLICIES



LEGEND

- Low Carb Fuels Standard
- Mandate - Transportation
- Tax Incentive – Sales/Income
- Tax Incentive - Production
- State Fleet Requirement
- Mandate - Bioheat® Fuel
- Policy not enforced
- SAF Tax Incentive
- Incentive - Bioheat® Fuel Blending

Current as of 06/25/2024
Data from DOE Alternative Fuels Data Center and Individual State Statues

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Biodiesel Infrastructure

- Biodiesel and biodiesel blends available nationwide at more than public locations
- Existing trucks, tanks, dispenser pumps and blending facilities can be used for B20 and lower
- Find retailers offering B20 & higher blends at: https://afdc.energy.gov/stations/#/find/nearest?fuel=BD
- Blends higher than B20 may require strategic partnerships with fuel suppliers, many already in development through the High Blend Infrastructure Incentive Program (HBIIP) & with major fleets
- 1430 N.A. retail stations offering B20+

SOME TECHNICAL HIGHLIGHTS

- Major Positive Changes at ASTM for the transportation market
  - New Low Metals (LM) grade has passed in D6751 for B100!
    - Each sulfur grade (S15, S500, S5000) of No. 1-B and No. 2-B of B100 has a LM grade
    - LM grades are 4 ppm max Na+K+Ca+Mg. All other grades remain at 10 ppm max (5 Na/K, 5 Ca/Mg)
    - Use of LM grade for B6-B20 in NTDEs passed in D7467 this past fall, DDC support for B20 in CA!
  - Cetane Number in D6751 for B100 has been changed to 45 minimum (previously 47)
    - EPA has updated D6751 references as part of their regulatory streamlining efforts
  - Fuel stability re-additization project

- Major Positive Changes at UL for the heating oil market
  - UL 296 listing procedures for heating oil burners now updated to allow up to B100
    - Carlin and Beckett have both released B100 capable and UL listed burners into the market!
    - Covers all blends between B20 and B100, uses current D6751!

CLEAN FUELS / NREL ANNUAL FUEL QUALITY SURVEY

- Conducted annually since 2018; roughly covering 92% of biodiesel industry production
- 14 fuel quality parameters; over 6,100 independent parameters analyzed in 2022
- Nearly all of them “meet or beat” the ASTM specification limits
- Key findings:
  - Metals (Na + K + Ca + Mg) significantly below 1 ppm
  - Phosphorus below 0.5 ppm
- Request for CY 2024 data coming in early February
- 2022 NREL report https://www.nrel.gov/docs/fy23osti/86227.pdf

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SOME TECHNICAL HIGHLIGHTS

- Major Railroads are now seriously looking at biodiesel and renewable diesel
  - Progress Rail at B20 approval
  - Wabtec at B11 approval – working up to B20 later in FY24
- The Ocean-Going marine diesel specification (ISO 8217) now allows up to B100
  - Major marine shipping companies have conducted B45, B100 field trials with success
  - Large ships are designed to work w/ low quality No. 6 Bunker Fuel and heavy fuel oils
    - Systems are heated, running B100 is easy compared to No. 6 oil!
- Major dispenser companies are partnering with Clean Fuels on B100 dispensers

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Questions?

LOW-CARBON LIQUID FUELS ARE THE LOWEST COST OPTION TOWARDS DECARBONIZATION

Scott Fenwick

Technical Director

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573-418-9677 (cell)

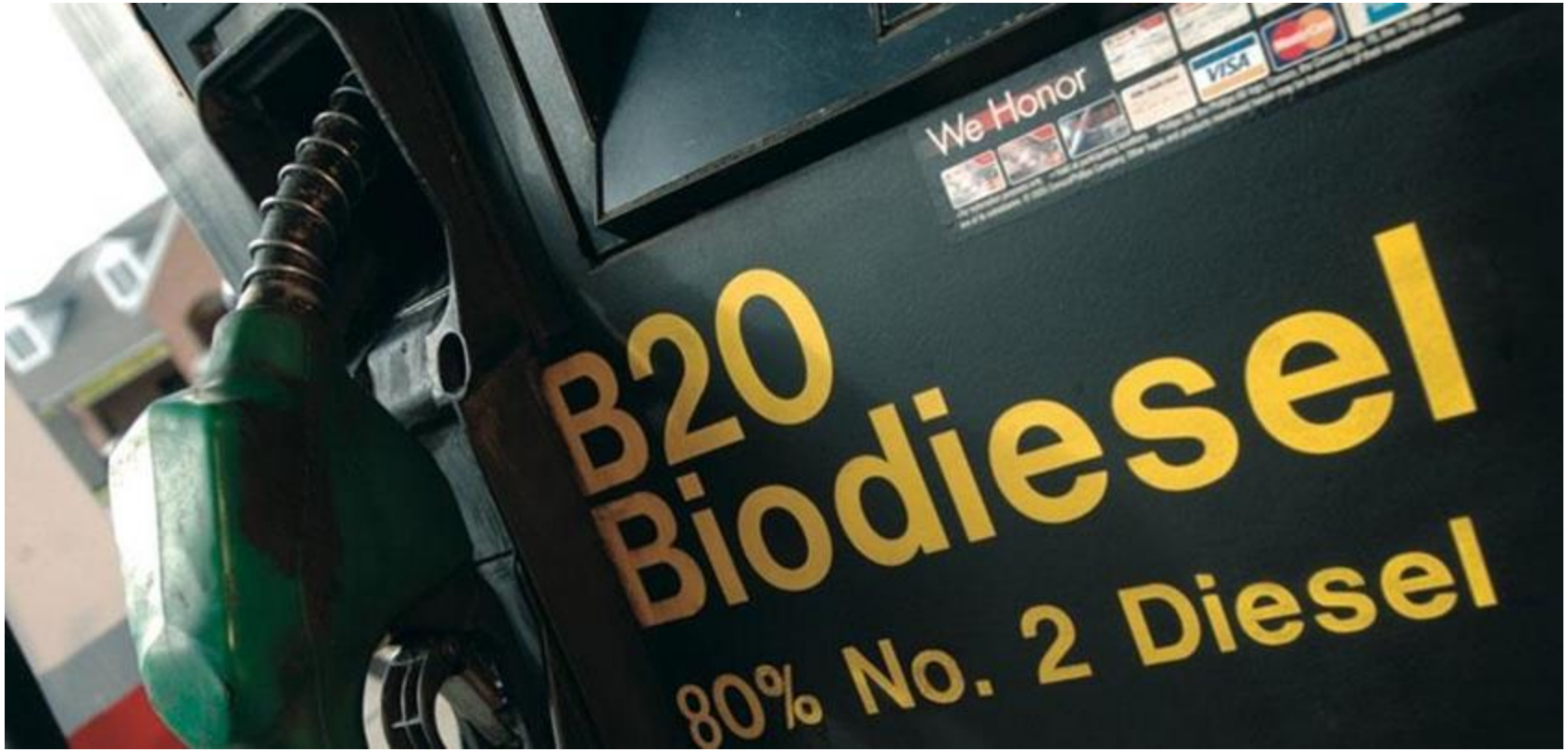
OPTIMUS TECHNOLOGIES

RUN ON LESS MESSY MIDDLE

February 11th, 2025

Colin Huwyler, CEO | c.huwyler@optimustec.com

Biodiesel Engine Compatibility



B20

Today's engines are compatible with biodiesel blends up to 20%

B100

Optimus upgrades engines to use 100% biodiesel

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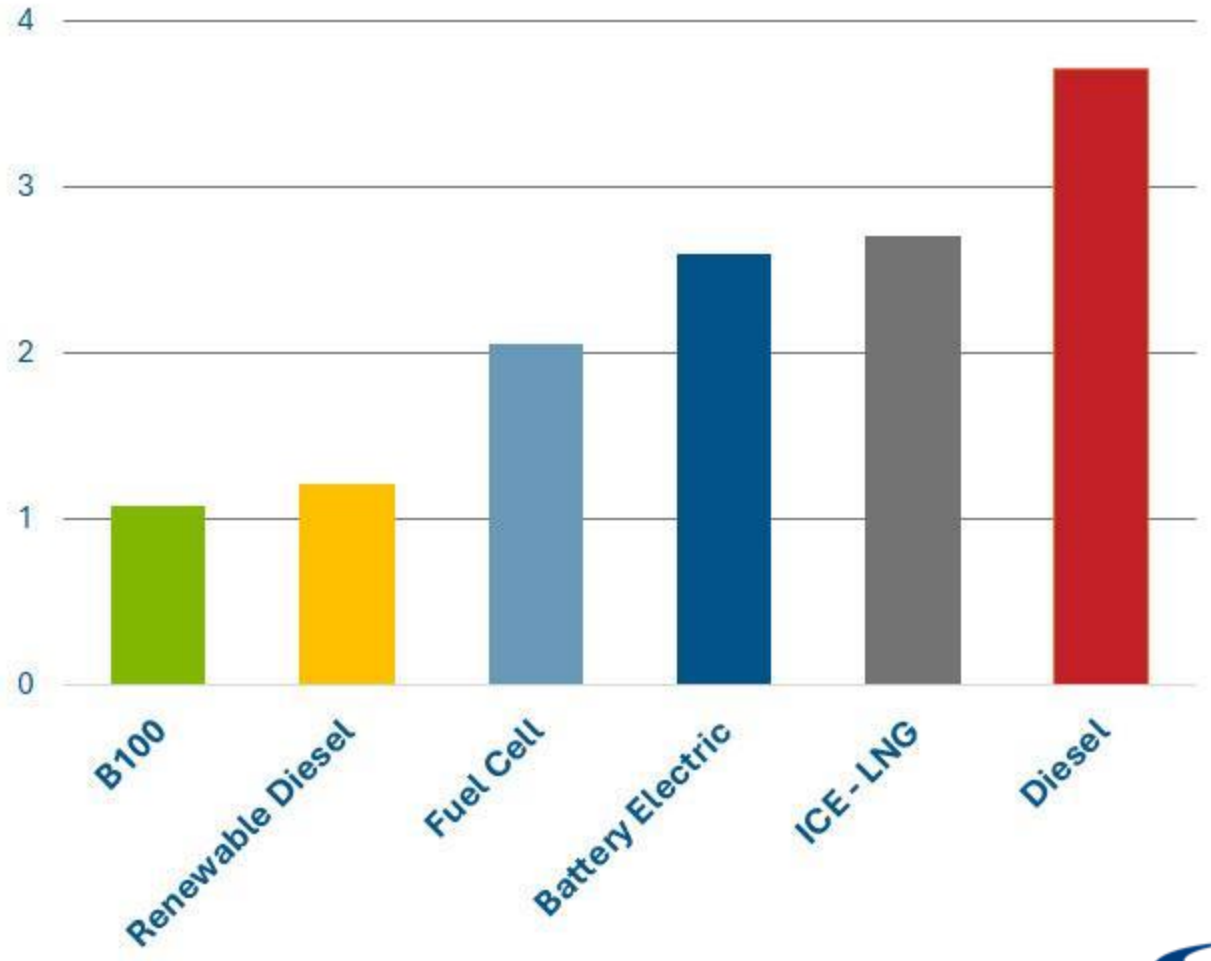
Total Lifecycle CO2 Emissions: Production, Operations, and Disposal (MM lbs)



ATRI American Transportation Research Institute

OPTIMUS TECHNOLOGIES

WHY B100?

- 100% Biogenic Carbon
- Utilizes Existing Infrastructure
- Available Nationwide
- Low Cost
- Improves Operational Performance

The Optimus Vector System

Biodiesel Tank

Customer Dashboard

Vector Manifold

Fuel Selector Valves

User Interface

1100+

Class 8 trucks are equipped and operating with the Optimus Vector System

85+ Million Miles

of validation that heavy-duty fleets can seamlessly decarbonize

OPTIMUS TECHNOLOGIES

Fully Automated

1. Driver turns key—system wakes up
2. Driver starts engine on diesel
3. B100 is preheated with waste heat from engine using coolant
4. After set points are met, B100 pump turns on and circulates fuel through entire Vector System and up to valves
5. When next step points are met, the fuel selector valves automatically switch the fuels from diesel to B100
6. The vehicle runs on B100 until it is turned off except during DPF regenerations or if any fault occurs
7. Driver turns the key off—engine keeps running, switches fuels and purges B100, shuts off engine

Hands Off

100% automated system doesn't require driver engagement

OPTIMUS TECHNOLOGIES

Proven in Arctic Conditions

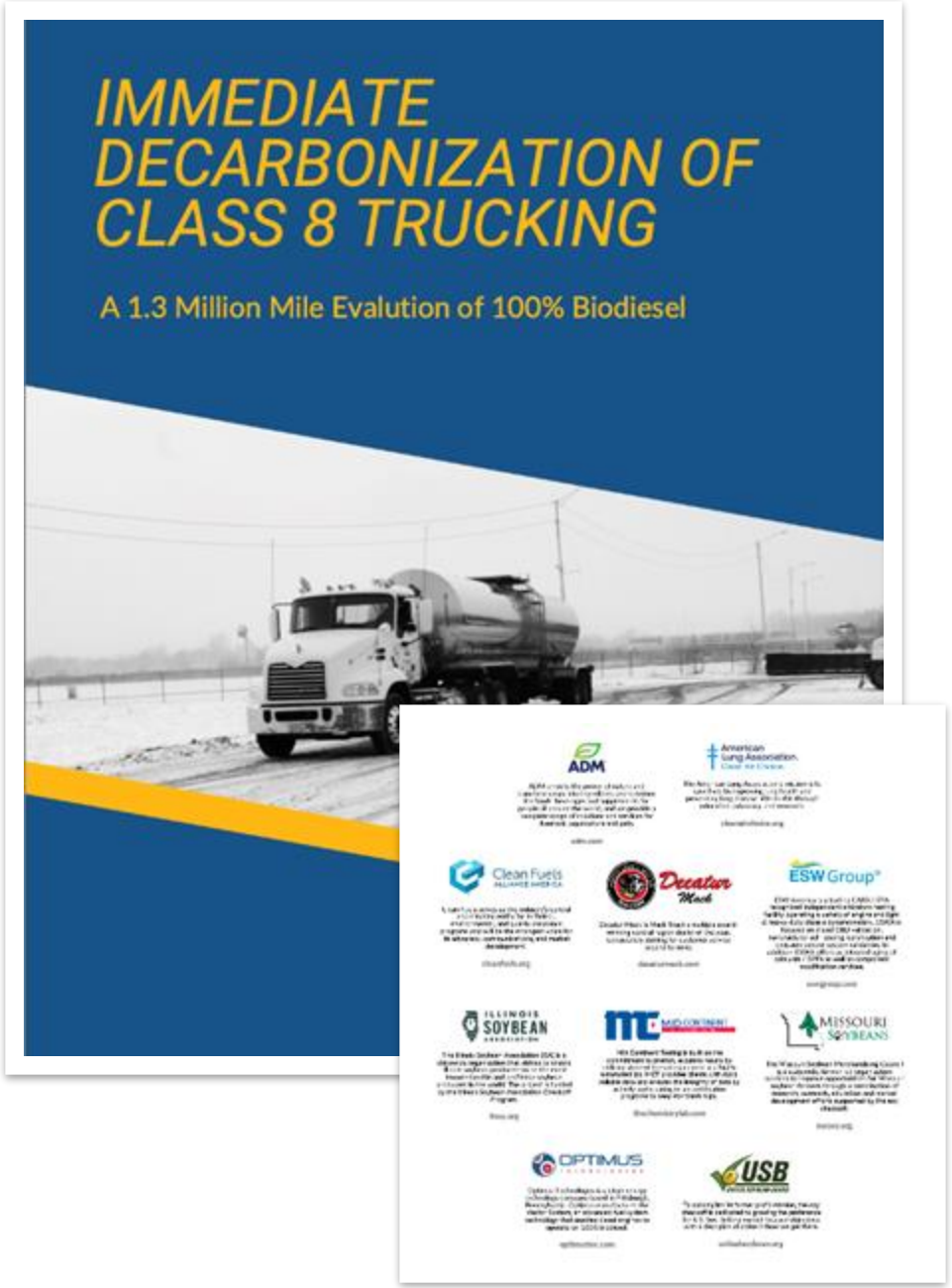
B100 with Optimus Technologies is proven to work in subzero conditions to below

-30°F

OPTIMUS TECHNOLOGIES

Validated Performance

- **B100 achieved fuel economy parity**
- **Improvement in diesel particulate filter (DPF) performance & operation**
- **Improvement in monitored parameters of engine oil**
- **No impact on cost of maintenance vs. diesel**
- **No impact on operations or performance of trucks**



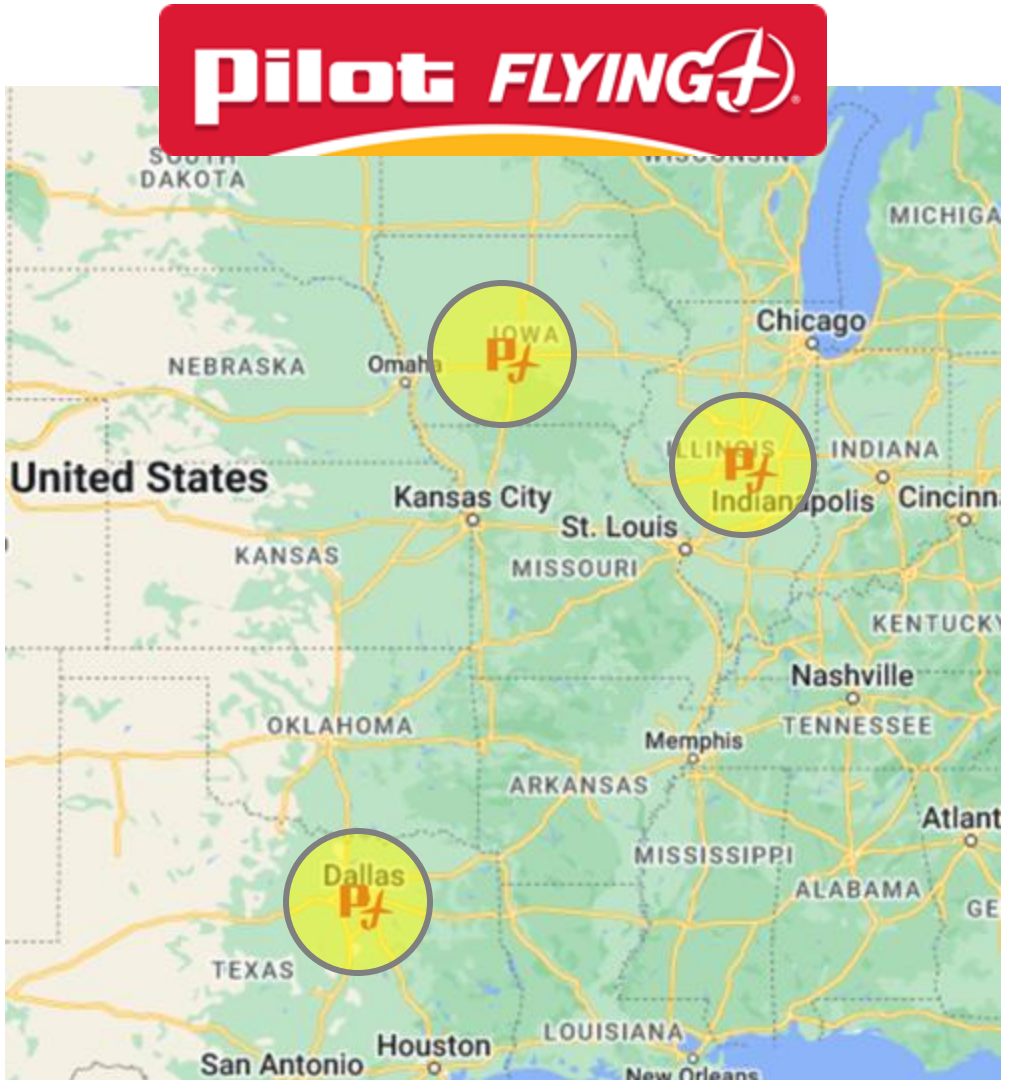
1.3MM

Mile evaluation of 100% biodiesel

Report available at:

OPTIMUS TECHNOLOGIES

B100 Retail Availability



Q1
2025

#368 Decatur, IL

#373 Des Moines, IA

#433 Dallas, TX

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Refueling Solutions

SMART Fuel

The SMARTFuel RFID technology restricts refueling to only customer vehicles upgraded to use 100% biodiesel, preventing misfueling.

OPTIMUS TECHNOLOGIES

Summary

- *B100 delivers proven carbon reductions*
- *1,100+ Vector Systems on the road with over 85+ million miles driven*
- *No disruption to operations*
- *No charging required*

The Optimus Vector Manifold

OPTIMUS TECHNOLOGIES

Thank You!

Colin Huwyler
Chief Executive Officer
412.727.8228
c.huwyler@optimustec.com

The Role of Lubricants in Truck Efficiency

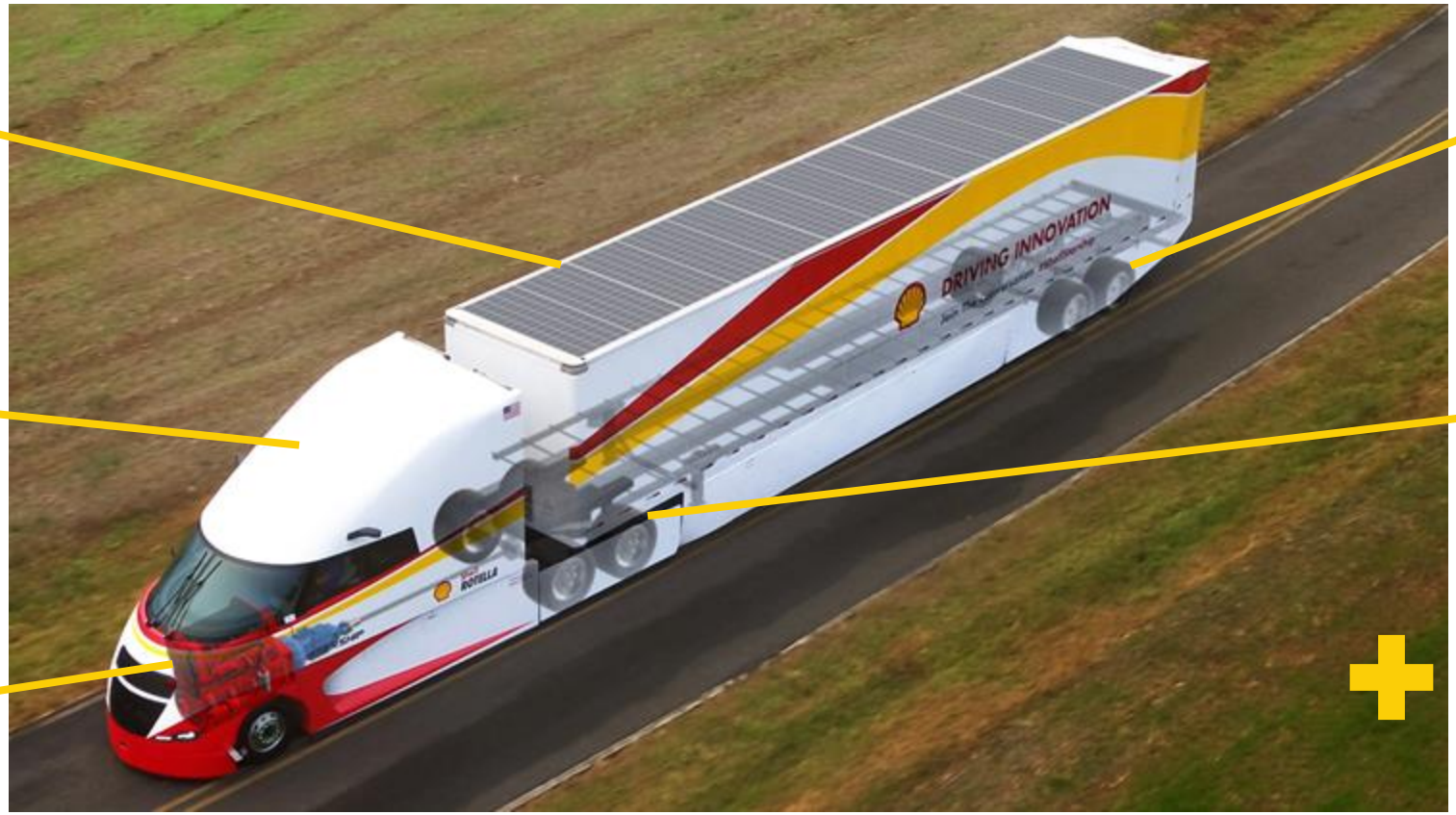
Andrew Gibson
Global Sector Marketing Manager Fleet
Global Brand Manager Shell Rimula

Where to Start: There are many ways to improve the efficiency of your truck and help reduce emissions

Trailer Aerodynamics

Tractor Unit Aerodynamics

Powertrain

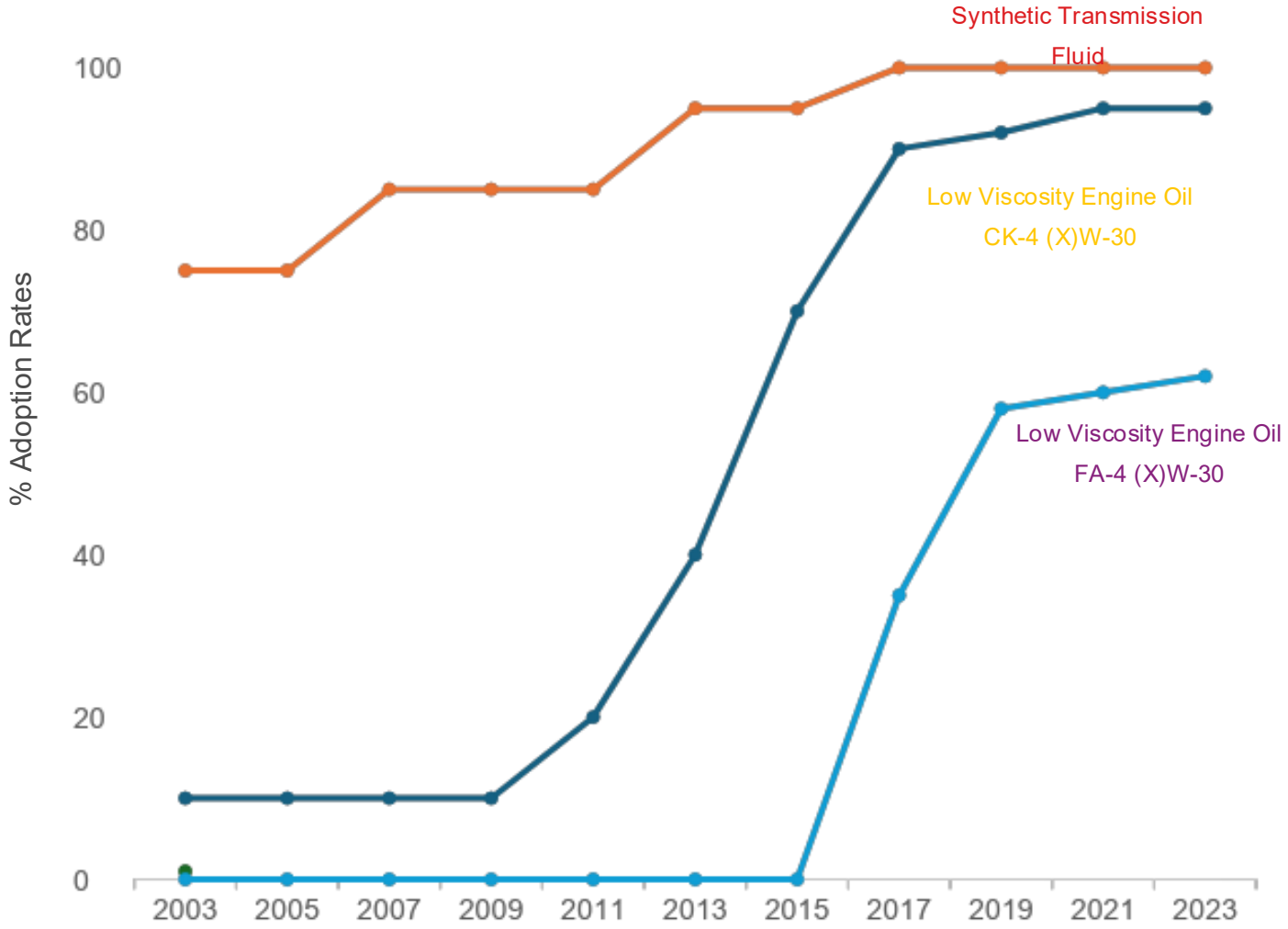


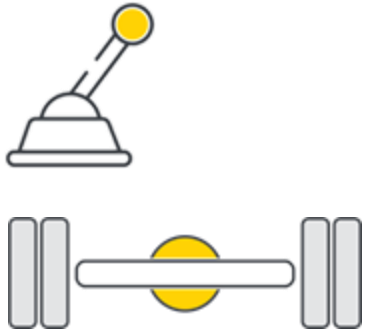
Tires & Wheels

Chassis

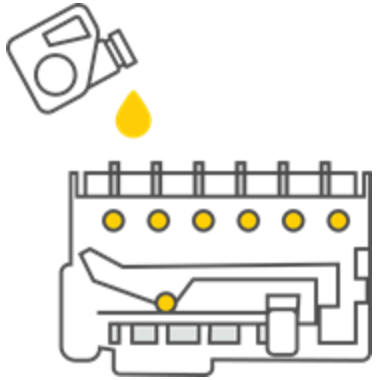
Operating Practices

By looking at the adoption rates of different technologies by leading fleets we see some interesting trends appear.





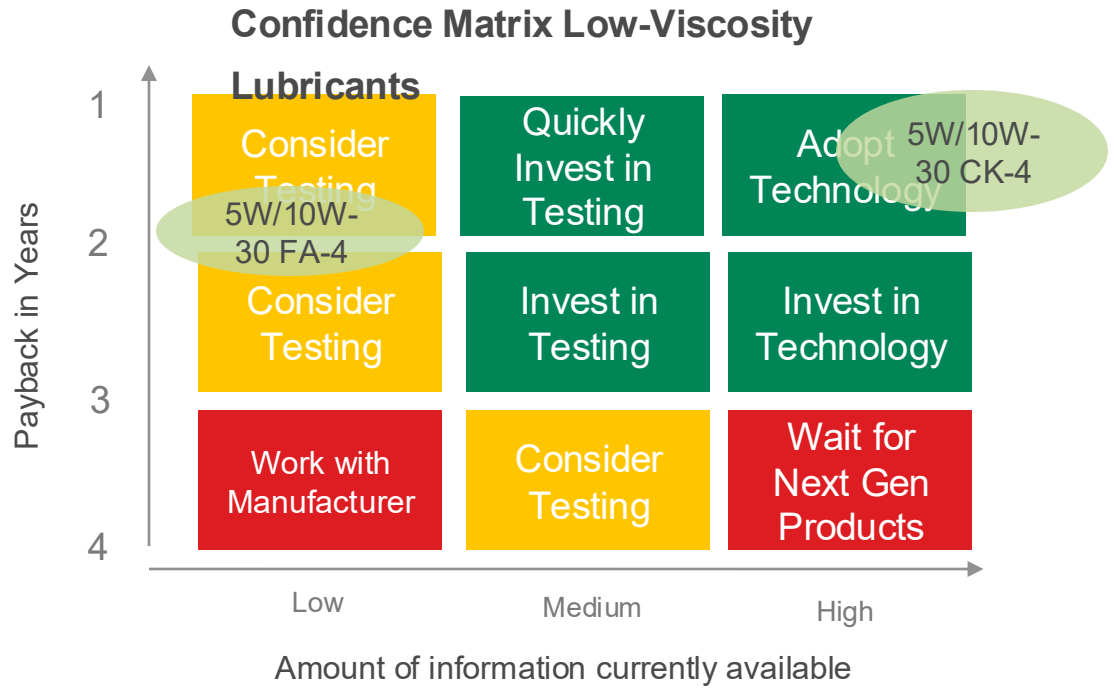
91% Adoption rate of Automated Manual Transmissions which require a synthetic gear oil for fuel economy and long drain reasons (100% adopted) & 100% Adoption rate of synthetic axle oils for fuel economy and long drain reasons



91% Adoption rate of 10W-30 Low Viscosity Engine Oils and 39% are going further adopting FA-4 super High Efficiency 10W-30 / 5W-30 Engine Oils

Source: NACFE Run On Less (NACFE | Run on Less)

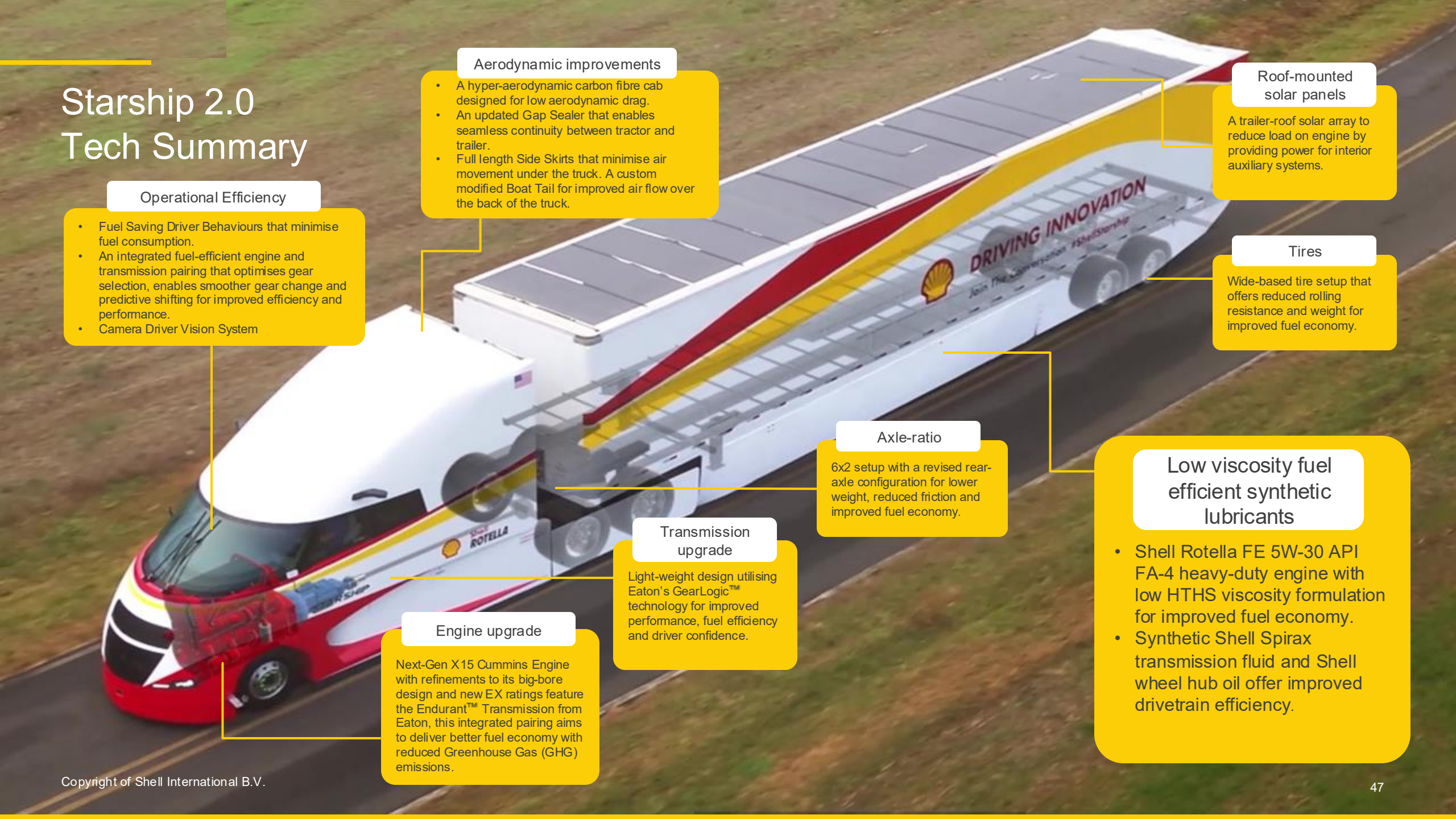
How mature is the technology? What should you consider doing and does it stack up commercially?



What is PC-12 ?

Source: Confidence_Matrix_Low_Viscosity_Lubricants_vB2_scm.jpg (1400×1050

Starship 2.0 Tech Summary



Operational Efficiency

- Fuel Saving Driver Behaviours that minimise fuel consumption.
- An integrated fuel-efficient engine and transmission pairing that optimises gear selection, enables smoother gear change and predictive shifting for improved efficiency and performance.
- Camera Driver Vision System

Aerodynamic improvements

- A hyper-aerodynamic carbon fibre cab designed for low aerodynamic drag.
- An updated Gap Sealer that enables seamless continuity between tractor and trailer.
- Full length Side Skirts that minimise air movement under the truck. A custom modified Boat Tail for improved air flow over the back of the truck.

Roof-mounted solar panels

A trailer-roof solar array to reduce load on engine by providing power for interior auxiliary systems.

Tires

Wide-based tire setup that offers reduced rolling resistance and weight for improved fuel economy.

Axle-ratio

6x2 setup with a revised rear-axle configuration for lower weight, reduced friction and improved fuel economy.

Transmission upgrade

Light-weight design utilising Eaton's GearLogic™ technology for improved performance, fuel efficiency and driver confidence.

Engine upgrade

Next-Gen X15 Cummins Engine with refinements to its big-bore design and new EX ratings feature the Endurant™ Transmission from Eaton, this integrated pairing aims to deliver better fuel economy with reduced Greenhouse Gas (GHG) emissions.

Low viscosity fuel efficient synthetic lubricants

- Shell Rotella FE 5W-30 API FA-4 heavy-duty engine with low HTHS viscosity formulation for improved fuel economy.
- Synthetic Shell Spirax transmission fluid and Shell wheel hub oil offer improved drivetrain efficiency.

Shell Starship 3.0 NG

Demonstrating the Art of the Possible

Shell Starship is Shell's technology demonstration vehicle. When we combined many of these technologies together, we achieved Fuel Economy figures of 9mpg* with 80,000lbs cargo.

*diesel gallon equivalent for Natural Gas

Predictive/Adaptive Cruise Control

Aerodynamic Features have been enhanced

Roof-mounted solar panels

Zeus Door redesign

Automatic Air Gap Closures

Cummins X15N an industry-first large-bore natural gas engine

Meritor FUELite Plus Axle with optimized 2.64 axle-ratio

Mirror Eye Camera Driver Vision System

Shell Rotella NG 5W-30 Engine Oil, Rotella ELC Coolant, Spirax synthetic drivetrain lubricants and Gadus chassis grease

Eaton Endurant 12 - Speed Automated Manual Transmission

Bridgestone wide-based, low-rolling resistance fuel economy tires on the truck and trailer

Q&A

Diesel Drop-In Alternatives: Ultra-Low Sulfur, Bio-, and Renewable

Scott Fenwick
Technical Director
Clean Fuels Alliance America

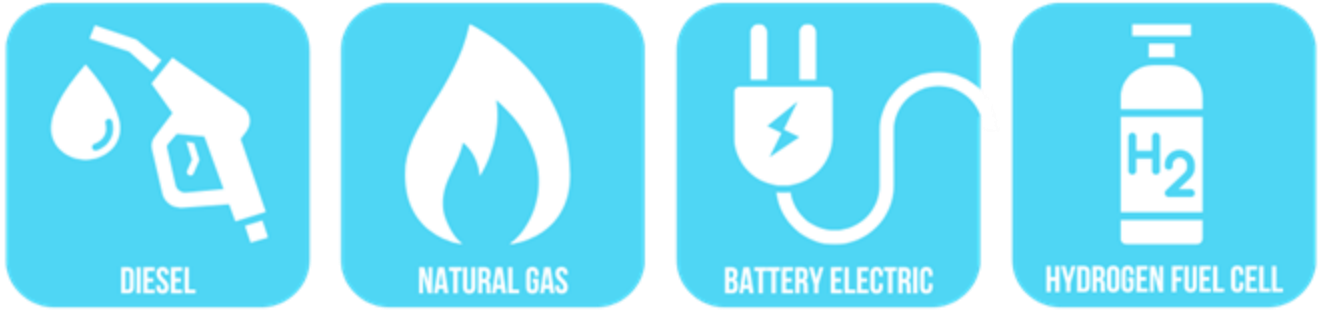
Andrew Gibson
Global Sector Marketing Manager Fleet & Global Brand Manager Shell Rimula
Shell

Colin Huwyler
CEO
Optimus Technologies

Jeff Seger
Clean Energy Consultant
NACFE

RUN ON LESS MESSY MIDDLE

MESSY MIDDLE BOOTCAMP



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