







The Role of Fuel Additives in the Future of Liquid Fuels

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41st Automotive - Petroleum Industry Forum, April 12, 2022

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Presentation Outline

-  Today's emission landscape
-  The evolution of transportation technology
-  Demonstrating the real-world benefits of fuel additives
 -  GDI Gasoline
 -  Diesel
-  Summary

US Emissions Landscape

External Forces

- ▲ Aspiration is zero emissions for transport
 - ▲ Regulators have goals of zero emission vehicles
 - CO₂ and criteria emissions
 - ▲ Corporate sustainability goals are a significant driver
 - ▲ Reduced carbon emissions/GHG are of particular interest
- ▲ Requires significant shift in vehicle technology and energy sourcing
 - ▲ OEMs are committed to zero emissions vehicles
 - ▲ Fuel industry is reformulating fuel blends to reduce carbon intensity
 - Diesel leading with RD and BD
 - Difficult to decarbonize gasoline – 15% ethanol limit except in FFVs
- ▲ Fuel additives can help achieve these aspirations by controlling deposits and reducing emissions degradation

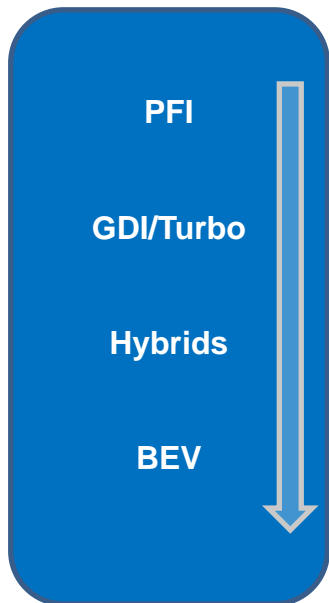


Source: BBC.com / Getty Images

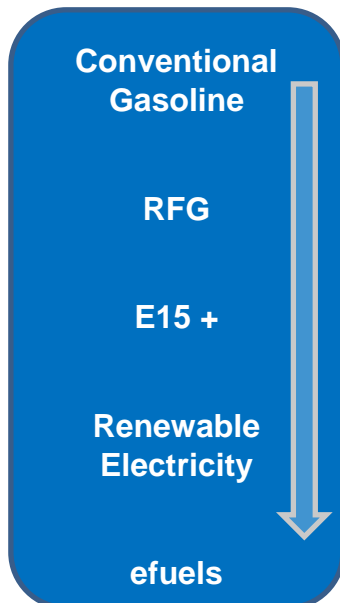
The Evolution of Engine and Fuel Technology

Light Duty / Passenger Car

Vehicle

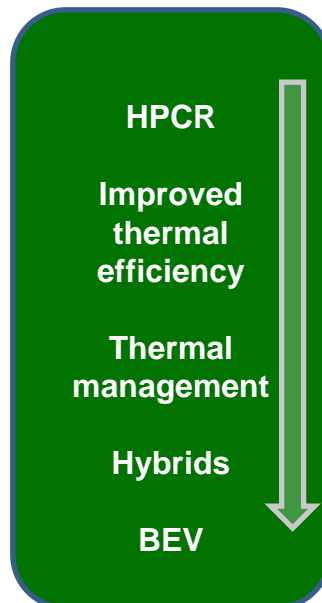


Fuel

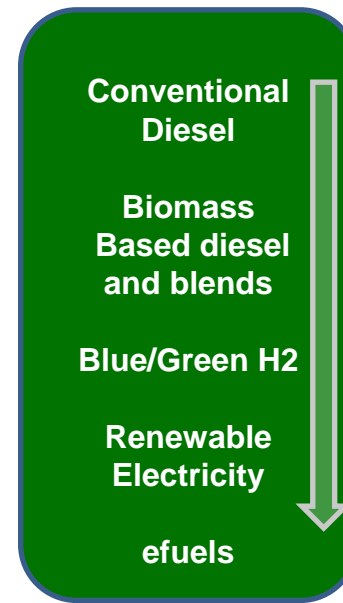


Medium / Heavy Duty Commercial

Vehicle



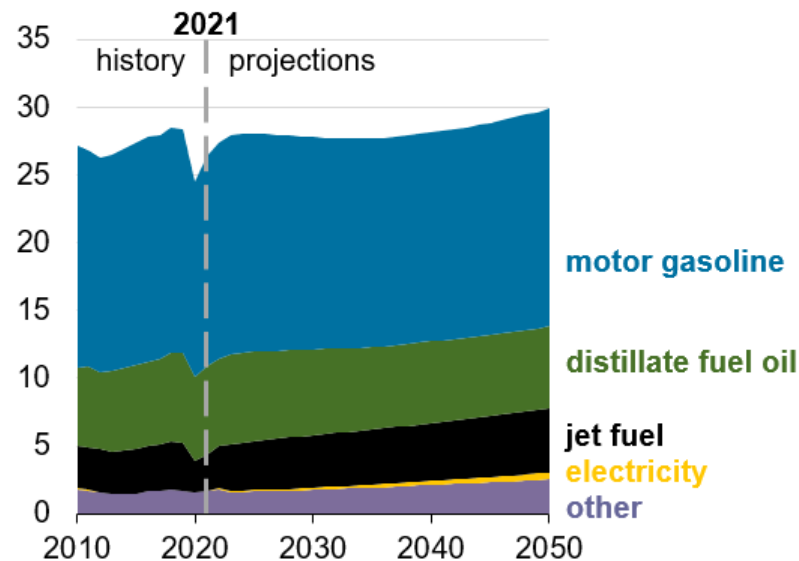
Fuel



Lowering the Carbon Emissions of the Vehicle Parc

- Vehicle manufacturers have delivered on lowering carbon emissions
- Fuel reformulations have also resulted in lower emissions and reduced carbon intensity
- Slow fleet turnover mitigates the immediate benefit of these advances
 - Leaves older technology in the car parc
 - Necessitates a continued and significant liquid fuels market
- The liquid fuel fleet benefits from engine deposit control to avoid emissions degradation and maximize fuel economy

Transportation sector consumption by fuel
AEO2022 Reference case
quadrillion British thermal units



Source: US Energy Information Administration, Annual Energy Outlook 2022

How Fuel Additives Help Lower Carbon Emissions

- 📈 Liquid fuels will be a major energy source for transportation for many years
- 📈 There is a large vehicle parc that benefits from higher fuel quality
- 📈 Fuel additives can control deposit formation in internal combustion engines

- 📈 What is the role of fuel additives in lowering carbon emissions?
- 📈 Afton completed fleet trials to answer this question
 - ▶ Real world in-use light duty evaluations of a fleet of used cars
 - ▶ Real world fuel economy monitoring of a fleet of heavy-duty trucks

Can fuel additives deliver real world benefits in reducing carbon emissions?

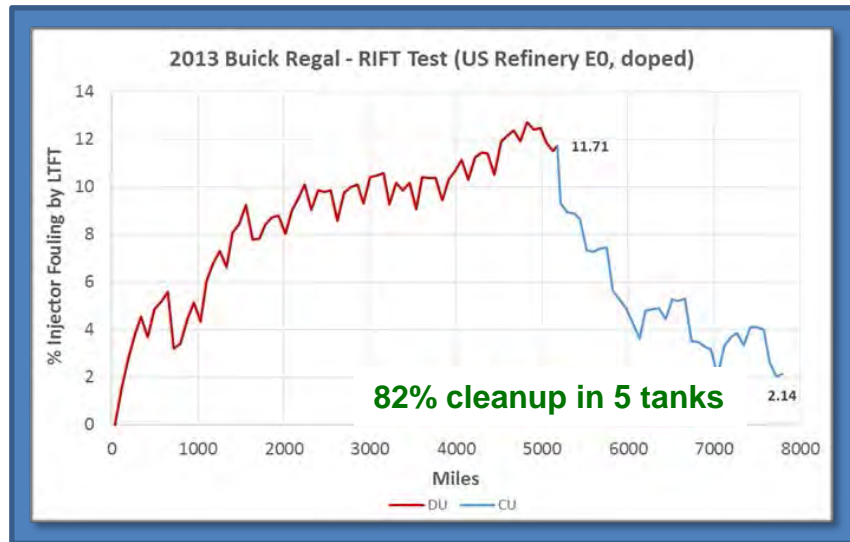
Restoring Fuel Economy in GDI vehicles

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Fuel Additives Provide Deposit Control in GDI Engines

- ▲ Afton has developed a vehicle-based testing protocol for GDI cleanliness
 - ▲ Accelerated injector fouling
- ▲ Used as a tool to develop fuel additive technology providing enhanced GDI deposit control

Does a fuel additive developed in an accelerated lab test deliver real world performance benefits?

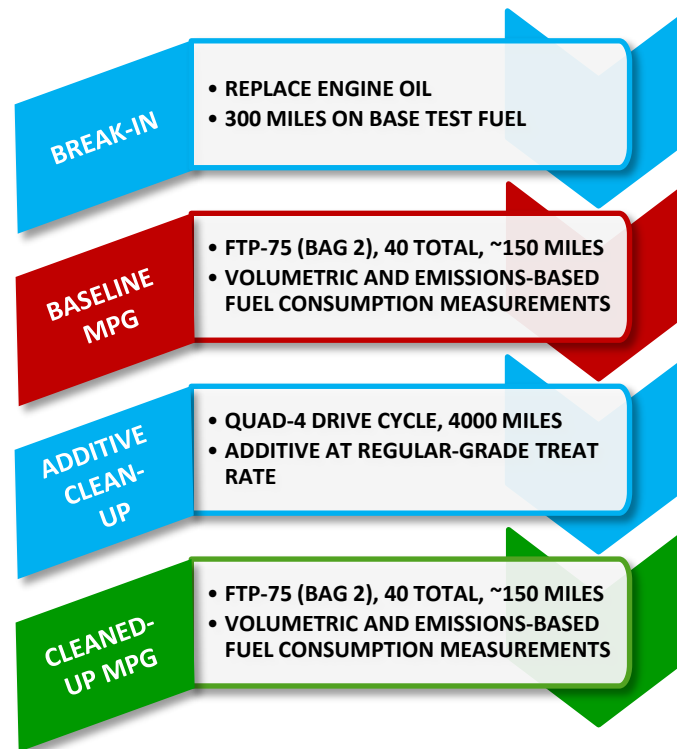


Source: SAE 2017-01-2298, A General Method for Fouling Injectors in Gasoline Direct Injection Vehicles and the Effects of Deposits on Vehicle Performance

Real-World GDI Fleet Study

Hypothesis: Real-world GDI vehicles of lower mileage (30-50k) have dirty injectors, which result in lost fuel economy. Clean-up with a **first intent GDI additive** can restore that lost fuel economy by cleaning up these harmful deposits.

- 📈 Vehicles bought as-is from a local dealership
- 📈 Newer model year GDI vehicles with 30 – 50K miles
- 📈 Fueled in the field with commercial pump fuel
- 📈 No pre-screening was conducted to determine if vehicles were “dirty”



Real-World GDI Fleet Results

Hypothesis: Real-world GDI vehicles of lower mileage (30-50k) have dirty injectors, which result in lost fuel economy. Clean-up with **first-intent GDI additive** can restore that lost fuel economy by cleaning up these harmful deposits

FUEL ECONOMY



2015 Ford F150



2016 Volkswagen GTI



2017 Kia Optima



2016 Buick Regal



2017 Honda Civic



2013 Kia Optima



2015 Chevy Equinox

A 1.5% Fleet Average Fuel Economy Improvement Was Measured

Do Fuel Additives Deliver Real-World Benefits?

Fleet study results:

- Average 1.5% Fuel Economy Restoration
- Fuel savings of 47 gallons per year
- 920 lbs. CO₂ avoided

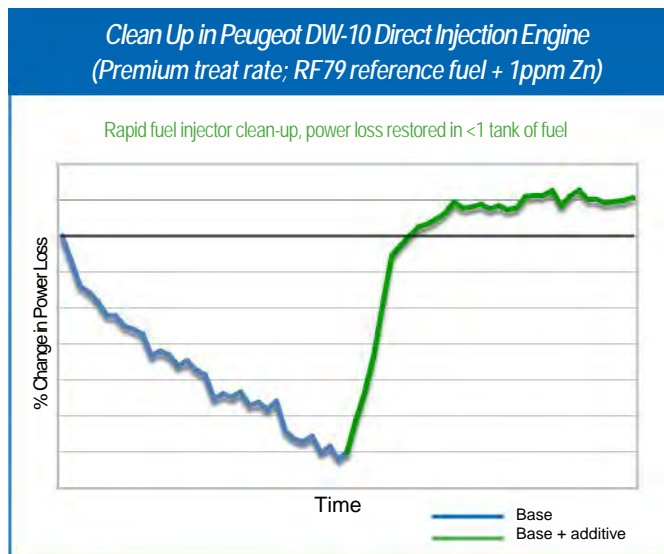
Yes, there is a real-world benefit!

- 📈 Significant fuel savings and CO₂ avoidance is available without hardware or fuel modification by using a **first-intent GDI additive**
 - ▲ There are about 62 million GDI vehicles on the road
- 📈 Calculations:
 - ▲ Assuming annual mileage of 11,500 for these seven vehicles only
 - ▲ One gallon of gasoline when combusted creates 19.6 lbs. CO₂
- 📈 If this fleet study is representative of the overall GDI car parc, the potential CO₂ reduction is a very big number!

Restoring Fuel Economy in a HD Diesel Fleet

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Fuel Additives for Deposit Control in Diesel Engines



- ▲ The DW10 B test is commonly used to test for injector deposit control in HPCR injectors
- ▲ This is an accelerated test
 - ▲ Severe cycle
 - ▲ Duration: 32 hours
 - ▲ Uses Zn in the fuel as an accelerant

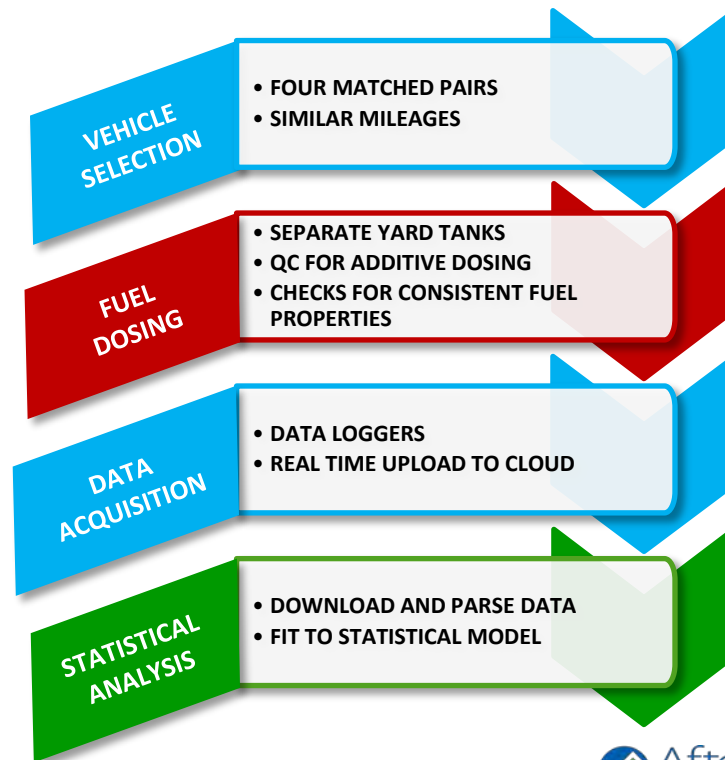
Does a fuel additive developed in an accelerated lab test deliver real world performance benefits?

Real-World Diesel Fleet Study



Hypothesis: Real-world diesel vehicles of lower mileage (150K) have dirty injectors, which result in lost fuel economy. Clean-up with **first-intent HPCR diesel additive** can restore that lost fuel economy by cleaning up these harmful deposits.

- ▲ No prior additive use by this fleet
- ▲ Vehicles operated under normal daily business routines
 - ▲ Real-world variability in daily operation
- ▲ Criteria were developed to parse and normalize the data
 - ▲ Engine at or very near operating temperature
 - ▲ Vehicle is at or very near “rated speed”
 - ▲ Vehicle is not coasting or idling
 - ▲ The final models are fit using linear regression



Real-World Diesel Fleet Study



010 – 2018 Mack/Dump - 155,585 miles



020 – 2018 Mack/Dump - 105,982 miles



009 – 2017 KW/Dump - 210,214 miles

016 – 2017 KW/Dump - 198,185 miles



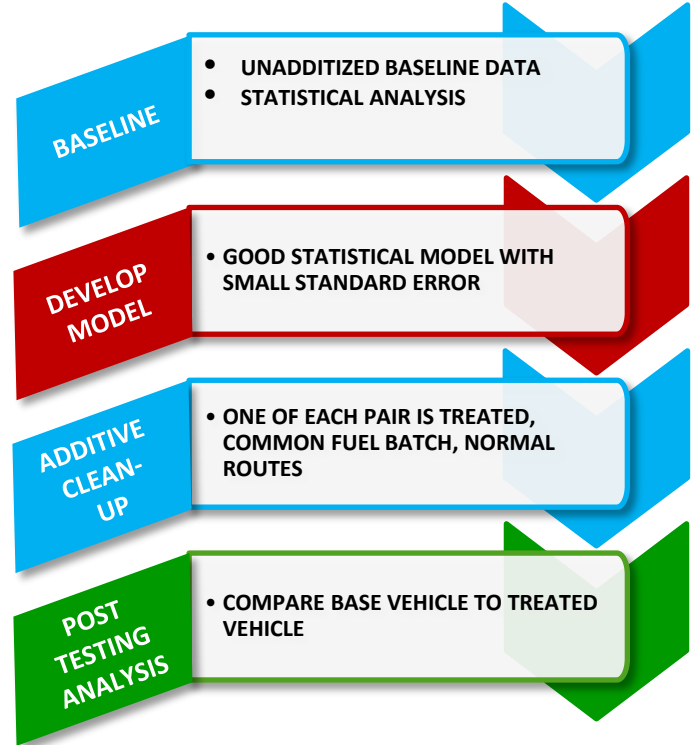
122 – 2017 KW/Tractor – 285,044 miles

127 – 2017 KW/Tractor – 216,520 miles



125 – 2019 Mack/Tractor – 183,256 miles

129 – 2019 Mack/Tractor – 167,105 miles



Real-World HD Fleet Fuel Economy Improvement

Hypothesis: Real-world diesel vehicles of lower mileage (150K) have dirty injectors, which result in lost fuel economy. Clean-up with **first-intent HPCR diesel additive** can restore that lost fuel economy by cleaning up these harmful deposits.

FUEL ECONOMY



2017 PACCAR
Dump Truck



2017 PACCAR
Tractor



2018 Mack
Dump Truck



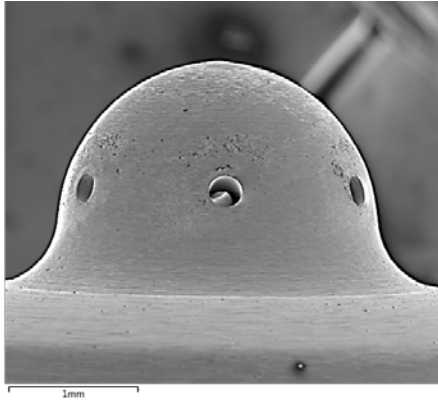
2019 Mack
Tractor

A 3.6% Fleet Average Fuel Economy Improvement Was Measured

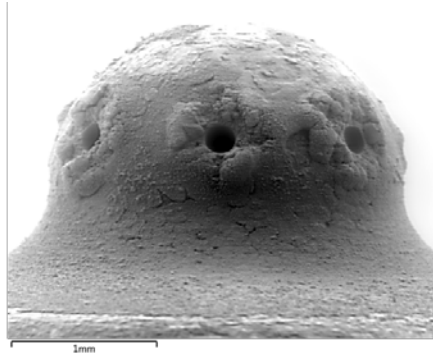
Confirmation of Fuel Injector Cleanliness

Mack Injector Tip Deposits - New, Base, and Additized SEM/EDX

New

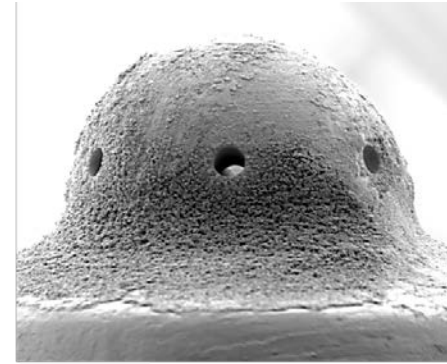


Base (unadditized)



Significant build up of carbonaceous deposits around and inside injector fuel flow holes

Additized



Significant clean-up of deposits around and inside additized injector fuel flow holes

A truck with relatively low mileage can have injector deposits and benefit from additized fuel

Do Fuel Additives Deliver Real-World Benefits?

Fleet study results:

- Average 3.6 % Fuel Economy Restoration
- 1470 gallons of diesel fuel
- 15 MT CO₂ avoided

Yes, there is a real-world benefit!

- Significant fuel savings and CO₂ avoidance is available without hardware or fuel modification by using a **first-intent diesel HPCR additive**
- Assumptions:
 - ▲ Benefits for this eight-vehicle fleet only over the duration of this test
 - ▲ One gallon of diesel fuel when combusted creates 22.4 lbs. CO₂
- If this fleet study is representative of the overall HD vehicle parc, the potential CO₂ reduction is a very big number!

Summary

📈 The aspiration is zero emissions for transport. All stakeholders are working toward this goal.

📈 Liquid fuels will remain in the market for years

📈 Deposits are causing a loss of fuel economy over time

📈 Afton fleet studies show that the use of properly-formulated fuel additives can restore fuel economy, resulting in a significant reduction of CO2 emissions



Source: clipground.com

Thanks for your attention

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