

Current State of Diesel Technology and Future Advancements

prepared for the



January 8, 2019



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Executive Director, Diesel Technology Forum



Meet the Leaders

In Clean Diesel Technologies



Today's Session

1. Overview of Diesel in New Jersey: commercial vehicles, new technology diesel engines, fuels, etc.
2. Update on the current state of diesel technology in on- and off-road applications
3. What is the current state of biofuels?
4. What is the penetration of new technology diesel engines in the U.S. and New Jersey trucking fleet?
5. What is expected in the near term for further criteria pollutant and GHG emission reductions?
6. Recent research into large engines and the benefits they provide near-port community
7. Q&A
8. Resources Available

One Out of Every Two Economic Sectors Relies on Heavy-Duty Vehicles, Equipment or Engines to Get the Job Done



Diesel Power in New Jersey



Positive Train Control cable installation on the Atlantic City Rail Line.



The first phase of work to replace wood catenary poles on the Gladstone Branch was completed in FY2018.



This mobile diesel generator can help provide backup power during major power outages.



NJ TRANSIT ordered 85 new articulated buses in FY2018 for use on high-ridership routes.



https://www.njtransit.com/pdf/NJTRANSIT_2018_Annual_Report.pdf

Diesel's many roles in NJ

Infrastructure, *Emergency Response*, *Resilience*, *Climate Plans*



WHAT'S NEW?

Governor Phil Murphy Signs [Executive Order #8](#) directing all New Jersey State Agencies with responsibilities under the Offshore Wind Economic Development Act (OWEDA) to fully implement [OWEDA](#) in order to meet a goal of obtaining 3,500 MW from offshore wind by the year 2030.



EMERGENCY STANDBY GENERATOR LOCATION LISTING –NJSP
CENTRAL AND SOUTHERN REGIONS (T2269)

LOCATION	ADDRESS	COUNTY	REGION	MAKE	FUEL	KW	TANK (gal)
Bordentown Tower	Rte 130, N. Bordentown, NJ 08505	Burlington	Central	Onan	Propane	60	1000
Bordentown	Rte. 130, Bordentown, NJ 08505	Burlington	Central	Onan	Diesel	50	200
	ington, NJ 08016	Burlington	Central	Onan	Diesel	30	200
	ghtstown, NJ 08562	Burlington	Central	Onan	Diesel	50	200
	n, NJ 08088	Burlington	Central	Onan	Diesel	30	200
	Springfield, NJ	Burlington	Central	Onan	Diesel	15	200
	537, Bass River Twp., NJ	Burlington	Central	Onan	Propane	30	1000
	ch Rd., W Trenton, NJ	Mercer	Central	Onan	Diesel	125	375
	NJ 08628	Mercer	Central	Katolight	Diesel	300	Shared 8000
	NJ 08628	Mercer	Central	Marathon	Diesel	295	Shared 8000
	NJ 08628	Mercer	Central	Katolight	Diesel	550	Shared 8000
	NJ 08628	Mercer	Central	Katolight	Diesel	550	Shared 8000
	NJ 08628	Mercer	Central	Kohler	Diesel	350	500
	NJ 08628	Mercer	Central	Onan	Diesel	100	200
	NJ 08628	Mercer	Central	Onan	Diesel	200	2000
	NJ 08628	Mercer	Central	Cummins	Diesel	200	3000
	NJ 08628	Mercer	Central	Murphy	Diesel	175	250
	NJ 08628	Mercer	Central	Onan	Diesel	500	Shared 15000
	nton, NJ 08628	Mercer	Central	Onan	Diesel	30	200
	Edison, NJ 08817	Middlesex	Central	Kohler	Natural Gas	15	N/A
	on, NJ 08540	Middlesex	Central	Onan	Diesel	30	200
Princeton Armory	166 River Road, Princeton, NJ 08540	Middlesex	Central	Onan	Diesel	50	200
Princeton Tower	3925 US Hwy 1, Princeton, NJ 08540	Middlesex	Central	Onan	Propane	50	1000
Allenwood	2101 Allenwood Avenue, Wall NJ 07719	Monmouth	Central	Onan	Diesel	30	200
Sea Girt Lab	Sea Girt Ave., Sea Girt, NJ	Monmouth	Central	Onan	Natural Gas	15	N/A

NJ State Profile

<https://www.dieselforum.org/new-jersey>



8,590

TOTAL CLEAN DIESEL JOBS IN NEW JERSEY¹¹

GOODS MOVEMENT: DELIVERING FOR NEW JERSEY

41%

HEAVY-DUTY DIESEL VEHICLES OF THE NEWEST GENERATION TECHNOLOGY THAT MEET THE LATEST U.S. EPA EMISSIONS STANDARDS FOR PARTICULATE MATTER AND NOX

Heavy-duty diesel vehicles manufactured beginning in 2010 must meet the stricter clean diesel emissions standards that further reduce near-zero particulate matter and NOx emissions even closer to zero, thanks to further refinements to engine and emission control technologies and the nationwide availability of ultra-low sulfur diesel fuel.⁴

50

FERRY BOATS POWERED BY DIESEL



4

BIODIESEL (B20 AND ABOVE) PUMPS IN NEW JERSEY⁹

Most diesel engines can run on high-quality biodiesel blends as well as next-generation renewable diesel fuels. Most diesel vehicles and equipment are compatible with biodiesel or renewable diesel fuel blends between five and 20 percent.



1,309

DIESEL FUEL CONSUMPTION (MILLIONS OF GALLONS)¹⁴

Diesel technology is the workhorse of the U.S. and global economy, powering over 78 percent of commercial trucks⁴, almost 90 percent of all transit buses⁵, nearly 100 percent of freight locomotives and marine work boats⁸, and two-thirds of all farm and construction equipment.

DIESEL VEHICLES ON THE ROAD

How does your state rank compared to the other states for adopting the latest clean diesel technology? Getting more new technology clean diesel vehicles on the road will deliver cleaner air faster.

#30

for Total Diesel Passenger Vehicles^{1,2,3}

#45

Total New Generation Clean Diesel Transit Buses⁵

#38

for Total Diesel Pickup Trucks²

#35

Total New Generation Clean Diesel School Buses⁶

#2

Highest Percentage Diesel Work Vans¹

#21

for Highest Percentage New Generation Clean Diesel Heavy-Duty Trucks⁴

BREAKDOWN OF LIGHT-DUTY DIESEL VEHICLES IN NEW JERSEY



PUBLIC TRANSPORTATION



21%

TRANSIT BUSES OF THE NEWEST GENERATION TECHNOLOGY THAT MEET LATEST U.S. EPA EMISSIONS STANDARDS FOR PARTICULATE MATTER & NOX

Transit buses manufactured beginning in 2010 must meet the latest U.S. EPA emissions standards for near-zero emissions of particulate matter and NOx. Today's ultra-low sulfur diesel fuel, advanced engines and effective emissions control combine to achieve near zero emissions that is smoke free.⁵



45%

SCHOOL BUSES ARE OF THE NEWEST GENERATION TECHNOLOGY THAT MEET LATEST U.S. EPA EMISSIONS STANDARD FOR PARTICULATE MATTER & NOX

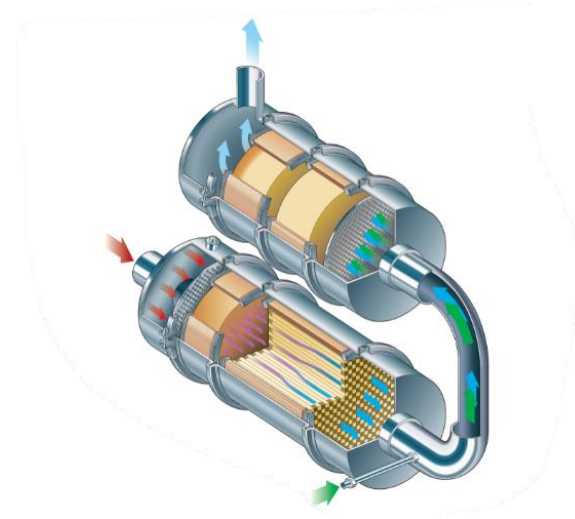
Diesel provides the safest, least combustible, most reliable power for student transportation. Over 95 percent of school buses in the U.S. are powered by a diesel engine with only 5 percent of the almost 550,000 school buses operating in the U.S. in 2017 powered by alternative fuels. Nationwide, 40 percent of America's school buses use the newest generation of advanced diesel technology that meet the latest U.S. EPA emissions standards for near-zero emissions of particulate matter and NOx. Today's ultra-low sulfur diesel fuel, advanced engines and effective emissions control combine to achieve near zero emissions that is smoke free.⁷

Diesel is a Platform of Continuous Improvement

First Generation



Current Generation



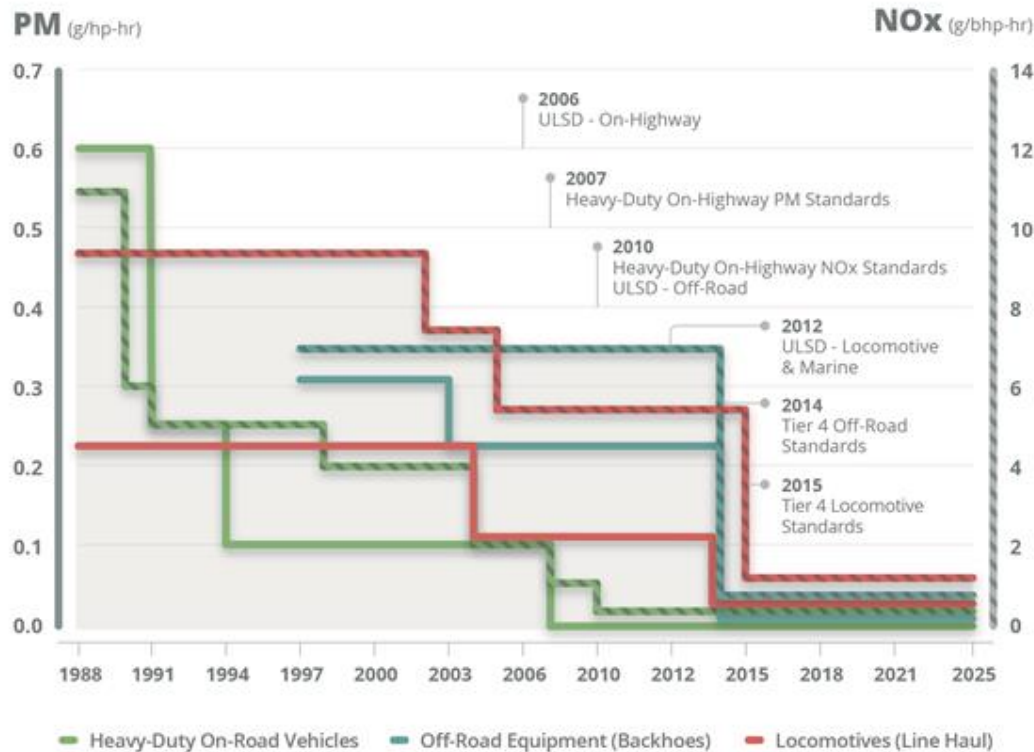
Next Generation



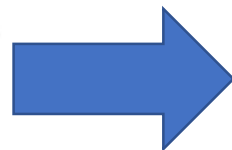
Continual Progress of Diesel Technology Delivers Benefits



PROGRESS TO NEAR-ZERO PM & NOx EMISSIONS



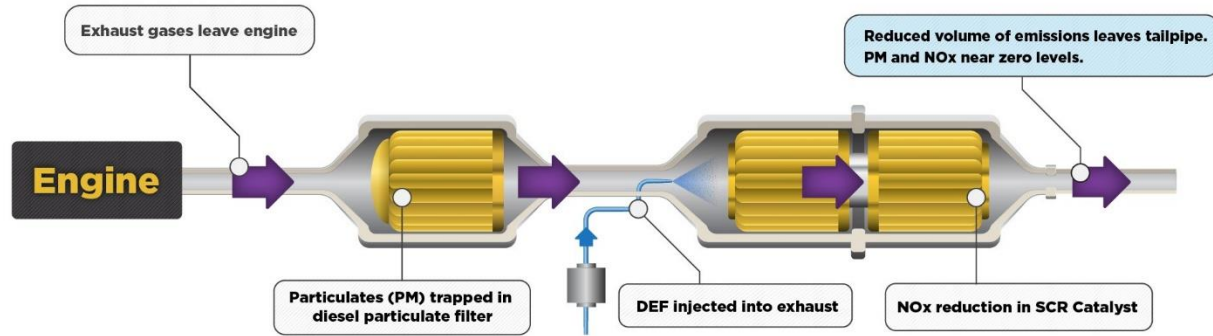
EPA Tailpipe Emissions Standards for Heavy-Duty On- and Off-road Applications



Source: U.S. EPA Office of Transportation and Air Quality (OTAQ)

What Is New Technology Diesel?

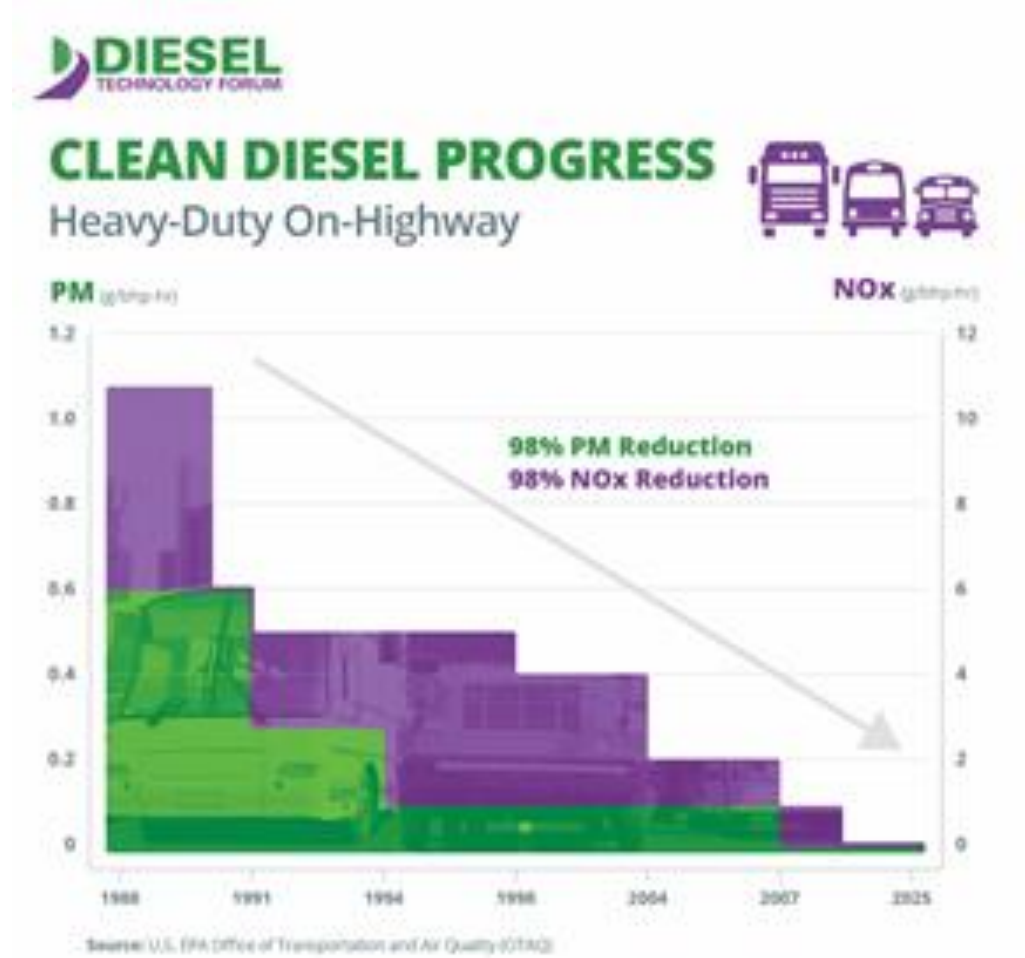
Diesel Emissions Control System



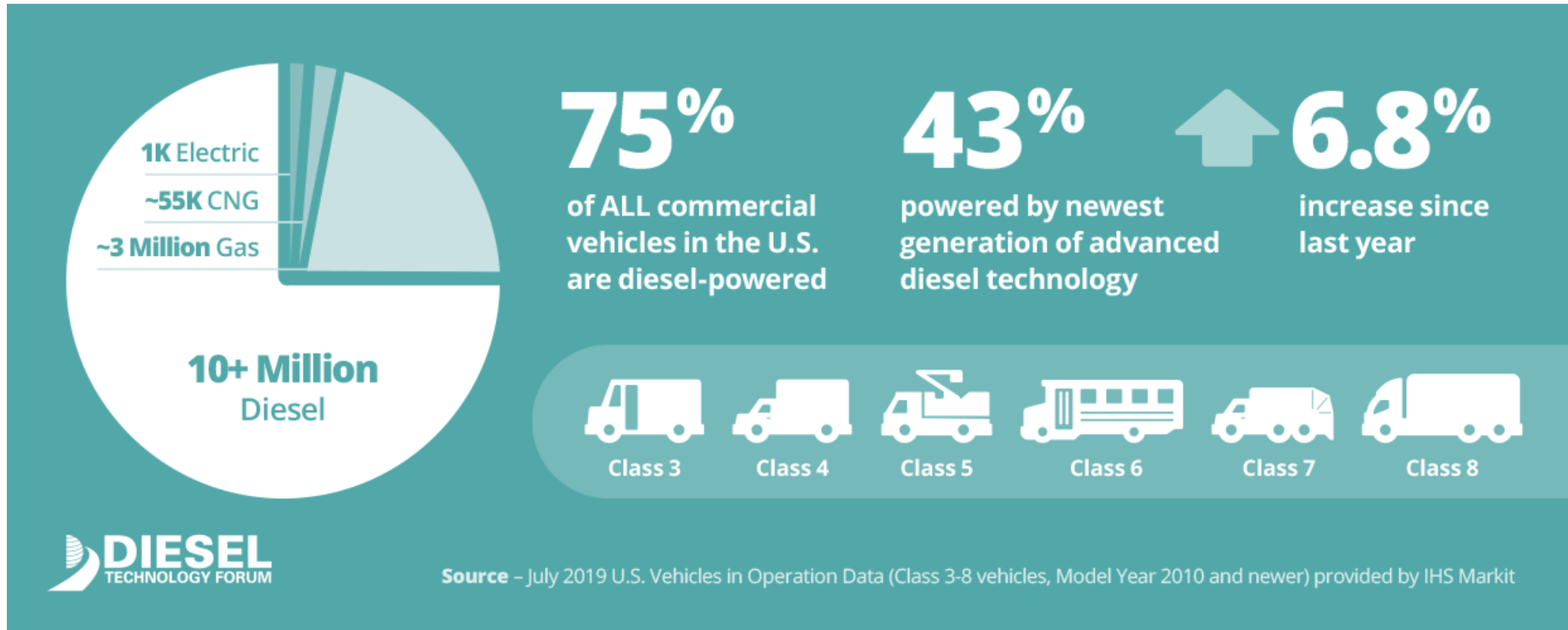
This schematic shows how Selective Catalytic Reduction (SCR) with a Diesel Particulate Filter (DPF) System works. Untreated exhaust gas passes from the engine into a DPF that traps over 95 percent of particulate matter or soot. The exhaust moves into a mixing chamber where the exhaust gas is dosed with a precise spray of diesel exhaust fluid (DEF) reacts with oxides of nitrogen (NOx) on a special catalyst and converts these gases into nitrogen dioxide and water vapor. The system reduces PM and NOx and other emissions to near zero levels.

*Schematic is not representative of all manufacturers' approach to achieve near zero emissions.

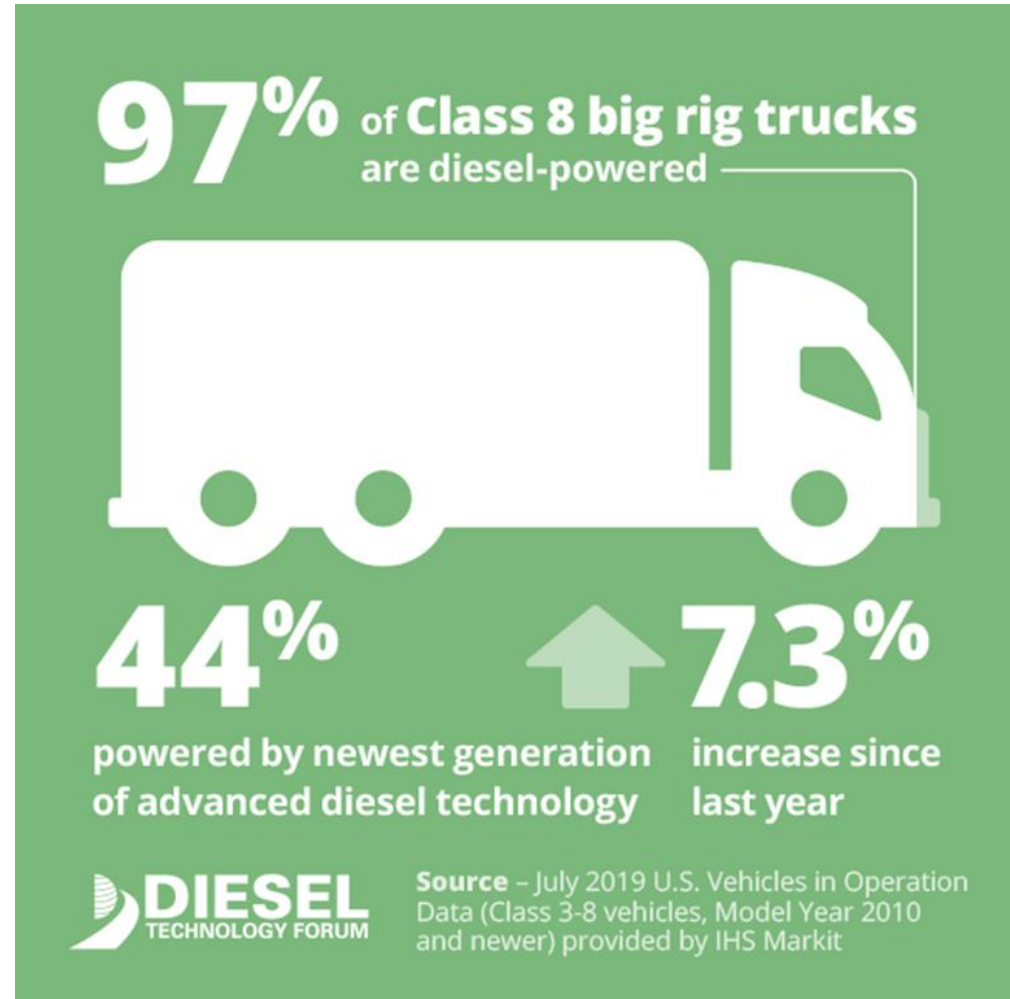
DieselForum.org/SCR



Diesel is the Technology of Choice for America's Trucks



Growth of New Technology Diesel Trucks on the Road Class 8, classes 3-8



Midwest Leads in Adoption of New Technology Diesel Trucks

Percentage of Newest Generation Heavy-Duty Trucks



Ranking

1	Indiana	65%	6	Tennessee	47%
2	Oklahoma	56%	7	Maryland	47%
3	Utah	55%	8	Illinois	46%
4	Texas	50%	9	D.C.	46%
5	Pennsylvania	48%	10	Wyoming	45%

Indiana is #1 for 7 years in a row
at 65% for MY 2010+ heavy-duty trucks



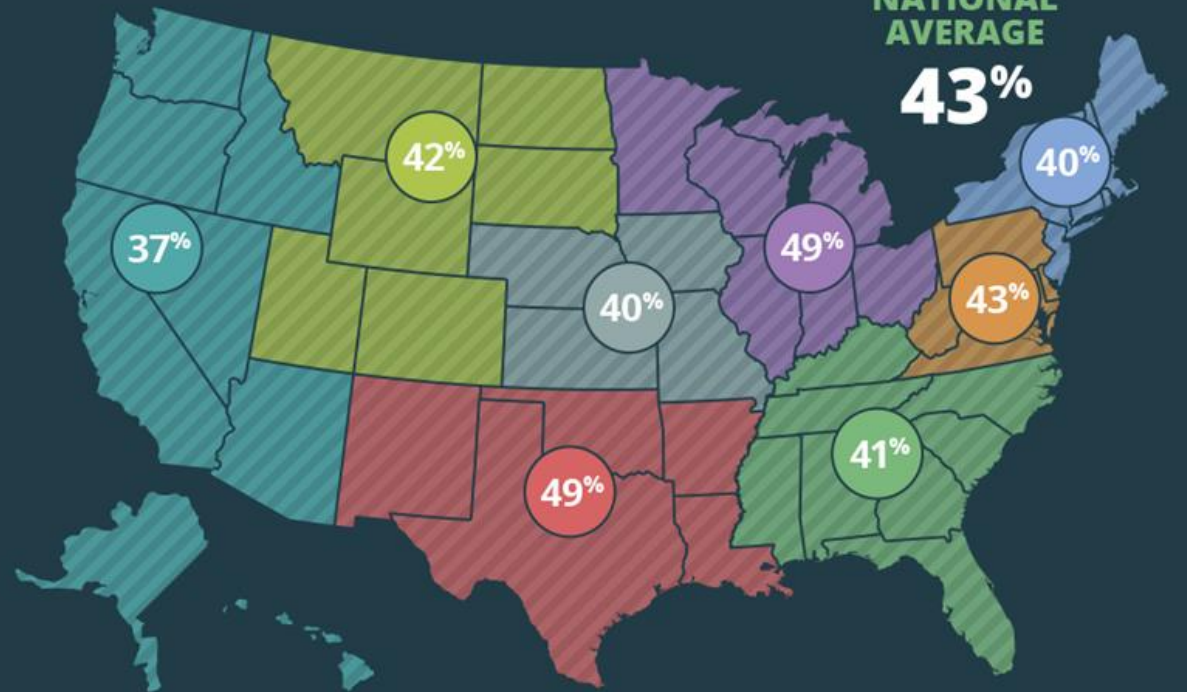
Source - July 2019 U.S. Vehicles in Operation Data (Class 3-8 vehicles, Model Year 2010 and newer) provided by IHS Markit

Percentage of Newest Generation Heavy-Duty Trucks by U.S. EPA Region



NATIONAL
AVERAGE

43%



Source - July 2019 U.S. Vehicles in Operation Data (Class 3-8 vehicles, Model Year 2010 and newer) provided by IHS Markit

New Jersey Ranks 21st nationwide for new technology diesel trucks on the road



#1 State at **64.8%**

Mid Atlantic Region

National Average = 43%

Share of New Tech Diesel Trucks	State
41.2%	New Jersey
45.5%	D.C.
39.4%	Delaware
35.1%	West Virginia
46.6%	Maryland
34.3%	Virginia
47.6%	Pennsylvania
38.6%	North Carolina
41.9%	Mid Atlantic Region

Bottom States for Adoption of New Diesel Trucks

State Ranking	Share of New Tech Diesel Trucks	State
#40	36.3%	CALIFORNIA
#47	32.3%	SOUTH DAKOTA
#48	32.0%	HAWAII
#49	31.8%	ARIZONA
#50	31.0%	ALASKA
#51	30.6%	KENTUCKY

The Benefits of New Diesel Trucks are significant

These new generation diesels are delivering significant clean air, and GHG benefits to society and fuel savings to truckers -- **TODAY.**

New Technology Diesel Trucks Deliver Big Benefits for Climate and Clean Air

Fewer Emissions



↓ **126^M**
Tonnes of CO₂

↓ **18^M**
Tonnes of NO_x

Saved Fuel



↓ **12.4^B**
Gallons of Diesel Fuel

↓ **296^M**
Barrels of Crude Oil



Source - July 2019 U.S. Vehicles in Operation Data (Class 3-8 vehicles, Model Year 2010 and newer) provided by IHS Markit

New technology diesel trucks reduced **126 million tonnes of CO₂** emissions since 2007



Equal to removing CO₂ emissions from **26M** passenger vehicles from the road for one year or making them **zero emission** electric vehicles



Source - July 2019 U.S. Vehicles in Operation Data (Class 3-8 vehicles, Model Year 2010 and newer) provided by IHS Markit

Health effects Institute findings on new technology diesel engines

- “In sum, the ACES results demonstrate the effectiveness of modern aftertreatment technologies used in the modern diesel engines: they greatly reduce the emissions of PM, NO_x, and NO₂, and the levels of other toxic components of NTDE, when tested in the laboratory using FTP and more stringent testing cycles. “
- “After a lifetime of exposure, NTDE does not produce tumors in rats, unlike TDE. Thus, the ACES results demonstrate the effectiveness of DPFs, not only in greatly diminishing the amount of PM from new-technology engines, but also in reducing the toxicity of NTDE significantly as compared with TDE.”

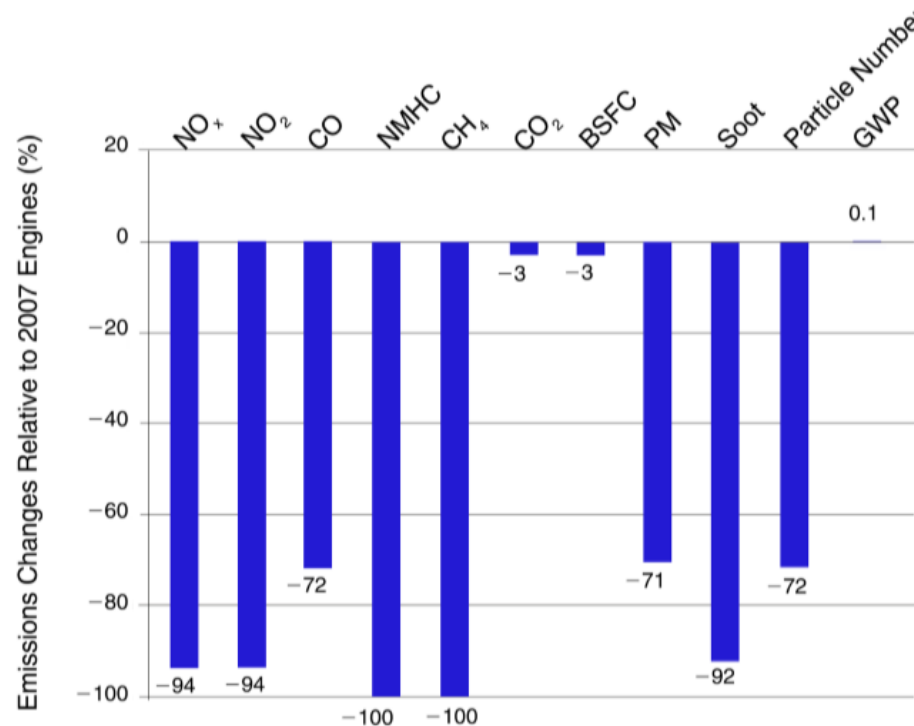


Figure 5. Percent change in emissions from 2010 engines relative to 2007-engine emissions. (BSFC = brake-specific fuel consumption; GWP = global-warming potential.) (From Khalek et al. 2012, Figure ES-2.)



https://www.healtheffects.org/system/files/ACES-Executive-Summary2015_0.pdf

DIESEL'S ROADMAP TO THE FUTURE

Emissions
Closer to
Zero



Increasing
Energy
Efficiency



Expanded
Use of
Renewable
Fuels



Hybridization
Where it
Makes Sense



What's up Next – Closer to Zero Emissions for Trucks

Cleaner Trucks Initiative:

EPA is Seeking Comments on the ANPRM for the Regulatory program for new HD truck Engines, on issues noted below

<https://www.epa.gov/sites/production/files/2020-01/documents/cleaner-trucks-initiative-anpr-2020-01-06.pdf>

- Lowering the tailpipe standard below the “0.2” current standard
- Test Cycle to include idling and low-load operations representative of urban driving
- Expanding useful life of emissions controls beyond 435,000 miles. Evidence suggests real-world useful life of over 900,000 miles
- Expanding warranties on emissions controls beyond 100,000 miles. Most OEMs offer 250,000 mile warranties
- Inclusion of real world driving standards for in-use testing
- Consider tamper resistant electronic controls for emissions
- Incentives for zero-emissions technologies



FOR PLANNING PURPOSES ONLY:

MEDIA ADVISORY

Administrator Wheeler to Make Policy Announcement on Cleaner Trucks Initiative

WASHINGTON (Jan. 3, 2020) – On Monday, January 6, U.S. Environmental Protection Agency (EPA) Administrator Andrew Wheeler and U.S. Representative Denver Riggleman (VA-05) will hold an event with stakeholders in Fauquier County, VA to make an announcement on the Cleaner Trucks Initiative (CTI).

Nationwide Benefits

Diesel Delivers Big Short Term Climate Benefits

Phase 1&2 Rules will be Implemented....and Diesel Will Continue to Deliver Significant Benefits.

Between 2011 and 2030, Diesel Class 3-8 Trucks Will Have Saved....

130 billion gallons of fuel

1.3B tonnes CO₂ = Emissions from the electricity used in 227M homes for 1 year

73 Million tonnes of NO_x = Emissions from all light-duty vehicles for 26 years

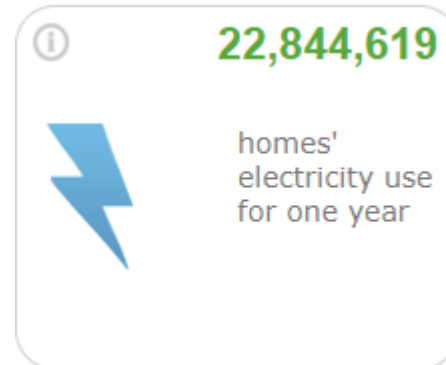
4 Million tonnes of PM = Emissions from all light-duty vehicles for 130 years

Anticipated Benefits to the Northeast

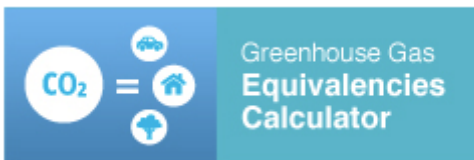
What are the benefits that more efficient commercial vehicles will bring to the region between 2010 and 2030?



- 12.9 billion gallons of fuel saved
- 307 million barrels of crude oil
- 131 million tonnes CO₂



Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont



How Will We Get There?

The National
Academies of

SCIENCES
ENGINEERING
MEDICINE

THE NATIONAL ACADEMIES PRESS

Reducing Fuel Consumption and Greenhouse Gas Emissions of
Medium- and Heavy-Duty Vehicles, Phase Two: Final Report
(2019)

2021 Model Year CO₂ Grams per Ton-Mile

	Day Cab		Sleeper Cab	Heavy-Haul
	Class 7	Class 8	Class 8	Class 8
Low roof	105.5	80.5	72.3	52.4
Mid roof	113.2	85.4	78	
High roof	113.5	85.6	75.7	

2024 Model Year CO₂ Grams per Ton-Mile

	Day Cab		Sleeper Cab	Heavy-Haul
	Class 7	Class 8	Class 8	Class 8
Low roof	99.8	76.2	68	50.2
Mid roof	107.1	80.9	73.5	
High roof	106.6	80.4	70.7	

2027 Model Year CO₂ Grams per Ton-Mile

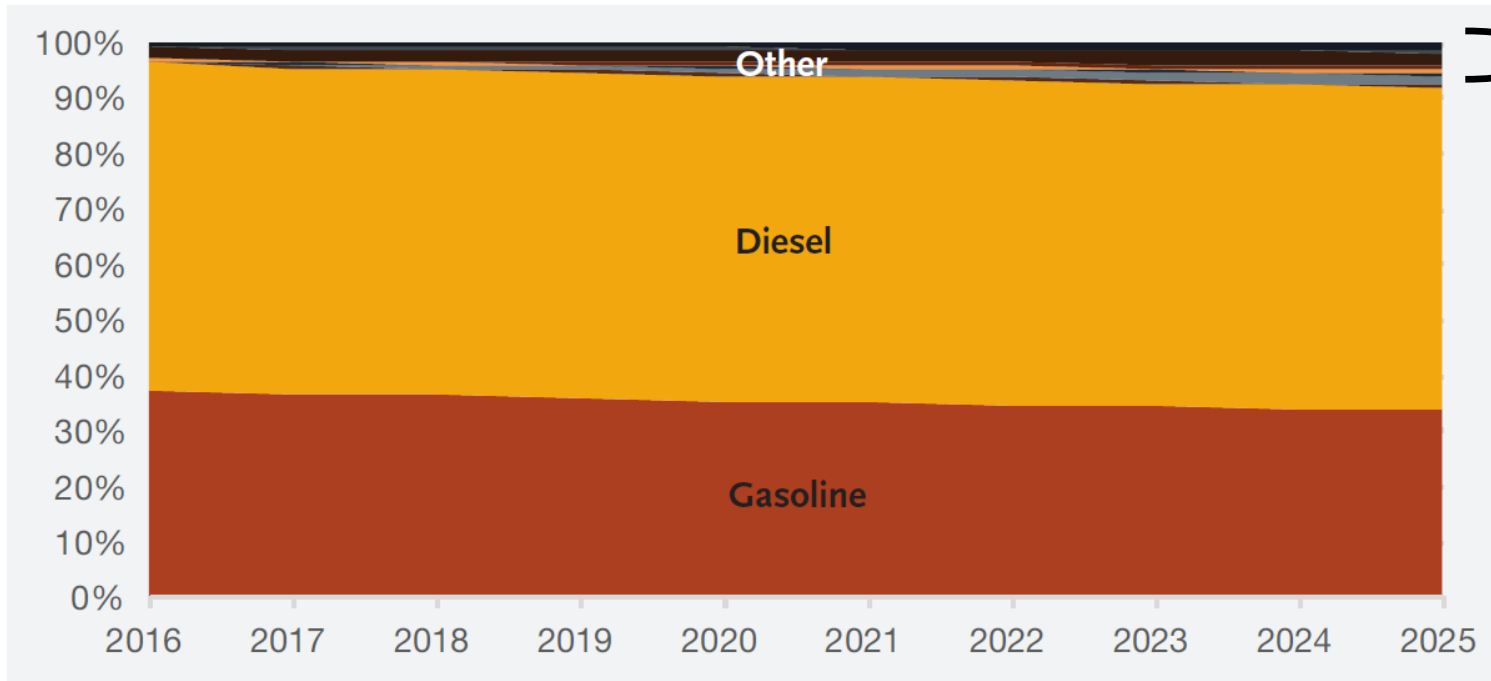
	Day Cab		Sleeper Cab	Heavy-Haul
	Class 7	Class 8	Class 8	Class 8
Low roof	96.2	73.4	64.1	48.3
Mid roof	103.4	78	69.6	
High roof	100	75.7	64.3	

Hybridization
 Electrification
 Waste Heat Recovery
 Engine Downsizing
 Engine Downsizing
 High Pressure Direct Injection CNG
 Predictive Cruise Control
 Low Rolling Resistance Tires
 Aerodynamic Designs
 Light Weight Components
 Advanced Transmissions
 Many More.....

SOURCE: EPA and NHTSA (2016c).

What Fuels Will Get Us There?

Figure 20a U.S. Market Share of Commercial Vehicle Sales (Aggressive Scenario)



“Hybrid diesels and CNG account for most of the lost market share.”

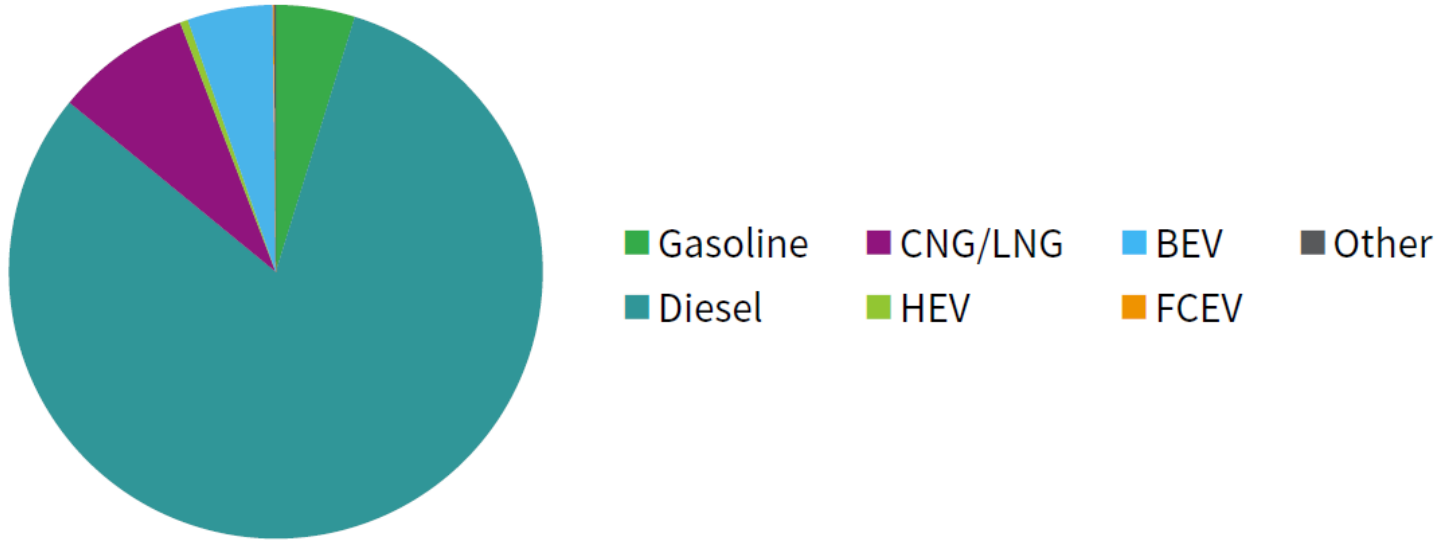
Fuels Institute

Tomorrow's Vehicles
A Projection of the Medium and Heavy Duty Vehicle Fleet Through 2025

(Sources: Navigant; Fuels Institute)

Diesel Technology will continue to dominate HD Truck Sector beyond 2040

Rivalry Scenario— Share of 2040 sales by fuel type



“Advancements in the diesel engine allow it to remain cost competitive to new technologies to 2040, but share will decrease over time.”



IHS Markit™

Reinventing the Truck

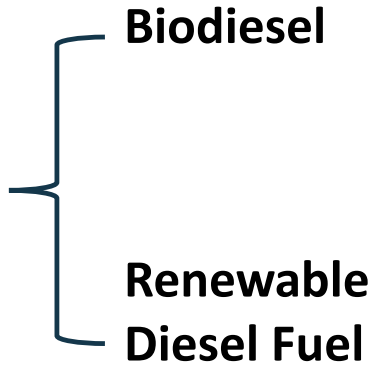
Analyzing the impact of electrification, alternative fuels and autonomy advances on fleets, OEMs and suppliers.

What about alternatives?

- **Diesel's combined core attributes are formidable:** Power density, performance, reliability, durability, maintainability, scalability, most energy efficient internal combustion engine, economical ownership and operation, near-zero emissions, able to utilize renewable biofuels, nationwide-accessible fuel, servicing, parts networks, known secondary sales markets, flexibility in routing.
- Truck and Engine Manufacturers are exploring a range of alternatives including all electric, hydrogen
- Greatest suitability for alternatives to diesel likely to come in regular routes, short range, urban operation, refueling/charging issues solvable and affordable.

What if Diesel Engines didn't run on diesel fuel?

Advanced Biofuels
=
at least 50% reduction in GHG emissions



Feedstocks:
Waste Animal Fats
Waste Vegetable Oils

Blends Up to 20%

No additional fueling infrastructure needs

Feedstocks:
Waste Animal Fats
Waste Vegetable Oils

100% Replacement to Petroleum Diesel Fuel –
meets the same technical specs as petroleum diesel

No additional fueling infrastructure needs



80% to 86% Reduction in GHG emission

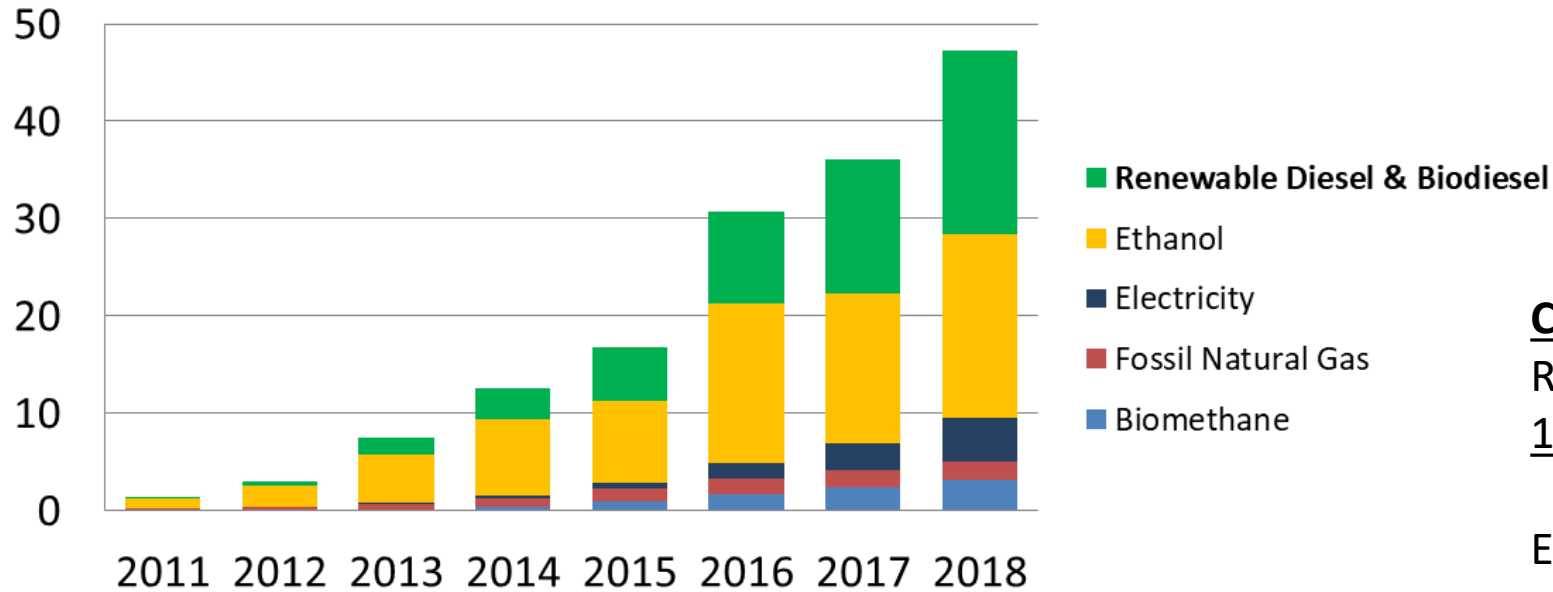
Use of Low-carbon renewable biofuels in existing diesel engines both new and existing can occur overnight with little to no changes in operations

Big Benefits from Advanced Biofuels



Cumulative CO2 Reductions (million tons)

SOURCE: California Energy Commission, Low Carbon Fuel Standard Dashboard



Of all the fuel types and technologies, biodiesel and renewable diesel are contributing the greatest CO2 reductions in California....and it takes a diesel engine to realize the benefits

CO2 Reduced (2011-2018)

Renewable Diesel and Biodiesel = 18.9 million tons

Ethanol = 18.8 million tons

Battery-Electric = 2.5 million tons

Biodiesel & Renewable Diesel Fuel Are Coming out East



Media Contact:
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 646-832-6533

DCAS to Expand Use of 99% Petroleum-Free Renewable Diesel in City Vehicles

City Aims to Phase Out Use of Traditional Diesel Fuel

NEW YORK – The NYC Department of Citywide Administrative Services (DCAS) today announced that it will expand use of renewable diesel fuel, a 99% petroleum-free alternative to traditional diesel fuel. The fuel reduces CO2 emissions by 65% compared to the petroleum-based version. This move is part of the City's efforts to phase out its use of regular diesel.

13,000 heavy-duty diesel trucks and equipment will be operating on a blend of biodiesel and renewable diesel fuel.



Neste and the Port Authority of New York & New Jersey (PANYNJ), have signed a Memorandum of Understanding on a joint sustainable fuel initiative.

The partners will be working together to facilitate the use of sustainable transportation fuels at Port Authority facilities and in its fleet vehicles and equipment, including renewable aviation fuel, **renewable diesel**, renewable propane and other sustainable fuel products

Timelines

	Vehicle and Equipment Sectors	Technology and Fuel Availability
Advanced renewable biofuels:	ALL (on road, off Road) No hardware changes to vehicles required; <i>change fuel filters at outset regular maintenance</i>	Available today; Fueling infrastructure in place; Barge or road or rail tanker loads to users;
New technology diesel engines	ALL – HDOH, (Since 2007 all have PM filters; Since 2011, all have PM Filters and SCR systems) Off road engines and equipment 2014 and later MY – construction, generators, marine, etc.	Available today. Diesel Exhaust Fluid (DEF) for SCR systems widely available Available today
Next step in Lower Emissions from new HDOH diesel trucks-	Commercial trucks over 10,000 lbs gwvr EPA Rule to further reduce NOx emissions	ANPRM Jan 6, 2020; NPRM by COB 2020 Final rule expected early 2021; <i>likely</i> implementation 2025 (optional)-2027;
Reductions in CO2 emissions, increase in fuel efficiency	Commercial trucks EPA NHTSA GHG Rules;	2014 Phase 1 rule implementation 2021 Phase 2 rule Implementation

Final Thoughts

- New Technology Diesel engines are achieving near zero emissions today; new rulemaking for Heavy duty trucks ensures lower emissions for the future, and lower greenhouse gas emissions.
- Legacy product solutions – emissions control devices and repowers are available for some sectors and applications; DERA funding available and successful; balance costs and investment versus buying new technology. Industry and DTF strongly supports state anti-tampering and emissions inspection efforts, crackdown on coal-rolling.
- Use of advanced renewable biofuels across existing fleets brings fast carbon reduction benefits to large vehicle populations with minimal investments.
- Promise of alternatives to diesel not borne out; economically, technically or temporally at this time. Manage expectations, balance hype with commercial product availability.
- Attacking climate and clean air challenge will require many solutions; new generation of diesel technology is one of them.

Coming Next Recent Research on Ports and Emission Reduction Strategies

The most cost-effective upgrades make the biggest health impact

New Tier 4 engines for tug boats reduce NOx emissions by 91%

The \$2.9 billion VW Environmental Mitigation Trust provides funding to upgrade older vehicles and equipment to rapidly reduce nitrogen oxide (NOx) emissions, which contribute to hazardous smog pollution. Upgrading just one of the oldest, dirtiest tug boats is like taking tens of thousands of passenger vehicles off the road per year, bringing substantial health benefits to at-risk communities. With states now deciding how to invest these funds, repowering these older vessels with cleaner Tier 4 engines is a game-changer for delivering immediate and cost-effective air quality benefits.

Upgrading an old tug boat with new Tier 4 engines removes **30 tons of NOx/year¹**

This is equivalent to

OR

Replacing **96** drayage trucks²

Removing **26,667** cars for 1 year³

Upgrading old engines means cleaner air for all

EPA estimates that by 2020, only 3% of tug boats will be replaced with cleaner Tier 4 engines. The VW Environmental Mitigation Trust provides a rare opportunity to retire the oldest diesel engines still in operation, which can last 50 years or longer. Tier 4 or Tier 3 engines will deliver cleaner, healthier air faster to at-risk communities. These new engines also improve fuel efficiency, which reduces CO₂ and black carbon emissions, two important greenhouse gas pollutants.

Tug projects are a better value

1 ton of NOx reduction costs

Other projects
\$30,000⁴

Tier 4 tug engines
\$5,000¹

1. Ramboll, 2016. Emission reductions and cost effectiveness for marine and locomotive projects

2. EPA, 2016. National Port Strategy Assessment

3. Tier 2 car driven 15,000 miles per year

4. FHWA, 2015 CMAQ Cost-Effectiveness Report



Marine engines are **2X as long lived** as EPA emissions models assume.

Marine engines are **among the most cost effective** projects to reduce criterial pollutant emissions

Significant benefits generated for near port communities in New Jersey by replacing older engines that power tugs, ferries and other marine workboats.

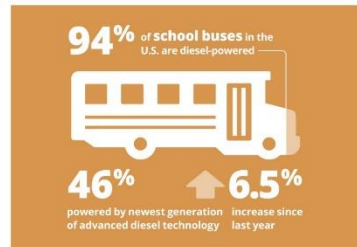
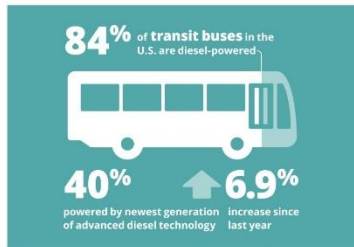
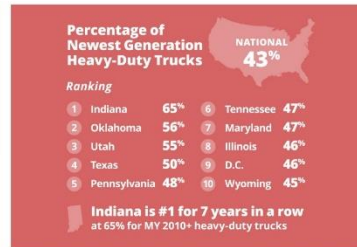
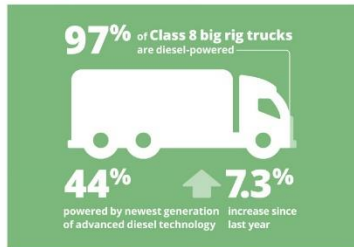
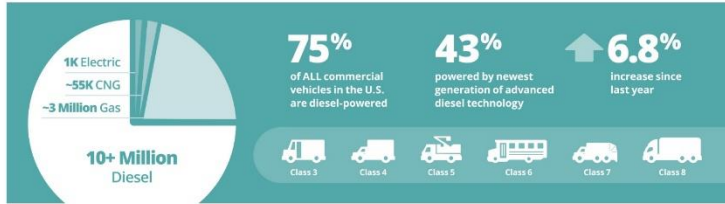
Resources for You

Find all this and more at

<https://www.dieselforum.org/news-and-resources/>

DIESEL DELIVERS

the Goods and the People



Source – July 2019 U.S. Vehicles in Operation Data (Class 3-8 vehicles, Model Year 2010 and newer) provided by IHS Markit

NEW JERSEY FACT SHEET

Did you know? 41% of heavy-duty vehicles in New Jersey meet or beat 2010 U.S. EPA emission standards for particulate matter and NOx. Learn more on the New Jersey Fact Sheet.¹

GET THE DETAILS

<https://www.dieselforum.org/in-your-state>

Thank You

More information may be found at
<https://www.dieselforum.org>

Contact Us: dtf@dieselforum.org

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