



RENEWABLE LOW CARBON FUELS BOOST THE FUTURE FOR DIESEL



Allen Schaeffer
Executive Director, Diesel Technology Forum



AGENDA

About the Diesel Technology Forum

State of Diesel Technology

Policy Trends and Other Influences

The opportunity for Renewable Fuels: Sustainability and Decarbonization



About the Diesel Technology Forum

Mission

To be the leading voice championing the unique value, progress and future potential of diesel fuel and technology;

To positively influence public and policymaker opinions regarding diesel technology; and

To contribute to the greater awareness and expanded use of clean diesel technology.

Vision

To champion energy conservation and environmental stewardship;

To encourage scientific inquiry and discussion;

To enable worldwide economic growth through the transformation of clean diesel technology engines, fuels, & emissions control technology;

To move diesel into the mainstream of technology options, positioning it as a sustainable energy technology.

Strategic Pillars

RAISE our industries share of voice

EDUCATE opinion framers, legislators, think tanks and selected environmentalists

REACH out to potential allies and Interest groups

RESPOND to inconclusive science - respond quickly and persuasively to unfounded attacks

DEFEND diesel as a technology of choice

DTF is a not-for-profit educational association headquartered outside of Washington DC, established March 2000.

WHAT WE DO

Energy-Efficiency
Emissions
Environment
Economics
Essential Uses

How Diesel Fits in the Carbon-
Constrained Clean Energy Future

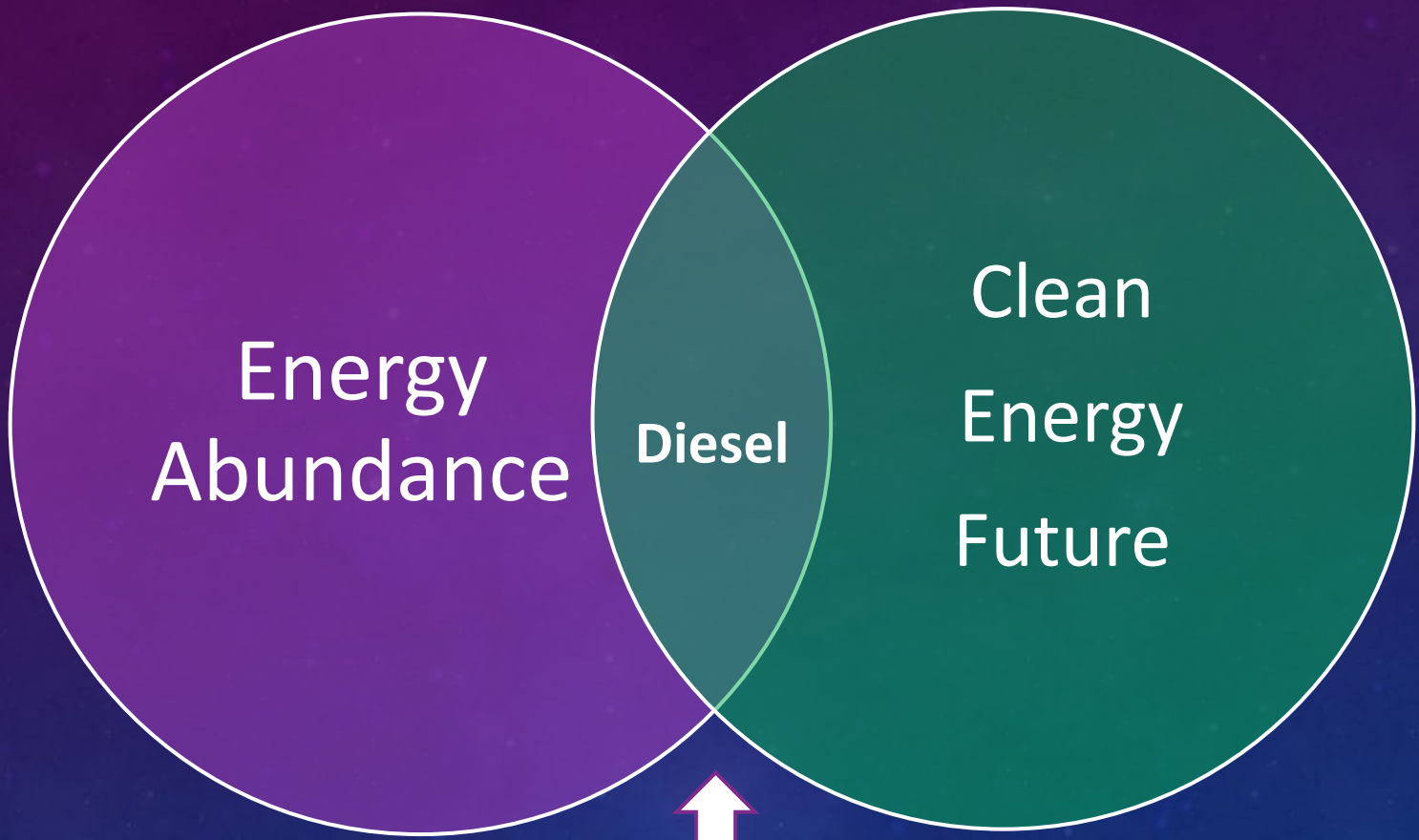


Members of the Diesel Technology Forum are leaders in advanced technology engines, vehicles, equipment, fuels and components



PROVIDING ENERGY. IMPROVING LIVES.





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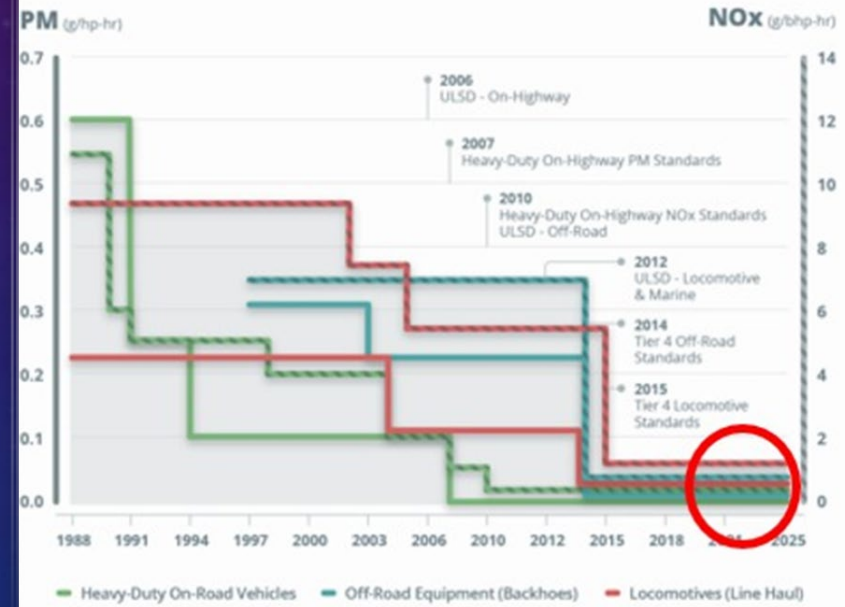
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PROGRESS TO NEAR-ZERO PM & NOx EMISSIONS



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

DIESEL POWERS KEY SECTORS OF THE GLOBAL ECONOMY (U.S. ONLY DATA

SHOWN)

- **Agriculture**

- More than 75% of all Ag Equipment; nearly all large machines and tractors

- **Construction**

- All large and medium size construction machines and equipment; most all small compact equipment

- **Goods Movement**

- Over 90 percent of commercial Trucks (U.S.)
- Nearly all workboats, harborcraft, inland waterway barges, passenger and vehicle ferries, buoy tenders,
- All Freight locomotives, nearly all switchers

- **People Movement**

- 70 percent of all transit buses
- 90 percent of all school buses
- About 1.5% of new personal vehicle sales have diesel engines (Pick up trucks, Large SUVs, Vans)

- **Power Generation**

- Emergency back up/standby generators; prime power generation in some parts of world

- **Military, Emergency Services and Industrial**

- Tactical military vehicles, drinking and wastewater system back-up pumps, Nuclear power plants and more.

MISSION-CRITICAL SERVICES DEPEND ON DIESEL POWER

Diesel is an essential partner powering vital emergency services 24 hours a day, 365 days a year. Count on proven technologies like diesel power to get the job done, no matter the conditions or circumstances.



Diesel engines are the gold standard for backing up grid electrical power due to their reliability, response time and load-carrying capability. Essential city services like drinking water treatment, wastewater systems and telecommunications are key to ensuring public health and safety.

Call **911** and odds are that a piece of diesel-powered equipment will respond. Nowhere is it more critical to have the ultimate performance and reliability than in fire and emergency vehicles, where diesel is the technology of choice.

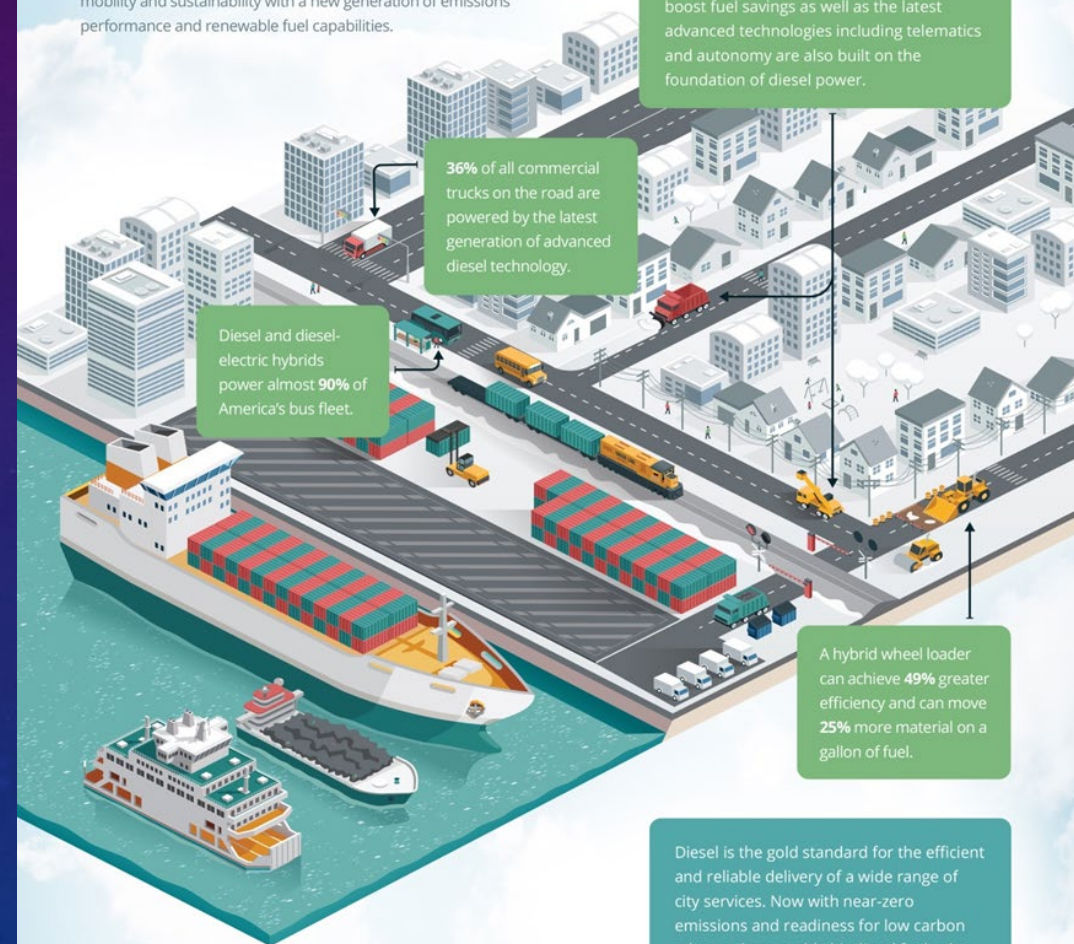


www.dieselforum.org/cities

DIESEL POWER Delivers Essential City Services

Because of its efficiency, safety, reliability and performance, diesel is the technology of choice for supplying a wide array of city services. Diesel facilitates the efficient delivery of city services, enhancing mobility and sustainability with a new generation of emissions performance and renewable fuel capabilities.

Maintaining, repairing or building roads and other infrastructure requires diesel-powered heavy equipment. The new generation of heavy equipment is greening construction by reducing emissions on job sites and using less fuel. Hybridization and advanced energy storage systems that boost fuel savings as well as the latest advanced technologies including telematics and autonomy are also built on the foundation of diesel power.



36% of all commercial trucks on the road are powered by the latest generation of advanced diesel technology.

Diesel and diesel-electric hybrids power almost 90% of America's bus fleet.

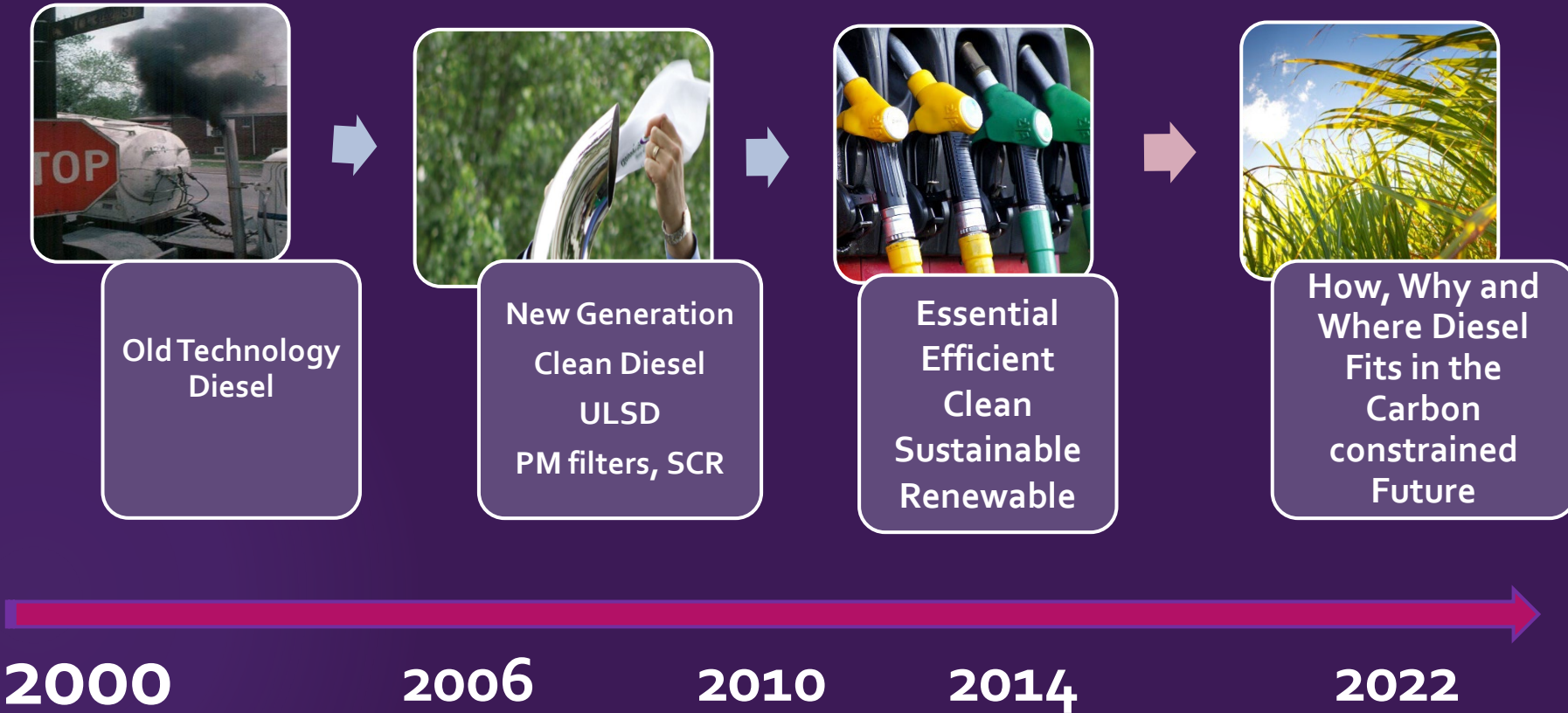
A hybrid wheel loader can achieve 49% greater efficiency and can move 25% more material on a gallon of fuel.

Diesel is the gold standard for the efficient and reliable delivery of a wide range of city services. Now with near-zero emissions and readiness for low carbon advanced renewable biodiesel fuels, the new generation of diesel power will help cities save money and be more sustainable and resilient.

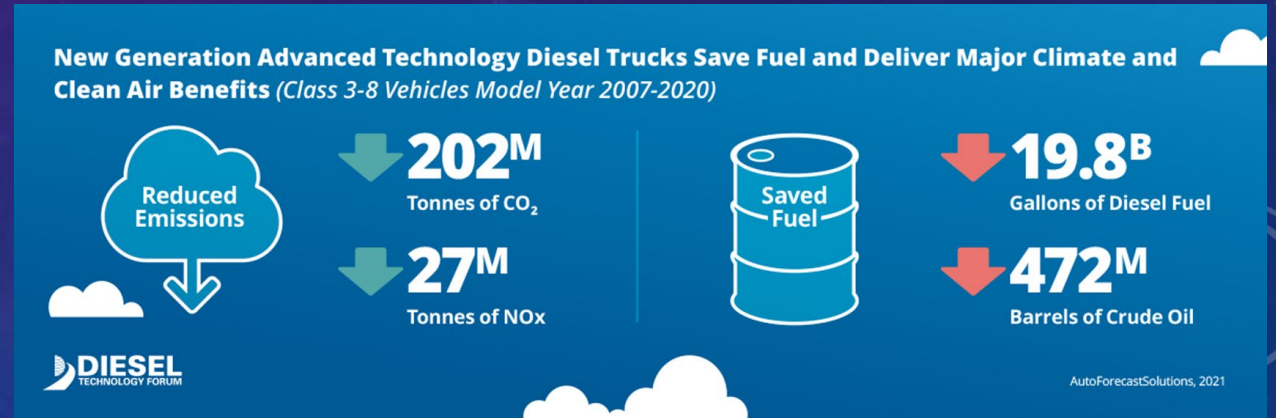
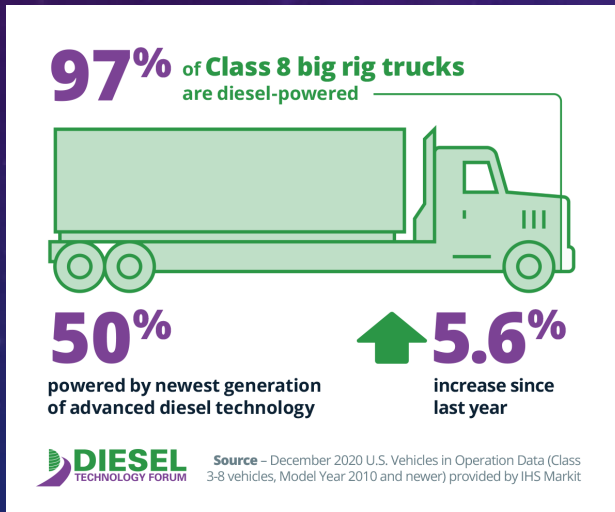
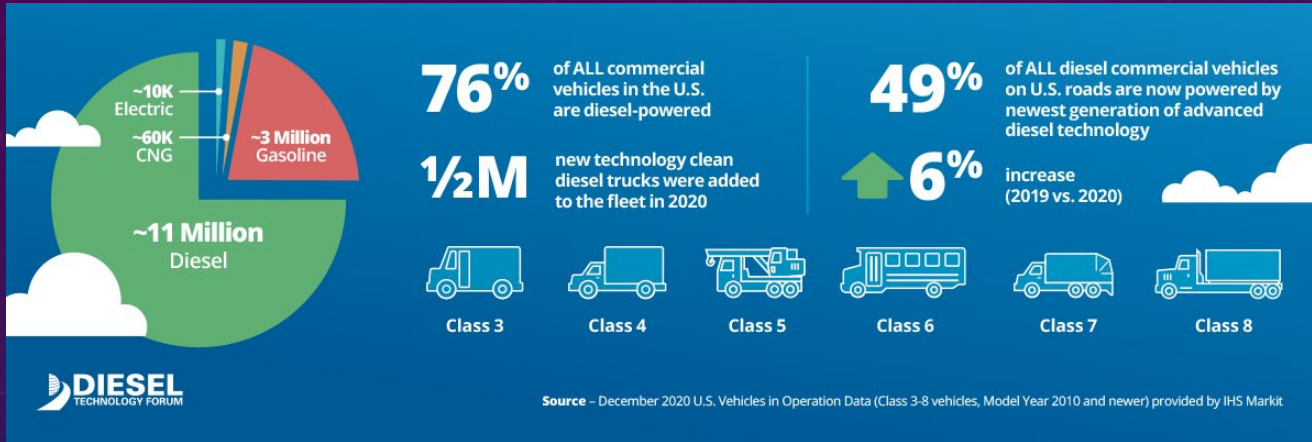


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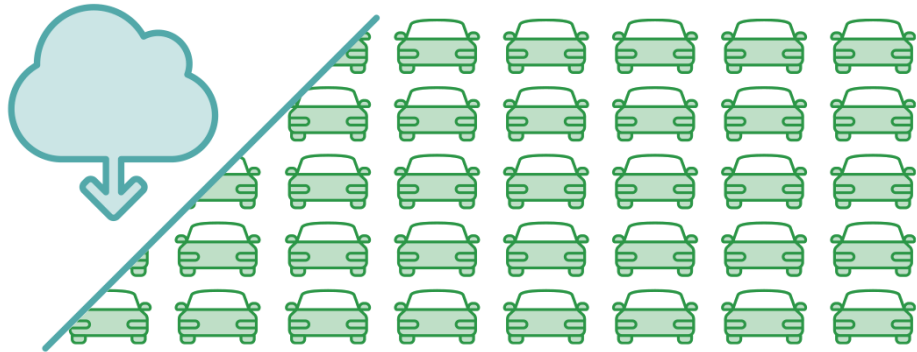
DIESEL DOMINATES TODAY'S US COMMERCIAL VEHICLE FLEET...



The new generation of diesel is near zero emissions and is decarbonizing trucking now. Since 2007 new diesel trucks have generated significant fuel savings and climate benefits.

AND NEW DIESEL TECHNOLOGY DELIVERS LARGE SCALE BENEFITS TODAY

New technology diesel trucks reduced **202 M tonnes of CO₂** emissions since 2007

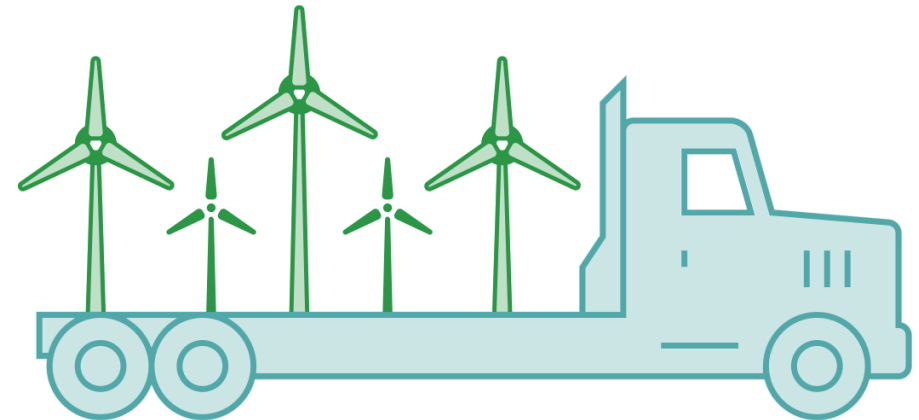


Equal to removing CO₂ emissions from **43M** passenger vehicles from the road for one year or making them **zero emission** electric vehicles



Source – AutoForecastSolutions, 2021

New technology diesel trucks reduced **202 M tonnes of CO₂** emissions since 2007



Equal to a wind farm with **42k turbines over 210k acres** (~5x the size of Washington D.C.)



Source – AutoForecastSolutions, 2021

DIESEL'S ROLE IN AGRICULTURE

- Diesel engines power more than two-thirds of all farm equipment,
- Transport 90 percent of its product and
- Pump one-fifth of its water in the United States.
- Ninety-six percent of the large trucks that move agricultural commodities to railheads and warehouses are powered by a diesel engine.
- One hundred percent of the freight locomotives, marine river grain barges and ocean-going vessels that deliver these products to markets at home and abroad are powered by diesel.



Agriculture Applications



JOHN DEERE



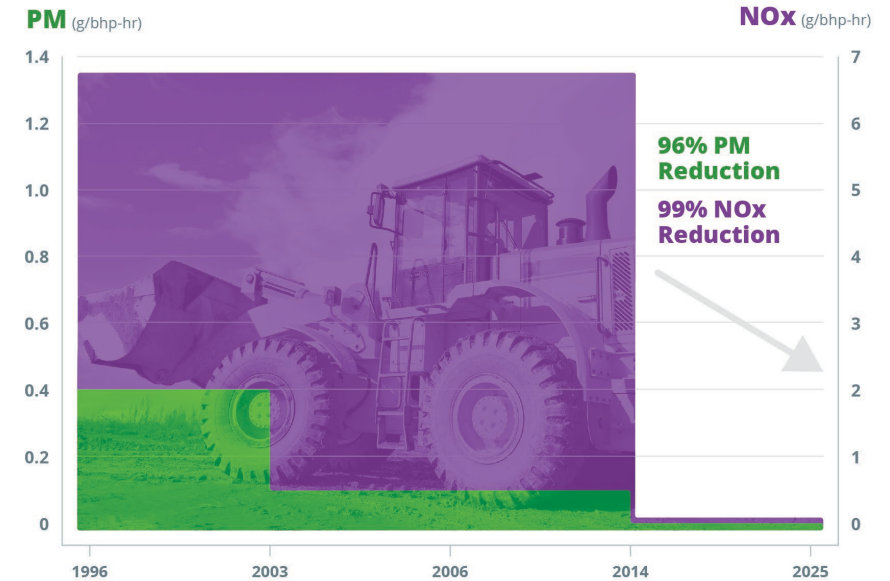
•Why Diesel?

- Energy density of the fuel
- Power of the engines
- Efficient operation/range of travel
- Reliability, durability
- Available, Established and widespread parts, service and fueling networks
- **Near zero emissions**
- **Suitability for existing and new equipment to use renewable biobased diesel fuels**



CLEAN DIESEL PROGRESS

Large Off-Road Equipment



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

DIESEL VALUE PROPOSITION

NOW CLEANER AND MORE EFFICIENT, NO OTHER TECHNOLOGY YET COMES CLOSE TO CHECKING ALL THE BOXES

- ✓ U.S. Nationwide fuel availability ~142,000 public stations;
- ✓ Unmatched global service and parts network
- ✓ Full compatibility with renewable low-carbon fuels
- ✓ Proven and reliable
- ✓ Durable – million-mile operation for trucks; thousands of hours for machines and equipment
- ✓ Remanufacturing/rebuilding well established
- ✓ Low cost of acquisition and ownership
- ✓ High resale value/well established secondary market



THERE ARE OPPORTUNITIES FOR DIESEL ALTERNATIVES IN THE AG SECTOR

Customer Requirements:

Fuel Availability

Energy Density

Energy/Fuel Cost

Powertrain Cost

Carbon Credits

CO₂ Emissions

System Ruggedness

Renewable/Biodiesel

Ethanol

Biomethane/CNG

Diesel

Propane

Battery Electric

Hydrogen

Diesel
Prevalence

STRATEGIES BOOSTING DIESEL'S FUTURE

Greater Efficiency

SuperTruck achieved 55% BTE 11/2021

- Combustion management, engine architecture - piston bowl design, coatings, CDA, WHR, hybridization, electrified components

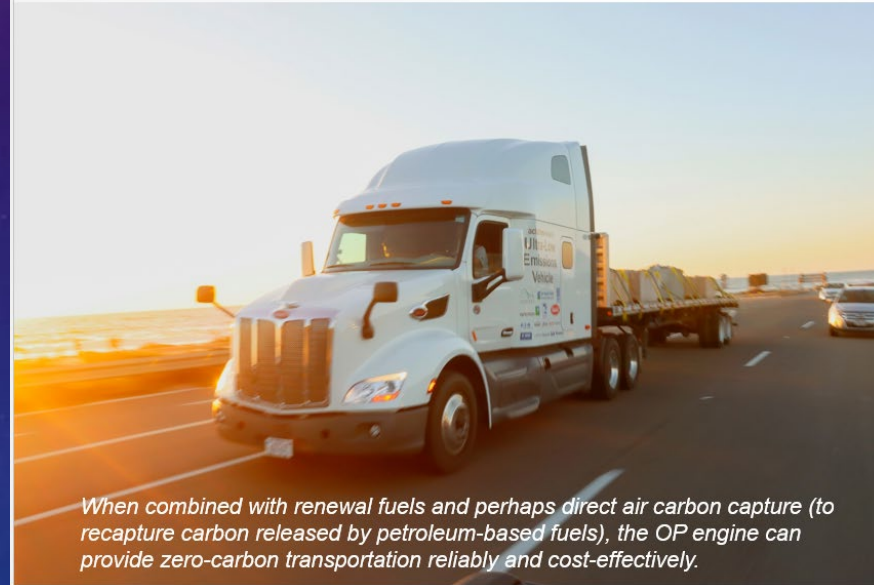
Lower Emissions

- Even lower NO_x and PM emissions starting in 2024-2027

New Fueling Options

- Low carbon renewable biodiesel fuels 20-80% lower GHG; no new vehicles or infrastructure required
- Ethanol, e-fuels boost opportunity for internal combustion engines

Heavy Duty Diesel Demonstration Project



When combined with renewal fuels and perhaps direct air carbon capture (to recapture carbon released by petroleum-based fuels), the OP engine can provide zero-carbon transportation reliably and cost-effectively.

- Funded by the California Air Resources Board
- The cleanest, most efficient diesel engine on the planet
- Currently used in revenue service by a major retailer
- 93 – 99.9% reduction in NO_x
- 10-16% reduction in CO₂
- Already meets CARB 2027 and EPA 2027 (GHG II)
- All with conventional underfloor aftertreatment system – no additional emissions control technology

AGENDA

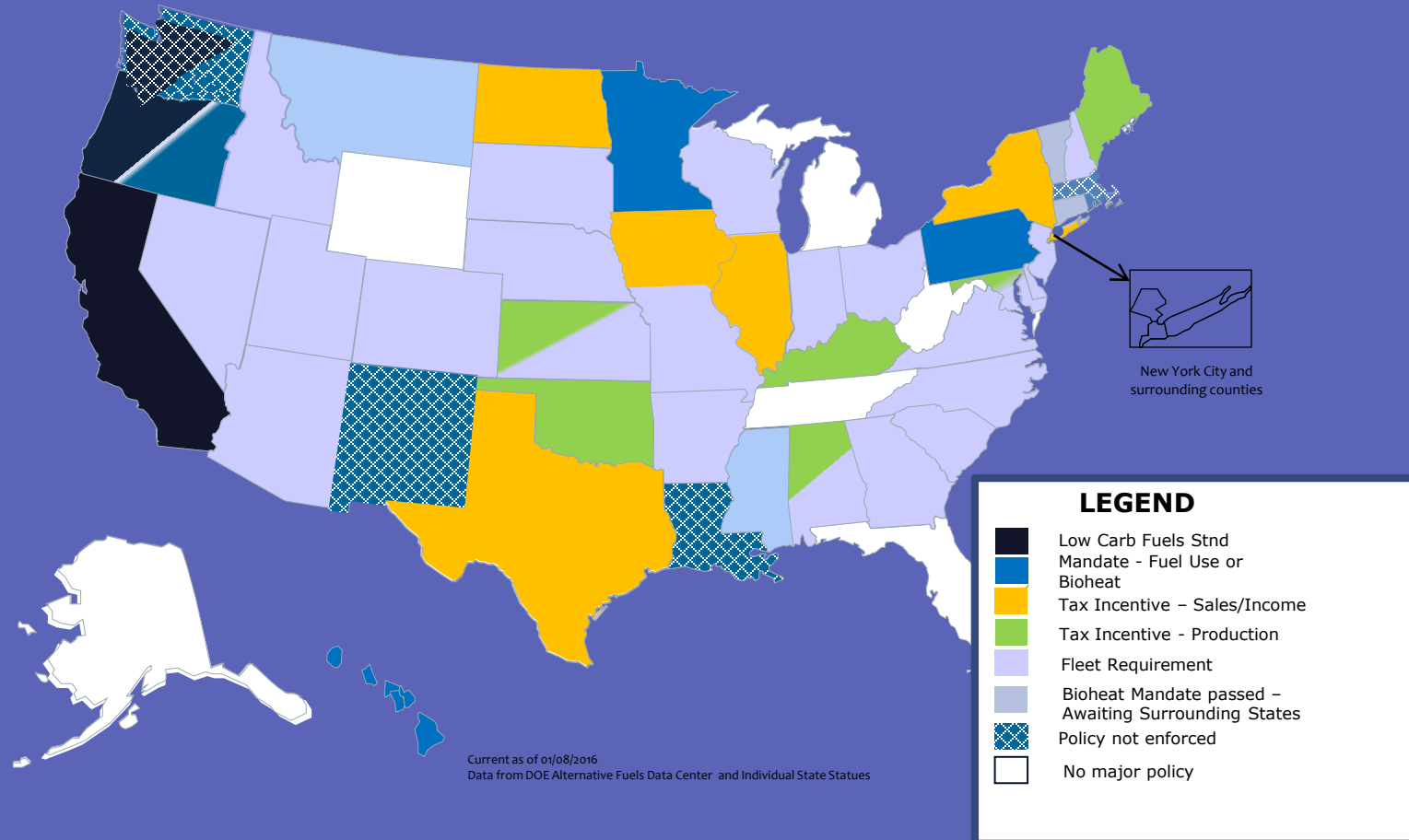
- About the Diesel Technology Forum
- State of Diesel Technology
- The opportunity for Renewable Fuels: Sustainability and Decarbonization: policies and data



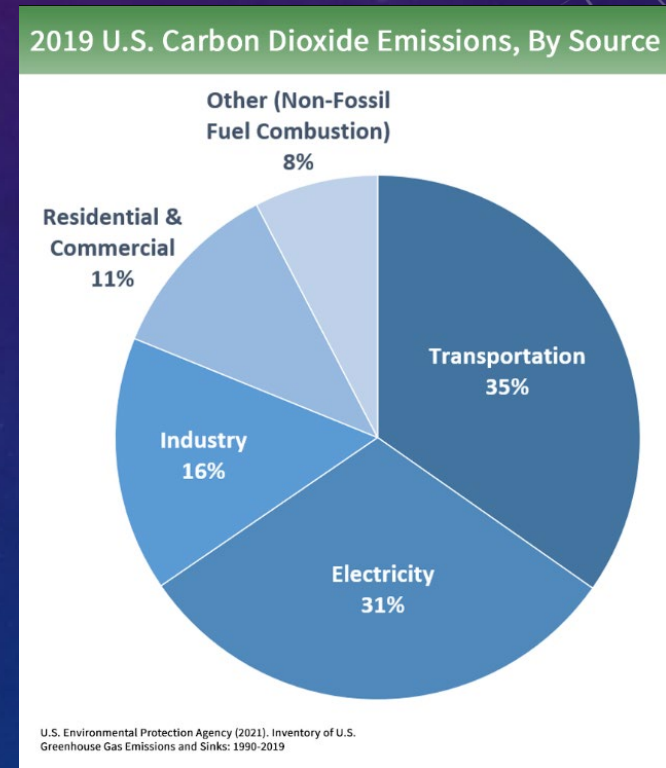
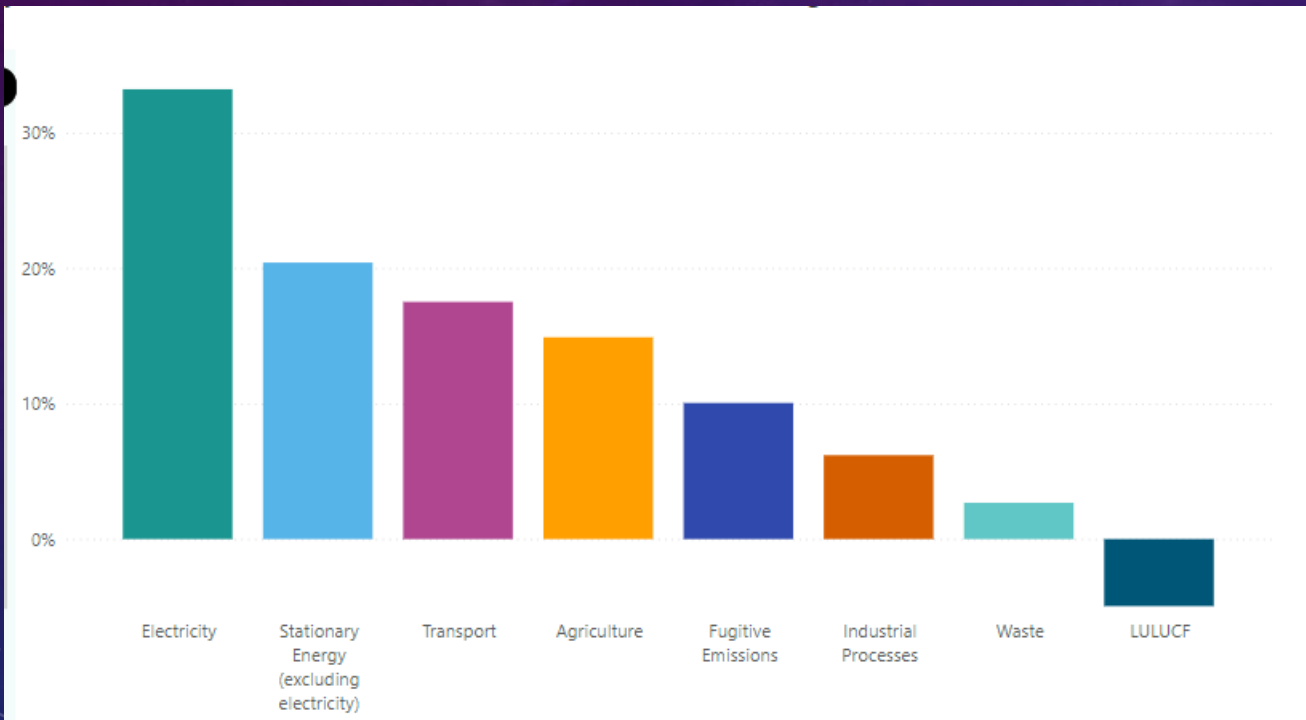
MOTIVATIONS FOR USE OF RENEWABLE BIODIESEL FUELS ARE GROWING!

- Attacking climate change: US Goal: Net Zero Carbon Emissions by 2050
 - Transportation Sector #1 for GHG emissions
 - Numerous state's have established separate goals – example New York 85% GHG reduction by 2050
- As part of Corporate Environmental, Social and Governance (ESG) efforts
- Compliance with current policies – Renewable Fuel Standard (RFS)
- Alternative to new technologies like electric and hydrogen
- Mitigate higher petroleum diesel fuel prices through blending biodiesel or use of 100% if possible
- **The U.S. Renewable Fuel Standard (RFS)** is a bipartisan policy passed in 2005 that requires certain volumes of renewable fuels to be used in our fuel supply.
- The law requires increasing volumes of advanced biofuels, such as biodiesel, each year.
- It is meant to drive innovation and investment by providing stability for biofuels in the US.
- Biodiesel is America's first and only commercially available advanced biofuel. To be named an advanced biofuel, renewable fuels must reduce lifecycle greenhouse gas emissions by at least 50 percent and must be manufactured from feedstocks meeting the definition of renewable biomass.

Many States are advancing their own Biodiesel²¹ Policies



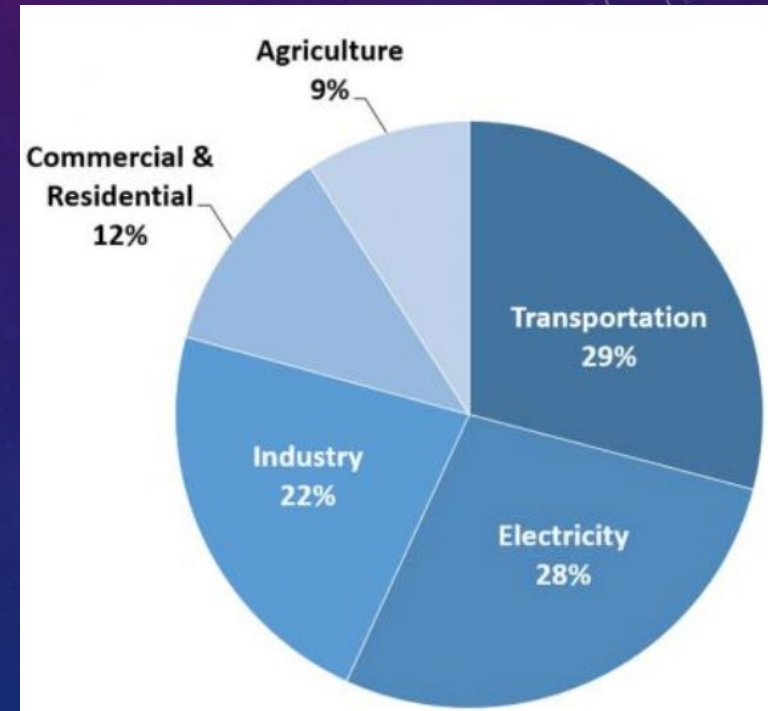
COMPARING AUSTRALIA (2021) AND US (2019) GHG INVENTORIES



TRANSPORTATION AND CLIMATE CHANGE

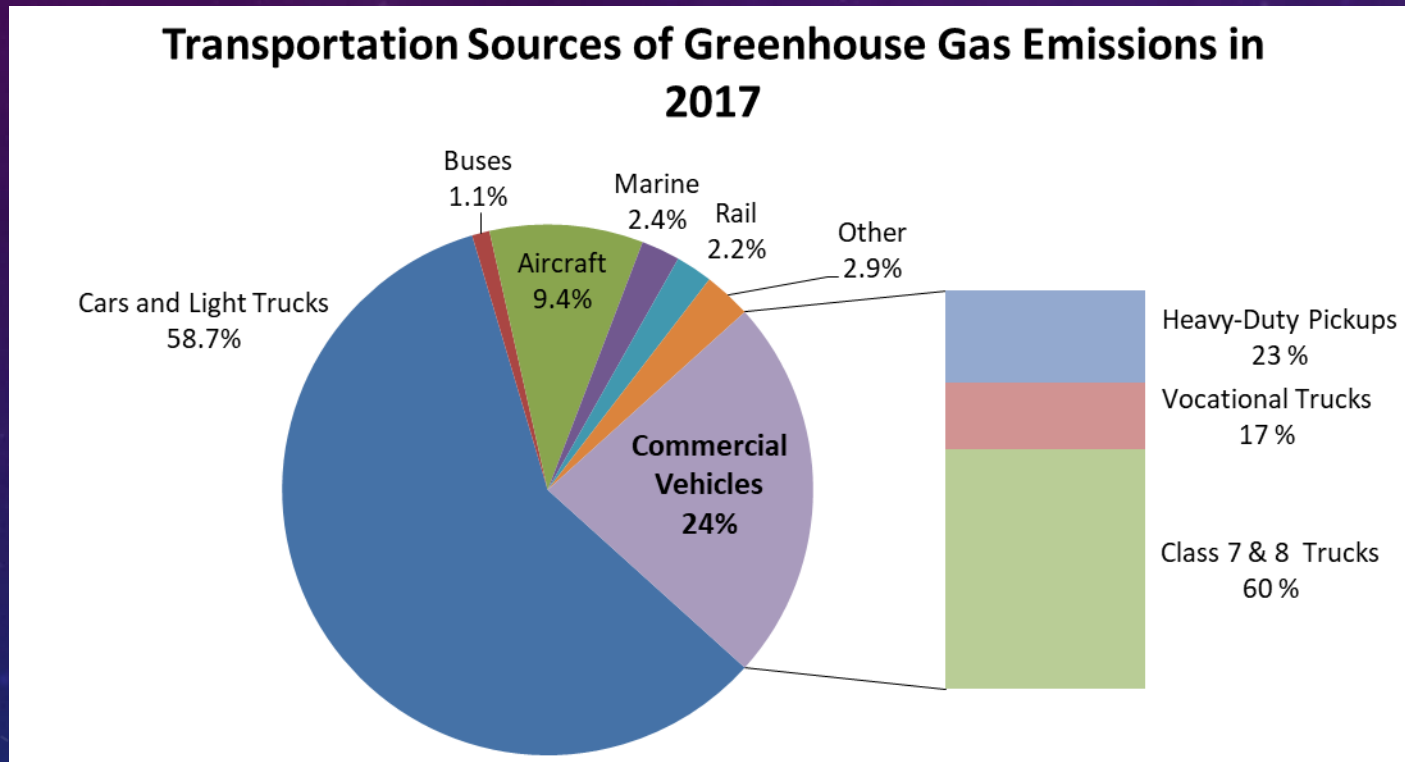
2017 U.S. GHG Emissions by Sector

- Transportation is the #1 source of GHG emissions in the U.S.
- Between 1990 and 2021, GHG emissions in the transportation sector increased more in absolute terms than any other sector.
- 78% of commercial vehicles are powered by diesel engines



Source: EPA

TRANSPORTATION SOURCES OF GHG EMISSIONS: CARS VS TRUCKS



What is the strategy to reduce emissions from this segment of commercial vehicles?

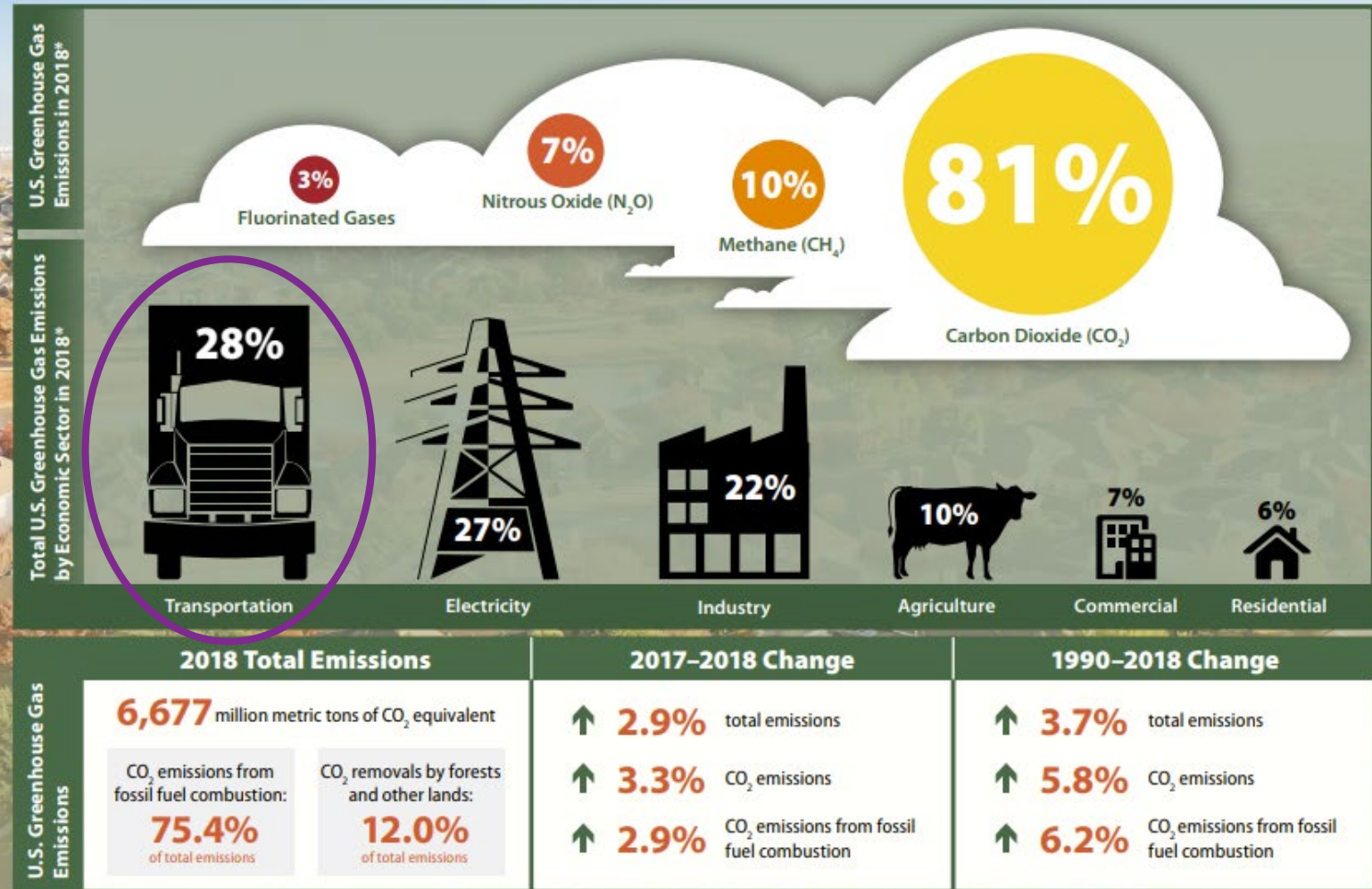
Fast Facts

1990-2018

National-Level U.S. Greenhouse Gas Inventory

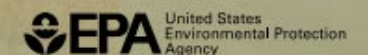
Transportation now the #1 Sources of GHG Emissions

Biden Administration goal of 50% reduction in GHG emissions (all sectors) by 2030



To learn more about the inventory, visit

www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks, or explore the data at <https://cfpub.epa.gov/ghgdata/inventoryexplorer/>.



April 2020

EPA 430-F-20-002

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The opportunity for Renewable Fuels: Sustainability and Decarbonization: Focus on fuels and feedstocks

**CLEAN DIESEL
TECHNOLOGY +
ADVANCED BIOFUELS =
REDUCED GREENHOUSE
GAS EMISSIONS**

Using renewable diesel or biodiesel in new or existing diesel engines can reduce GHG emissions by **50-85%**.

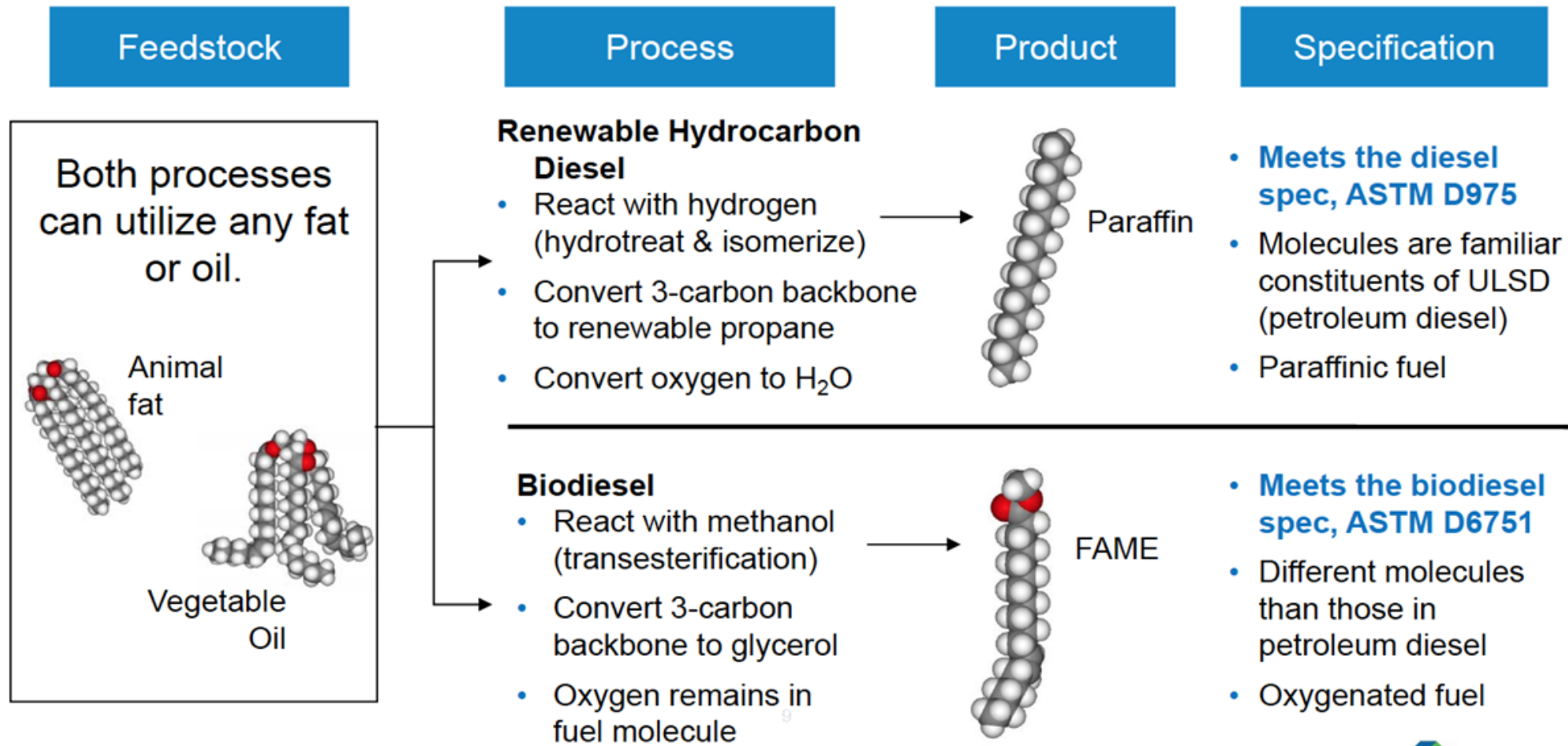


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Biomass-based diesel review

Renewable Hydrocarbon Diesel and Biodiesel



Biodiesel and renewable diesel in the U.S.A. Today



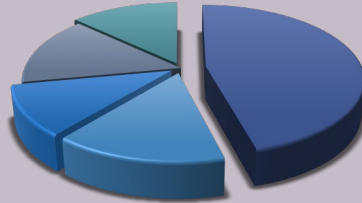
Production

Today's market has reached 3.0 billion gallons with more than 3.2 billion gallons of domestic production capacity online today.

Capacity of planned US expansions will grow to nearly 5 Billion gallons by 2023.



Feedstocks



Soybean oil makes up the largest supply of biodiesel/renewable diesel today at 54%. The rest make up the balance almost 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

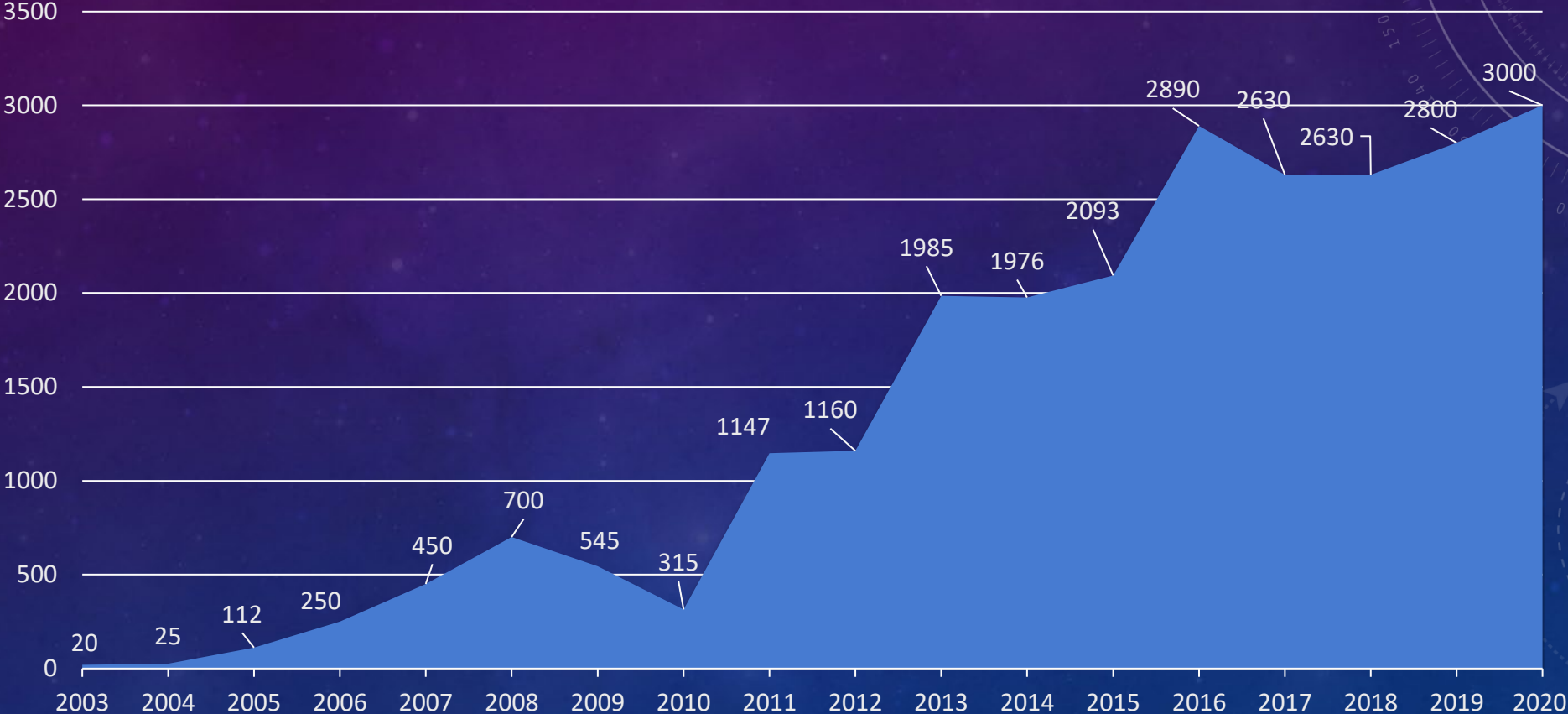
Combination of legislation that drives biodiesel success:

- Renewable Fuel Standard
- Federal Tax Incentive
- Carbon Policies
- State Mandates and Incentives



U.S. BIODIESEL & RENEWABLE DIESEL MARKET (MILLIONS OF GALLONS)

SOURCE: EPA EMTS*



■ Biodiesel and Renewable Diesel

*Volumes reported under the RFS in the D4, D5, and D6 categories.

NBB INDUSTRY VISION



***Biodiesel, renewable diesel, and renewable jet 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 six billion gallons by 2030**, eliminating over 35 million metric tons of CO₂ equivalent greenhouse gas emissions annually. With advancements in feedstock, use will reach 15 billion gallons by 2050.*

WHAT IS RENEWABLE DIESEL?

- It is ULSD and CARB diesel and is certified as a drop-in fuel by CARB
- Produced from 100% renewable and sustainable raw materials
- Pre-treatment of raw materials ensures near zero contaminants
- A premium quality, high cetane diesel fuel that is colorless, odorless, cleaner burning, and very stable
- **Renewable diesel is NOT biodiesel**



NESTE MY BENEFITS

Combustion

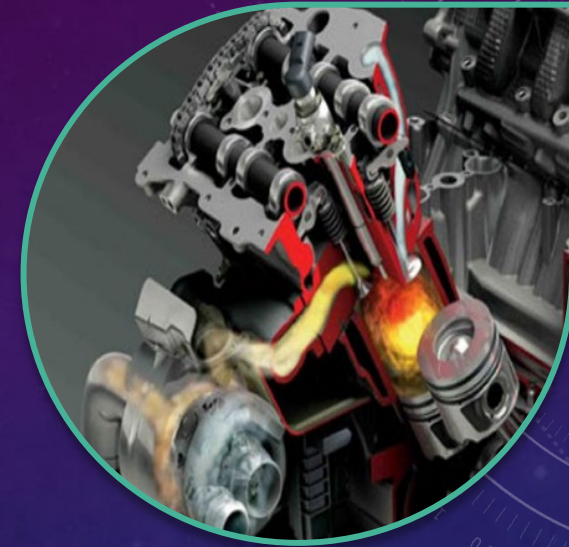
- **High cetane (70+)** for greater pick up, quicker cold start, and quieter operation
- **33% less soot** to plug DPFs and reduce fuel economy
- **Better lubricity** than CARB ULSD – 460 μm HFRR (EN590), compared to 520 HFRR for D975
- Maintenance intervals & costs can be reduced (high pressure pumps, fuel injectors, after-treatment systems)

Fuel injectors


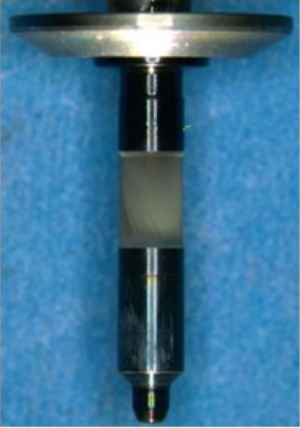

- Example from Detroit Diesel engine testing
- Test artificially aged fuel similar to real-world, longer term storage applications
- Demonstrated much lower risk of deposits in injectors which lead to failures
- Purity and lack of oxygen in RD showed no injector failures on Neste test where others failed

Exhaust system

- **Burns cleaner** due to high cetane number and zero aromatics
- **33% less soot** can lead to fewer regenerations and lower backpressure, improving fuel economy
- **Improved DPF safety** due to reduced soot load and less risk of over-temp
- **Near zero ash-forming components** reduce ash accumulation extend cleanout intervals



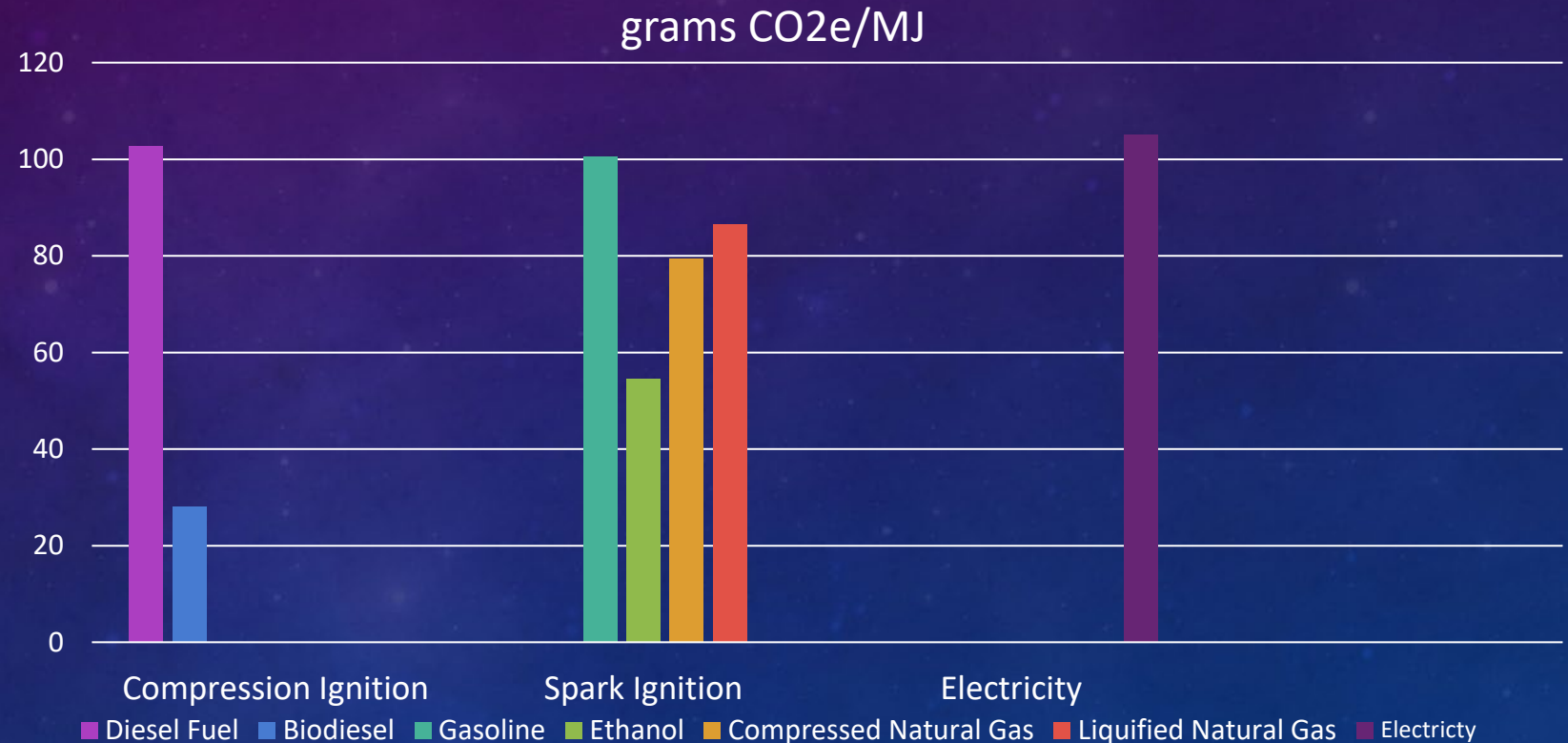
Simulated Harsh Environment Testing

B5 Blend	ULSD	Neste MY
		
Injectors failed after 13 test cycles. Armature showed heavy deposits & corrosion, and had to be <u>hammered out of the body.</u>	Injectors ran for 49 test cycles, but showed carboxylate deposit build up on armature and <u>required significant force to remove.</u>	Injectors ran for <u>60 test cycles</u> without incident. Although discolored, the armature <u>fell out of injector body upon disassembly.</u>

* Detroit Diesel Presentation to Detroit Advisory Panel 2017

CARBON INTENSITY OF FUELS

- **U.S. biodiesel on average provides an 80% Reduction in Carbon Emissions compared to petroleum diesel**
- Offers the lowest carbon intensity of any liquid fuel, and substantial carbon reductions compared to electricity produced from coal and natural gas.



RENEWABLE DIESEL FUEL IS SUCCESSFULLY USED IN A WIDE VARIETY OF APPLICATIONS BY PUBLIC AND PRIVATE ENTITIES

- The City of Oakland was an early adopter of renewable diesel fuel as all of the **city owned trucks, equipment and emergency generators** are now operating on 100 percent renewable diesel fuel to displace 230,000 gallons of petroleum diesel and reduce greenhouse gas emissions by 75 percent.
- The City of San Diego is now fueling its fleet of **1,125 heavy-duty vehicles and equipment** with renewable diesel fuel to achieve more than 80 percent reduction on greenhouse gas emissions.
- All passenger ferries in service in the Bay Area are operating on 100 percent renewable diesel fuel to cut greenhouse gas emissions by 80 percent or 22,000 tons per year.



CITY OF OAKLAND ESTABLISHES A CIRCULAR FUEL ECONOMY

The City's fleet has run on renewable diesel since 2015, and now that fuel is produced with raw materials gathered from Oakland itself, establishing a circular fuel economy and reducing greenhouse gases.

"Oakland is a proud leader in protecting our environment and practicing the highest levels of sustainability," Mayor Libby Schaaf said. "This bold move will give our residents cleaner air, and it takes us one important step forward in our work to reduce greenhouse gas emissions."



City of Oakland Mayor Libby Schaaf



City of Oakland's Fleet Running on Renewable Diesel



Renewable Diesel Fuel Demonstrates Success, boosts case for inclusion in future ZEV/carbon reduction strategies

Bay Area to Become First U.S. Region to Use Renewable Diesel Ferries

By Bay City News • Published on April 12, 2018 at 7:52 pm



SF Bay ferry fleet floats toward renewable diesel Reduces 22,000 tons of GHG per year

Renewable Diesel to the Rescue!!!



PG&E procured hundreds of large mobile diesel generators to provide substation level power during 2020 public safety power shutoff events.

Fueled with 600,000 gallons of renewable diesel fuel to reduce GHGs and criteria pollutants

The Renewable Diesel success story is not well known outside of California...

NYC Clean Fleet

New York City will lead by example in pursuing 80x50 transportation emissions reductions by improving the sustainability of its municipal vehicle fleet

Switching to Biodiesel,
Renewable Diesel Fuel and
Natural Gas = **34% Reduction**

Adding all-electric vehicles =
9% Reduction

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



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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.



CITY OF OAKLAND

All city owned diesel vehicles, equipment and generators operate on renewable diesel fuel to deliver a 75 percent reduction on GHG emissions and displace **230,000 gallons of petroleum diesel per year.**

<https://www.oaklandca.gov/news/2019/city-of-oakland-drives-environmental-progress-with-new-renewable-diesel-model#:~:text=In%202015%2C%20the%20City%20switched,priced%20similarly%20to%20petroleum%20diesel.>

Biofuels key in the sustainable future of diesel - core message and campaign for DTF

POLICY
PRIMER ON FUELS: DIESEL AND ADVANCED RENEWABLE BIOFUELS

Diesel's sustainability is enhanced through the engine's increasing efficiency - lower greenhouse gas emissions - and its ability to use low-carbon advanced biofuels like blends of high-quality biodiesel and renewable diesel fuel.



POLICY INSIGHTS

December 4, 2020

MORE

POLICY OVERVIEW

What's the fastest and cheapest way to reduce greenhouse gas emissions from big things that move?

LATEST POLICY INSIGHT:

Take waste vegetable oil and animal fats and turn them into renewable diesel fuel. According to *The New York Times*, more and more traditional petroleum refiners are retooling facilities to produce renewable diesel fuel that can reduce greenhouse gas emissions by upwards of 80 percent. Companies like *Neste* are leading the way producing low carbon renewable fuels.

policy insider

ENERGY

energy sec
 biofuels

ECONOM

powering t
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 and wages
 motor fuel

The New York Times

Oil Refineries See Profit in Turning Kitchen Grease Into Diesel

Struggling energy companies are increasing the production of renewable diesel, which can reduce greenhouse gas emissions.

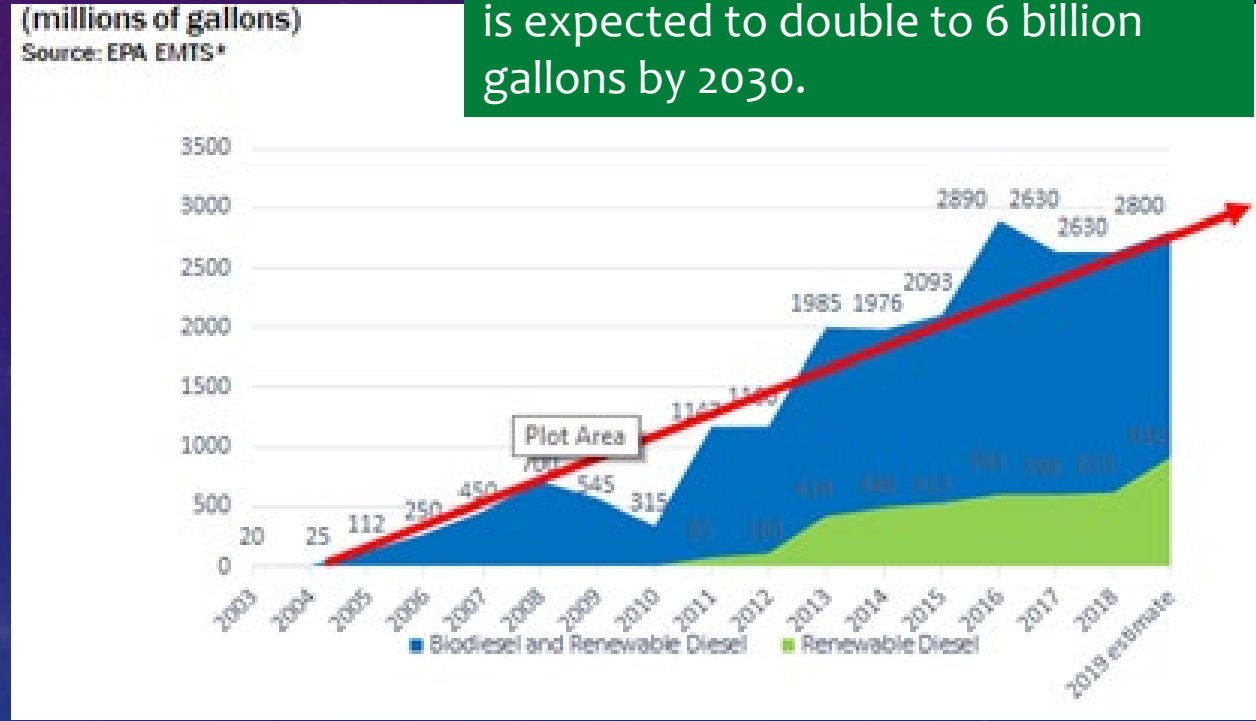
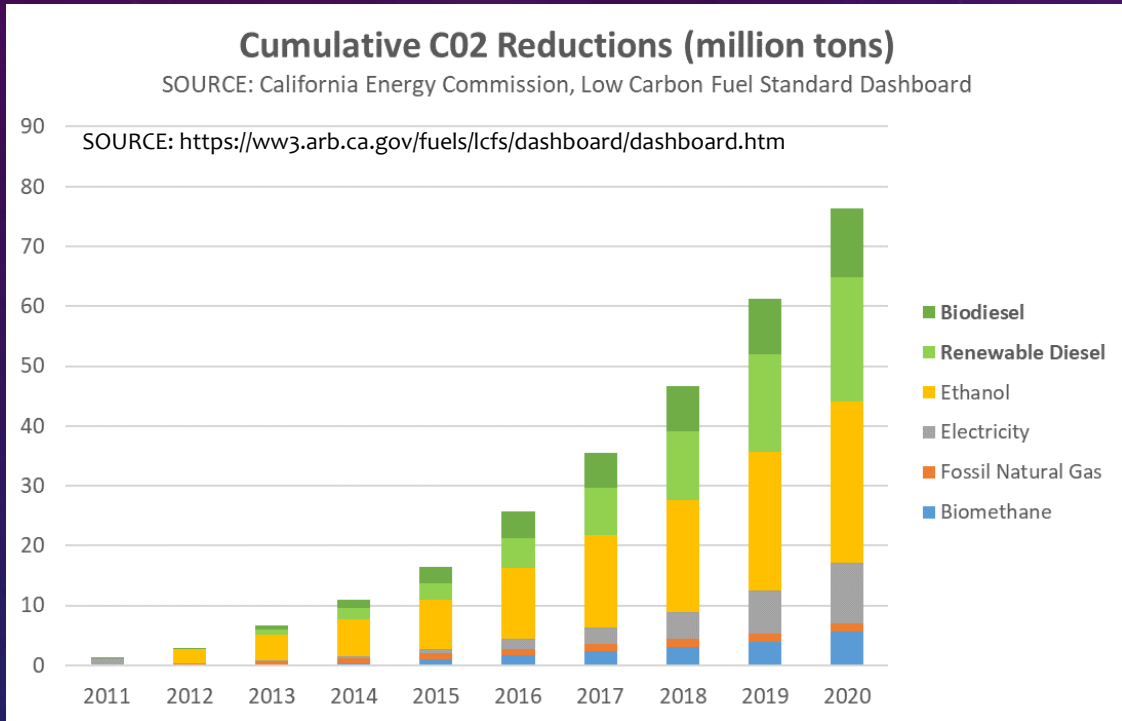


FUELS THAT WORK: ULTRA-LOW SULFUR DIESEL AND BIODIESEL POWER THE U.S. ECONOMY

Unlike gasoline, diesel fuel, vehicles & equipment is platform of work. About 1 out of every 2 economic sectors rely on diesel. Diesel engines, old and new, are capable of operating on biofuels delivering sustainability at low cost.

USE OF LOW-CARBON RENEWABLE BIODIESEL FUELS OFFERS NEAR TERM BENEFITS TODAY...

Nationwide, biobased diesel supply is expected to double to 6 billion gallons by 2030.



California 2020 LCFS Benefits: > 4 X GHG reduction comes from biobased diesel fuels than EVs

Biobased Diesel Fuel = 43% of GHG Reduction

EV Cars, Trucks & Buses = 10% of GHG Reduction

No new vehicles or infrastructure required!

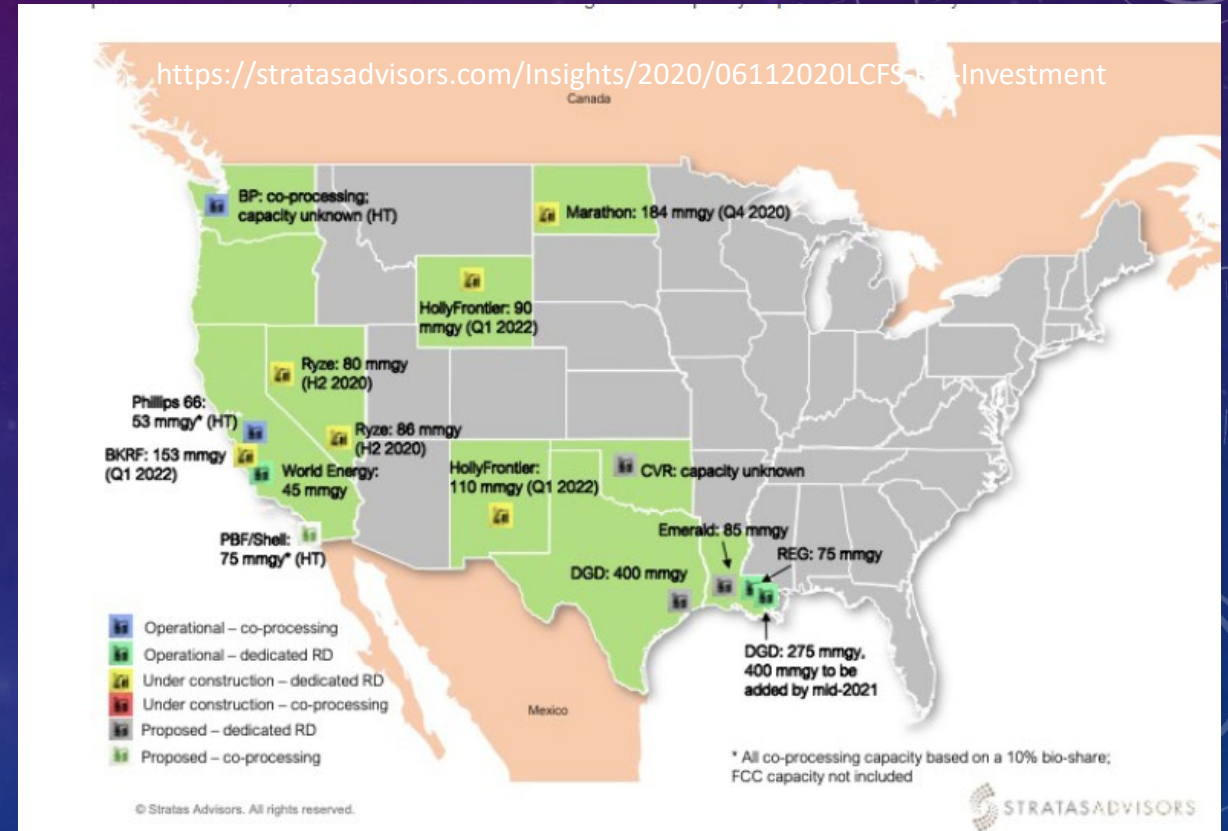
.. AND RENEWABLE DIESEL FUEL SUPPLY SET TO EXPAND AS OIL MAJORS ARE RETOOLING PETROLEUM REFINERIES



Produced from **100%** renewable raw materials

Up to 75% reduction of GHG emissions compared to fossil diesel *

Suitable for **all diesel engines**, no modifications required



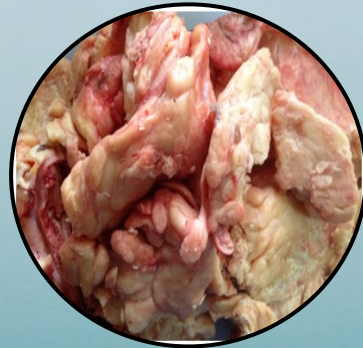
Announced petroleum refineries retooling to produce renewable diesel fuel. If actual production yields meets planned production... equals all petroleum diesel consumed in California in 2019.

FEEDSTOCKS

NESTE MY IS REFINED FROM A MIX OF MORE THAN 10 DIFFERENT WASTES & RESIDUES AND VARIOUS VEGETABLE OILS



Used cooking oil



Waste animal fat



Waste fish fat



Vegetable oils

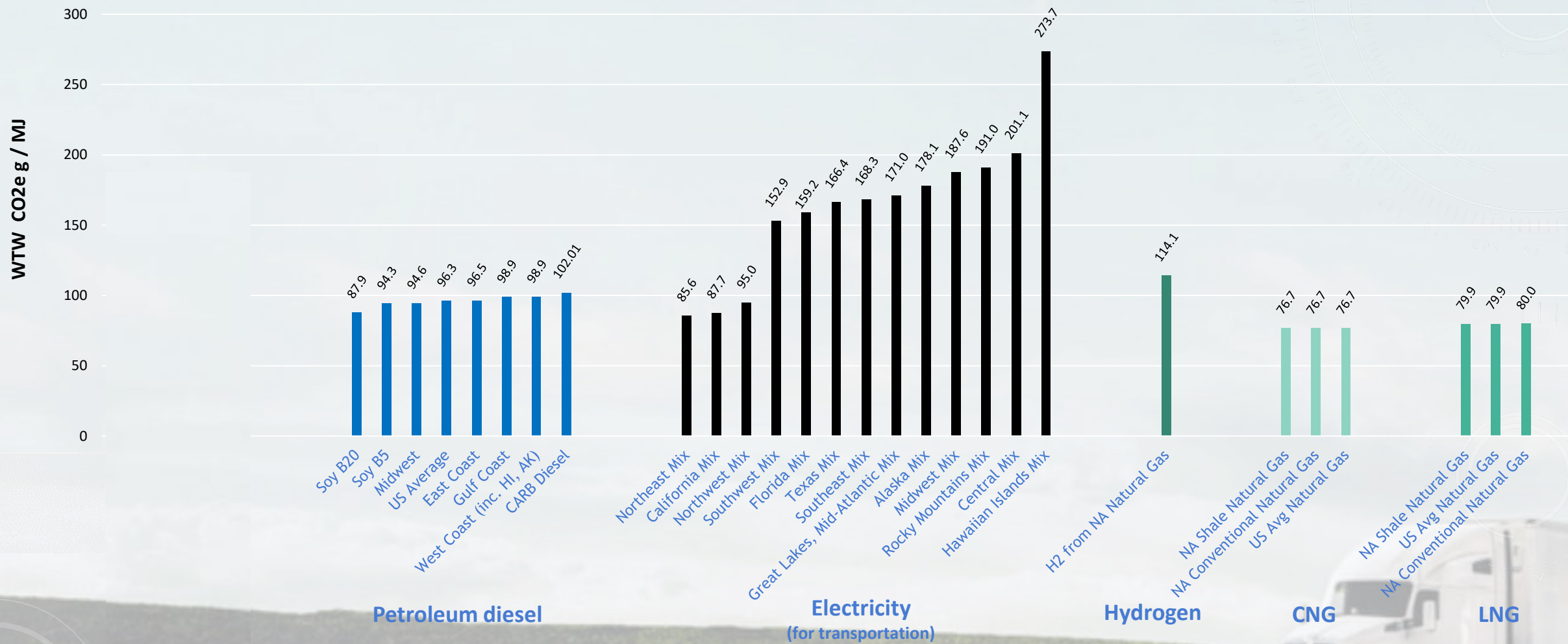


Residue oils



Neste MY Renewable Diesel

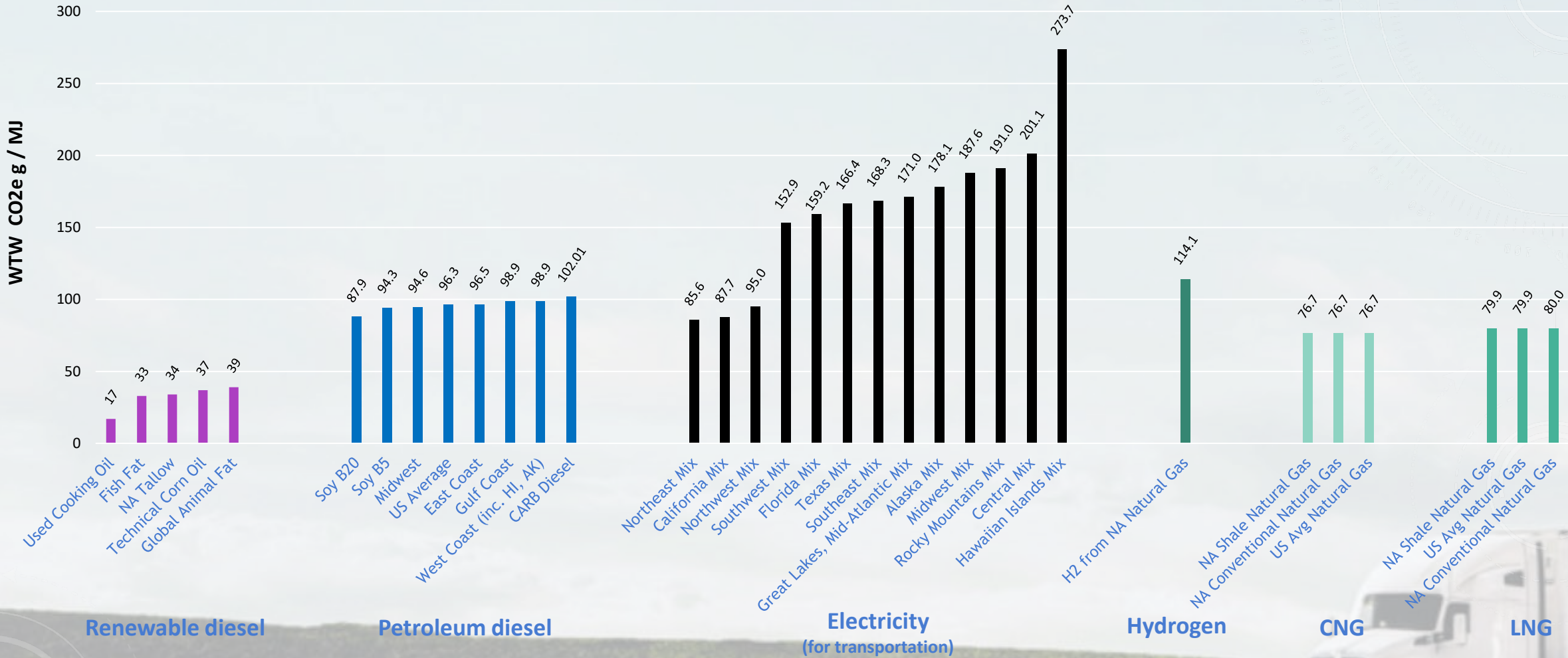
ALTERNATIVE TRANSPORTATION FUEL CARBON INTENSITIES PER MJ



Courtesy of Neste



ALTERNATIVE TRANSPORTATION FUEL CARBON INTENSITIES PER MJ



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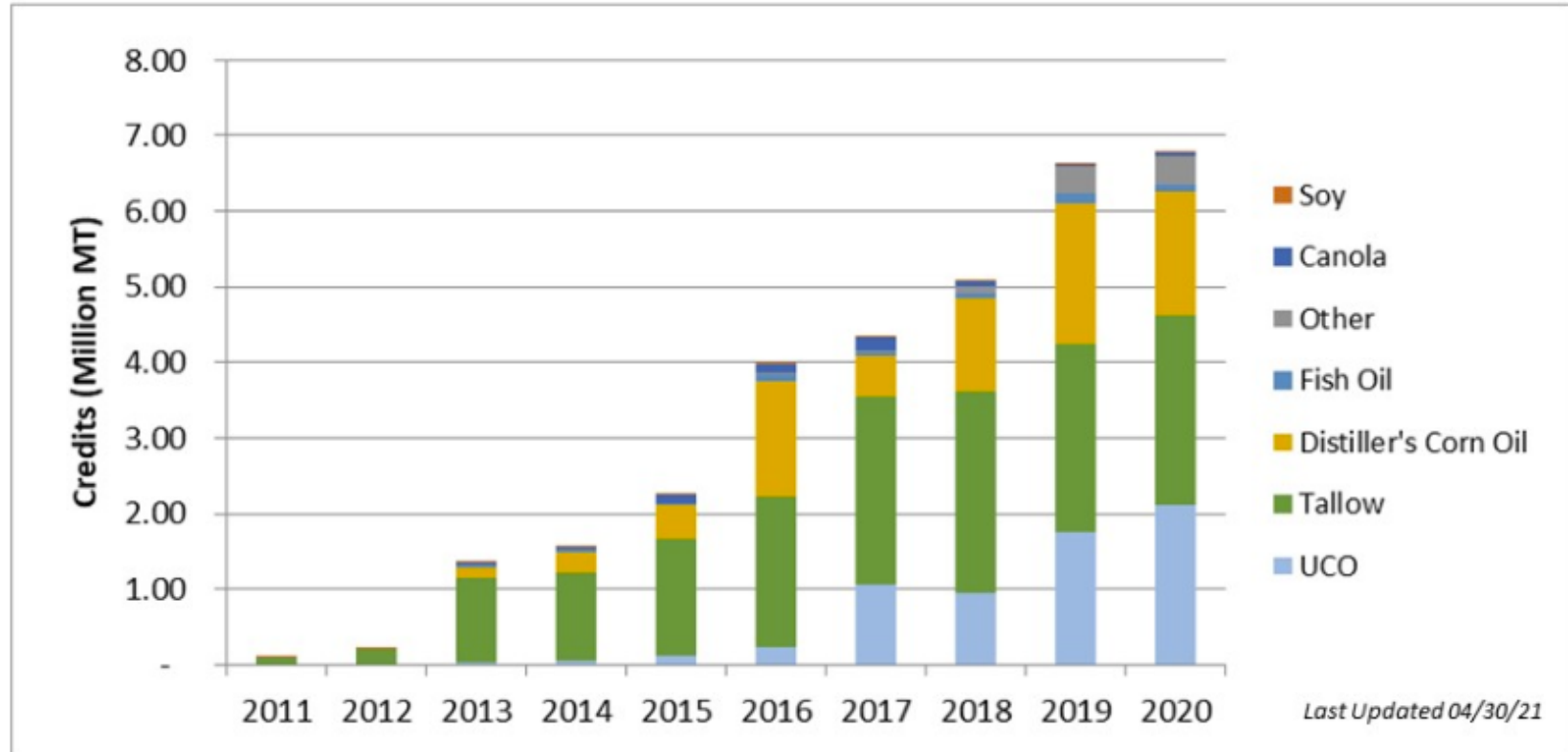
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California
Low Carbon
Fuel Standard

Figure 6

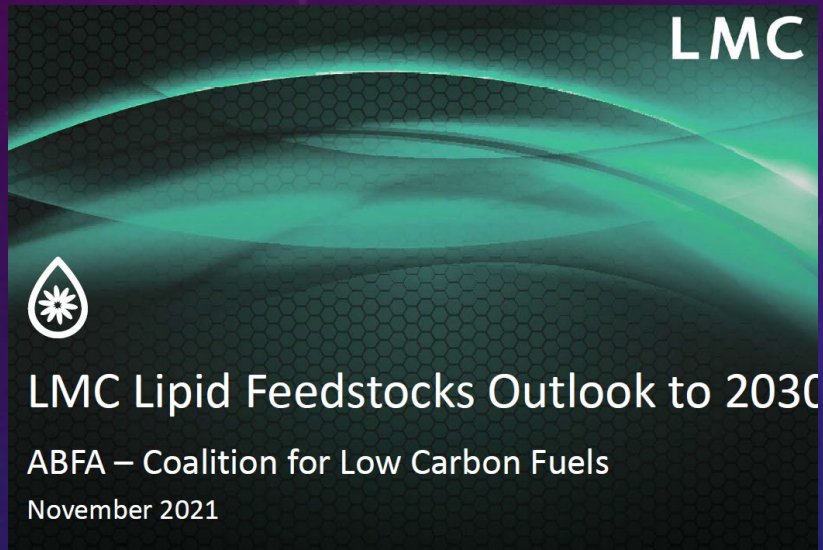
Crops and Residues used in Biomass-based Diesel Production Q1 2011 – Q4 2020



The LCFS incentivizes growth in fuels derived from non-land based sources. In 2020, 93% of total credits generated by biodiesel and renewable diesel fuels were derived from wastes or residues rather than conventional crop-based fuel credit generation. One LCFS credit is equal to 1 metric ton CO₂-equivalent (MTCO₂e), as determined on a life-cycle basis which takes into account the emissions during raw material extraction or recovery, feedstock cultivation, fuel production, transport, processing and use of the fuel. The feedstocks used to produce California's low-CI biomass-based diesel fuels include industrial by-products such as used cooking oil (UCO), tallow, corn oil extracted from distiller grains and solubles (DGS), and oils from fish processing.

WHAT IS THE ADEQUACY OF FEEDSTOCKS FOR GROWTH IN U.S.A?

HIGHLIGHTS FROM NOV 2021 LMC STUDY FOR ABFA



Project overview

- Demand for biofuels globally is growing strongly, particularly for biomass-based diesel, as countries aim to meet environmental goals.
- The Advanced Biofuels Association has set a goal for the U.S. to reach 21 billion gallons of biomass-based diesel (BBD) to replace fossil fuels by 2040. To reach this goal means 9 billion gallons of BBD by 2030.
- The critical question: Will there be enough lipid feedstock to meet this demand?
- The ABFA commissioned LMC International to forecast the outlook for supply of lipid feedstocks to determine their ability to meet the ABFA's goal.

Sneak preview – *The big-picture takeaways are:*

- Global oils and fats supplies are forecast to rise from 246 million metric tons in 2020 to 330 million metric tons in 2030.

This is the equivalent of 93 billion gallons of renewable diesel in 2030.*

- In 2030, U.S. biofuel demand is set to reach close to 9 billion gallons, on route to the 2040 goal.
- **The lipid feedstock supplies available for use in the U.S., after taking demand for food and feed into account, will be more than enough to meet this forecast demand.**

* This conversion of feedstocks to renewable diesel equivalents assumes the maximum use of lipids: namely, that 100% of biomass-based diesel is lipid-based. As a growing proportion of renewable diesel and biojet fuel will be non-lipid-based (including made from biomass, starches, ag waste products, waste g

More excerpts from LMC study

Meeting the ABFA's goal

How we prepare the analysis

To assess whether the U.S. will be able to meet the ABFA goal, we take a tiered approach.

- First, we remove the supply needed to meet demand from non-biofuel end uses (food, feed and oleochemicals). These end uses are inelastic – the need for them is relatively fixed and is not impacted by price.

It is important to note that our analysis allows fully for food requirements before evaluating the feedstock supply for biofuels.

- Then, we remove the demand from biofuels in four other markets with strong biofuel policies. (This is arguably overly conservative in that the U.S. might well come 2nd in line for feedstocks, after the EU, not 5th. In addition, of course, if policies in the U.S. change, the relationship with other markets with biofuels policies could change.)
- The remaining volume is then compared to the required volume needed to meet ABFA's U.S. biofuel target.

AVAILABILITY OF BIODIESEL FUELS



BETTER TOGETHER...

A combination of biodiesel and renewable diesel produces a cost-effective full replacement option for petroleum diesel. As a paired fuel, biodiesel and renewable diesel optimize petroleum displacement and cost, as well as particulate matter, carbon and nitrogen oxide reductions.



Up to 86% less carbon emissions.



80% particulate matter reduction.



75% fewer aromatic compounds.



42% less carbon monoxide.



NOx neutral.



Up to 86% less carbon emissions.

Up to 28% particulate matter reduction.

30% fewer aromatic compounds.

18% less carbon monoxide.

11.5% NOx reduction.



Up to 86% less carbon emissions.

29% particulate matter reduction.

39% fewer aromatic compounds.

23% less carbon monoxide.

9% NOx reduction.



Up to 86% less carbon emissions.

56% particulate matter reduction.

53% fewer aromatic compounds.

30% less carbon monoxide.

6% NOx reduction.

ABOUT BIODIESEL AND RENEWABLE DIESEL

Sources: Impact of biodiesel and renewable diesel on emissions of regulated pollutants and greenhouse gases on a 2000 heavy duty diesel truck, Argonne National Lab GREET 2021; Effects of biodiesel blends on emissions, National Renewable Energy Laboratory, 2006.



Made from plant-based oils, used cooking oils, and animal fats



Clean-burning ultra-low carbon



Can be used in any diesel engine without modification



Commercially available nationwide



Today's solution for heavy-duty trucking, emergency vehicles, bus fleets, and farm equipment

THE TIME VALUE OF CARBON

When we evaluate emission reduction strategies, there are 2 things to keep in mind: the *amount* of the reduction, and *when* it happens.

Because the heating effect associated with emissions is cumulative and because we have a limited amount of time to reduce them, carbon reductions now have significantly more value than carbon reductions in the future.

The Time Value of Carbon is key, and the next decade is critical.

The Future for Diesel

How	Why	Where
Emissions closer to zero	Unmatched set of attributes central to key sectors of the economy	Everywhere customers demand it
Increasing energy efficiency	Availability Extensive nationwide parts and servicing networks Resale value 142,000 fueling stations Million-mile operation	CV: Especially long-haul, irregular route, fleets of 20 or fewer trucks CA-CV: In 2035 even with ACT rule, 40% sales = ZEV; <i>60% of CV sales can be diesel</i>
Suitability for use of low carbon renewable fuels	Uncertainties with alternatives	PV: Heavy-duty pickups, some heavy-duty vans, SUVs
Hybridization/electrified components	Customers will still demand diesel: 97.4% of all trucking fleets operate 20 or fewer vehicles	Off-road Ag/construction/marine/rail/industrial/power generation
	Time for transitions: Costs more, takes longer, detours along the way	



DIESEL

Light-Duty
Pickups and Vans
On Road HDT
On Road MDT
Construction
Agriculture
Forestry
Industrial
Power Generation
Marine /Rail

**Diesel fuel
dominates many
applications and
sectors today,
but...**



Electric



Hydrogen



Diesel



Renewable Natural Gas



Biobased Diesel



Fuel Cells

**The Future
Is likely to
be more
Eclectic**

*Tackling the climate challenge
requires many fuels and
technologies as part of the
solution.*



CLOSING THOUGHTS

- **Diesel will continue to dominate key sectors of the economy** because it continues to improve, has a set as of yet unmatched attributes
- Changing the transportation energy paradigm will likely take longer and cost more than projected. Many variables impact the future for the alternatives: successful public policy, public and private \$\$\$, infrastructure
- Structure and diversity of the user industry, psyche of the customer base beyond early adopters, risk aversion and other factors all play a role
- Expanding Use of renewable low-carbon biodiesel fuels can bring significant benefits across new and existing vehicles, engines and equipment, without the need for new vehicles/equipment or fueling infrastructure
- We need all these solutions: The Future is likely to be more *eclectic* than *electric*



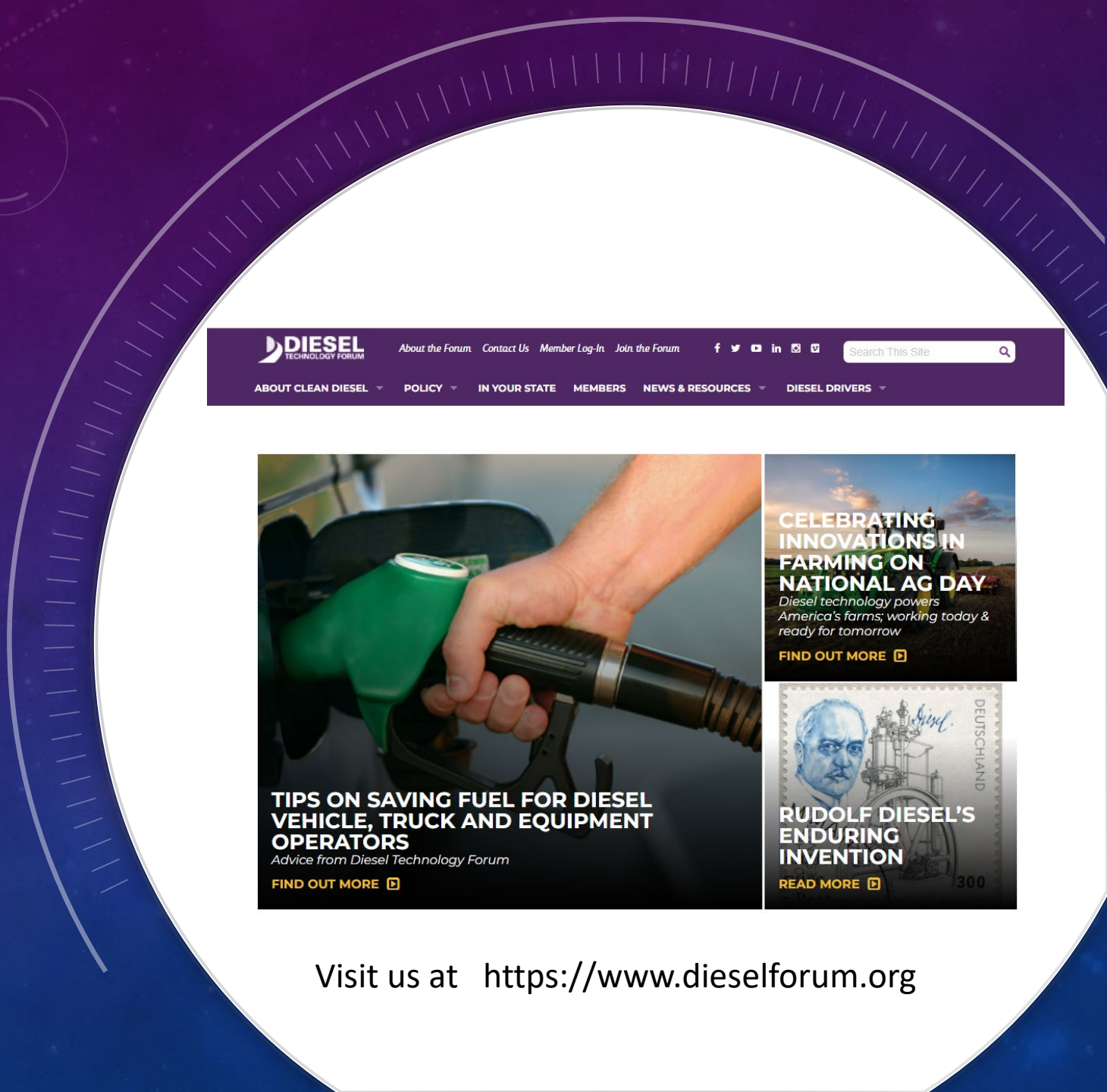


Thank You

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