

TMC»23

ANNUAL MEETING

& Transportation Technology Exhibition



ADVANCING RELIABILITY
Through Root Cause Analysis

#TMCAnnual23

ATTENTION PLEASE

- In accordance with TMC Board Policy, all personal phones without a silent feature must be turned off during business sessions.
- If you must use your phone —please leave the room!



ATTENTION PLEASE

- This is an open meeting of the Technology & Maintenance Council, held in accordance with ATA Antitrust Guidelines which are listed in your meeting packet.
- Audio or video recordings are not permitted at this session. However, photography is permissible.
- The opinions expressed in this meeting are those of the individual and not necessarily the opinion of his/her company nor of TMC unless stated otherwise.

ANTITRUST/PATENT DISCLOSURE

- To minimize the possibility of antitrust problems, the guidelines detailed in your registration packet should be followed at all TMC meetings, task force and study group sessions.
- All participants in any group involved in the development of standards or recommended practices shall disclose, as stated in the antitrust/patent disclosure guidelines in your registration packet, all patents or patent applications that are owned, controlled or licensed by the Participant or Participant's employer when the Participant reasonably believes such patent or patent application may become material to the standard or RP development process.

S11 Leadership Team

Position	Name	Company
Chairman	Ken Marko	US Foods, Inc.
1 st Vice Chairperson	Kirk Rutherford	Bridgestone Americas Fleet
2 nd Vice Chairperson	Amy Winfield Mike Roeth	Suburban Seating & Safety NACFE
Secretary	Eileen Lindberg	Cummins
Meeting Mechanic	Zack Ruderman	Orange EV
Sgt.-at-Arms	Gary Miller	Volvo Trucks North America
Future Truck Liaison	Ken Marko	US Foods
Board Liaison	Scott Bartlein	Barry Trucking



Dr. Ameya Joshi

Director of Emerging
Technologies, Regulations and
Electrification
Corning Incorporated

CORNING



Adam Buttgenbach

Director of Fleet Engineering
and Sustainability
PepsiCo



PEPSICO



Mark Ulrich

Director - Customer Support –
North America Field Sales and
Support
Cummins, Inc.



Rob Reich

Executive Vice President, Chief
Administrative Officer
Schneider



Mike Roeth

Executive Director
NACFE



Technical Session #1: Powertrains of the Future!

February 28, 2023

Transitioning commercial vehicles to zero impact emissions – A Supplier's Perspective

Dr. Ameya Joshi

Date : February 28th, 2023



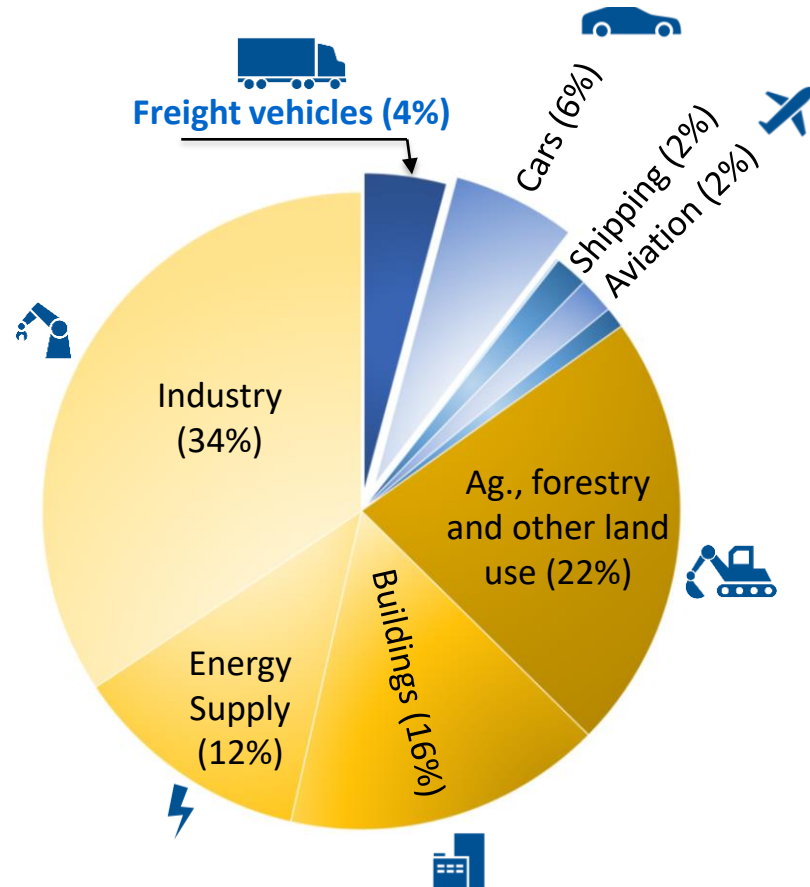
joshia@corning.com



<https://www.linkedin.com/in/joshiav/>

What problems are we trying to solve in the transportation sector?

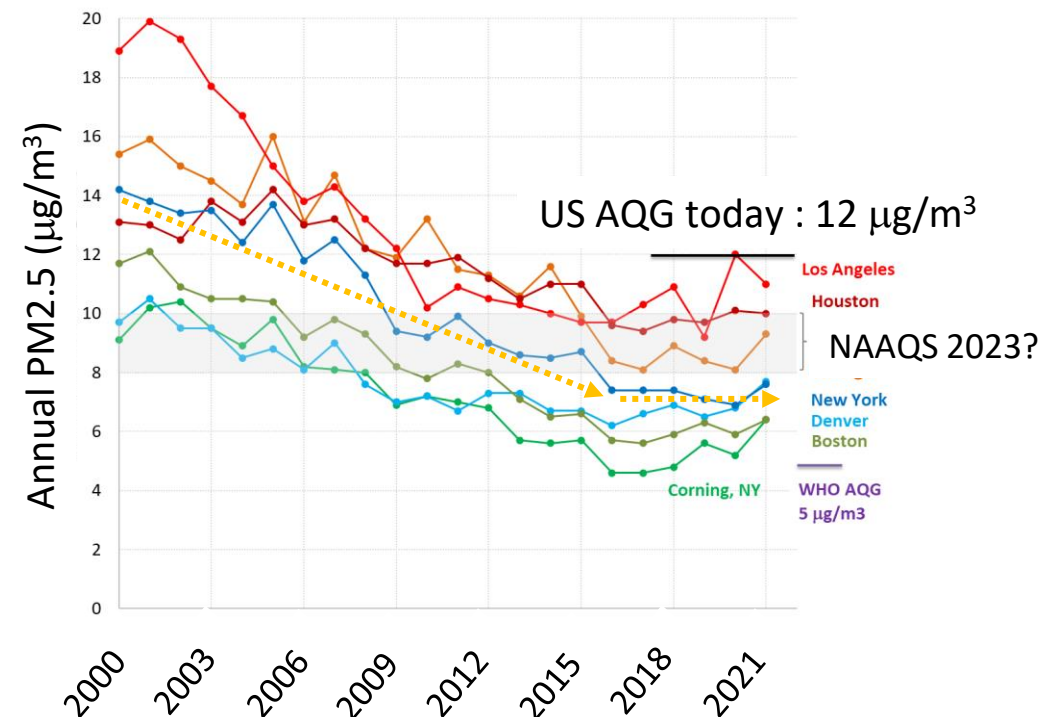
Global Greenhouse Gas emissions



Source: IPCC 2022 <https://www.ipcc.ch/report/ar6/wg3/>

Local Criteria Pollutants

We are nearing zero-impact emissions with upcoming regulatory steps (~ Euro 7/VII/EPA Tier 4/Low NOx/CN 7 ...)



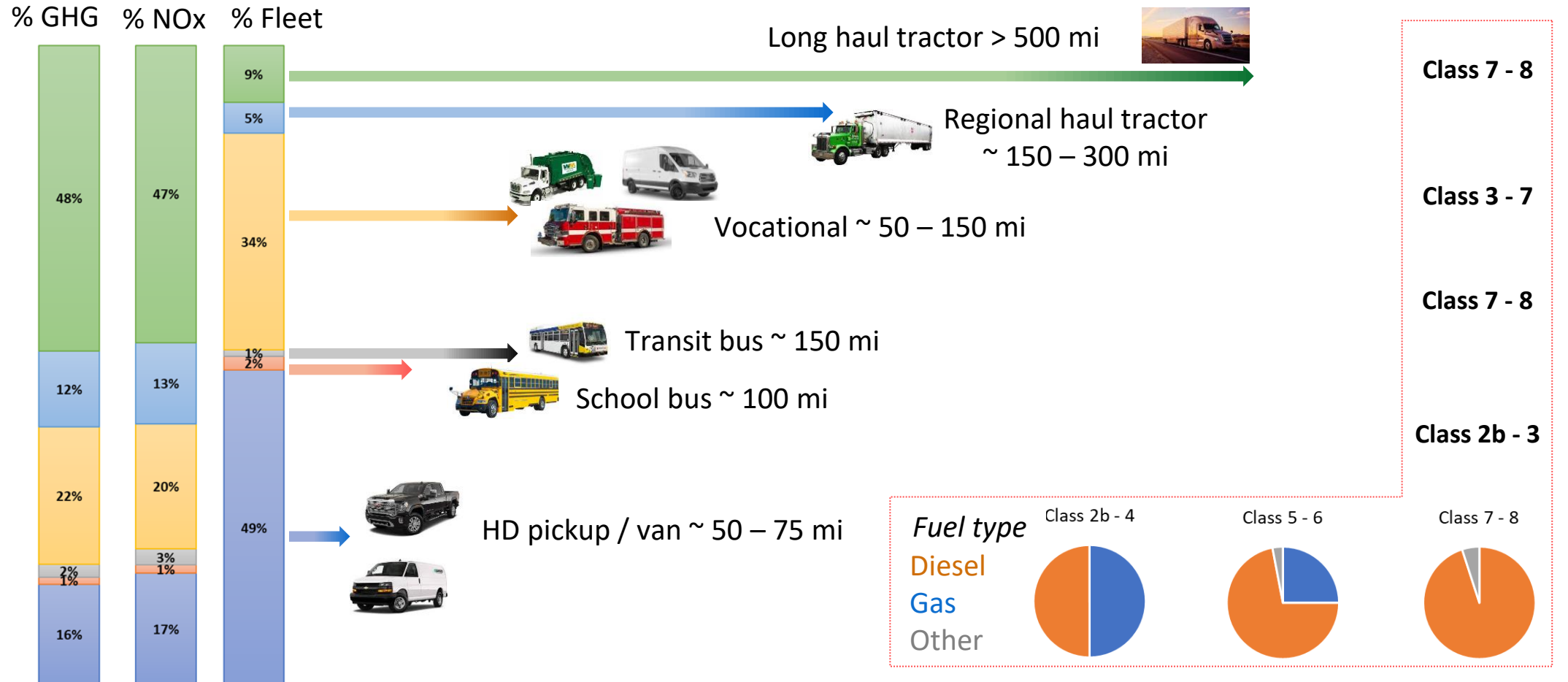
Source: <https://www.epa.gov/air-trends/air-quality-cities-and-counties>

Heavy duty engines serve diverse vehicle applications

Decarbonization will require a range of technology solutions

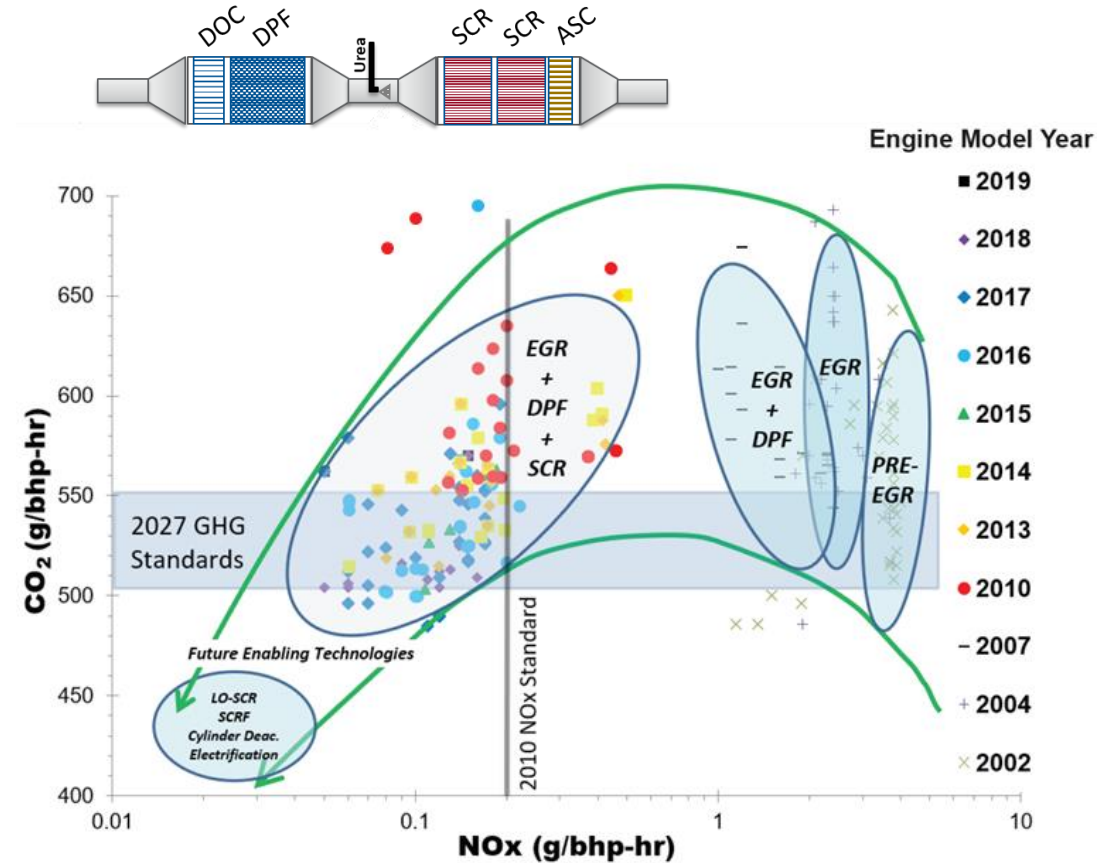
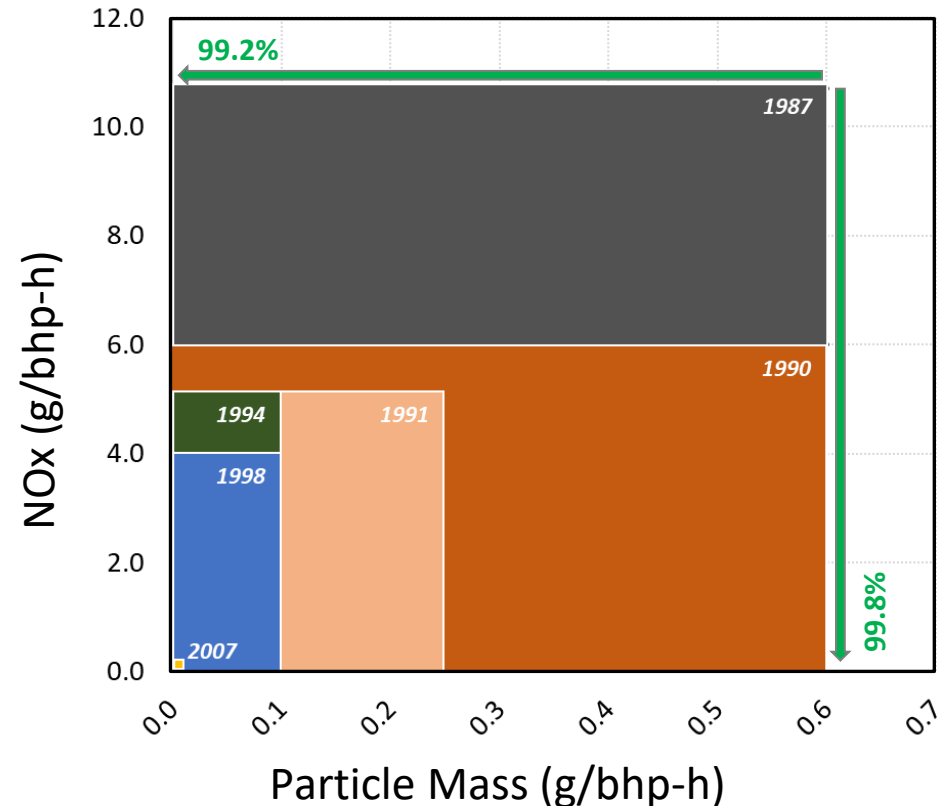


Total in-use ~ 23 million



In the past 35 years, tailpipe criteria pollutants have reduced by >99% ... while also reducing fuel consumption

 US EPA heavy-duty diesel tailpipe standards



DOC = Diesel Oxidation Catalyst, DPF = Diesel Particulate Filter
SCR = Selective Catalytic Reduction (of NOx), ASC = Ammonia slip catalyst
EGR = Exhaust gas recirculation

Super-Truck II : Doubling freight efficiency demonstrated



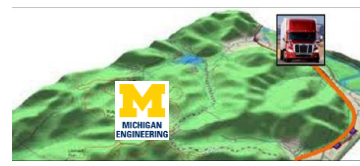
55% Brake Thermal Efficiency Engines

Improved combustion
 High compression ratio
 Thermal barrier coatings
 Lower friction



CLEMSON
SOLUTION SPRAY
OAK RIDGE
National Laboratory

Model-based control



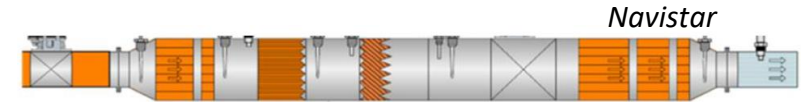
Improved air handling
 EGR pump
 Miller cycle
 Optimized turbochargers



Eaton

ENGINE

Improved after-treatment



Navistar

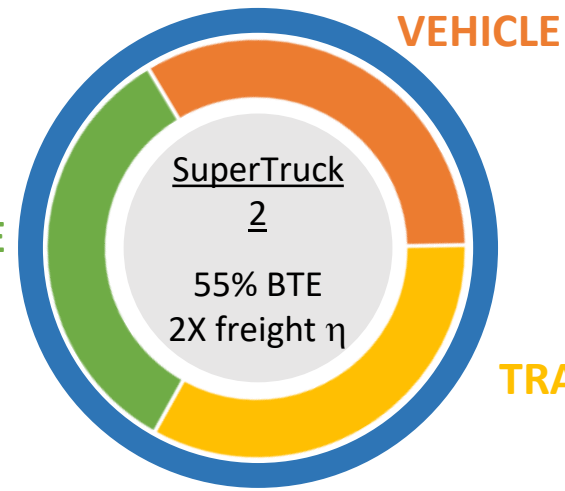
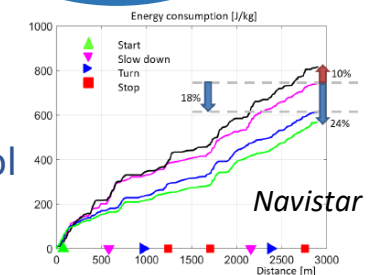
Low pressure drop designs
 Close-coupled SCR

Waste heat recovery
 Organic Rankine Cycle



BorgWarner
Exhaust Tailpipe ORC Evaporator

Predictive cruise control

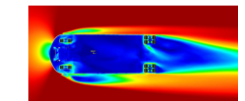


Weight reduction

Cummins: Lightweight chassis & trailer - 4,700 lbs
 Peterbilt: Lightweight chassis - 500 lbs

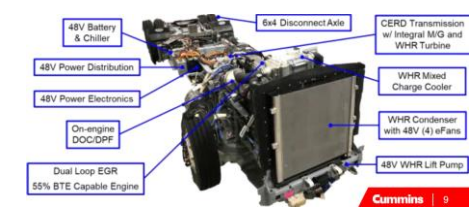
Aerodynamics & tires

Kenworth: 60% aero drag ↓
 Chassis height control
 Low rolling R tires : Up to +5% fuel economy expected (Volvo)



TRANSMISSION, ELECTRIFICATION

48V mild hybridization. Electrification of HVAC, P-steering, coolant pumps, CAC, e-hoteling, etc.



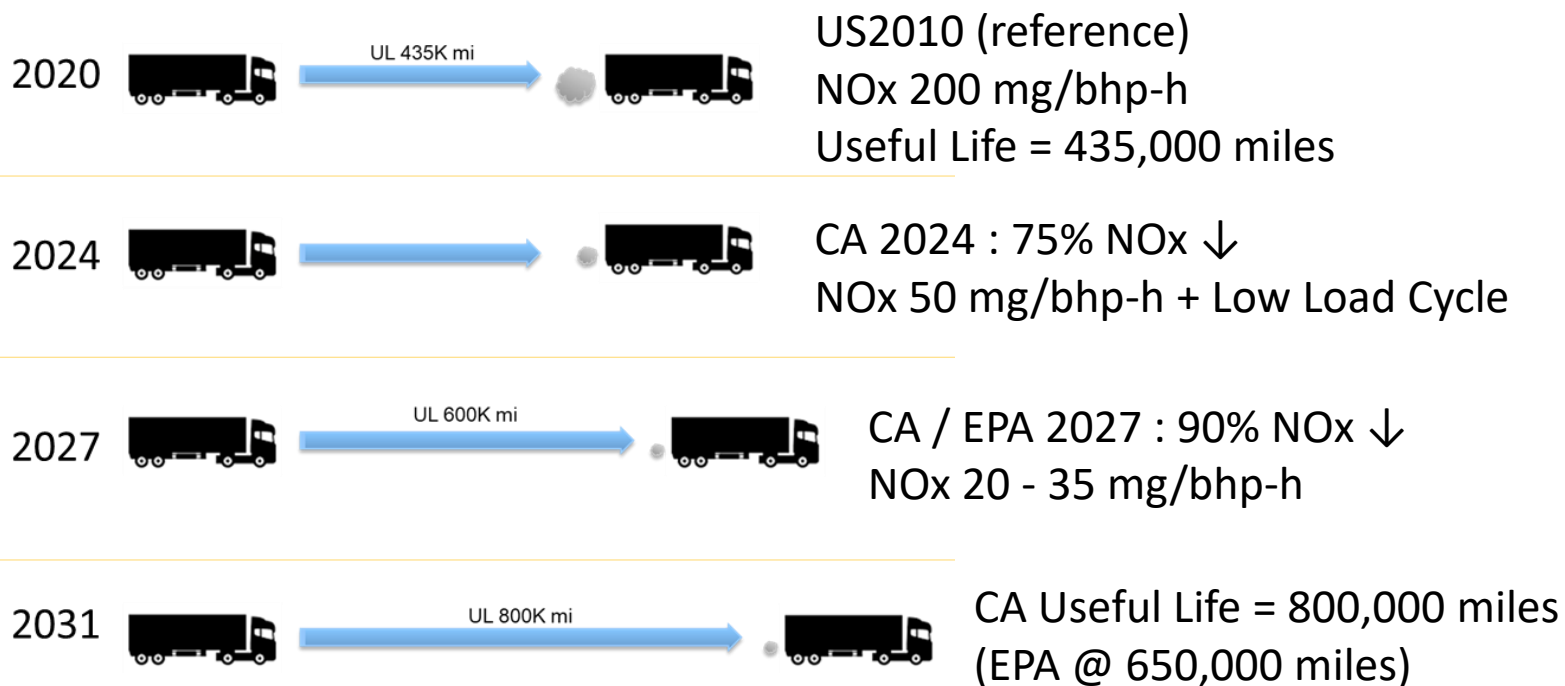
Cummins

<https://www.energy.gov/eere/vehicles/annual-merit-review-presentations>

EPA & CARB MY 2027 regulations will require an additional 90% NOx reduction

Low NOx standards

90% NOx reduction, low load cycle, increased useful life, ...



California Advanced Clean Trucks Regulation

Manufacturer ZEV* requirements as % of annual sales

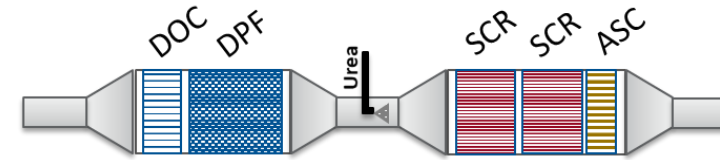
Model Year (MY)	Class 2b-3	Class 4-8	Class 7-8 Tractors
2024	5%	9%	5%
2025	7%	11%	7%
2026	10%	13%	10%
2027	15%	20%	15%
2028	20%	30%	20%
2029	25%	40%	25%
2030	30%	50%	30%
2031	35%	55%	35%
2032	40%	60%	40%
2033	45%	65%	40%
2034	50%	70%	40%
2035+	55%	75%	40%

* ZEVs defined as vehicles with zero tailpipe CO₂ (BEV, FCEV)

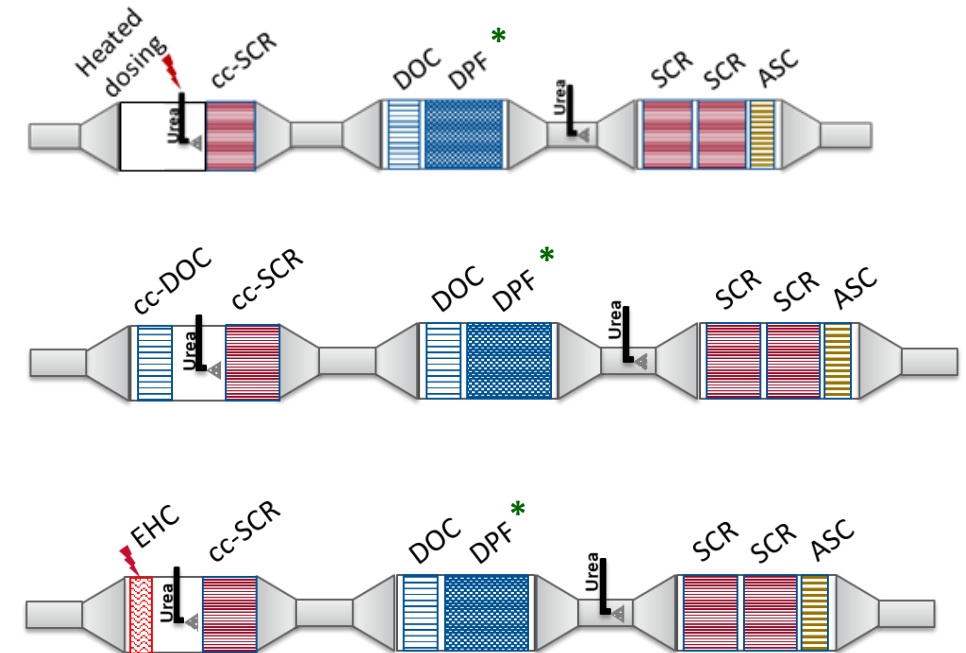
Technologies developed for meeting low NOx standards in the US

Engine	Engine calibration
	Cylinder deactivation
	EGR pump
	SuperTurbo
	Opposed piston
	Hybridization
+ Added SCR	Increase SCR volume and catalyst loadings
	Added cc-SCR w/ twin dosing
	+ cc-DOC for NO ₂
	SCR on filter
	Model based A/T controls, NH ₃ storage
+ Heat	Late & multiple injections
	Heated urea dosing
	Electrical heater / EHC
Fuel	Diesel → CNG / LPG / Gasoline / H ₂ -ICE / ...
	Low S, low impurity fuels

US 2010 Ref. System

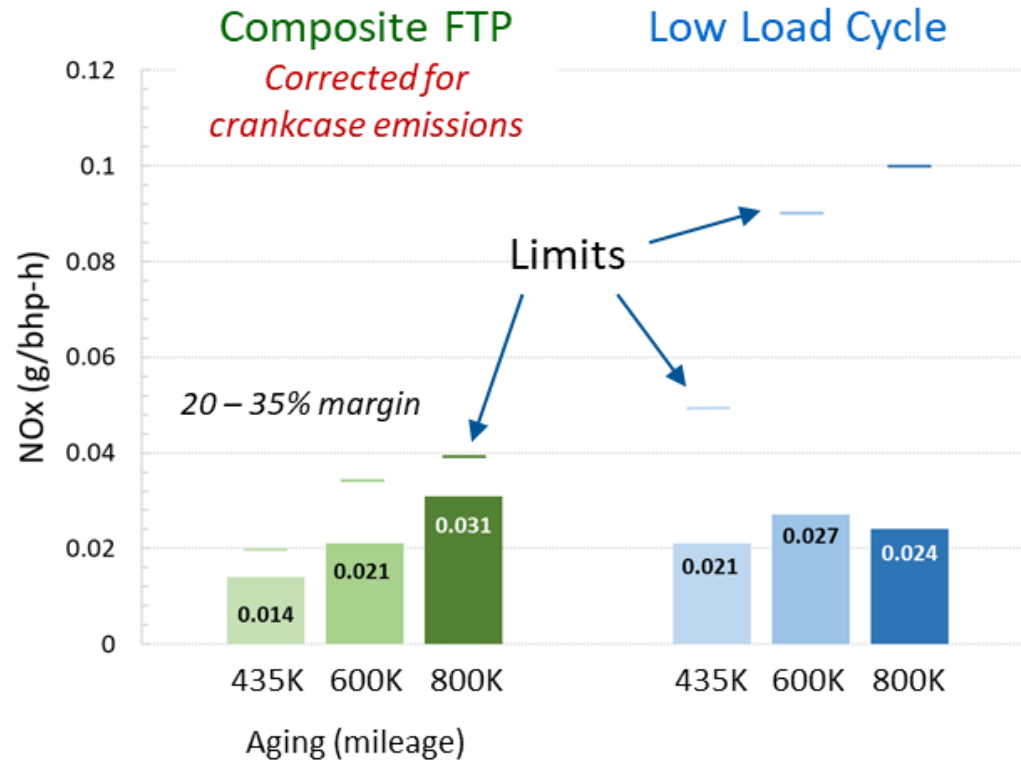


CA/EPA MY 2027
(example configurations)

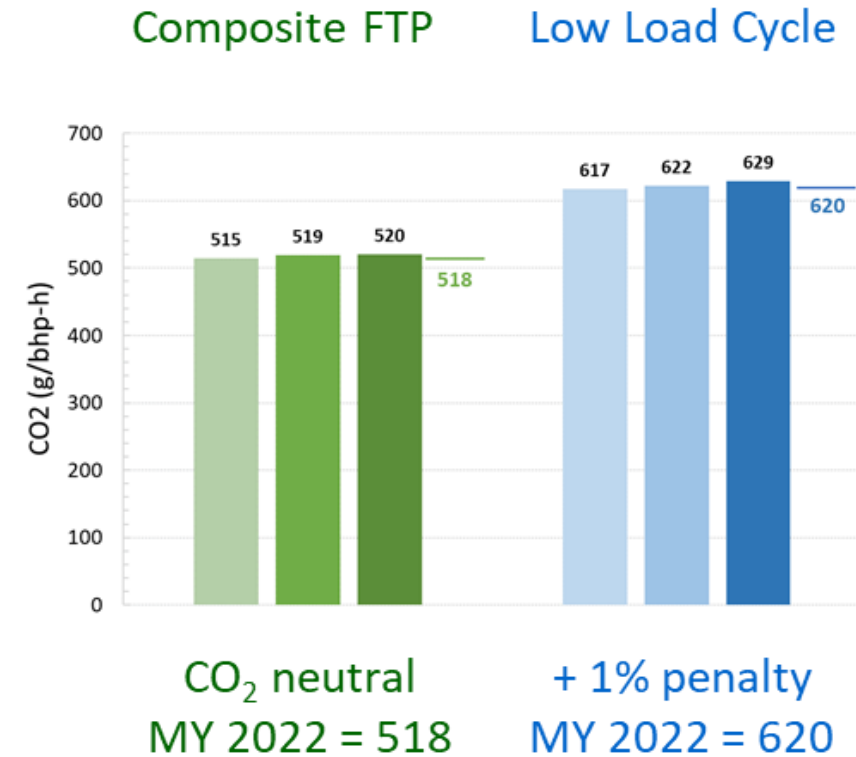


Advanced technologies can meet upcoming Low NOx standards *Without impacting CO₂ / fuel economy*

NOx



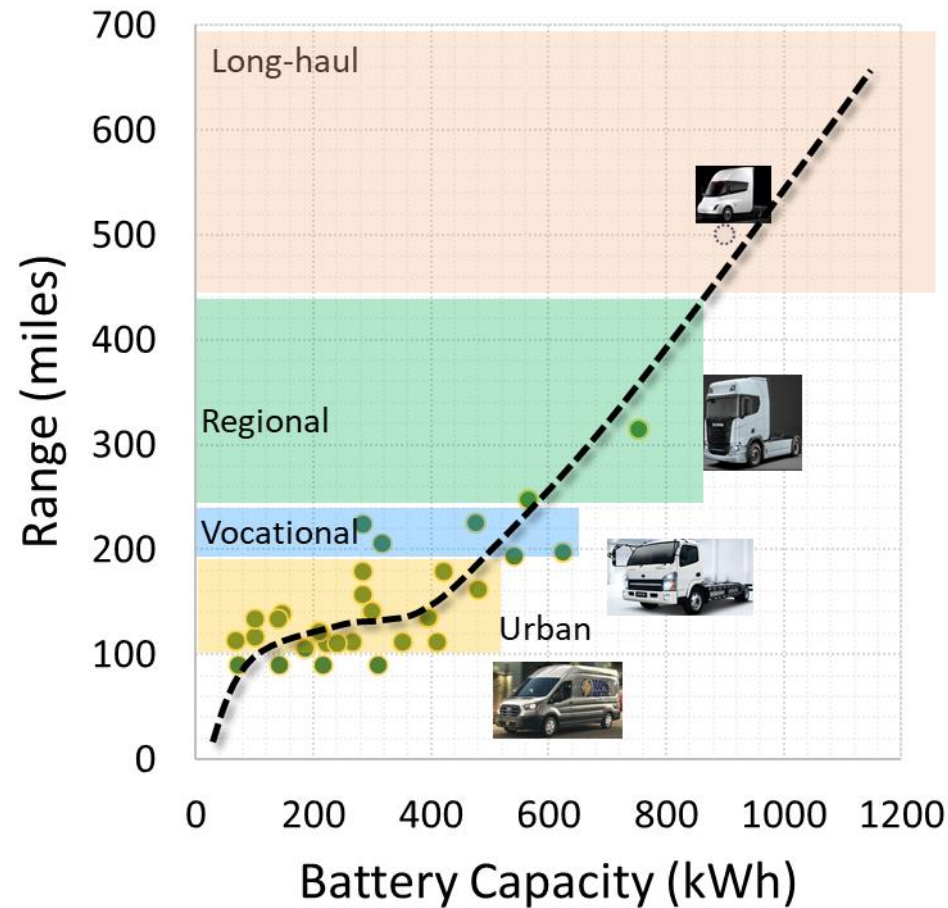
CO₂



Zero-emitting long-haul trucking : Need to address infrastructure

Battery Electric Trucks

> 1MWh battery pack needed for 500+ mile range



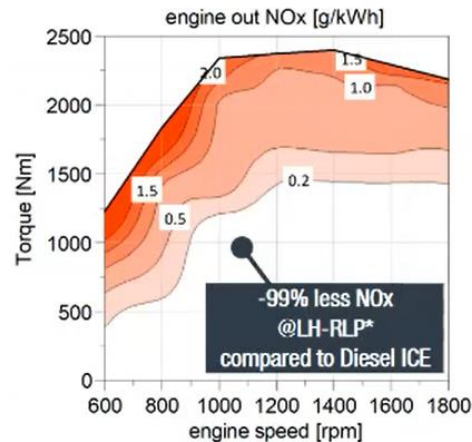
H₂ combustion – why ?!

Utilization of existing hardware



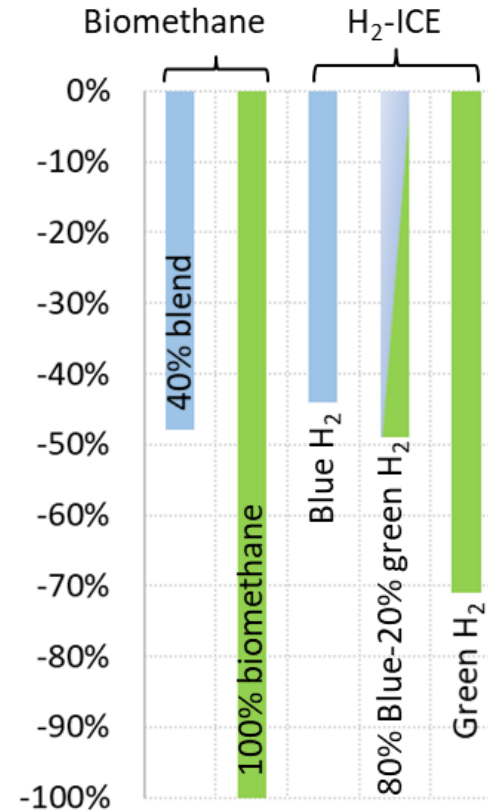
Carry over hardware from diesels

Peak BTE 45% (similar to diesel) – but with 99% lower NO_x



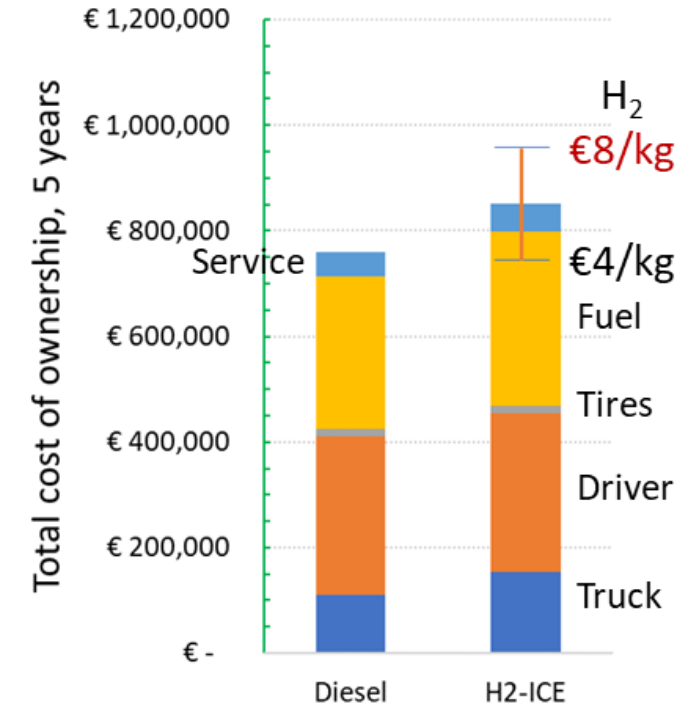
MAN, 42nd Intl. Vienna Motor Symposium, 2021

Well-to-wheel CO₂ reduction vs. diesel



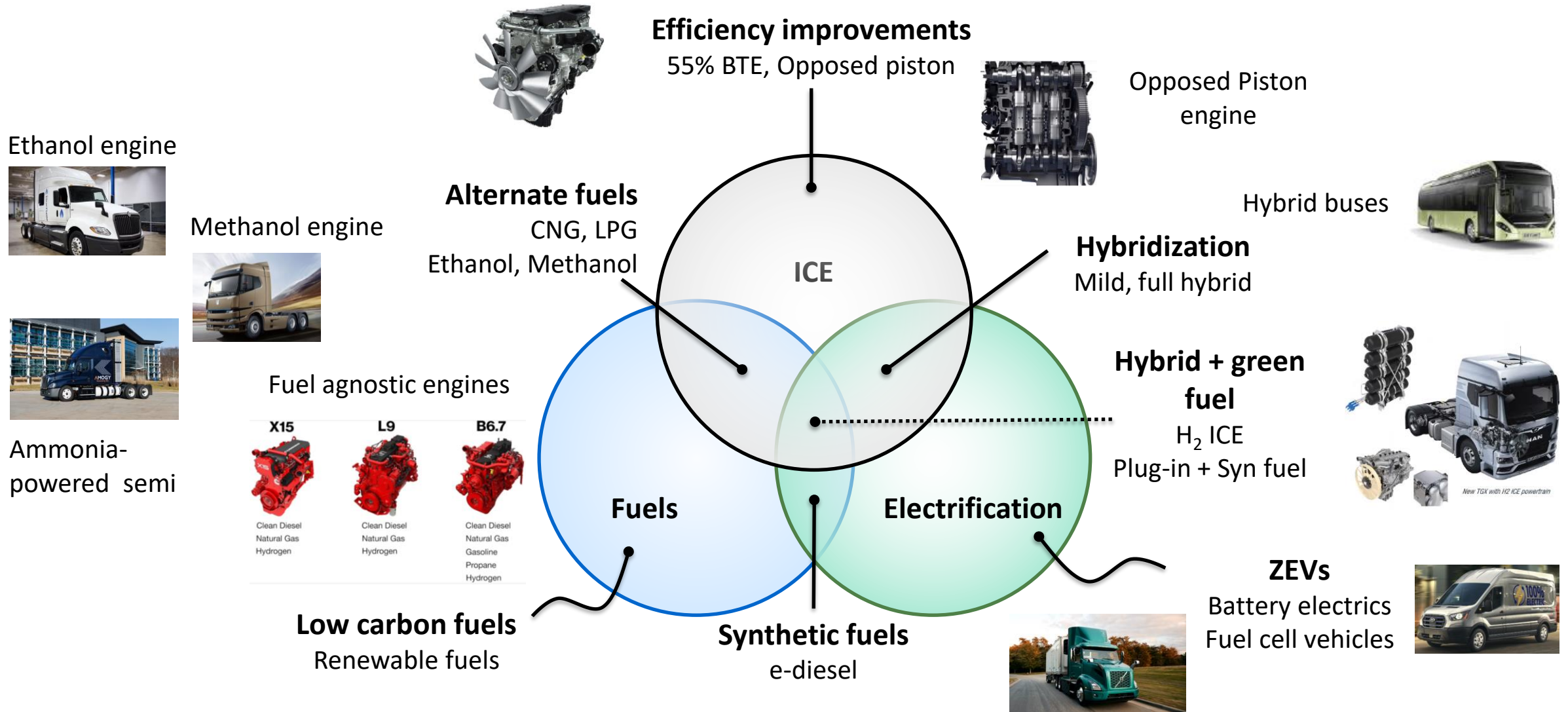
Westport Fuel Systems
43rd Intl. Vienna Motor Symposium, 2022

TCO parity needs significant H₂ price reduction



Truck cost Diesel truck : €110K, H₂ ICE : 1.3 – 1.4X, FCEV : 2.6 – 3.4X
Fuel cost Diesel : €1.5/liter, H₂ : €6/kg
Driver cost : €60K/yr

Various pathways will need to be pursued for transport decarbonization



Powertrains of the Future

Adam Buttgenbach



PEPSICO



PEPSICO



One of North America's Largest Private Fleets



Straight Trucks

CNG



OTR/Transport Tractors



Delivery Tractors



Service/Support Vehicles



Trailers



80,000+ Assets



Delivery Vans



Yard Tractors



Company Cars



Material Handling

pep+ Represents Our End-to-End Transformation



POSITIVE AGRICULTURE

Spread regenerative agriculture across

7 million acres



Sustainably source



100%

of our key crops + ingredients

Improve the livelihoods of more than

250,000 people

in our agricultural supply chain and communities



POSITIVE VALUE CHAIN

Achieve

Net-Zero emissions

by 2040

Cut virgin plastic per serving by

50%

across our global food & beverage portfolio



Net Water Positive

Reduce use + replenish more



Execute our DE&I agenda, invest more than

\$570 million



POSITIVE CHOICES

Evolve our portfolio of products so they are better for the planet + people, by:



- ✓ Diversifying ingredients
- ✓ Expanding position in nuts & seeds category
- ✓ Accelerating science-based targets
- ✓ Scaling little to no single-use packaging platforms

Leverage our iconic brands to inspire positive choices

Lay's will support farmers moving to regenerative practices

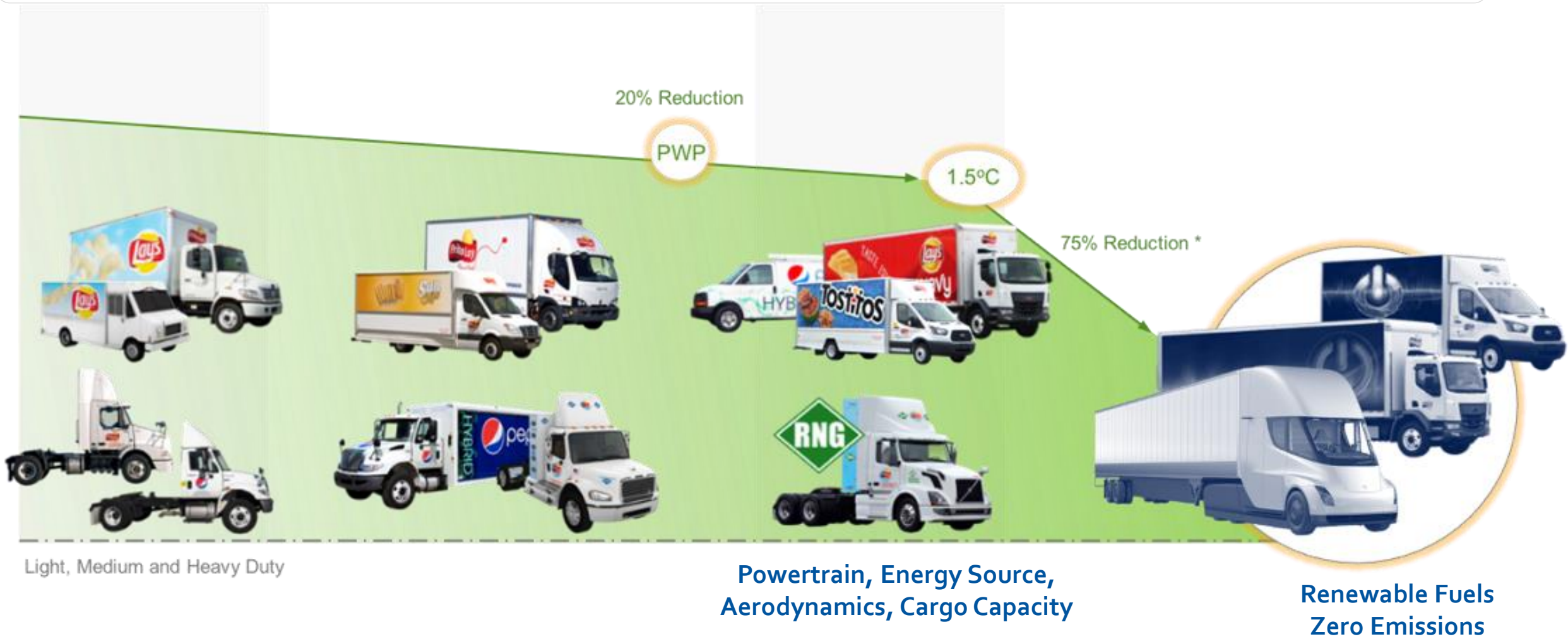


Pre-2010

2010

2020
Efficiency Improvements

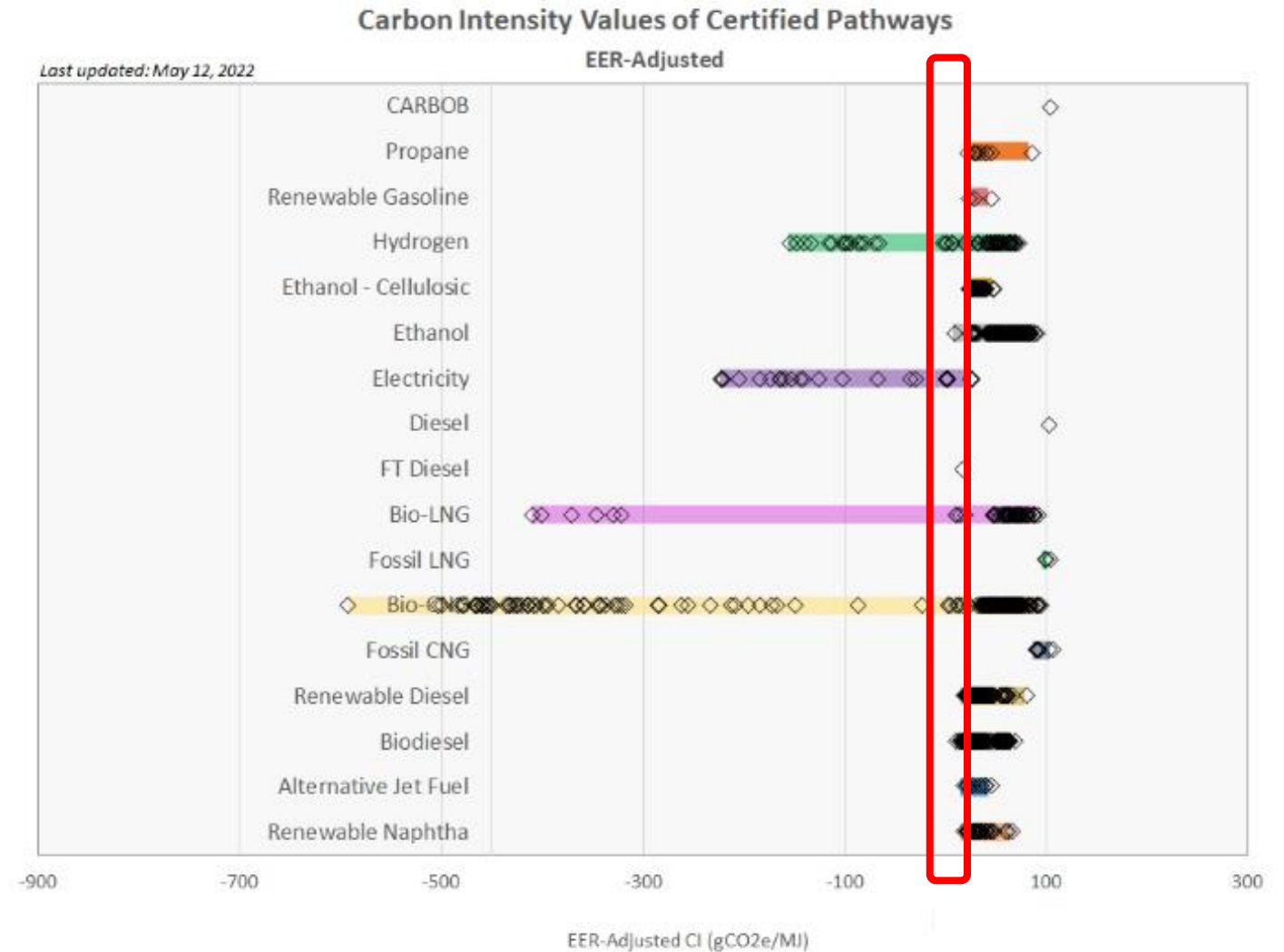
2030



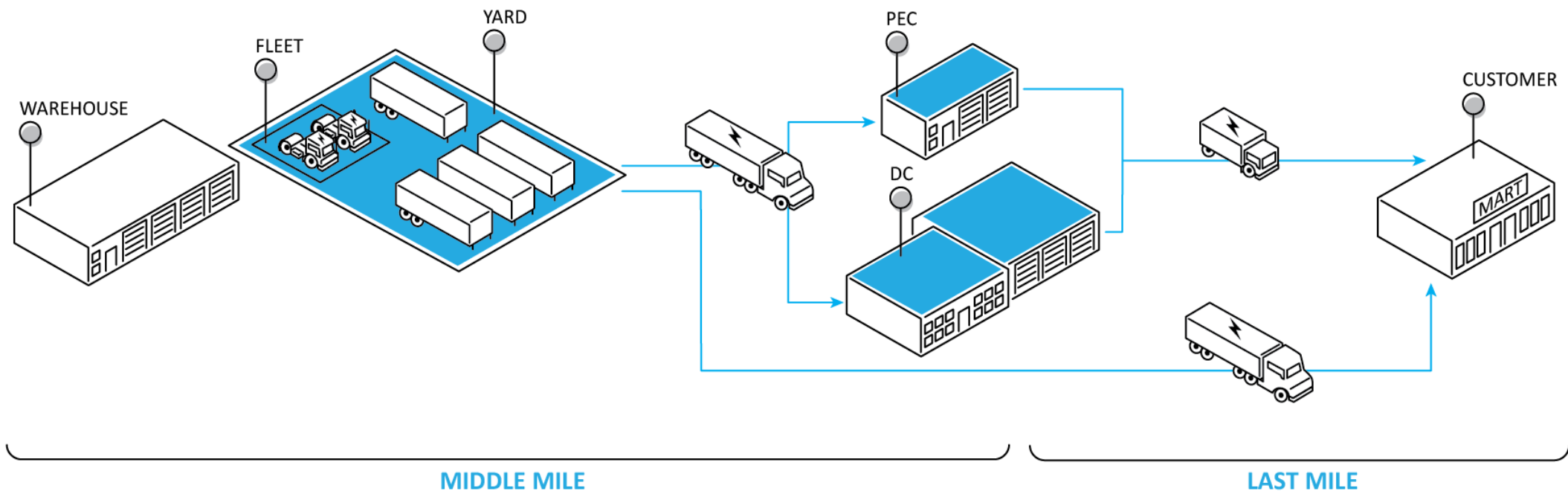
The Energy that Powers our Movement

➤ Energy sources with a Carbon Intensity (CI) that is Zero, Near Zero, or Negative.

1. What is the availability of that Energy?
2. What is the cost of that Energy?
3. What is the Infrastructure?
4. What it the Truck Technology?



Movement of Goods – Right Truck Right Duty Cycle



Battery Electric Vehicles



Renewable Natural Gas



Renewable and Bio Diesel



Electric Delivery Vans

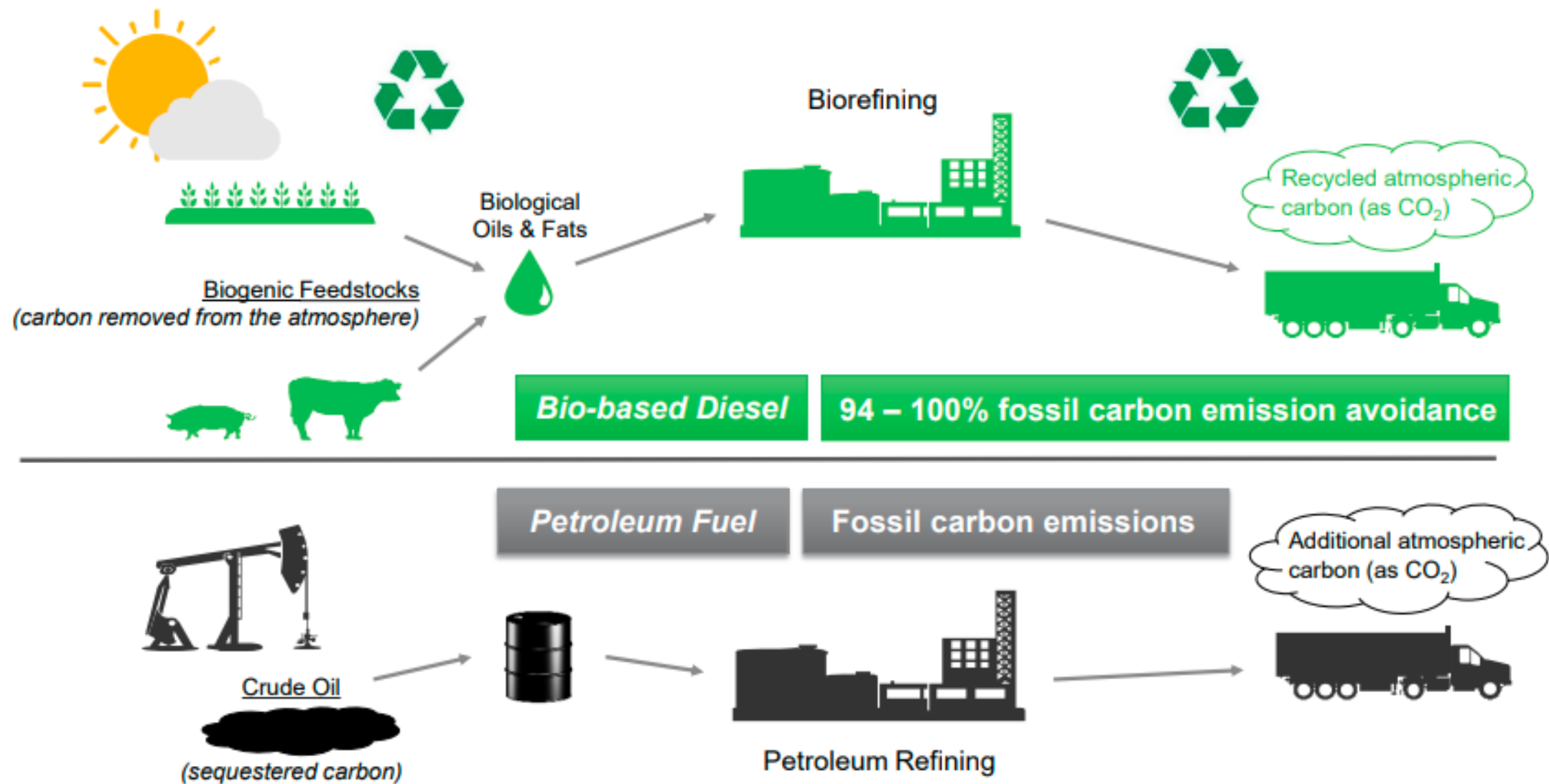


Electric Box Trucks



Electric Tractors

Fossil vs Renewable Fuels



Battery Electric Vehicles (BEVs)

Considerations

- Sustainability Impact
- Site Readiness & Communication
- Equipment Interoperability
- Resilience - Grid Stability
- Duty Cycle
- Size of the project
- % of Units
- Electricity Cost + Utility Status



Modesto - Zero and Near Zero Emissions Freight Facility (ZANZEFF)



- ✓ CNG Station
- ✓ RNG Tractors
- ✓ Renewable Diesel Tractors
- ✓ Li-Ion Forklifts and Chargers
- ✓ Box Truck/Yard Tractor EVSE
- ✓ Electric Yard Tractors
- ✓ Electric Box Trucks
- ✓ Employee Chargers
- ✓ Solar and Battery Storage
- ✓ Semi Charging Stations
- ✓ Tesla Semi Electric Tractors

90%+ Reduction in GHG Emissions

Template for Future Decarbonization

Powertrains of the Future

Mark Ulrich
Director Customer Support
Cummins Inc.





CUMMINS

On-highway engine technology

Powering **line haul** and **regional haul** truck, **urban delivery** truck, **pickup truck**, and **bus** with **diesel**, **natural gas**, and **EV** powertrains.

- 100+ year legacy
- Power options for any duty cycle
 - 2.8 to 15L
 - 161 – 605 hp range (120 – 451 kW)
 - 310 – 2,050 lb-ft torque range (420 – 2,779 Nm)



Destination Zero



**Lower emissions
today**



**Reduce well-to-
wheels emissions**



**Drive wide-scale
customer adoption**

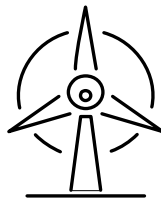


**Achieve zero
emissions by 2050**

ENERGY SOURCES

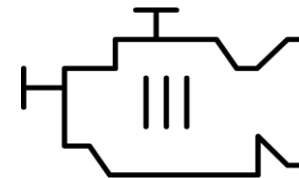


**LOW CARBON
FUELS**



**DECARBONIZED
GRID**

POWER SOLUTIONS



**ADVANCED
POWERTRAINS**

EPA / CARB Emission Regulations

Heavy Duty (HHDE) On-Highway

2022

2024

2027

2031

EPA

EPA 0.2 NO_x

435k mi/10 YRS EUL

100k mi/5 YRS Warr.

EPA 0.2 NO_x

435k mi/10 YRS EUL

100k mi/5 YRS Warr.

EPA 0.035 NO_x

650k mi/11 YRS EUL

450k mi/10 YRS Warr.

EPA 0.035 NO_x

650k mi/11 YRS EUL

450k mi/10 YRS Warr.

CARB

CARB 0.2 NO_x

435k mi EUL

350k mi Warranty

CARB 0.05 NO_x

435k mi EUL

350k mi Warranty

CARB 0.02 NO_x

600k mi EUL

450k mi Warranty

CARB 0.02 NO_x

800k mi EUL

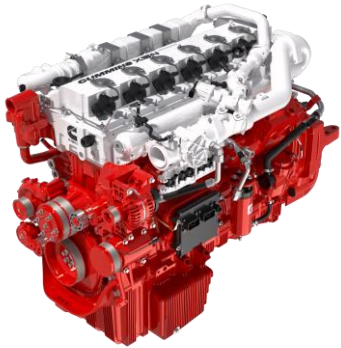
600k mi Warranty

*EPA waiver CARB for
2024 under review*

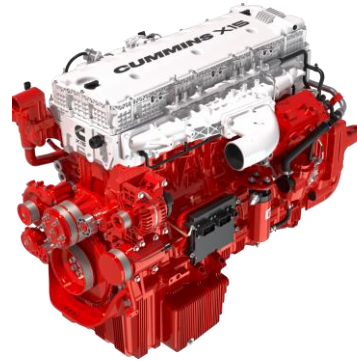
Future Powertrain Vision – Provide Fleets With Options

Fuel-agnostic ICE Platforms

Natural Gas



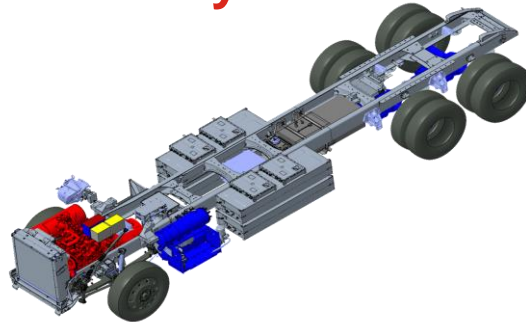
Diesel



Hydrogen



Hybrid



New Powertrain Choices

Fuel Cell Systems



ePowertrain Systems



Traction Systems



Provide Fleets With Powertrain Decision Making Tools

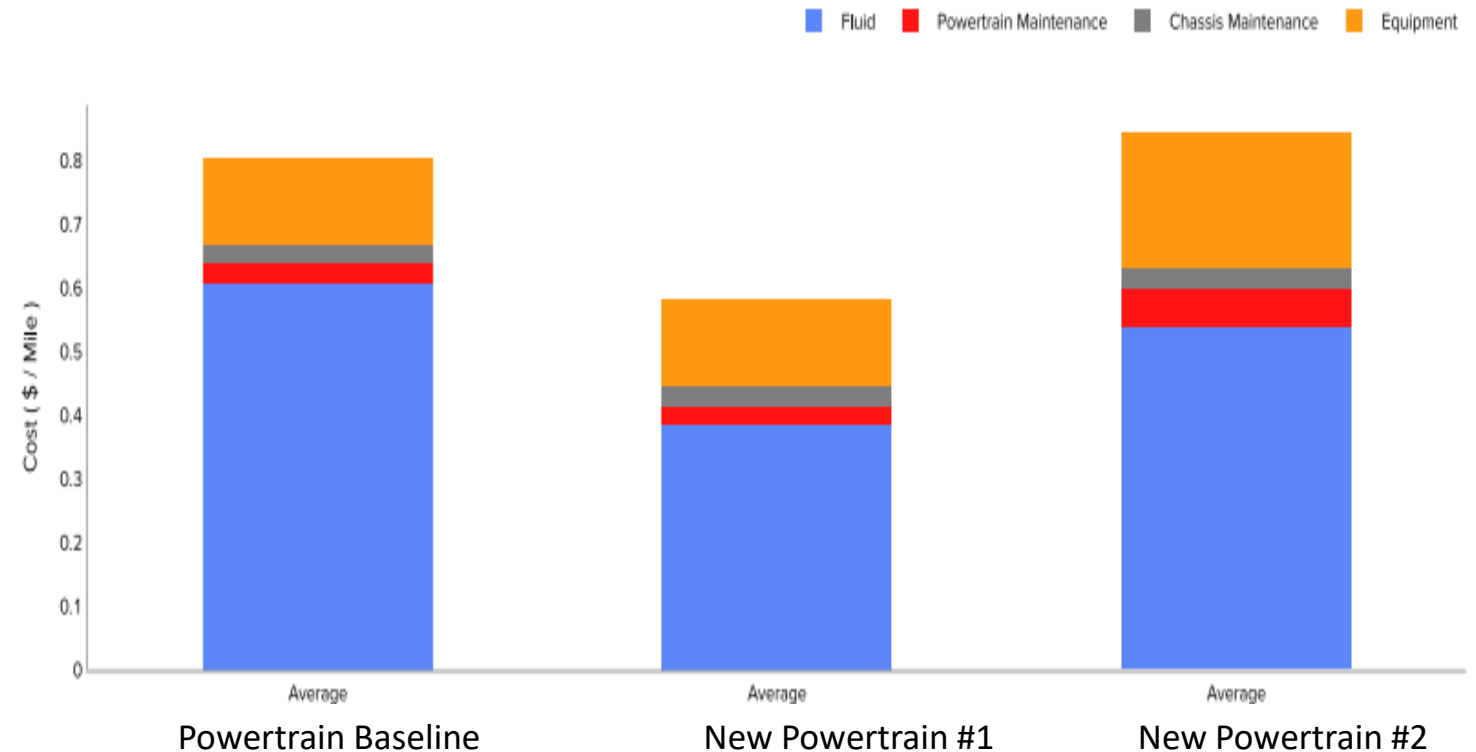
Inputs:

- Fleet specific operational characteristics
 - Duty cycle / fuel economy
 - Vehicle / powertrain specs

Outputs:

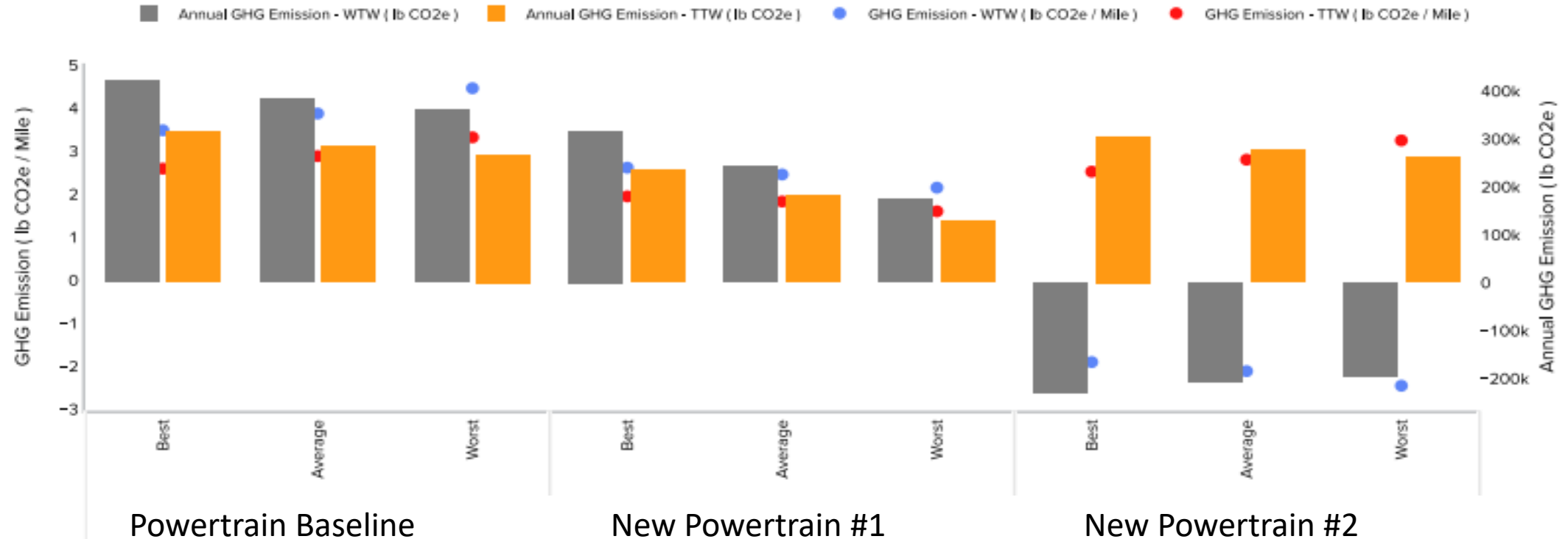
- TCO and GHG delta between powertrain choices
- Range Requirements
 - CNG tank size
 - Battery pack size and system weight impacts
- Infrastructure specing support
 - Required energy and charger needs
 - Required CNG compressor needs

Operational Cost



Provide Fleets With Powertrain Decision Making Tools

GHG Emissions Analysis



Summary

- Act Now to Reach Sustainability Targets
- Right Powertrain for your Company
- Consultative Approach
- Fleet Specific Recommendations based on Your Fleet's Duty Cycles
 - TCO Analysis
 - GHG Analysis

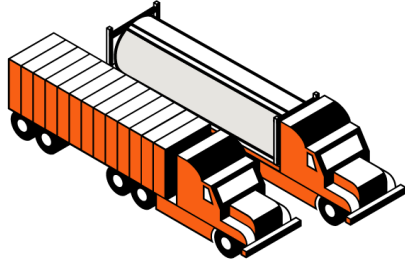
Powertrains of the Future

Rob Reich, Schneider

The Future of Freight

SCHNEIDER[®]





Intermodal

Bulk

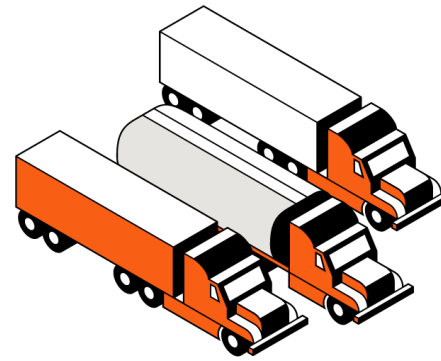
Express Services

North America Cross-Border

Regional

Transcontinental

Rail Dray



Truckload

Bulk

Dedicated

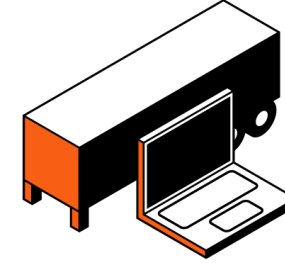
Long-Haul

North America Cross-Border

Regional

Expedited

Power Only



Logistics

Cross-Dock Logistics

Port Dray

Supply Chain Management

Transloading and Distribution

Brokerage

Warehousing

Approximately

10,302

company
tractors

Approximately

72,463

company trailers
and containers

Approximately

2,149

owner-operator
business relationships

Over

64,000

qualified carrier
relationships

Approximately

17,048

associates
worldwide



1935

operations in
United States



1992

operations
in Mexico

Topics

- Corporate Sustainability
- Direct BEV Experience with ~90 Class 8 in SoCal
- BEV vs. FCEV and Other Powertrain Considerations



Source: MSCI ACWI, as of Jan. 5, 2021

Based on MSCI ACWI constituents. Decarbonization targets aim to reduce emissions but do not necessarily target net-zero. For example, a company may set a target to reduce emissions by 50% by 2050.

Shipper Sustainability Plan Roadmap



Network Optimization

Assess if your network footprint minimizes time and distance to fulfill product demand based on changes to your consumers buying behavior.



Freight Consolidation

Are you utilizing TMS technology that can help you reduce the number of loads shipped?



Re-evaluate Mode Selection

Intermodal can reduce emissions by nearly 50%.



Emissions Reporting

Do you have a means of quantifying ESG results from freight consolidation or mode conversion initiatives?



Consider Carrier Fuel Efficiency

Because of the age and type of equipment utilized there is a broad range of emissions.



Electric Vehicles

Set up a fleet as the infrastructure gets built out.



Buy Carbon Offsets

With the remaining carbon emitted buy carbon credits. Offset credits are inexpensive now, but trade on an open market the cost will likely increase.

How Schneider can help shippers.....

Shippers Options:

- Reduce, Reuse and Recycle
- Reduce Road Emissions
- Purchase Carbon Offsets
- Travel Green
- Green Web Hosting
- Reduce Food Waster
- Invest in Renewable Energy



Commitment to Sustainability Goals



Create a Fleet of Electric Trucks



Double Intermodal Size Reducing CO2 Emissions



Our Sustainability Goals

ESG = SUSTAINABILITY

7.5% BY 2025

REDUCED CO2 EMISSIONS PER MILE

2X INTERMODAL SIZE BY 2030

REDUCING EMISSIONS BY ADDITIONAL 700M POUNDS PER YEAR

60% BY 2035

REDUCED CO2 EMISSIONS PER MILE

NET ZERO BY 2035

FOR ALL COMPANY-OWNED FACILITIES

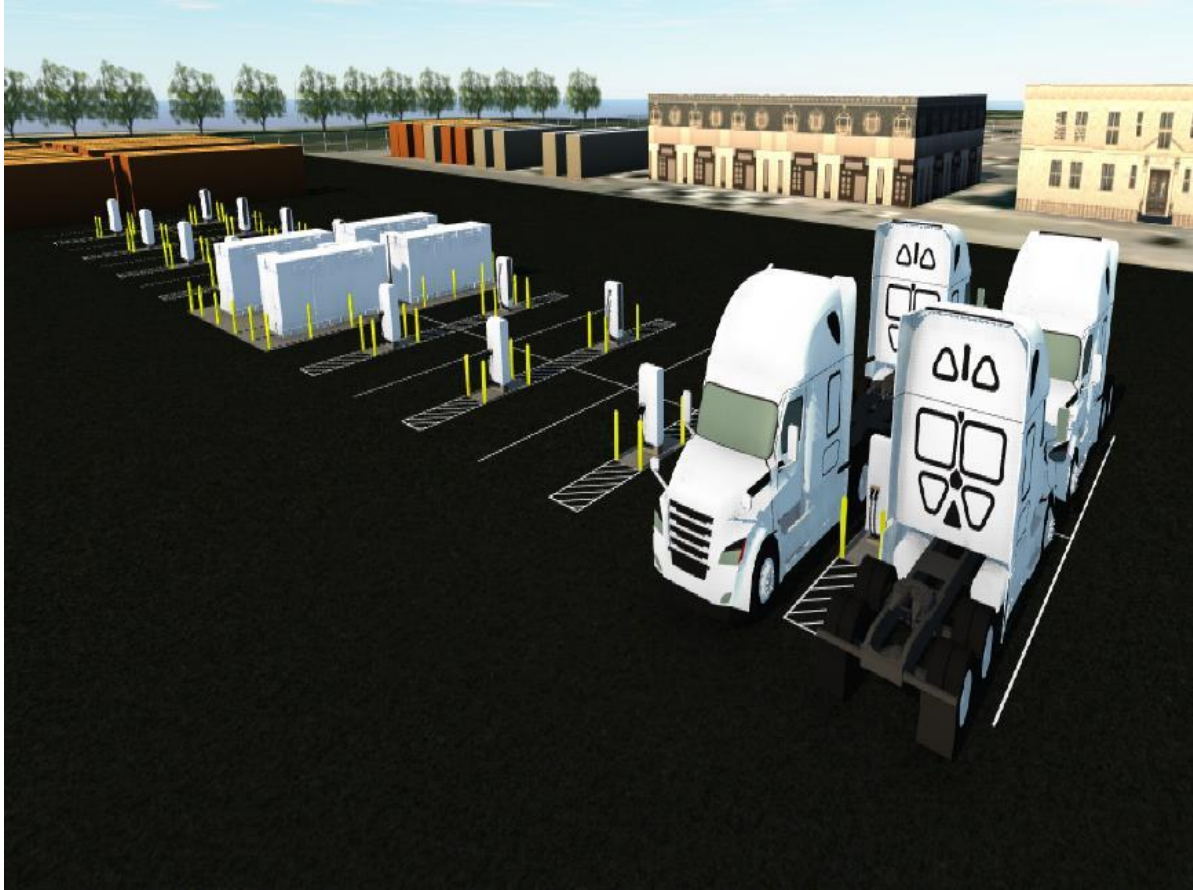
Schneider will become one of the largest battery electric truck fleets in North America.

Beginning in 2022, Schneider will add 90 Freightliner eCascadias — the truck manufacturer's first commercial Class 8 battery-electric truck— to its Southern California intermodal operations.

Funding for 50 of the BEVs was announced August 2021 as part of the Joint Electric Truck Scaling Initiative (JETSI), which is sponsored by the South Coast Air Quality Management District (South Coast AQMD), California Air Resources Board (CARB) and the California Energy Commission (CEC).



The JETSI program has a \$27.2M budget to deploy 50 battery electric vehicles.

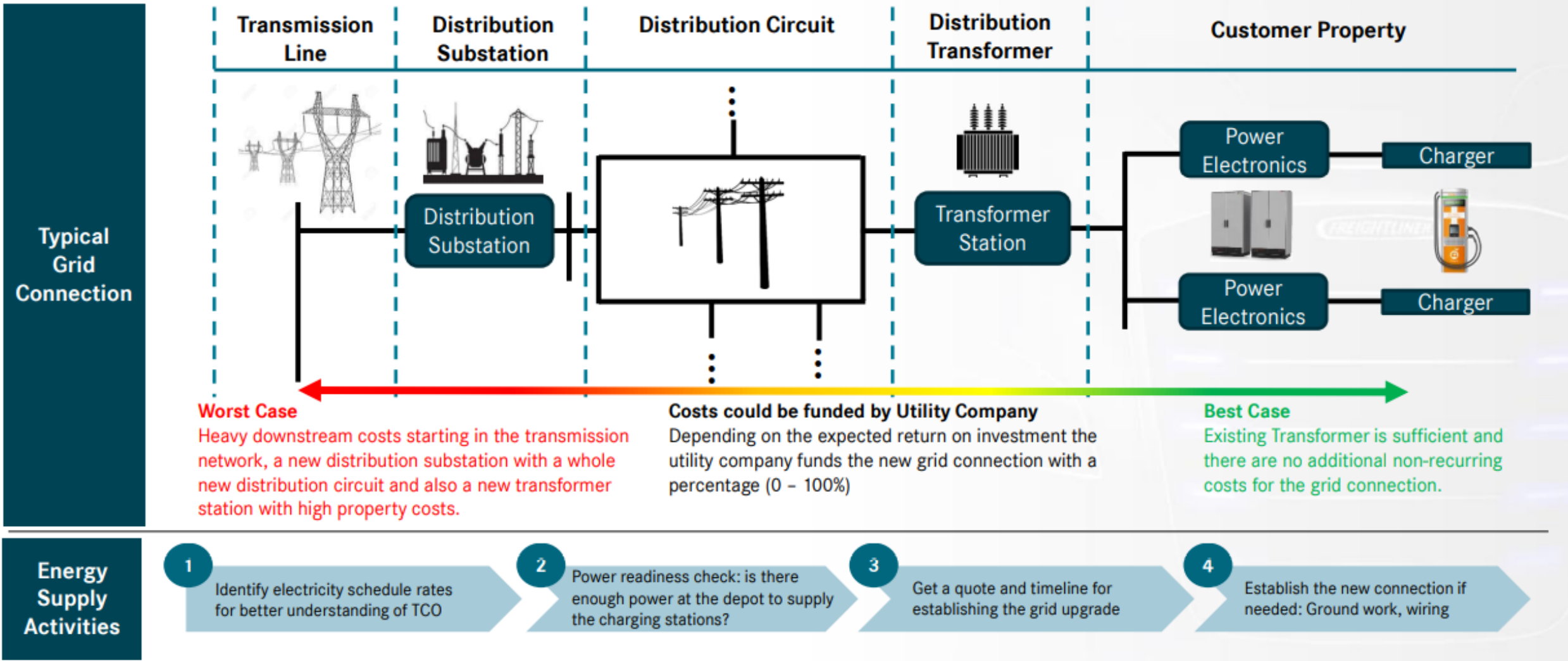


- Schneider's investment is \$8.7M of the \$27.2M
- The key cost elements of the program:
 - \$19.2M for the 50 vehicles (\$385K each)
 - \$1.3M for charging equipment
 - \$800k construction costs
 - \$2.5M improvements for charging infrastructure
 - \$2.7M power costs for two years
 - \$700k reporting, communication, support
- Construction began in Q1 of this year.
- Delivery of trucks started in January.
- The eCascadia day cab will have a range of approximately 200-225 miles.

BEV Plan Focus Areas

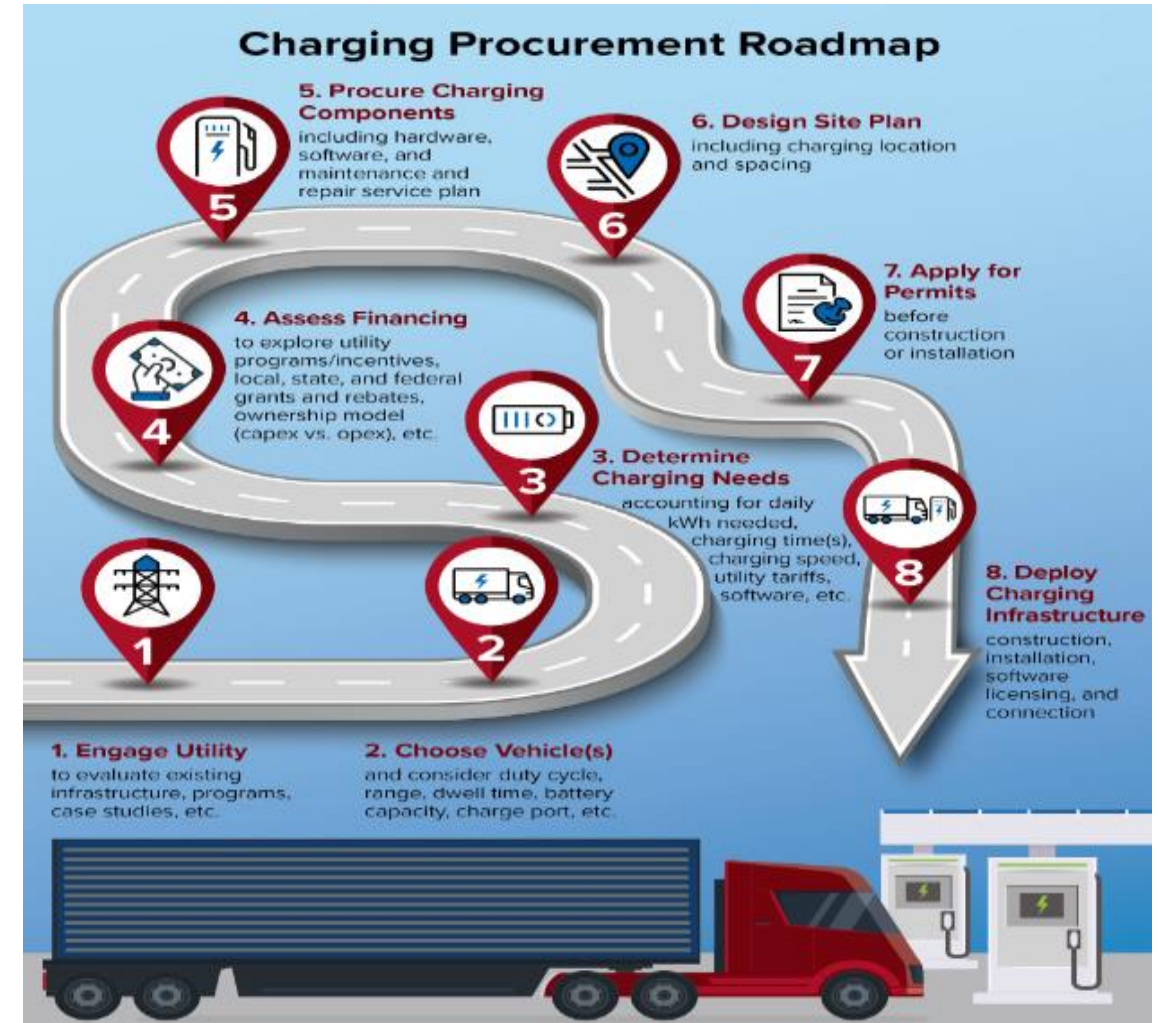


Electrical Grid Considerations



We have learned a lot about Battery Electric Vehicles (BEV).

- The 2nd generation of BEVs is being delivered now.
 - Range of 220 miles
 - 4000 lbs. heavier than standard day cab
 - 2–3-hour fast charging time
 - They don't like cold weather
- Charging at the park site will be the answer.
- The next generation will arrive in 2025/6.
 - Still day cabs
 - 350-mile range
- Our biggest lessons are on infrastructure.



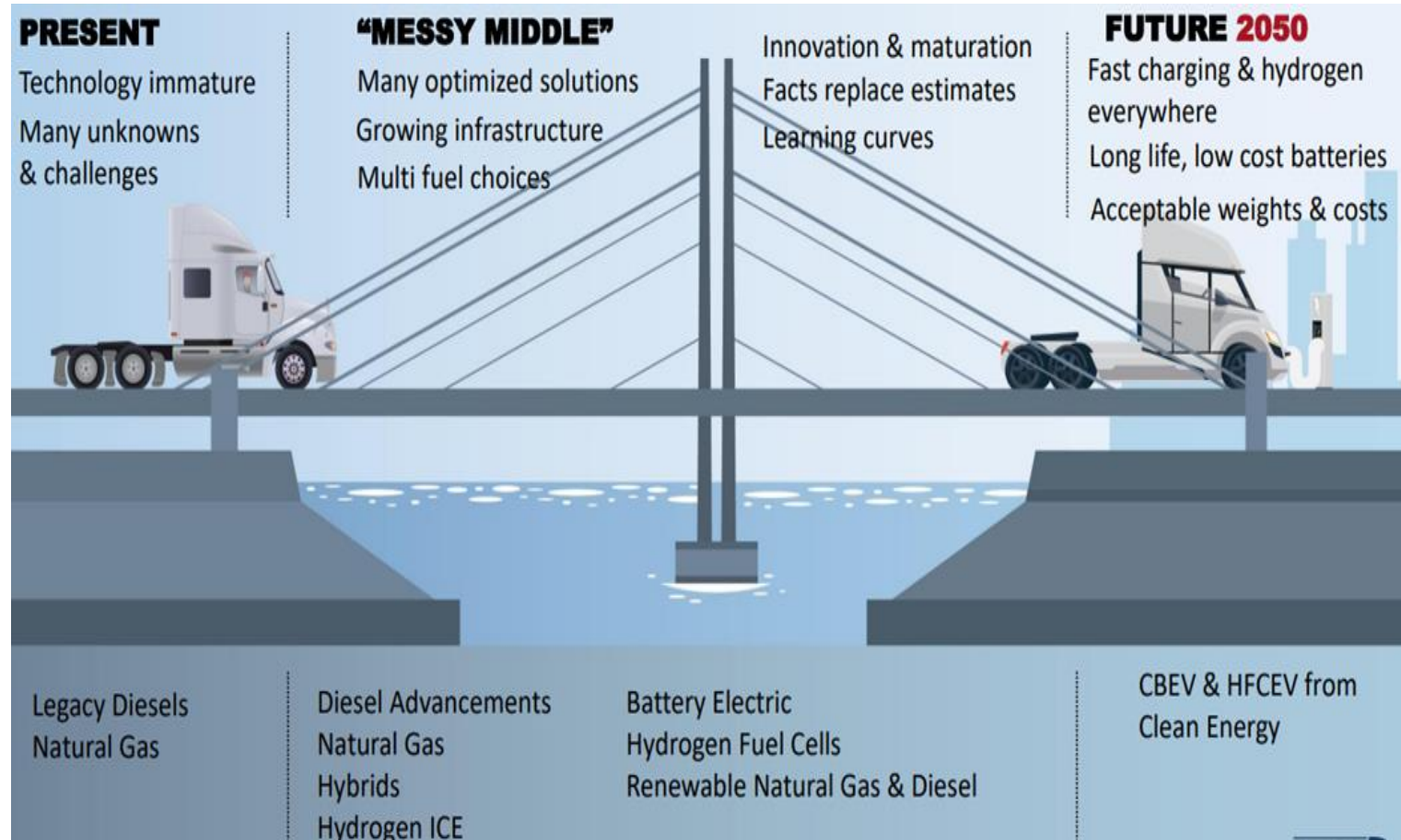
Hydrogen looks to be a good medium distance solution, but there is a lot of infrastructure work ahead of us.



- Hydrogen fuel cell ranges are expected to be 400-800 miles.
- The current cost of hydrogen is \$12-16/kg. It needs to be \$4-6/kg to compete with diesel.
- We will have a test truck in 2023.
- Hydrogen could be the best option in the colder parts of the country.

There are other low- and zero-emission alternatives as we move through the “messy middle” to fully zero emission future.

- Diesel technology continues to get more efficient.
- Natural gas is making a comeback with the new Cummins 15L engine.
- New technology may support higher percentages of biodiesel.
- Renewable diesel is 2X the cost of standard diesel, but production is growing.
- The market and technology won't solely influence direction.....



Final Thoughts

- Many pressures to move forward
- Regulations are also driving change
- Many solutions with various levels of maturity and infrastructure readiness
- Big financial and business implications

"This report was prepared as a result of work sponsored, paid for, in whole or in part, by the California Air Resources Board ("CARB"), the California Energy Commission ("CEC") and the South Coast Air Quality Management District (SCAQMD). The opinions, findings, conclusions, and recommendations are those of the author and do not necessarily represent the views of CARB, CEC or SCAQMD. CARB, CEC, SCAQMD, their officers, employees, contractors, and subcontractors make no warranty, expressed or implied, and assume no legal liability for the information in this report. CARB, CEC or SCAQMD have not approved or disapproved this report, nor has CARB, CEC or SCAQMD passed upon the accuracy or adequacy of the information contained herein."

Powertrains of the Future

Mike Roeth, NACFE

North American Council for Freight Efficiency



Unbiased, fuel agnostic, non-profit
Mission to double freight efficiency
All stakeholders

Scale available technologies, guide
emerging change and Run on Less
demonstrations

www.NACFE.org

www.RunonLess.com



Fleet Decisions

- There are a complex number of factors driving fleets to decarbonize.
- Actions
 - Burn less diesel through efficiency
 - Go to zero
 - Consider alternatives



More Regional Haul and Electrification

2017



2019



2021



2023



Long Haul
7 Fleets
10.1 MPG



Regional Haul
10 Fleets
8.3 MPG



All BEVs
13 Fleets
New metrics!



BEV Depots
8 Depots
Infrastructure

PRESENT: 2020

Technology immature
Many unknowns
& challenges



"MESSY MIDDLE": 2030

Many optimized solutions
Growing infrastructure
Multi fuel choices

Innovation & maturation
Facts replace estimates
Learning curves

FUTURE: 2040

Fast charging everywhere
Long life, low cost batteries
Acceptable weights



Legacy Diesels
Natural Gas

Diesel Advancements
Natural Gas
Hybrids

Battery Electric
Hydrogen Fuel Cells
Renewable Natural Gas & Diesel

CBEV & HFCEV from
Clean Energy



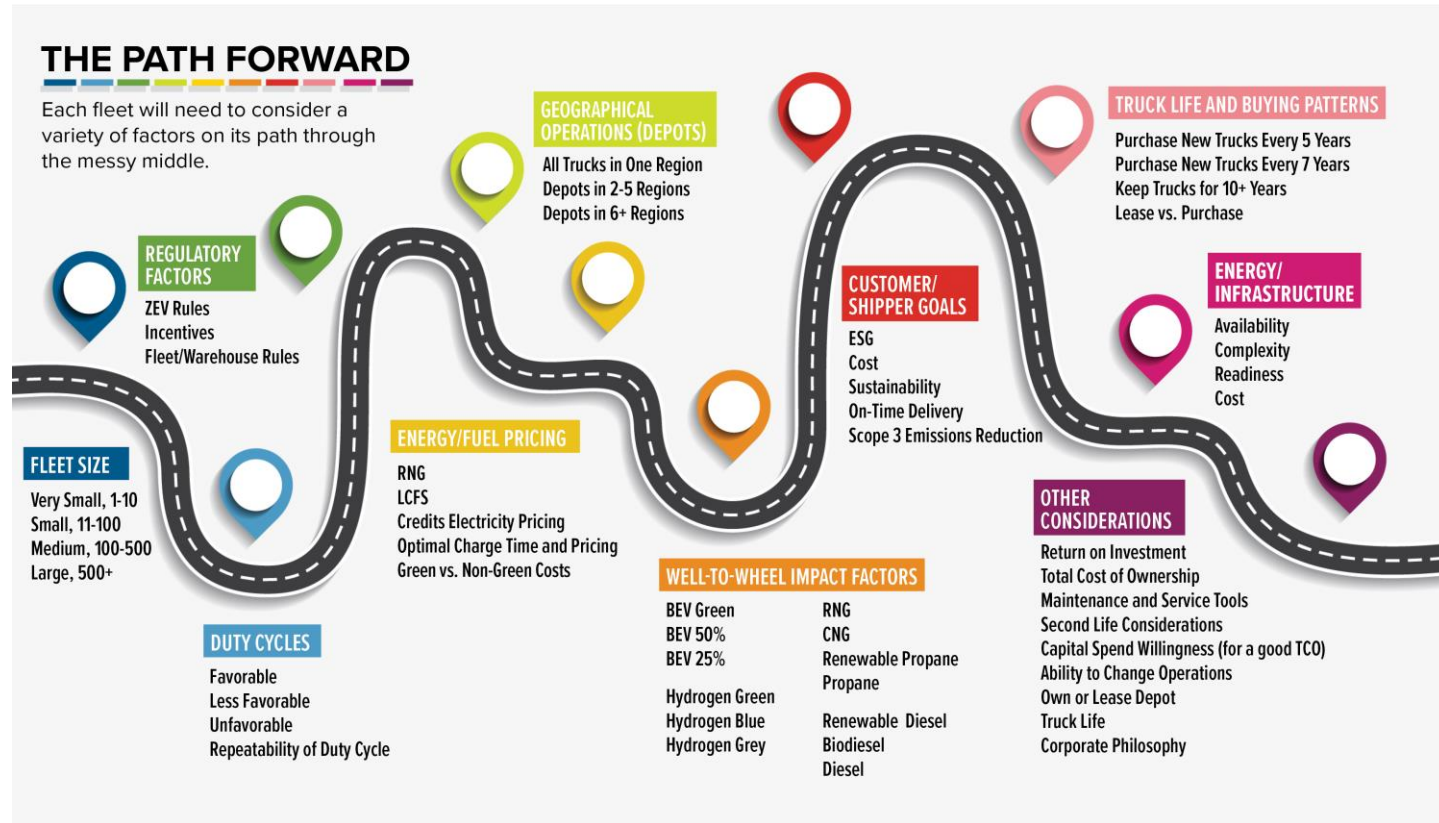
Many Options – Some now, others soon and more later

- Advanced Diesel
- Natural Gas – CNG and RNG
- Hybrids
- Renewable Fuels
- Battery Electric
- Hydrogen Engines
- Hydrogen Fuel Cell Electric



















































Market Dynamics

- Customer and stakeholder expectations
- Progress on battery electric and hydrogen fuel cells
- Greener energy
- Regulations and incentives
- Introductions of new engines
- Operational changes
- Others



POWERTRAIN ALTERNATIVES

Estimate of Technology Readiness by 2025

	SUSTAINABILITY			FLEET OPERATIONAL		INFRASTRUCTURE	INTEGRATION CHALLENGES	MATURITY
	ZEV	Well-to-Wheels	NOx/PM	Range	Route Flex			
DIESEL								
ICE RENEWABLE *								
NATURAL GAS								
HYDROGEN ICE								
BATTERY ELECTRIC								
HYDROGEN FUEL CELL								

* ICE Renewables = Renewable Natural Gas, Renewable Diesel, Renewable Propane, etc.

 = UNFAVORABLE

 = FAVORABLE

THE MESSY MIDDLE: A TIME FOR ACTION

PRESENT

- Technology immature
- Many unknowns & challenges



"MESSY MIDDLE"

- Many optimization solutions
- Growing infrastructure
- Multi-fuel choices
- Innovation & maturation
- Facts replacing estimates
- Learning curves

FUTURE 2050

- Fast charging
- Hydrogen everywhere
- Long-life, low-cost batteries
- Acceptable weights & costs



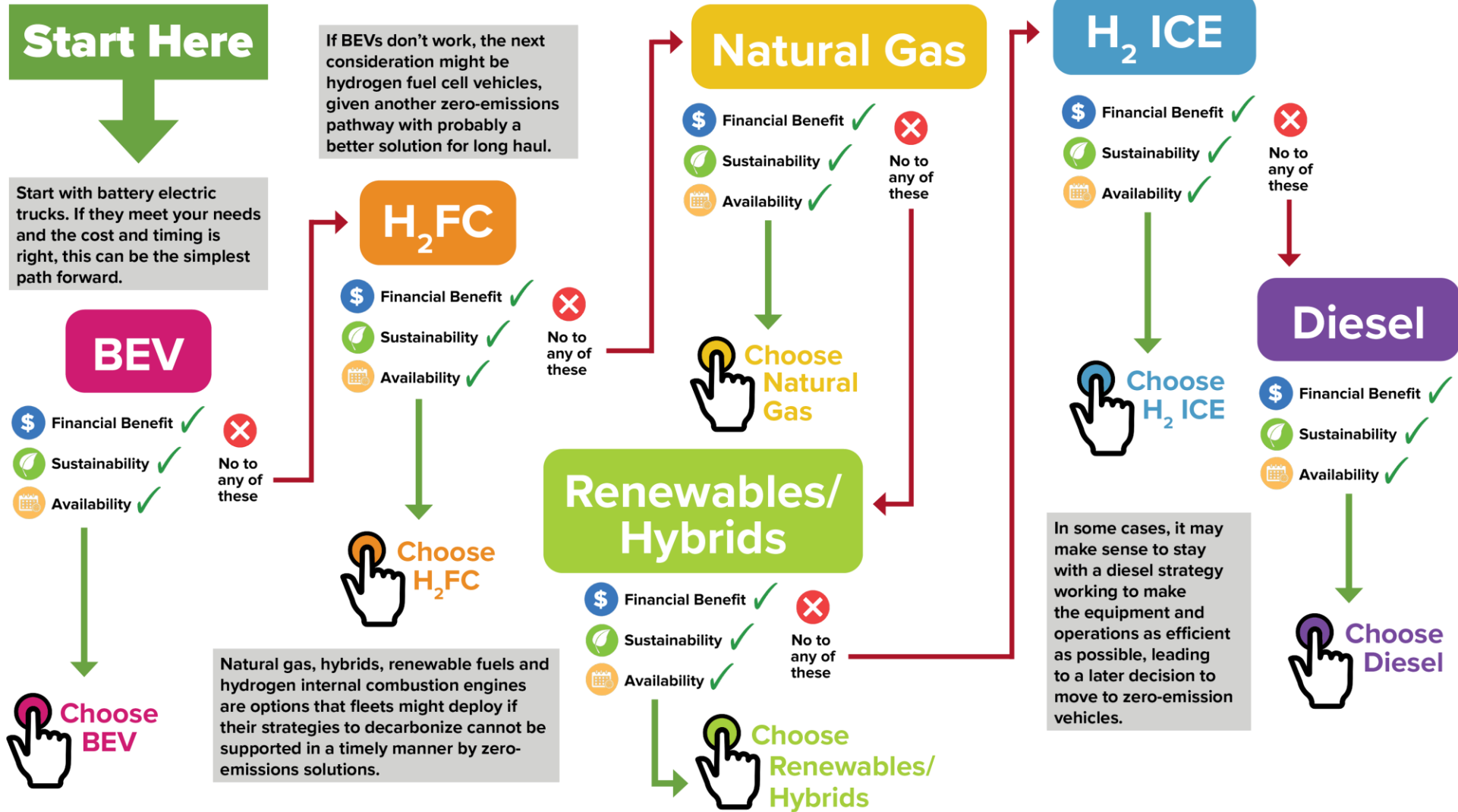
- Legacy Diesels
- Natural Gas

- Diesel Advancements
- Natural Gas
- Hybrids
- Hydrogen ICE

- Battery Electric
- Hydrogen Fuel Cells
- Renewable Natural Gas & Diesel
- More

- CBEV & HFCEV from Clean Energy

Framework for Powertrain Decision Making



In Summary

- This is a time for action
- Support fleets in making the right adoption decisions
- Decisions should include realistic understanding of your pipeline
- An even higher level of collaboration is essential



North American Council for Freight Efficiency



Mike Roeth, Executive Director

mike.Roeth@nacfe.org

260,750,0106

www.NACFE.org

www.RunonLess.com



IN
PARTNERSHIP
WITH

Constructive Comments Are Always Appreciated!

TMC welcomes your comments, but please make certain that they are constructive and appropriate before you turn in your evaluation sheet!

Thank You for Your Cooperation!

save the date

TMC23 FALL MEETING

& Transportation Technology Exhibition
SEPTEMBER 17-21, 2023 | CLEVELAND, OH

ATA'S TECHNOLOGY & MAINTENANCE COUNCIL



TEC
SUPERTECH 2023



SAVE THE DATE

TMB24

ANNUAL MEETING & Transportation Technology Exhibition

MARCH 4-7 | NEW ORLEANS, LOUISIANA
ERNEST N. MORIAL CONVENTION CENTER

*New
Orleans*