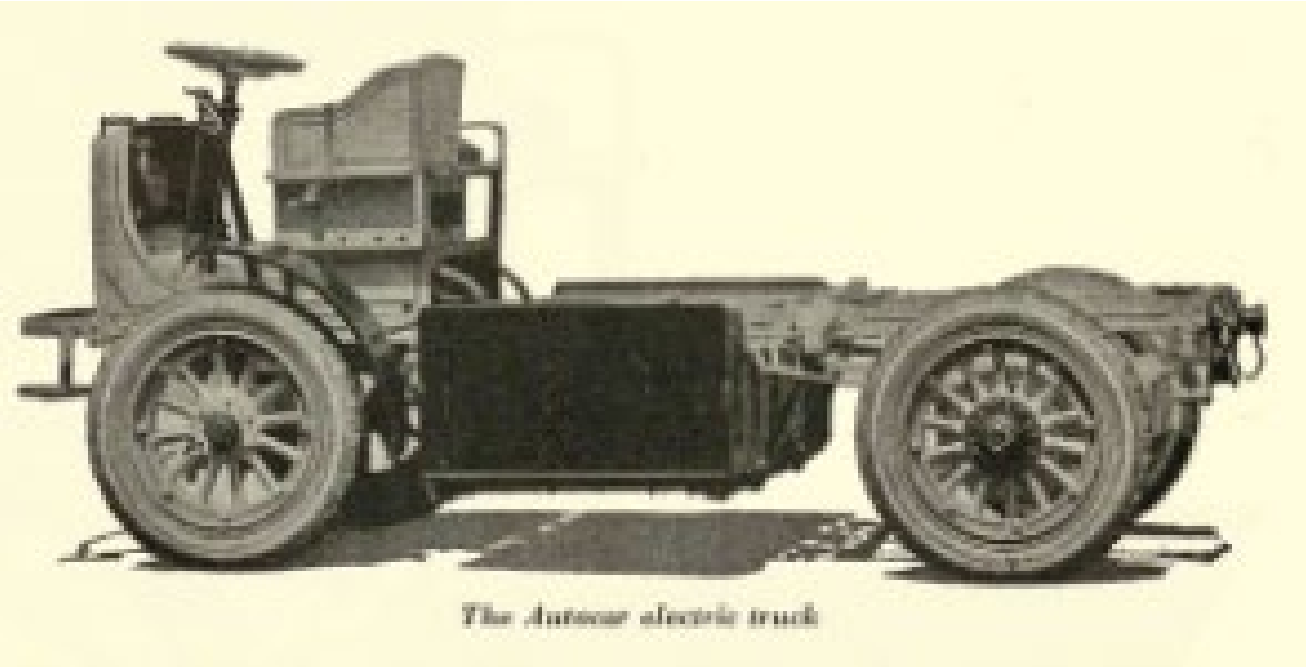
Challenges with Electrical Conversion of Commercial Vehicles

Rebecca Oyler

Pennsylvania Motor Truck Association

December 7, 2023

The Pennsylvania Motor Truck Association promotes the professional and economic growth of the trucking industry and the businesses that support it.



The Autocar electric truck

1923 Autocar E1 electric truck

The Trucking Industry in the U.S.

- 72.6% of all goods in the U.S. are moved by truck
- 11.46 billion tons of freight
- Small businesses (96% less than 10 trucks; 99.7% less than 100 trucks)
- 8.4 million people are employed in jobs related to trucking, including 3.5 million drivers; more than 40% are minorities
- Consumes 18% of total transportation fuel

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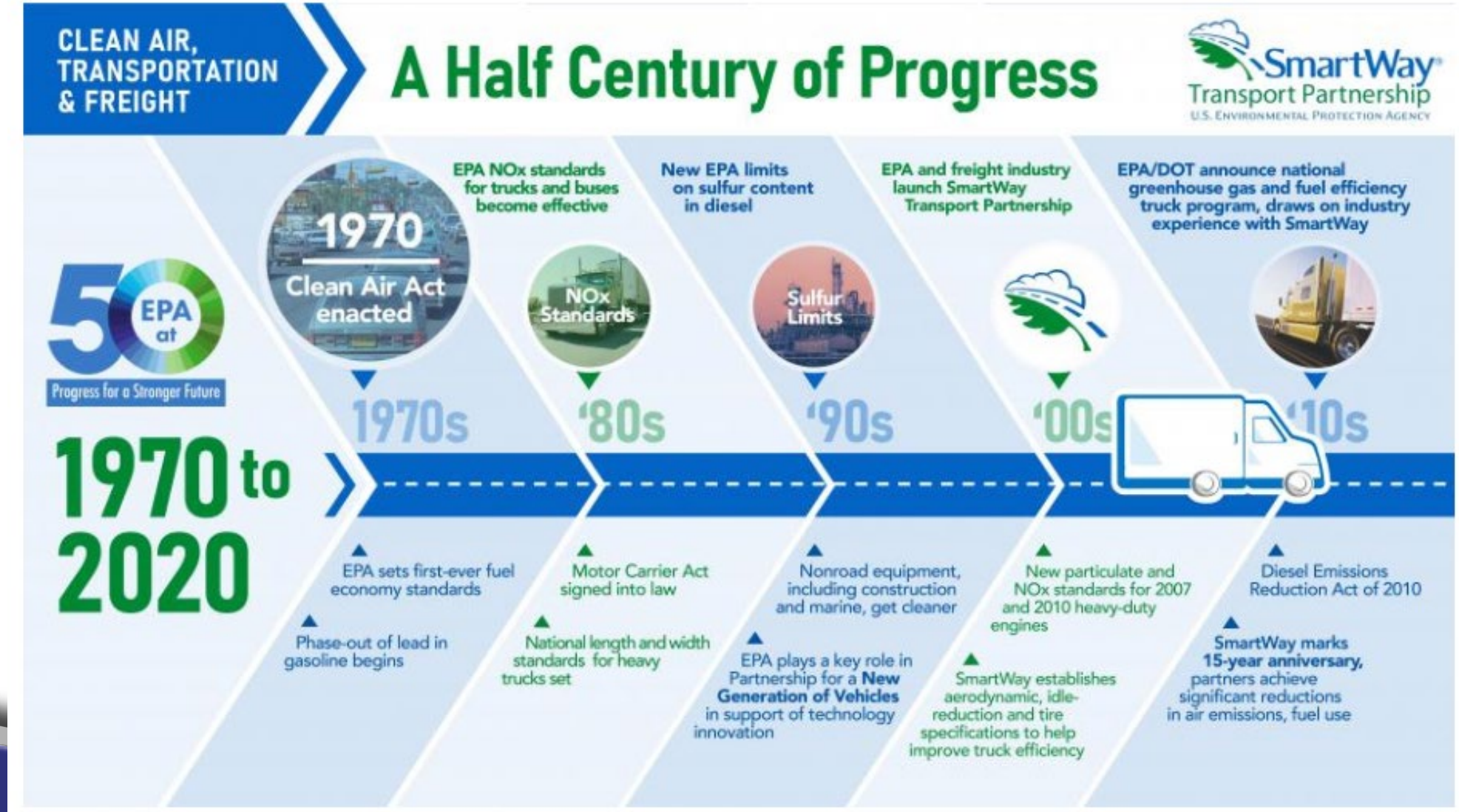
The Trucking Industry in PA

- 96.2% of manufactured tonnage (414,630 tons/day)
- 87.9% of communities depend exclusively on trucks to move their goods
- $1.8 billion in federal/state roadway taxes (38% of taxes, despite driving 10% of miles)
- 68,790 trucking companies employing 341,030 (1 in 15 jobs)


CLEAN AIR, TRANSPORTATION & FREIGHT
A Half Century of Progress
SmartWay Transport Partnership
U.S. Environmental Protection Agency
50 EPA at
Progress for a Stronger Future
1970 to 2020
1970
Clean Air Act enacted
EPA NOx standards for trucks and buses become effective
NOx Standards
New EPA limits on sulfur content in diesel
Sulfur Limits
EPA and freight industry launch SmartWay Transport Partnership
EPA/DOT announce national greenhouse gas and fuel efficiency truck program, draws on industry experience with SmartWay
1970s
'80s
'90s
'00s
'10s
EPA sets first-ever fuel economy standards
Phase-out of lead in gasoline begins
Motor Carrier Act signed into law
National length and width standards for heavy trucks set
Nonroad equipment, including construction and marine, get cleaner
EPA plays a key role in Partnership for a New Generation of Vehicles in support of technology innovation
New particulate and NOx standards for 2007 and 2010 heavy-duty engines
SmartWay establishes aerodynamic, idle-reduction and tire specifications to help improve truck efficiency
Diesel Emissions Reduction Act of 2010
SmartWay marks 15-year anniversary, partners achieve significant reductions in air emissions, fuel use

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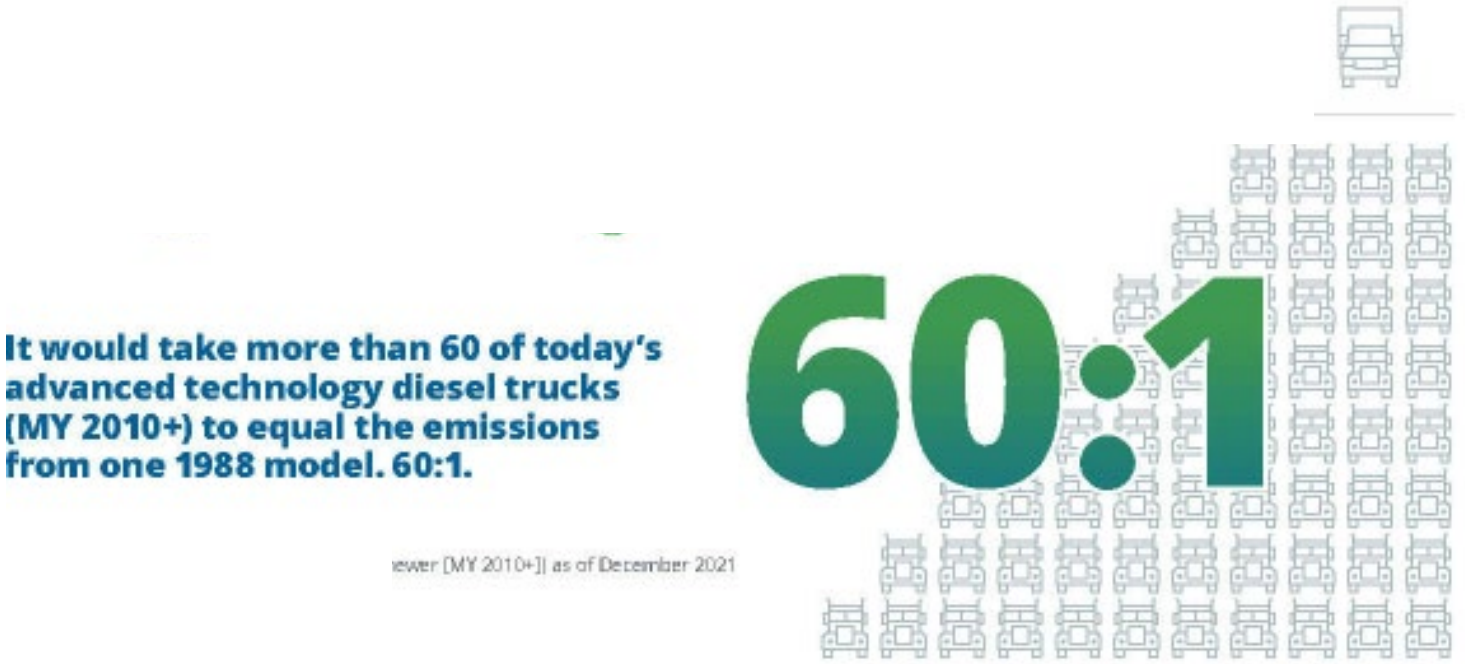
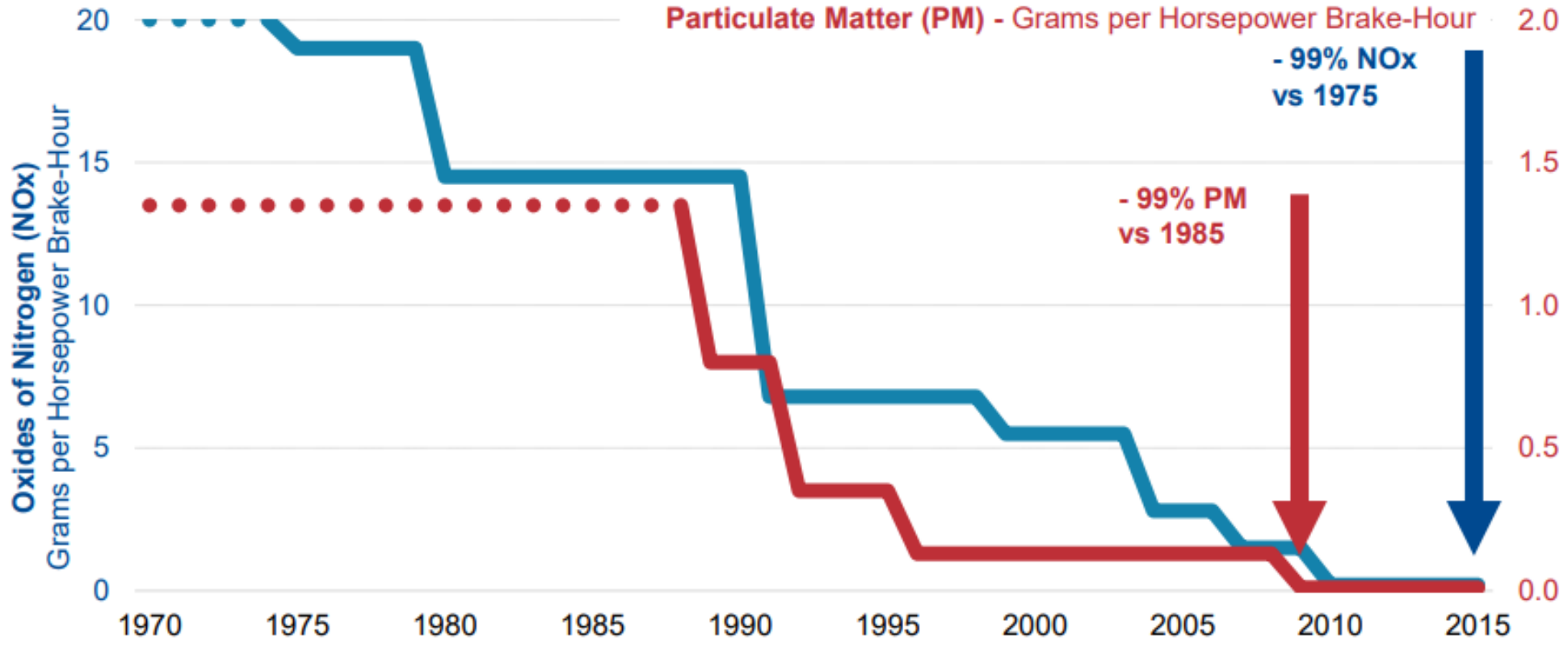


https://dieselforum.org/trucking

U.S. On-Highway Emissions Standards

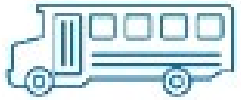


Source: ATA analysis of EPA emissions regulations.

Class 3

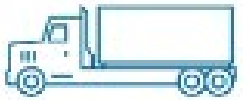
Class 4

Class 5

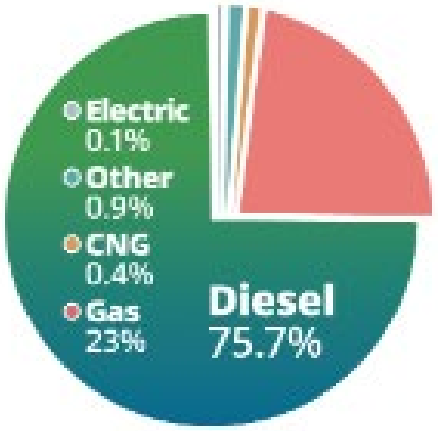


Class 6

Class 7

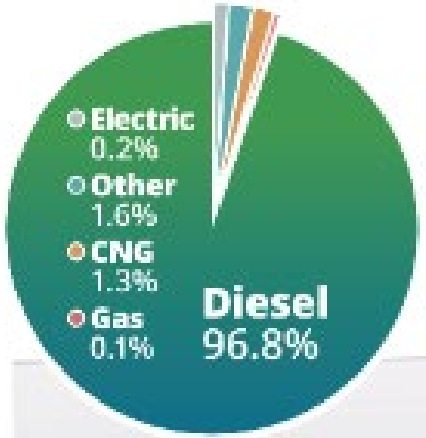


Class 8



76%

of all commercial vehicles in the U.S. are Diesel Powered (Class 3-8)



97% **of the Largest Commercial Trucks (Class 8) are Diesel Powered**

56% are powered by newest generation of advanced diesel technology

3%

increase from 2021

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#12	#23	#3
Total New Generation Clean Diesel School Buses[3]	Total New Generation Clean Diesel Transit Buses[2]	for Highest Percentage New Generation Clean Diesel Heavy-Duty Trucks[1]

Goods Movement: Delivering for Pennsylvania

66%

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

0.2%

PERCENT OF ALL COMMERCIAL TRUCKS THAT ARE ELECTRIC IN Pennsylvania

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https://enginetechforum.org/in-your-state

Regulatory Factors

CA Low-NOx Omnibus Rule and EPA GHG Reductions (Diesel engines)

CA Advanced Clean Trucks Rule (ACT)

Requires manufacturers to sell a growing % of zero-emissions trucks (8500+ GVWR) starting in 2025

CA Advanced Clean Fleets Rule (ACF)

Requires that fleets purchase a growing % of zero-emissions trucks (8500+ GVWR)

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Advanced Clean Trucks (ACT) Regulation

- Major manufacturers must sell ZEVs as a percentage of sales*
- Credit for sales start in 2021
- Minimum tractor sales
- Flexibility to shift sales between categories
- Approved June 2020

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%

CARB

*Partial credit for near-zero emissions vehicles (NZEVs) with minimum all electric range

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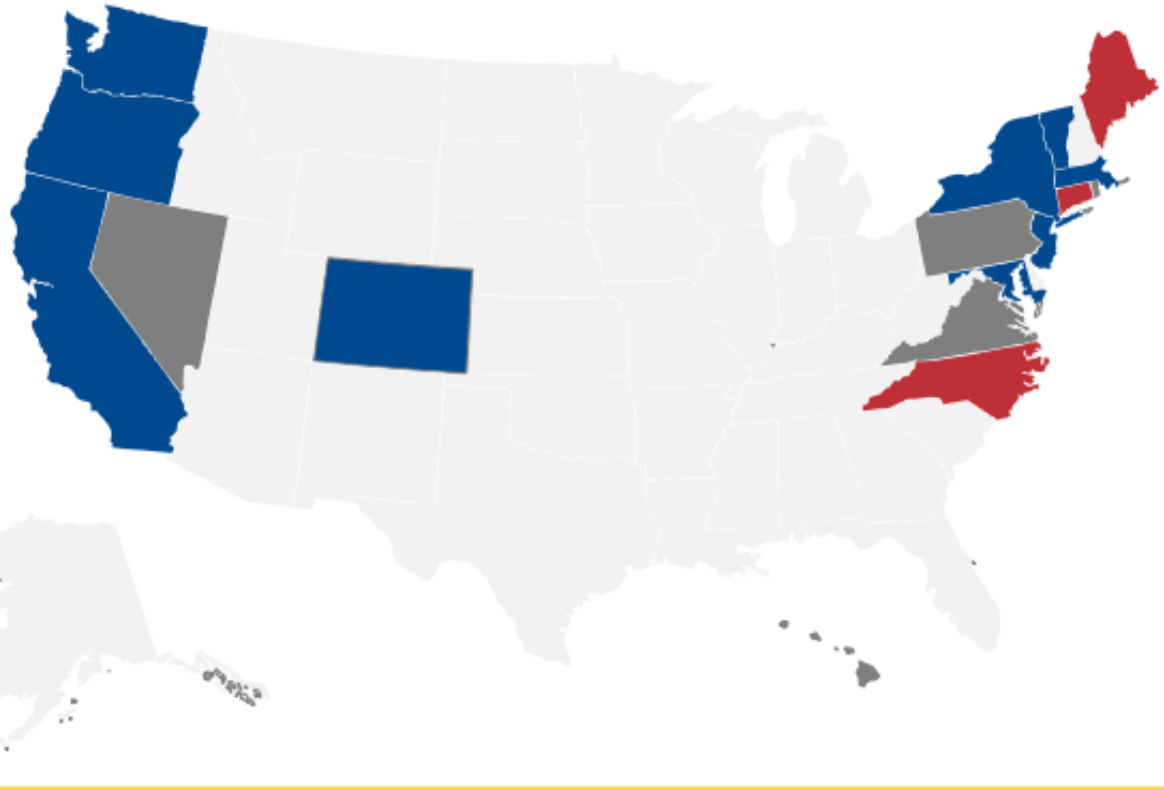
Advanced Clean Trucks (ACT) Rule

ZEV Patchwork

ZEV Patchwork: State of Play



Adopted ACT

CA, CO, MA, MD, NJ, NY, OR, VT, WA

ACT Rulemakings Underway

CT, ME, NC

Other MOU Sign-ons

DC, HI, NV, PA, RI, VA

MOU states commit to achieve 100% sales of electric trucks by 2050, with an interim target of 30% zero-emission vehicle sales by 2030.

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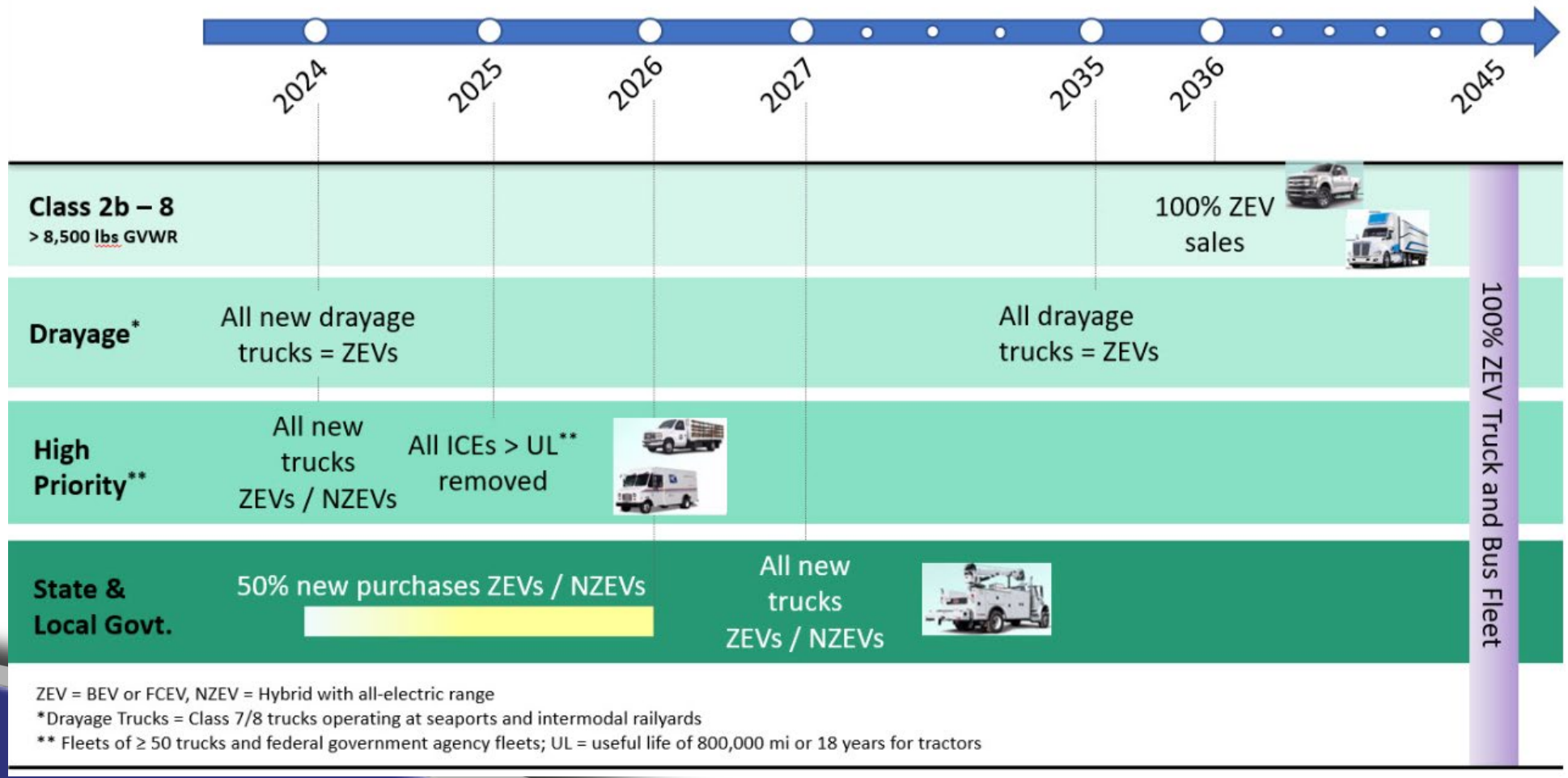
Advanced Clean Fleets Rule



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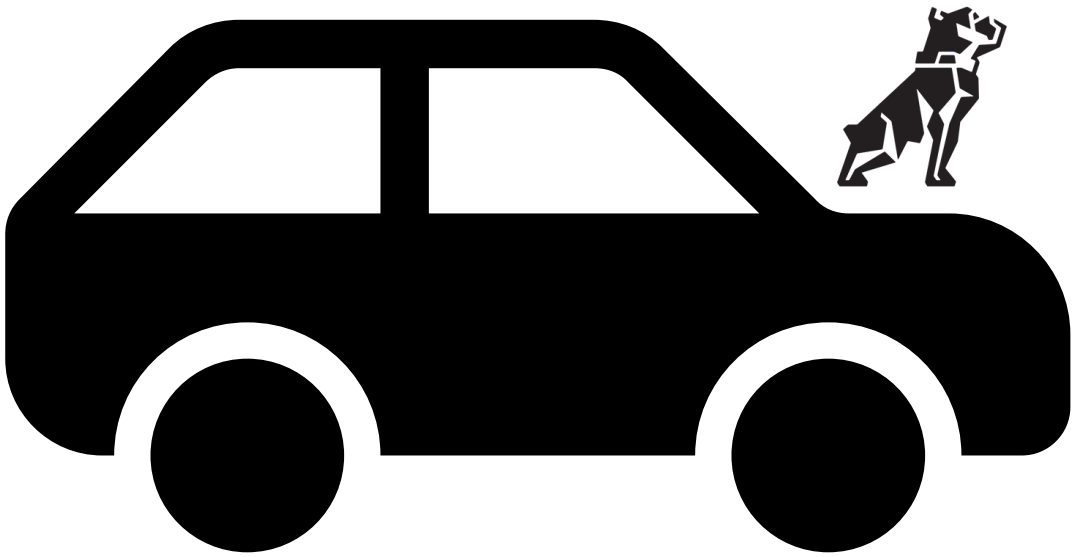
Other Factors

- Manufacturers
- Government incentives/funding for vehicles and infrastructure
- Public pressure

Trucks are Not Big Cars



Requirements:

- Torque for heavy loads
- Distance
- Fuel efficiency
- Long-lasting engines
- Convenient to refuel and repair

Advantages of Electric

- Reduced tailpipe emissions
- Reduced maintenance
- High performance
- No noise

Considerations

- Cost
- Battery weight and impact on payload
- Range
- Charging infrastructure and parking
- Impact on Hours of Service
- Electric supply
- Equipment availability
- Safety and emergency response

Cost (2022)

Representative Vehicle Modeled	Conv	BEV	PHEV	FCEV
Compact Car	$24,500	$32,000	$31,500	$35,500
Midsize Car	$28,500	$37,000	$36,500	$43,500
Midsize SUV	$33,500	$47,500	$43,000	$52,500
Pickup Truck	$36,000	$55,500	$50,000	$71,500
Class 4-6 Box	$72,500	$107,000	$100,500	$113,500
Class 7 Daycab	$117,500	$211,000	$183,500	$198,000
Class 8 Longhaul	$160,000	$457,500	$324,000	$265,500

https://www.ttnews.com/articles/doe-outlines-higher-upfront-costs-green-heavy-trucks

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Truck Batteries

- A semi-truck can weigh up to 80,000 – its battery can take up to ¼ of that weight
- Electric long-haul trucks could be up to 5,328 lbs heavier than a regular diesel truck
- 5000 lbs less cargo on a truck translates to:
    - 16,000 apples
    - A car
    - 51,613 Hershey bars

https://www.eesi.org/papers/view/fact-sheet-the-future-of-the-trucking-industry-electric-semi-trucks-2023

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Range

- The two tanks in a diesel class-8 truck have a range of 1500-2400 miles and take about 15 mins to refuel
- Electric class-8 trucks range = 150-330 miles; can take up to 10 hours to recharge
- Drivers' hours-of-service requirements will mean the need to put more trucks on the road
- Will exacerbate driver shortage

2023 Electric Class 8 Trucks

Model	Range miles (mi)	Charging Time minutes (mn)	Battery Capacity kilowatt hour (kWh)
Kenworth T680E	150 mi	125mn (80%)	396 kWh
Peterbilt 579EV	150 mi	120mn (90%)	400 kWh
Freightliner eCascadia	150-230 mi	90mn (80%)	291 - 438 kWh
Volvo VNR Electric	275 mi	90mn (80%)	565 kWh
Nikola Tre BEV	330 mi	160mn (80%)	733 kWh
Tesla Semi	500 mi	30mn (70%)	500 - 1,000 kWh

All figures are courtesy of the manufacturers

https://www.eesi.org/papers/view/fact-sheet-the-future-of-the-trucking-industry-electric-semi-trucks-2023

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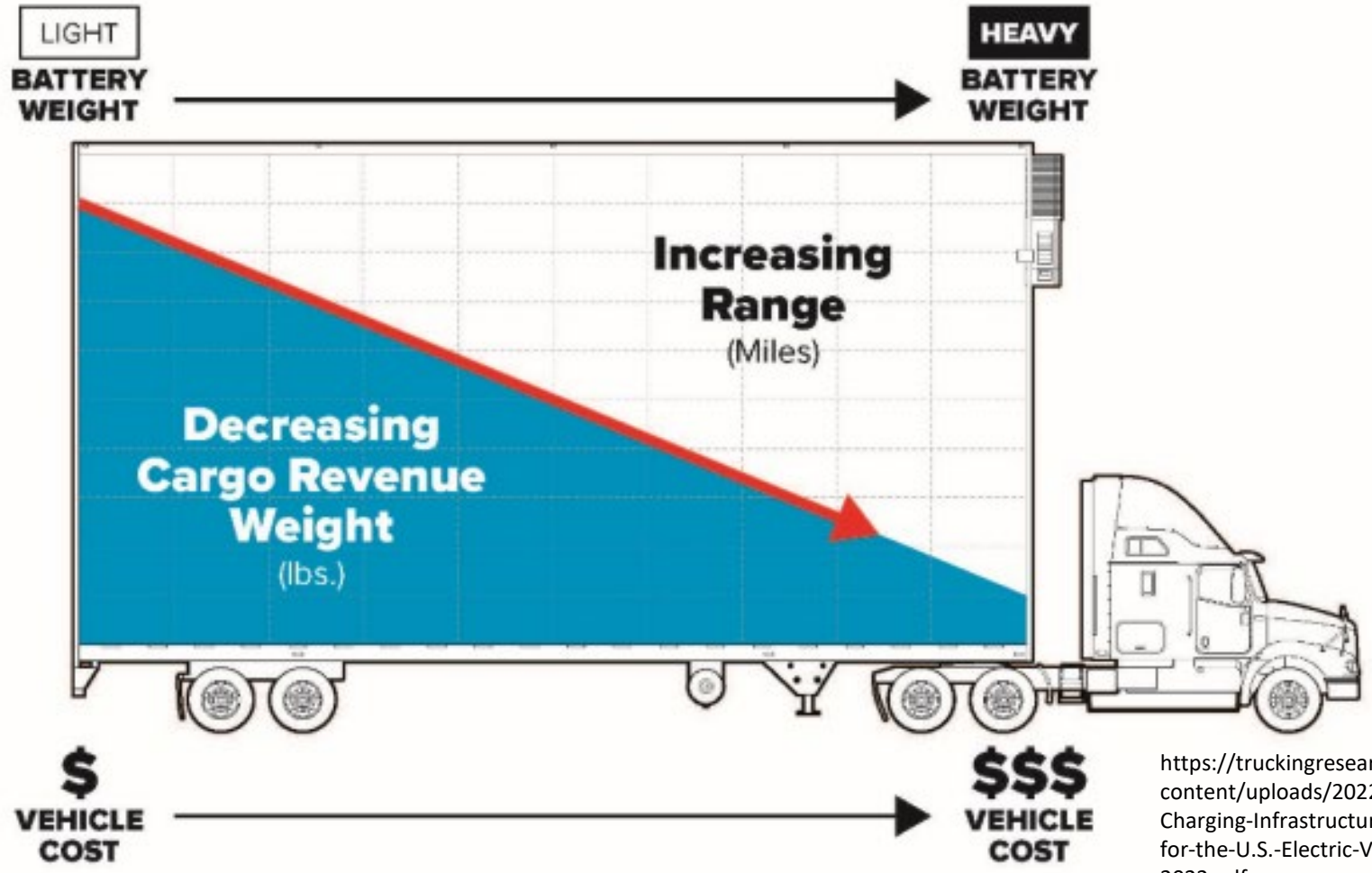
Figure 9: BEV Truck Conundrum



https://truckingresearch.org/wp-content/uploads/2022/12/ATRI-Charging-Infrastructure-Challenges-for-the-U.S.-Electric-Vehicle-Fleet-12-2022.pdf

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Charging Infrastructure

- Many truck parking locations are remote, where electric infrastructure doesn't currently exist
  - A single rest area would require enough daily electricity to power more than 5000 U.S. households
  - Federal limitation preventing commercial charging at public rest areas
- Will exacerbate already existing truck parking crisis
- Initial equipment and installation costs at the nation's truck parking locations will top $35 billion, based on average per-unit cost of $112,000
- Will also require construction of more high-voltage transmission lines and smaller distributions lines and transformers for last-mile delivery

https://www.eesi.org/papers/view/fact-sheet-the-future-of-the-trucking-industry-electric-semi-trucks-2023

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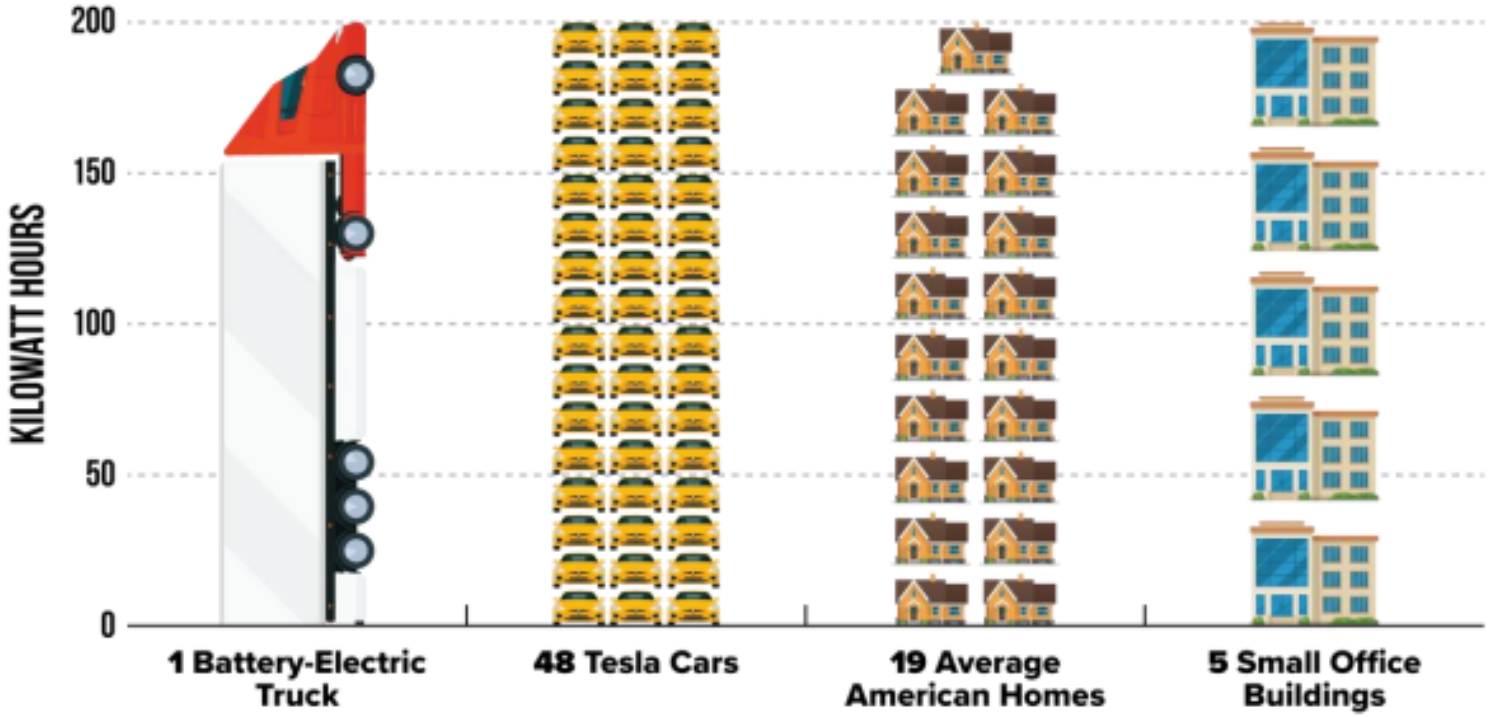
I. ZERO-EMISSION TRUCK TRADE OFFS

Annual Electricity Consumption of One Battery-Electric Truck

1 Battery Electric Truck = 18 American Homes



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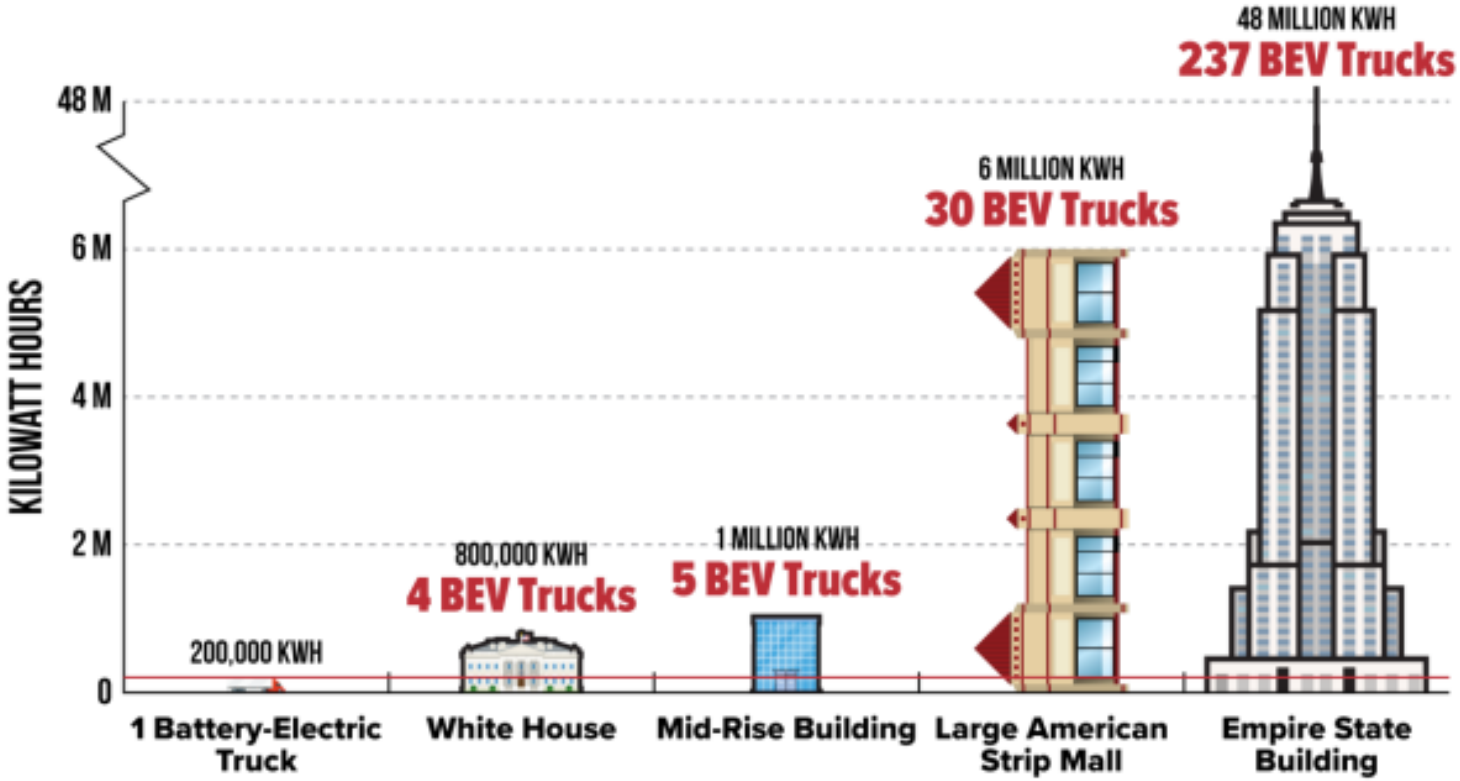
I. ZERO-EMISSION TRUCK TRADE OFFS

Annual Electricity Consumption Comparisons



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Electric Supply

- Concerns about reliability of U.S. power grid
  - 180 major disruptions in 2020 compared to 24 in 2000
  - PJM Interconnection has expressed concern about future
- Electrifying the U.S. vehicle fleet
  - Autos: >253 million cars/light duty trucks
    - Electricity Needs: 1,039.9 billion kWh representing 26.3% of total U.S. consumption
  - Trucks: >12 million medium- and heavy-duty trucks
    - Electricity Needs: 553.5 billion kWh representing 14% of U.S. consumption
    - 10.6% for 2.95 million combo trucks
  - Total: 1,593.8 billion kWh representing 40.3% of U.S. consumption

https://truckingresearch.org/wp-content/uploads/2022/12/ATRI-Charging-Infrastructure-Challenges-for-the-U.S.-Electric-Vehicle-Fleet-12-2022.pdf

https://www.eesi.org/papers/view/fact-sheet-the-future-of-the-trucking-industry-electric-semi-trucks-2023

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Electric Supply

- Trucks will likely only be able to charge at certain times and places (or part of a fleet between certain hours) – more charging at night means more trucks on the road during the day
- Overly strained grid more vulnerable to extreme weather events and prone to blackouts
- Availability of electricity in certain places at certain times could constrain the ability of goods to move throughout the U.S.

https://truckingresearch.org/wp-content/uploads/2022/12/ATRI-Charging-Infrastructure-Challenges-for-the-U.S.-Electric-Vehicle-Fleet-12-2022.pdf

https://www.eesi.org/papers/view/fact-sheet-the-future-of-the-trucking-industry-electric-semi-trucks-2023

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Equipment Availability

- Supply of electric trucks in certain configurations is limited now
- Raw materials, especially rare earth minerals, are limited
- Will become more critical as demand increases

Safety & Emergency Response

- Safety considerations related to weight
- Battery fires
  - On the road
  - Warehouses and places of business
  - Emergency response training
- Need for mobile chargers

Where Can Electric Play a Role?

- Local, relatively short-haul delivery and service markets where charging can happen overnight is a short-term goal
- Sectors where advantages in noise and emissions reduction is most beneficial

Alternatives

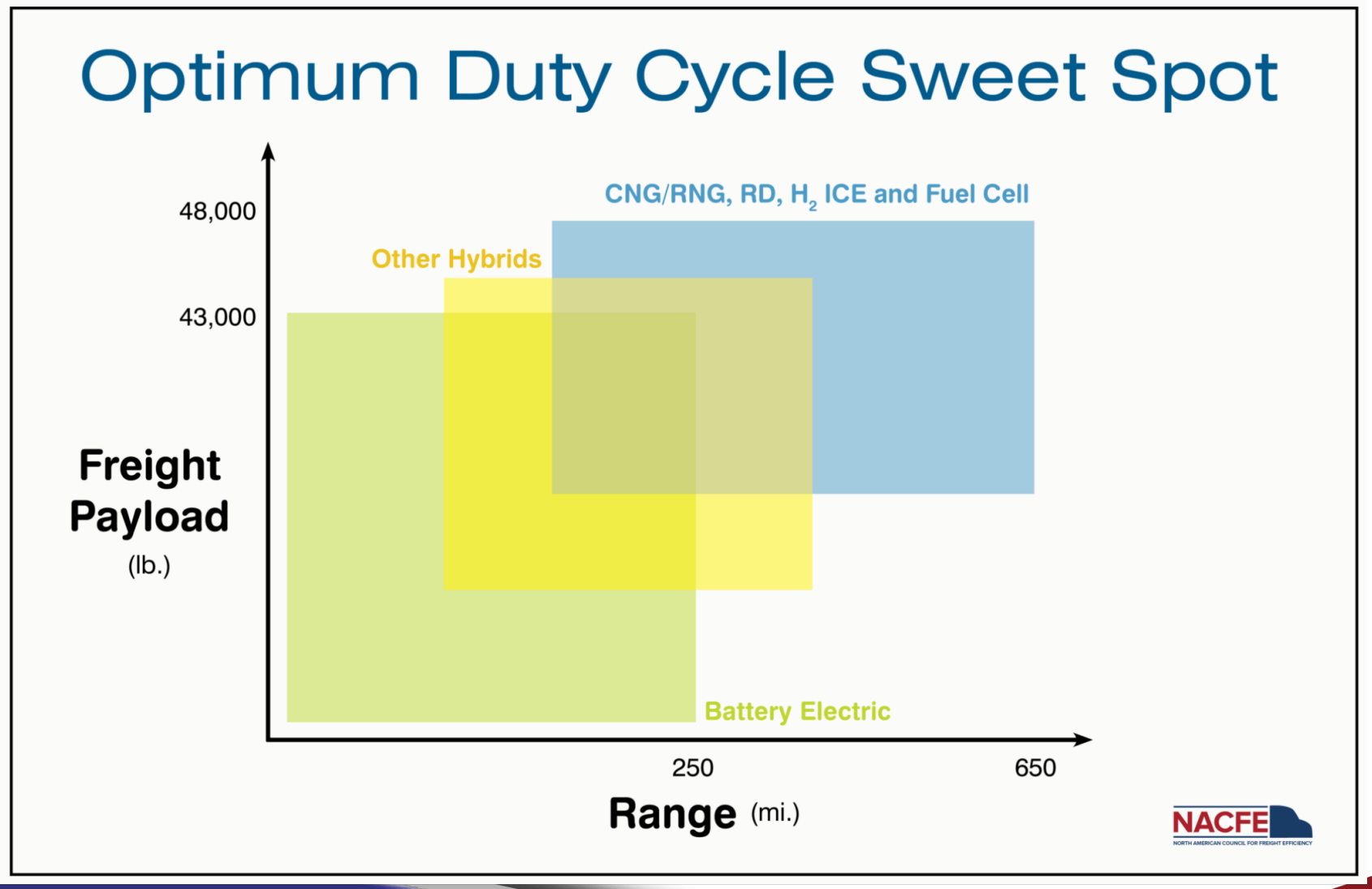
Now:

- Near-zero emissions diesel (already in use and improving)
- Renewable Diesel
- Biofuels
- CNG, Renewable Natural Gas

On the horizon:

- Hydrogen ICE
- Hydrogen Fuel Cell

Optimum Duty Cycle Sweet Spot



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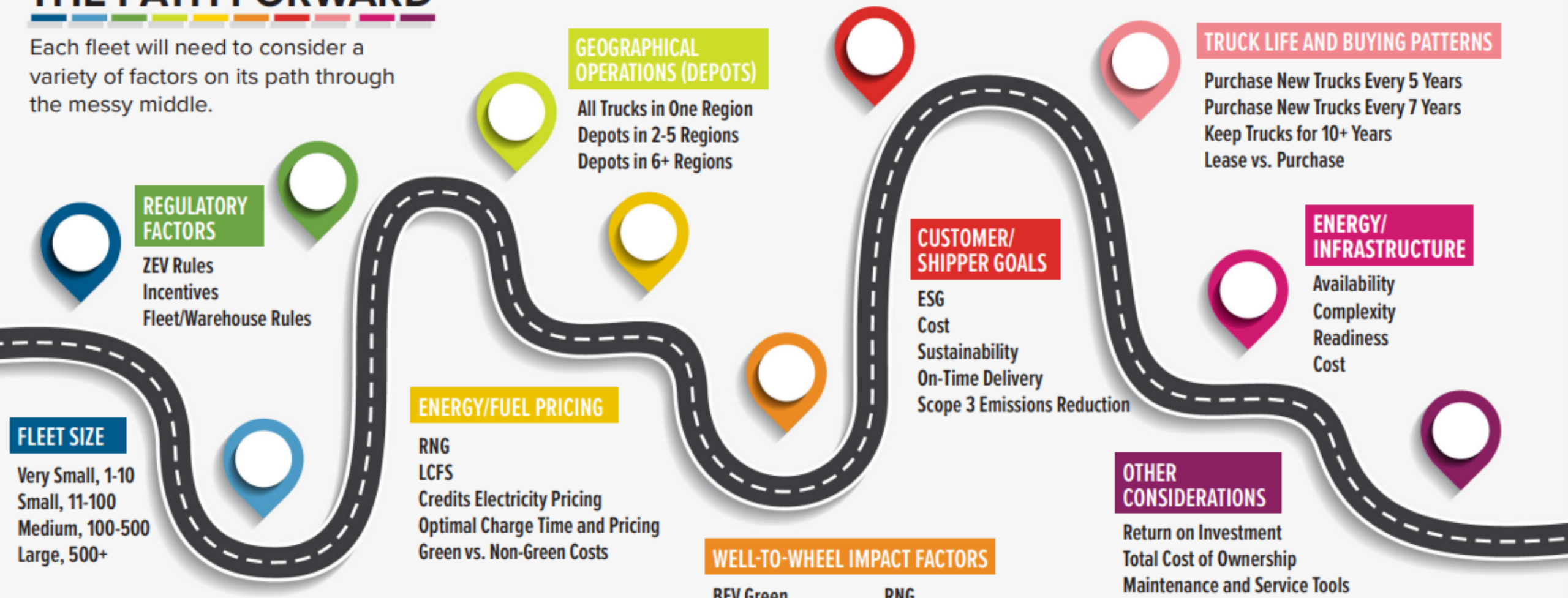
https://nacfe.org/research/electric-

THE PATH FORWARD

Each fleet will need to consider a variety of factors on its path through the messy middle.



FLEET SIZE

Very Small, 1-10
Small, 11-100
Medium, 100-500
Large, 500+

REGULATORY FACTORS

ZEV Rules
Incentives
Fleet/Warehouse Rules

DUTY CYCLES

Favorable
Less Favorable
Unfavorable
Repeatability of Duty Cycle

GEOGRAPHICAL OPERATIONS (DEPOTS)

All Trucks in One Region
Depots in 2-5 Regions
Depots in 6+ Regions

ENERGY/FUEL PRICING

RNG
LCFS
Credits Electricity Pricing
Optimal Charge Time and Pricing
Green vs. Non-Green Costs

WELL-TO-WHEEL IMPACT FACTORS

BEV Green
BEV 50%
BEV 25%

Hydrogen Green
Hydrogen Blue
Hydrogen Grey

RNG
CNG
Renewable Propane
Propane

Renewable Diesel
Biodiesel
Diesel

CUSTOMER/ SHIPPER GOALS

ESG
Cost
Sustainability
On-Time Delivery
Scope 3 Emissions Reduction

TRUCK LIFE AND BUYING PATTERNS

Purchase New Trucks Every 5 Years
Purchase New Trucks Every 7 Years
Keep Trucks for 10+ Years
Lease vs. Purchase

ENERGY/ INFRASTRUCTURE

Availability
Complexity
Readiness
Cost

OTHER CONSIDERATIONS

Return on Investment
Total Cost of Ownership
Maintenance and Service Tools
Second Life Considerations
Capital Spend Willingness (for a good TCO)
Ability to Change Operations
Own or Lease Depot
Truck Life
Corporate Philosophy

NACFE
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