

# Exhibit to Agenda Item #1

Provide the Board with external and internal presentations in support of SMUD's **Clean Transportation Strategy**.

Board Strategic Development Committee and Special SMUD Board of Directors Meeting

Tuesday, October 8, 2024, scheduled to begin at 6:00 p.m.

SMUD Headquarters Building, Auditorium



# *The Road Ahead*

## Clean Transportation Market Outlook

*Sacramento Municipal Utility District | Board of Directors Meeting*

Ben Shapiro | October 8, 2024



# Agenda

- Overview
- Light-duty Vehicle Market Update and Outlook
- Medium- and Heavy-duty Vehicle Market Update and Outlook
- Key Considerations for Utility Planning



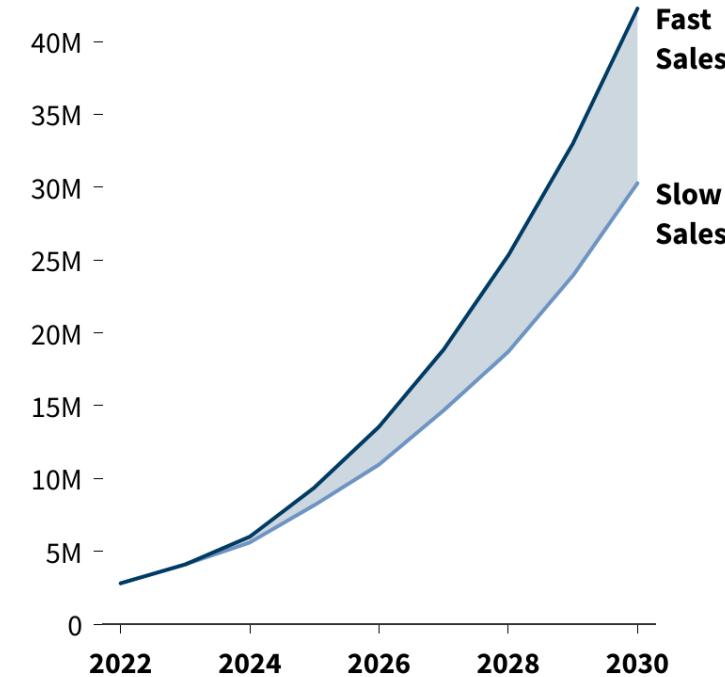
# Overview



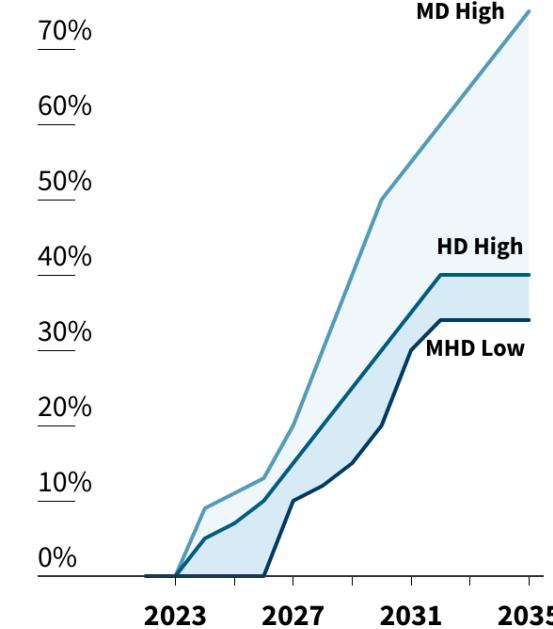
# All signs point to rapid EV load growth

Even lower-end estimates of EV adoption signal dramatic growth...

Light-Duty EVs on US Roads



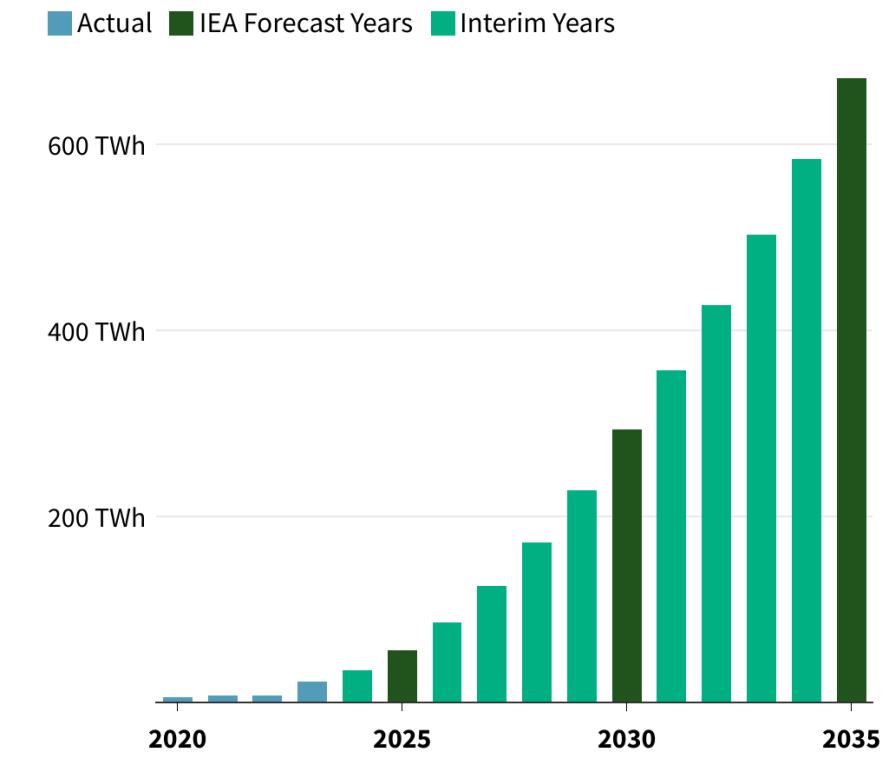
US Zero Emission Truck Sales Share



MD: Medium-duty | HD: Heavy-duty | MHD: Medium/heavy-duty

...with corresponding growth in energy and power needs.

Electricity Demand for On Road EV Charging in the US



# Specific pace to be determined by balance of headwinds and tailwinds



- Pace of infrastructure deployment
- Mass market vs. early adoption
  - Cost and range
  - Charging availability (MFH, depots)
  - Fitness for diverse duty cycles (MHDV)
- Political uncertainty
- CA continues as zero emission vehicle leader
- Strong policy undergirds transition
  - CA: Advanced Clean Cars II, Advanced Clean Trucks; Advanced Clean Fleets
  - Federal: EPA GHG standards; incentives
- Federal investments
  - Beginning to produce steel in the ground

# Battery electric and fuel cell electric vehicles will play distinct roles



## Light-duty Vehicles

- LD ZEVs likely to be dominated by BEVs and PHEVs
- Unlikely there will be meaningful role for FCEVs
- Sales data strongly supports this perspective



## Medium- and Heavy-duty Vehicles

- MD ZEV also likely to be primarily BEV
- HD powertrain shares ~ an open question; FCEV may play larger role for long-haul

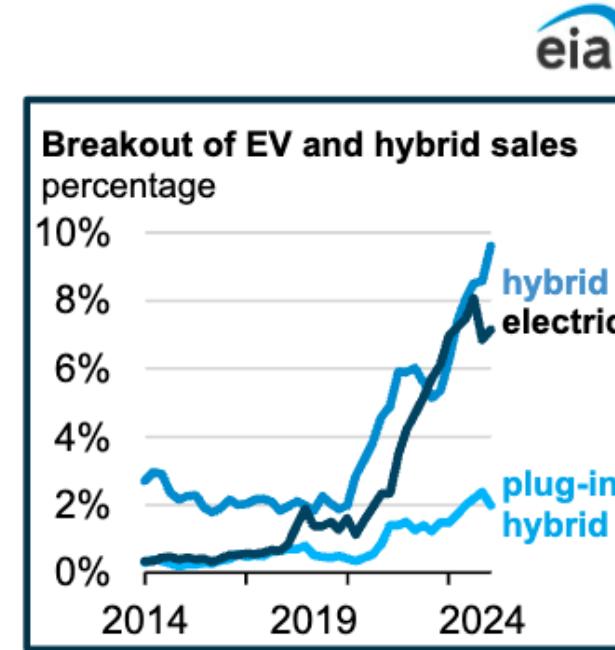
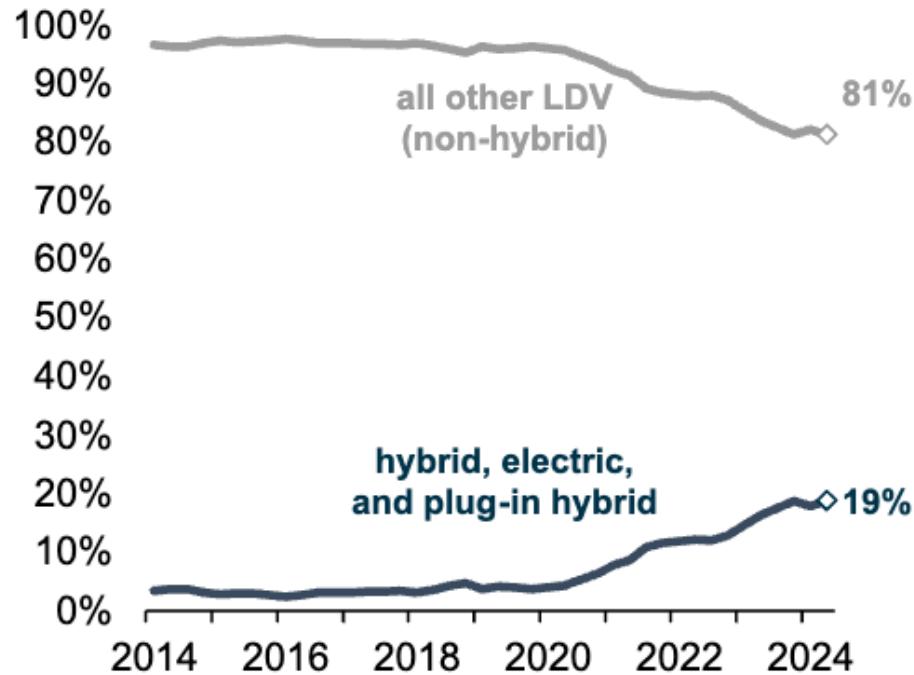


# Light-Duty Vehicle Market Update and Outlook



# Despite recent automaker scale backs, US light-duty EV sales continue to grow

Quarterly U.S. light-duty vehicle (LDV) sales by powertrain (Jan 2014–June 2024)  
percentage of sales



**Data source:** Wards Intelligence

**Note:** EV=electric vehicles, which include both battery electric and plug-in hybrid electric vehicles

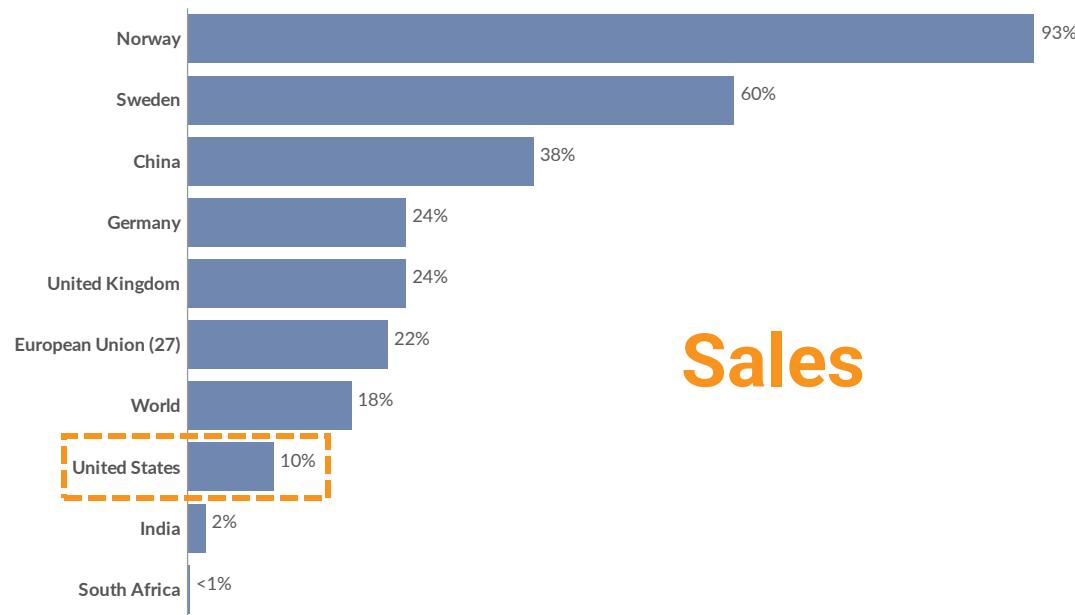
Note: discrepancy between this figure and the previous slide is due to inclusion of non-plug-in hybrid ("hybrid") vehicles in the EIA accounting.

# Global EV sales and stock increasing rapidly

US lags leaders, but “S-curve” shape increasingly clear

Share of new cars sold that are electric, 2023

Electric cars include fully battery-electric<sup>1</sup> and plug-in hybrids<sup>2</sup>.



Data source: International Energy Agency. Global EV Outlook 2024.

OurWorldinData.org/energy | CC BY

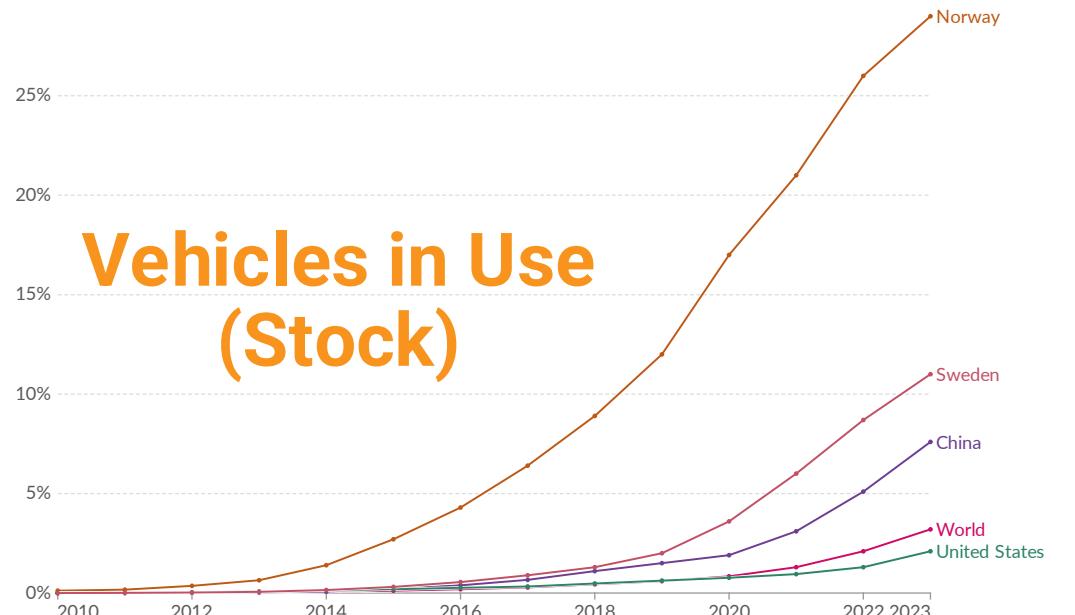
1. Fully battery-electric: Cars or other vehicles that are powered entirely by an electric motor and battery, instead of an internal combustion engine.

2. Plug-in hybrid: Cars or other vehicles that have a rechargeable battery and electric motor, and an internal combustion engine. The battery in plug-in hybrids is smaller and has a shorter range than battery-electric cars, so over longer distances, the car starts running on gasoline once the battery has run out.

## Sales

Share of cars currently in use that are electric, 2010 to 2023

Electric cars include fully battery-electric<sup>1</sup> and plug-in hybrids<sup>2</sup>.



Data source: International Energy Agency. Global EV Outlook 2024.

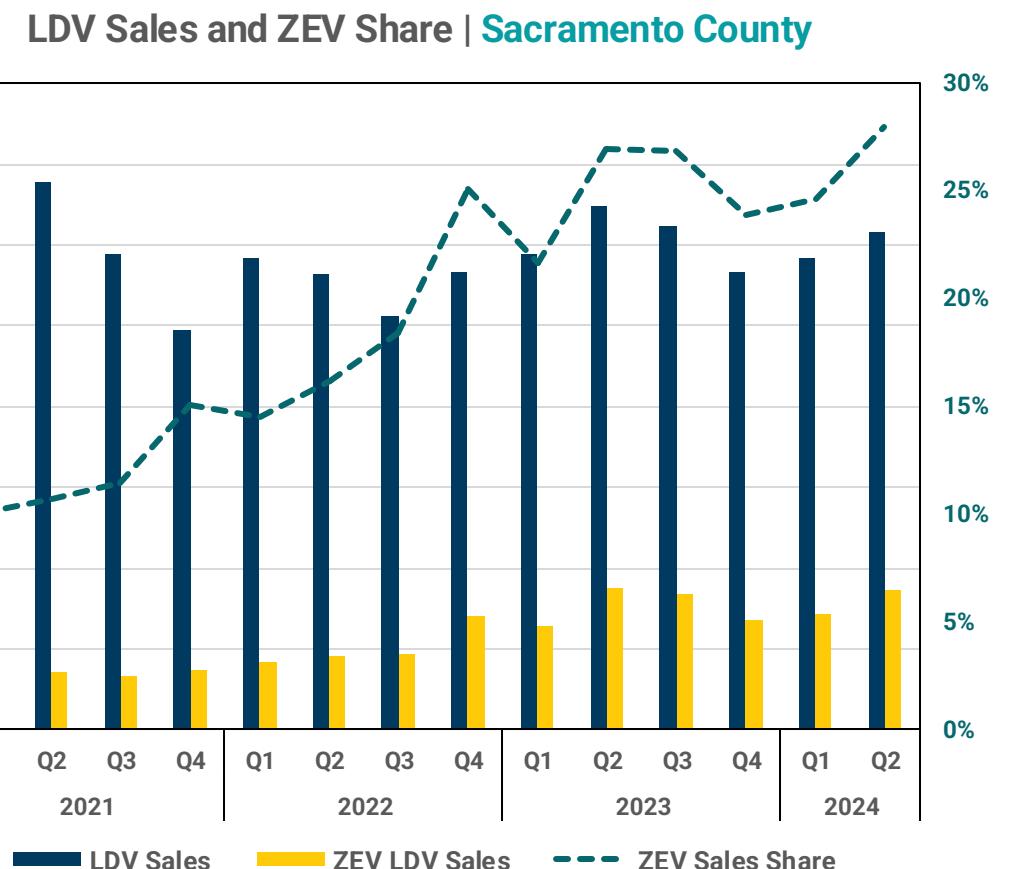
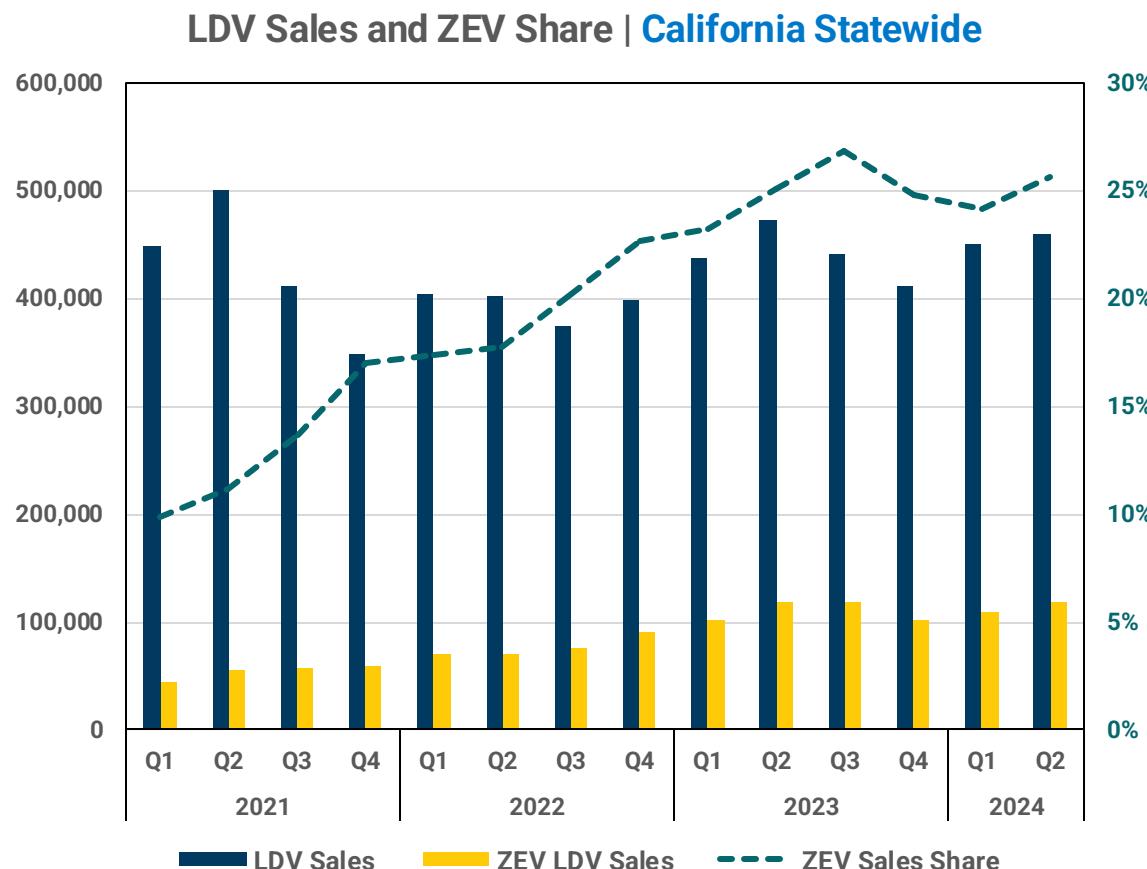
OurWorldinData.org/energy | CC BY

1. Fully battery-electric: Cars or other vehicles that are powered entirely by an electric motor and battery, instead of an internal combustion engine.

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# California continues to be a national leader in EV adoption

Sacramento area largely tracks statewide trend in ZEV market share





## Batteries are winning out over fuel cells

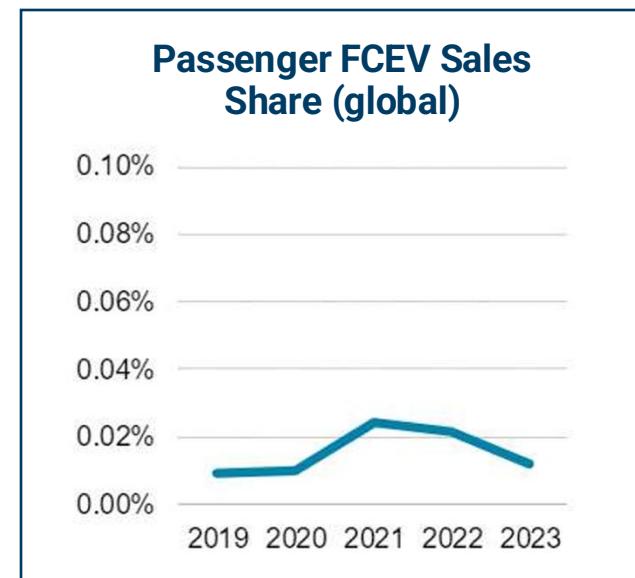
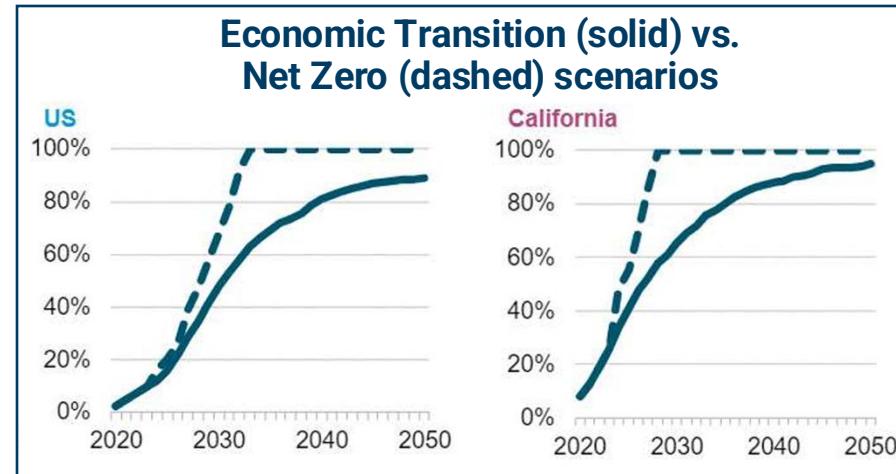
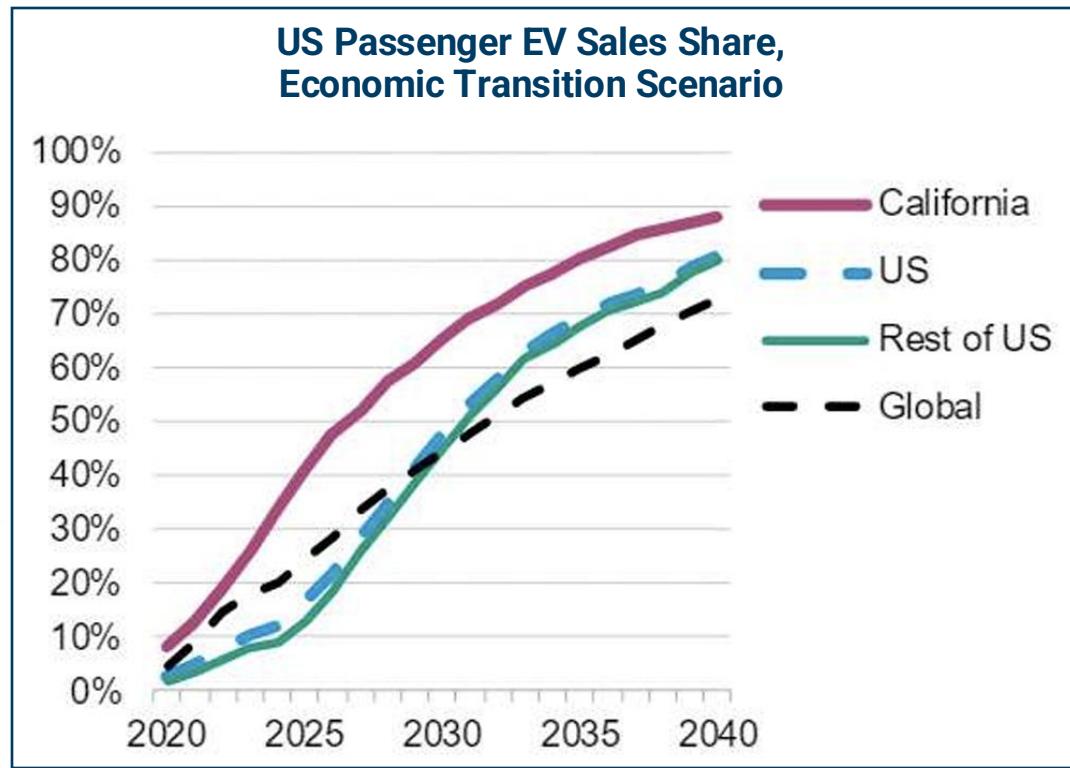
- Less than 1% of California's cumulative light-duty ZEV sales have been fuel cell EVs

Cumulative through Q2 2024	LD ZEV Sales	Percent
LD ZEV Sales	1,996,931	100.0%
Battery EV (BEV)	1,469,110	73.5%
Plug-in Hybrid EV (PHEV)	509,951	25.5%
Fuel Cell EV (FCEV)	17,870	00.8%

Source: California Energy Commission | <https://www.energy.ca.gov/files/zev-and-infrastructure-stats-data>.

# How quickly will the US market grow?

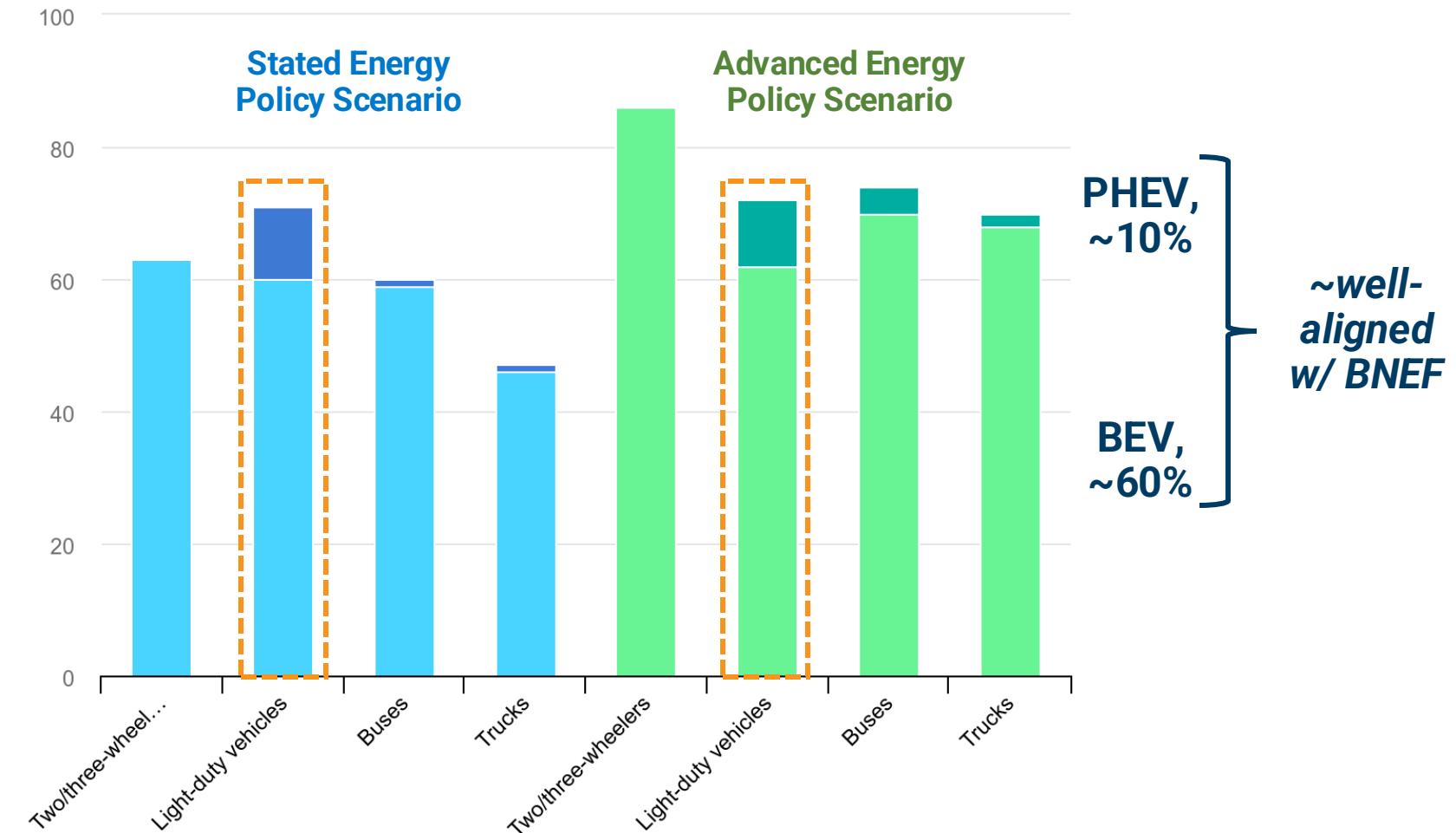
Bloomberg New Energy Finance perspective



# How quickly will the US market grow?

International Energy Agency perspective

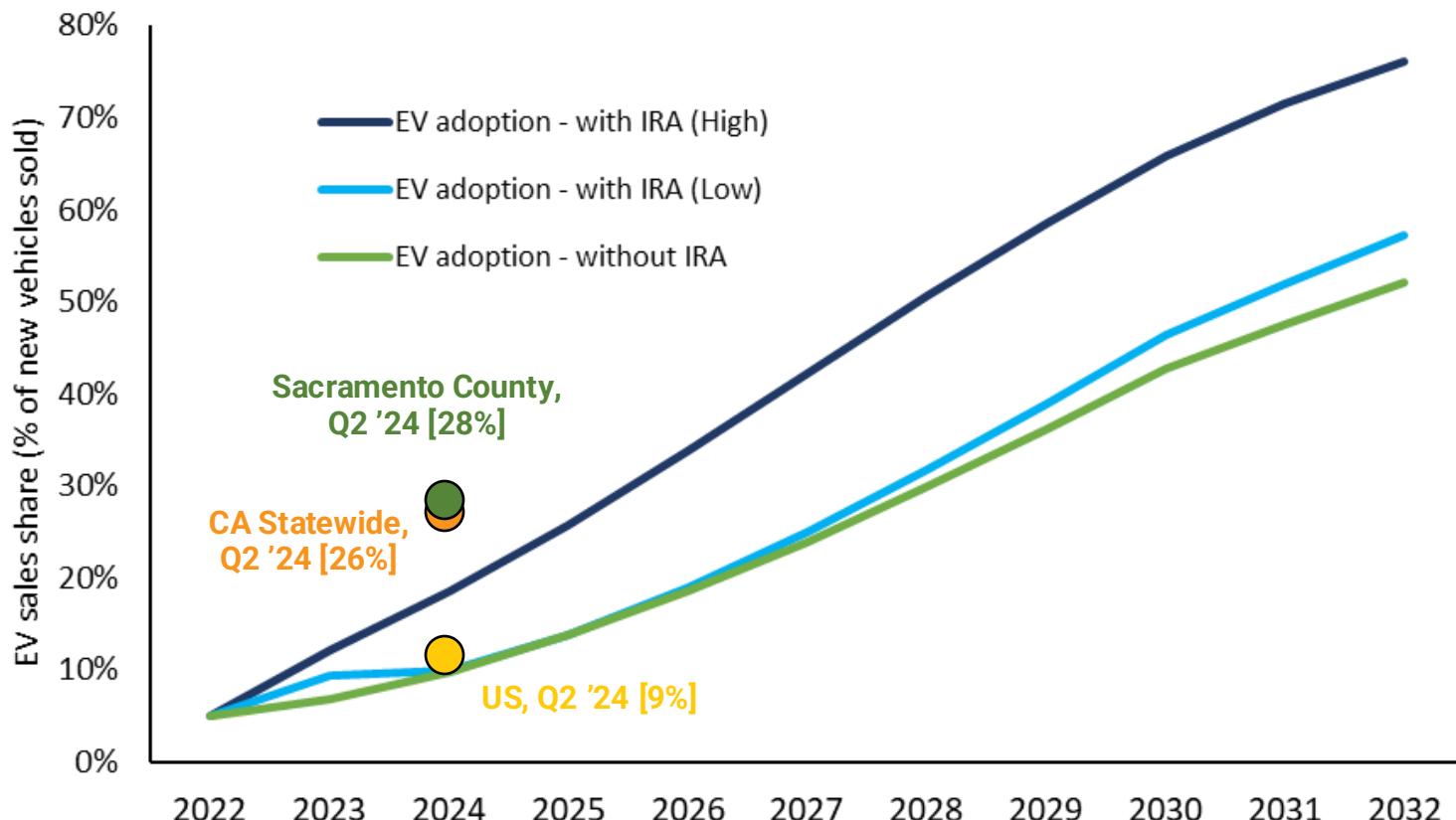
US EV Sales Share  
by Mode, 2035



# How quickly will the US market grow?

RMI perspective

Impact of IRA on passenger EV sales penetration in U.S.





# Medium- and Heavy-Duty Vehicle Market Update and Outlook



# Carbon Reduction – No Single Solution

## PRESENT

- Technology immature
- Many unknowns & challenges



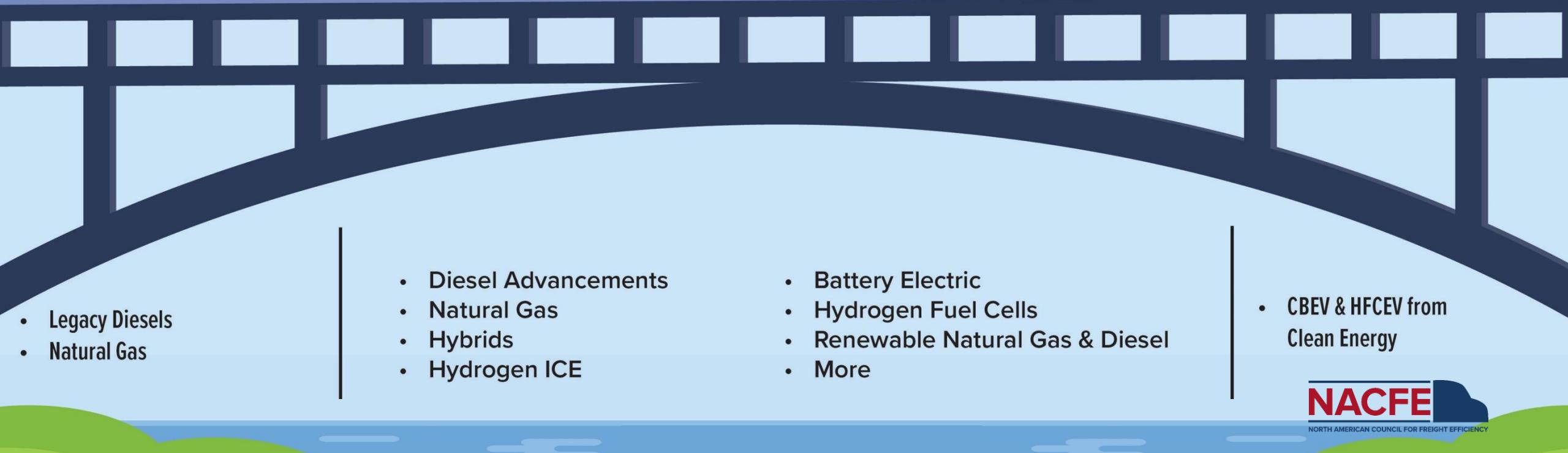
## "MESSY MIDDLE"

- 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

# A Growing Abundance of ZEV Choices

9



19



30



8



> 40 OEMs  
> 160 ZEV Models

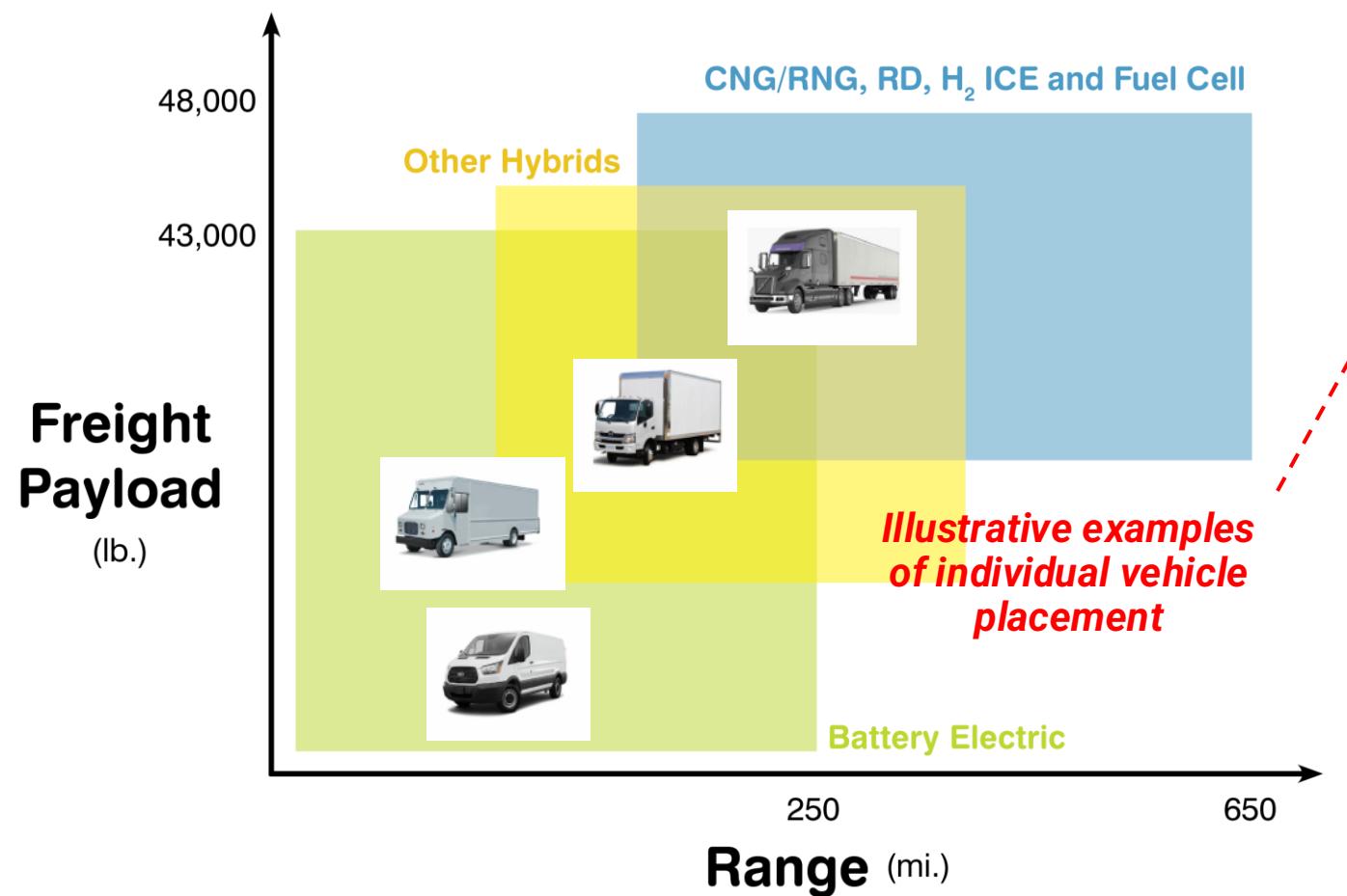
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**ZEV OEMs**  
by Vehicle Type  
North America

# Weight and Range

## Optimum Duty Cycle Sweet Spot

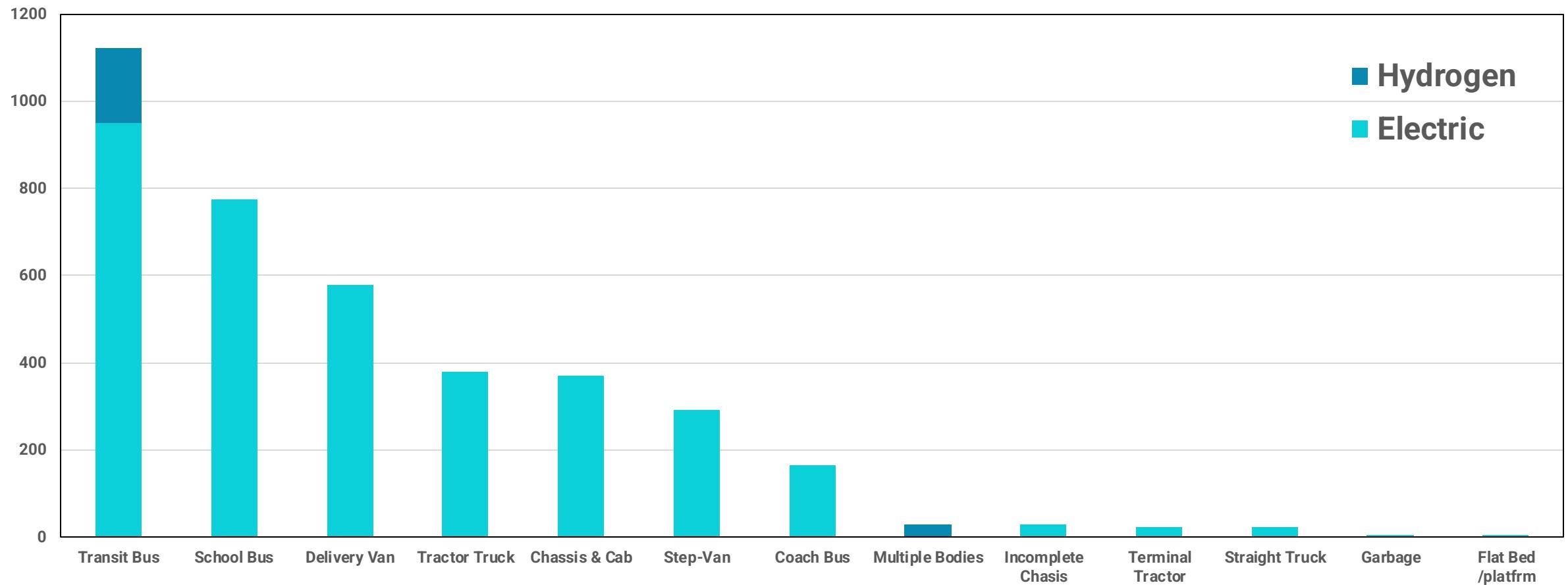


"If you've met one fleet...you've met one fleet."

*Different ZEV Solutions Perform Differently*

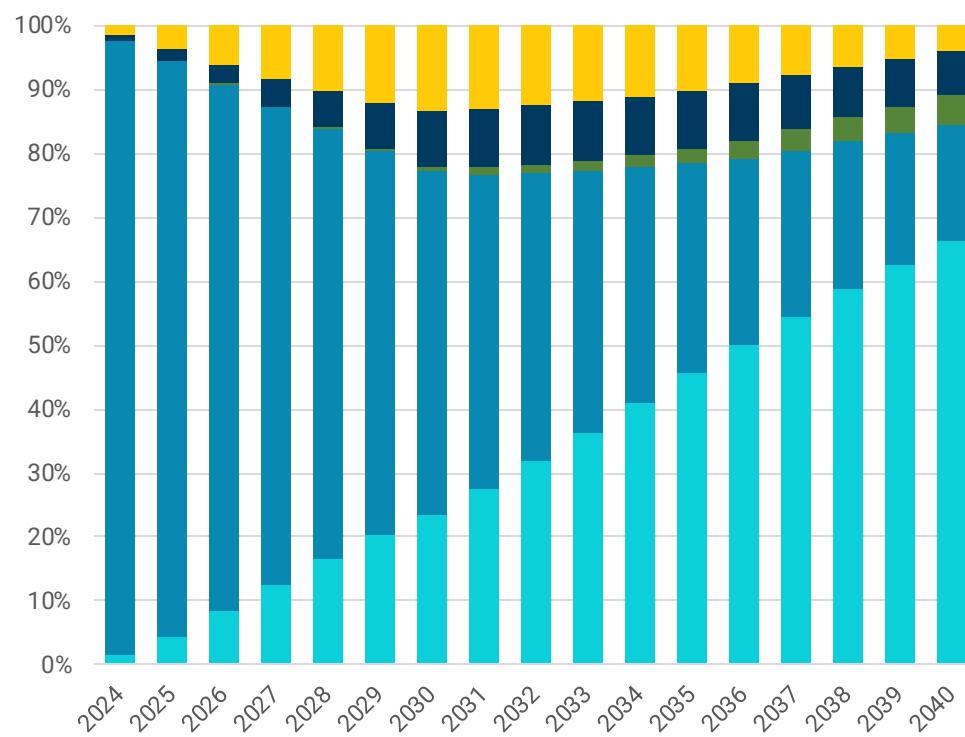
# Zero emission MHDV registrations have to date been primarily battery electric

End of Year 2023 California Registrations

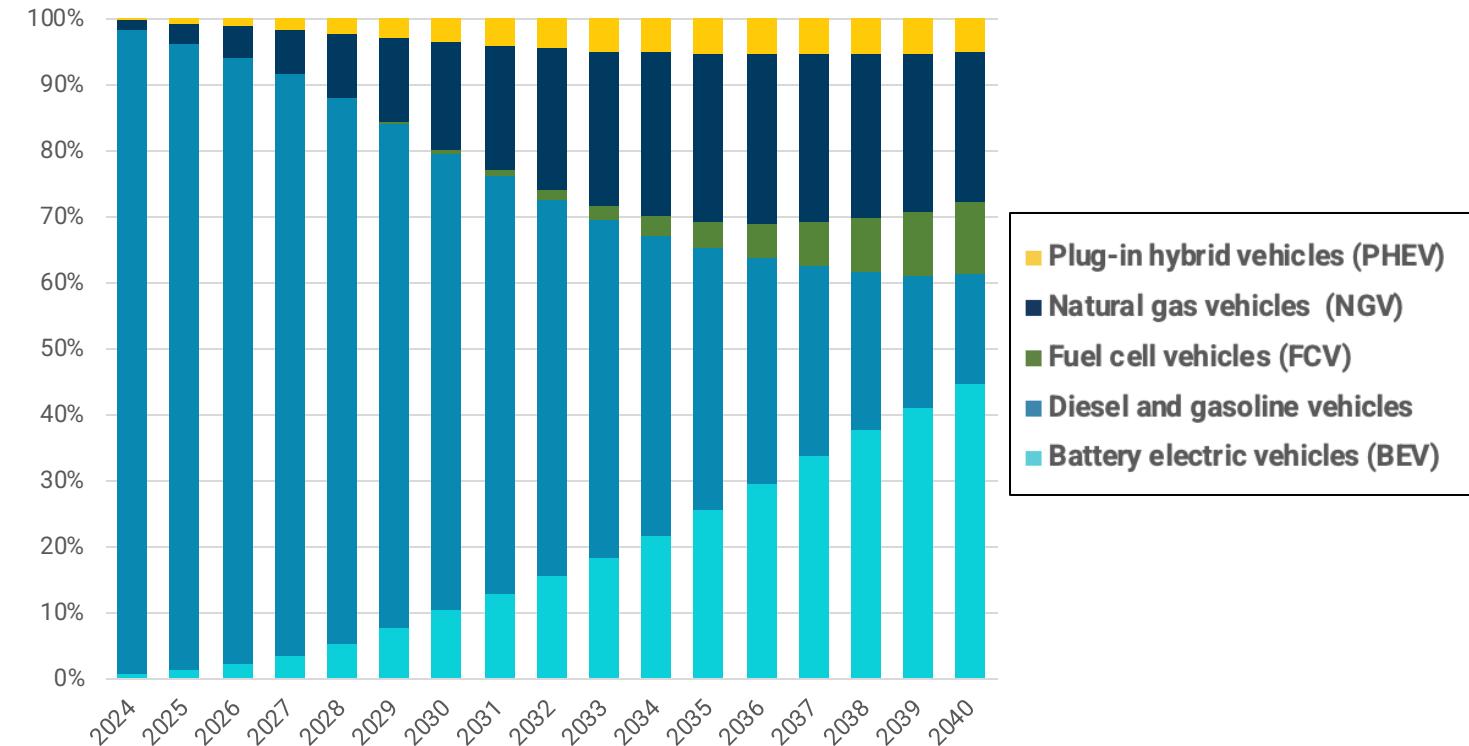


# US Medium- and Heavy-duty Vehicle Sales Share Outlook, BNEF

## Medium-Duty Vehicles

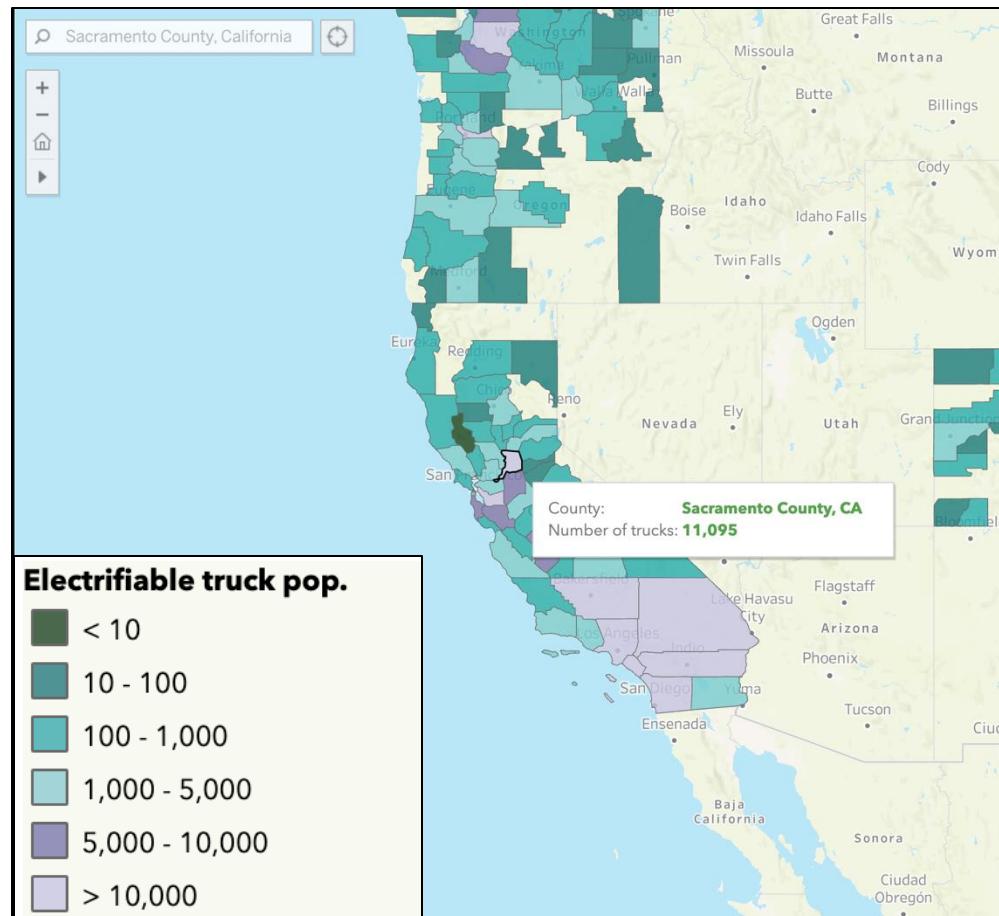


## Heavy-Duty Vehicles



# Sacramento has many “electrifiable” trucks

RMI's Advanced Clean Trucks Dashboard assesses potential truck electrification by county



- **Vehicle telematics report local travel patterns and operating needs**
- **“Electrifiable” vehicles return to depot after driving < 300 miles, on 95% of journeys**
- **~11,100 electrifiable medium-/heavy-duty trucks in Sacramento county**

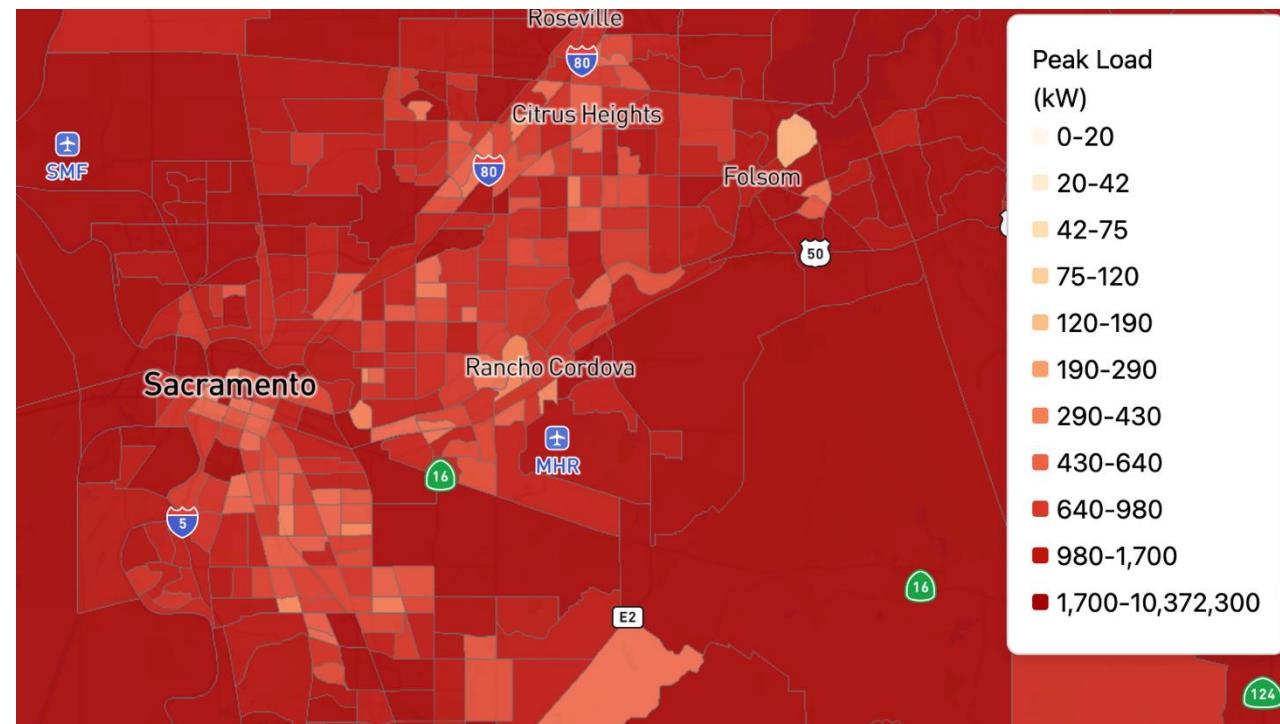
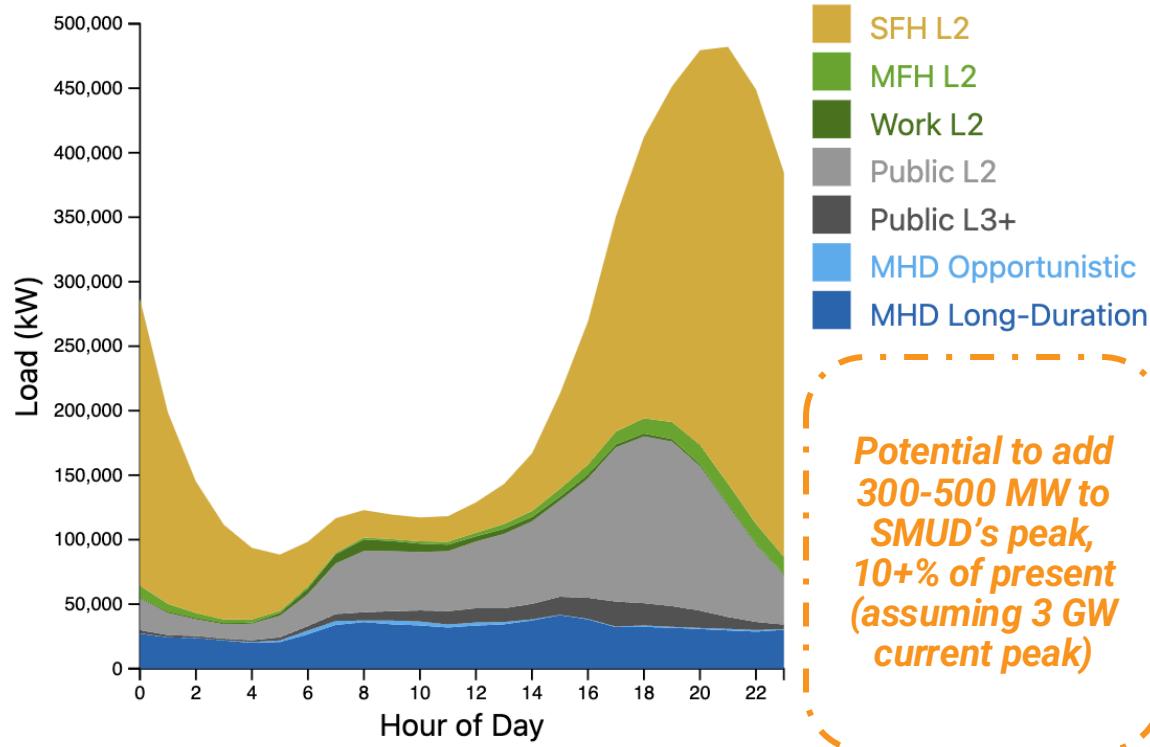


# Key Considerations for Utility Planning



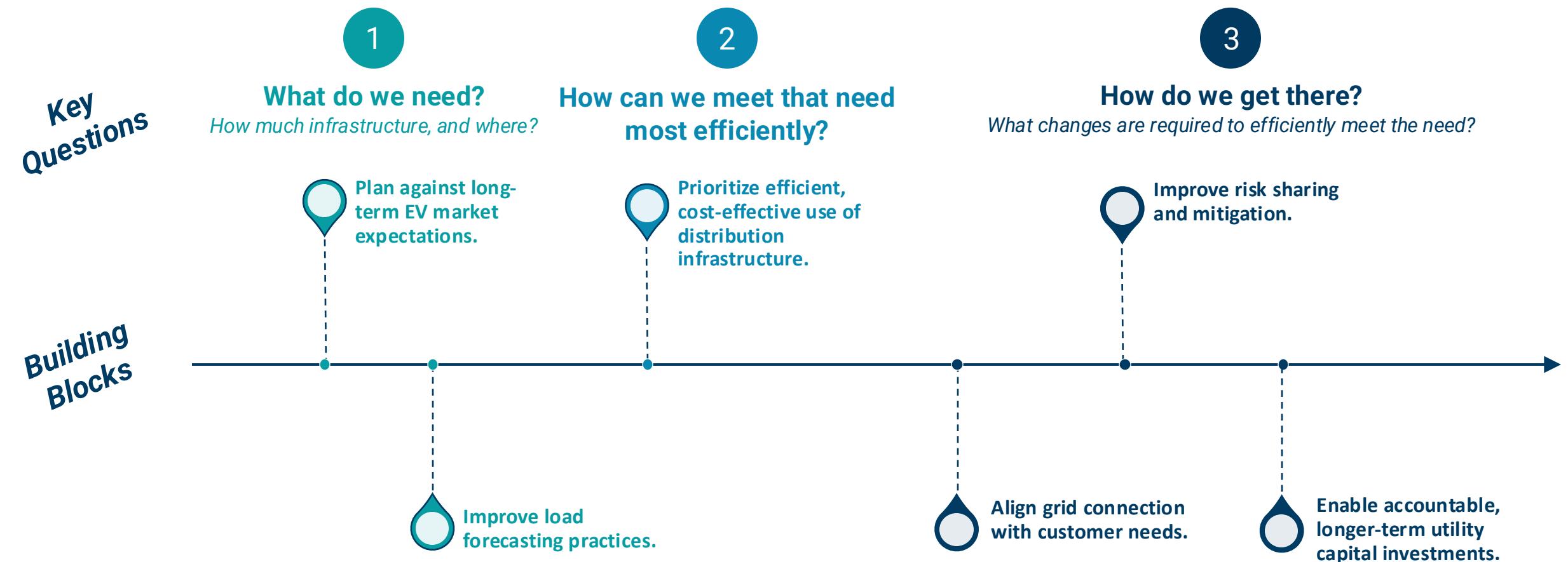
# What do ZEV market forecasts imply is necessary for infrastructure?

## Sacramento County, 2035 unmanaged EV load shape and spatial distribution



# How can utilities prepare for growth in transportation electrification?

Transportation electrification “building blocks” help answer three key questions





# Thank You!



**Ben Shapiro**  
Principal, Transportation  
[bshapiro@rmi.org](mailto:bshapiro@rmi.org)





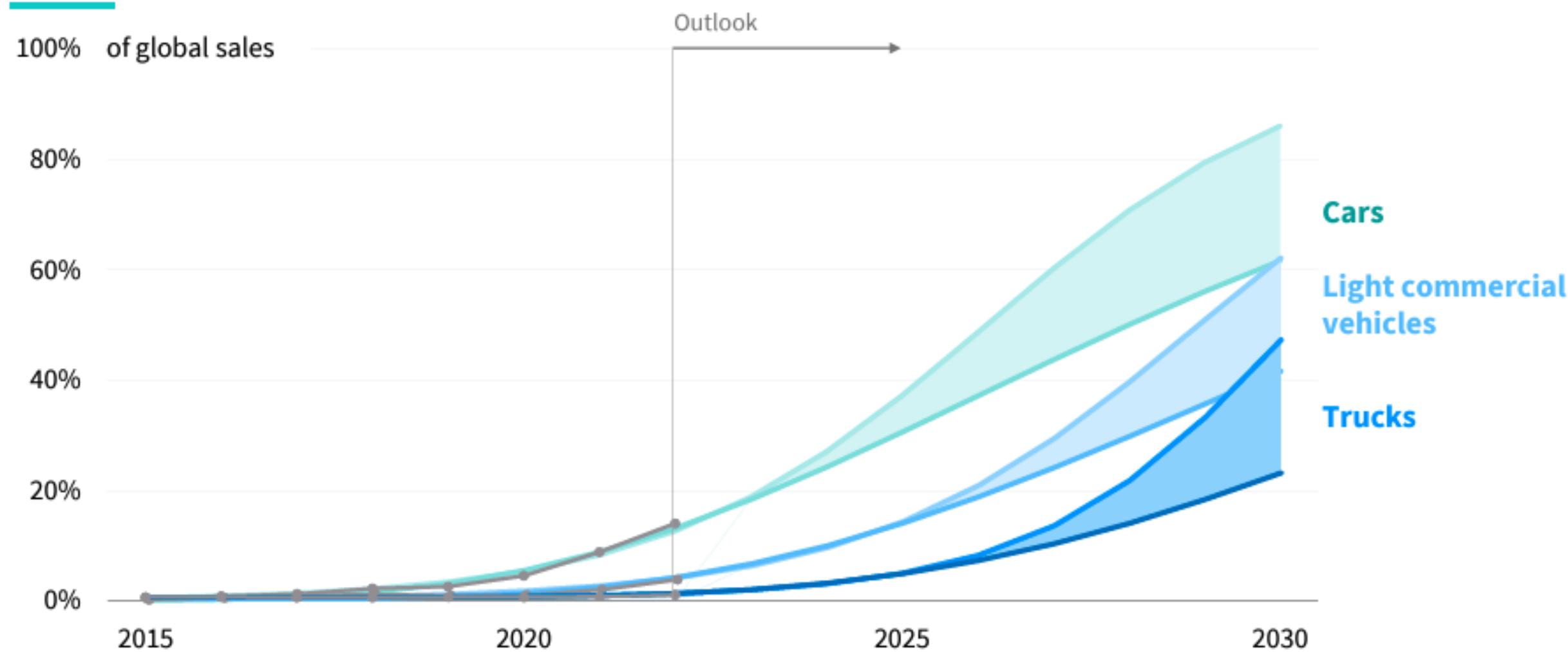
# Appendix



# The electric vehicle domino effect will continue

Where cars go, vans and trucks follow

## **The electric vehicle domino**

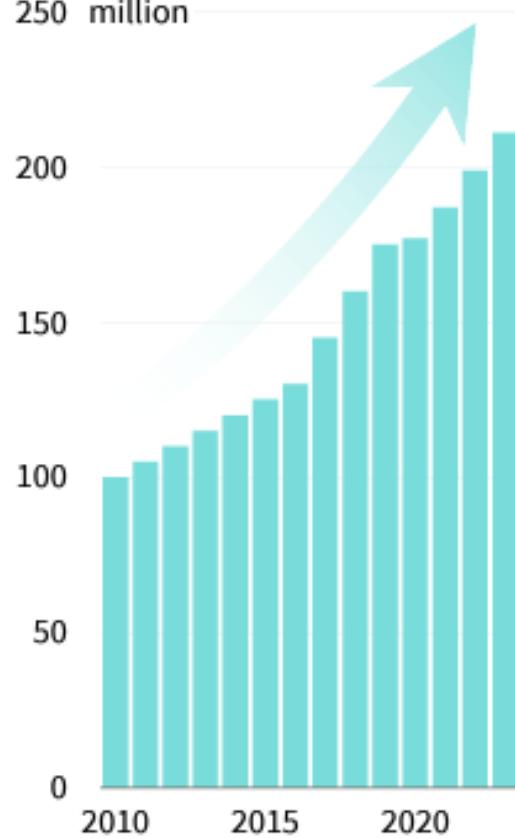


# We are poised to electrify the rest of the system

The global stock of EV cars and digital devices has been doubling every 2 years

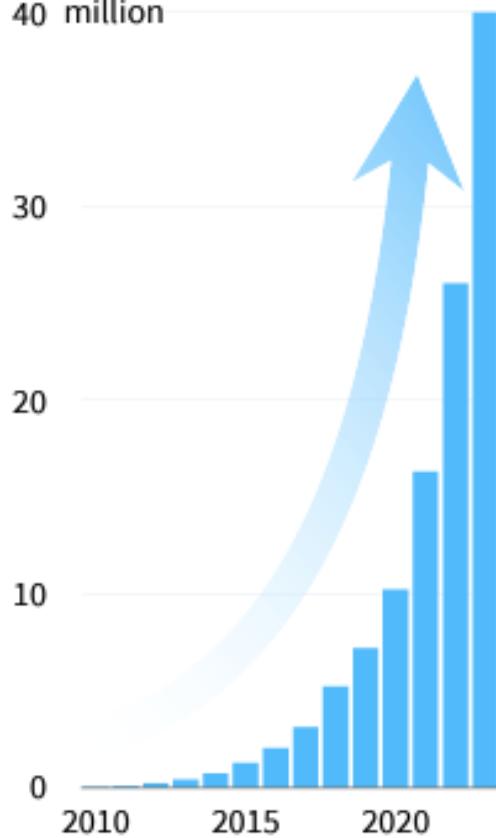
**Heat pumps**

250 million



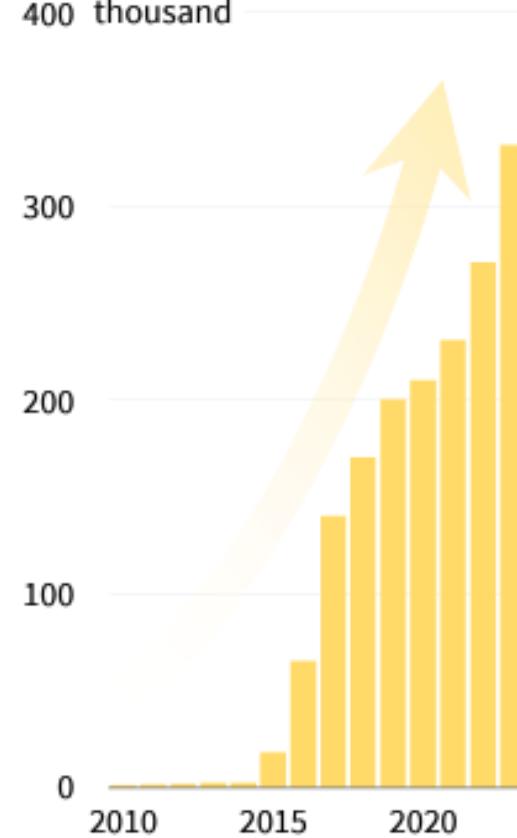
**EV cars**

40 million



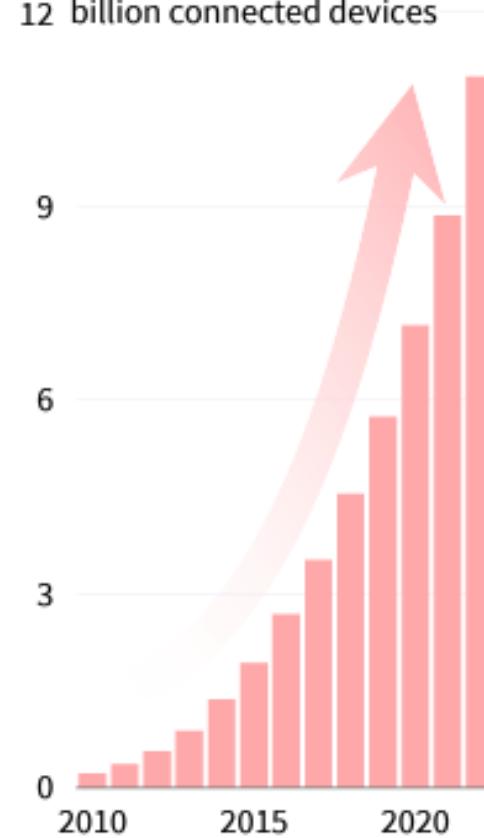
**EV trucks**

400 thousand



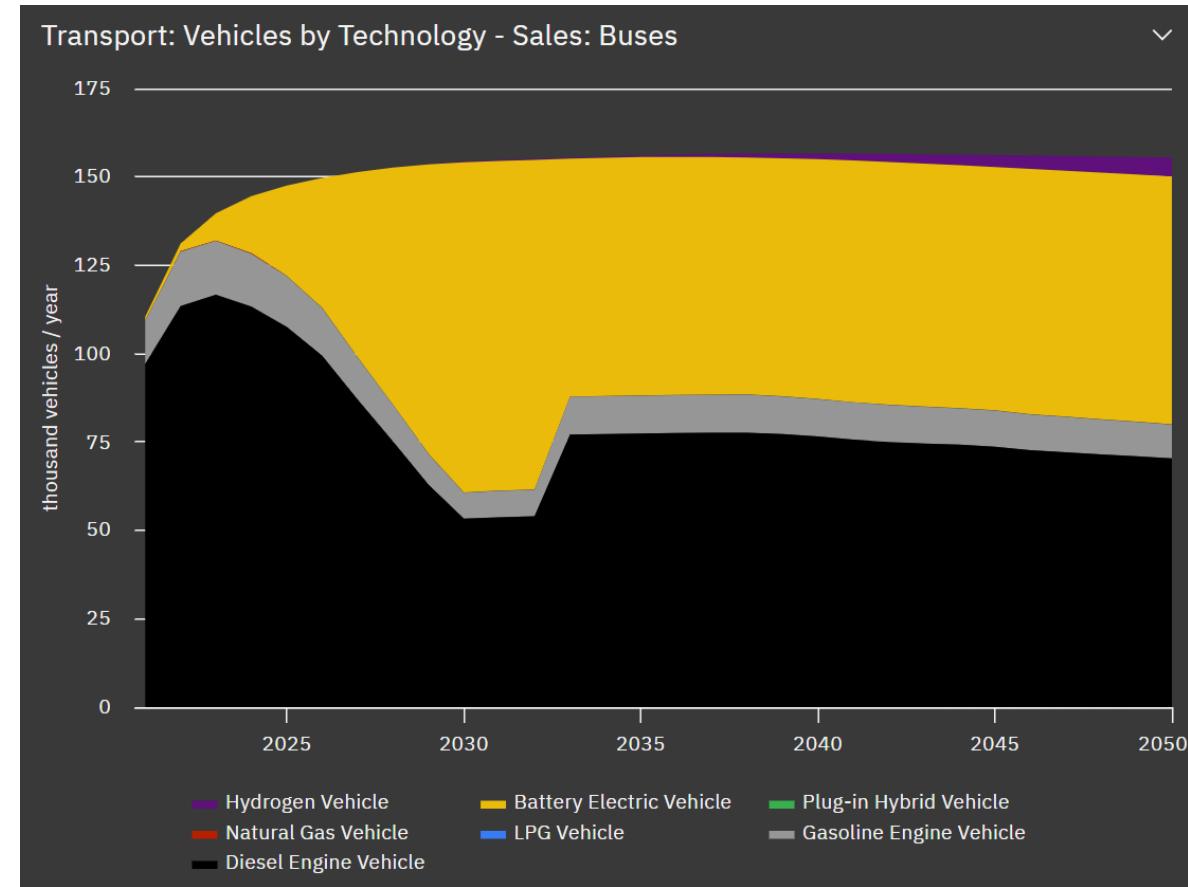
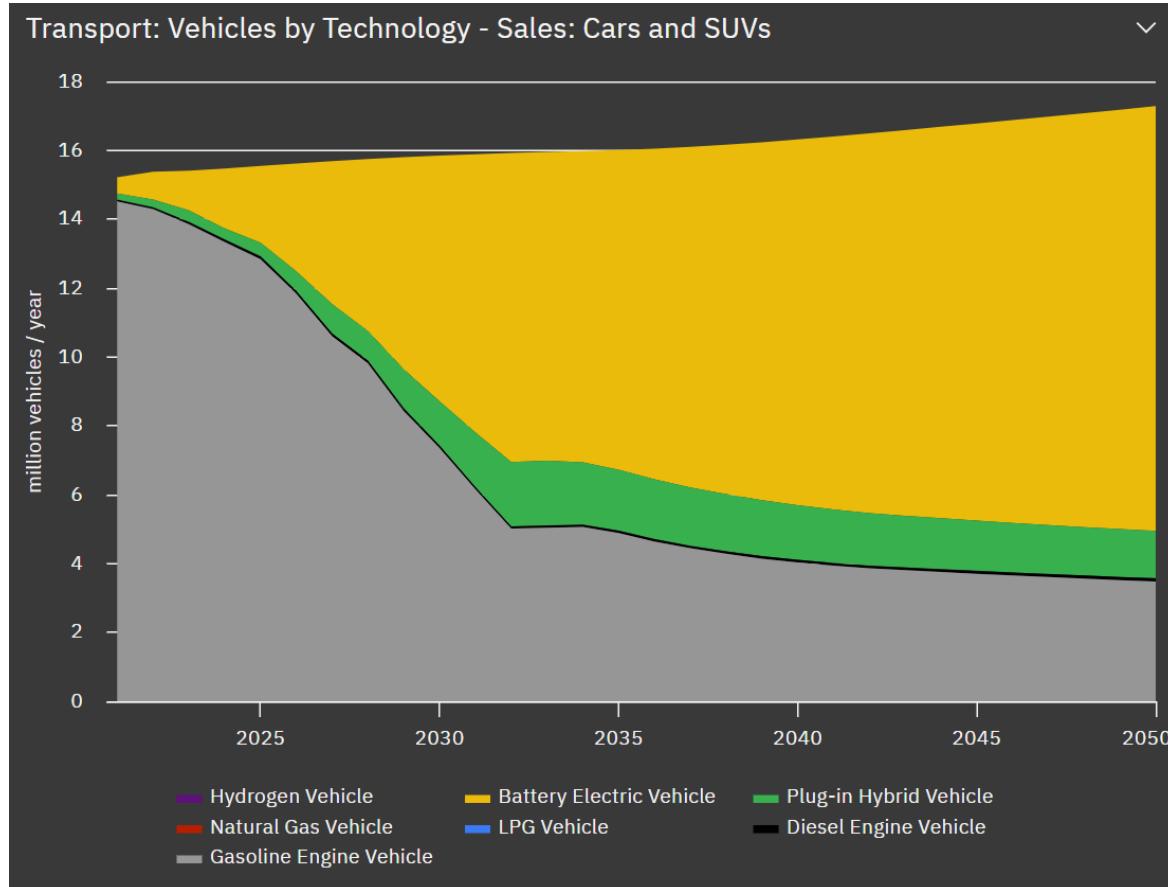
**Digitally enabled automated devices**

12 billion connected devices

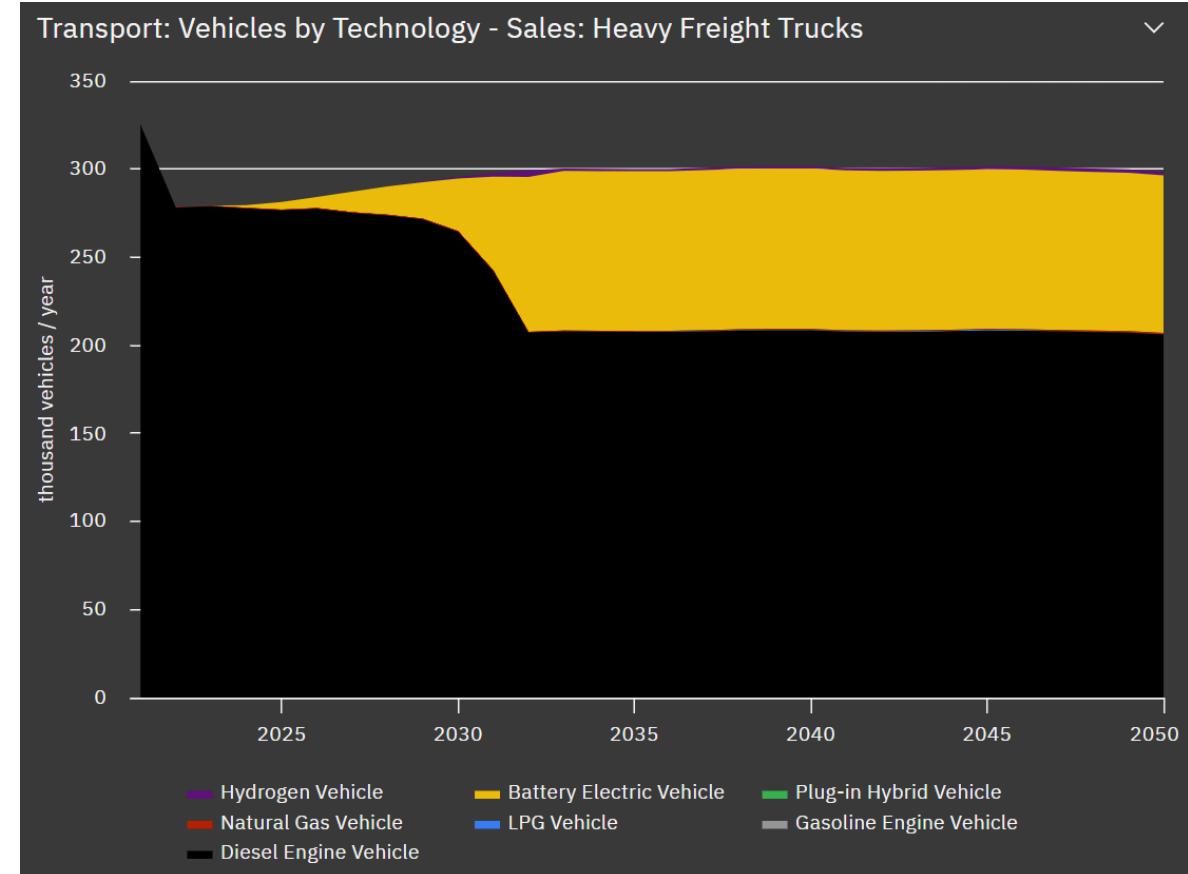
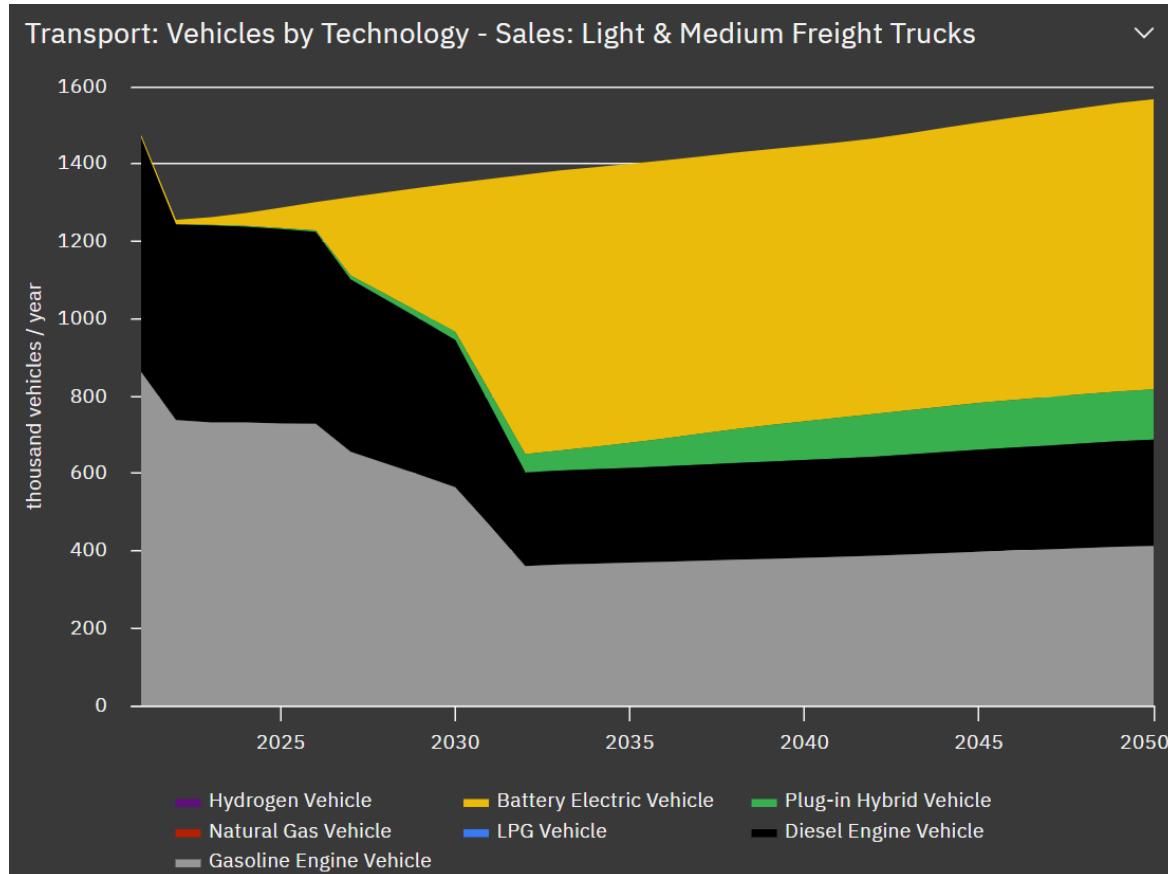


Source: IEA, Carbon Brief for heat pumps.

# US LDV and Bus Sales Estimate: EI Energy Policy Simulator

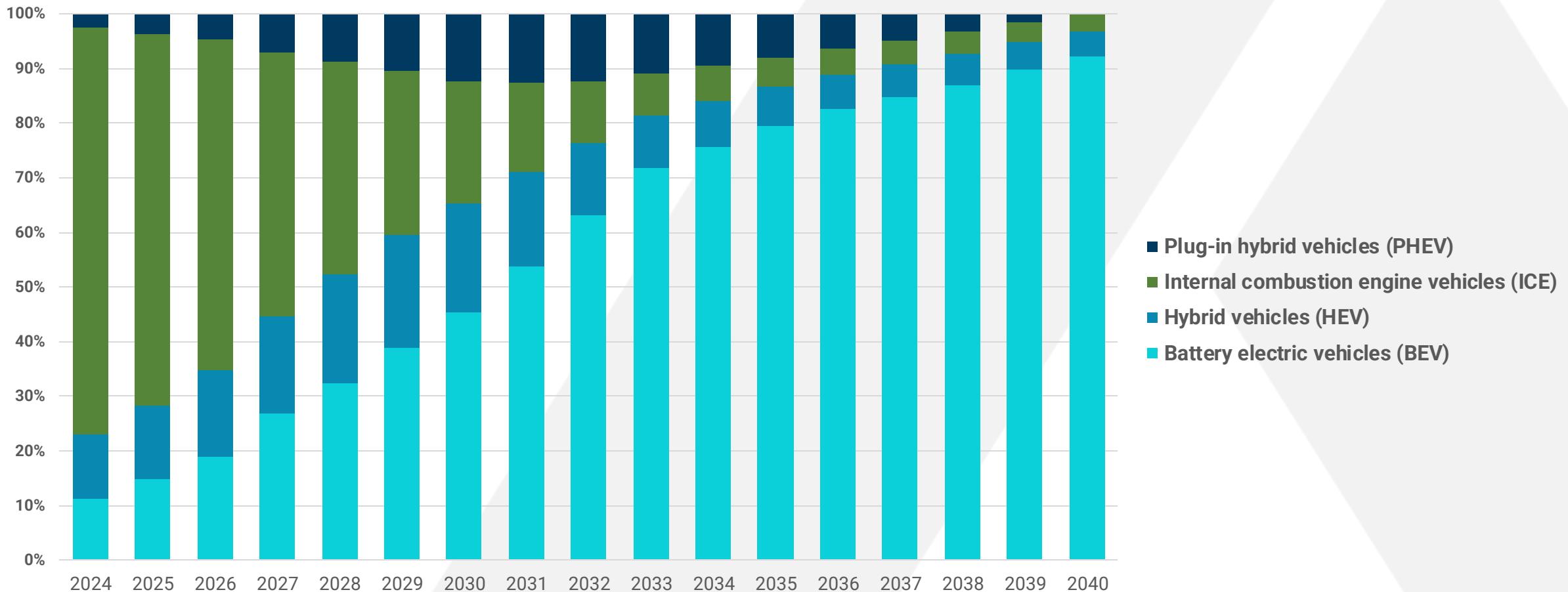


# US MDV and HDV Sales Estimate: EI Energy Policy Simulator

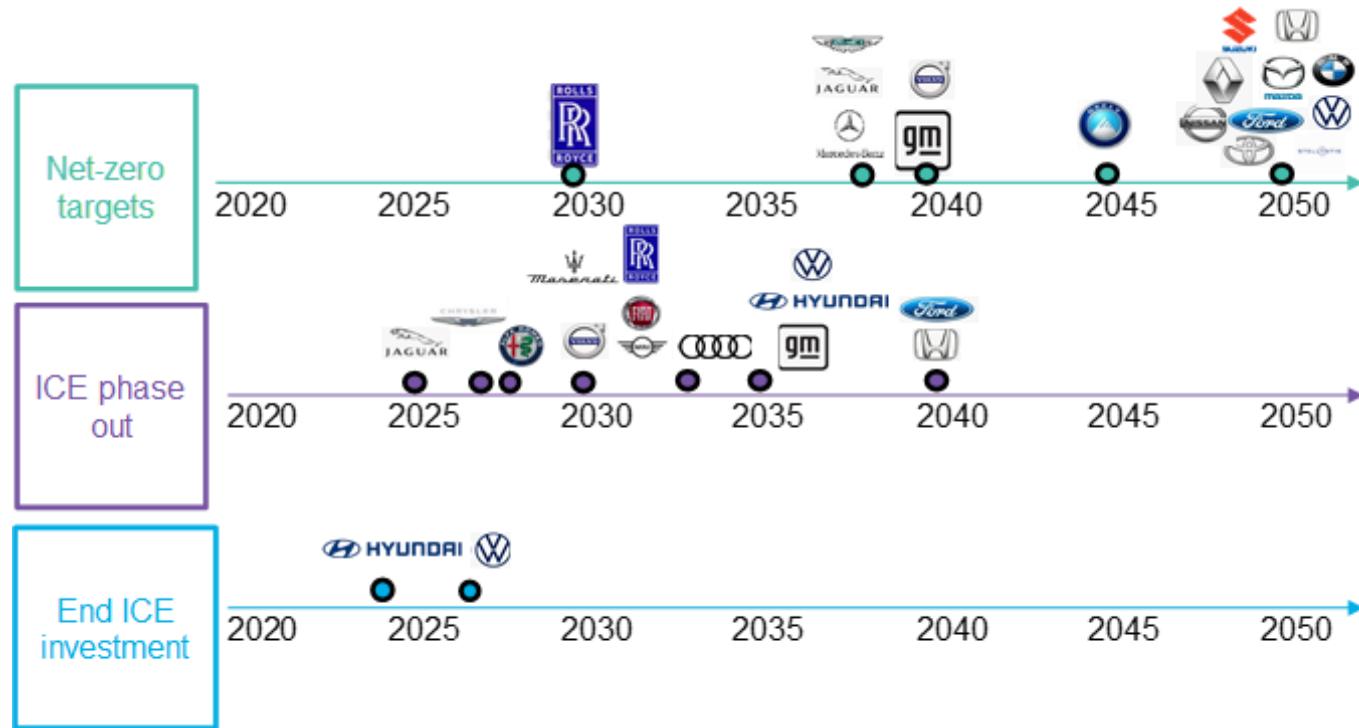


# BNEF EV Outlook 2024

## US Passenger Vehicle Sales Share by Fuel Type



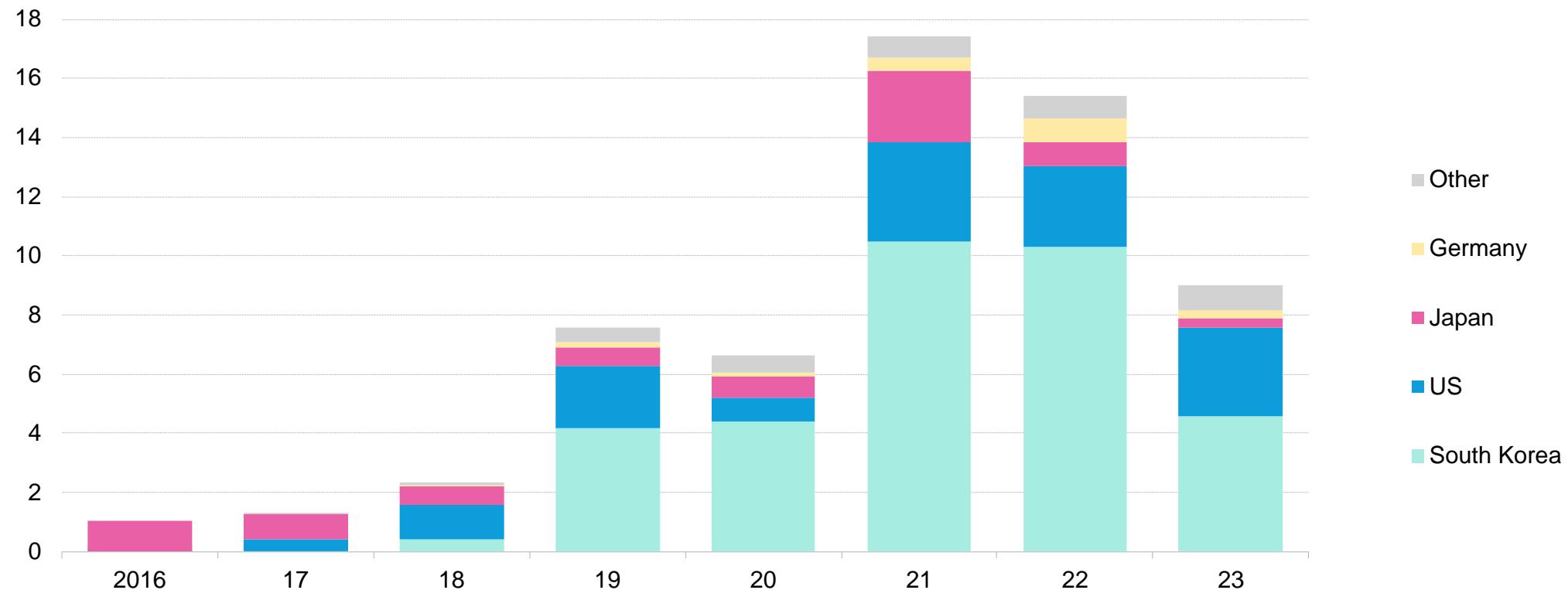
## Automakers' drivetrain development targets



Source: BloombergNEF. Note: Hyundai, Stellantis and VW internal combustion engine (ICE) phase-out target is for Europe only. On November 9, 2021, Ford signed the COP26 declaration on accelerating the transition to 100% zero-emission cars and vans, which called for working toward an ICE phase-out globally by 2040 and in leading markets by 2035. Excludes interim targets. Net-zero target scope varies by company, as some only cover Scope 1 and 2 emissions. For more details, see BNEF's Net-Zero Assessment Tool ([web](#)).

## Global Passenger fuel-cell vehicle sales

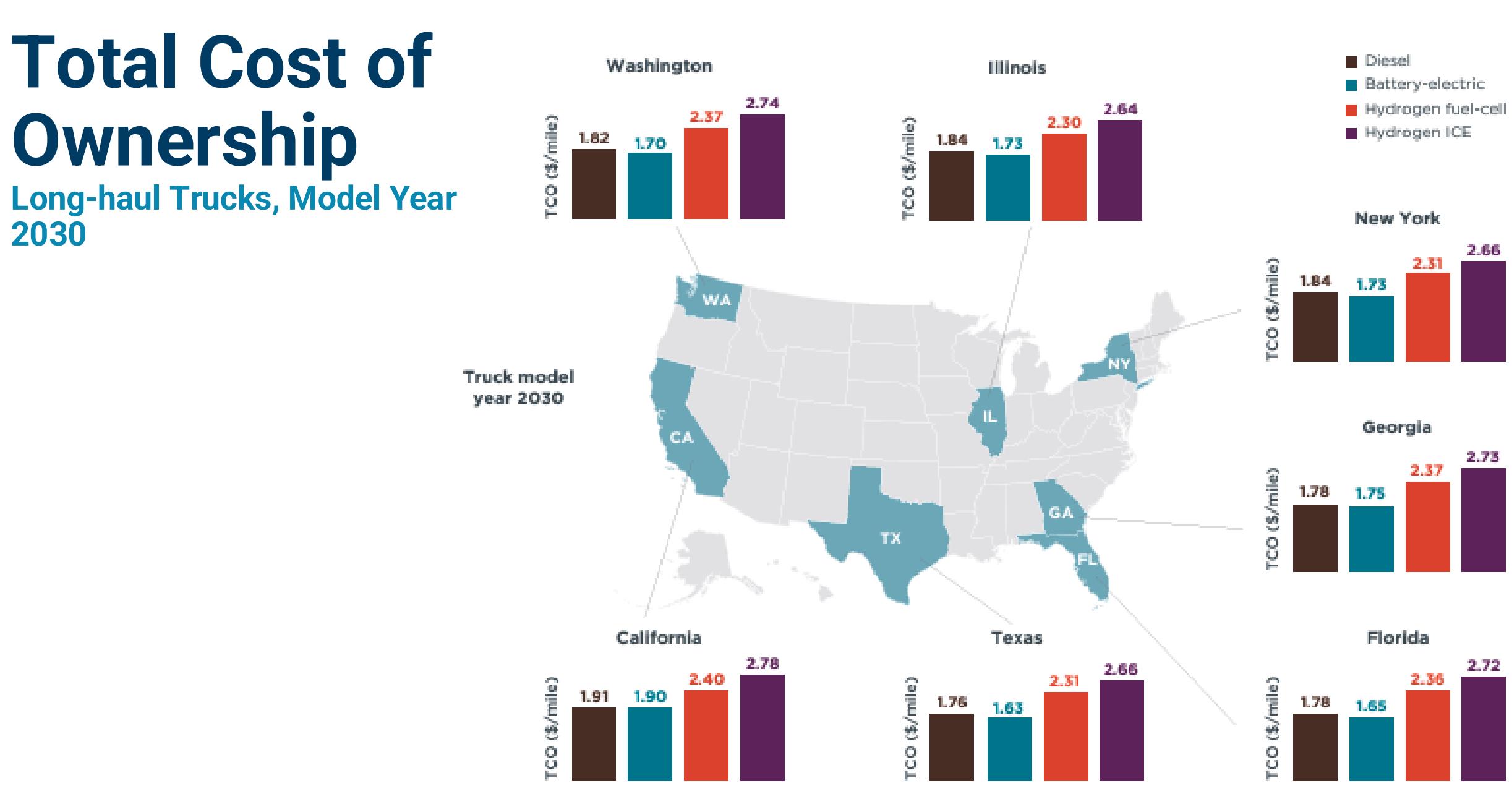
Thousand vehicles



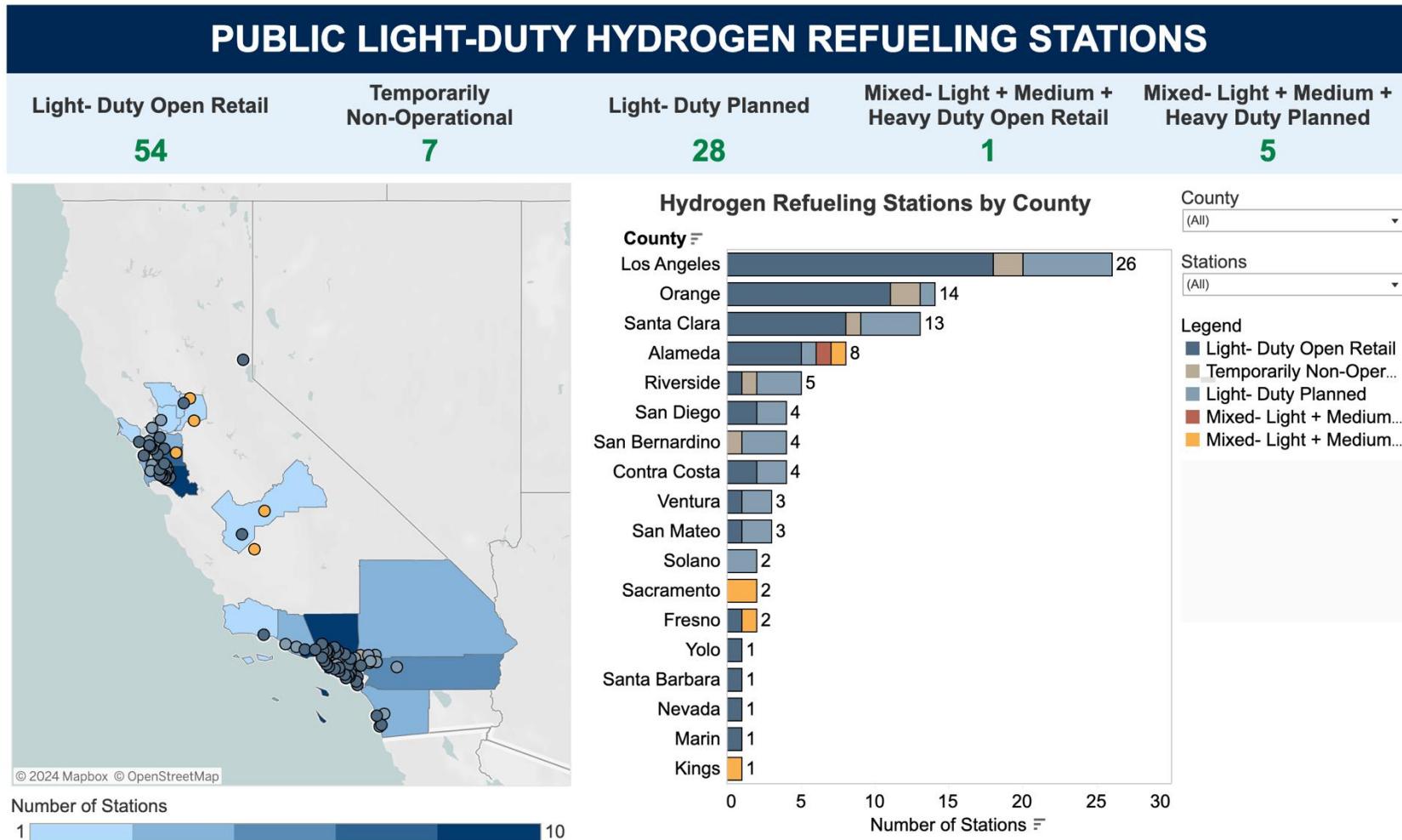
Source: BloombergNEF, MarkLines. Note: Includes passenger fuel-cell vehicles only.

# Total Cost of Ownership

Long-haul Trucks, Model Year 2030

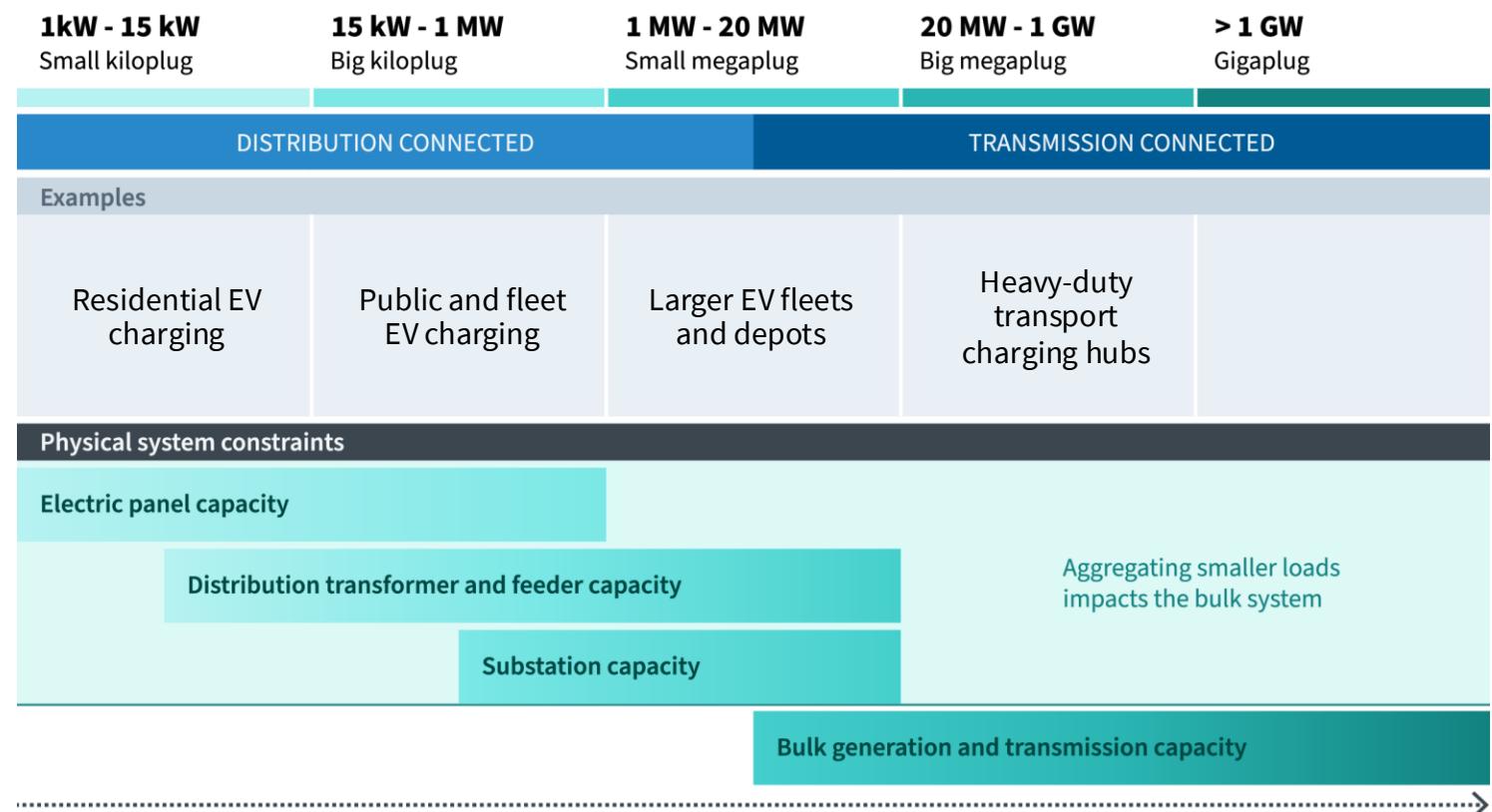


# Public Light-duty Hydrogen Refueling Stations

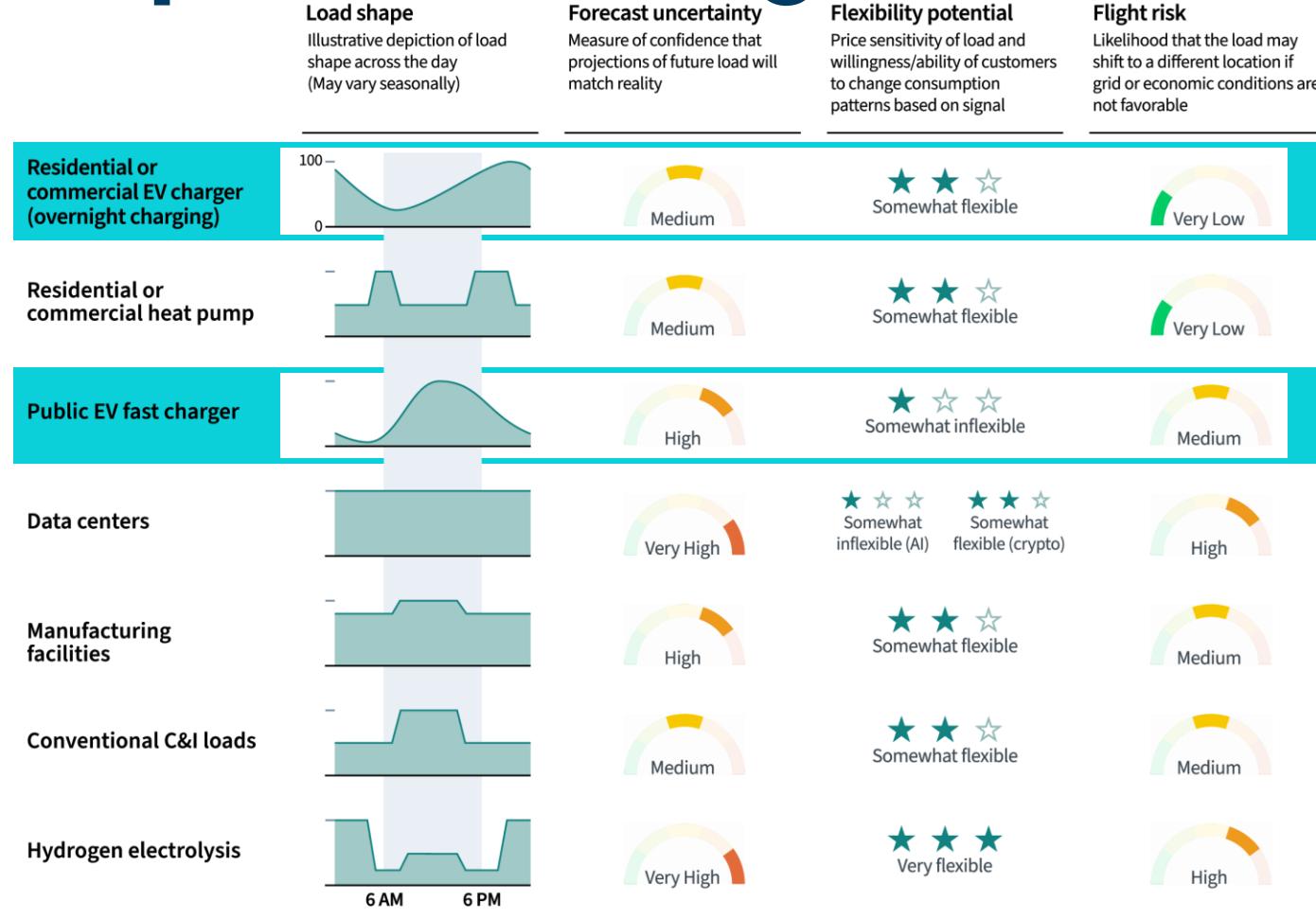


# EV load growth will impact all levels of grid infrastructure

The equipment providing this charging will require a range of power availability, from the low kilowatt-scale power supplied by Level 1&2 chargers in residences to 25+ Megawatts at truck charging depots that are currently being developed. This range of power demand corresponds to a variety of impacted grid infrastructure equipment. Utilities will need to manage investment and upgrades to all types of equipment on their system as EV loads grow.



# EV load is different than other types of expected load growth



Transportation electrification will occur alongside growth in electricity demand in several other sectors of the economy – notably data centers and building electrification. While these loads should all be considered when utility's plan investments, EV loads have distinct characteristics which must be considered. They will peak at different times, with large overnight peaks for most home and depot-based charging and day-time peaks for fast chargers. They have some potential for flexibility and can serve as distributed resources in Virtual Power Plant (VPP) or Vehicle-to-Everything (V2X) programs. It is notable that, even within the EV charging category, different types of vehicles and charging equipment will likely present different load characteristics that must be considered when planning.

# MHDV Market Segmentation

## Freight Vehicle Segmentation

Vehicle Class	Market Segment
Class 2b-6	Vans & Step Vans
Class 6	Medium-Duty Box Trucks
Class 7 & 8	Regional Haul Return-to-Base <i>Short • Medium • Long</i>
	Long Haul Irregular Routes

**NACFE**  
NORTH AMERICAN COUNCIL FOR FREIGHT EFFICIENCY

# What is a Zero Emission “Electric Truck”?

- Electric motors power the wheels

## Powertrain Choices:

Battery Electric  
Vehicle  
BEV

Catenary Electric  
Vehicle  
CEV

Hybrid Electric  
Vehicle  
HEV

Fuel Cell  
Electric Vehicle  
FCEV

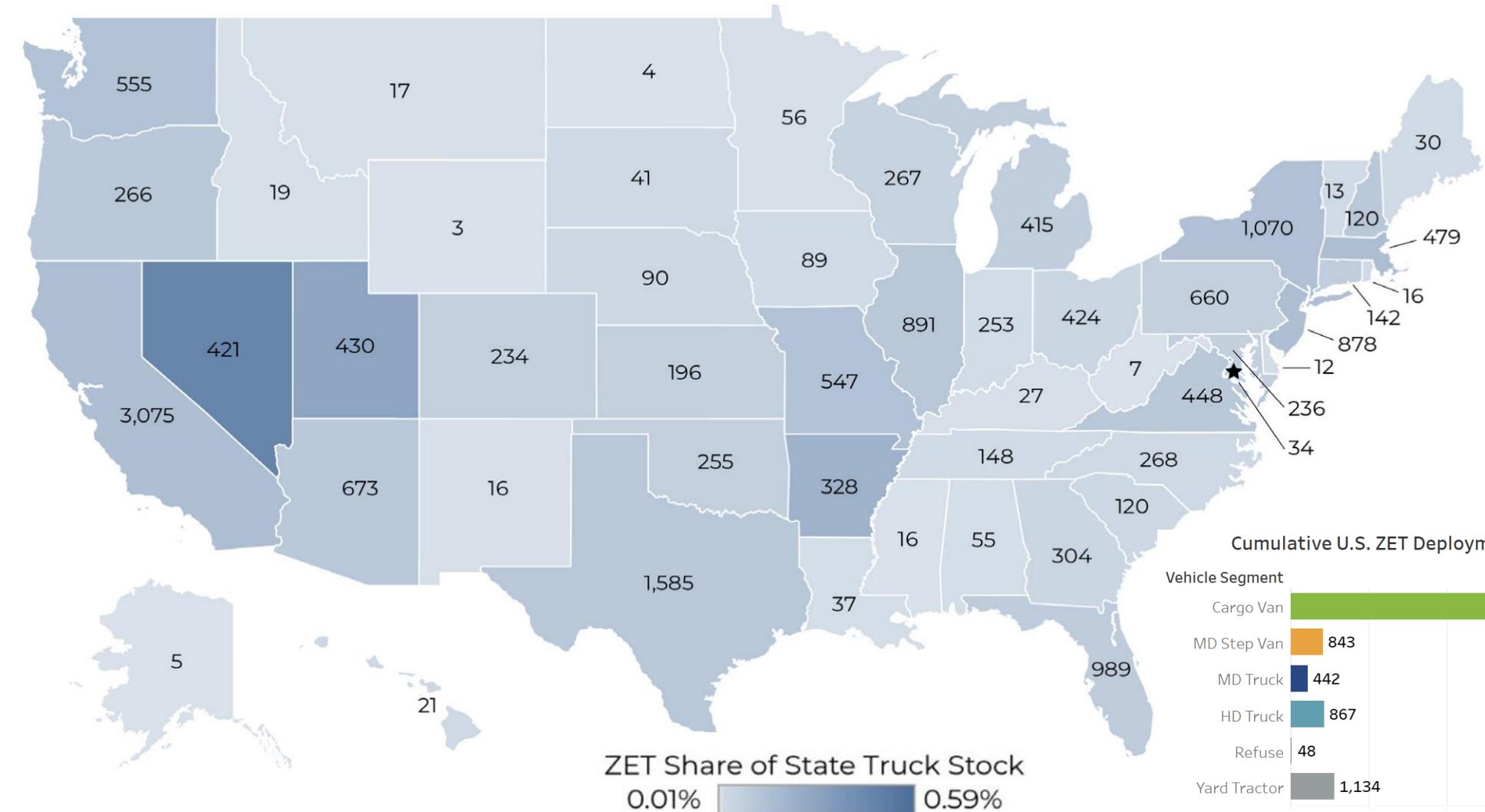
Diesel Hybrid  
Electric Vehicle

CNG Hybrid  
Electric Vehicle

Other Hybrid  
Electric Vehicle

These also could be called range extended BEVs

# ZEV Truck Deployments (Jan '24)



- Deployed as of June 2023
- 17,734 Zero Emission Trucks Deployed 2b-8
- 13% are in California (2022 = 46% and 2021=60%)

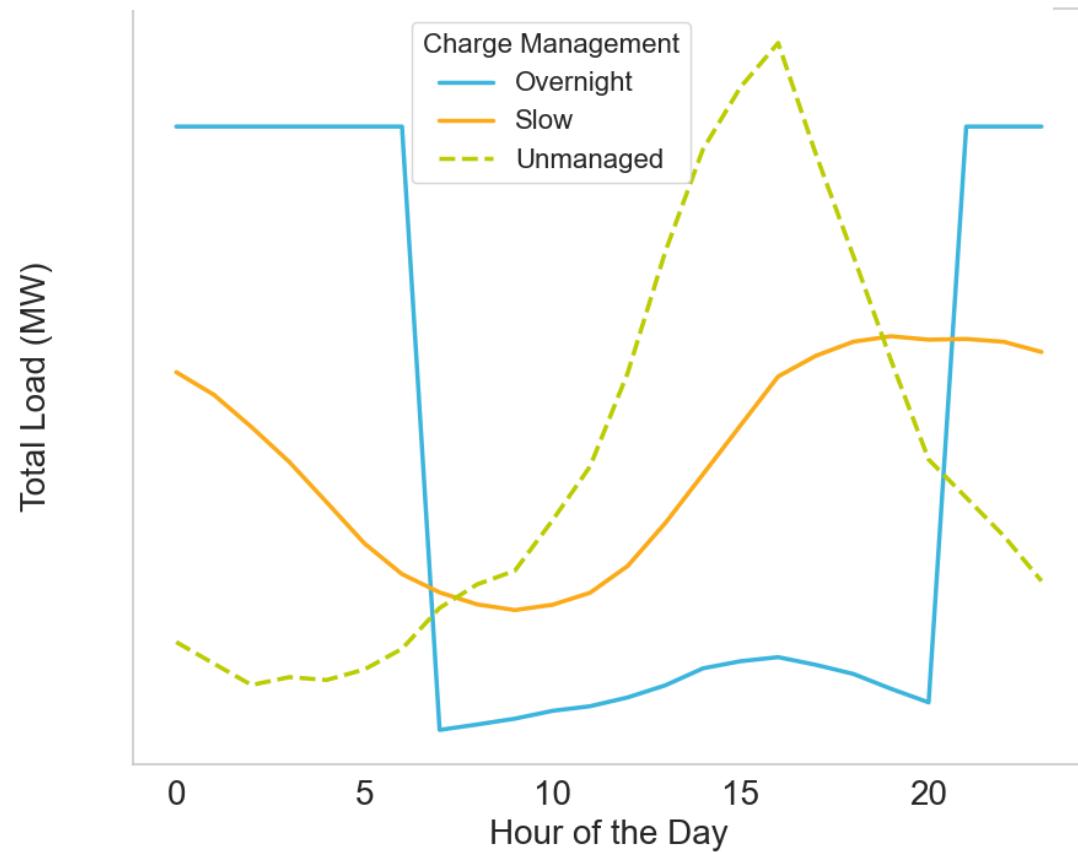
Source: Calstart January 2024

[Zeroing in on Zero-Emission Trucks: The State of the U.S. Market \(calstart.org\)](https://calstart.org)

RMI – Energy. Transformed.

# Fleets Can Optimize Grid Capacity

- **Unmanaged loads**  
~4pm peak
- **Site-level managed charging**  
<50% unmanaged demand
- **Overnight charging**  
<15% peak coincidence



# Fleets and Industry Grapple with Grid Constraints

## California's backlogged grid is holding up its electric truck dreams

Electric truck-charging projects face years of waiting to get the power they need. Clean-transport advocates say regulators must push utilities harder to speed up.

By Jeff St. John  
23 September 2024



- “No one has said infrastructure will be able to meet the targets at this point” – Matt Schrap, Harbor Trucking Association regarding Advanced Clean Fleet regulation
- “Fleets preparing for Class 8 EV tractors, obtaining permits and installing suitable high-power grid interconnections can take from two to four years” – Society of Automotive Engineers
- “The US’s largest heavy-duty electric truck microgrid is powered by... natural gas”. 96 E-truck depot in California relies predominately on generators due to insufficient grid capacity. May 24<sup>th</sup>, 2024



## Answering Trucking's Biggest Questions

- 2017 – What is the best freight efficiency in Long Haul?
- 2019 – What is Regional Haul and what is its efficiency?
- 2021 – Are electric trucks real and can they do the job?
- 2023 – What does it take to scale electric trucks?
- 2025 – #5?

# Run on Less – #5 Coming Soon

**2017**



**Long Haul**  
Seven Fleets  
10.1 MPG

**2019**



**Regional Haul**  
10 Fleets  
8.3 MPG

**2021**



**All BEVs**  
13 Fleets  
EV Truck Pilots

**2023**



**BEV Depots**  
10 Depots  
Infrastructure

**2025**

**Coming Soon**

# Run on Less - Electric DEPOT

- 10 fleet locations
- Each has at least 15 electric trucks
- Many have more
- Fleet videos:
  - 122 Interviews
- Telematics data

All information at:  
[RunOnLess.com](http://RunOnLess.com)



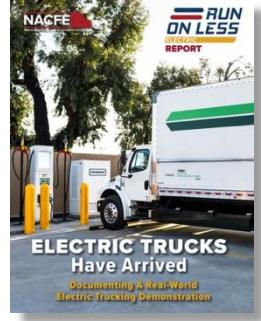
# Pepsi: Sacramento CA

## Long Haul & City Delivery with Tesla Semis

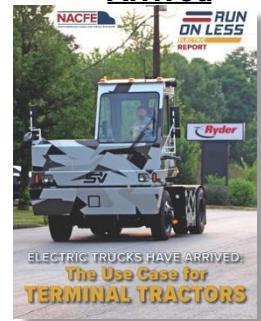


- 21 Teslas (3 LH & 18 City)
- 4 Tesla 750 kW chargers
- LH Beverages: 250-450 miles/day
- City Beverages: < 75 miles/day
- Sacramento Municipal Utility District

# Key NACFE Reports on ZEV Trucks



Jan 2022  
Review Of Complete  
Demonstration:  
**Electric Trucks Have  
Arrived**



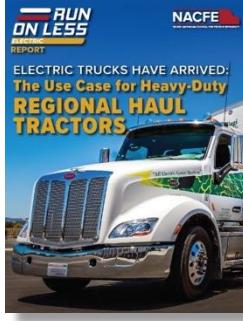
Mar 2022  
The Use Case For  
**Terminal Tractors**



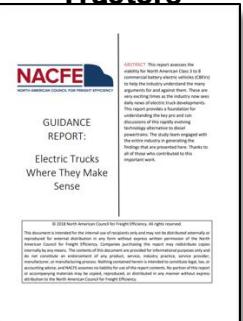
Jun 2022  
The Use Case  
For  
**Medium Duty  
Box Trucks**



Apr 2022  
The Use Case For  
**Vans & Step Vans**



May 2022  
The Use Case  
For  
**Regional Haul  
Tractors**



May 2018  
**Electric Trucks:  
Where They Make  
Sense**



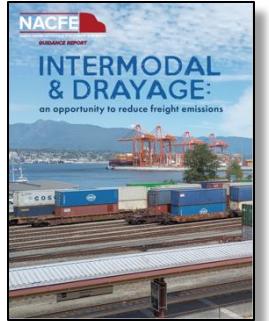
Feb 2023  
**The Messy Middle:  
A Time For Action**



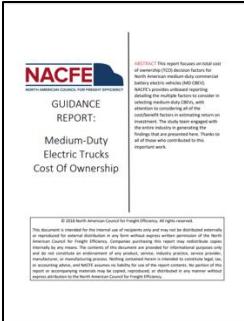
Dec 2020  
**Making Sense of Heavy  
Duty Hydrogen Fuel Cell  
Tractors**



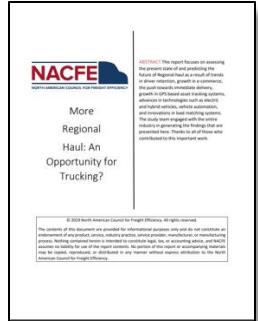
Apr 2023  
**Hydrogen Trucks:  
Long-Hauls  
Future?**



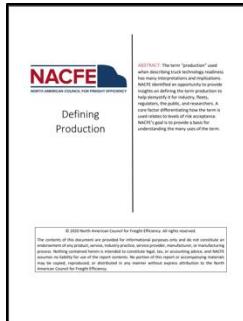
Dec 2023  
**Intermodal &  
Drayage**



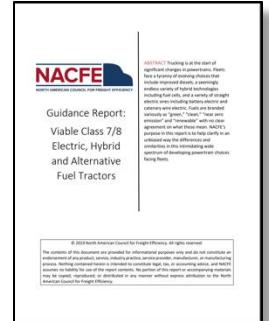
Oct 2018  
**Medium Duty  
Electric Trucks  
TCO**



Apr 2019  
**More Regional  
Haul: An  
Opportunity for  
Trucking?**

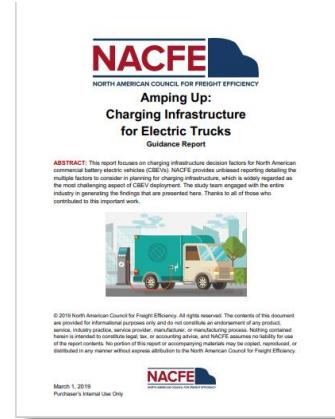


Jan 2020  
**Defining  
Production**



Dec 2019  
**Viable Class 7/8  
Electric, Hybrid and  
Alternative Fuel  
Tractors**

# Key NACFE Reports on Infrastructure



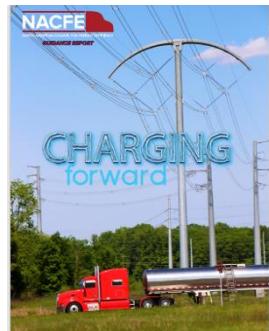
[Amping Up](#)



[Charting the Course for Early Truck Electrification](#)



[High Potential Regions for Electric Truck Deployments](#)



[Infrastructure Report](#)