Electric Vehicle Charging Power Demand Forecast

PJM Interconnection

Final Report

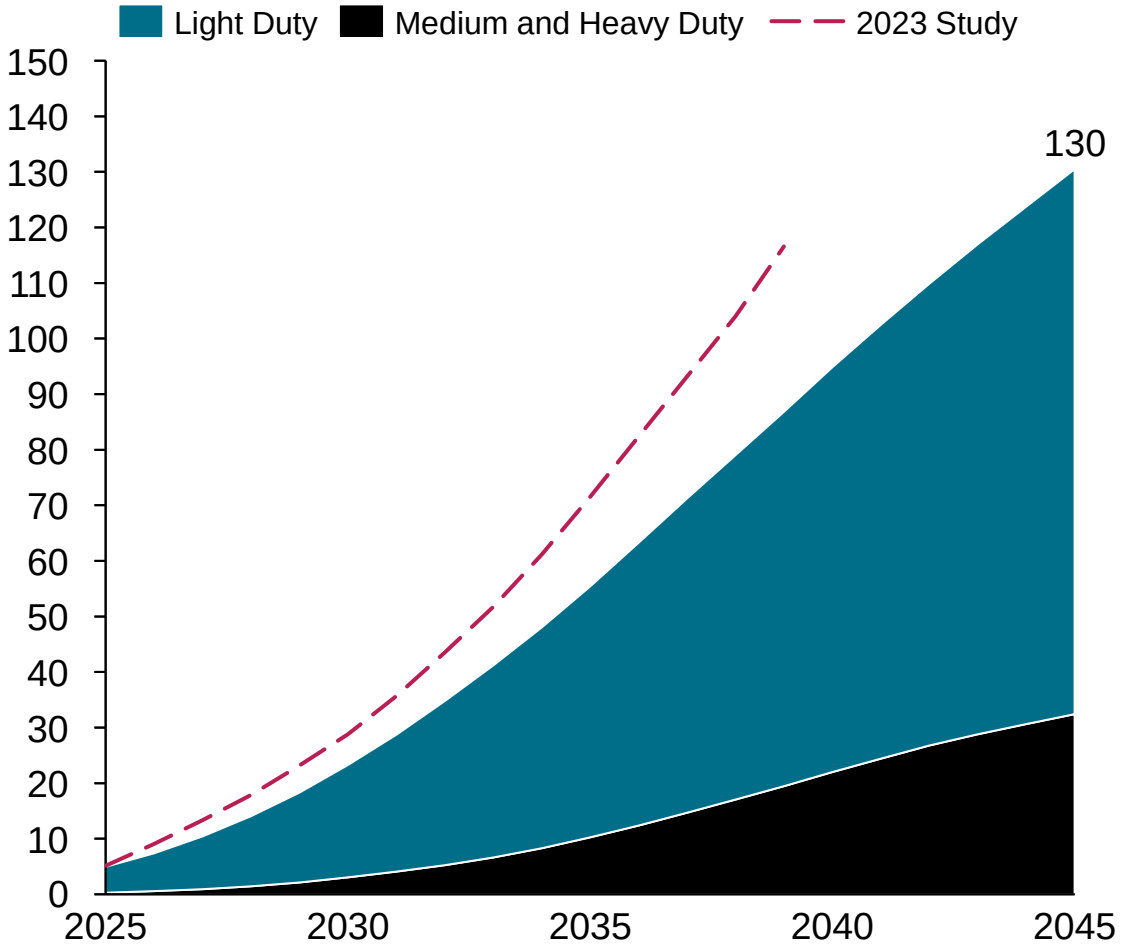
October 7, 2024

S&P Global
Commodity Insights

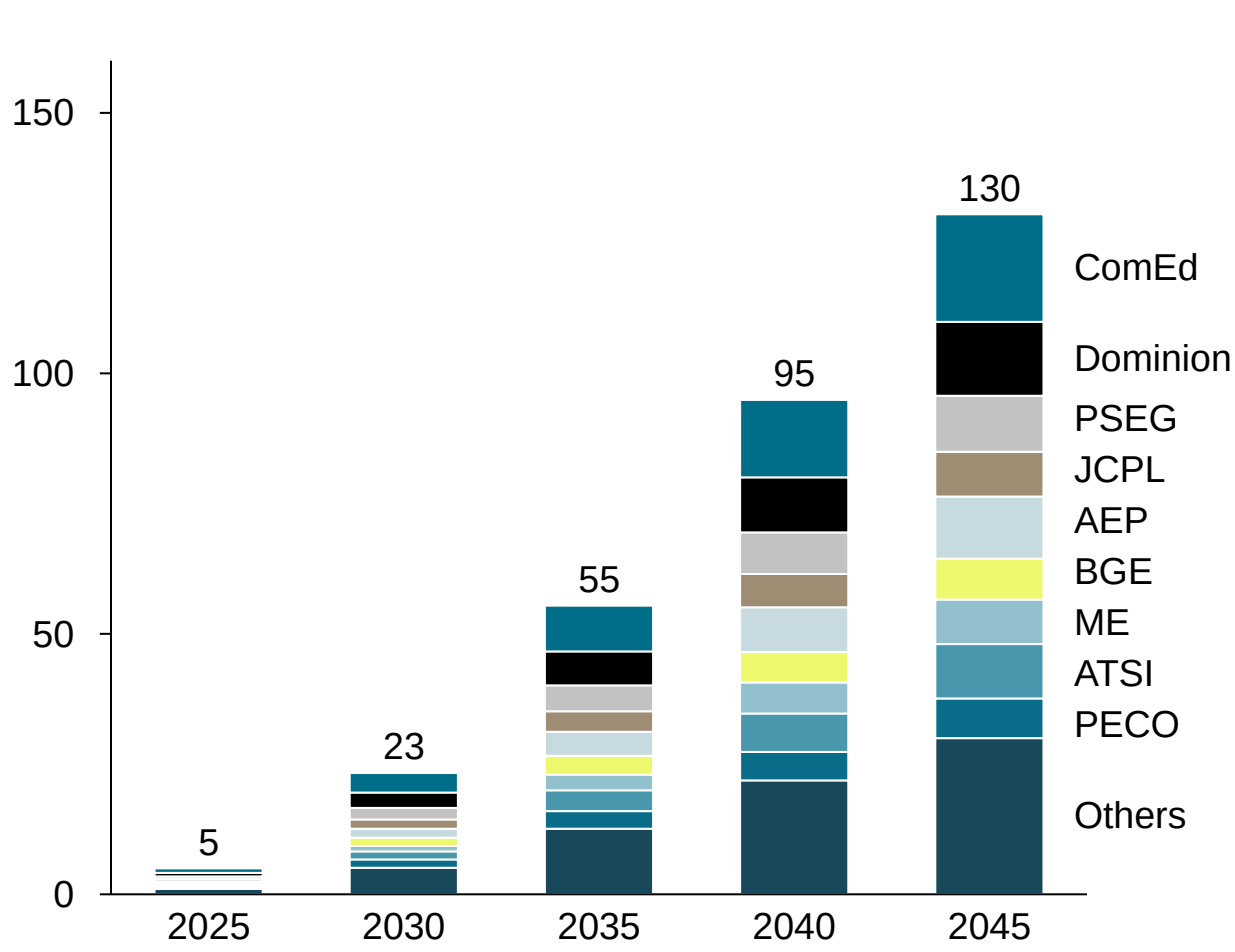
Contents

Total EV load in PJM will increase dramatically, however our outlook has been revised down compared to 2023 due to a lower Vehicle in Operation (VIO) projections

Total yearly EV load – PJM



Total yearly EV load by PJM zone



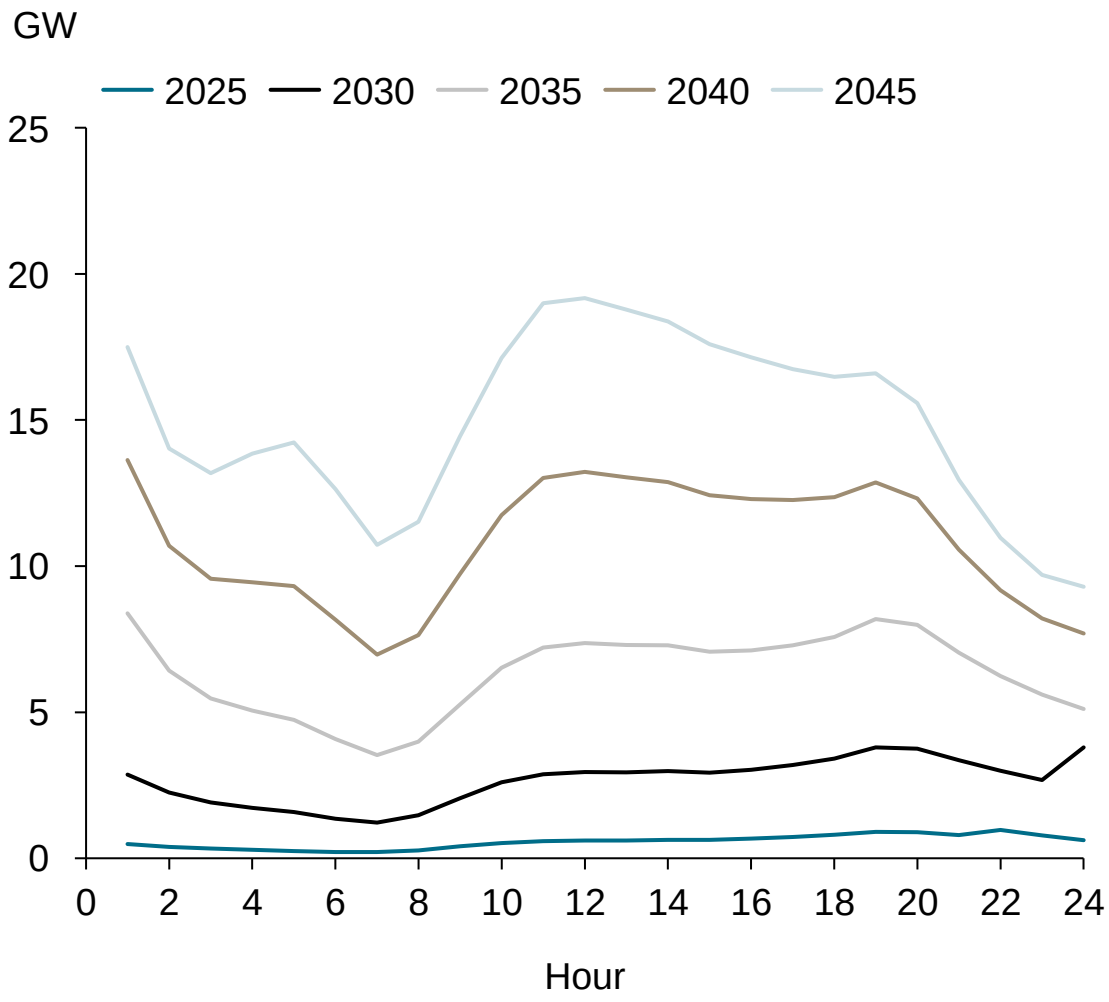
Source: S&P Global

With higher penetration of managed charging and higher access to public charging, load shifts from early evening to middle of the day and overnight charging

Total EV hourly load statistics - PJM

Year	Average Load (MW)	Peak Load (MW)	Month of peak	Hour of peak
2025	568	1,417	December	22
2030	2,657	5,302	December	24
2035	6,324	11,680	December	1
2040	10,799	18,853	December	1
2045	14,896	24,105	December	1

Average total EV load by hour - PJM

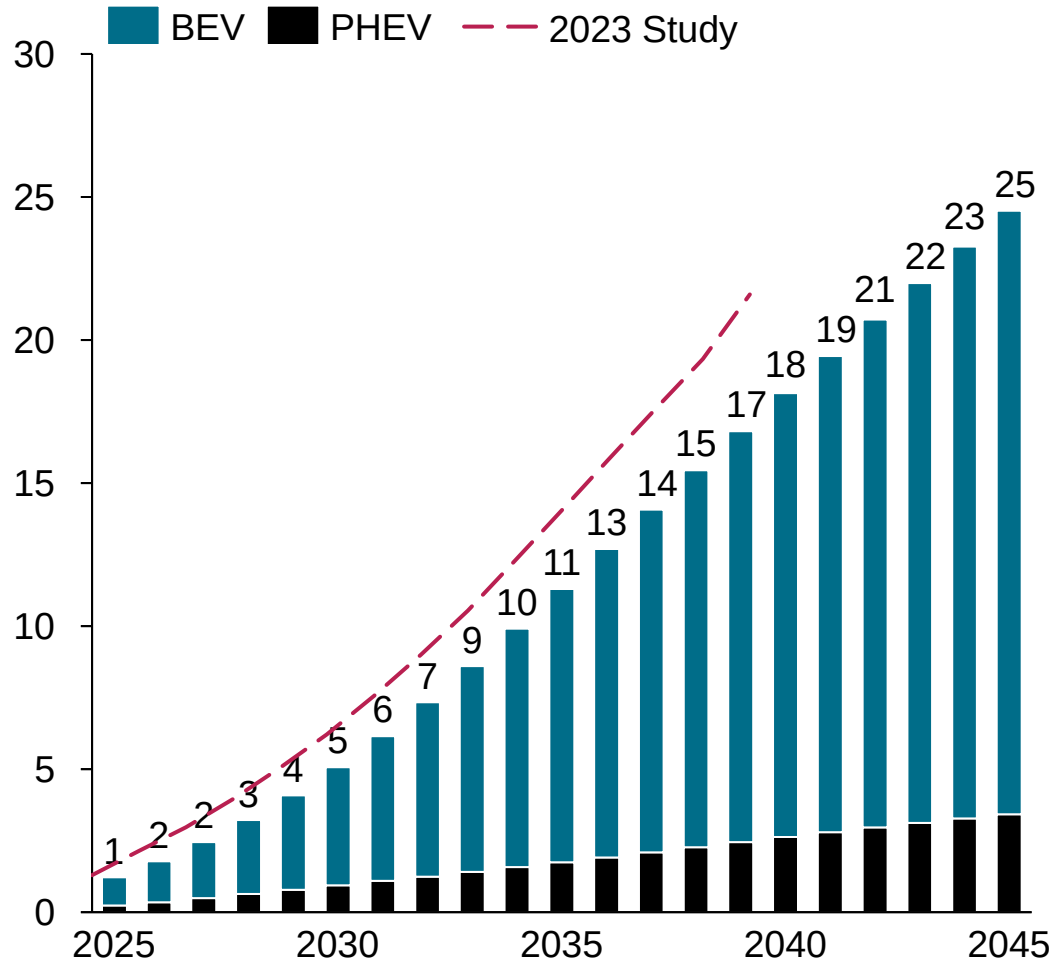


Source: S&P Global

We developed a forecast of the light duty EVs in operation which translates to a 98 TWh load by 2045

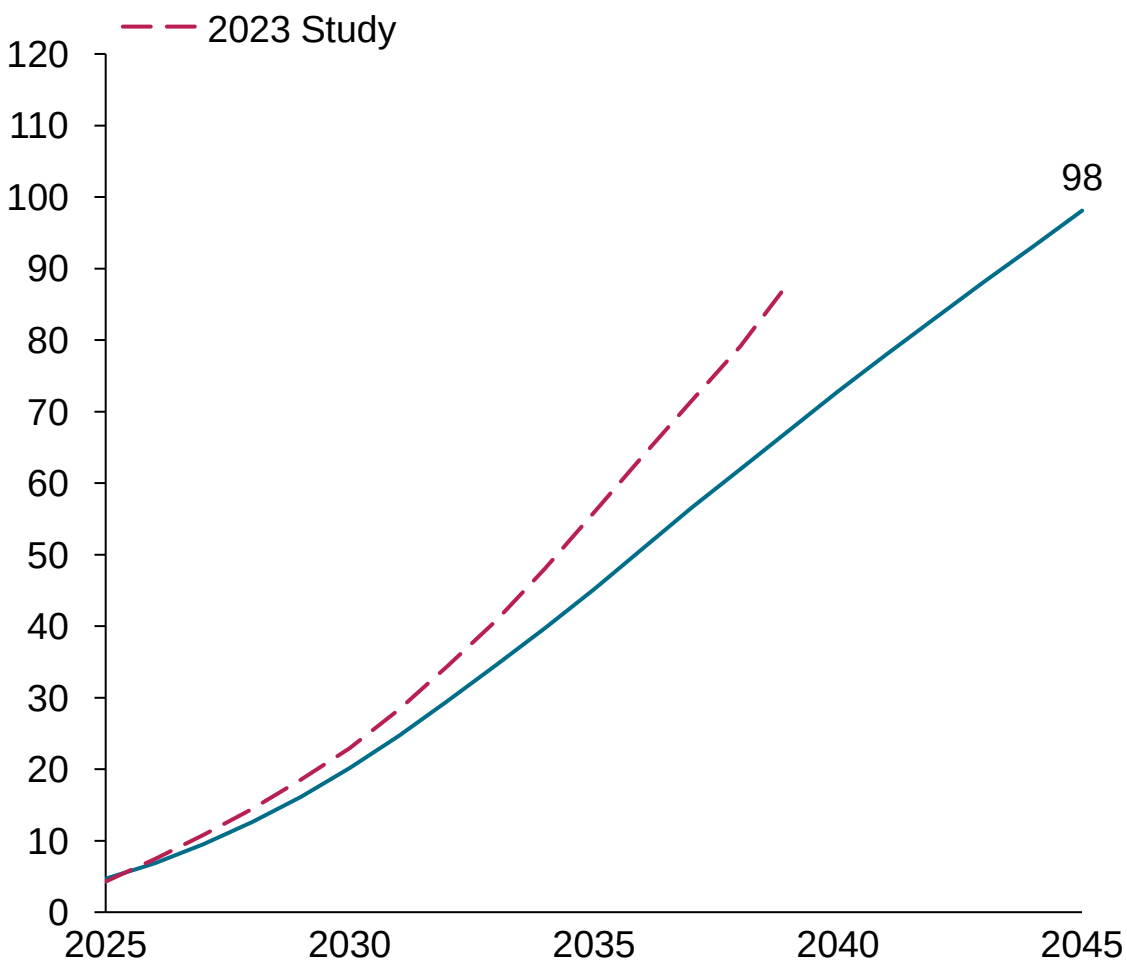
Total Light-Duty EVs in operation - PJM territory

Million of EVs



Total yearly light duty EV load

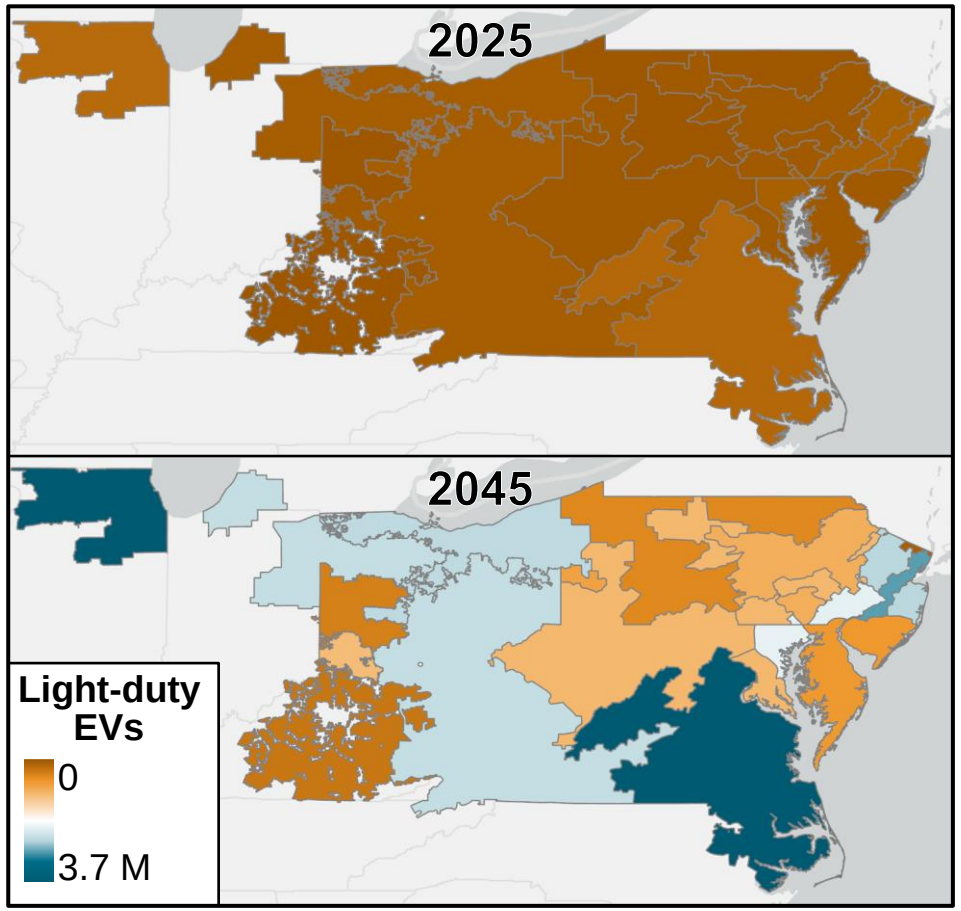
TWh



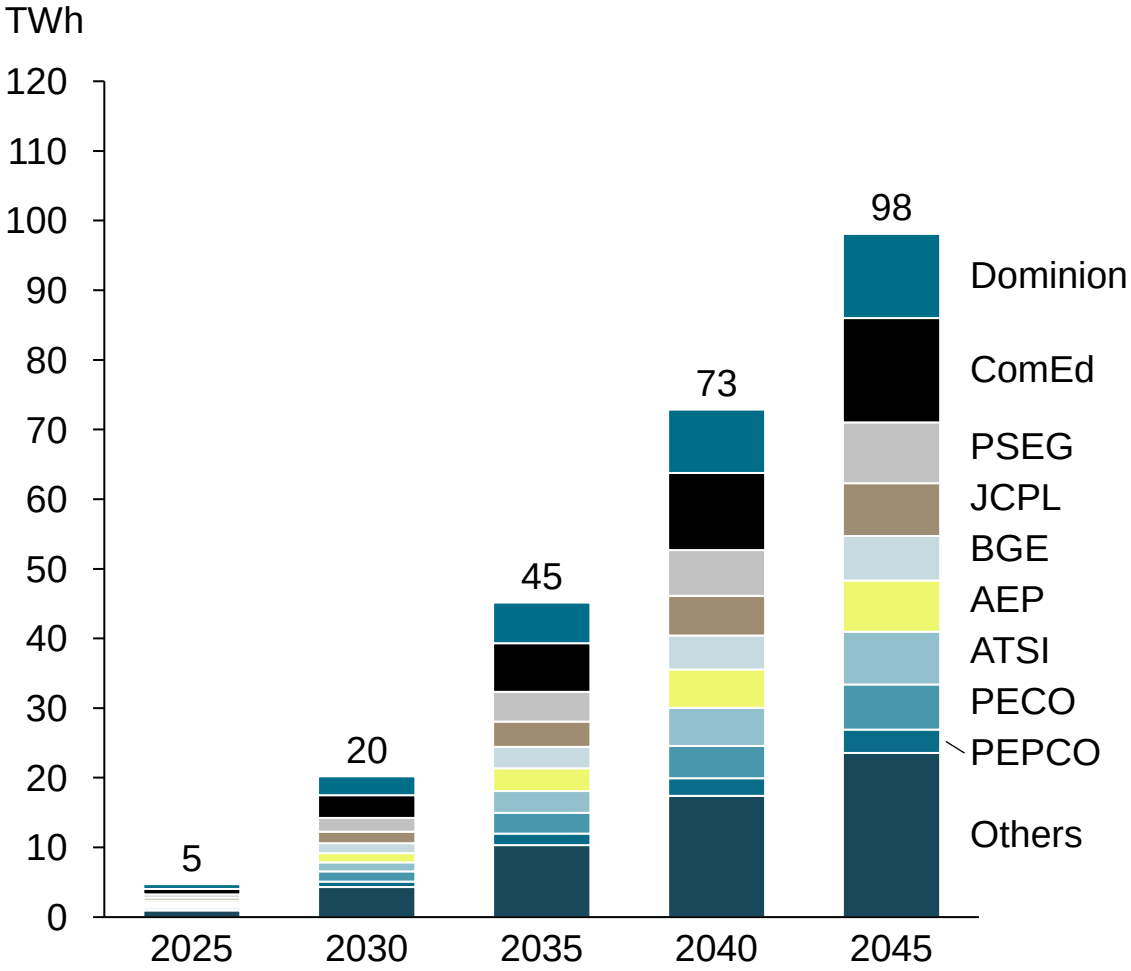
Source: S&P Global

PJM zones with large urban areas is where we see higher levels of light-duty EV load

Total light duty EVs in operation by PJM zone



Total yearly light duty EV load by PJM zone

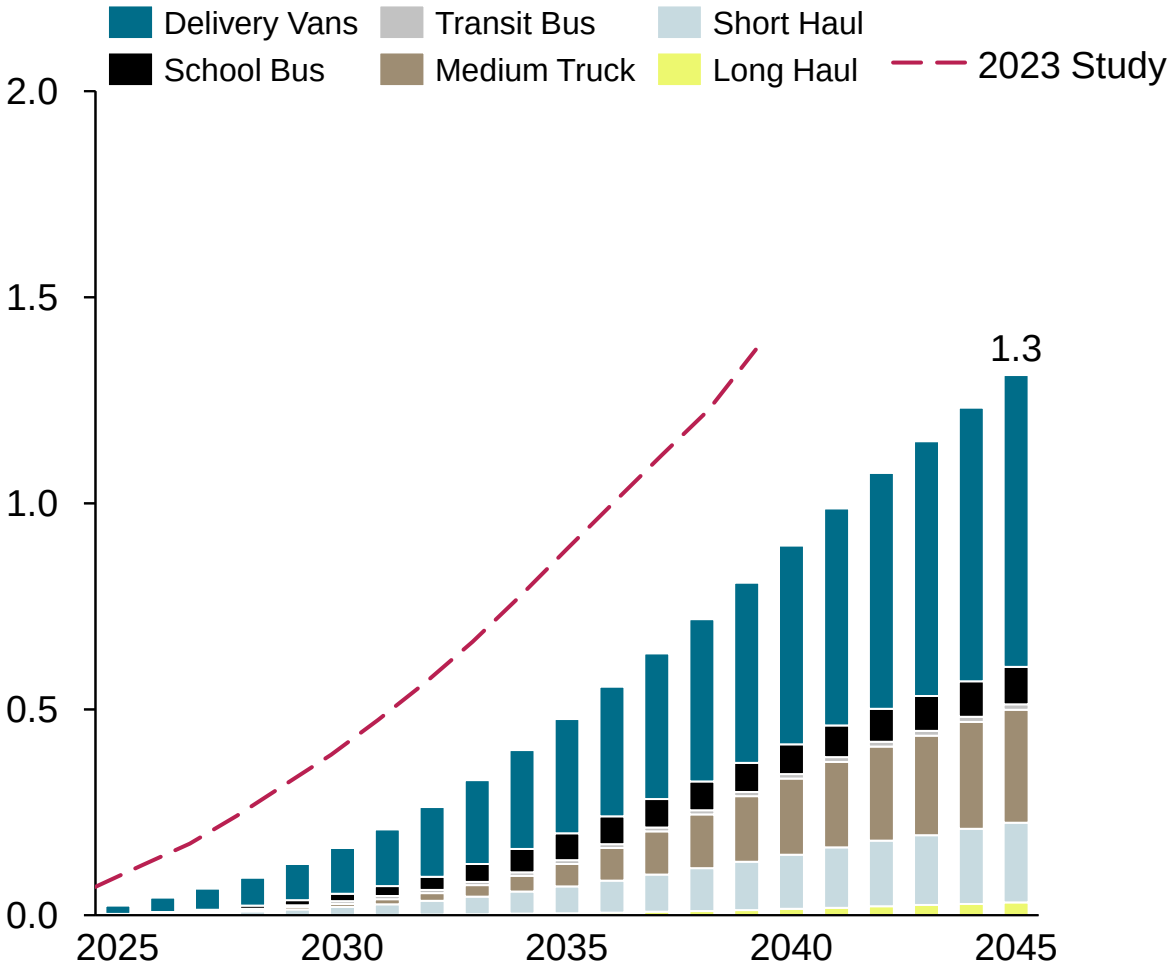


Source: S&P Global

We developed a forecast of the MDHD EVs in operation which translates to 32 TWh load by 2045

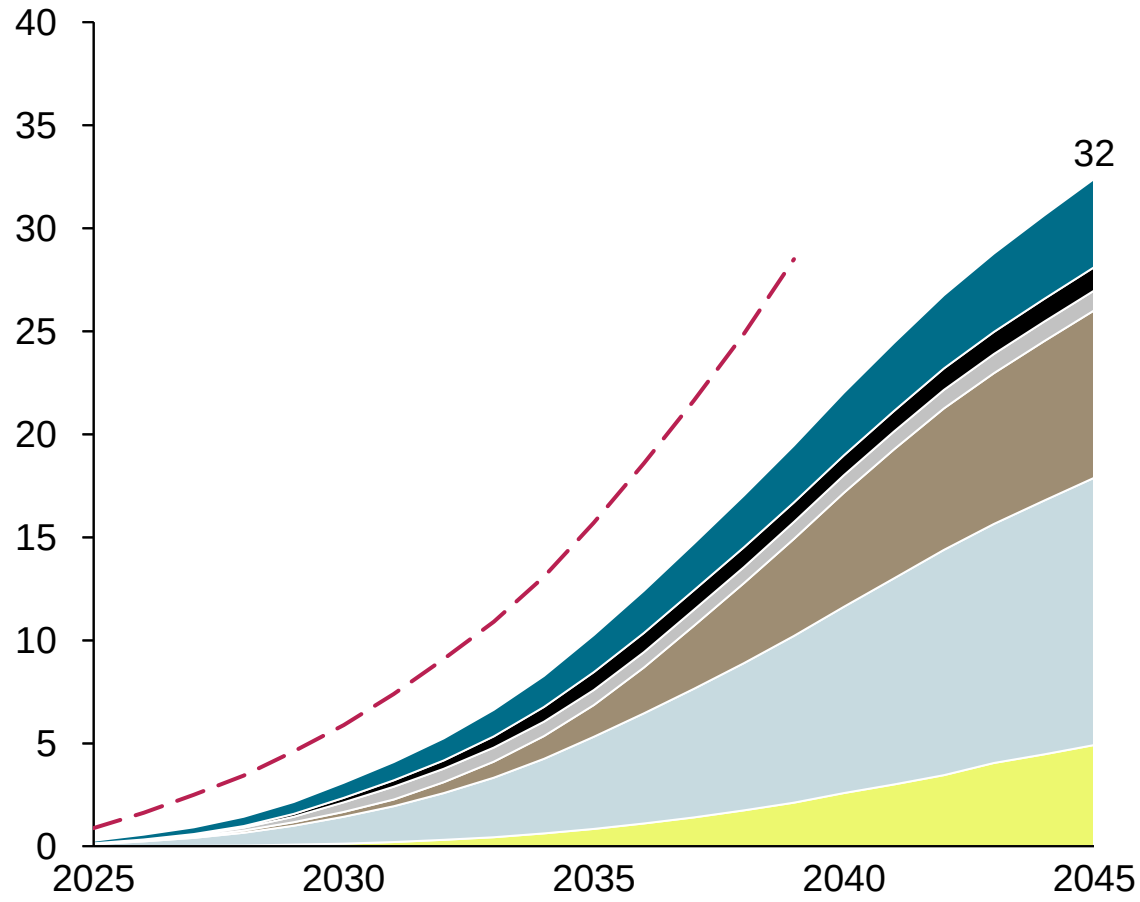
Total MDHD EVs in operation - PJM

Million of EVs



Total yearly MDHD EV load - PJM

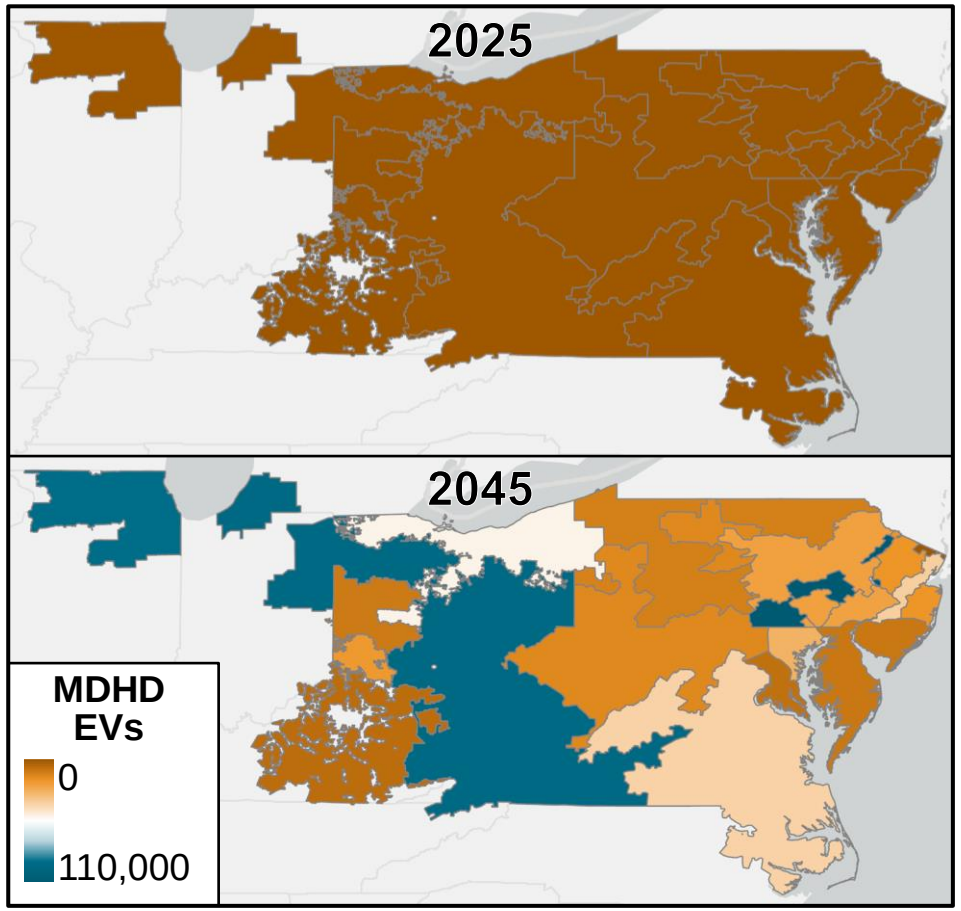
TWh



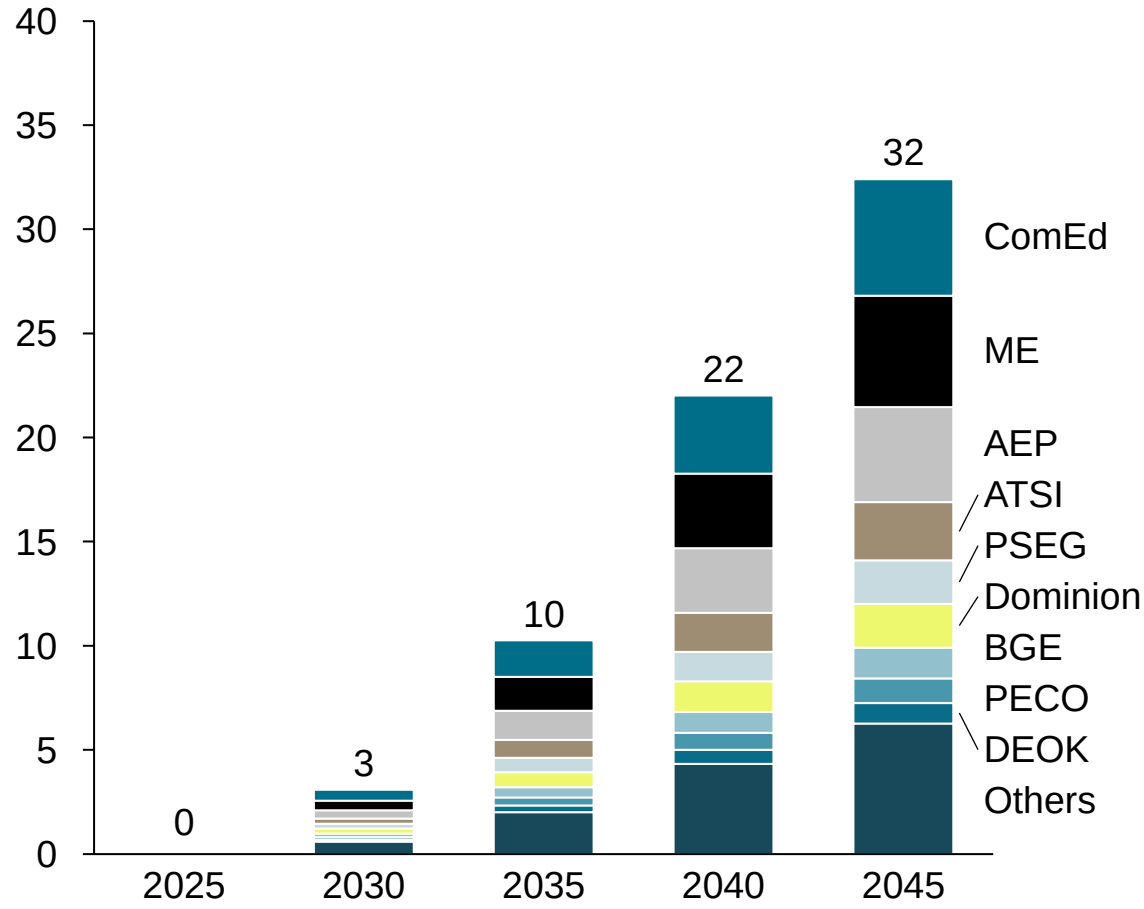
Source: S&P Global

MDHD load demand sees growth across PJM with zones within Illinois, Jersey, Ohio and Pennsylvania leading

Total Medium- and Heavy-Duty EVs in operation by PJM zone



Total yearly MDHD EV load - PJM



Source: S&P Global

Contents

Summary of key changes in the approach to the light duty vehicle analysis

Assumption	Description	Impact on Load	Magnitude of Change
Vehicles in Operation (VIO)	• EV penetration reaches 31% by 2039 and 45% by 2045 (compared to 40.8% by 2039). This is response to revisions made to final EPA mandate for MY2027 to MY2032 (envisioning a best-case scenario of 44% BEV rate of new vehicle sales in 2030) from August 2023 proposal (54% BEV rate of new vehicle sales).		High
Efficiency and temperature losses	• Updated vehicle efficiency based on latest update of S&P Global Vehicle Performance Database (VPaC). • Revised efficiency losses for cold/hot weather temperatures based on new data from real-world driving performance. • Incorporated relevant S&P Global technology forecasts (heat pump and refrigerant medium) to account for improvements in vehicle thermal management		Medium
Vehicles Miles Traveled (VMT)	• Vehicle miles travelled are expected to remain flattish at roughly 11,000 miles per year, with MaaS (Mobility as a Service) increasing from a present 35,000 miles per year to 40,000 miles per year.		Low

Source: S&P Global

Industry rebalances its BEV ambitions as profitability and consumer demand remain constrained leading to lower VIO outlook

Regulations

- **NHTSA** Aug 2023 CAFE proposal combined with DOE's Petroleum Equivalency Factor means **more room for HEV**[1]
- **Softening of EPA** on GHG[2] and partially on pollutants, but exhaust cleanup remains a challenging requirement
- **EPA super-credits on BEV/PHEV effective only 2023-2024**
- **CARB: mixed response on ACC2** as not all ACC1 members sign up (Connecticut, Maine, Minnesota, Nevada), but some new members join (Virginia, Washington, New Mexico)

Incentives

- **IRA passes** both houses of Congress
- **IRS strongly limits IRA eligibility** due to foreign entity of concern extending to battery raw materials
- **With tighter FEOC, PHEVs may be easier to qualify** for full tax credit due to lower amount of battery materials
- Politicization of BEVs is **creating uncertainty** around regulations and governmental investment support

OEM

- **Assumptions on BEV profitability have been re-evaluated** due to cost, strong price competition, and supplier volume shortfall claims
- **UAW deal** will result in higher costs for OEMs, meaning less room to cross-finance BEVs
- **Ford and GM** have **reduced and/or postponed EV investments**
- **Openness to PHEV** announced by **GM**, but portfolio allocation remains open
- **Toyota** says 30% BEV is reasonable, any gap in compliance to be closed with purchased credits

Customer Readiness

- **BEV growth slows down** under consumer uncertainty and technology + economic headwinds
- **Difficulty moving from early adopters to the early majority** due to expectations on range, ease of charging and upfront vehicle cost not being satisfied
- **NACS plug** standardization and timeline of vehicle-side rollout **defers some BEV purchases**
- **Reduced disposable income** driven by inflation and high interest rates creates an economic challenge for consumers
- **HEV gains further leadership as affordability remains key**

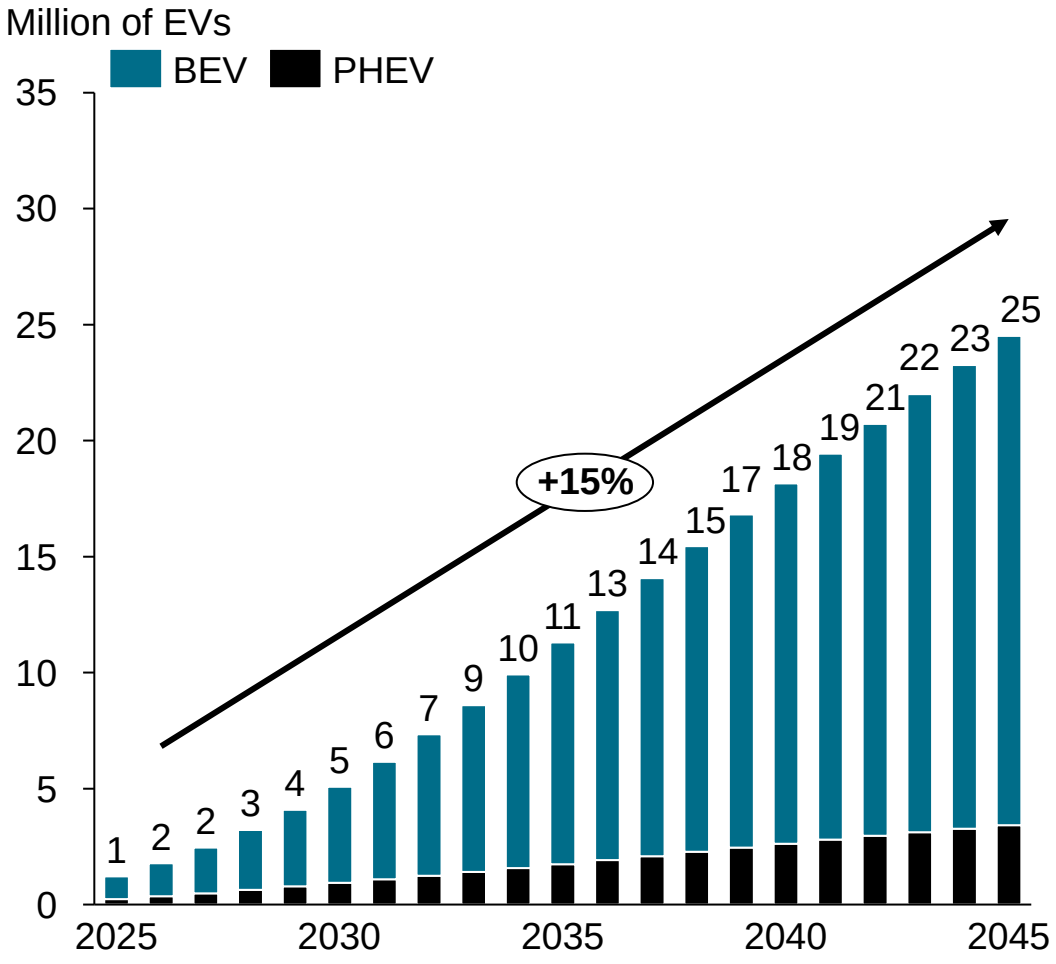
Forecast consequence: More powertrain flexibility and delay of BEV trajectory by minimum 2 years

Source: Sales-based Powertrain Forecast (March 2024)

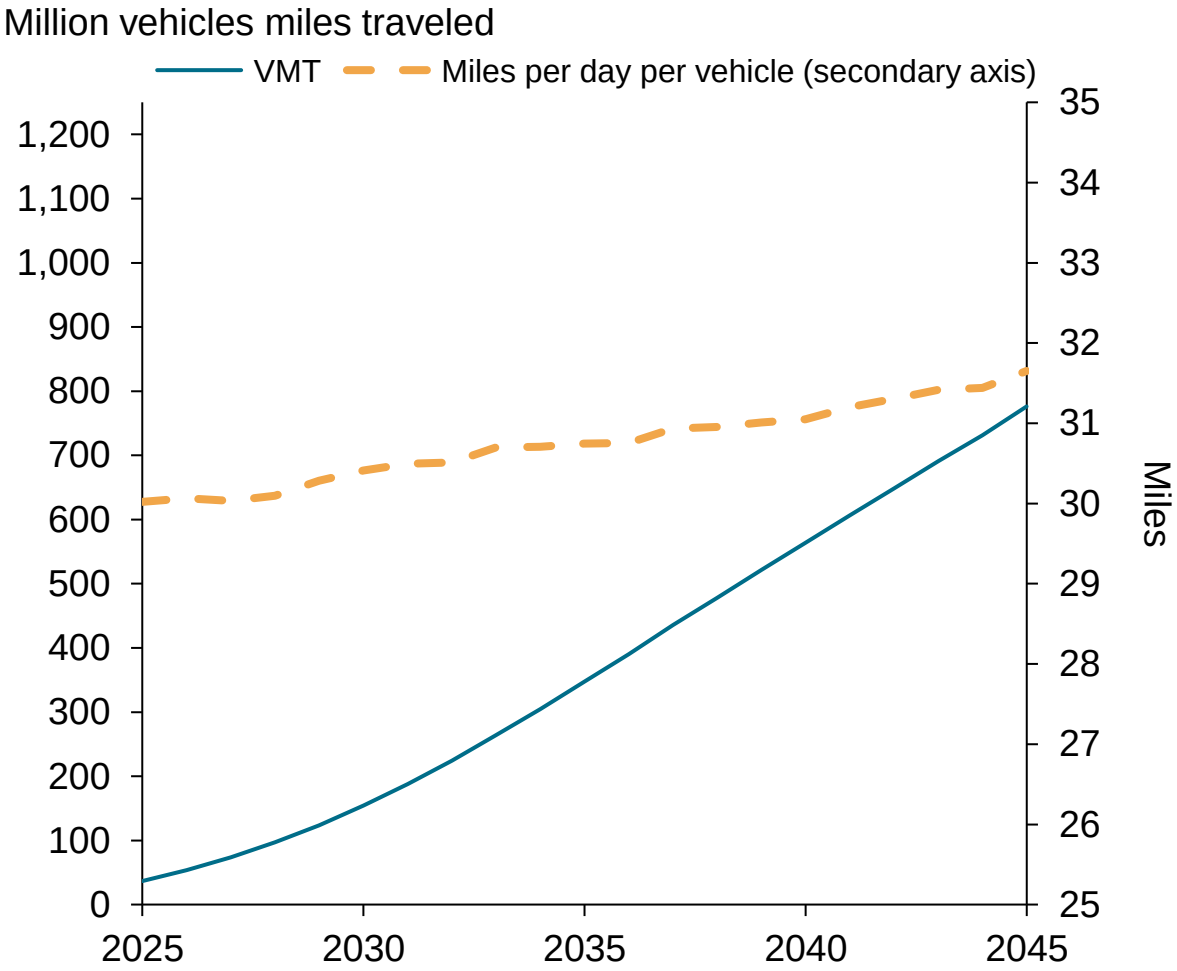
1. The CAFE proposal by NHTSA is very demanding for BEVs due to the new mpg-e calculation by DOE, which requires 3.5x more BEVs to reach the previous equivalent fleet efficiency. It additionally relaxed the limit values.
2. The EPA Final Rule for GHG standards softened requirements in 2027-2031, but the 2032 value remains unchanged, with a 50% reduction against the 2027 standard. Also, the strict Tier IV pollutant limits have been adopted, although with a longer phase-in. Compliance will likely require more BEVs or additional exhaust management technology (GPF and potentially eHCC), making ICE/FHEV more expensive and closer to BEV in terms of compliance efficiency.

Lower VIO in our forecast is counterbalanced to a degree by slightly higher vehicle miles traveled

Total Light-Duty EVs in operation - PJM territory



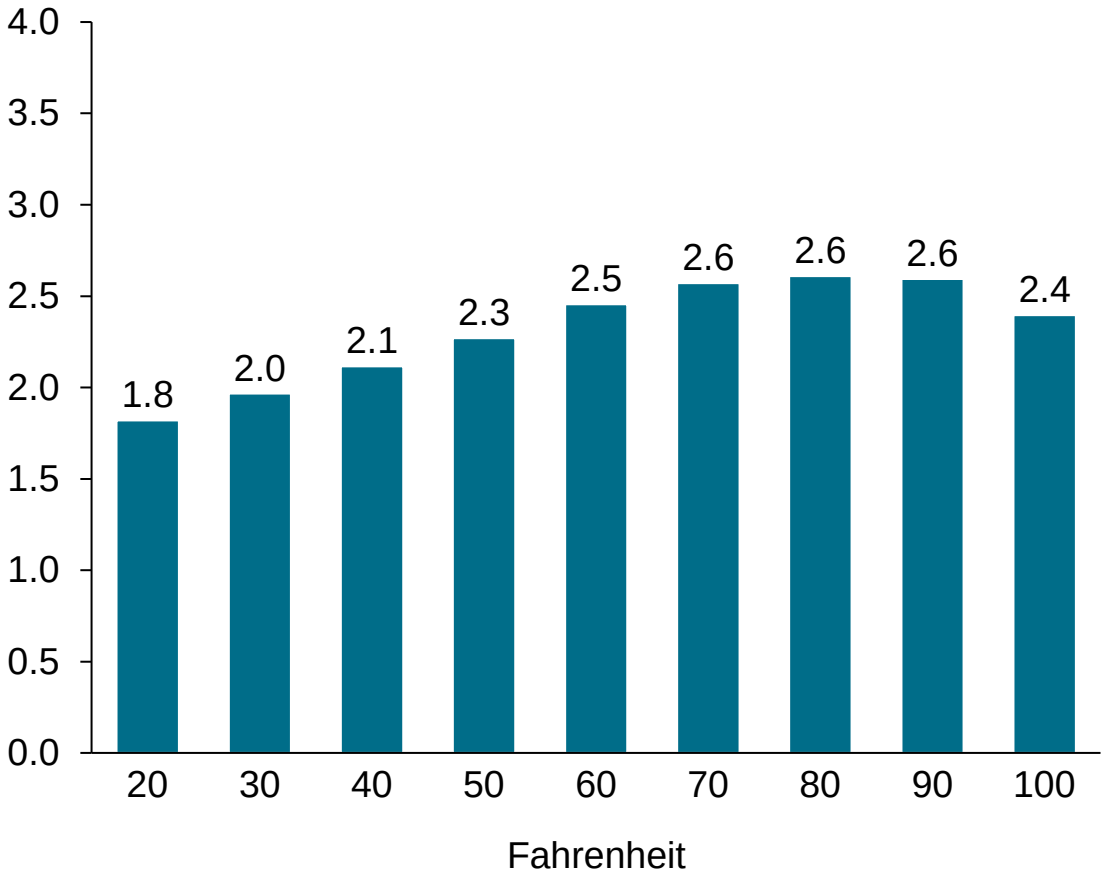
Light-Duty EVs vehicle miles traveled (VMT) - PJM territory



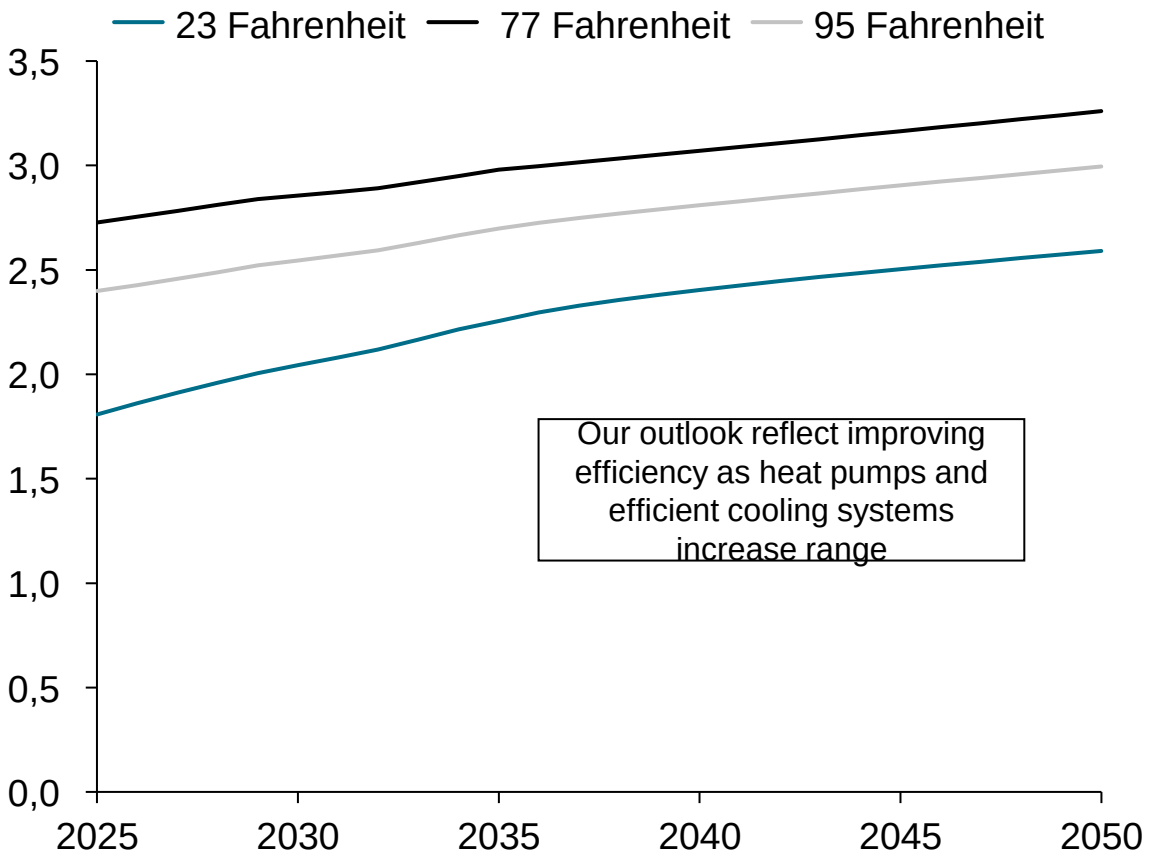
Source: S&P Global

We revised our approach to vehicle efficiency changes due to outside temperature fluctuations to reflect better understanding of improving technologies and real-world data observations

Average vehicle efficiency under different daily temperatures - 2025
Miles per kWh



Monthly average temperature per PJM zone
Miles per kWh



Note: Temperature assumed for the study is a 10-year historical average on a daily basis.
Source: S&P Global Commodity Insights, U.S. Environmental Protection Agency (EPA), Recurrent real world driving observed range

Utilities currently incentivize charging during the night and early morning. Going forward, TOU rates will evolve to incentivize EV charging away from the evening due to solar penetration

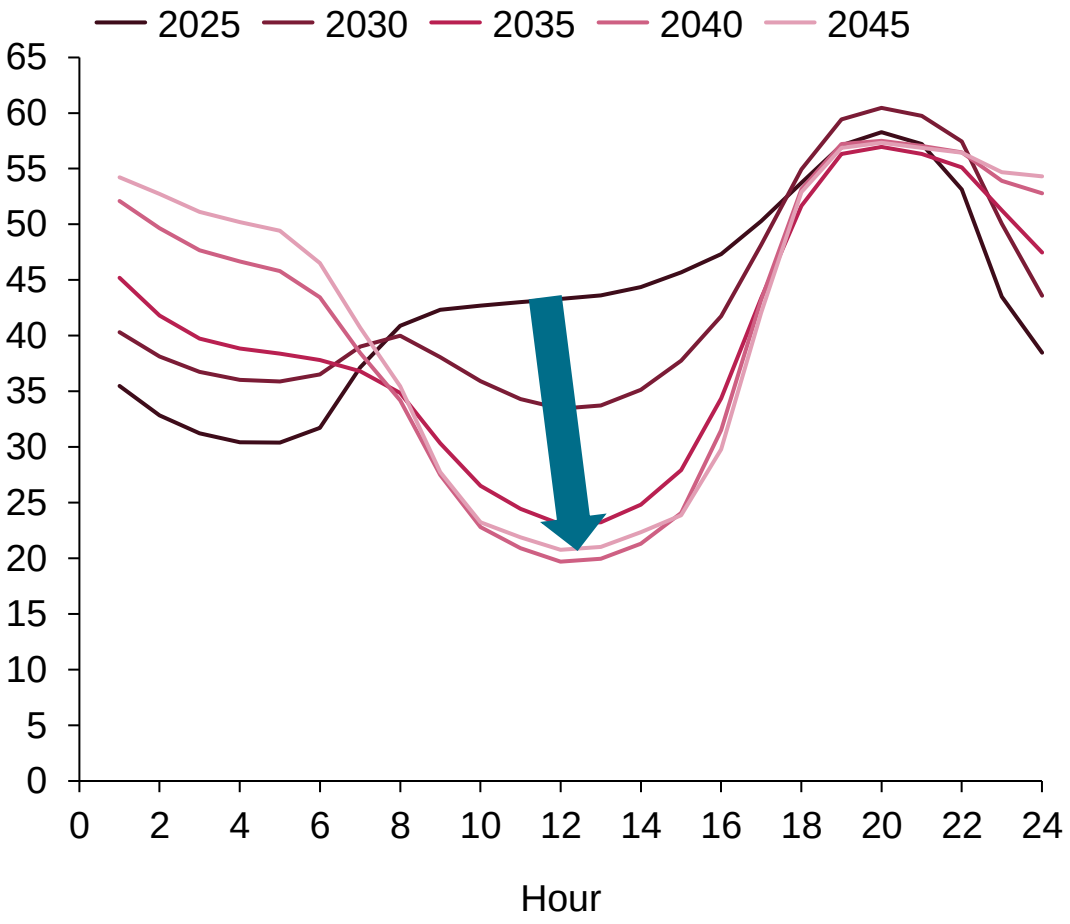
Selected PJM utilities with Time-of-use (TOU) rate structure - 2024

Utility	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Atlantic City	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Off-peak	Off-peak	Off-peak	Off-peak
AEP Ohio	Super off-peak	Super off-peak	Super off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Off-peak	Super off-peak
Appalachian Power	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Super off-peak
First Energy	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Peak	Peak	Peak	Peak	Off-peak	Off-peak	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Super off-peak
BGE	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak
ComEd	Follows PJM real-time pricing																							
Duquesne Light	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Off-peak	Off-peak	Super off-peak	Super off-peak
Dominion Virginia	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Peak	Peak	Peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Super off-peak
Delmarva Power	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak
PECO Energy Co.	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Peak	Peak	Peak	Peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Super off-peak
PEPCO	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak
PPL	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Peak	Peak	Peak	Peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak
PSEG	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Peak	Peak	Peak	Peak	Off-peak	Off-peak	Off-peak	Super off-peak	Super off-peak	Super off-peak
Orange & Rockland	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Super off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Peak	Peak	Peak	Peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Super off-peak

Super off-peak (If available)
Off-peak
Peak

Average PJM East wholesale prices

Real 2022 $/MWh



Source: S&P Global Commodity Insights

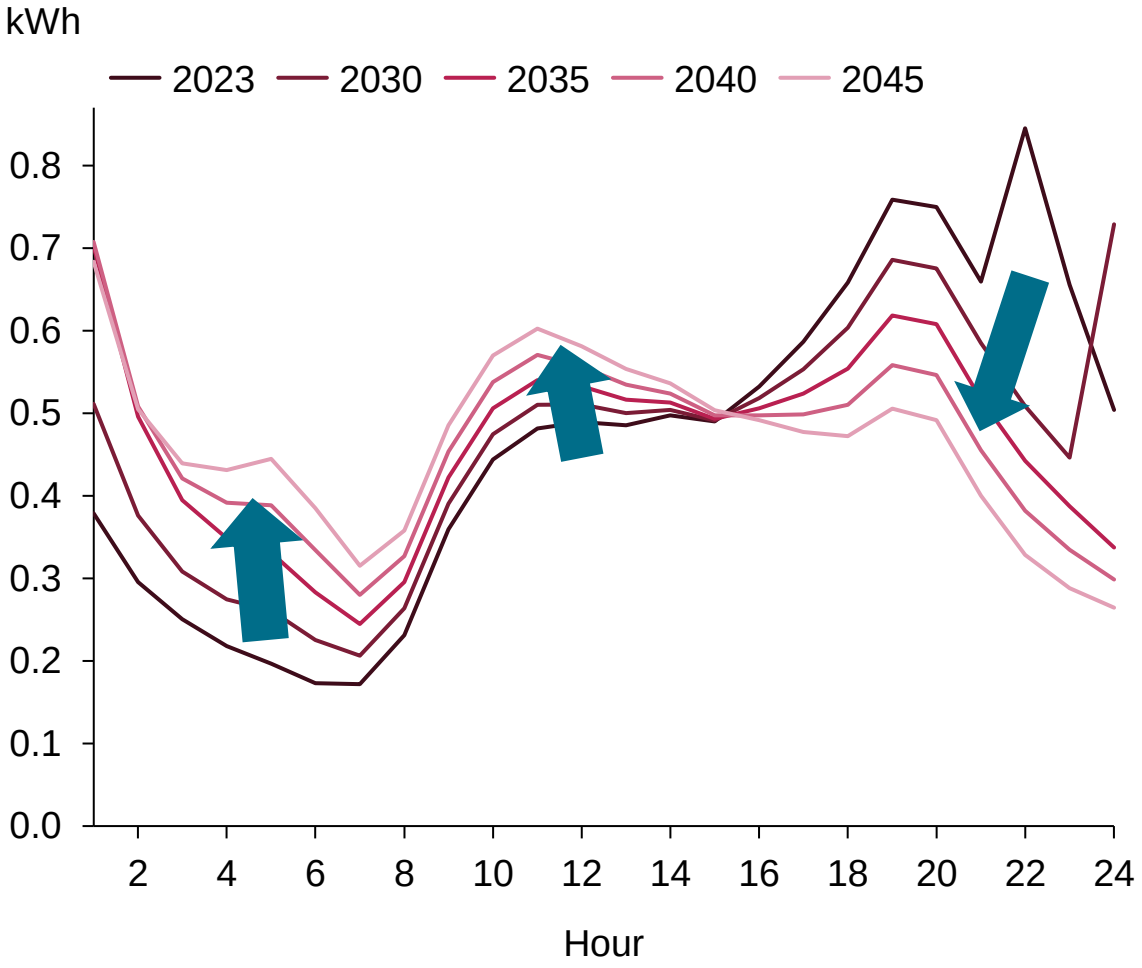
Lower access to home charging, managed charging, and TOU rates will drive changes in charging behavior. Our charging shapes are a combination of different charging strategies.

Charging Strategy	Access to Home Charging	Description	Preferred charging time	Type of charger	Reliance on managed charging	Trend
Immediate	Yes	Will choose to charge as soon as they get home, regardless of cost.	Evening	L2: 80% L1: 20%	Low	
TOU - As soon as possible (ASAP)	Yes	Starts to charge as soon as the off-peak pricing ends.	Late night to midnight	Level 2	High	
TOU – As late as possible (ALAP)	Yes	Starts to charge a few hours before commuting for the day.	Early morning	Level 2	High	
Work and public charger	No	Reliant on public charging, will start charging as soon they arrive to work.	Morning through midday	Mostly L2 and DCFC	Low	
Ride - hailing	50%	Mostly reliant on public charging, will charge throughout the day.	Middle of the day	Mostly L2 and DCFC	Low	

Source: S&P Global

As charging behavior evolves, EVs will charge less during the evening and more overnight and the middle of the day

Light duty EV average weekday charging



Key trends impacting the load shape

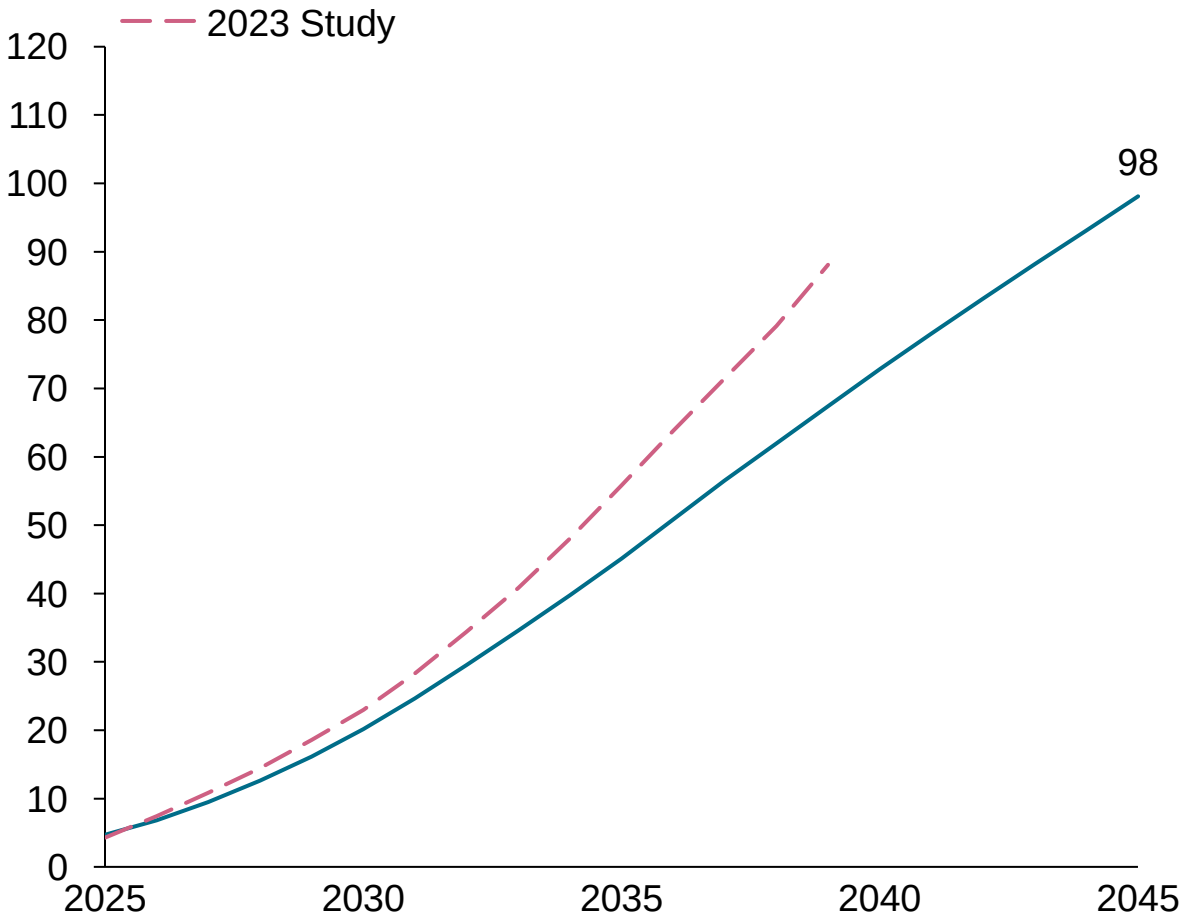
- Due to lower access to home charging as a share of total, EV owners will increase charging in the middle of the day at the workplace/public chargers.
- Evolution of TOU rates will nudge people to not charge immediately as they get home in the evening.
- As more people adopt managed charging, they will increase charging either overnight or early morning before departure.

Note: Assuming 34 miles per day driven and no mileage loss from temperature.
Source: S&P Global Commodity Insights, NREL.

Load from light-duty vehicles is forecasted to reach 98 TWh by 2045, with zones with high urban areas leading

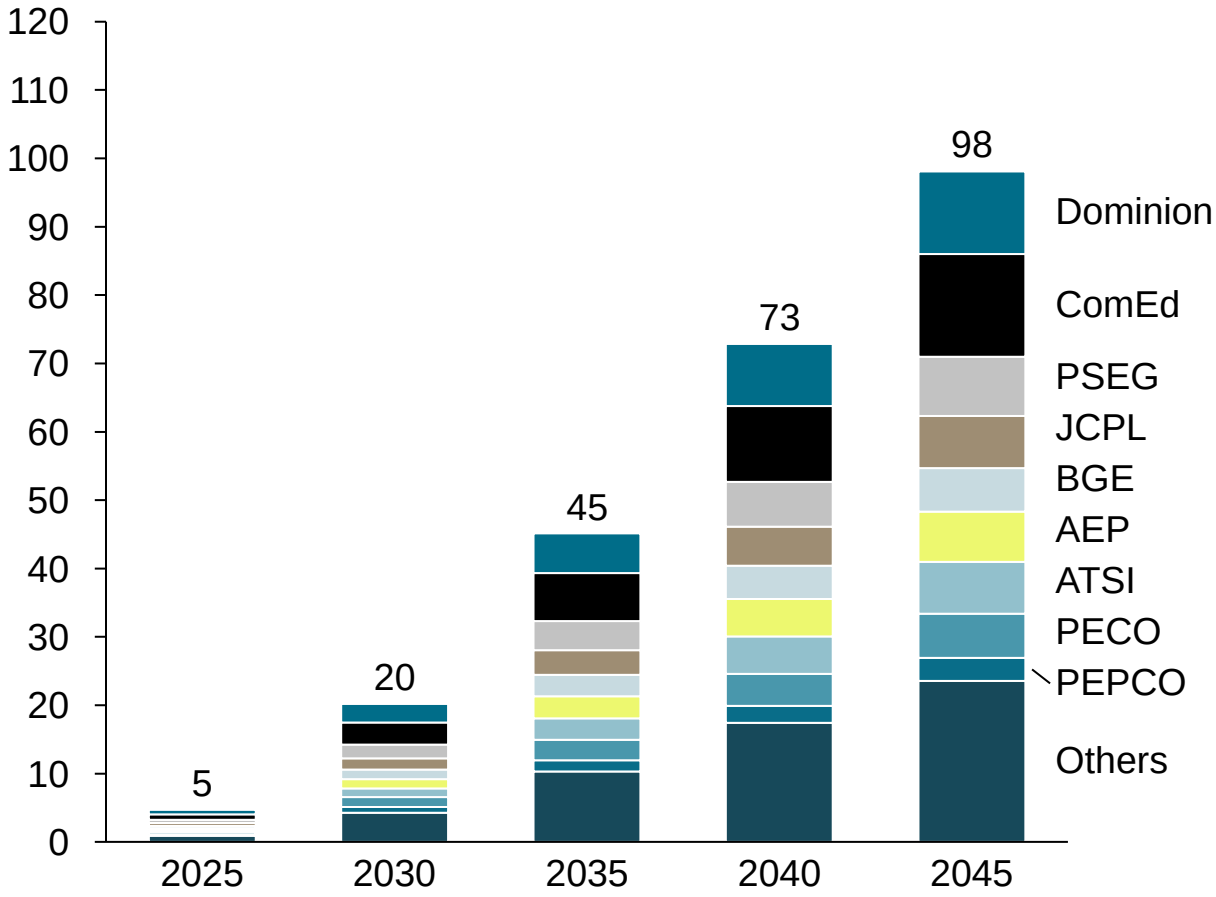
Total yearly light duty EV load - PJM

TWh



Total yearly light duty EV load by PJM zone

TWh



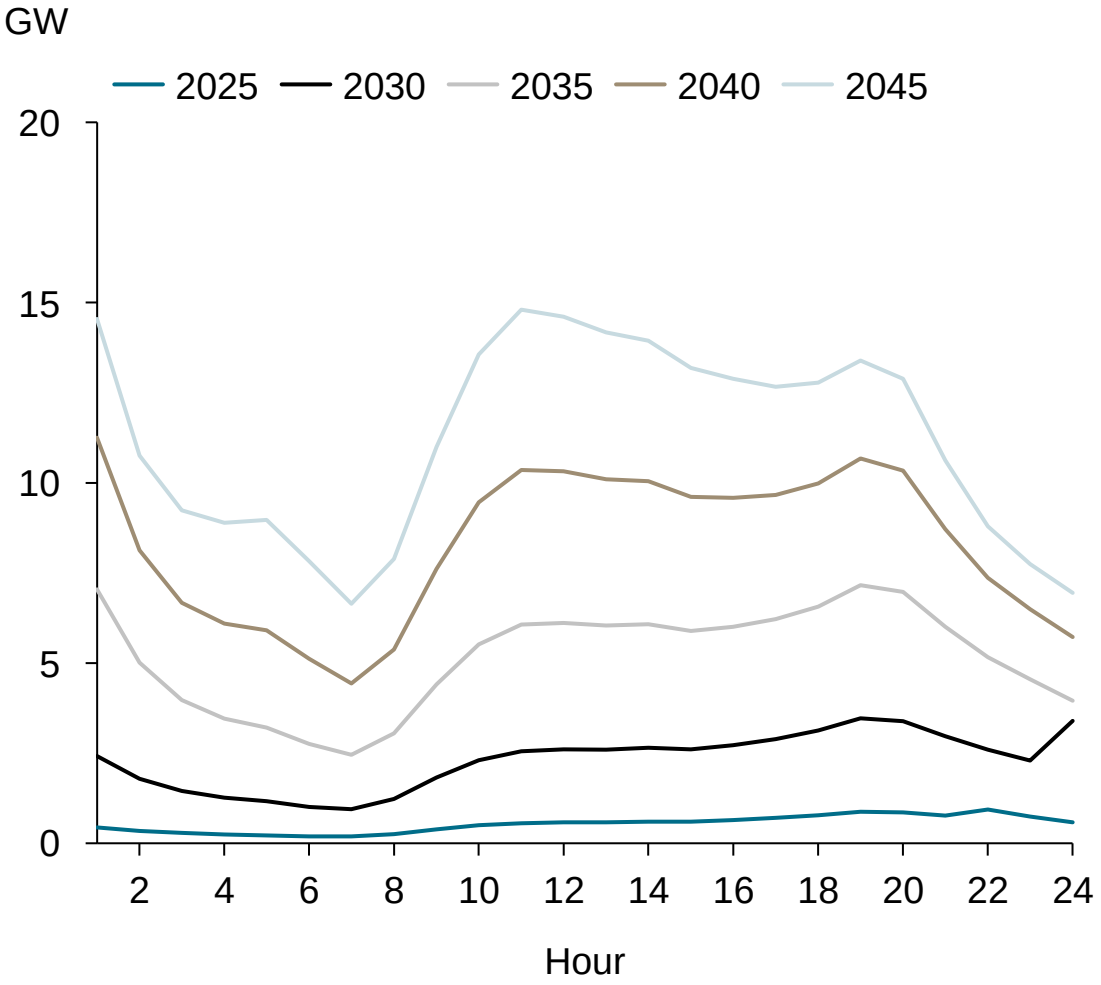
Source: S&P Global Commodity Insights

We developed 8760 load shapes for the next 20 years for each zone based on the light duty EV forecast

Light-duty EV hourly load statistics

Year	Average Load (MW)	Peak Load (MW)	Month of peak	Hour of peak
2025	537	1,348	December	22
2030	2,305	4,667	December	24
2035	5,153	9,713	December	1
2040	8,293	15,400	December	1
2045	11,198	19,884	December	1

Average light-duty EV load by hour



Source: S&P Global

Contents

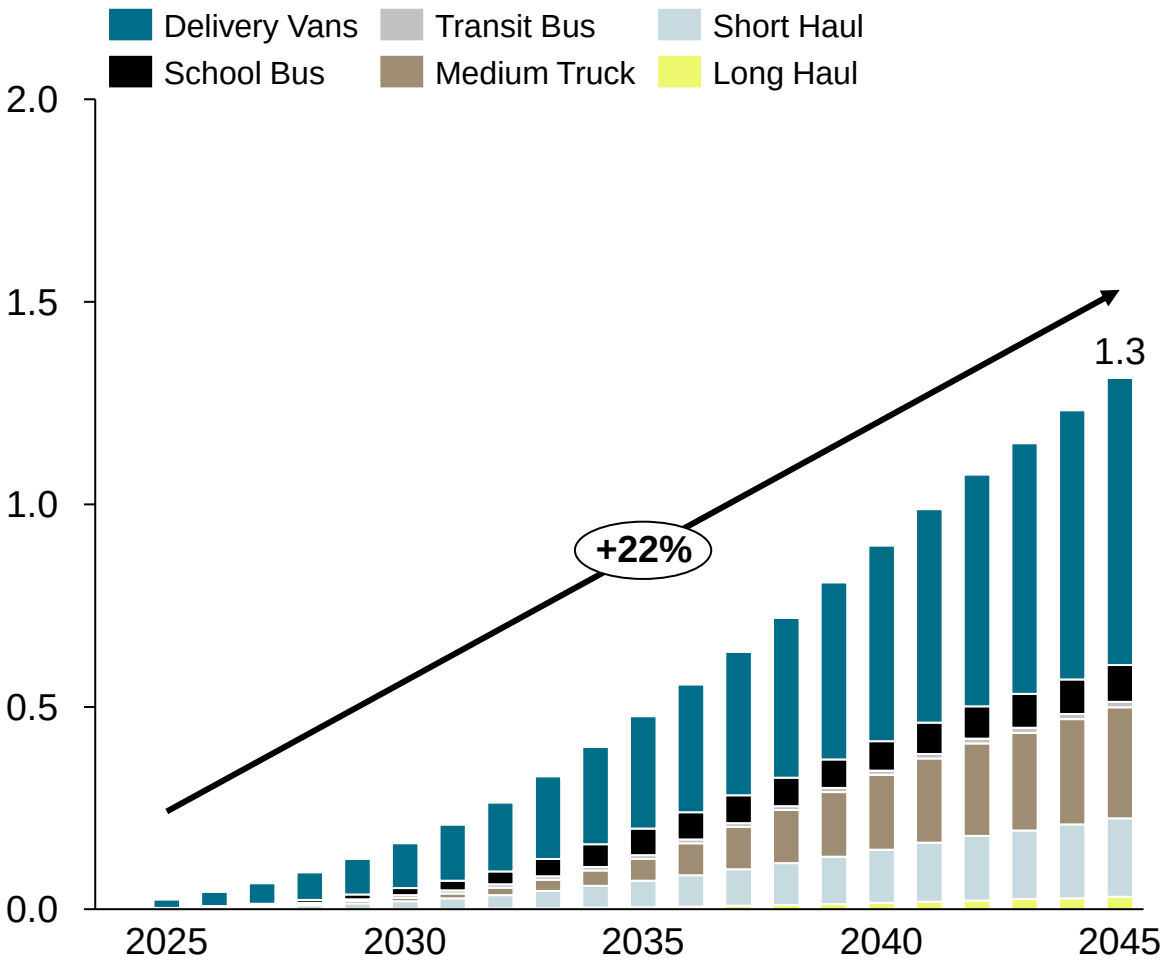
Summary of key changes in the approach to the medium and heavy-duty vehicle analysis

Assumption	Description	Impact on Load	Magnitude of change
Vehicles in Operation (VIO)	• Similar to LV we have revised MDHD down drastically as a result of legislation, we now have a BEV VIO of 11.9% in 2039 and 18.9% in 2045 for Class 8 (we previously had 15.7% in 2039). • Similarly for Class 4-7 we have BEV VIOs of 18.6% in 2039 and 27.2% in 2045 (we previously had 25.6% for 2039).		High
Efficiency and temperature losses	• Revised MDHD efficiency (miles per kWh) by class and outlook of efficiency improvements based on latest S&P Global MDHD Vehicle Sales forecast • Revised efficiency losses for cold and hot weather temperatures based on real world fleet performance data. Updated sources: CALSTART MHD EV Deployment Data		Medium
Managed charging	• Introduced additional charging shapes that reflect the penetration of managed charging.		No impact on total load

Delivery vans will dominate the overall electric medium and heavy-duty vehicle fleet, but short haul trucks become a sizeable portion of miles traveled

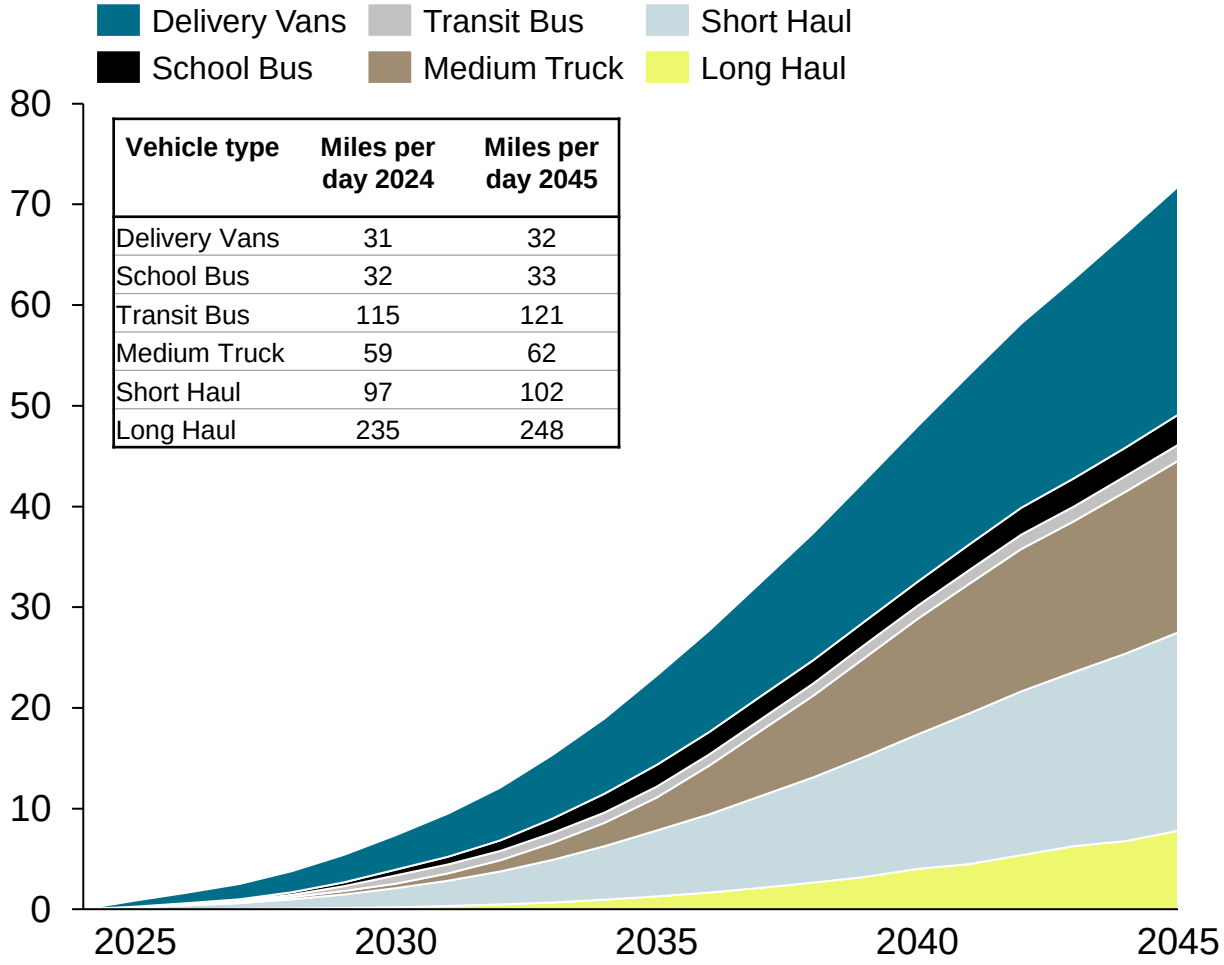
MDHD total EVs by type – PJM territory

Million of EVs



MDHD EVs vehicle miles traveled - PJM territory

Million vehicle miles traveled



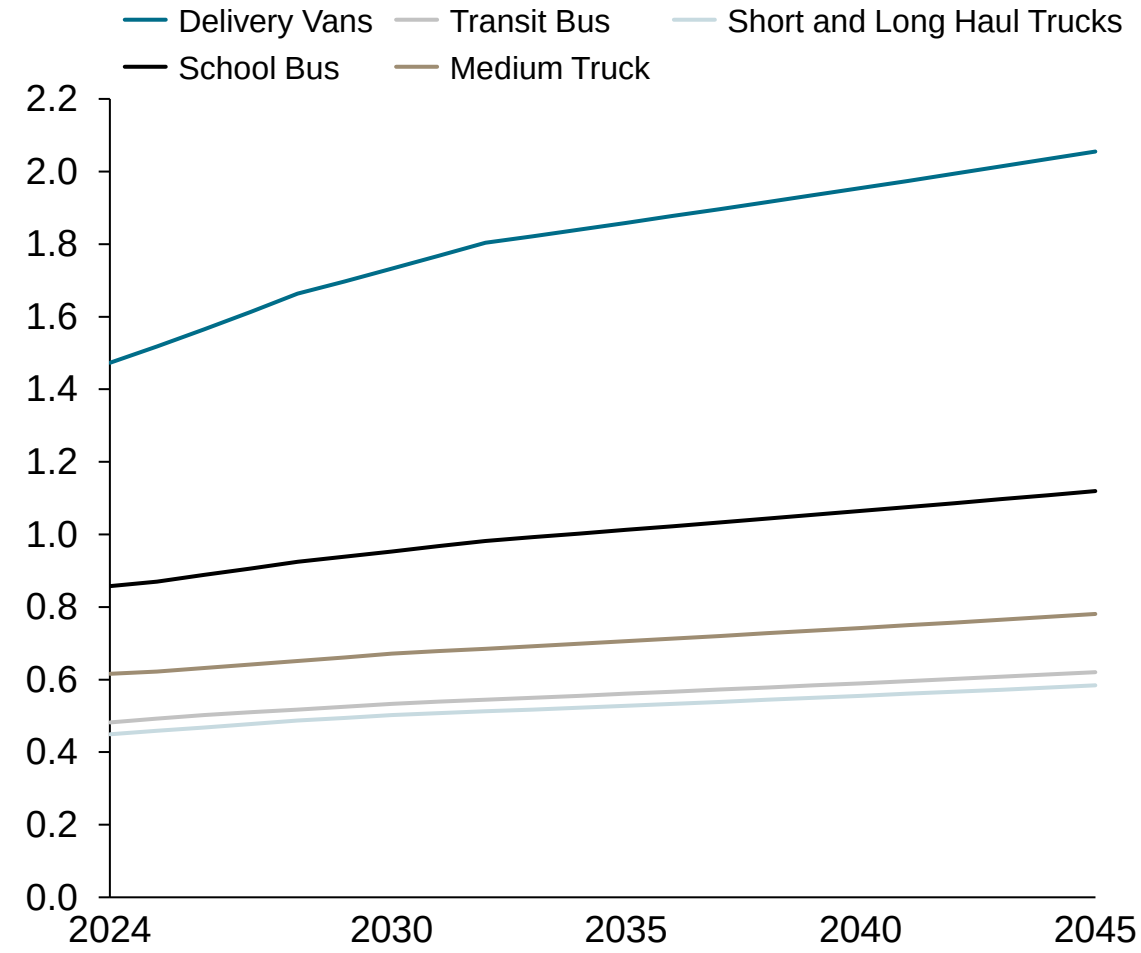
Vehicle type	Miles per day 2024	Miles per day 2045
Delivery Vans	31	32
School Bus	32	33
Transit Bus	115	121
Medium Truck	59	62
Short Haul	97	102
Long Haul	235	248

Source: S&P Global

Vehicle efficiency by type defines the load, temperature conditions reduce performance which translates to higher load needs

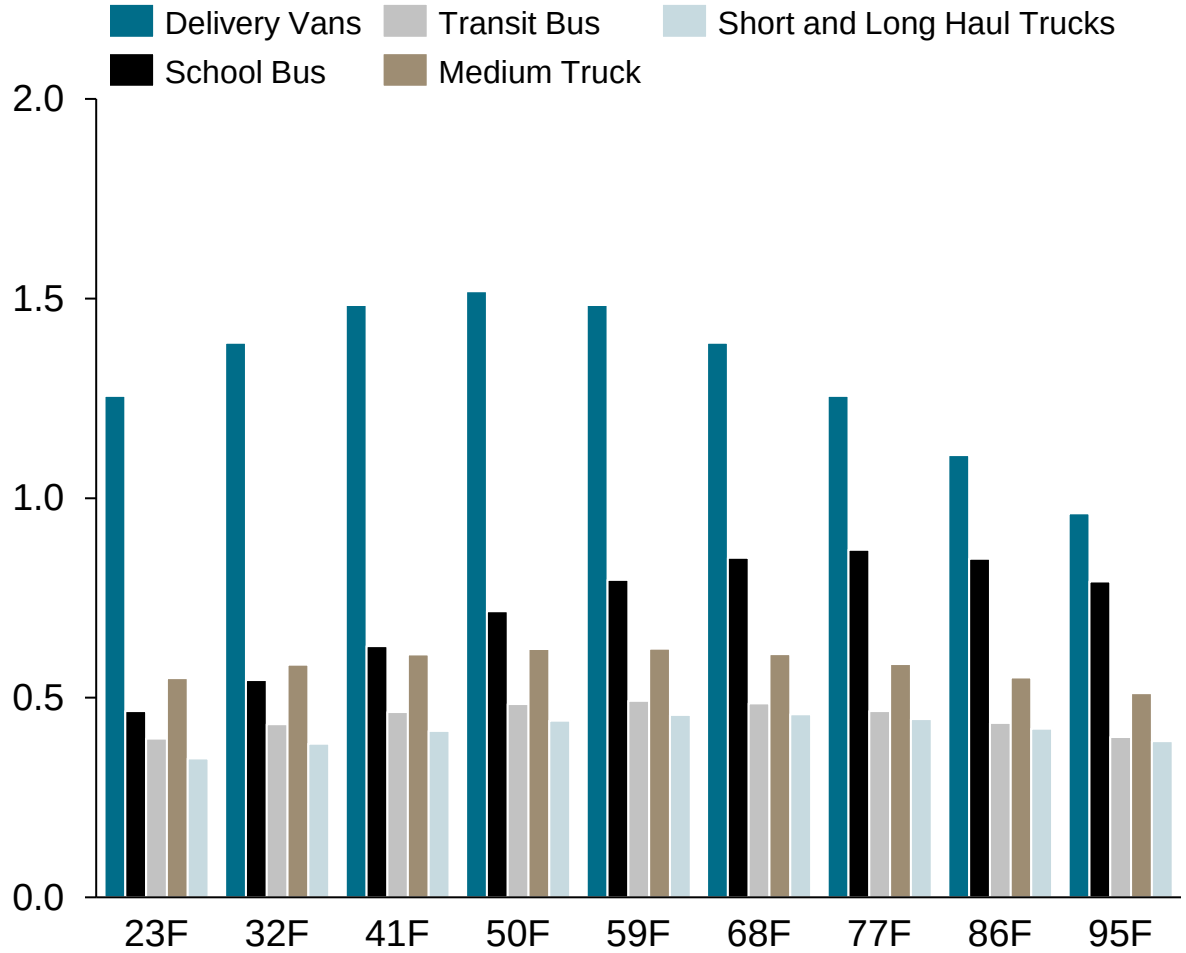
MDHD EVs vehicle efficiency (optimal temperature conditions)

Miles per kWh



MDHD EVs vehicle conditions under different conditions

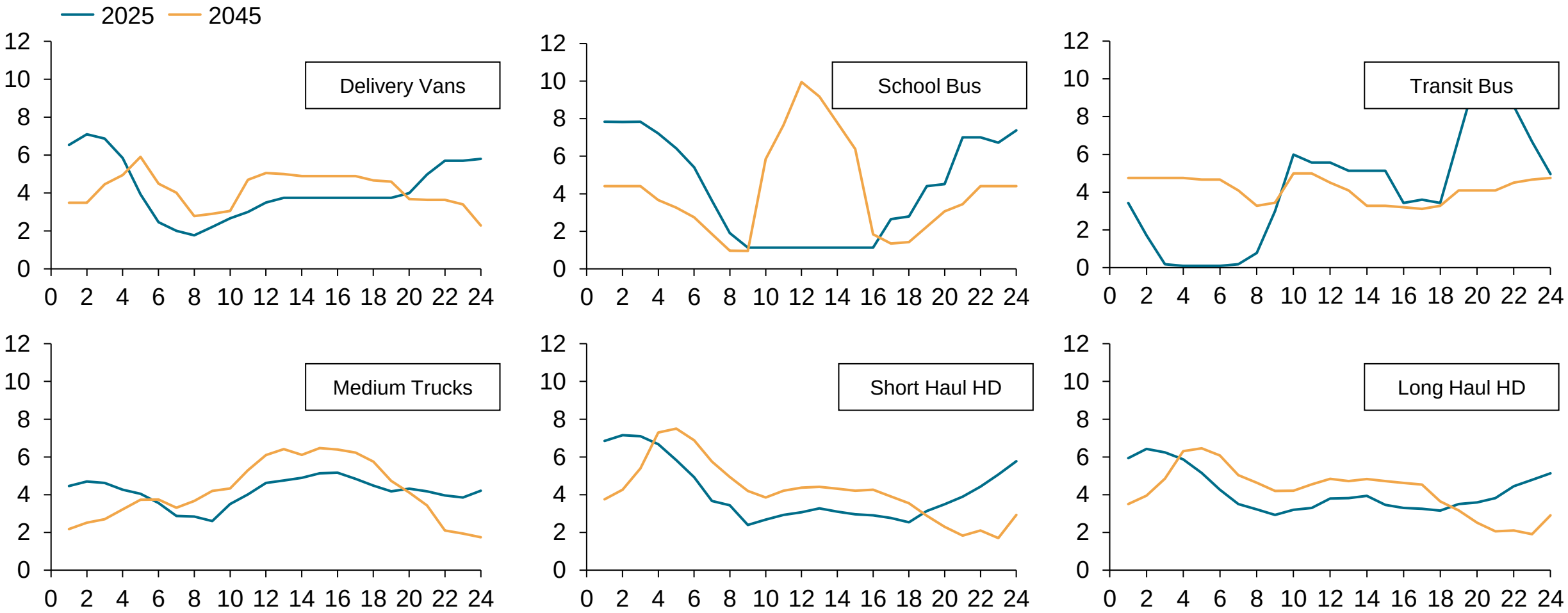
Miles per kWh



Source: S&P Global Commodity Insights, NREL, CALSTART

MDHD charging shapes are specific to the types of vehicles and their duty cycle, going forward load shape react to higher managed charging and electricity prices

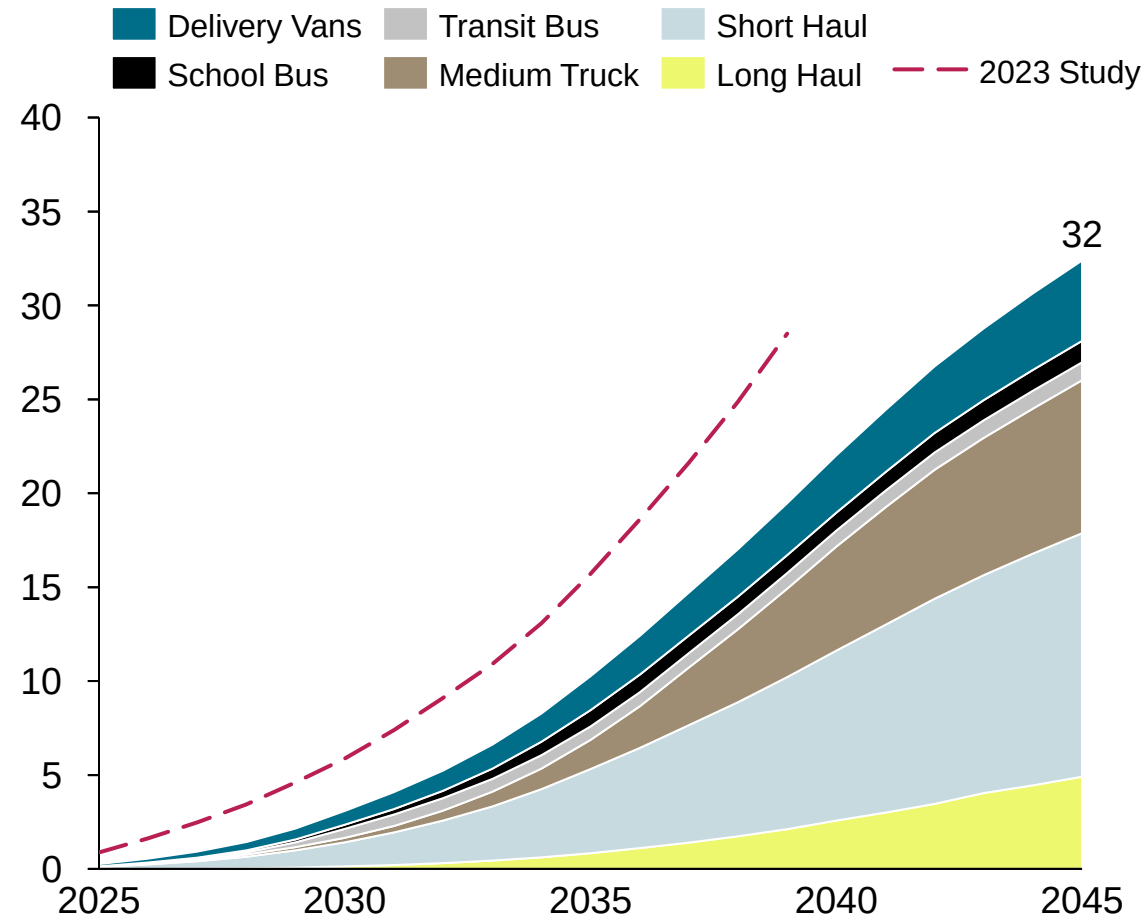
MDHD charging profile
Percentage of daily charging (%)



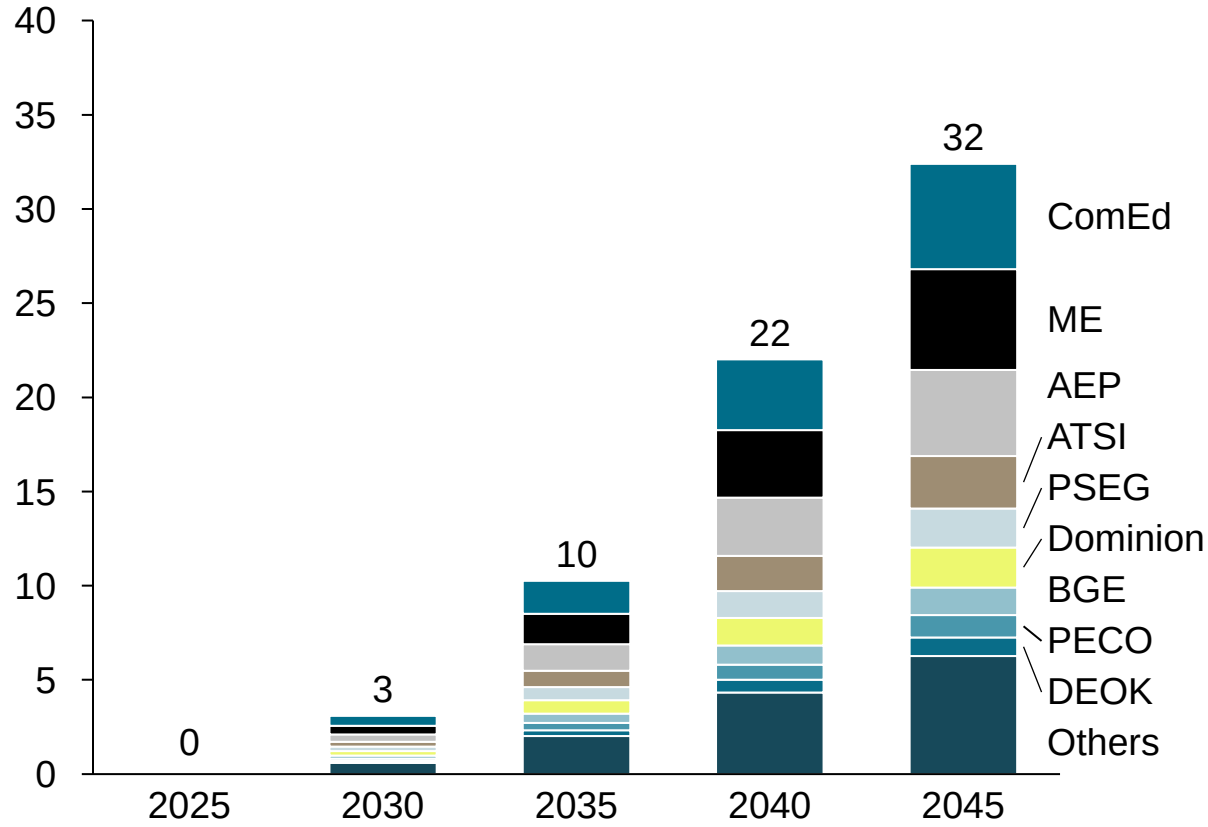
Source: S&P Global Commodity Insights

Load from MDHD is forecasted to reach 32 TWh by 2045, with short haul trucks having the highest share of load by 2045

Total yearly MDHD EV load - PJM
TWh



Total yearly MDHD EV load - PJM
TWh



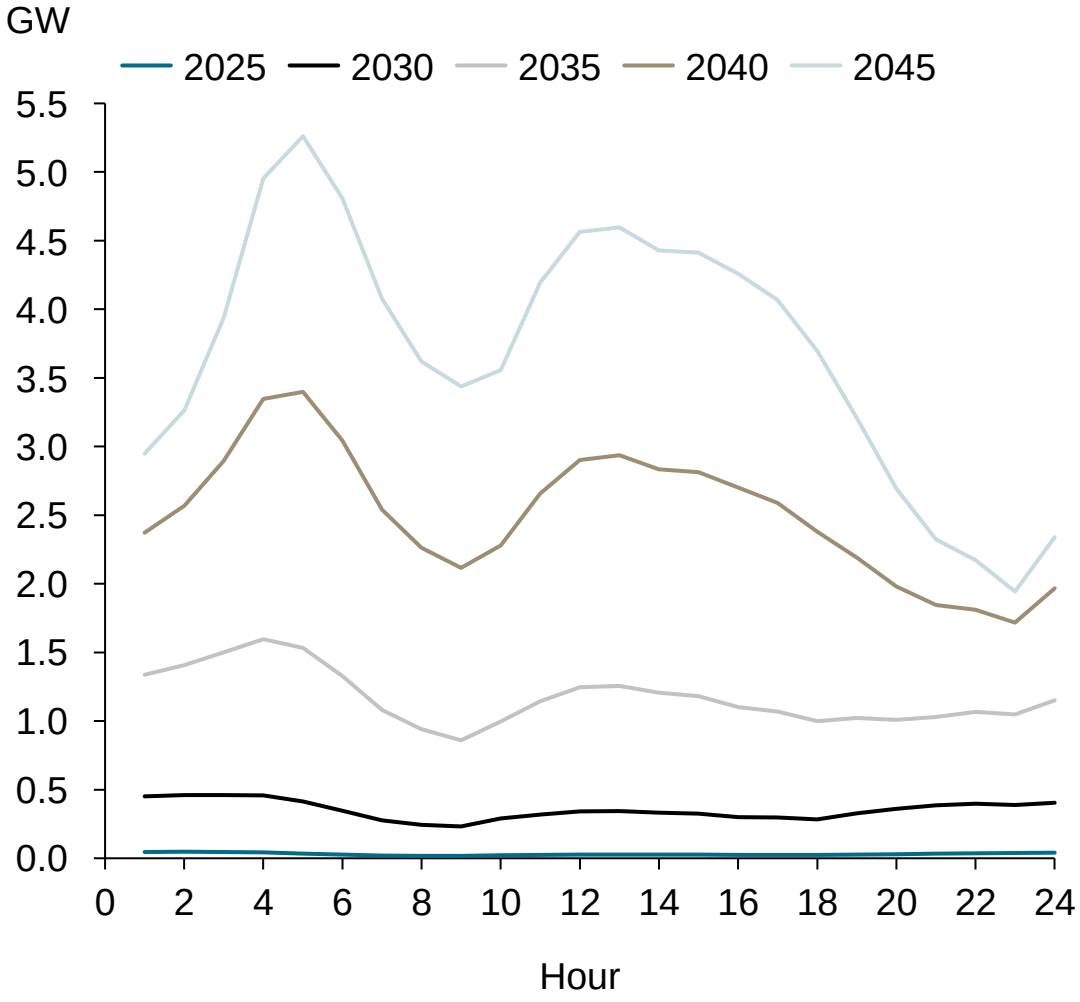
Source: S&P Global

We developed 8760 load shapes for the next 20 years for each zone based on the MHDV EV forecast

MHDV EV hourly load statistics

Year	Average Load (MW)	Peak Load (MW)	Month of peak	Hour of peak
2025	31	89	December	2
2030	352	731	November	3
2035	1,171	2,435	November	4
2040	2,506	5,018	December	5
2045	3,698	7,630	December	5

Average MHDV EV load by hour



Source: S&P Global

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