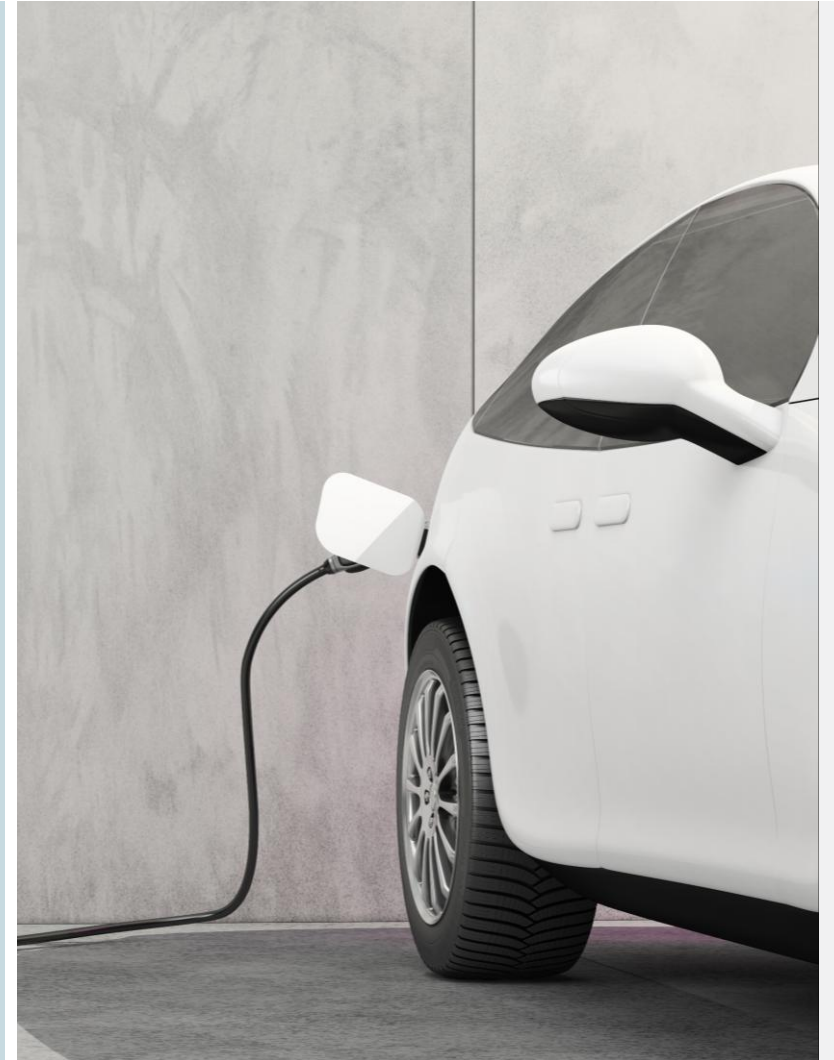
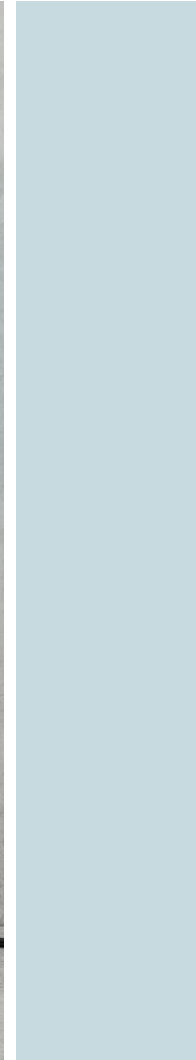


CI Consulting

Electric Vehicle Charging Power Demand Forecast

PJM Interconnection

September 19, 2025



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- Electric vehicle forecast

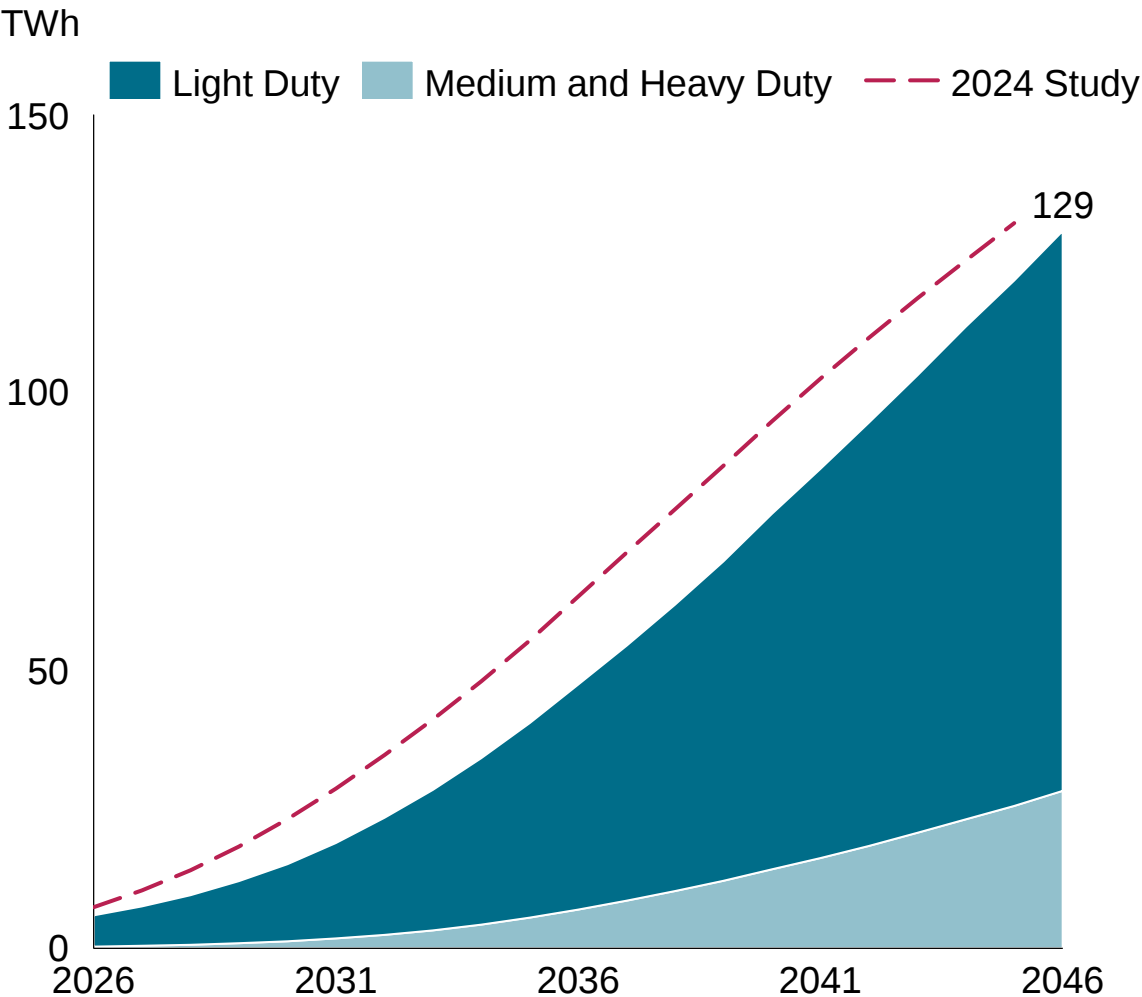
- Charging demand forecast

Appendix

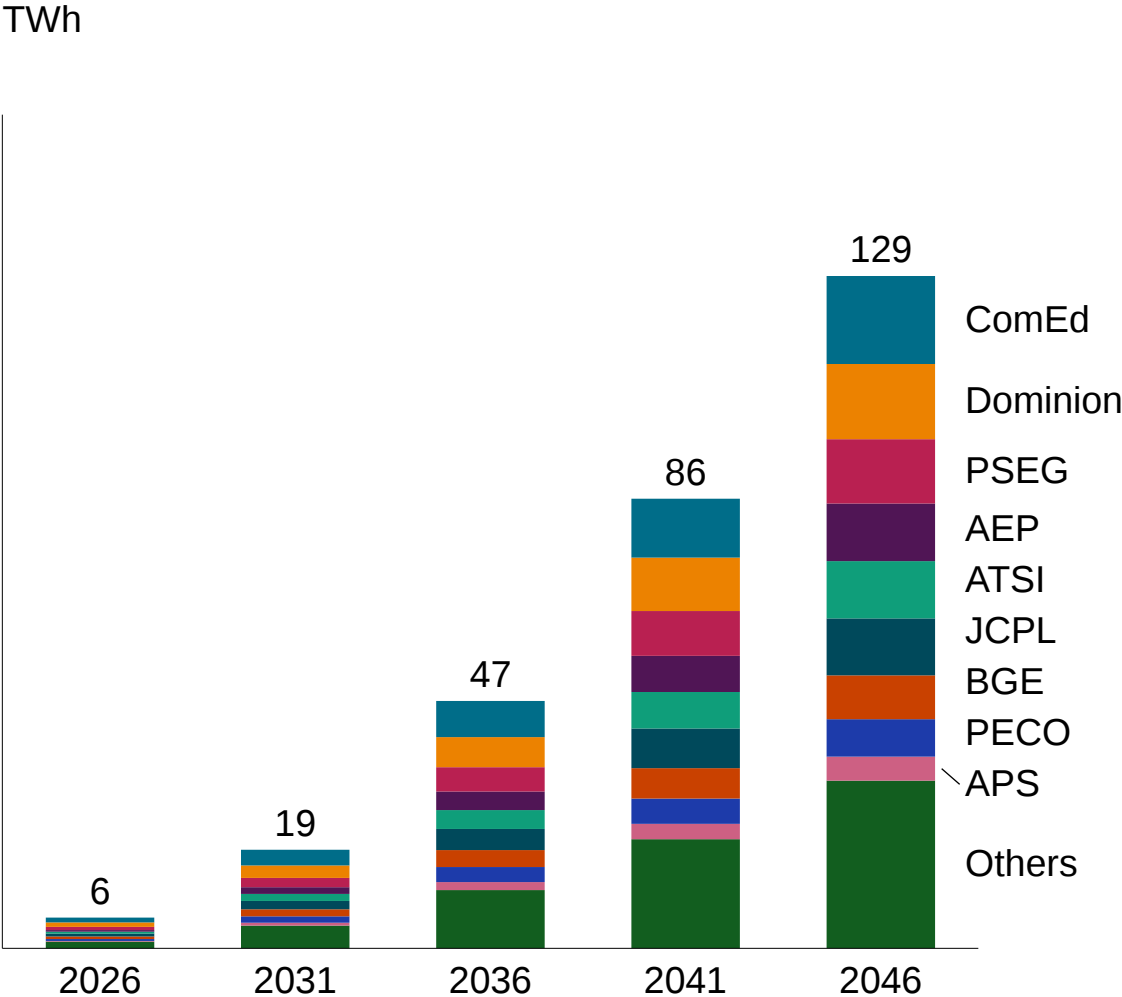


Total EV load in PJM will increase dramatically; however, the outlook has been revised down compared to 2024 due to slower BEV growth

Total annual EV load – PJM



Total annual EV load by PJM zone



Note: Refer to Appendix for light-, medium- and heavy-duty electric vehicle definition by vehicle class.

Source: S&P Global

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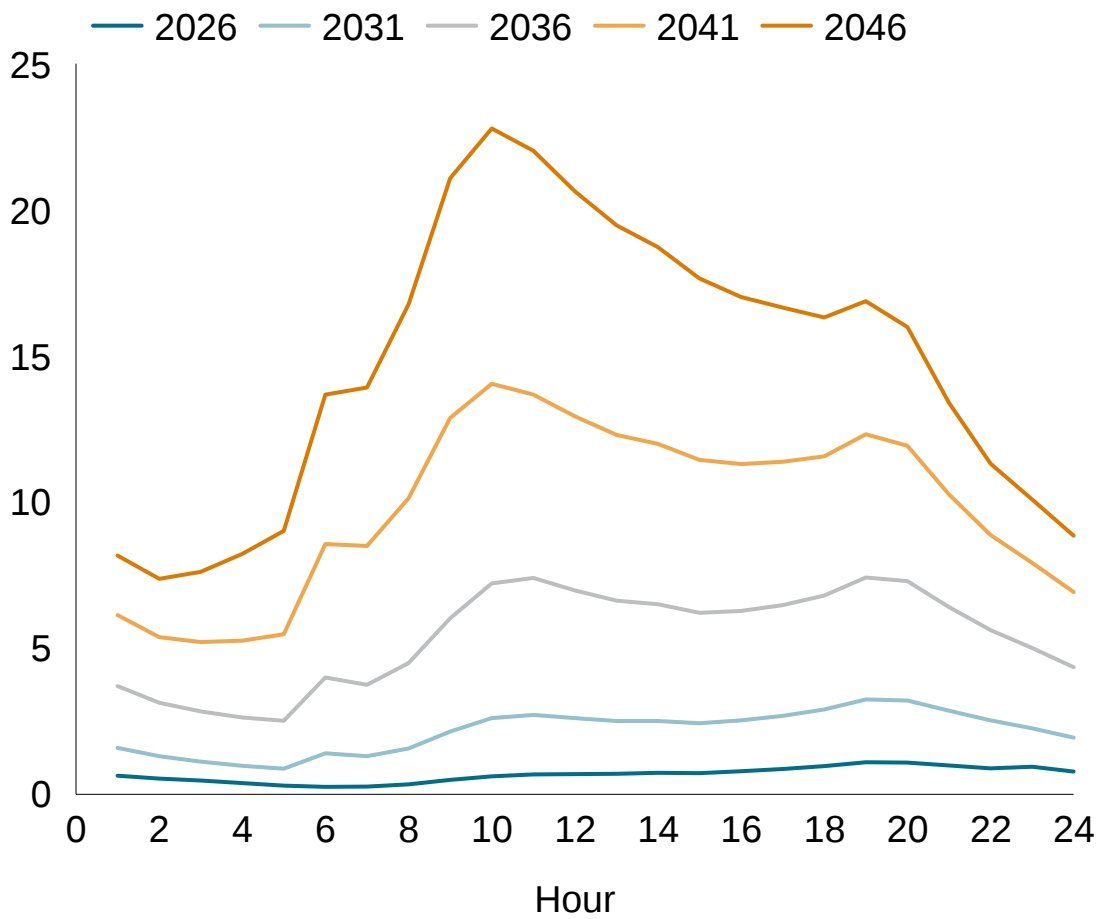


With higher penetration of managed charging and higher access to public charging, load shifts from early evening to morning and midday charging

Total EV hourly load statistics – PJM

Year	Average Load (MW)	Peak Load (MW)	Month of peak	Hour of peak
2026	676	1,462	December	20
2031	2,160	4,302	December	19
2036	5,402	9,653	December	10
2041	9,849	18,120	December	10
2046	14,733	29,095	December	10

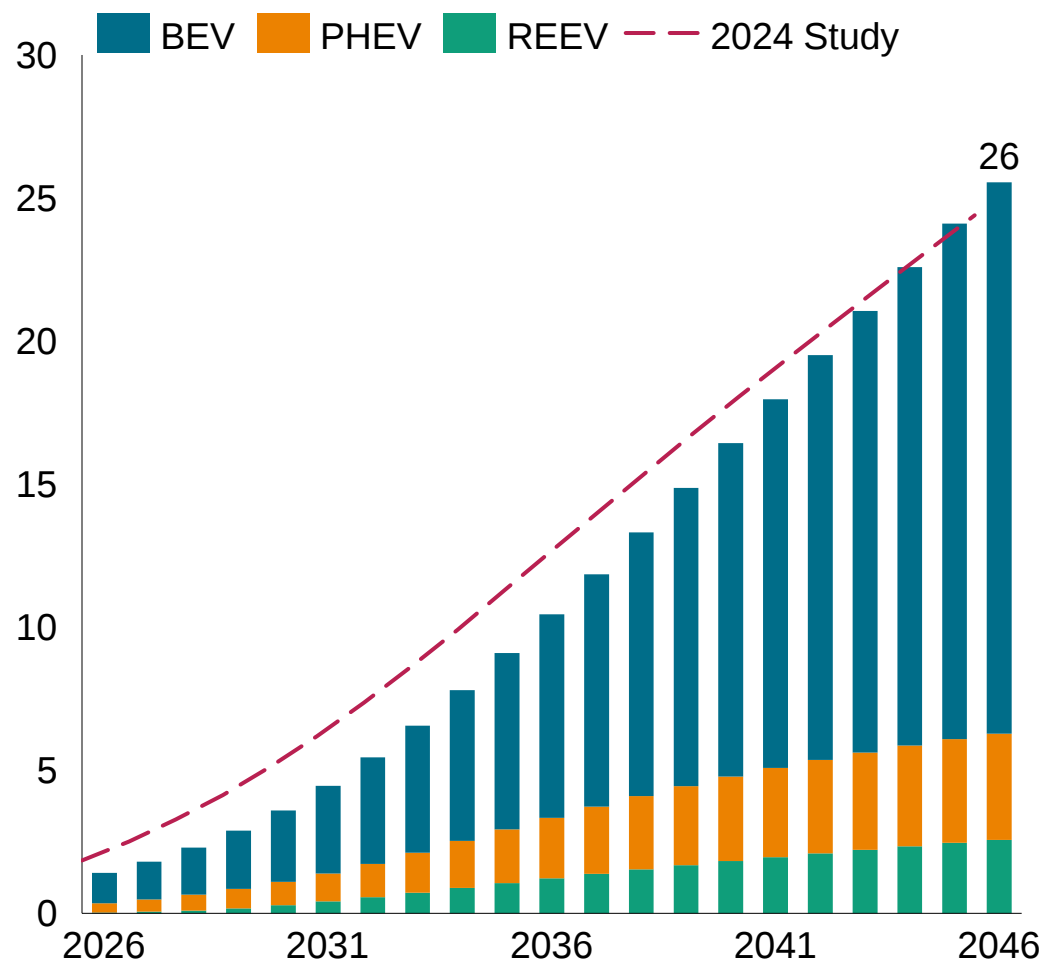
Average total EV load by hour – PJM
GW



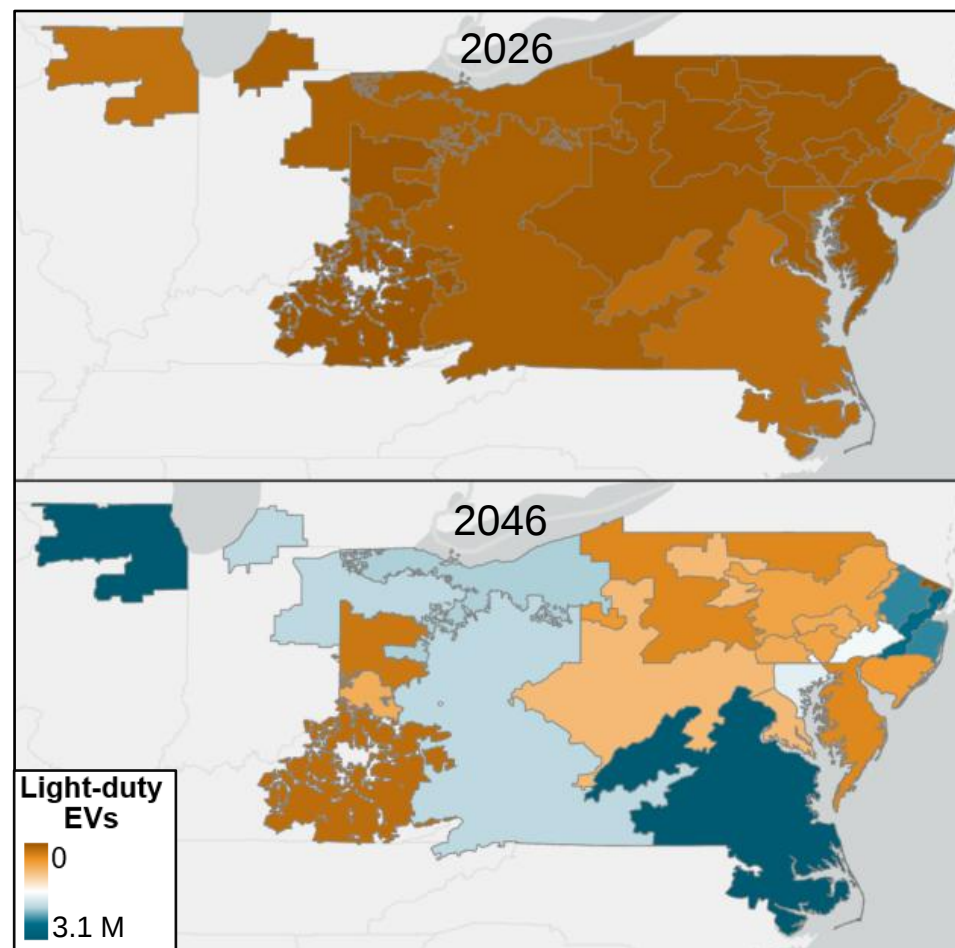


PJM zones with large urban areas see a higher share of light-duty EVs in operation

Total light-duty EVs in operation – PJM territory
Million of EVs



Total light-duty EVs in operation by PJM zone

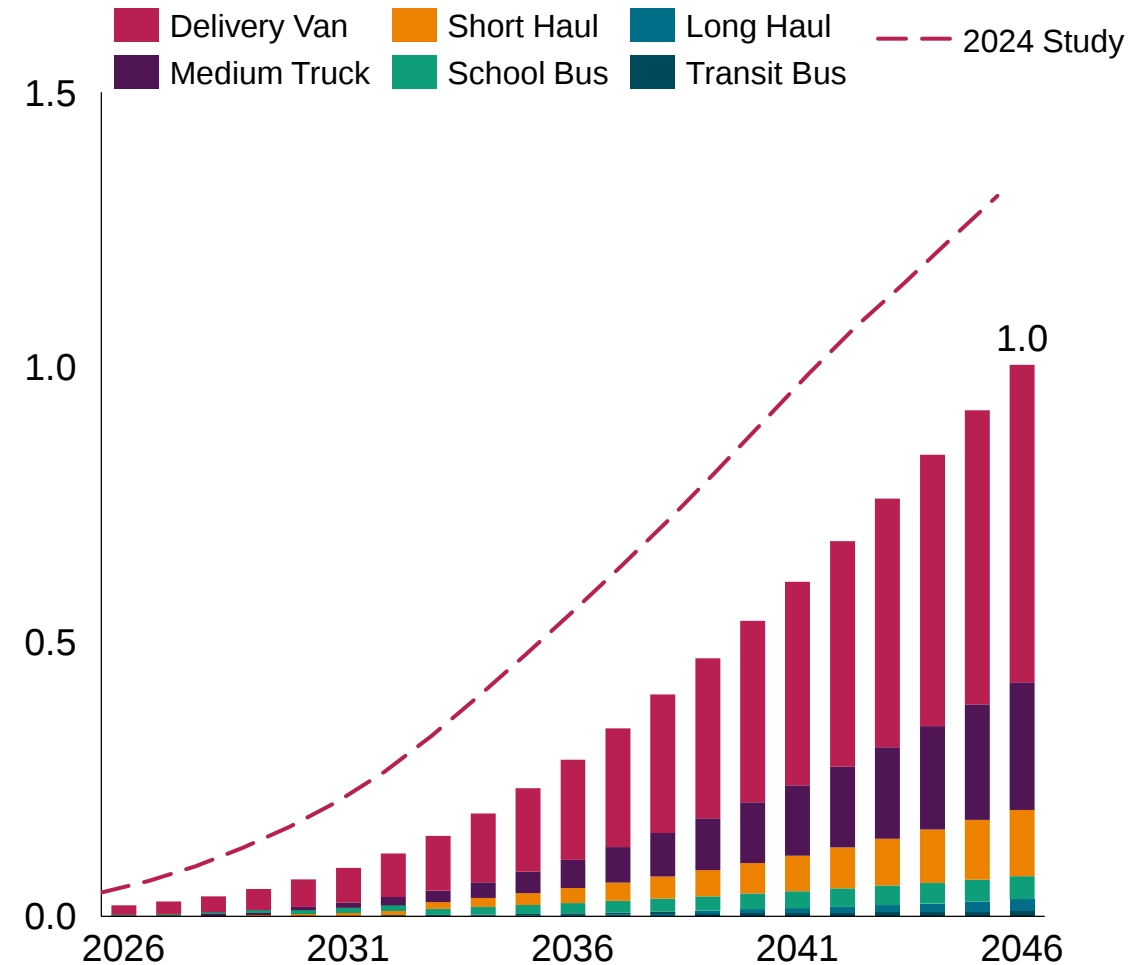




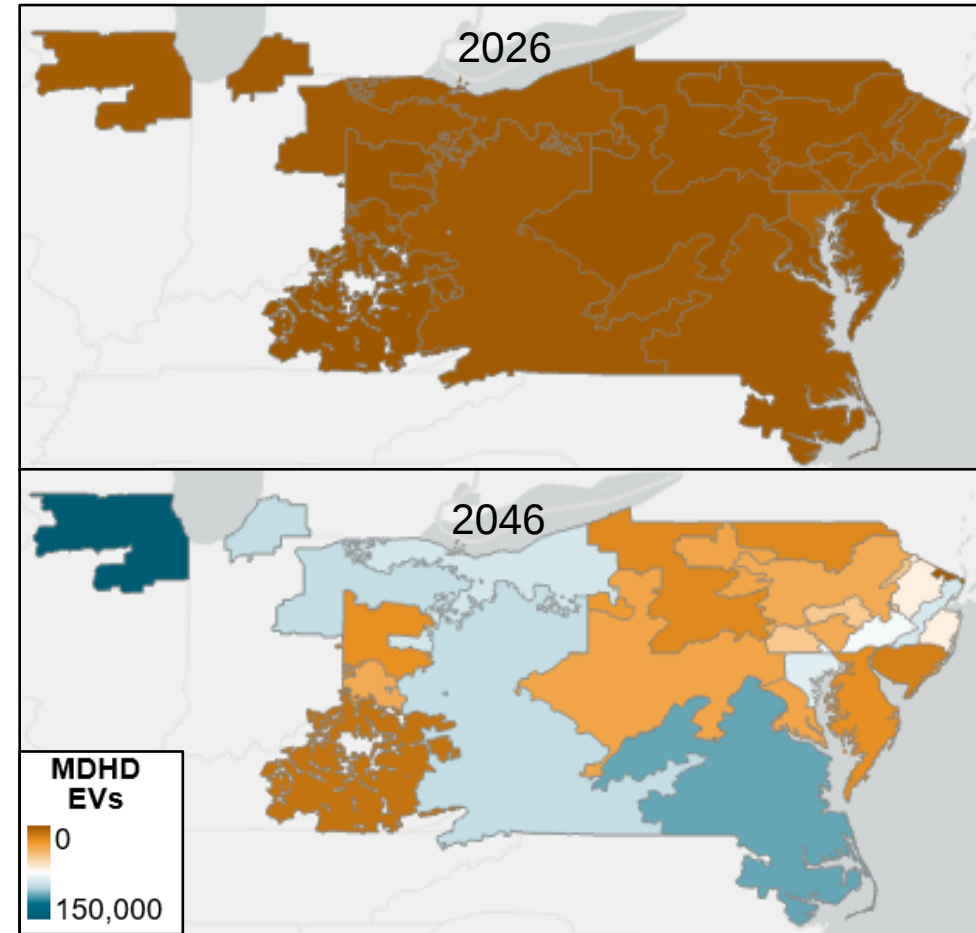
MHD EV growth spans PJM reaching 1 million vehicles in operation by 2046

Total MHD EVs in operation – PJM

Million of EVs



Total MHD EVs in operation by PJM zone



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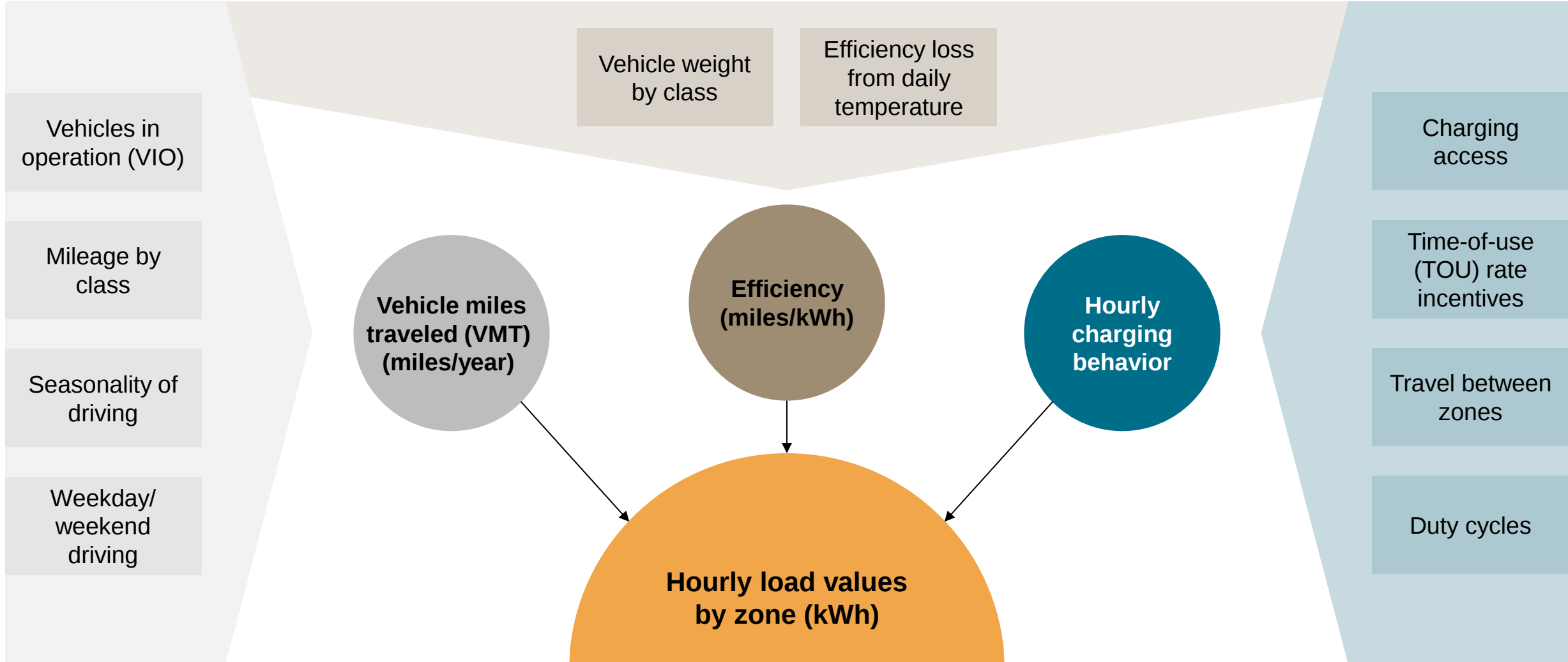
- Charging demand forecast

Appendix





Hourly load shapes are driven by three key variables: vehicle miles traveled, vehicle efficiency, and charging behavior





VIO, mileage, and efficiency for each vehicle type throughout the study time horizon are calculated based on a mix of field data and assumptions

Variable	Description	Methodology	Sources
Vehicles in Operation (VIO)	The total amount of vehicles that are on the road throughout the year	VIO forecast is created by forecasting yearly BEV sales, applying a scrappage rate by age class, and adding the forecast years together to calculate VIO	S&P Global Mobility
Vehicle Miles Traveled (VMT)	The number of miles driven each year by vehicle type	VMT is calculated by the number of vehicles on the road and their mileage. Average annual mileage per vehicle and vehicle usage patterns are also factored. SPGCI data was also supplemented by California Air Resource Board data.	S&P Global Mobility, California Air Resource Board
Efficiency	The numbers of miles driven per each kWh of charging	Field/manufacturer data is used where available (e.g., Tesla Model 3) to estimate the overall fleet efficiency of the vehicle category. Incremental efficiency improvements are considered through the end of the outlook.	Manufacturer published data, S&P Global Mobility



S&P Global's regularly updated base-case scenario, built on integration of regional and sectoral energy analysis, formed the foundation for this project

Scenario description



- S&P Global Commodity Insights base-case scenario represents the integration of **regional and sector analysis** from across Commodity Insights, illustrating the pace of change in long-term global energy supply, demand and trade, based on current views and assumptions about markets, policy, consumer behavior and technology.
- This scenario illustrates the **challenges and opportunities** in the global energy transition. It underscores the complexities of achieving ambitious climate and energy goals in an unpredictable geopolitical landscape. The scenario highlights the **critical role of national and multilateral policies**, corporate strategies, and public sentiment in shaping the future of energy markets, and despite the hurdles in delivery of targets and goals, paints a picture of gradual but sustained progress.
- For the United States, the scenario incorporates the most recent policies and programs shaping the energy and economic landscape, including the **impact of the One Big Beautiful Bill Act** on tax policy, inflation, supply chains, and energy markets.
- **Key themes of this scenario include:**
 - A period of geopolitical instability and economic uncertainty through the earlier years
 - Energy security, geopolitics and climate are inextricably linked
 - Through the medium term there is a multidimensional world focused on national interests. In later years, there is a rejuvenation of multilateral cooperation
 - While ambitious climate and energy transition goals set in the 2010s and early 2020s become increasingly difficult to achieve, there is incremental but sustained progress in global decarbonization and energy transition, even if climate targets are missed

Key indicators (global)



		History			Inflections			
		2023	2024	2025	2030	2035	2040	2045
Real GDP	(Billion 2023 \$)	\$104,899	\$107,593	\$110,403	\$126,288	\$143,553	\$161,887	\$181,769
	Average annual growth	2.8%	2.8%	2.8%	2.7%	2.7%	2.6%	2.5%
		(1990–2023)	(1990–2024)	(1990–2025)	(2025–2030)	(2025–2035)	(2025–2040)	(2025–2045)
Primary energy consumption	(mmtoe)	15,183	15,407	15,649	16,162	16,495	16,674	16,861
	Average annual growth	1.7%	1.7%	1.7%	0.6%	0.5%	0.4%	0.4%
		(1990–2023)	(1990–2024)	(1990–2025)	(2025–2030)	(2025–2035)	(2025–2040)	(2025–2045)
US light-duty EV penetration ¹	Sales	9.4%	10.1%	9.7%	28%	49%	60%	72%
	Fleet	1.1%	1.7%	2.3%	8%	19%	31%	45%
Primary energy intensity of GDP	(toe per million 2023 \$)	145	143	142	128	115	103	93

1. Includes battery-electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), range extender electric vehicles (REX or REEV), and fuel-cell electric vehicles (FCEVs)

toe: metric ton of oil equivalent; mmtoe: million metric tons of oil equivalent; our assumptions and estimates were further updated based on the anticipated regulatory changes (OBBBA, CAFÉ, EPA, CARB and TARIFF)

Source: S&P Global Inflections (2024)



Demand forecasts are created in 3 layers: top-down (national) and bottom-up (metro) to arrive at state/zone level

An established **multi-factor demand forecast model** integrates sales trends, household growth estimates, customer brand and dealer loyalty, leasing return-to-market, and hundreds of demographic purchase predictor variables, to create an EV adoption prediction at the granular **census tract level** geography. Bottom-up demand analysis at census tracts is then **reconciled** with our industry-leading national and State level forecasts to observe macro-economic boundaries.





There is a number of state and regional level key drivers we consider in the EV forecast

National Forecast Drivers

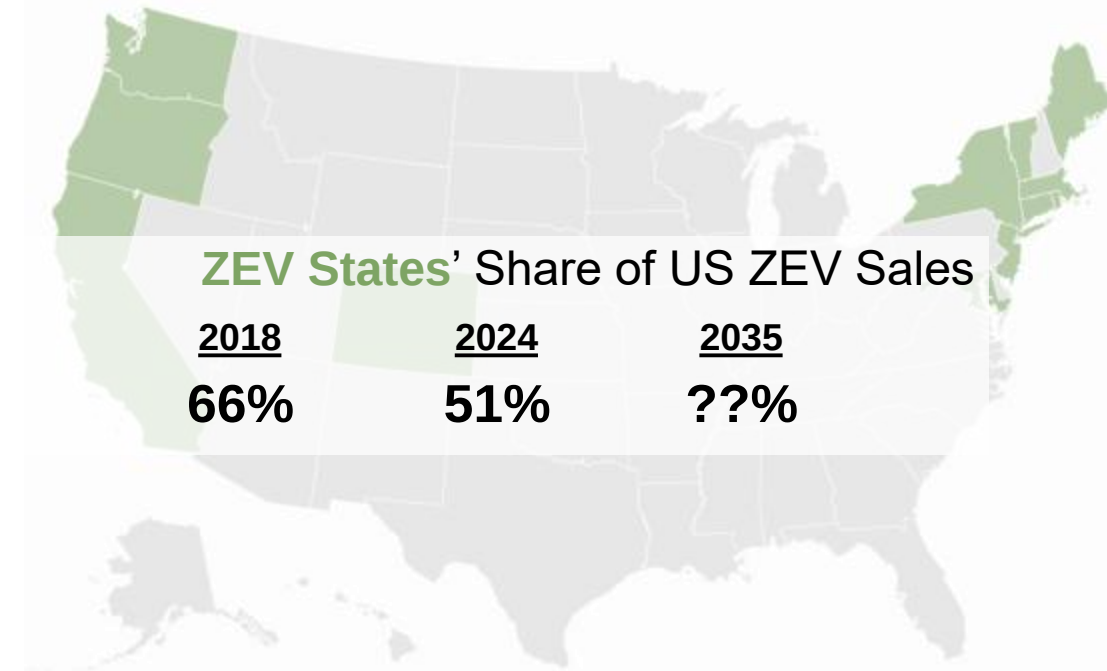


State and Region level:

- Segment preferences
- Brand performance
- Fuel-type share
- State legislation
 - ZEV requirements
 - ICE bans



Due to EV affordability issues, EV adoption is expected to remain concentrated in ZEV states until 2035





There are a number of micro-level key drivers we consider in developing the light-duty EV forecast

State/Regional Forecast Drivers

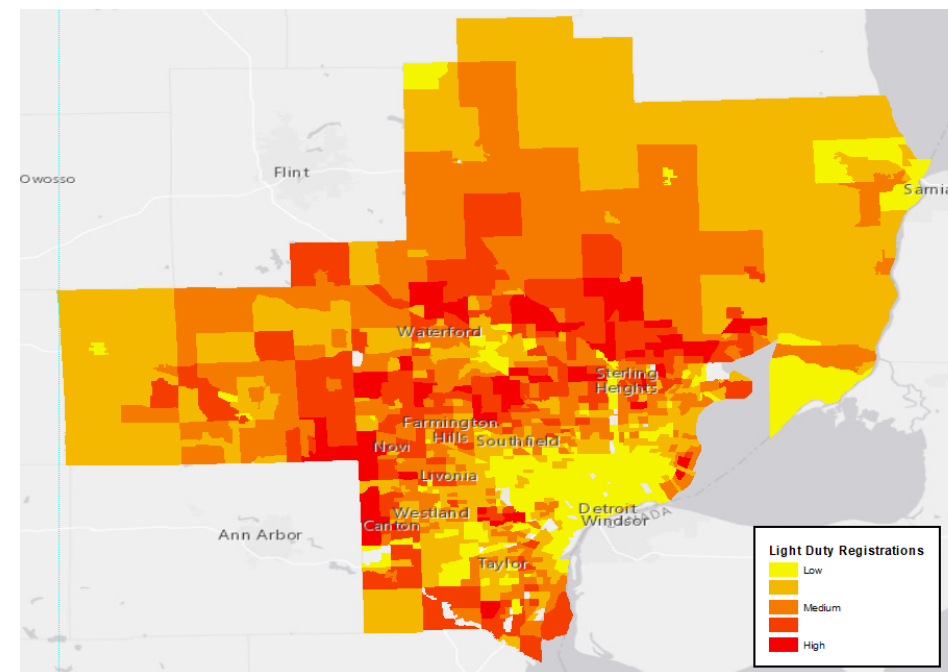


Census Tract level:

- Historical Registrations and Share
- Demographic Growth
 - Household Volume
 - Household Income
- EV Purchase Predictors



Registration density for light-duty vehicles





There are a number of micro-level key drivers we consider in developing the medium- and heavy-duty EV forecast

State/Regional Forecast Drivers

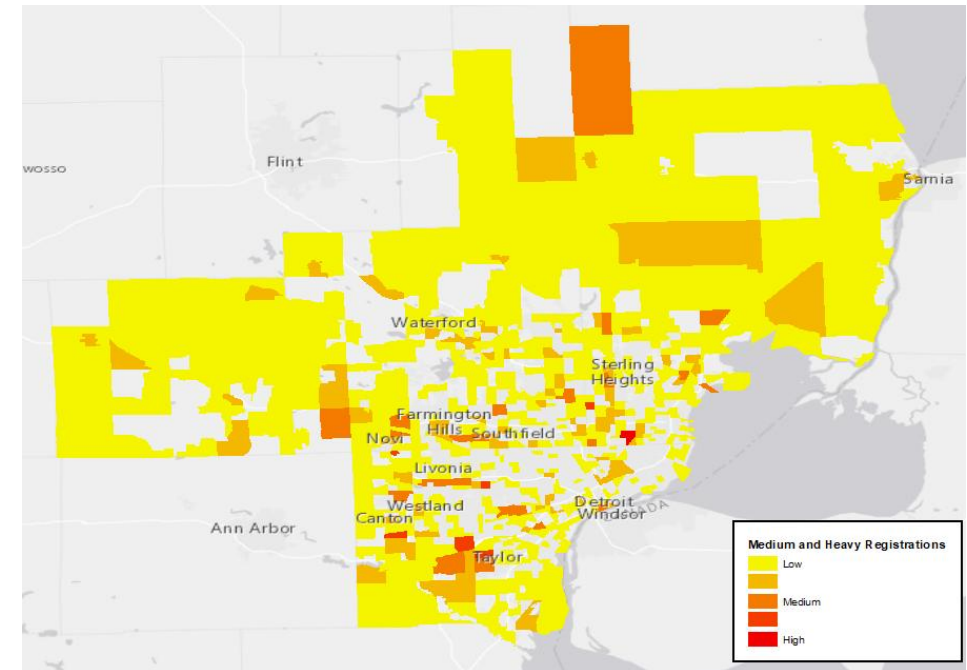


Census Tract level:

- Historical Registrations: segment and fuel type
- MHDV VIO
- Where the vehicle is used vs where the vehicle is sold
- EV-Fleet transition incentives

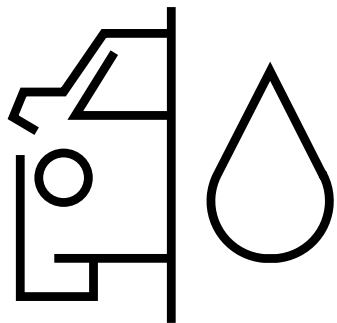


Registration density for medium- and heavy-duty vehicles



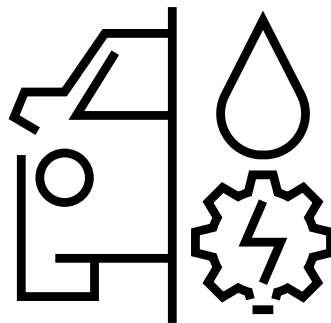


We use purchase predictor drivers such as income and age to forecast household adoption of EVs, Hybrid and ICE vehicles



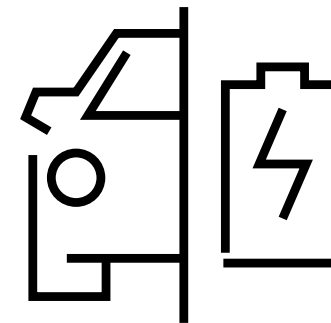
Internal Combustion HHs

- HH Income \$150K+: 43%
- Under 55: 46%
- Multicultural: 24%



Hybrid HHs

- HH Income \$150K+: 50%
- Under 55: 49%
- Multicultural: 27%



EV HHs

- HH Income \$150K+: 65%
- Under 55: 64%
- Multicultural: 37%



In contrast to gas vehicle buyers, EV households have much higher incomes and younger age, which limits EV growth potential

EV Purchase Patterns

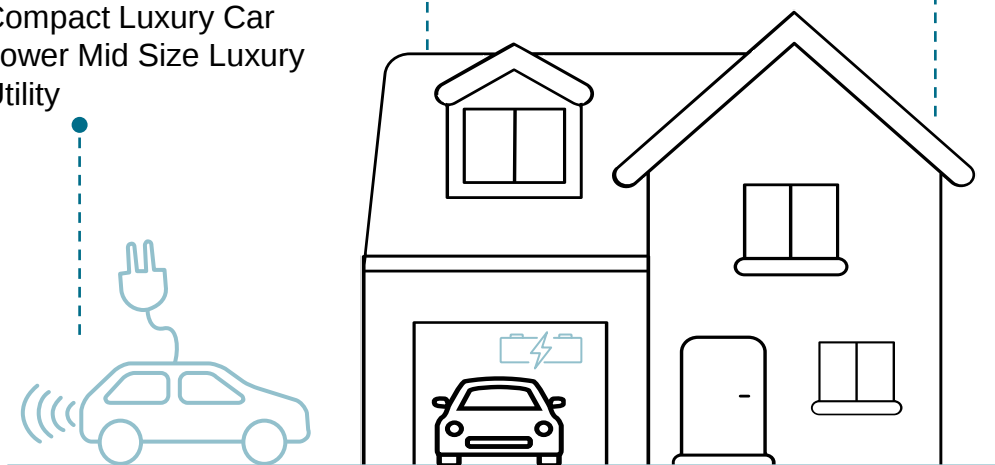
- New vehicle every 2 years: 23%
- Own 2+ new: 46%

Top Electric Vehicle Segments ~71% of new purchases

- Compact Luxury Utility
- Compact Utility
- Compact Luxury Car
- Lower Mid Size Luxury Utility

EV Household Profile

- 56%: HHI \$100K+
- 70%: Thriving financial profile
- 55%: Age 30-59
- 70%: Prime life stage



Gas Purchase Patterns

- New vehicle every 2 years: 16%
- Own 2+ new: 32%

Gas Household Profile

- 26%: HHI \$100K+
- 63%: Thriving financial profile
- 44%: Age 30-59
- 59%: Prime life stage

Top Gasoline Segments ~55% of new purchases

- Compact Utility
- Upper Mid Size Utility
- Subcompact Plus Utility
- Full Size Half Ton Pickup



Note: Range extenders enter the market in 2026 and could present a new household dynamic.

Source: S&P Global: Net-To-New CYTD July 2025

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We used the following key assumptions to develop a forecast for electric vehicle and charging demand

Type of EV vehicles		Assumptions and inputs
Electric vehicles	Light-duty	EV national “natural demand” and performance based on expected revised CAFE standards, with some sub-national EV targets
		EPA regulations revision
	Medium and heavy-duty	EV national “natural demand” and performance by class and expected revised sub-national EV targets
		Description of vehicle types by commercial function within classes 2–8
Charging demand	Light-duty	Miles per kWh (normal operating conditions)
		Miles driven (weekday/weekend)
		Loss in battery efficiency due to temperature
		Charging infrastructure
		Charging behavior
	Medium and heavy-duty	Miles per kWh by class (normal operating conditions)
		Miles driven (weekday/weekend) by class
		Loss in battery efficiency due to temperature by class

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Industry rebalances its BEV ambitions as profitability and consumer demand remain constrained

Regulations	Incentives	OEM	Customer readiness
▪ NHTSA: June 2025 CAFE statement eases viability for more ZEV¹. We are likely to see the MPG goals released in coming months, thus, for this forecast natural demand is now expected through at least CY2030. ▪ EPA will likely no longer be allowed to pursue a 50% reduction in GHG gases. ▪ CARB: has lost rights to set their own emission/ZEV ambitions. Unlikely California backs down from an ICE Ban, however legal challenges to federal government likely to delay ICE ban from 2035 to 2038. Here we expect other states to follow: New Jersey, Oregon Massachusetts, and Washington.	▪ IRA passed both houses of Congress in 2023. ▪ One Big Beautiful Bill Act (reconciliation bill) eliminates the federal ZEV purchase incentives (30D and 45W) for both light duty and medium & heavy-duty vehicles. These are phased out by September 30, 2025 and natural demand is expected to drive the market. The IRA Advanced Manufacturing Credit (45X) on battery/cell assembly remains and will help to ease some of the cost pressures.	▪ Assumptions on BEV profitability have been re-evaluated due to cost, strong price competition, and supplier volume shortfall claims. ▪ Ford and GM have reduced and/or postponed EV investments. ▪ Openness to REX (Range extenders) likely to come with product development by the likes of VW, Hyundai, Ford and Stellantis. ▪ Toyota, Honda double on their HEV aspirations with Toyota offering only an HEV version for some of its best-selling models.	▪ BEV growth slows down under consumer affordability concerns. ▪ Consumer is stating concerns on range, charging and pricing for ZEVs. ▪ NACS plug standardization will improve charging access over time ▪ Reduced disposable income driven by inflation and high interest rates creates an economic challenge for consumers. ▪ HEV gains further leadership as affordability remains key. ▪ Medium and heavy-duty fleet owners increasingly shifting from a public to private charging infrastructure, increasing associated CAPEX requirements.

Forecast consequence: More powertrain flexibility and delay of BEV trajectory by roughly 5 years

1. The CAFE update by NHTSA signals a clear intention to ease demands for Zero Emission Vehicles, new MPG goals likely to follow.

Source: S&P Global Mobility Sales-based Powertrain Forecast (August 2025)



Light-duty and medium- and heavy-duty vehicle assumptions: Policy and regulations

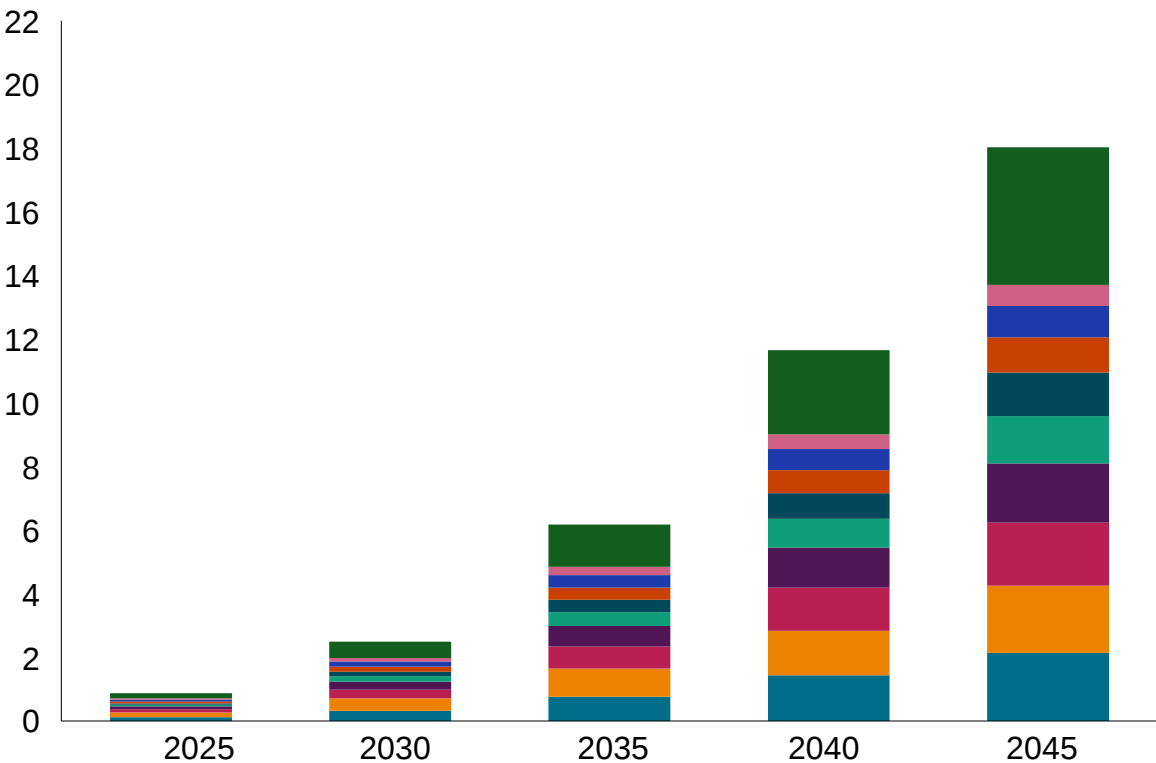
Type of vehicle applicability	Assumptions and inputs	Value	Sources
Light-duty	EV national ambitions abandoned, and CAFE is revised starting MY2028	Goal: Revised CAFE standards (MPG) starting MY2028 ~1% minimum BEV sales requirement S&P Global Forecast for ~20% sales to be BEV in 2030	S&P Global Mobility
Light-duty	EPA regulations	Pressure removed through ~2030 but possible return to pursuit of carbon neutral by 2050	S&P Global Mobility
Medium and heavy-duty	Sub-national “aspirational” likely to lead short term	Primarily driven by California’s ACT with a 75% ZEV target for MDT sales in 2035 and 40% ZEV target for HDT sales. Waiver removal likely means a three-year delay. California is highly likely to continue pursuing ZEV ambitions. MA, NJ, OR and WA likely to follow.	S&P Global Mobility
Medium and heavy-duty	Vehicle types by function	Delivery van: 45% by 2035, 83% by 2045 School bus: 52% by 2035, 81% by 2045 Transit bus: 27% by 2035, 59% by 2045 Medium truck: 20% by 2035, 59% by 2045 Short haul truck: 20% by 2035, 59% by 2045 Long haul truck: 6% by 2035, 29% by 2045	S&P Global Mobility



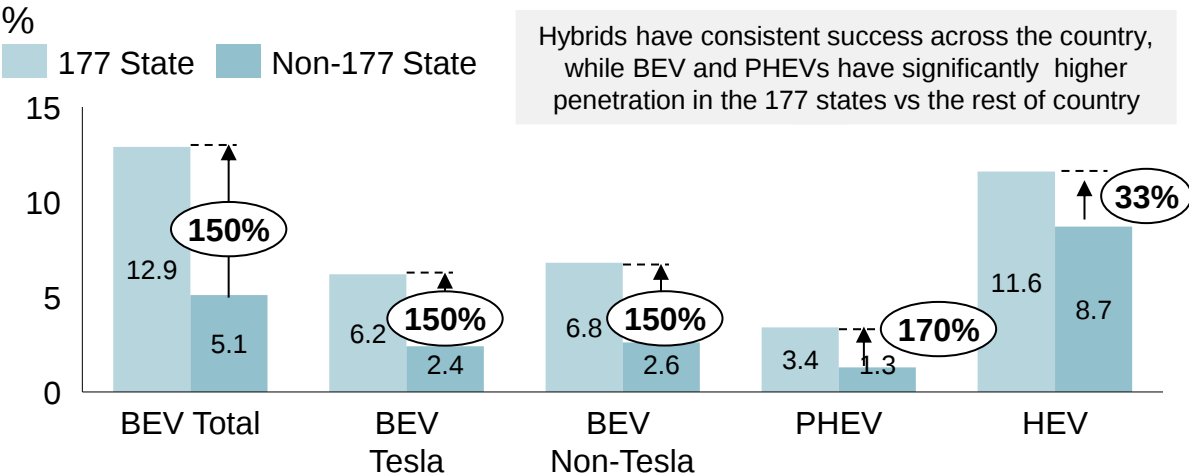
California/ACCII waiver eliminated, challenged in court. S&P now expects a three-year delay for ACCII; push back from 2026-2035 to 2029-2038. NJ stays, all other states drop.

Total annual light-duty EVs by PJM zone

Million vehicles



EV penetration for section 177 states and non-177 states¹



State	Incentive type – status	2025 ZEV program	Remains on ZEV
NJ	Rebate – Yes	ACC II	Yes
MD	Tax credit – Yes	ACC II	ACC I
VA	Rebate – Not funded	ACC I	ACC I
DE	Rebate – Yes	ACC II (till 2032)	ACC I
PA	Rebate – Yes	–	–
IL	Rebate – Yes	–	–

1. 177 States are those that have adopted California’s Low-Emissions Vehicle (LEV) criteria pollutant and greenhouse gas emissions regulation and Zero-Emission Vehicle (ZEV) regulations under Section 177 of the Clean Air Act.

Source: S&P Global

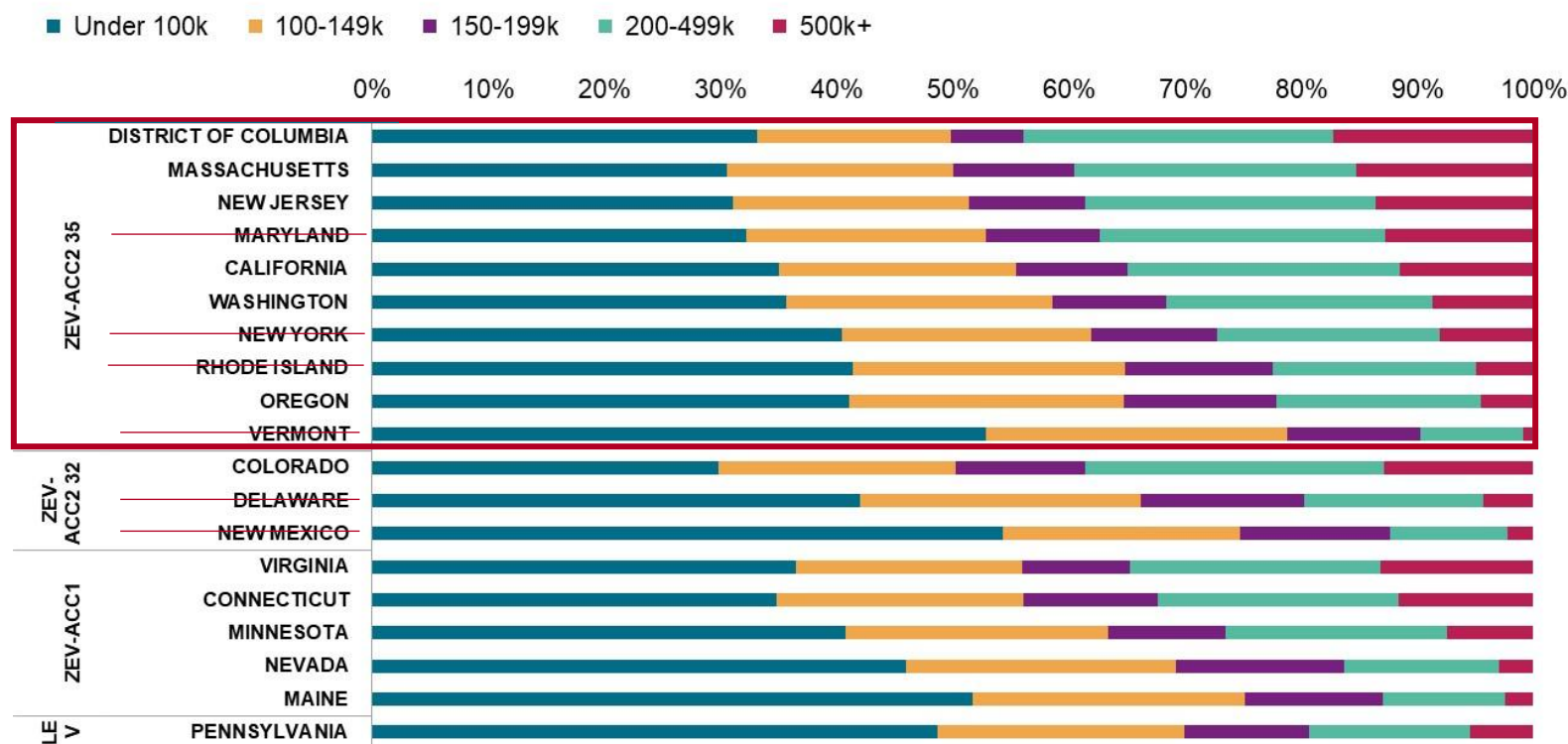
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Federal government has removed the California waiver for ACCII; this will be challenged in court and is likely to delay the ICE ban from 2035 to 2038

Light-duty EV sales by income

US New Car Owner VIO by Household Income and State (\$177)



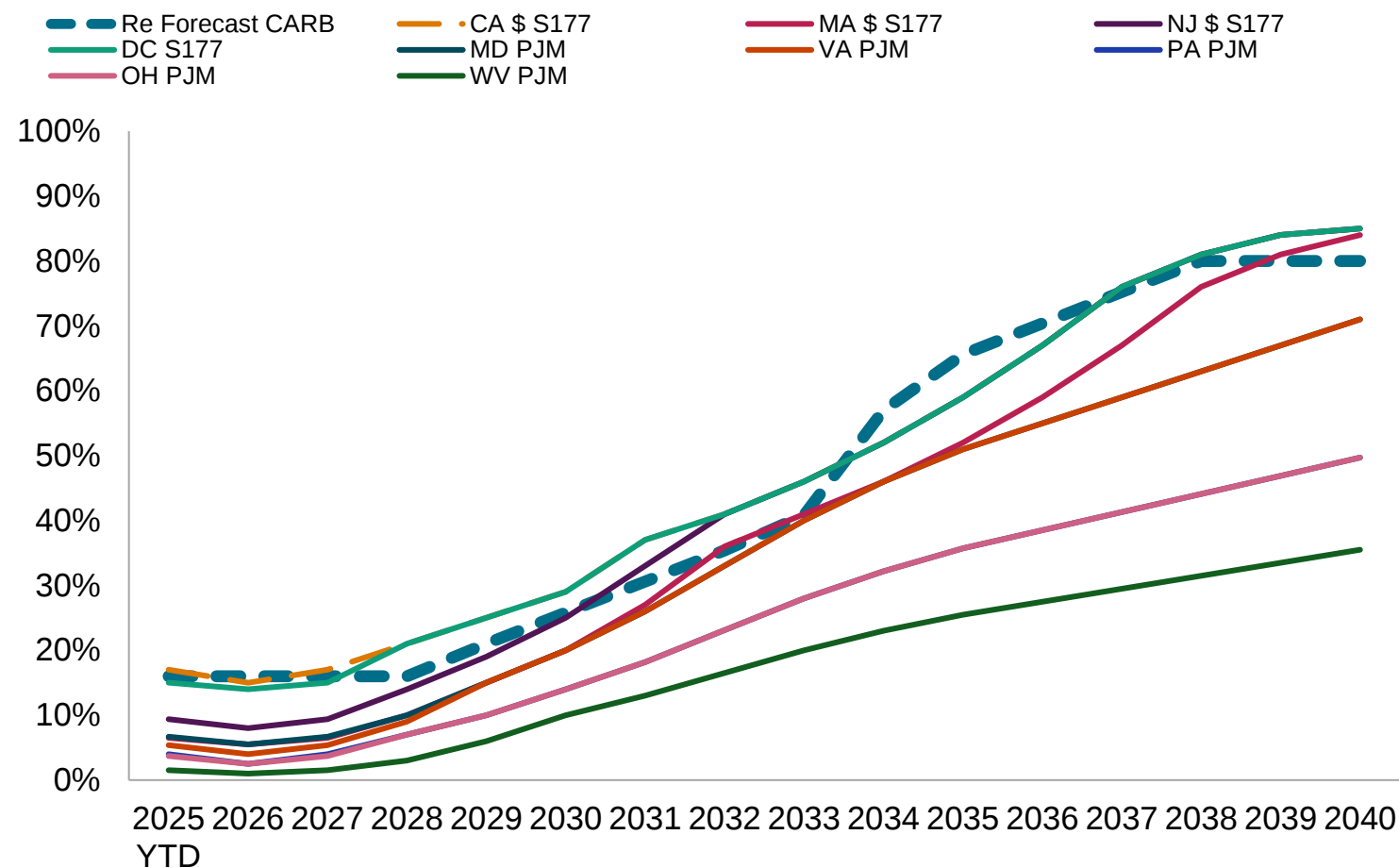
Potential re-write of CARB ZEV aspiration

- The California ACCII 2035 ICE ban is under pressure, as Federal government has taken the waiver away.
- California aspiration is likely delayed, but not derailed, we expect a push of ACCII from CY2026-2035 to CY2029-2038. This, as CA challenges the Federal government in courts.
- Further magnified as registrations of BEVs are dropping YTD in California and many of the other ACCII states.
- The situation is even more dire for 177 States, all of which have a lower electrification rate than that of CA.
- California will still aim for an ICE ban albeit delayed.
- We now expect a smaller ACCII cohort with only Massachusetts, New Jersey, Oregon and Washington remaining.

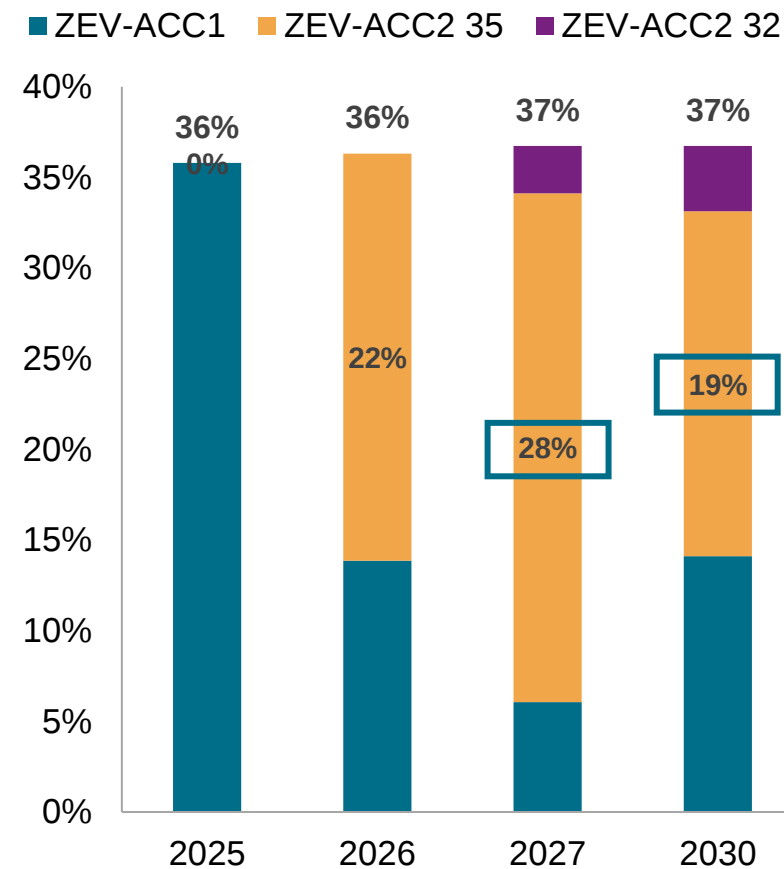


Projected PJM zone BEV take rates by state (also featuring CA and other 177 States)

Light-duty BEV rate assumption for CA and PJM territories



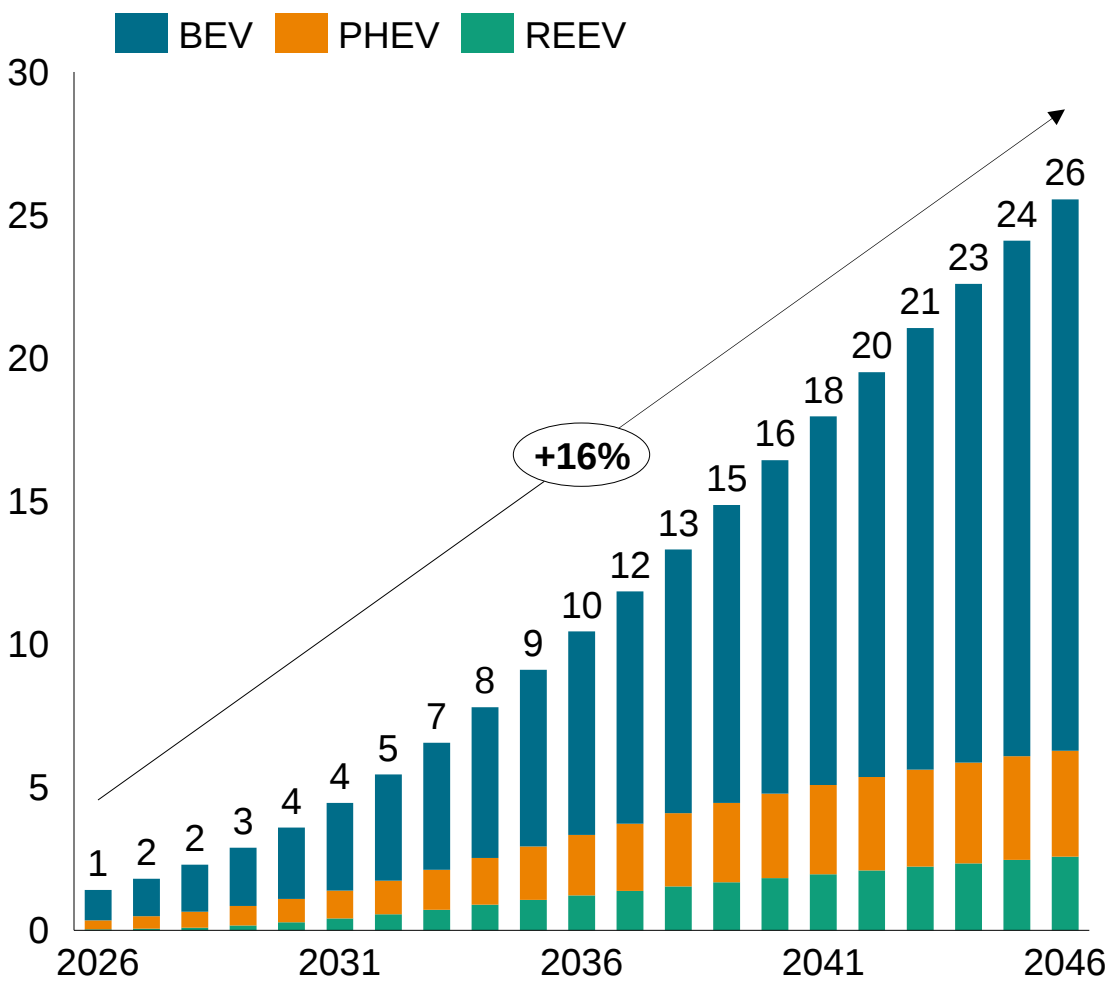
S177 states share of US LV sales





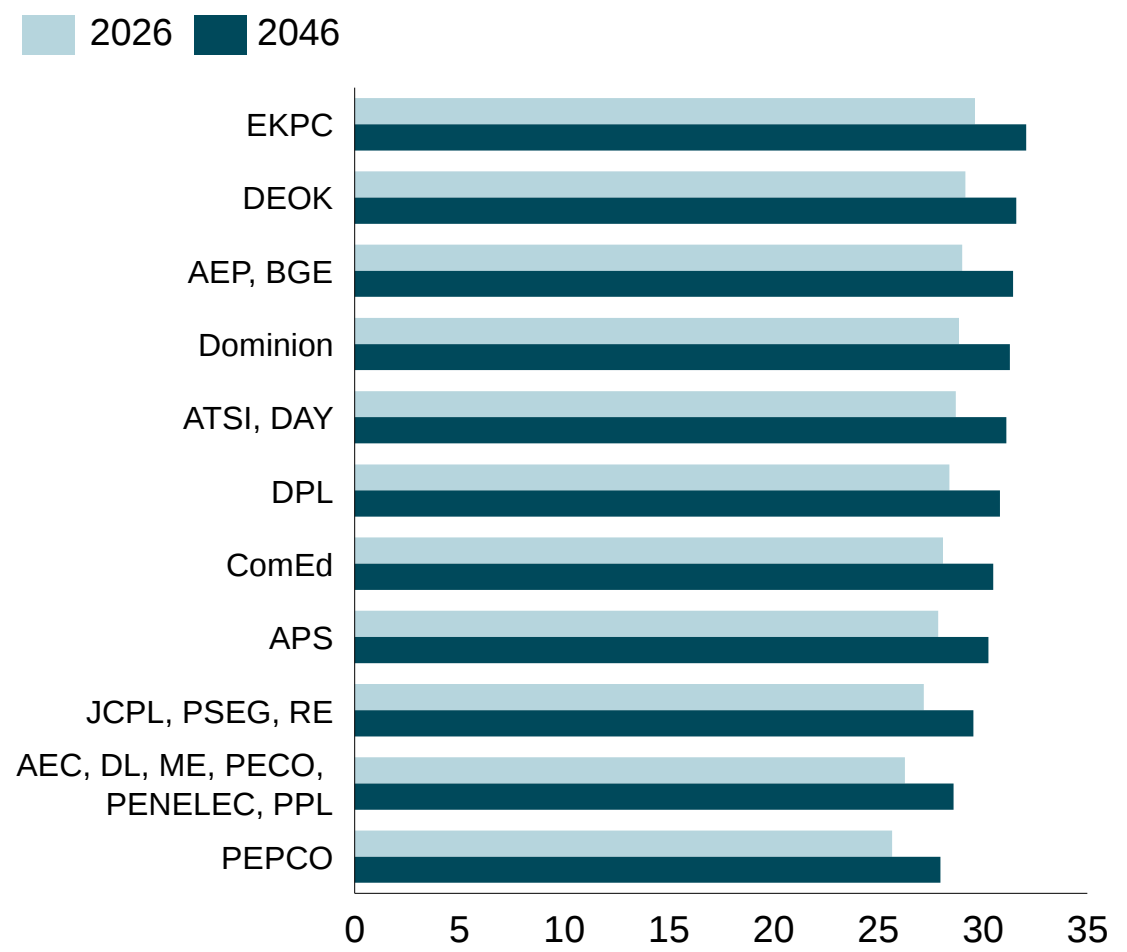
This year we introduced range extenders as a distinct EV category and incorporated vehicle miles traveled data at the zonal level

Total light-duty EVs in operation – PJM territory
Million of EVs



Light-duty EVs vehicle miles traveled by PJM zone

Average daily vehicle miles traveled

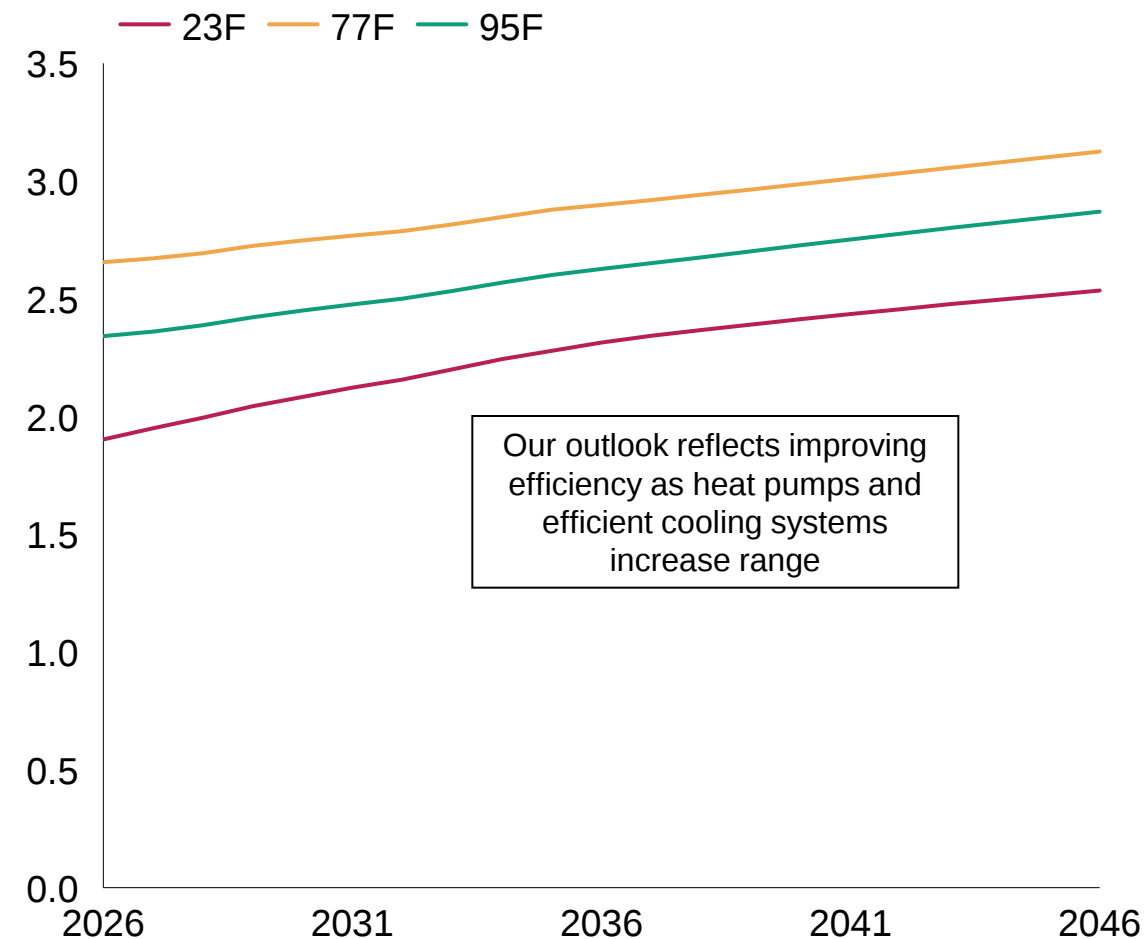




Daily temperatures outside the optimal range lower light-duty EV efficiency and raise charging needs

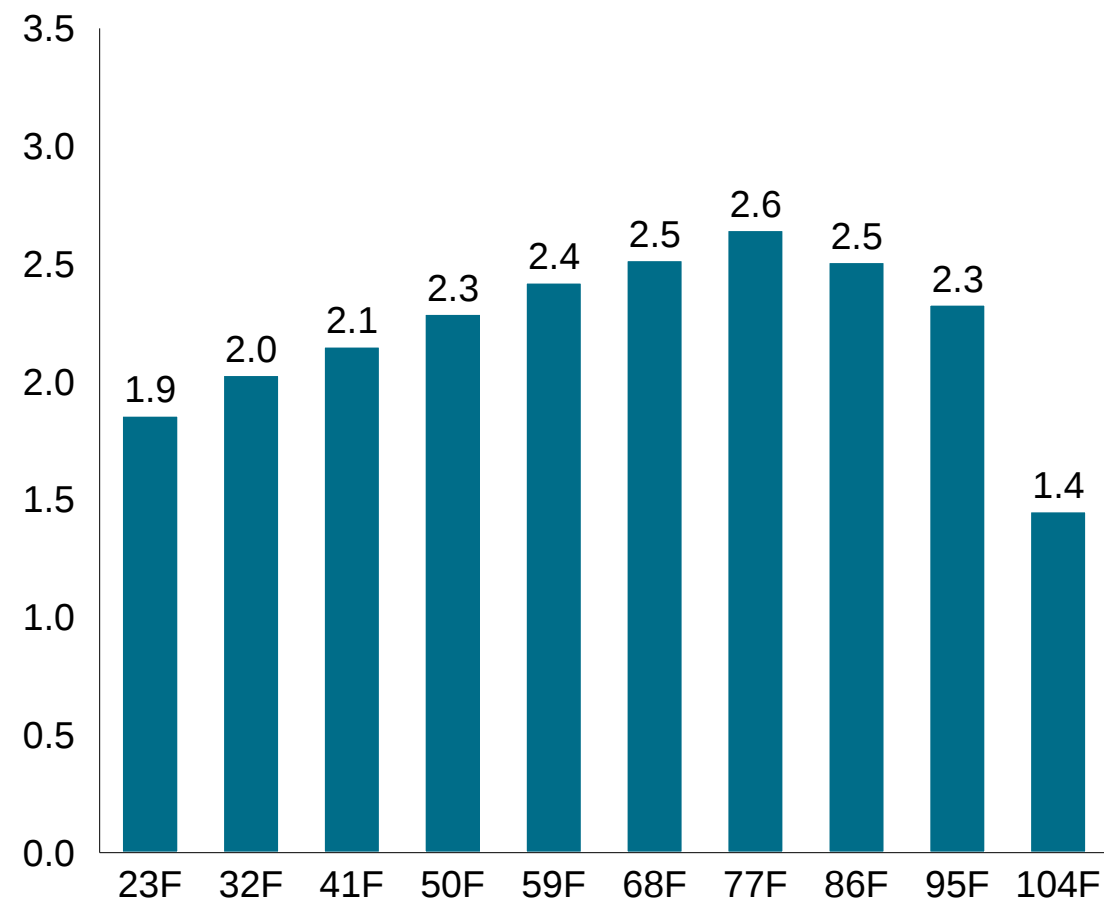
Light-duty EV vehicle efficiency at different daily temperatures

Miles per kWh



Light-duty EV vehicle efficiency at different daily temperatures

Miles per kWh



Note: Temperature assumed for the study is a 10-year historical average on a daily basis

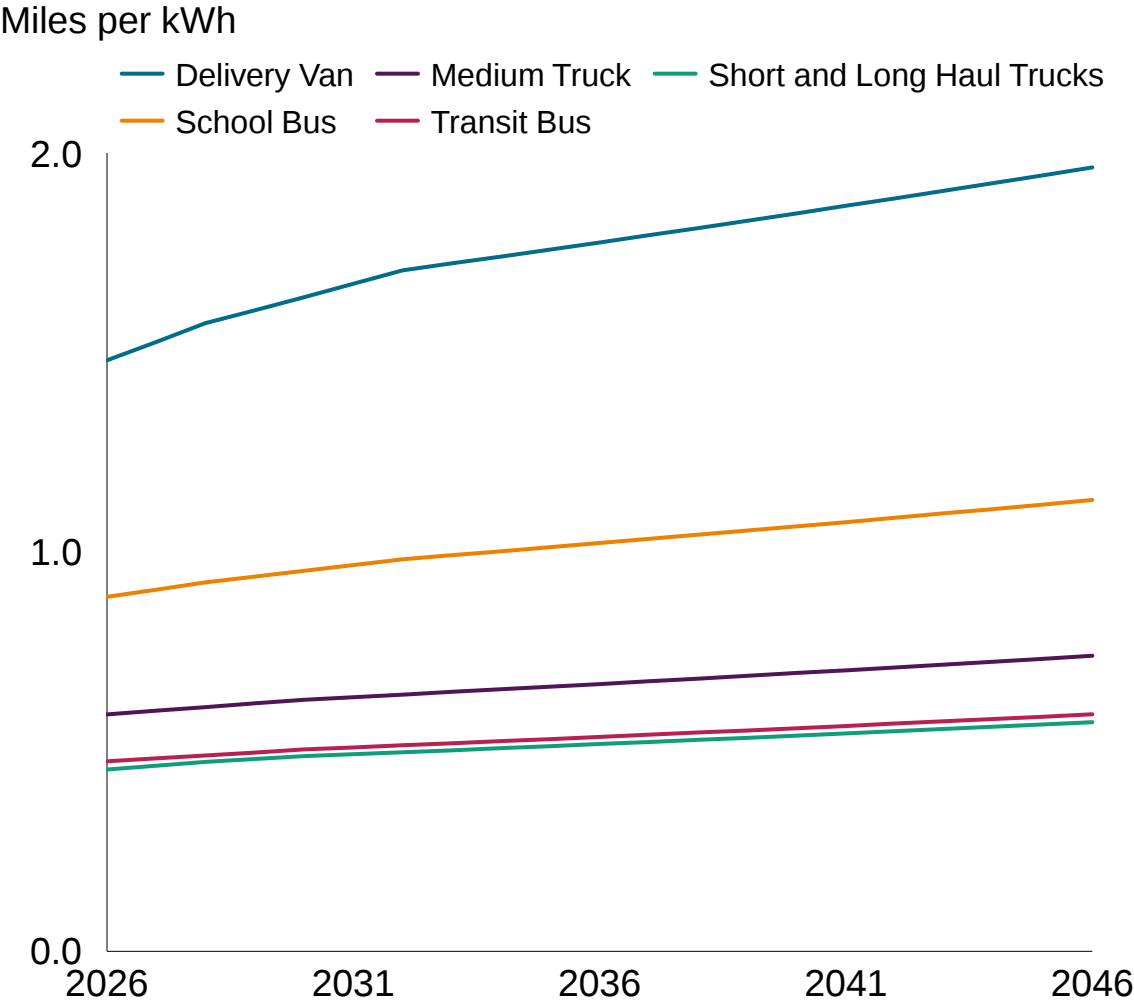
Source: S&P Global Mobility, Recurrent EV driver field survey data.

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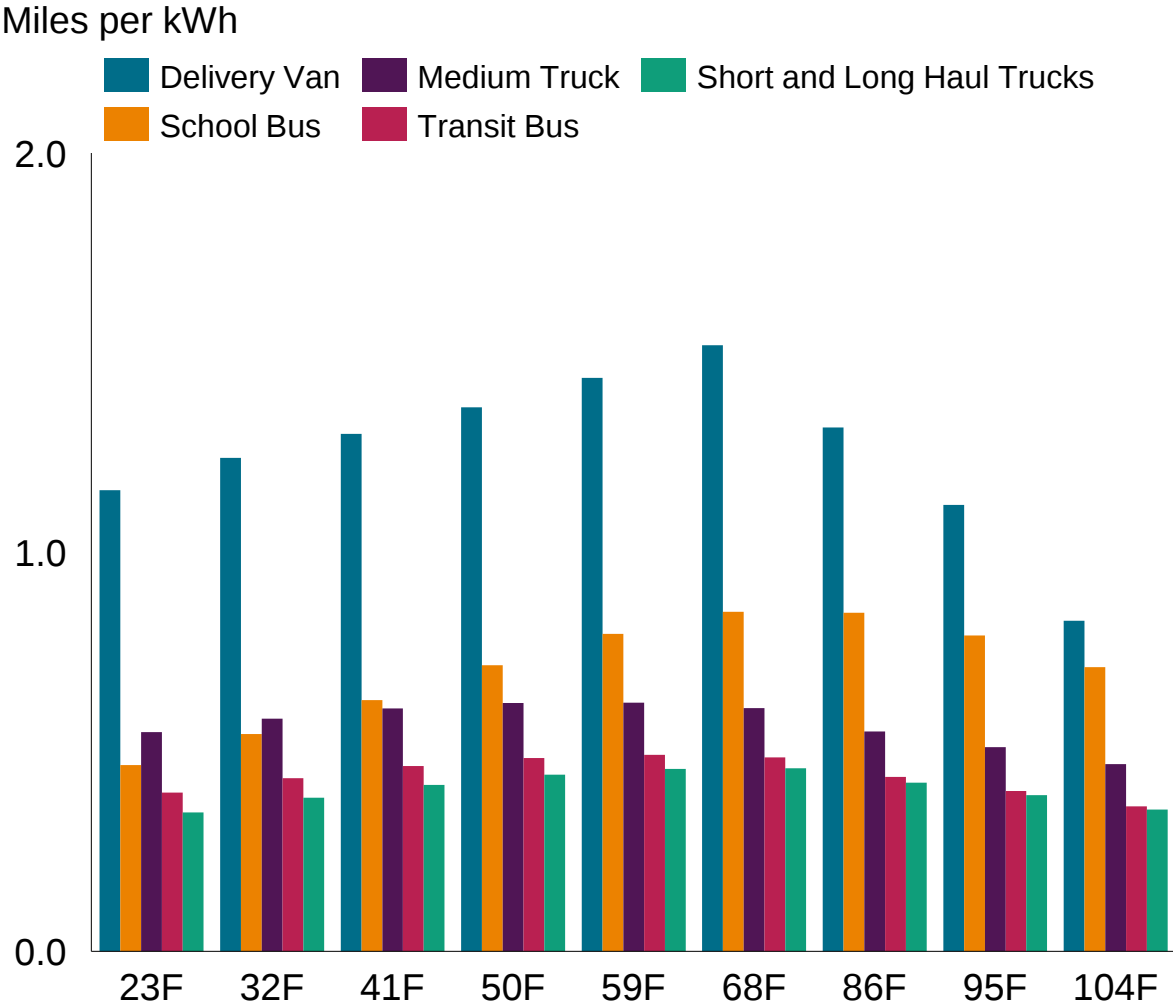


Vehicle efficiency varies among MHDV classes, with delivery vans performing best

MHD EVs vehicle efficiency in optimal temperature conditions¹



MHD EVs vehicle efficiency at different daily temperatures



1. Optimal temperature conditions are estimated at 77 Fahrenheit
Source: S&P Global Mobility, NREL, CALSTART
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Light-duty vehicle assumptions: Electric vehicle utilization

Type of vehicle applicability	Assumptions and inputs	Value	Sources
Light-duty	Miles driven (weekday/weekend)	AEC, DL, ME, PECO, PENELEC, PPL: 9,592 miles/year (2026) to 10,445 miles/year (2046)	S&P Global Mobility
		AEP, BGE: 10,593 miles/year (2026) to 11,480 miles/year (2046)	
		APS: 10,176 miles/year (2026) to 11,049 miles/year (2046)	
		ATSI, Dayton: 10,482 miles/year (2026) to 11,365 miles/year (2046)	
		ComEd: 10,259 miles/year (2026) to 11,135 miles/year (2046)	
		DEOK: 10,649 miles/year (2026) to 11,538 miles/year (2046)	
		Dominion: 10,537 miles/year (2026) to 11,422 miles/year (2046)	
		DPL: 10,370 miles/year (2026) to 11,250 miles/year (2046)	
		EKPC: 10,815 miles/year (2026) to 11,710 miles/year (2046)	
		JCPL, PSEG, RE: 9,926 miles/year (2026) to 10,790 miles/year (2046)	
		PEPCO: 9,370 miles/year (2026) to 10,215 miles/year (2046)	
		75% of miles are driven during weekdays	



Light-duty vehicle assumptions: Electric vehicle efficiency

Type of vehicle applicability	Assumptions and inputs	Value	Sources
Light-duty	Miles per kWh ¹ (normal operating conditions ²)	2026: 2.7 miles/kWh 2046: 3.1 miles/kWh	S&P Global Mobility
Light-duty	Loss in battery efficiency due to temperature fluctuations	43% additional energy at 23 Fahrenheit (heating) 5% additional energy at 86 Fahrenheit (cooling) Temperature assumed for the study is a 10-year historical average on a daily basis	S&P Global Mobility, National Oceanic and Atmospheric Administration

1. Accounts for real-world performance, not EPA lab test; includes weighted average performance of car parc

2. Normal operating conditions are assumed at 77 Fahrenheit

Source: S&P Global



Light-duty vehicle assumptions: Charging infrastructure

Type of vehicle applicability	Assumptions and inputs	Value	Sources
Light-duty	Access to home and workplace charging	2026: 81% access to home charging 2046: 66% access to home charging	S&P Global Mobility – Charging Infrastructure
Light-duty	Type of home charging (Level 2 vs Level 1)	80% Level 2 charging	S&P Global Mobility – Charging Infrastructure
Light-duty	Charging strategy (for drivers with access to home charging)	2026: 94% Immediate / 6% Delayed 2046: 65% Immediate / 35% Delayed	S&P Global Commodity Insights



Light-duty vehicle assumptions: Charging behavior

The light duty charging shapes are a combination of different charging strategies

Charging strategy	Home charging	Description	Preferred charging time	Type of charger
Immediate	Yes	Starts to charge as soon as gets home, regardless of cost	Evening	Level 2: 80% Level 1: 20%
TOU – As soon as possible (ASAP)	Yes	Starts to charge as soon as on-peak pricing ends	Dynamic based on pricing	Level 2
TOU – As cheap as possible (ACAP)	Yes	Charges during super off-peak hours	Dynamic based on pricing	Level 2
Work and public charger	No	Relies on public and workplace charging, starts to charge as soon as arrives to work	Morning through midday	Mostly Level 2 and DCFC
Ride hailing	50%	Typically relies on public charging, charges throughout the day	Middle of the day	Mostly Level 2 and DCFC



Summary of key changes in the approach to the light-duty vehicle analysis as compared to last year's analysis

Assumption	Description	Magnitude of change	Impact on load
Vehicles in Operation (VIO)	US EV penetration reaches 14% by 2035 and 39% by 2045 (compared to 50% by 2045 previously). This is a response to expected revisions to EPA and CAFE rules for MY2028-2032 as well as the challenges with the Advanced Clean Cars and Advanced Clean Trucks rules, resulting in the delay in the targets as well as some states leaving the California rule.	High	
Efficiency and temperature losses	- Updated vehicle efficiency based on latest update of S&P Global Vehicle Performance and Compliance Database (VPaC). - Efficiency losses for cold/hot weather temperatures based on data from real-world driving performance and S&P Global vehicle simulation datasets. - 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)	VMT data expanded to reflect differences in PJM zones based out of state-level data. National VMT is expected to increase at a pace of about 0.5% per year from a present 11,000 miles per year to 12,000 miles per year by 2046, with MaaS (Mobility as a Service) increasing from a present 35,000 miles per year to 40,000 miles per year.	Medium	
Access to home charging	Increased long-term access to home charging to 66% in 2046 (previously 50% in 2045) based on new data on housing structure (single v. multi family), home ownership/rental, vehicles per household, electrical access by housing type, and BEV adoption within housing categories.	Low	
Charging behavior	- Adjusted the share of immediate charging during weekdays/weekends to 65% in 2046 (previously 50% on weekdays and 90% on weekends in 2045). - Replaced the ALAP (as-late-as-possible) category with ACAP (as-cheap-as-possible) within the delayed charging strategy and revised the allocation between ASAP and ACAP charging according to projected on- and off-peak times.	Medium	



Utilities currently incentivize charging during the night and early morning; going forward, TOU rates will evolve to incentivize EV charging during the day to due to solar penetration

Selected PJM utilities with time-of-use (TOU) rate structure – 2025

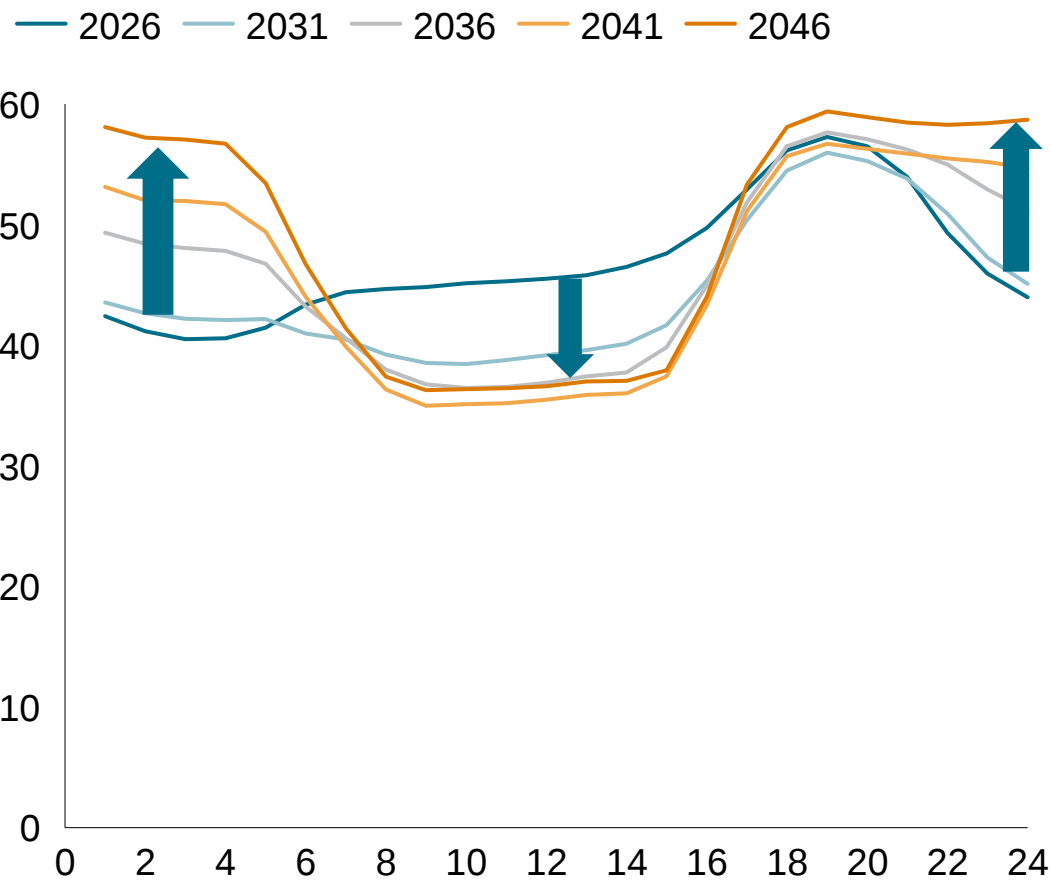
Utility	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Atlantic City	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak
AEP Ohio	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak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

Expected time-of-use (TOU) rate structure in PJM utilities – 2046

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Peak	Peak	Peak	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	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak

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

Average hourly PJM East wholesale prices
Real 2024 \$/MWh





Medium and heavy-duty assumptions: EV utilization and efficiency

Type of vehicle applicability	Assumptions and inputs	Value	Sources
Medium and heavy-duty	Miles driven (weekday/weekend)	Delivery van: 19,345 miles/year (2026) to 28,288 miles/year (2046); 96% of miles driven during weekdays School bus: 11,680 miles/year (2026) to 12,045 miles/year (2046); 96% of miles driven during weekdays Transit bus: 41,975 miles/year (2046) to 44,530 miles/year (2046); 88% of miles driven during weekdays Medium truck: 21,535 miles/year (2026) to 22,630 miles/year (2046); 71% of miles driven during weekdays Short-haul truck: 35,040 miles/year (2026) to 37,230 miles/year (2046); 96% of miles driven during weekdays Long-haul truck: 85,410 miles/year (2026) to 90,520 miles/year (2046); 88% of miles driven during weekdays	S&P Global Mobility
Medium and heavy-duty	Miles per kWh (normal operating conditions ¹)	Delivery van: 1.48 miles/kWh (2026) to 1.96 miles/kWh (2046) School bus: 0.89 miles/kWh (2026) to 1.13 miles/kWh (2046) Transit bus: 0.48 miles/kWh (2026) to 0.59 miles/kWh (2046) Medium truck: 0.59 miles/kWh (2026) to 0.74 miles/kWh (2046) Short-haul truck: 0.46 miles/kWh (2026) to 0.57 miles/kWh (2046) Long-haul truck: 0.46 miles/kWh (2026) to 0.57 miles/kWh (2046)	S&P Global Mobility
Medium and heavy-duty	Loss in battery efficiency due to temperature fluctuations	Additional energy at 23 Fahrenheit (heating): 24% (delivery vans), 17% (transit buses), 87% (school buses), 6% (medium trucks), 28% (short-haul and long-haul trucks) Additional energy at 86 Fahrenheit (cooling): 9% (delivery vans), 7% (transit buses), 3% (school buses), 6% (medium trucks), 6% (short-haul and long-haul trucks)	S&P Global Mobility, National Renewable Energy Laboratory, CALSTART MHD EV Deployment Data

1. Normal operating conditions are assumed at 77 Fahrenheit

Source: S&P Global

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Summary of key changes in the approach to the medium and heavy-duty vehicles as compared to last year's analysis

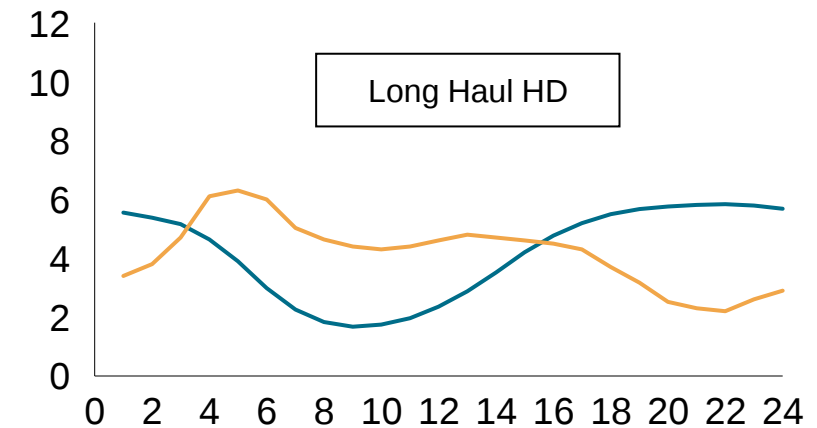
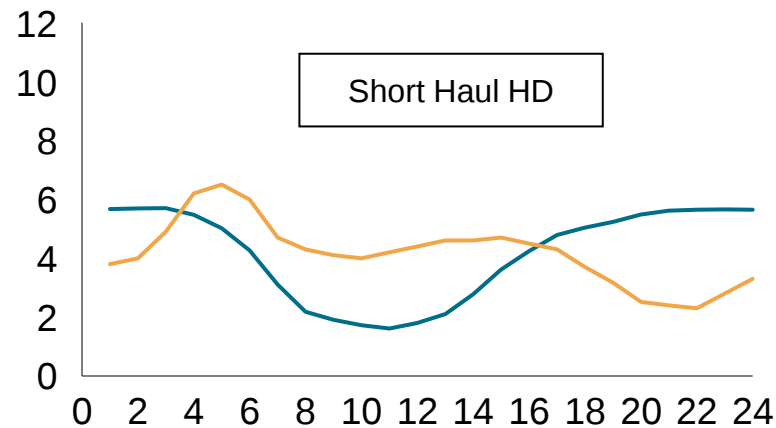
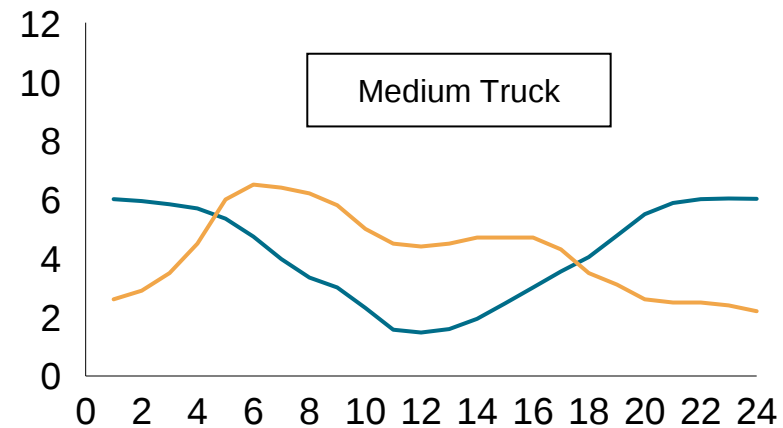
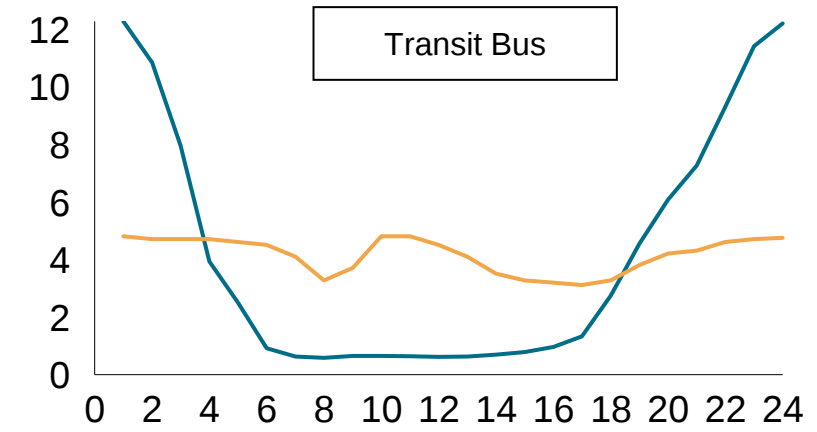
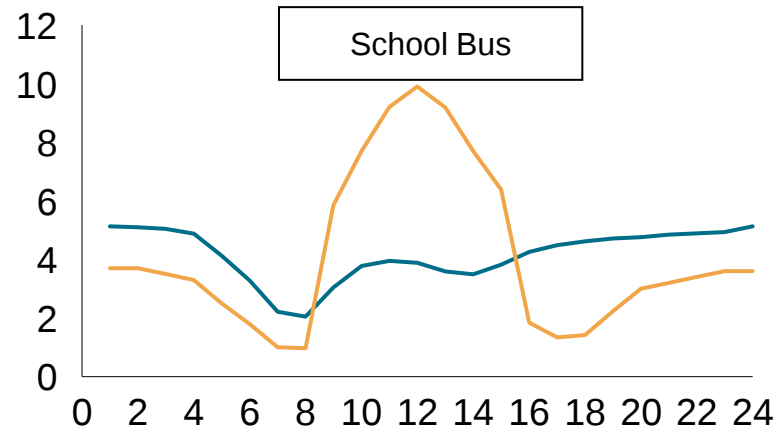
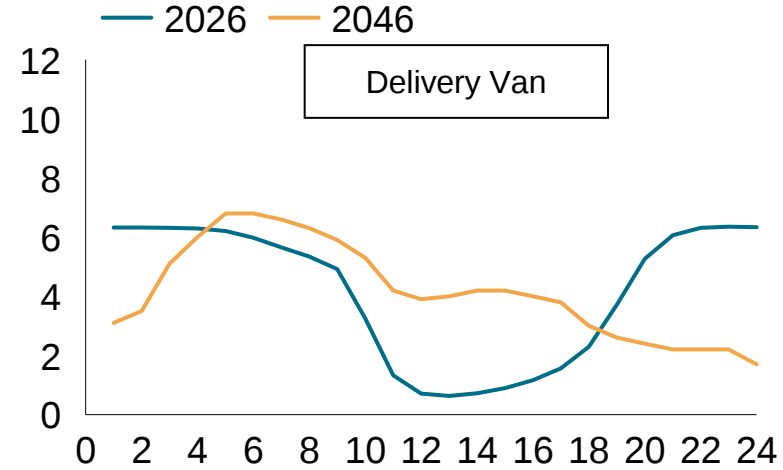
Assumption	Description	Magnitude of change	Impact on load
Vehicles in Operation (VIO)	▪ Similar to LV we have revised HDTs down drastically as a result of legislation, we now have a BEV VIO of 2% in 2035 and 14% in 2045 for Class 8 (we previously had 6.4% in 2035 and 24% in 2045). ▪ Similarly for Class 4-7 we have BEV VIOs of 5% in 2035 and 27% in 2045 (we previously had 12% for 2035 and 43% for 2045). ▪ For Commercial Vans BEV VIO of 13% in 2035 and 45% in 2045 (previously 27% in 2035 and 70% in 2045).	High	
Vehicle Miles Traveled (VMT)	▪ Updated vehicle miles travelled data for delivery vans based on latest S&P Global Mobility Reinventing the Truck study (Dec 2024), as well as latest trends in last mile delivery operations that led to an increase of daily miles travelled from 30 miles to 53 miles in 2026 and from 32 miles to 70 miles in 2045.	Low	
Charging shapes	▪ Updated unmanaged charging load shapes for MHDV vehicles by class based on NREL Depot-Based MHD EV Charging Data. ▪ Refined managed charging load curves based on the evolution of time-of-use (TOU) rates.	Medium	



MHDV charging shapes are specific to the types of vehicles and their duty cycle; going forward, load shapes will react to higher managed charging penetration and electricity prices

Medium and heavy-duty charging profile

Percentage of daily charging (%)



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Electric vehicle forecast

Charging demand forecast

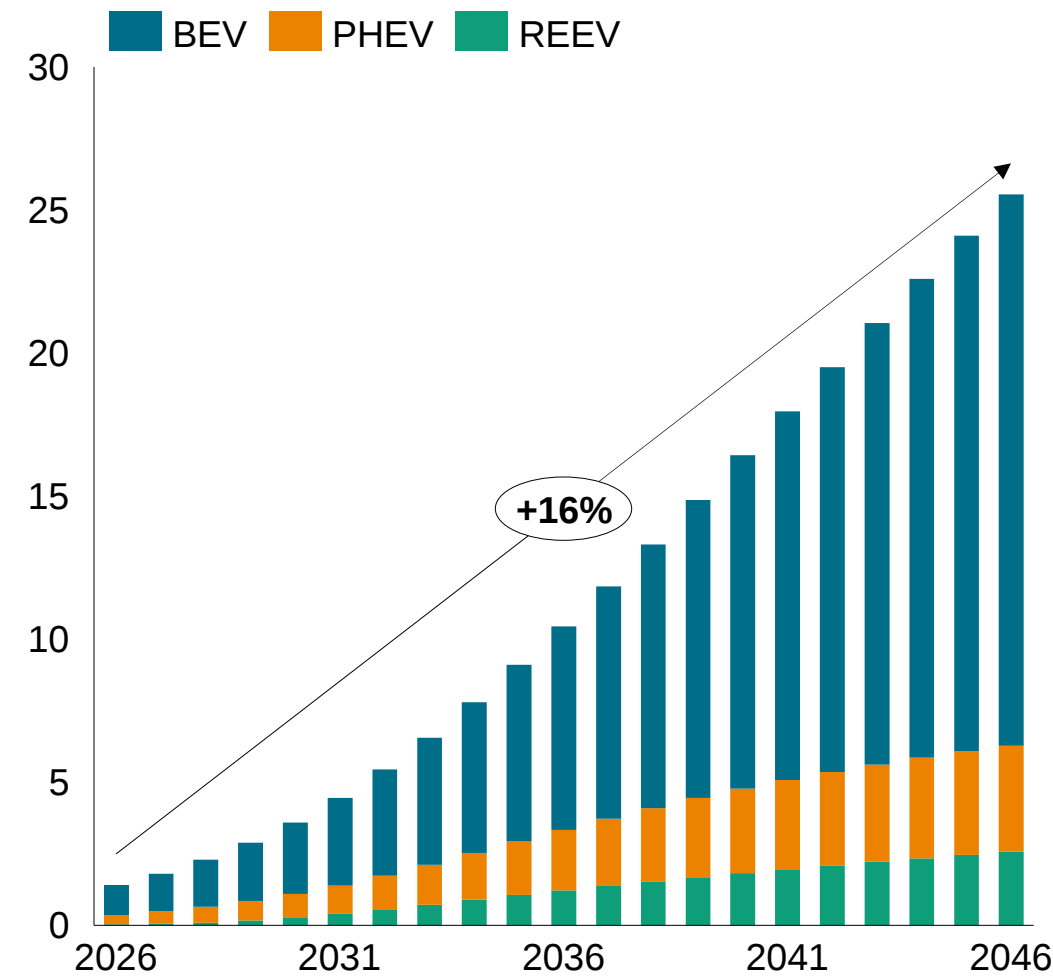
Appendix



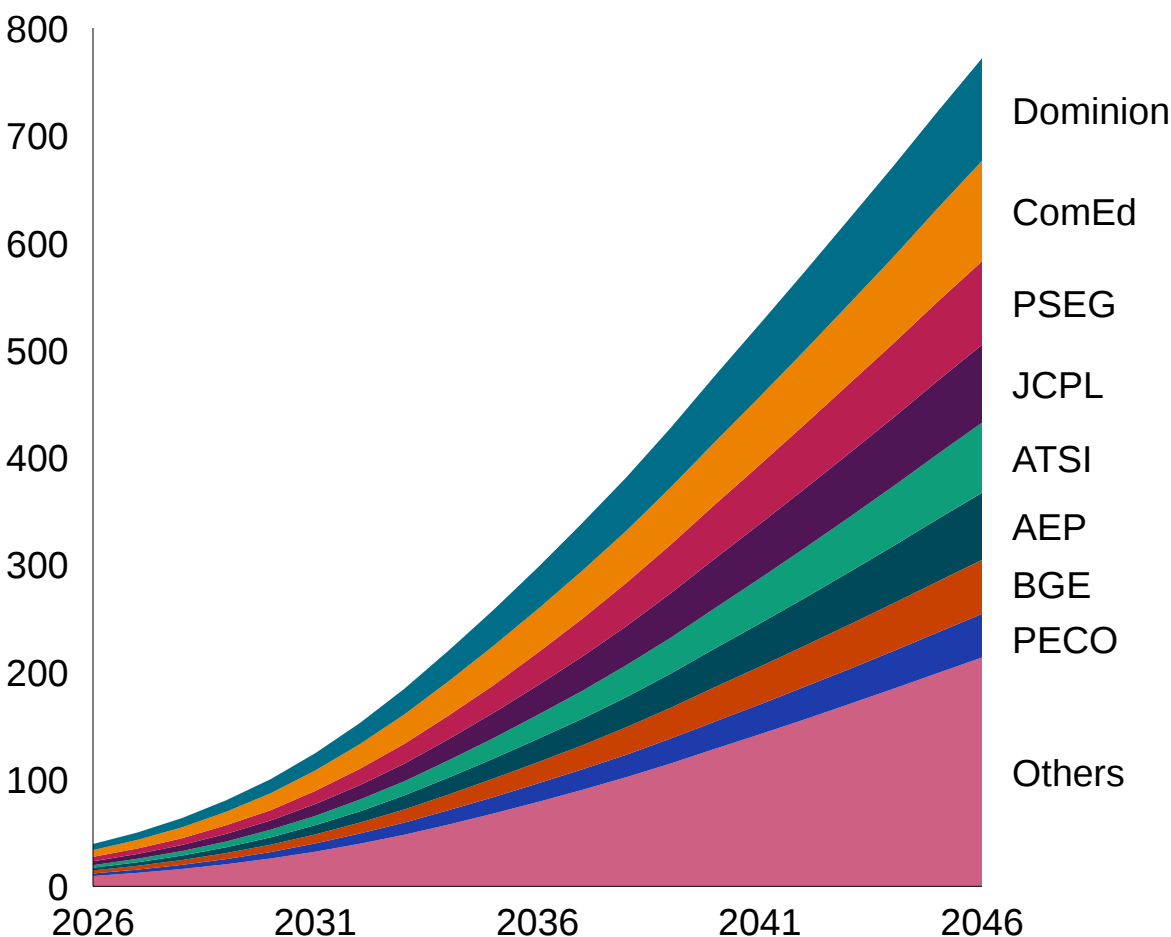


Light-duty EV fleet will reach nearly 26 million vehicles 2046, with BEVs accounting for 75% of the total

Total light-duty EVs in operation – PJM territory
Million of EVs



Light-duty EVs daily vehicle miles traveled – PJM territory
Million daily vehicles miles traveled

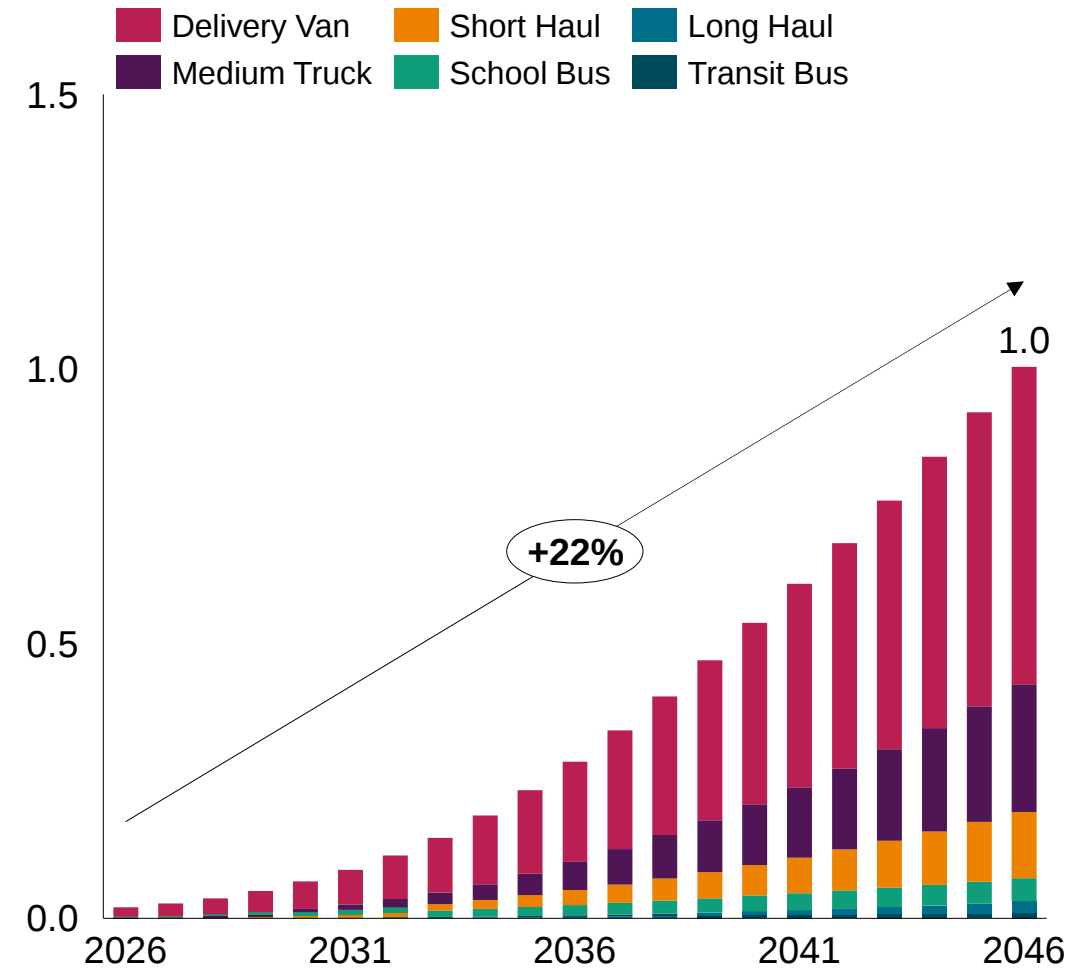




Vehicle adoption and usage vary sharply by MHDV class

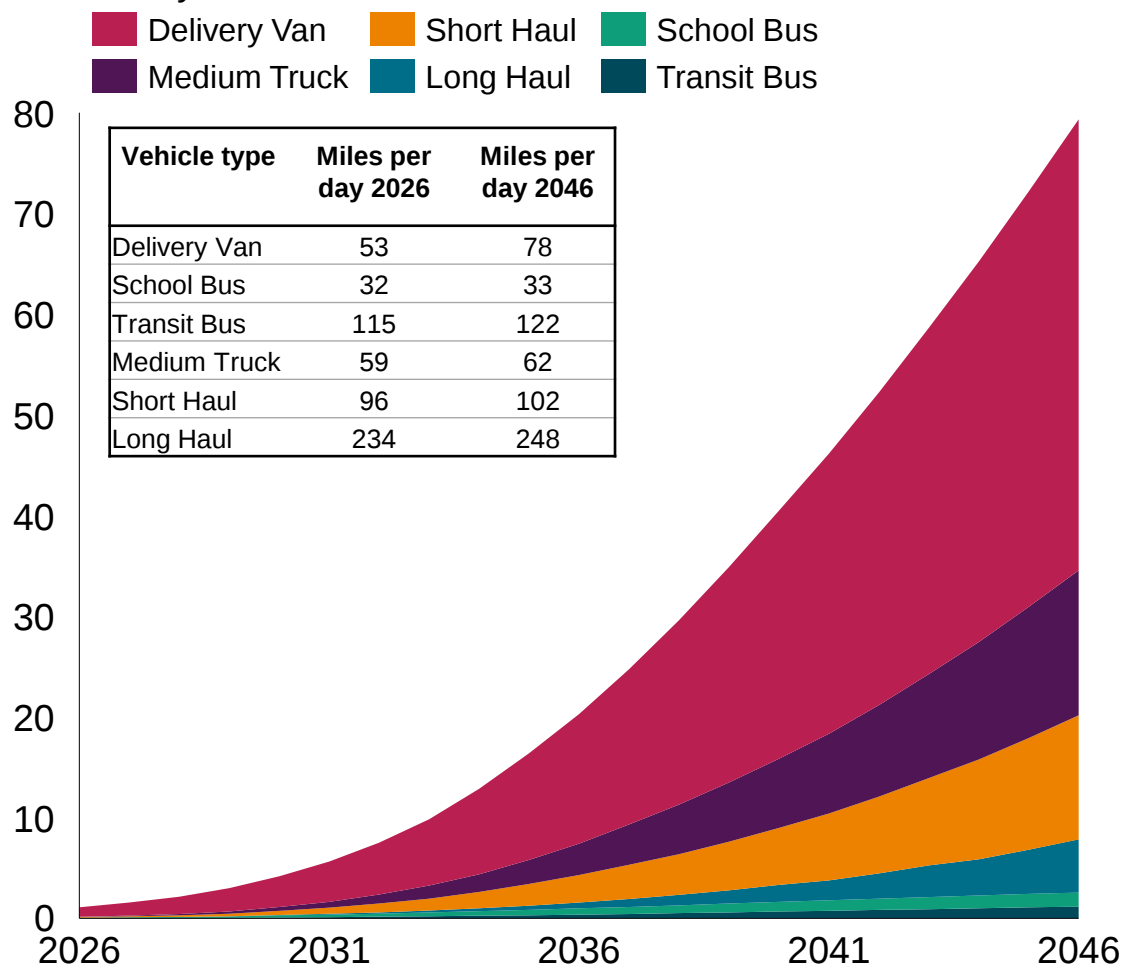
MHD EVs by type – PJM territory

Million of EVs



MHD EVs vehicle miles traveled – PJM territory

Million daily vehicle miles traveled



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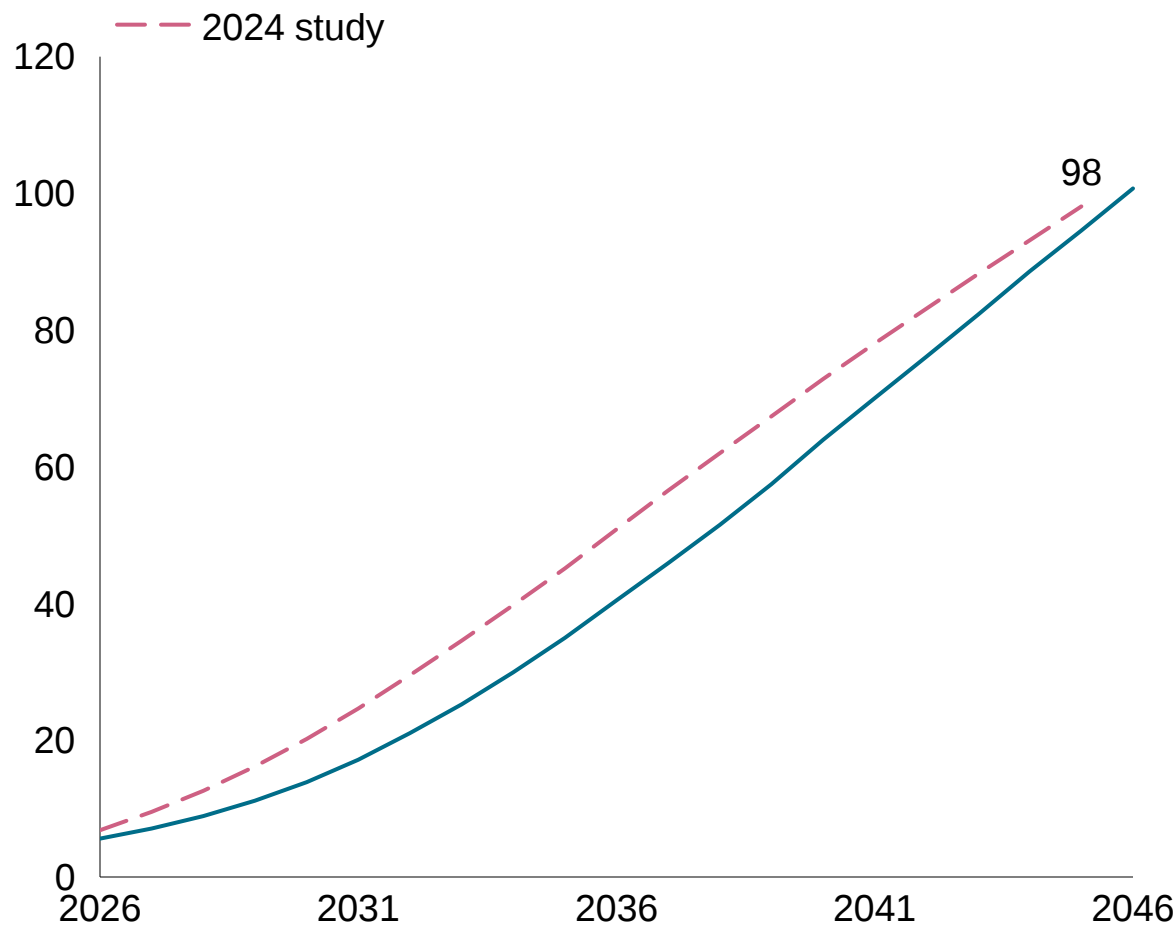
Charging demand forecast

Appendix

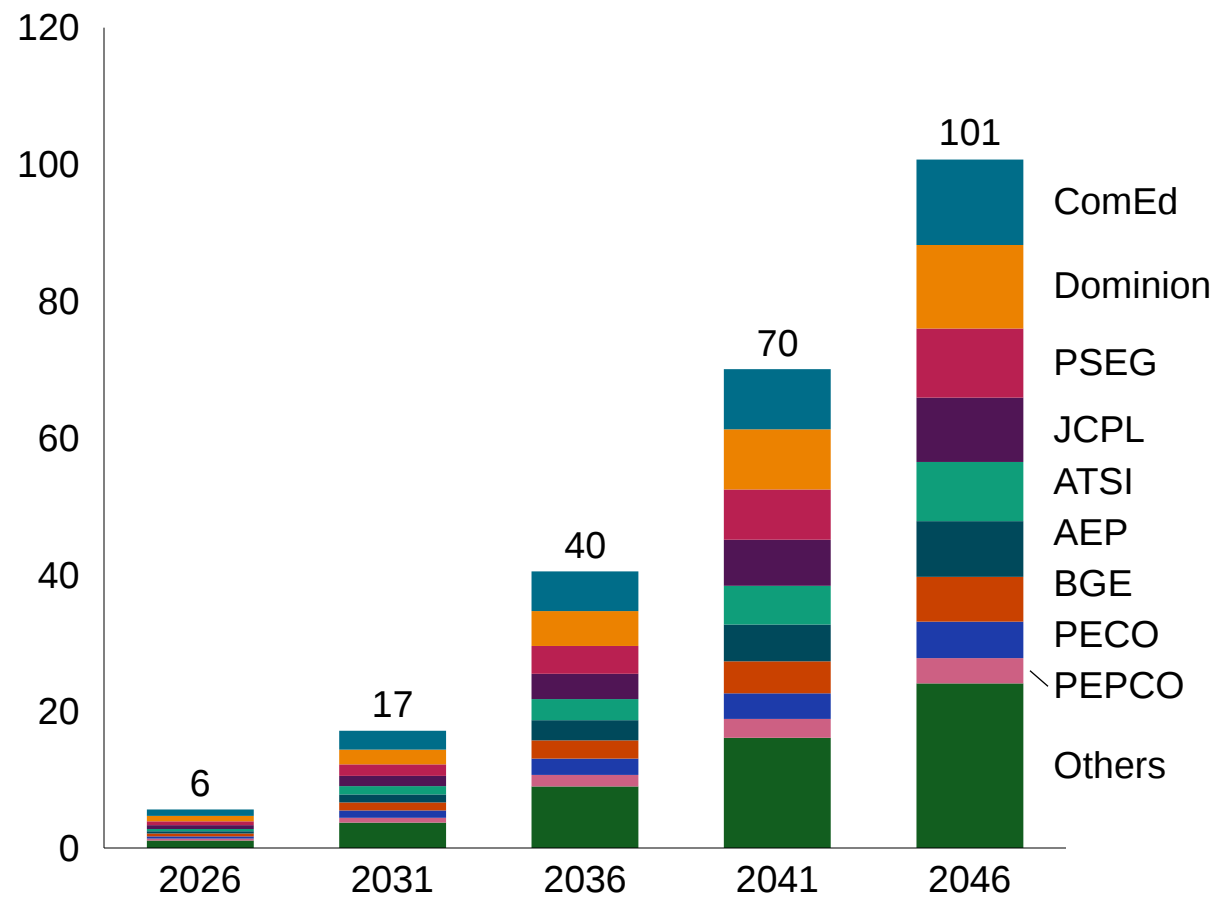


Load from light-duty vehicles is forecasted to surpass 100 TWh by 2046, led by zones with high urban density

Total yearly light duty EV load – PJM
TWh



Total yearly light duty EV load by PJM zone
TWh



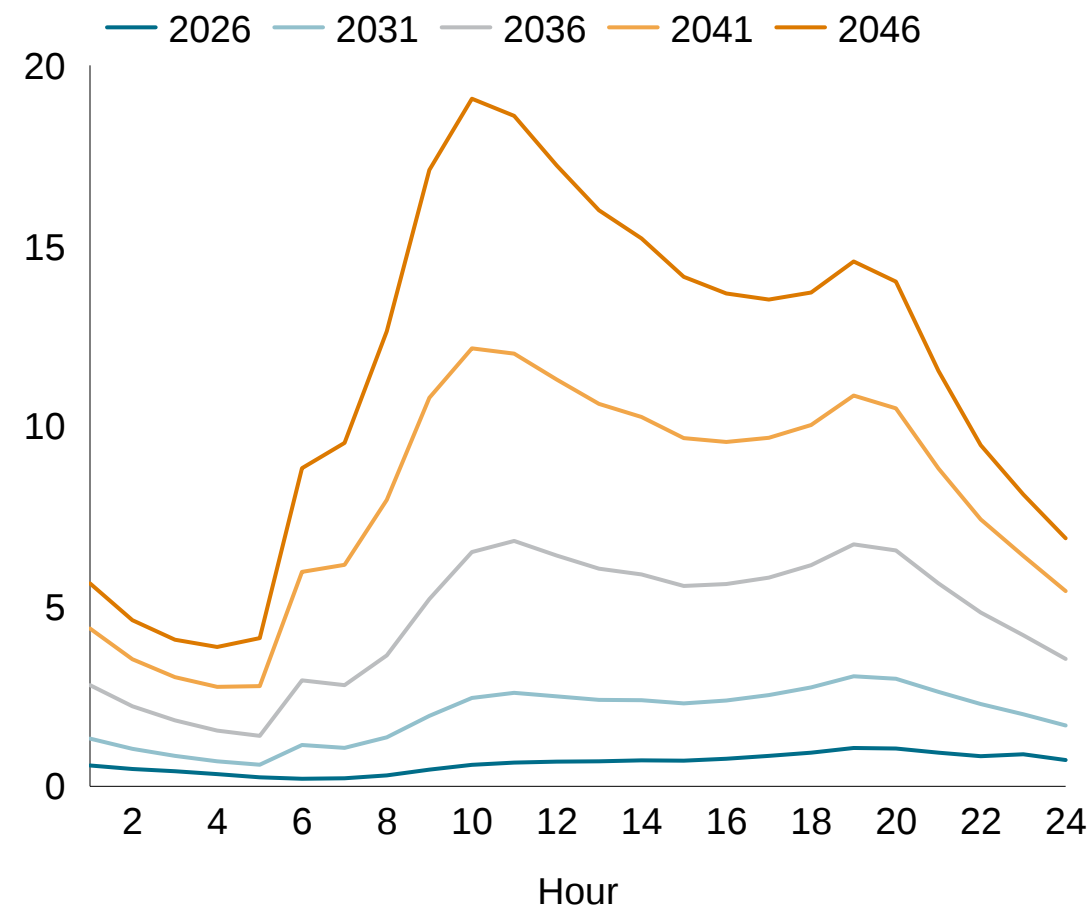


We developed 8760 load shapes for the next 20 years for each zone based on the light-duty EV forecast

Light-duty EV hourly load statistics – PJM

Year	Average load (MW)	Peak load (MW)	Month of peak	Hour of peak
2026	641	1,403	December	19
2031	1,955	3,997	December	19
2036	4,605	8,628	December	11
2041	7,993	15,346	December	10
2046	11,498	23,732	December	10

Average hourly light-duty EV load – PJM GW

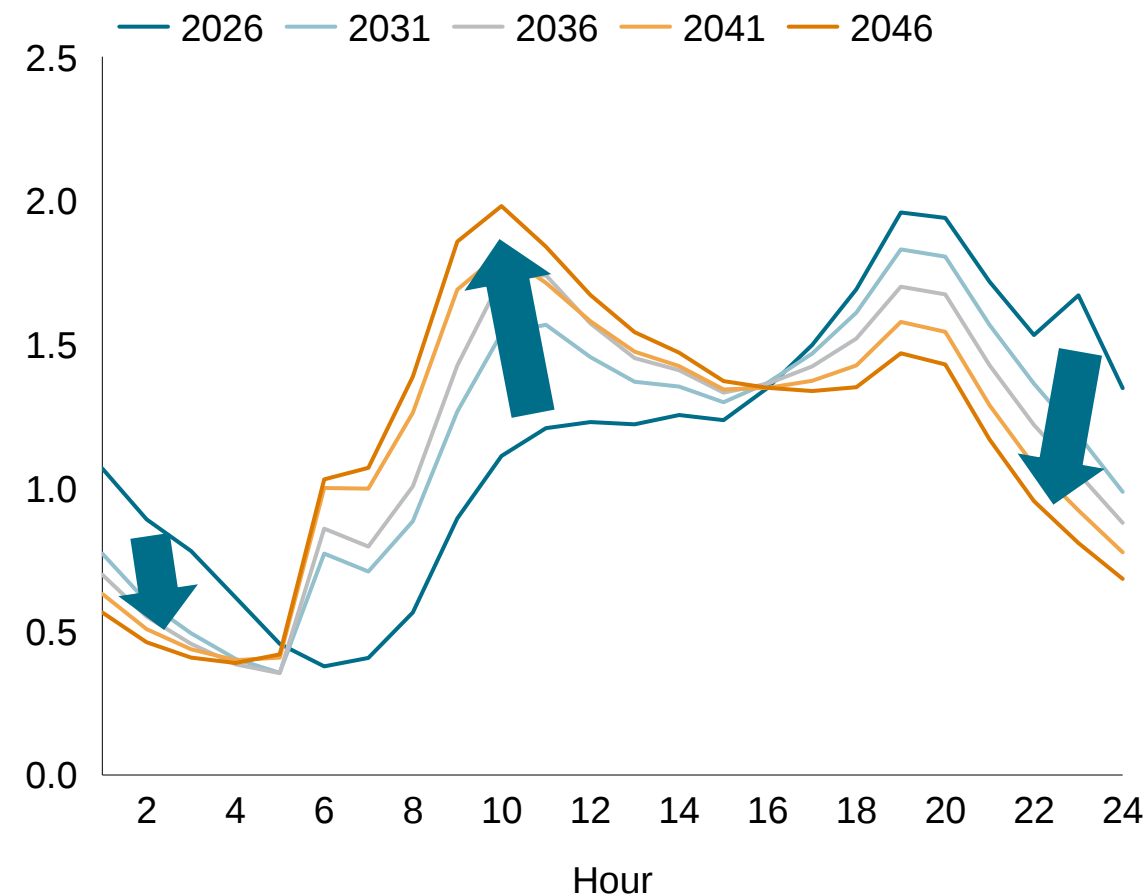




As charging behavior evolves, EVs will charge less during the evening and more in the morning and middle of the day

Light duty EV average weekday charging profile

kWh



Key trends impacting the load shape

- Due to lower access to home charging as a share of total, EV owners will increase charging during work hours at the workplace/public chargers
- Evolution of time-of-use 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 in the morning or midday to take advantage of low-cost electricity resulting from higher solar penetration

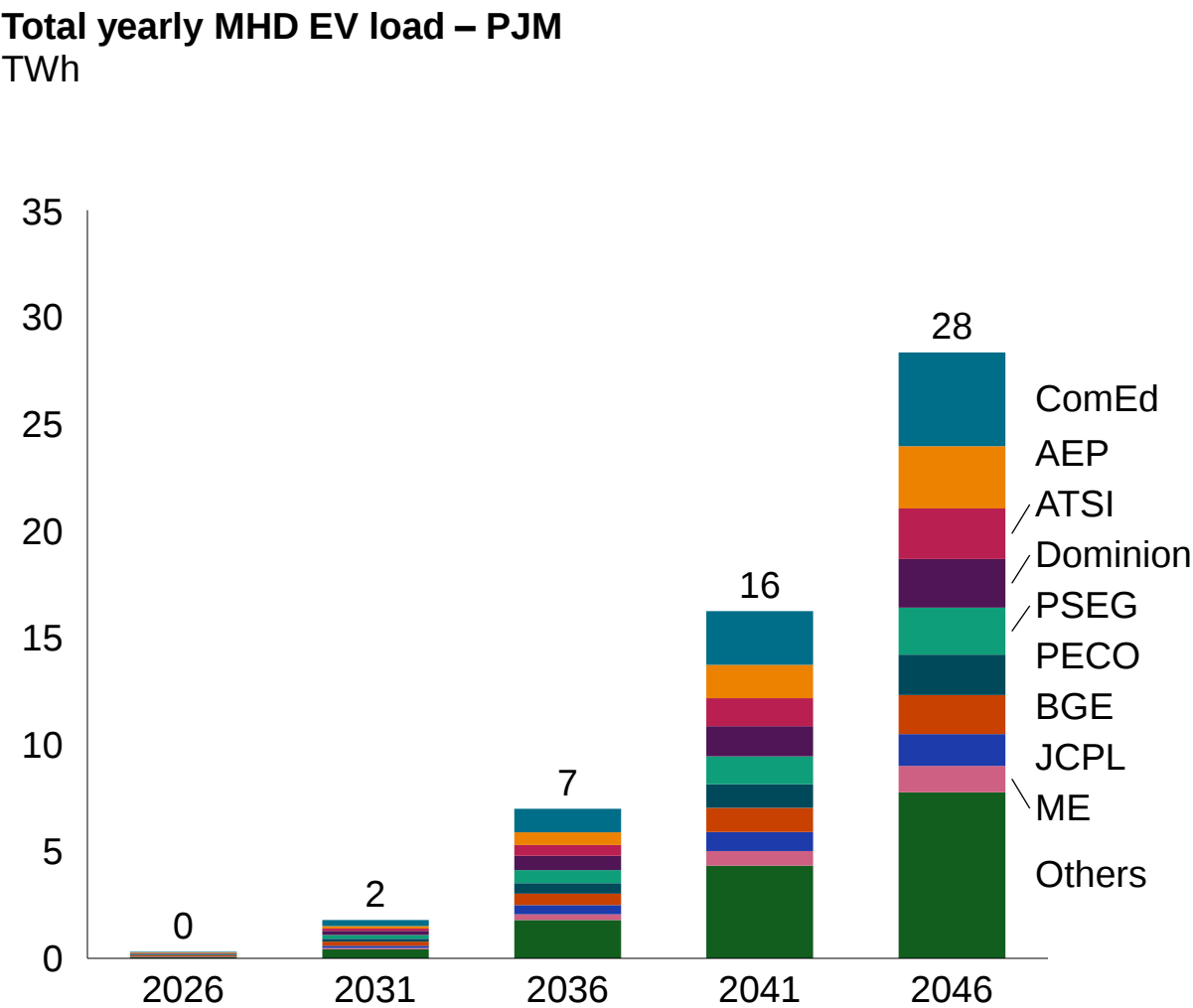
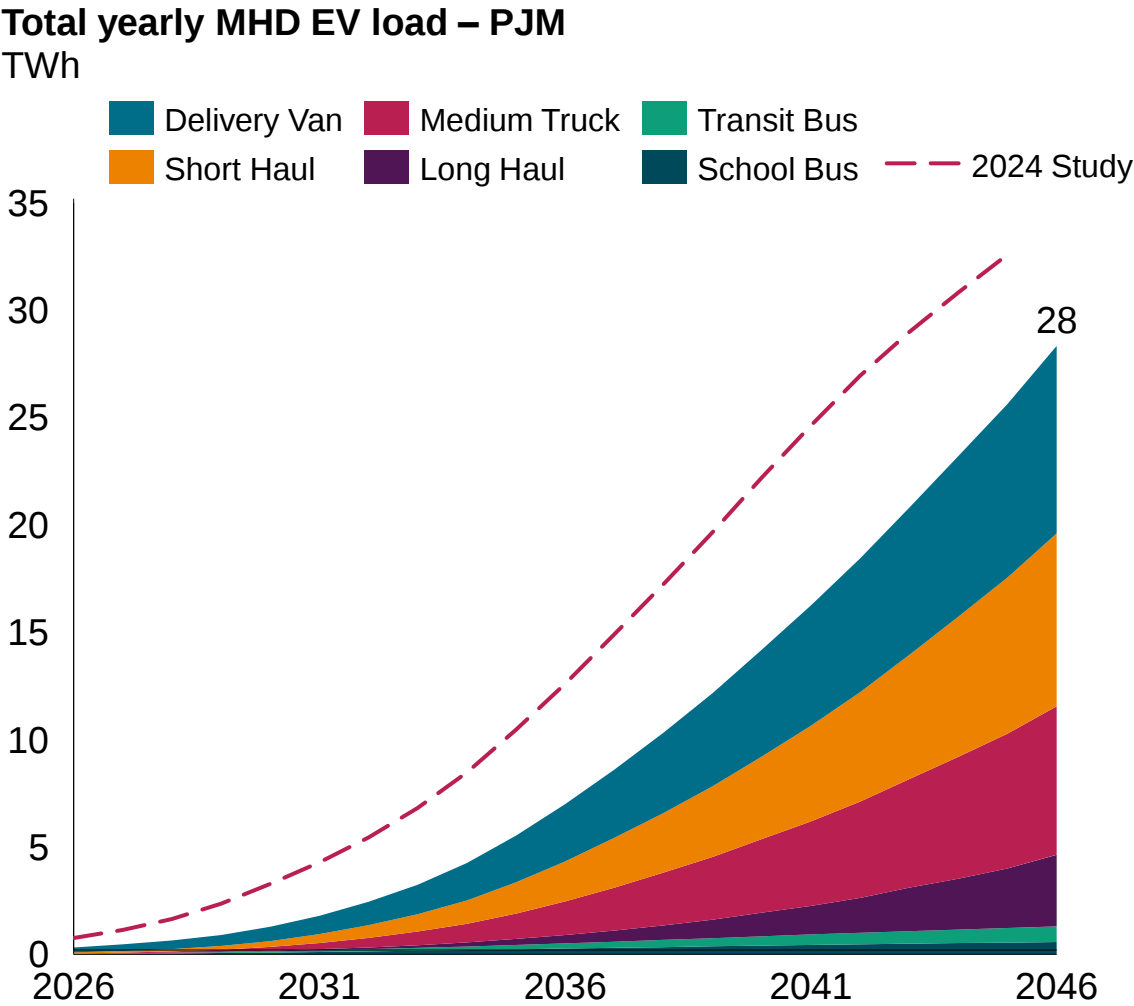
Note: Assuming 28 miles per day driven and no mileage loss from temperature

Source: S&P Global

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Load from MHDV is forecasted to reach 28 TWh by 2046, with delivery vans, short-haul and medium trucks contributing the largest shares



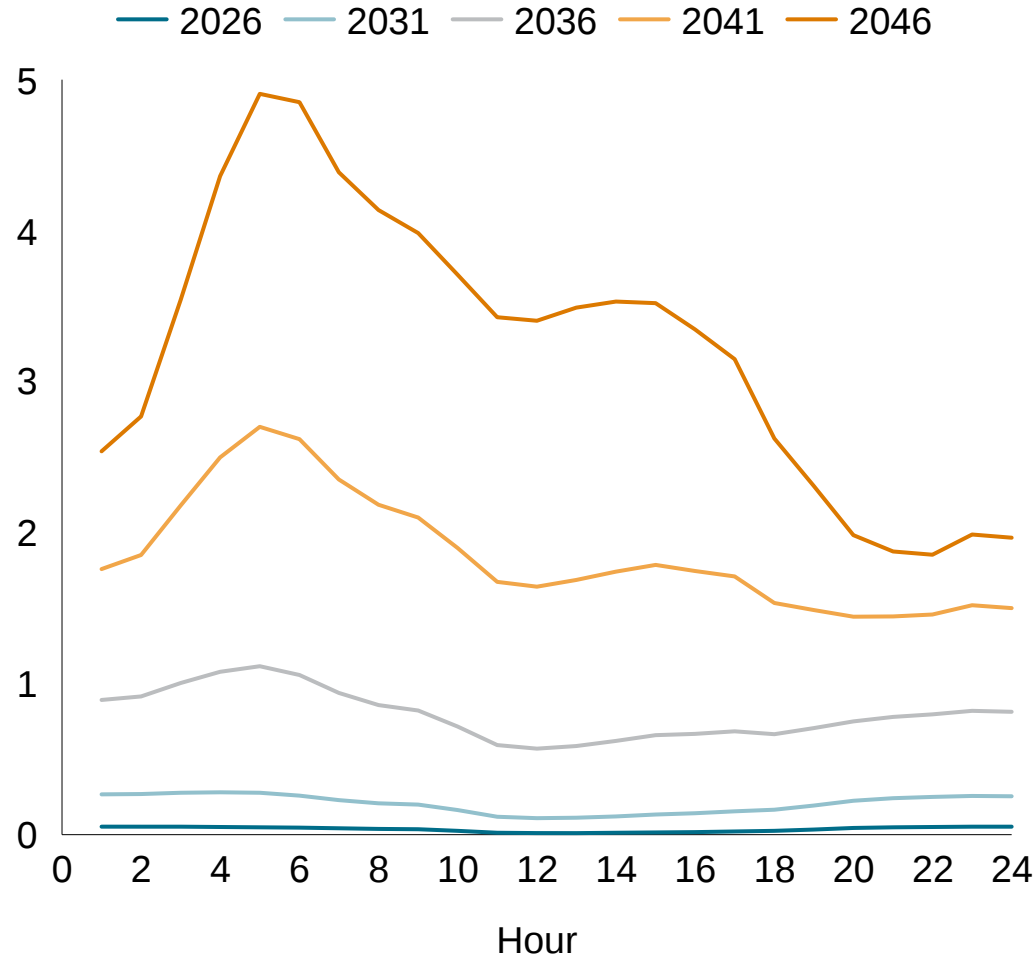


We developed 8760 load shapes for the next 20 years for each zone based on the MHD EV forecast

MHD EV hourly load statistics – PJM

Year	Average load (MW)	Peak load (MW)	Month of peak	Hour of peak
2026	35	87	December	1
2031	204	443	December	4
2036	796	1,705	December	5
2041	1,855	3,999	December	5
2046	3,235	7,176	December	5

Average MHD EV load by hour – PJM
GW



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Vehicle classification

Type of EV vehicle	Definition
Medium- and heavy-duty trucks (MHDT)	MHDTs refer to, with some regional nuance, vehicles in the US Department of Transportation's gross vehicle weight rating (GVWR) categories 4-8 (more than 14,001 lb)
Medium-duty trucks (MDTs)	Medium or medium-duty vehicles refer to those in GVWR categories 4-7 (14,001-33,000 lb)
Heavy-duty trucks (HDTs)	Heavy or heavy-duty vehicles refer to those in GVWR category 8 (more than 33,001 lb)
Long-haul HDTs	HDT with a sleeper cab, not requiring to return to depot at the end of the day
Short-haul HDTs	HDT with a day cab for regional transportation
Transit Buses	Medium/Heavy Duty vehicles for the transportation of people in transit systems (incl. inter-city coaches)
School Buses	Medium/Heavy Duty vehicles for the transportation of pupils and students to educational facilities
Delivery Vans	Commercial vans for transporting goods (all GVWR categories, primarily Class 2, 3 and 4)
Light Duty Vehicles (LDV)	Passenger vehicles including SUVs and pickup trucks (GVWR categories 2-3, up to 14,000 lb)

Acronyms

ACC: Advanced Clear Car

ACT: Advanced Clean Truck

BEV: Battery Electric Vehicle

CAFE: Corporate Average Fuel Economy

CARB: California Air Resources Board

DCFC: Direct Current Fast Charging

EPA: Environmental Protection Agency

EV: Electric Vehicle

GHG: Greenhouse Gas

HEV: Hybrid Electric Vehicle

ICE: Internal Combustion Engine

IRA: Inflation Reduction Act

kWh: Kilowatt Hour

LDV: Light Duty Vehicle

NACS: North American Charging Standard

NHTSA: National Highway Traffic Safety Administration

MaaS: Mobility as a Service

MHD/MHDV: Medium and Heavy Duty Vehicle

PHEV: Plug in Hybrid Electric Vehicle

MPG: Miles per Gallon

MWh: Megawatt Hour

S-177 States: 177 states that choose to pursue California legislation as opposed to national

REX/REEV: Range Extender Electric Vehicle

TOU: Time of Use

VIO: Vehicles in operation

VMT: Vehicle miles traveled

ZEV: Zero Emission Vehicle

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