Bottom-Up EV Load Forecasting and System-Level Electrification Impacts

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ESIG Long-Term Load Forecasting Workshop
June 13, 2023


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GRID INTELLIGENCE, DELIVERED.

Racing up the S-curve of EV adoption: Challenges

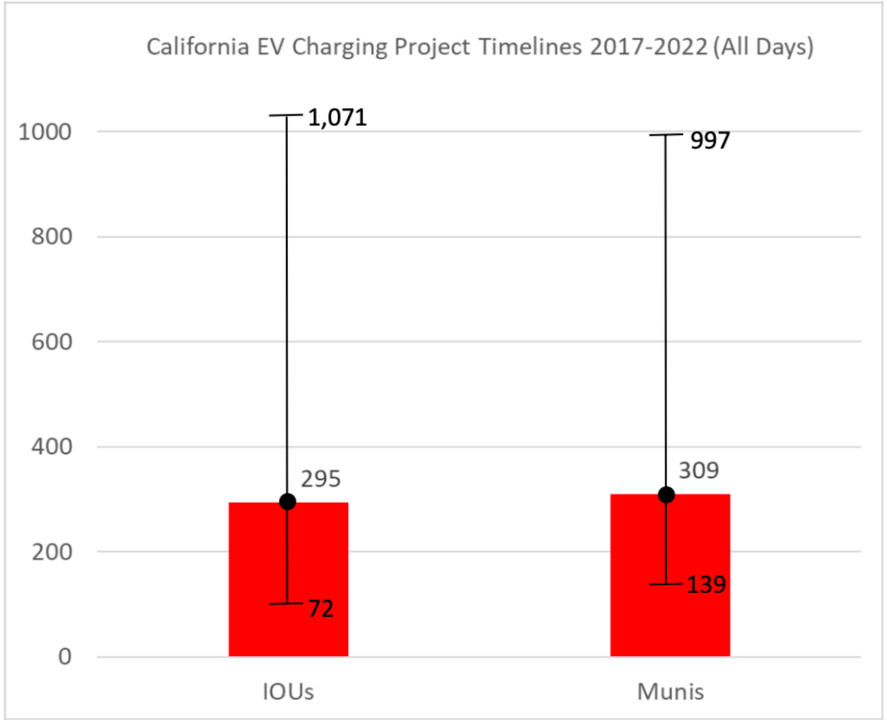
Now

Utility interconnection processes are not keeping up with the current pace of EV charging station requests

Up Next

Distribution planning processes are not preparing grids for the coming wave of transportation electrification in 5-15 years

CA Tesla Supercharger project lengths are ~300 days, but can be much longer



Lease Signed to Open to Public (Median)

Reasons for Delays:

Transformer shortage (18-24 months)

Capacity upgrades (24+ months)

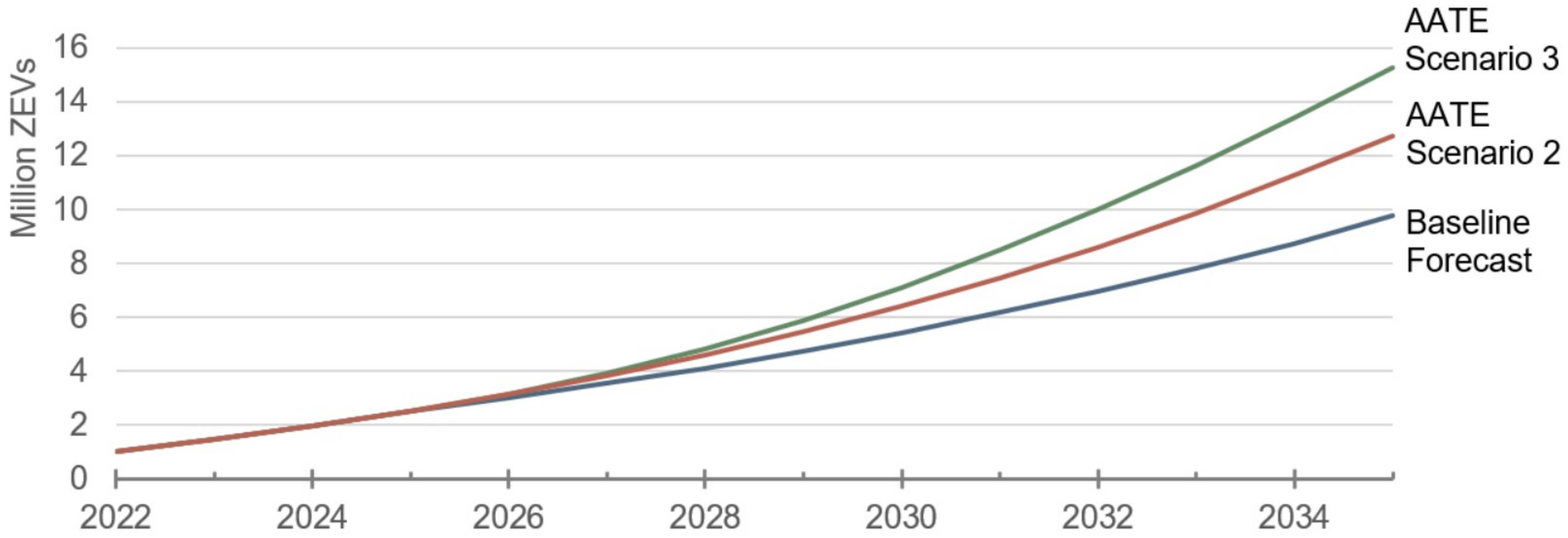
Disruption to construction (weather, events) (6+ months)

Right-of-way permitting with AHJs and CalTrans (3-6 months)

Source: Tesla, *Scaling EV Charging Infrastructure*, 2023

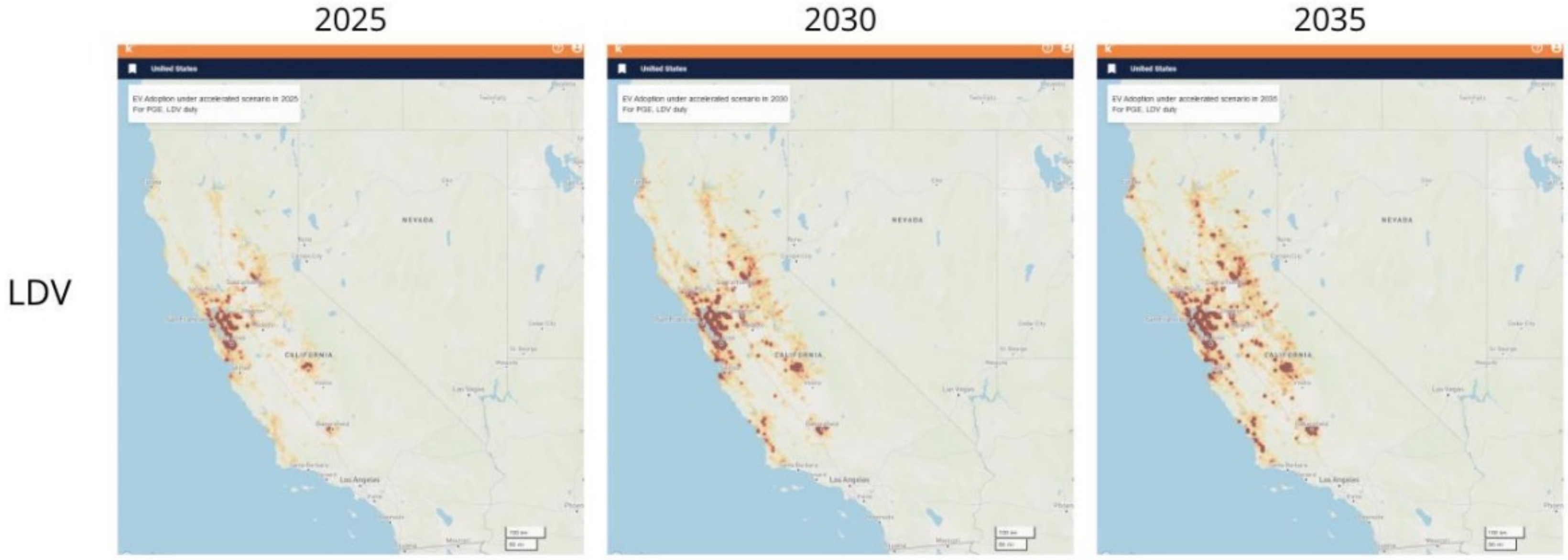
5 Year planning horizons miss the coming EV adoption wave

Integrated Energy Policy Report Light-Duty Zero-Emission Vehicle Scenarios



5 Year planning horizons miss the coming EV adoption wave

Figure 36: PG&E Accelerated High Transportation Electrification scenario ZEV adoption counts, by year and ZEV duty *(Sources: CEC, Kevala)*



Source: Kevala, Electrification Impact Study Part 1, 2023

Electrification Impacts Study (EIS)

A new full-scale approach to premise-level analysis that identifies where and when the distribution grid will need enhancements under specific policy or planning scenario assumptions.

Forecasted Net Loads

- Estimate net loads at a premise level.
- Incorporate adoption of PV, batteries, EVs, and building electrification.
- Aggregate premise load to locations on the grid.
- Generate scenarios of adoption of DERs to test a range of outcomes.

Capacity Needs

- Identify current capacity from secondary transformers to sub-transmission feeder banks.
- Determine additional capacity needs due to forecasted net loads.
- Determine range of capacity needs based on scenarios of DER adoption.

Locational Costs

- Estimate unit costs to meet capacity needs.
- Determine incremental capital investments to meet capacity needs.
- Quantify revenue requirement and marginal costs by distribution asset.
- Aggregate grid asset marginal costs by location.

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CA EIS: Load and DER forecasts for 12 million+ premises in CA's 3 large IOUs

2022-2035 ZEV Adoptions in PG&E, SCE and SDG&E

Base Scenario	High Scenario	Accelerated Scenario
LDV (BEV/PHEV): 3,172,598	LDV (BEV/PHEV): 10,013,953	LDV (BEV/PHEV): 9,530,034
MDV/HDV: 227,140	MDV/HDV: 218,710	MDV/HDV: 230,876

*Targets sourced from California Energy Commission and California Air Resources Board studies

CA EIS: Data Ingestion

Data ingestion and joining, or linking, comprised the vast majority of the Part 1 analysis

- 100 terabytes total, 64 terabytes in AMI data alone

IOU	AMI Data (Terabytes)	No. of AMI Meters* (Millions)	No. of AMI Data Records (Millions)	No. of Distribution Assets** (Thousands)
PG&E	31	6.07	318,347	916
SCE	25	5.3	251,145	753
SDG&E	7	1.51	75,949	171

*Combination of 15-minute and hourly meters
**Feeders, (service and bank) transformers, and substations

- Mapping geospatial grid infrastructure, AMI, and rates
- Data quality and completeness
  - AMI data: Outliers and missing time series data
  - Premises associated with multiple feeders, rates, billing, and interconnection data all had gaps
  - Gaps remain: feeder connectivity to transformer banks and asset ratings

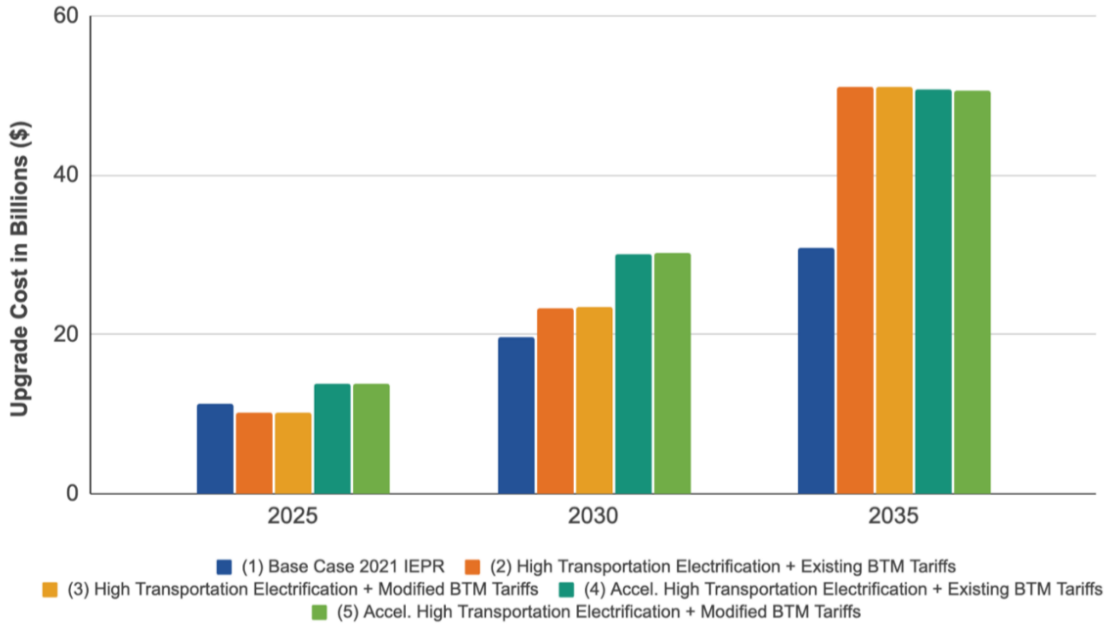
CA EIS: EV and EVSE Modeling Summary

	Target	Size	Adoption	Behavior
EVs	**Input** is a target of vehicle counts	**Output** is total count and type of vehicles for a premise	**Output** is 1) ranked likelihood of adopting EVs, and 2) simulated adoptions of EVs	**Output** is hourly charge profile over year of simulation
EVSE	**Input** is adopted personal and fleet EVs	**Output** is type and quantity of chargers at premise	**Output** is 1) ranked likelihood of adopting EVSEs and 2) simulated adoption of EVSEs	

See Kevala, Electrification Impact Study Part 1, 2023, for full methodology and assumptions

Up to $50 billion in traditional investments by 2035 if no mitigation

Figure ES-1: Estimated total capacity upgrade costs for the three large California IOUs, including new substations, transformer banks, feeders, and service transformers *(Source: Kevala)*



Adding 3.2-10.0M light-duty (LD) ZEVs by 2035 has roughly the same energy impacts as 2.9-8.7M residential customers' worth of new energy demands

Base Case

- **ZEV adoption sources:**
  - **LD:** CEC 2021 IEPR Base Case
  - **Medium duty/heavy duty (MD/HD):** CEC 2021 IEPR Base Case
- **2035 ZEV-equivalent energy:**
  - **3.2M LDs:** 2.9M residential customers
  - **227k MD/HDs:** 173k commercial customers

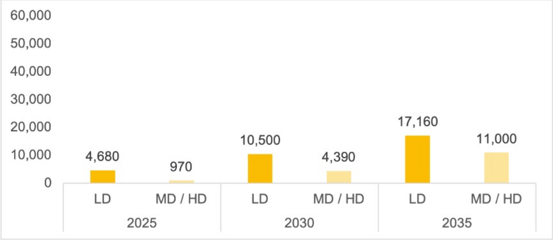
High Electrification

- **ZEV adoption sources:**
  - **LD**: CARB ACC II
  - **MD/HD**: CARB 2020 SSS (ACT & ACF)
- **2035 ZEV-equivalent energy:**
  - **10.0M LDs:** 8.7M residential customers
  - **219k MD/HDs:** 164k commercial customers

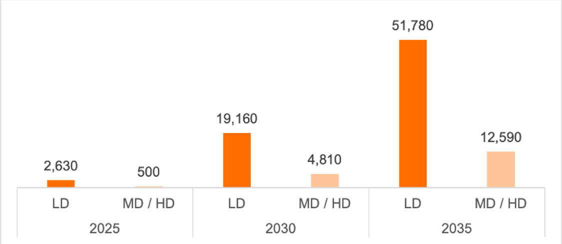
Accelerated High Electrification

- **ZEV adoption sources:**
  - **LD**: CEC 2021 IEPR Bookend Case
  - **MD/HD**: CEC 2021 IEPR High Case
- **2035 ZEV-equivalent energy:**
  - **9.5M LDs:** 8.2M residential customers
  - **231k MD/HDs:** 198k commercial customers

Three IOUs' Total EV Energy (GWh)
Base Case



Three IOUs' Total EV Energy (GWh)
High Electrification



Three IOUs' Total EV Energy (GWh)
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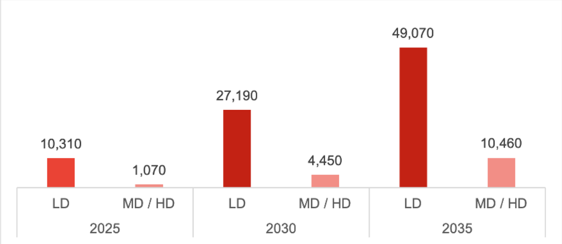

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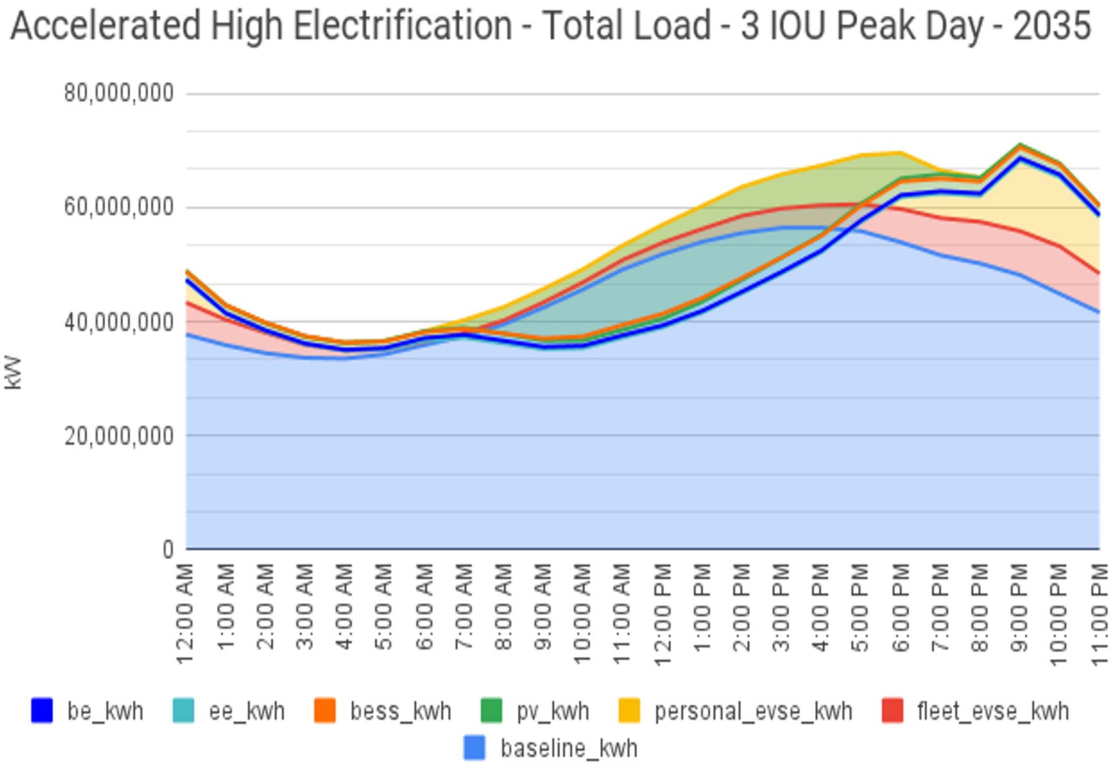
EV charging drives peak load timing change

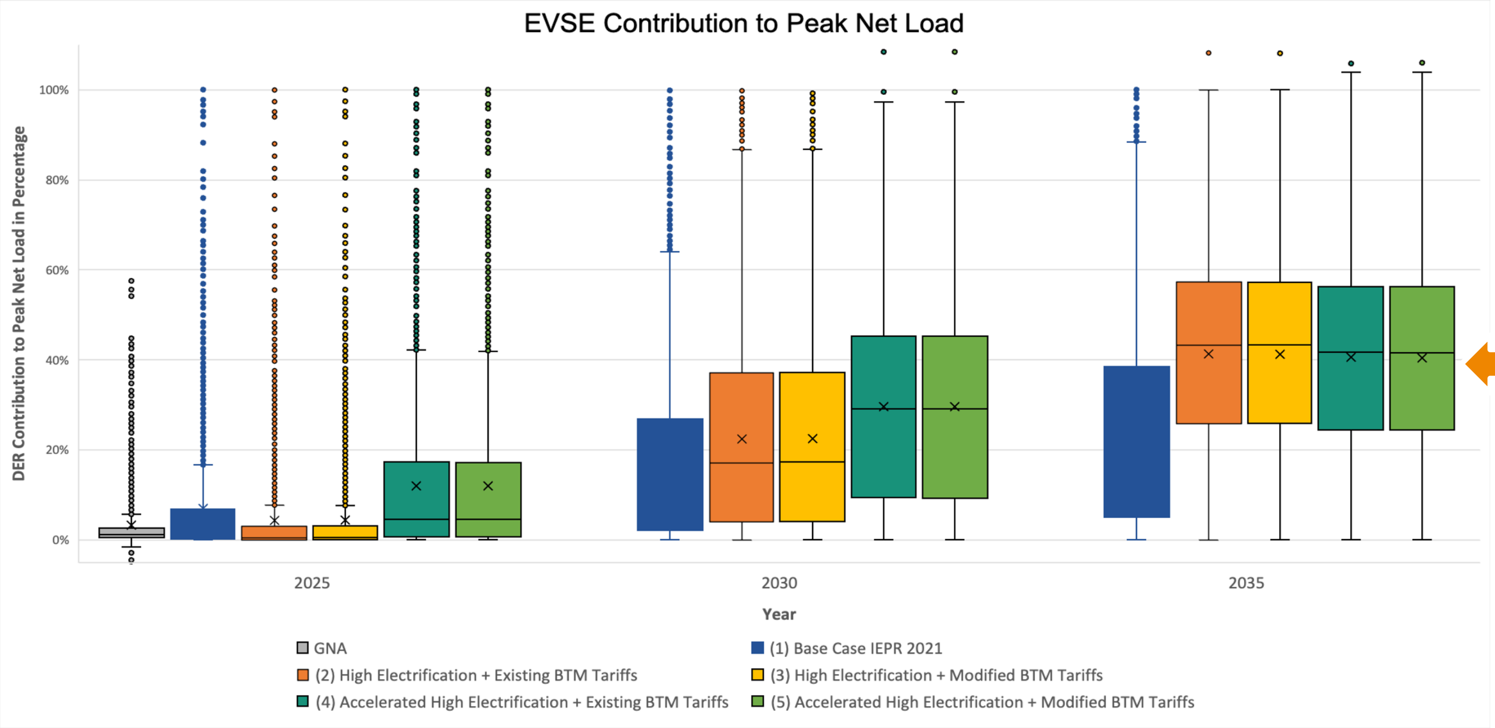
The study assumed **adherence to existing time-of-use (TOU) periods** through 2035 to study what may be a worst-case scenario for peak load impacts from concurrent vehicle charging

As a result, the **system peak shifts to 9 pm**, which is the current end of the peak period for most of the IOU's TOU rates



Source: Kevala, Electrification Impact Study Part 1, 2023

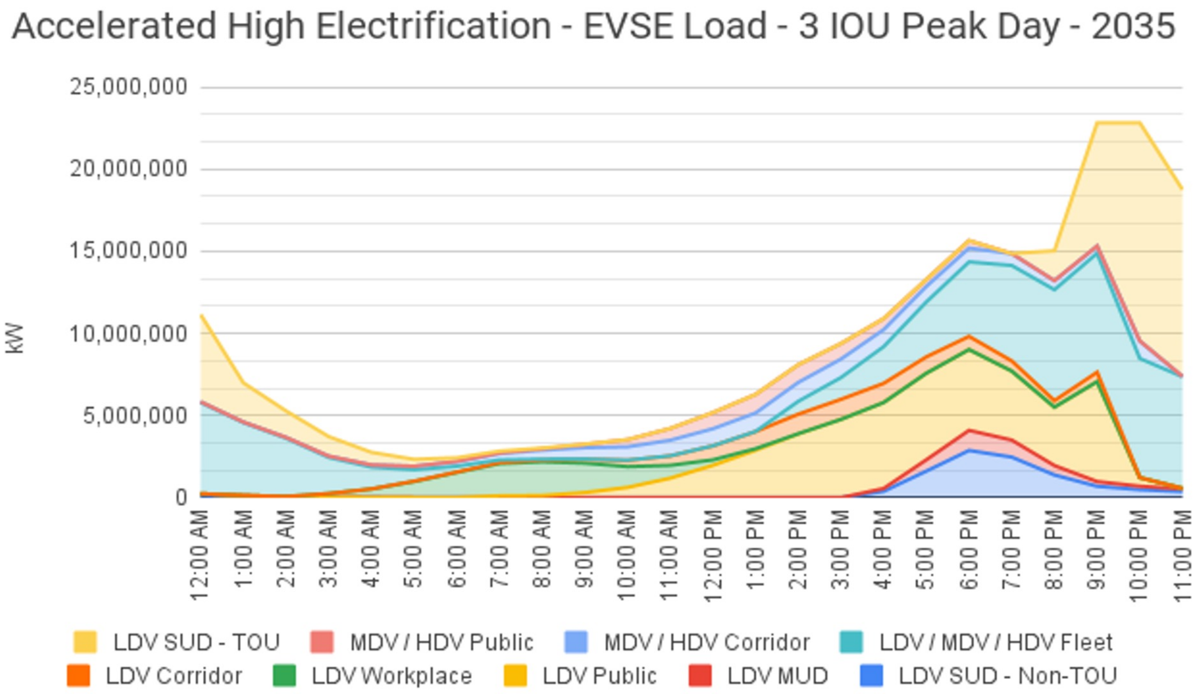
For all scenarios, EV charging contributes greatly to average feeder peak net load beyond 2025



By 2035, EV charging can be as much as 40% of the average feeder peak net load under high EV penetration scenarios

Source: Kevala, Electrification Impact Study Part 1, 2023

Granular EVSE load curves by use case allows targeted mitigation modeling



Source: Kevala, Electrification Impact Study Part 1, 2023

CA Electrification Impacts Study Part 1 Key Takeaways

California has an **opportunity to manage and mitigate electrification impacts at the distribution system first** before making costlier transmission system upgrades.

Premise-level forecast enables **planning to start with DERs, not end with them.**

Transportation electrification is the primary driver of grid requirements, and these costs escalate in earnest in 2030 and **dramatically increase by 2035 regardless of scenario.**

The **"hockey stick" of grid requirements and costs is coming,** and the distribution planning process and tools that support it need to adapt to be **proactive** and anticipate it.

Bottom-Up EV load forecasting is not without its challenges…

Granular modeling needs high quality, granular data

Granular modeling means granular assumptions – these all require rigor!

Mapping datasets across multiple domains (*AMI, distribution networks, built environment, zoning, transportation patterns, vehicle registrations, demographics, etc.*) requires diligence and innovative solutions

But it’s worth it!

Go beyond the average customer class load shape and capture dynamic DER adoption and energy usage behavior at the customer level

Calculate system cost impacts from the service transformer up to identify unseen impacts and opportunities

Model the value of DERs and EV charge management as hyper local grid planning solutions

Thank you

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