

Evolving Grid Planning Practices for Electric Vehicles

ESIG Grid Planning for Vehicle Electrification Task Force

Webinar introducing Whitepaper
Charging Ahead: Grid Planning for Vehicle Electrification

December 2023



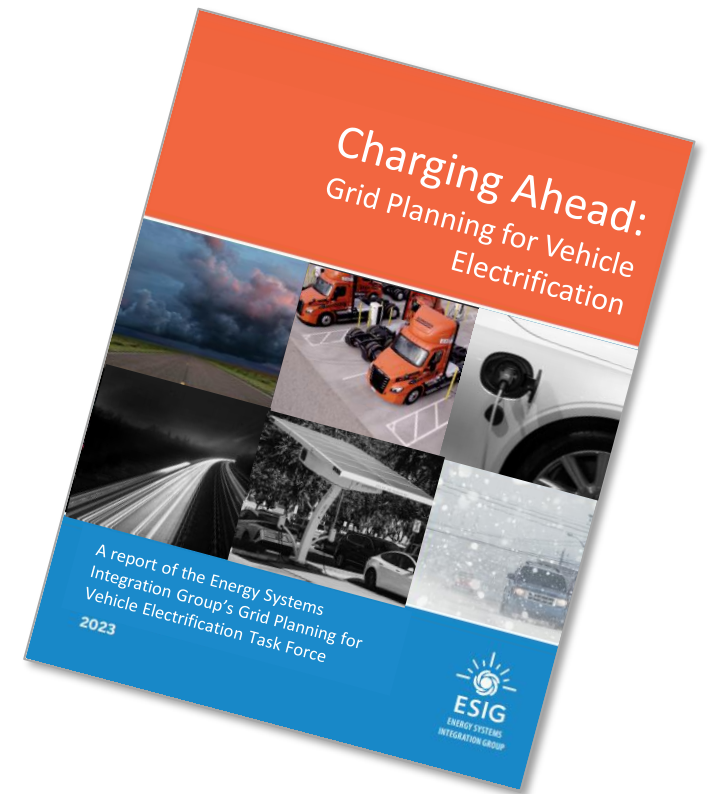
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 - Utilities
 - Vehicle Manufacturers
 - Aggregators
 - Charging Operators
 - Regulators
 - State Energy Offices



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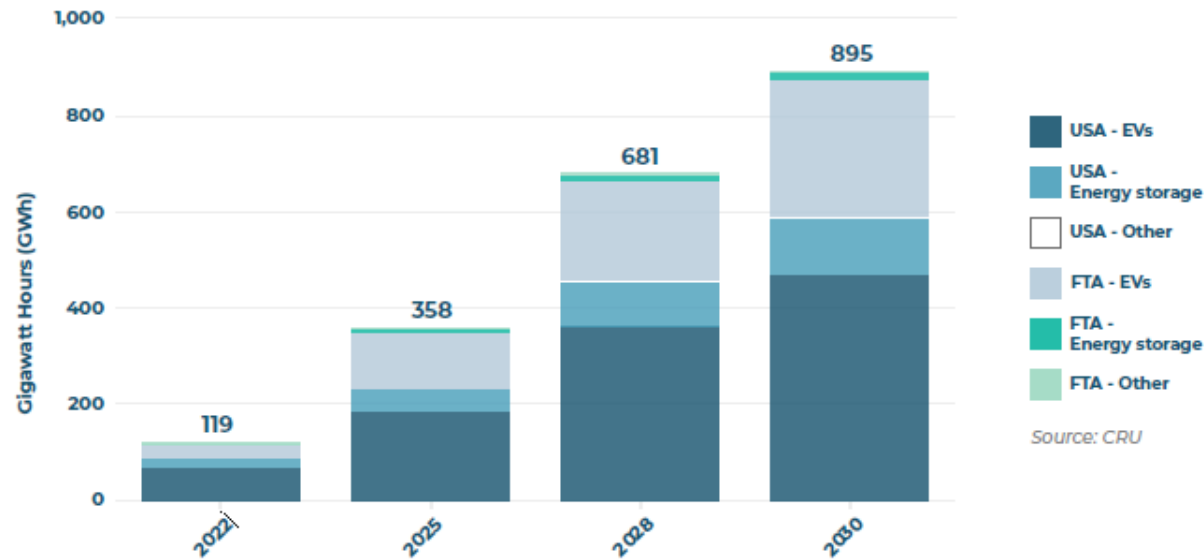
How big of a change is this?

25
GWh

126 GWh

Stationary Battery
Storage in the US today²

Storage in the 2.1M EVs
on the road today²



Nearly unprecedented change:

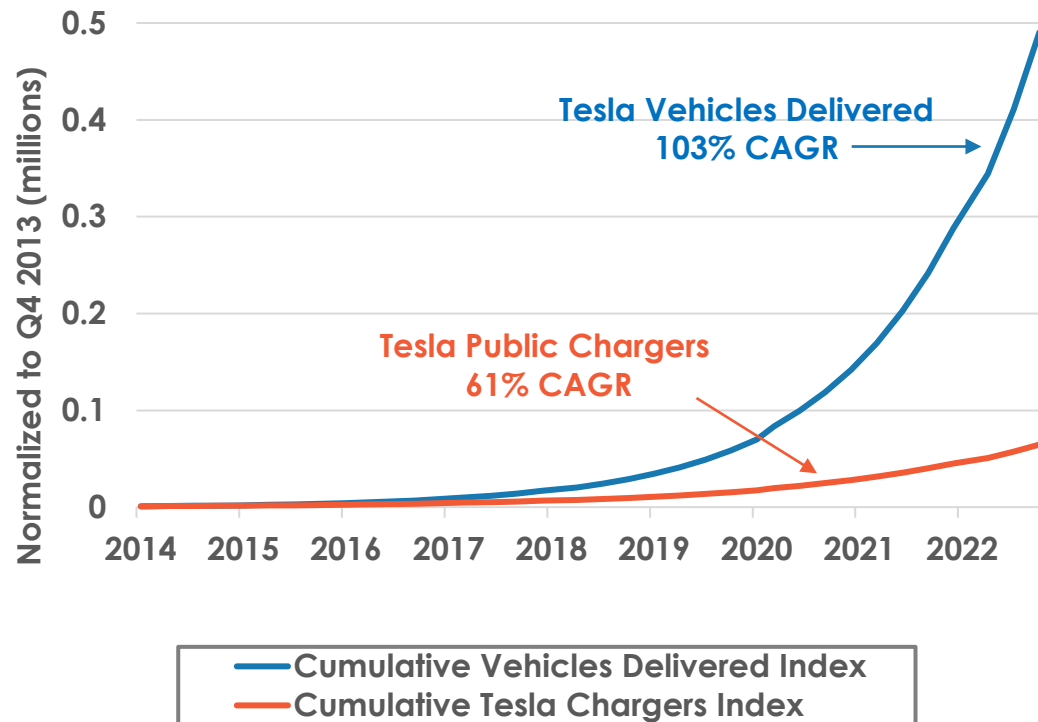
- EVs are first major load growth since air conditioning in the 1960s.
- Demand from 1 EV $\approx$ 1 house
- Concentration of EVs can overwhelm local distribution system capacity.
- Adoption rates to vary significantly across communities
- Cumulative distribution investment across the country could be \$200B by 2050 to facilitate EVs.¹

Transportation electrification continues to accelerate

Drivers: customer demand, commitments from vehicle manufacturers, public policy targets and incentives

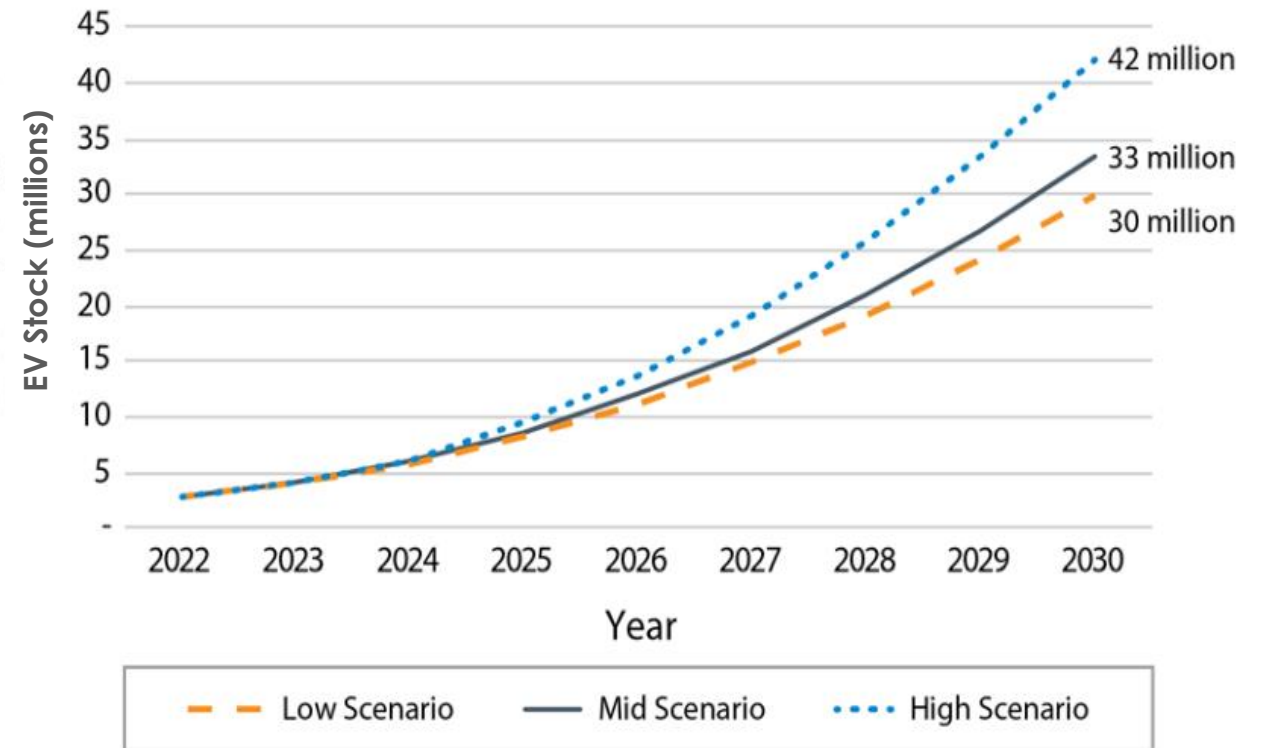


Tesla vehicles delivered and public chargers¹



U.S: EV Adoption Scenarios (light-duty)²

33million EVs = 1200+ GWh



The pace of EVs on the road has far exceeded public charging network roll-out for a variety of reasons, including a lack of sufficient grid infrastructure. This trend is also seen in non-Tesla charger deployments and highlights the accelerating demands of grid planning to support vehicle electrification.

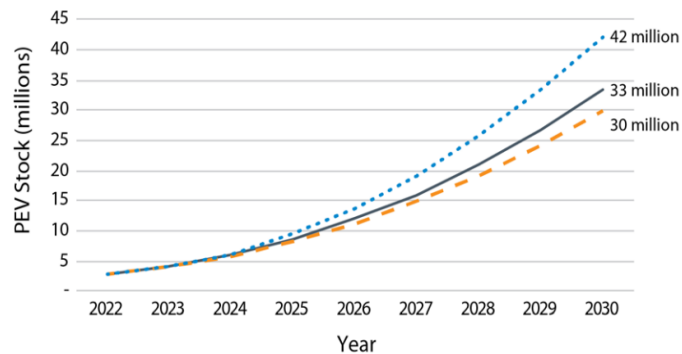
Uncertainty Abounds



Adoption Rates?

How many vehicles are expected by when?

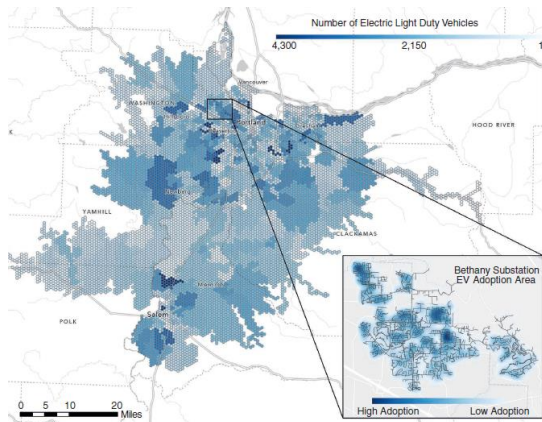
- Type of vehicles (SUV, trucks)
- Technology Change (efficiency & battery technology)
- Use Cases (LDV, MDV, fleets)



Location of Charging?

Where will charging take place?

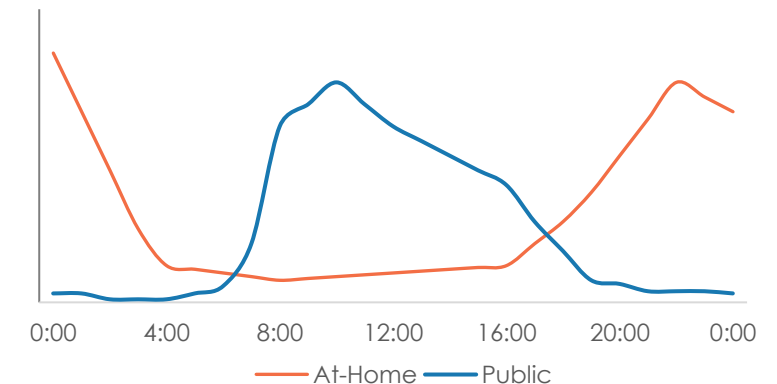
- Home vs. workplace charging?
- Which communities will see adoption first?
- Where do people drive?



Timing of Charging?

When will vehicle owners charge?

- Hourly charging profiles
- Event-based planning (holidays, storms, etc.)
- Rate design and incentives

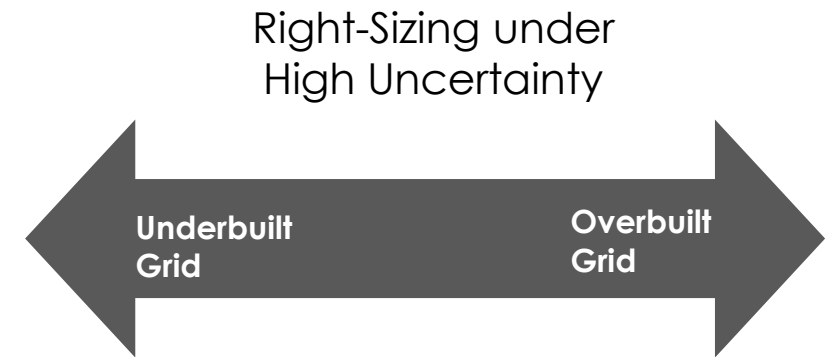
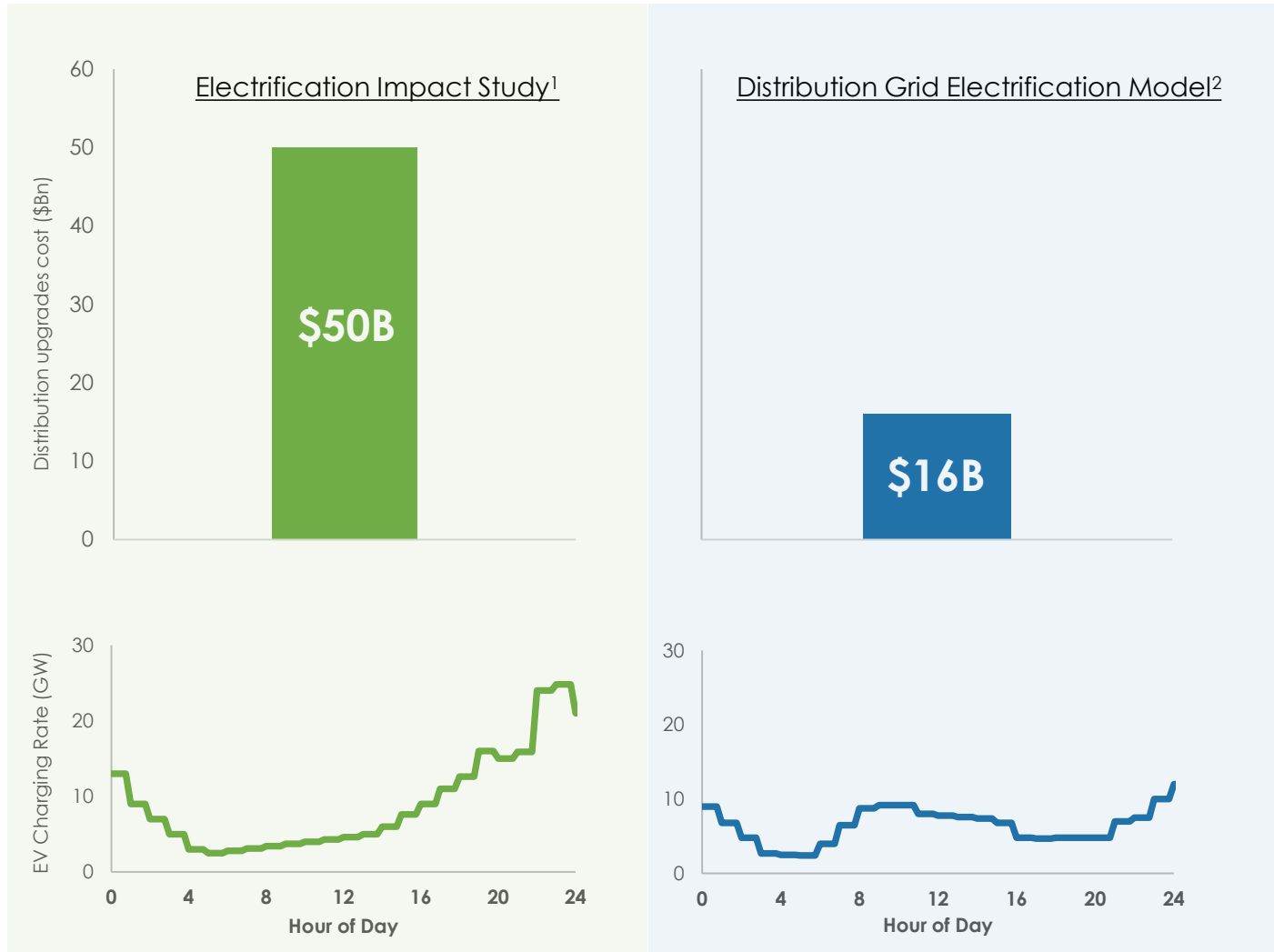


The answer to each of these questions has significant implications for power system planning and cost, particularly for distribution networks.

Rightsizing upgrades

Need to balance cost and pace of distribution upgrades under uncertainty

Two studies looking at California, show vastly different costs...



Risks:

- Unreliable grid
- Stunted public interest in EVs
- Long waits for charger installs

Risks:

- Expensive underutilization
- Inequitable burden of costs

Prioritizing Grid Planning Actions to Take Today



Priorities for effectively integrating vehicle electrification into grid planning

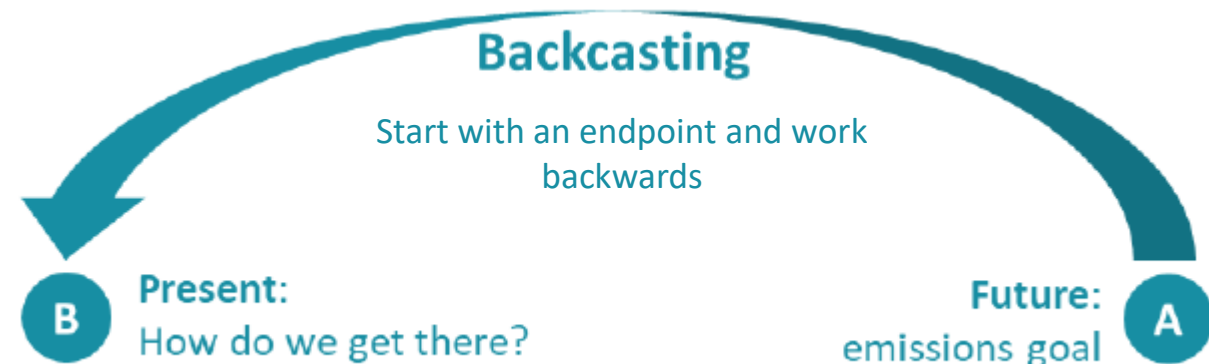


1. **Improve forecasting** by considering multiple vehicle end uses, new vehicle technologies, and more data sources. Use of scenarios to capture the uncertainty of locational and temporal grid impacts .
2. **Embrace smart charging** options at every level of the grid from the premise to the bulk system. Targeted smart charging, operating limits, and strategically located storage can help bridge immediate load growth while long-term solutions are implemented.
3. **Incorporate future-ready equipment** to allow for upsizing of infrastructure or enable future upsizing whenever equipment is being replaced.
4. **Promote proactive upgrades** identified by a multi-stakeholder group because EV adoption and charging needs can grow much faster than utility upgrades can be implemented.

Use scenario planning to capture adoption trends, location, and timing of load impacts

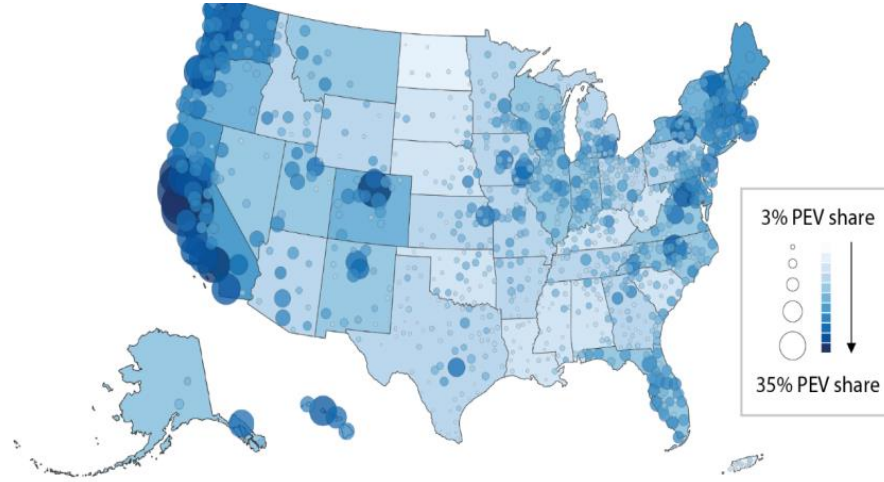
Forecast at a granular level by capturing the key variables

- **Adoption:** how many and when will people switch to EVs?
- **Use Case:** Differentiate how a particular vehicle will be used across the year
 - School buses vs. city buses
 - Commuter vs. secondary vehicles
- **Technology**
 - Larger batteries with faster charging
 - Potential future technology development
 - Different charging rates across state of charge

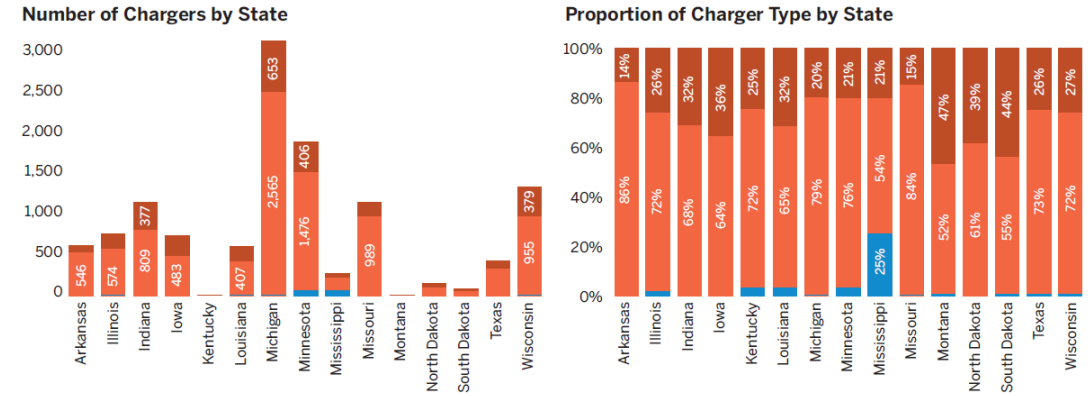


Improving Forecasting: Getting to location through Use Cases

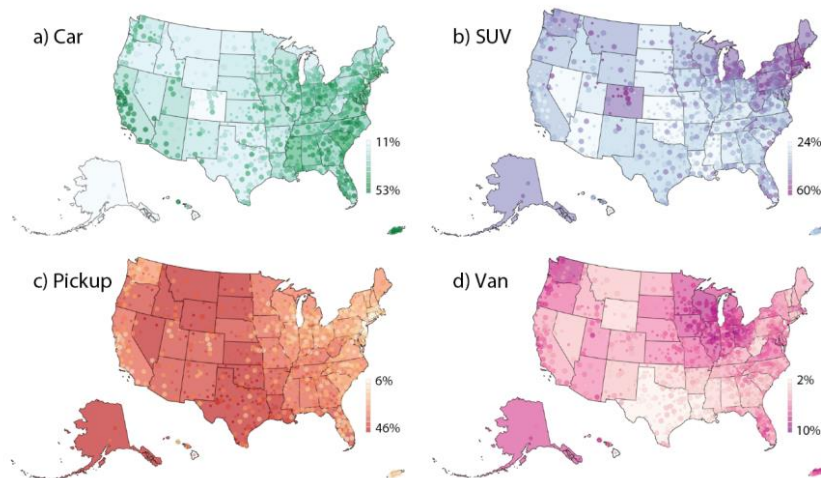
2030 EV National Adoption¹



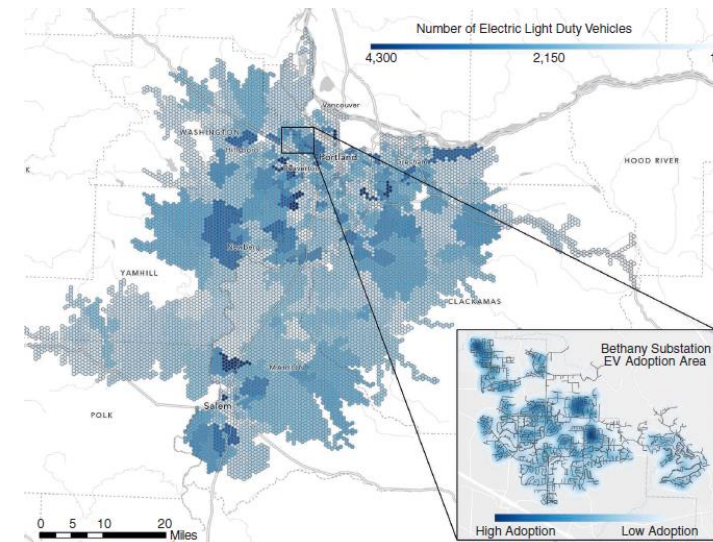
MISO Changes By State²



Use Cases – Current LDVs¹



Within a service territory (Portland, Oregon)³



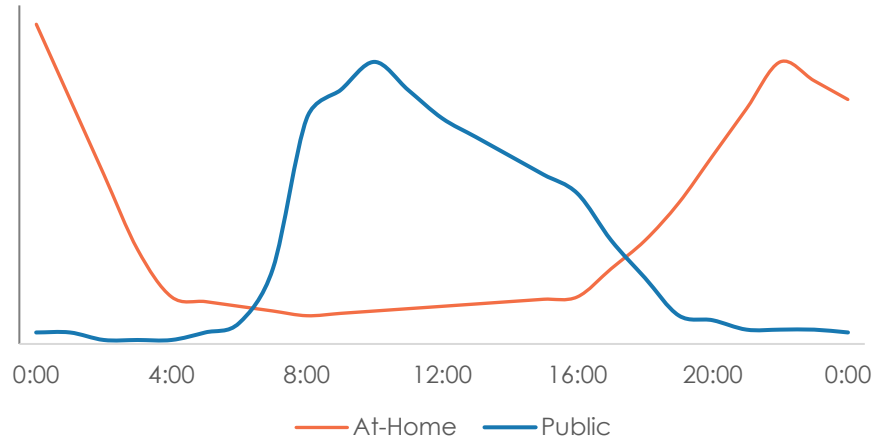
¹NREL. 2023. The 2030 National Charging Network
²MISO. 2023. Based on EIA data with participation rates applied.

³PGE. 2023.

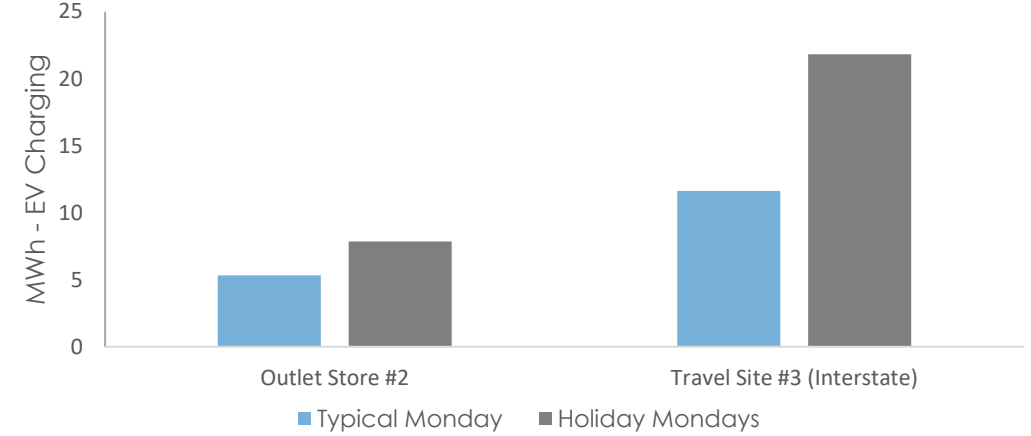
Improving Forecasting: Getting to Timing



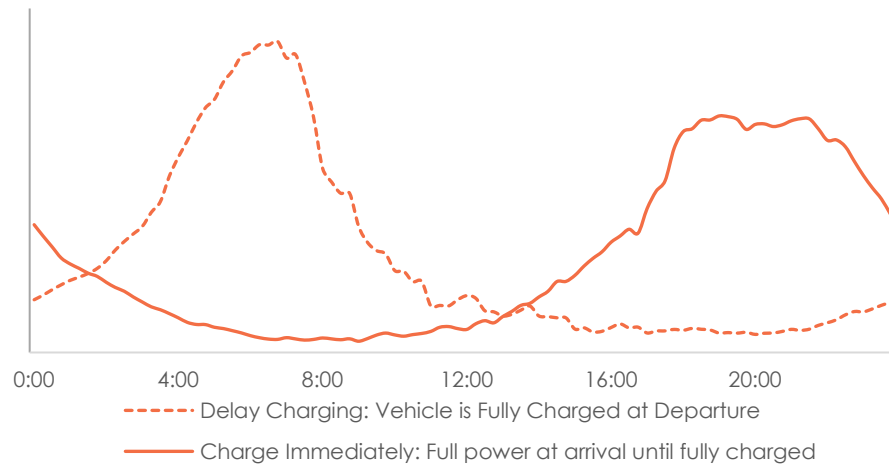
At Home Vs Public Charging¹



Public Charging: Holidays vs Workdays³

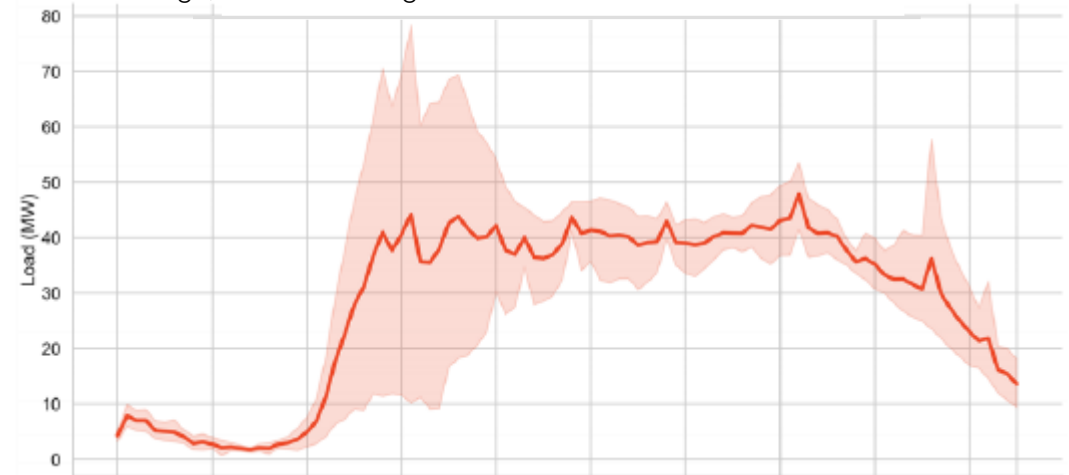


At Home Charging: Immediate vs Delayed²



Charging Profiles Vary by Location and time of year⁴

Cambridge, MA has ~10% higher winter traffic



¹ Data: 2022. Powell, Cezar, & Rajagopal

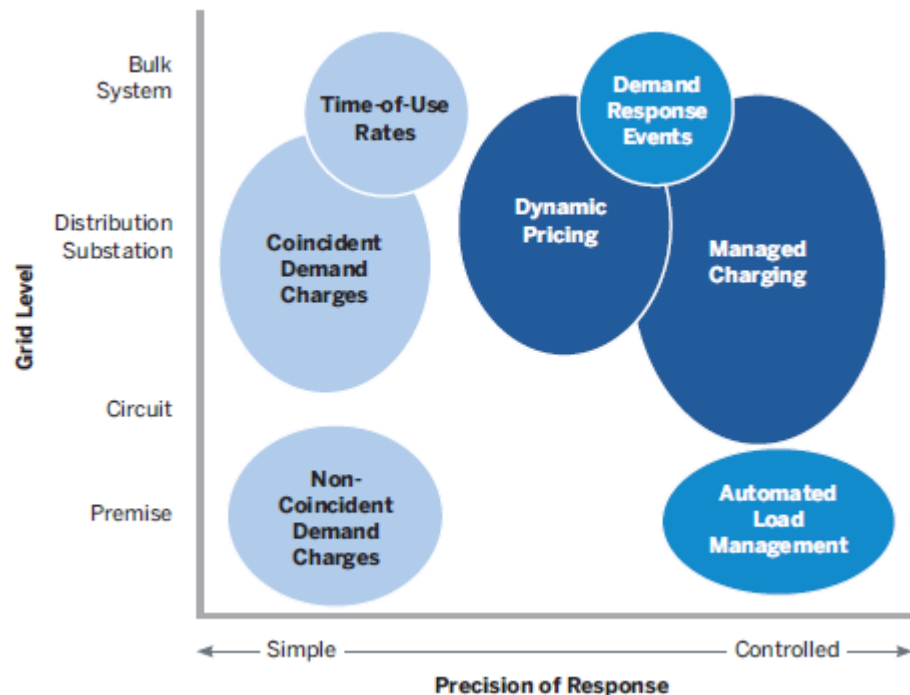
² Data: EVI-lite-Pro

³ Data: Provided to ESIG

⁴ Eversource/Walker. 2023. Vehicle Electrification and Grid Impact Modeling.

Many Flavors of Smart Charging – pricing, control, preset, and dynamic

- Traditional assumptions for what can be accomplished with demand flexibility should be re-evaluated in the context of EVs.
 - San Diego Gas & Electric observed that 77% to 87% of charging happened off-peak.¹
 - TOU pilots from 2008-2012 targeting the whole home resulted in a 2% to 21% peak reduction.²
 - UK study showed participants with EVs reduced peak by 47% compared to 28% for non-EV drivers.³



Mitigation Measure	Classification		Suitability to Address Challenges at Multiple Levels				Ease of Implementation	Cost
	Signal	Timing	Site	Distribution	Transmission	Generation		
Demand charge	Pricing	Preset						
Time-of-use rate	Pricing	Preset						
Dynamic price signal	Pricing	Dynamic						
Consumer response to event-based demand response	Control	Dynamic						
Dynamic managed charging	Control	Dynamic						
Automated load management	Control	Preset						

More to less suitable ►►► Less to more complex ►►►

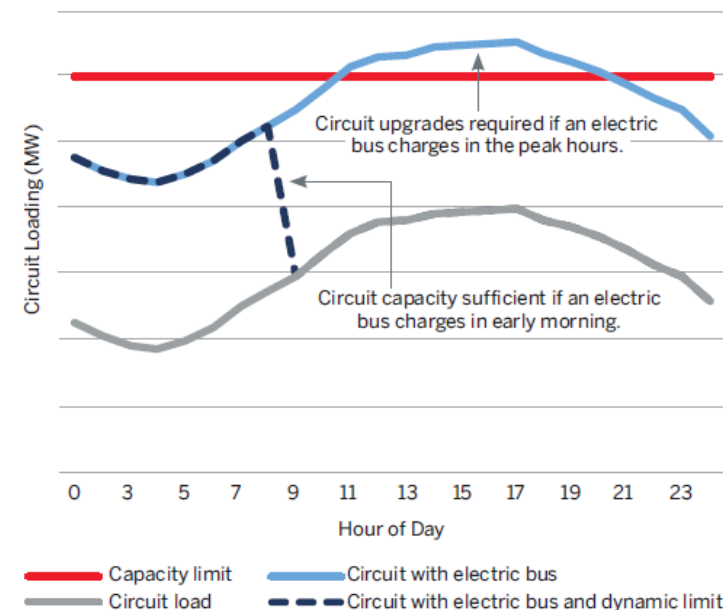
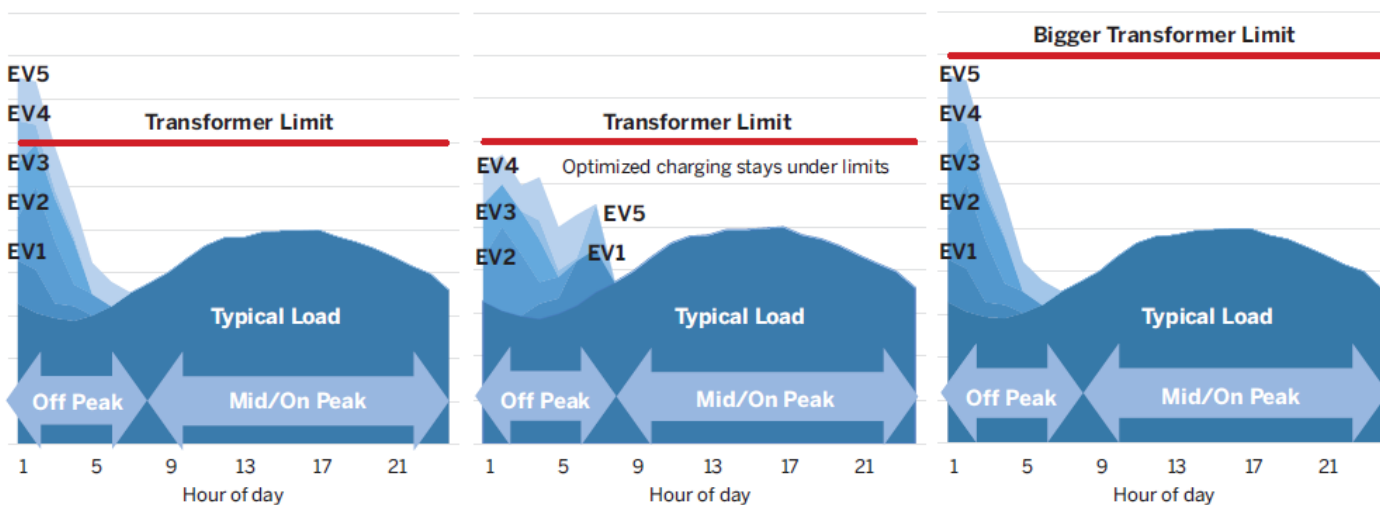
Cost and ease to implement smart charging measures are characterized relative to each other and should be evaluated against alternatives, such as infrastructure improvements.

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Can address multiple grid needs simultaneously

Care should be given to avoid unintended consequences in the design of programs, with costs evaluated against traditional upgrades

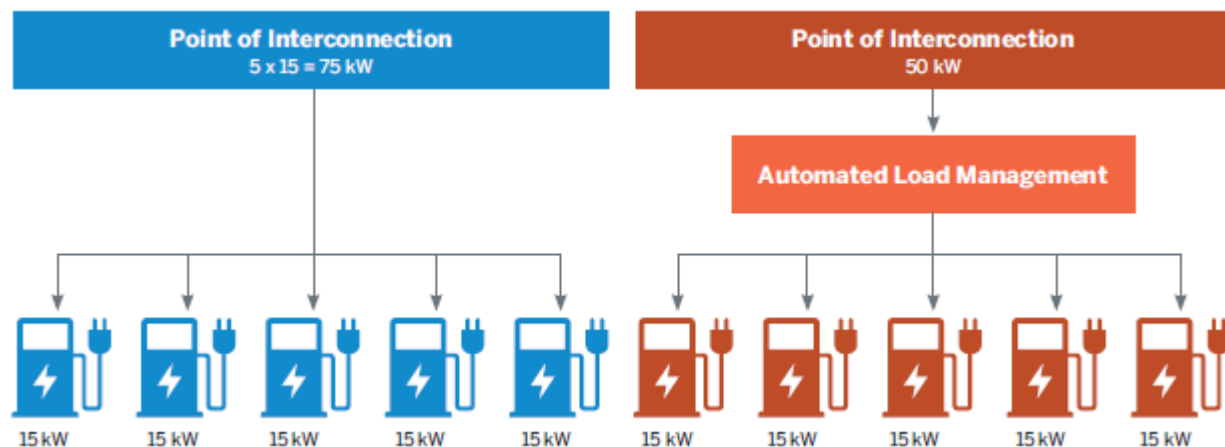
Managed charging allows dynamic operating and interconnection limits with restrictions on when the EV can charge.



Embrace Smart Charging: Solve Site-Level Constraints with Automated Load Management



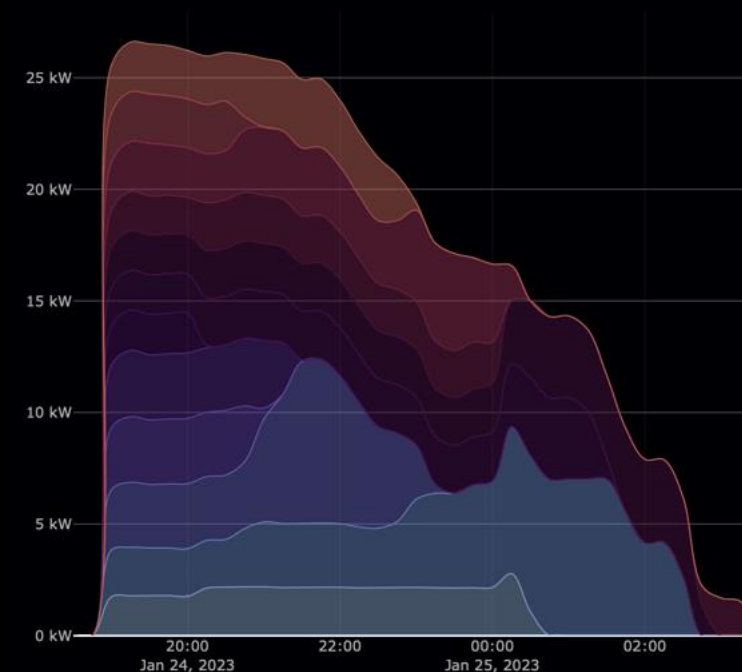
Automated Load Management (ALM) is software that schedules and prioritizes EV demand at a given point of interconnection (POI) to remain within a specified range over time.



- The CPUC found that “utilization of ALM will help lower program costs and promote efficient use of electric grid infrastructure.”¹
- When using ALM, PG&E observed cost savings ranging from \$30,000 to \$200,000 per project.²

ALM in Action

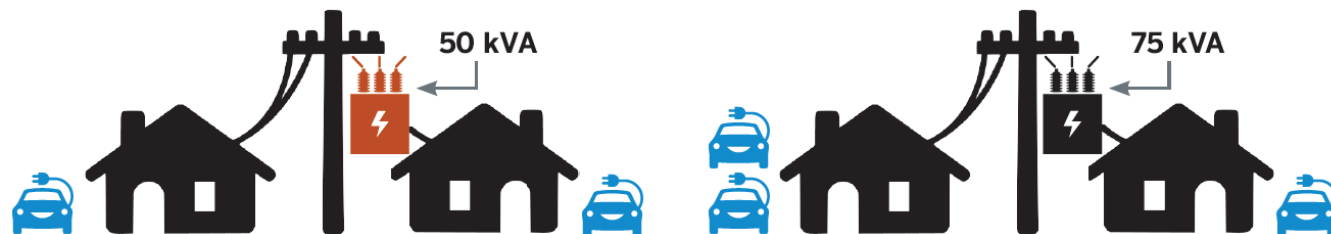
The Irish Post uses ALM to manage infrastructure constraints. In this example, the total nameplate rating of the supply equipment is 88 kW, while the site interconnection limit is 28.9 kW. By using ALM to charge the vehicles at different times of night, the aggregate vehicle profile remains under the interconnection limit.



Incorporate Future-Ready Equipment: Use Infrastructure that can support the future



Equipment Standards



Exegol Utility District

When equipment is a candidate for replacement, the utility replaces legacy designs with similar design standards that may become overloaded with incremental EVs.

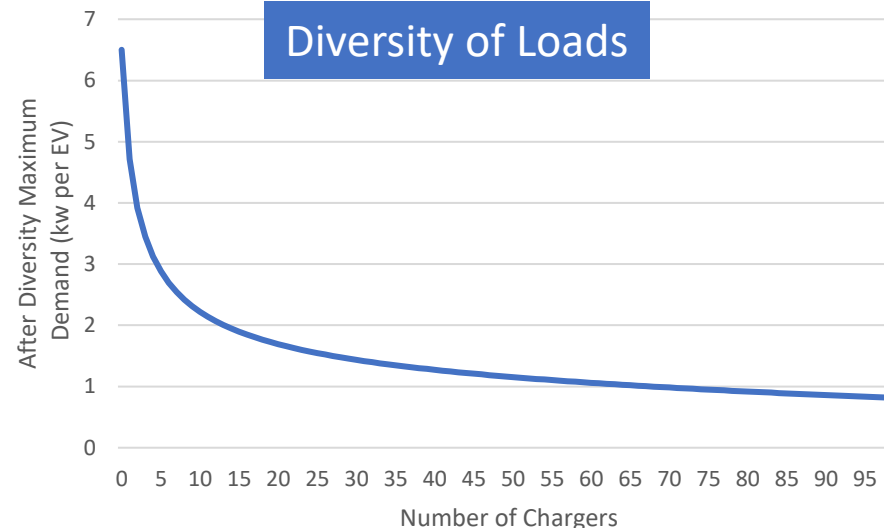
Tatooine Cooperative

When equipment is a candidate for replacement, either at end of life or when the utility is doing things like pole replacement, the utility replaces legacy designs with future-ready solutions.

Equipment Standards are used to streamline inventory, installations, engineering, etc.

- Can direct decisions about:
 - Voltage class: 4kV->12kV->26kV
 - Equipment sizing: 50 kVA ->75kVA transformer for 10 customers
 - Land parcel procurements: square footage required for substations

Diversity of Loads



Diversity of Loads inform equipment sizing

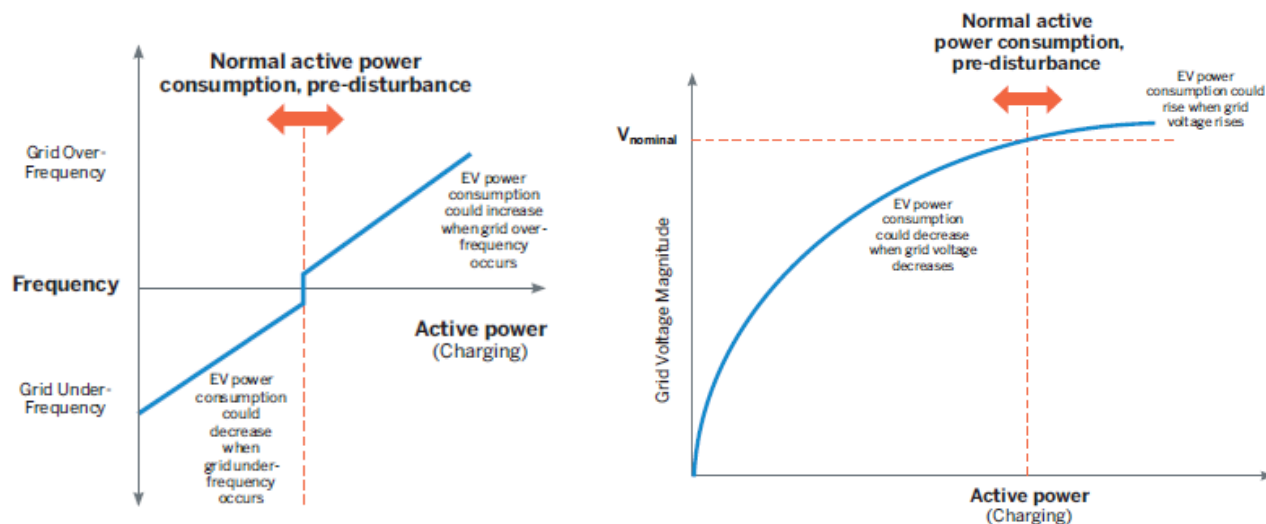
- Example: Pat charges on Tuesday, Sam on Wednesday, so grid equipment is sized for one EV
- EVs are new, so diversity needs to be calculated
 - Coordinate with smart charging designs
 - Coordinate with loss of equipment life strategy

Incorporate Future-Ready Equipment: Lessons Learned from BTM PV



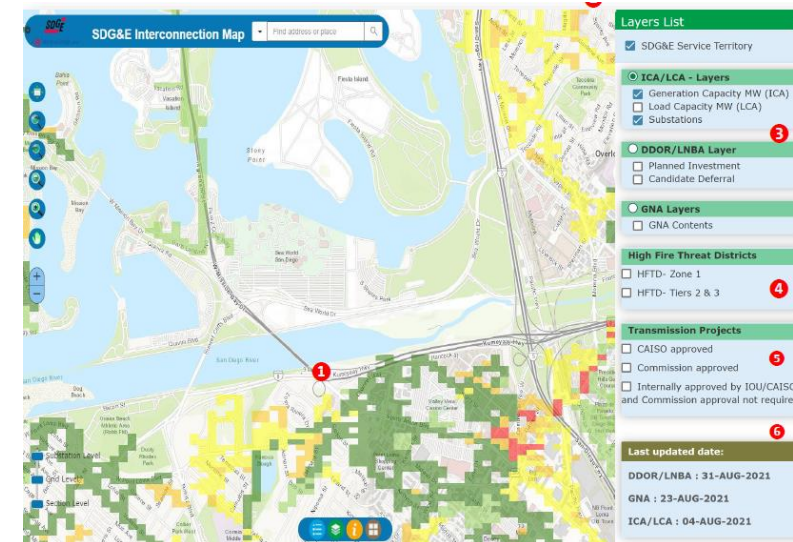
Learn from recent developments in rooftop PV

At the charger level



Define Grid Friendly
Behavior

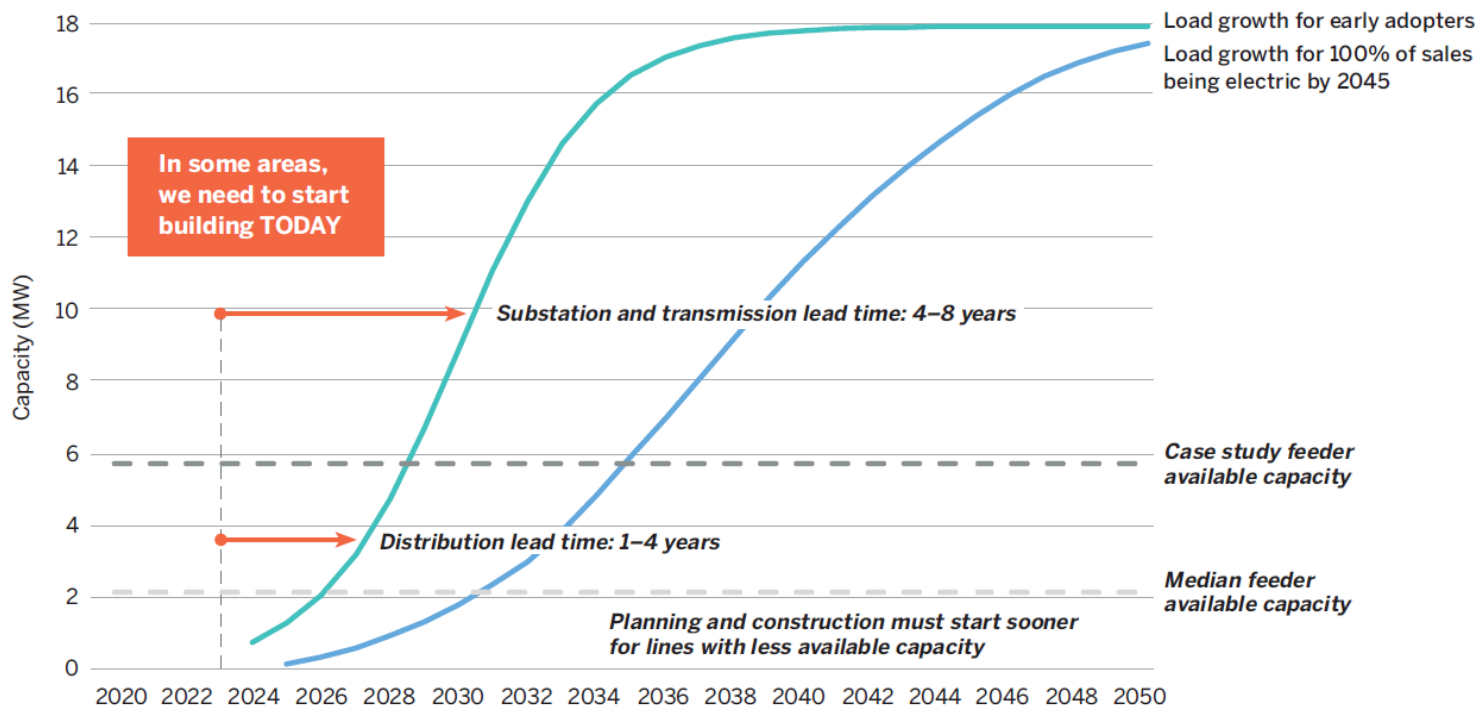
In the digital infrastructure



Capacity Maps and Queues

Getting Proactive, but intelligently

Future-ready grid upgrades that take place over decades will not be sufficient to meet all projected EV charging needs. Some locations may need upgrades today. Widespread just-in-time upgrades of distribution equipment to support the level of electrification projected would be both costly and infeasible for utility construction crews.



Right-Sizing under High Uncertainty



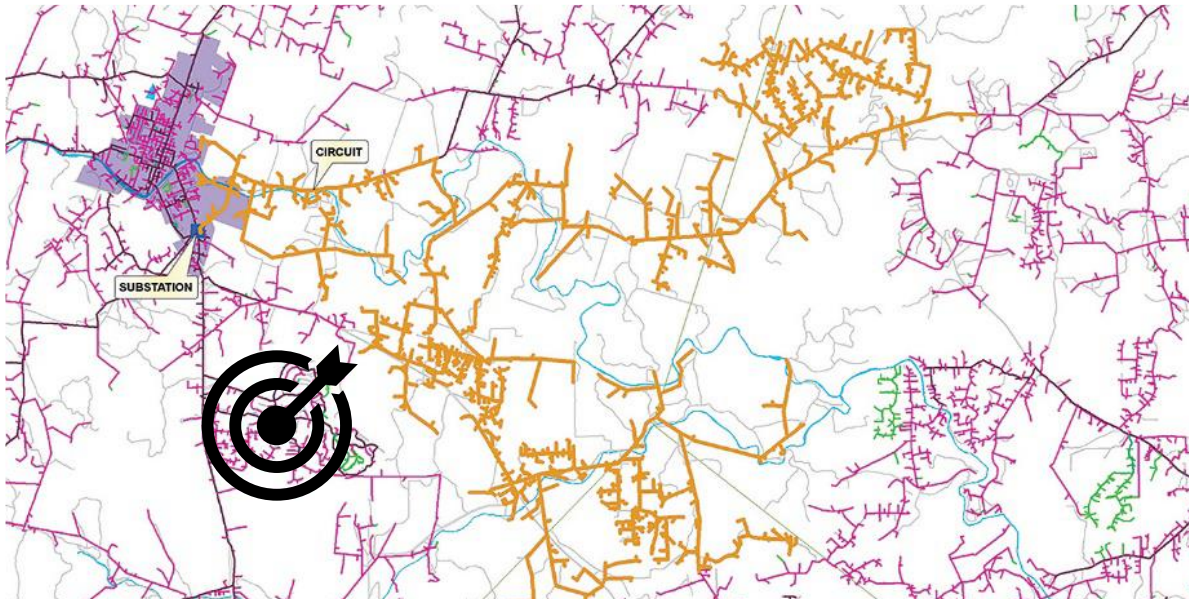
Risks:

- Unreliable grid
- Stunted public interest in EVs
- Long waits for charger installs

Risks:

- Expensive underutilization
- Inequitable burden of costs

Reduce Risk through Adaptable Plans and Multi-Stakeholder Input



Storage Deployed for EV Integration:

SCE is planning to use relocatable storage as a short-term solution to facilitate a timely customer interconnection while a permanent solution (wires or non-wires solution) is being constructed. Attempting to serve customers that are asking for large service upgrade in short lead times, SCE plans to procure thirty-seven 1MW/4MWh energy storage units over the next 5 years and anticipates a large need for these to facilitate MHD electrification.

Adaptability

- Short-term solutions may look different than the long-term answers as we learn more about customer behavior and adoption rates.

Multi-Stakeholder Input

- These upgrades can be strategically implemented, based on improved forecasting techniques, and identified by a multi-stakeholder group, to help ensure a targeted and efficient response to changing needs

Practice and Process Adaptations



ESIG

ENERGY SYSTEMS
INTEGRATION GROUP

Planning practices can change

Overarching Goal: Long-term study findings are integrated in the medium- and short-term plans to avoid widespread interconnection constraints. Too often, long-term study results are left in isolation.



FUTURE-READY EQUIPMENT

Start now; spread costs of labor and infrastructure upgrades over many years.



TARGETED SYSTEM UPGRADES

Occur where forecasting scenarios or historical data show grid needs at specific locations.



(INTER)CONNECTION PLANS

Deal with discrete near-term requests to connect new EV chargers.

Align the Grid Planning Process with the Need



Existing Processes

While today's grid planning processes vary across the country, they generally include:

- Annual system reviews
- Regularly updated grid plans with a medium- to long-term planning horizon
- Isolated evaluation of interconnection requests

Customer-Collaborative Processes

A customer-collaborative process between planners and customers allows for open communication about:

- Multiple options for interconnection
- Multiple locational alternatives

Proactive, Multi-Stakeholder Processes

Given the volume and multiple use cases of EVs, proactive processes can be well suited to:

- Ensure equity
- Facilitate regional networks
- Provide clear roadmaps for electrification planning progression

Given the scale of grid planning for vehicle electrification, new processes can help

- Even with the best planning practices (what the grid engineer can do), process changes can enable more effective and holistic grid planning for EVs.
- Regulatory and policy support will be needed for proactive upgrades.

When to Use Which Process

Shading indicates suitability of process to address EV Need



Managed Charging of Light-Duty Vehicles		
Existing processes	Customer-collaborative processes	Proactive processes
• Daily-routine charging • Demand for L1 charging • Elastic demand	• Perceived charging deserts • Service provider requests	• High vehicle deployment • Heavily loaded distribution • Inflexible demand

Charging Along Highways and Corridors		
Existing processes	Customer-collaborative processes	Proactive processes
• Minimal highway usage	• Along private highways	• Grid limitations along highways • Regional EV growth • Interregional trucking

Charging of Vehicle Fleets		
Existing processes	Customer-collaborative processes	Proactive processes
• Small fleets • Sufficient highway charging	• Inflexibility in timing and location • Large fleets	• Multiple fleets competing for capacity • Limited land availability

Charging in Underserved Communities		
Existing processes	Customer-collaborative processes	Proactive processes
• Equity considerations included • Incentives for EV purchase and smart charging	• New multi-family housing	• Insufficient opportunity for charging • MHD vehicles near communities

Summary and Key Points



- **Lots of uncertainty, but decisions are needed today**
 - Opportunities to improve forecasting
 - Opportunities to shape customer perception
- **Smart Charging will be helpful**
 - Learn how to rely on it in grid planning
 - Prioritize infrastructure where demand management cannot defer investment
- **Many grid planning improvements are outside of normal activities:**
 - Future-ready systems – reconsidering design standards
 - Proactive upgrades with uncertainties
 - Collaborative and multi-stakeholder processes



THANK YOU

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