Charging Ahead: Grid Planning for Vehicle Electrification

A Whitepaper from the ESIG Grid Planning for Vehicle Electrification Task Force

New Mexico PRC Workshop

9 July 2024

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INTEGRATION GROUP

Presentation by

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Acknowledgements

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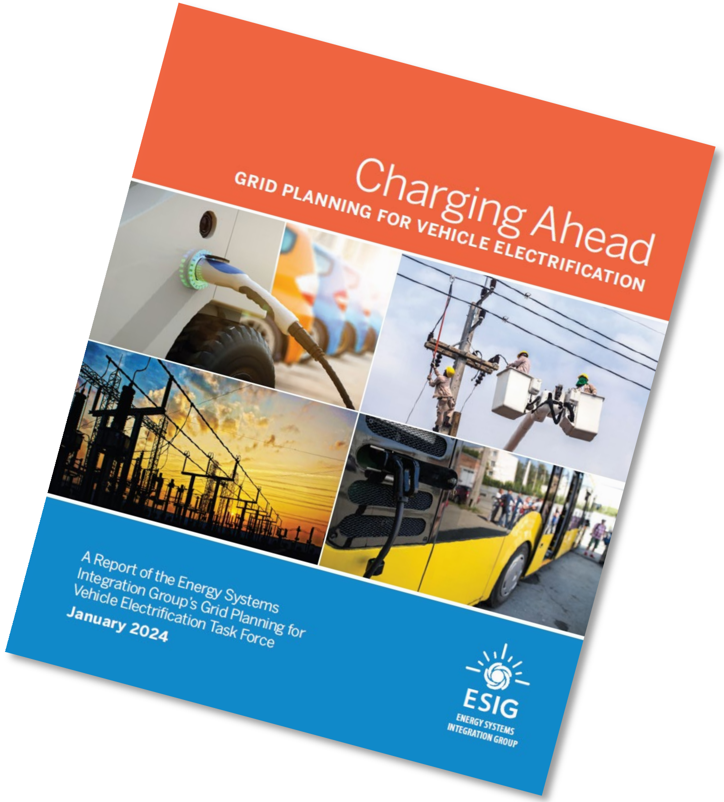
  - Utilities
  - Vehicle Manufacturers
  - Aggregators
  - Charging Operators
  - Regulators
  - State Energy Offices



https://www.esig.energy/grid-planning-for-vehicle-electrification/

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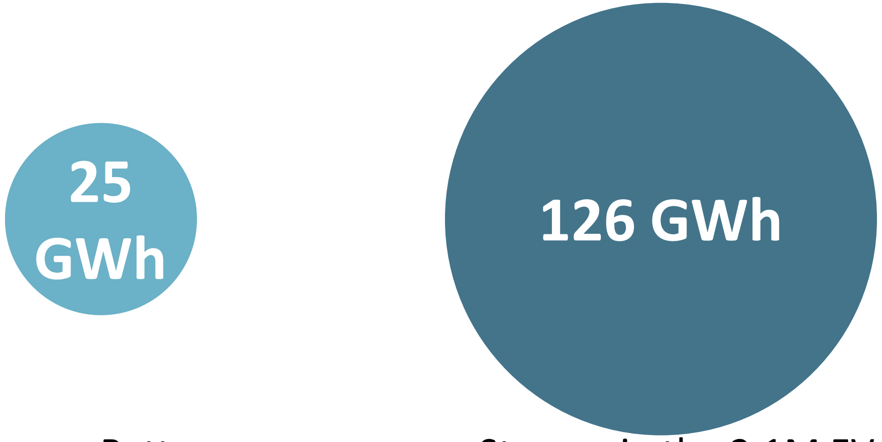
How big of a change is this?



Stationary Battery Storage in the US[2]

Storage in the 2.1M EVs on the road[2]

Values constantly growing

Manufacturers in the United States could supply around 10M new light duty plug-in electric vehicles each year by 2030, assuming an average pack size of 80-100 kWh.[3]

Nearly unprecedented change:

- EVs are first major load growth since air conditioning in the 1960s.
- Demand from 1 EV ≈ 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]

Sources: 1. Cutter, 2021. 2. SEPA, 2023. 3. Argonne National Lab - Light Duty Electric Drive Vehicles Monthly Sales Updates

Transportation electrification continues to accelerate

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

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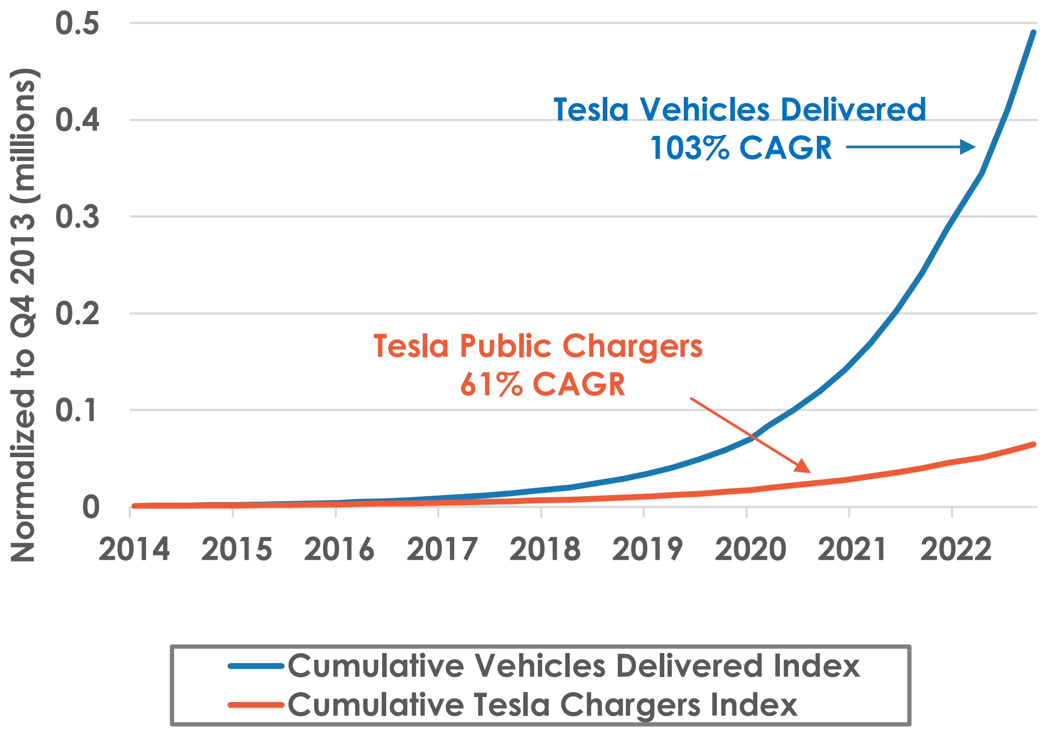
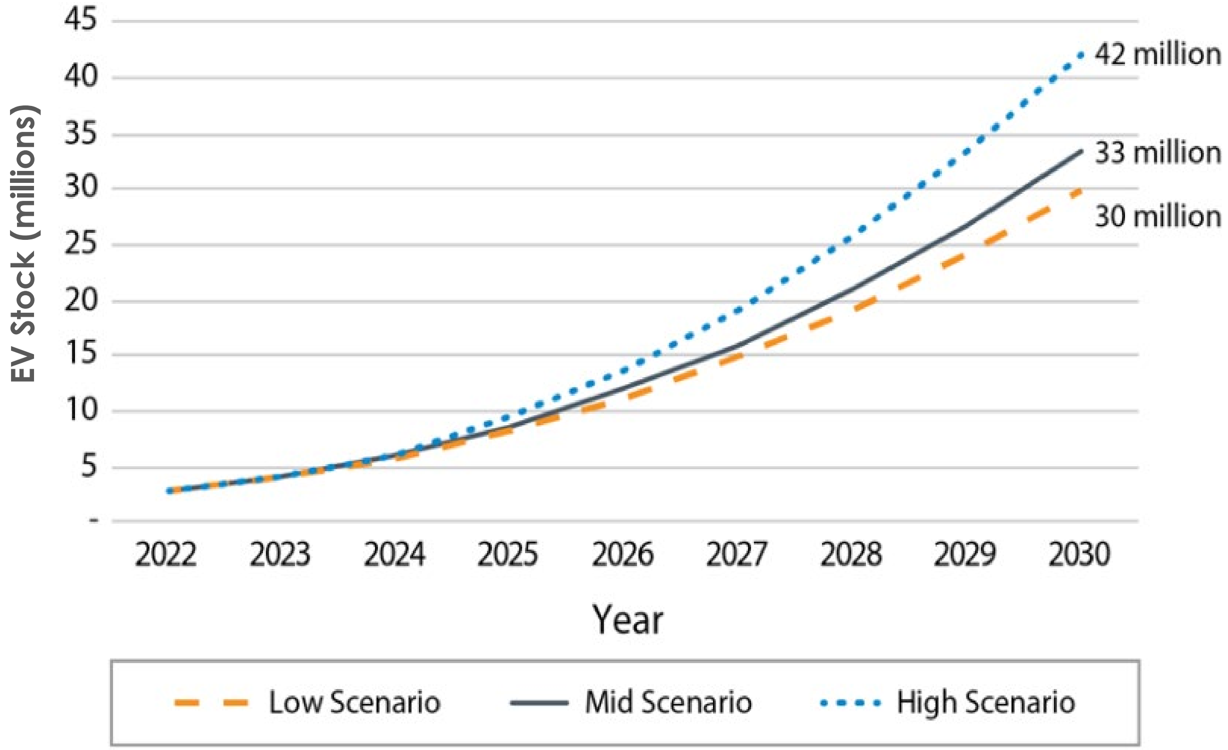
Tesla vehicles delivered and public chargers[1]



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.

[1]Tesla Comments to the California Energy Commission, 9/1/2023. [2]NREL. 2023. *The 2030 National Charging Network*

Uncertainty Abounds

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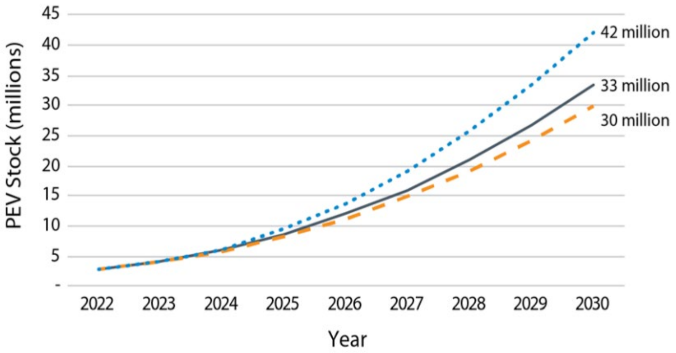
Adoption Rates?

How many vehicles are expected by when?

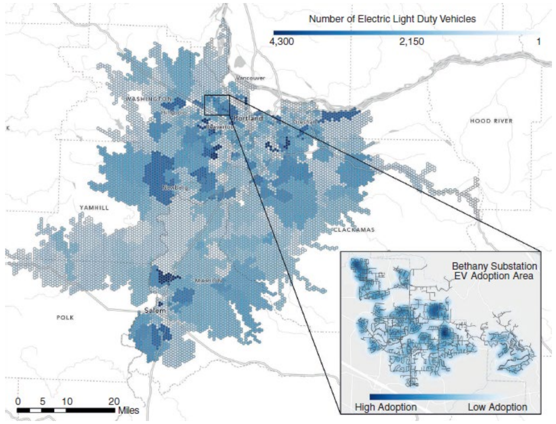
- Type of vehicles (SUV, trucks)
- Technology Change (efficiency & battery technology)
- Use Cases (LDV, MDV, fleets)



Location of Charging?

Where will charging take place?

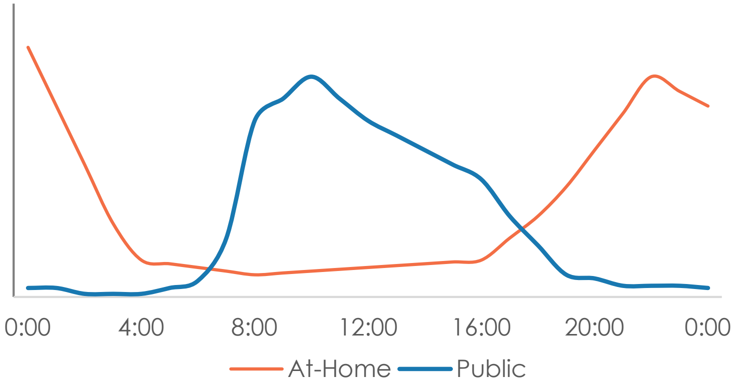
- Home vs. workplace charging?
- Which communities will see adoption first?
- Where do people drive?



Timing of Charging?

When will vehicle owners charge?

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

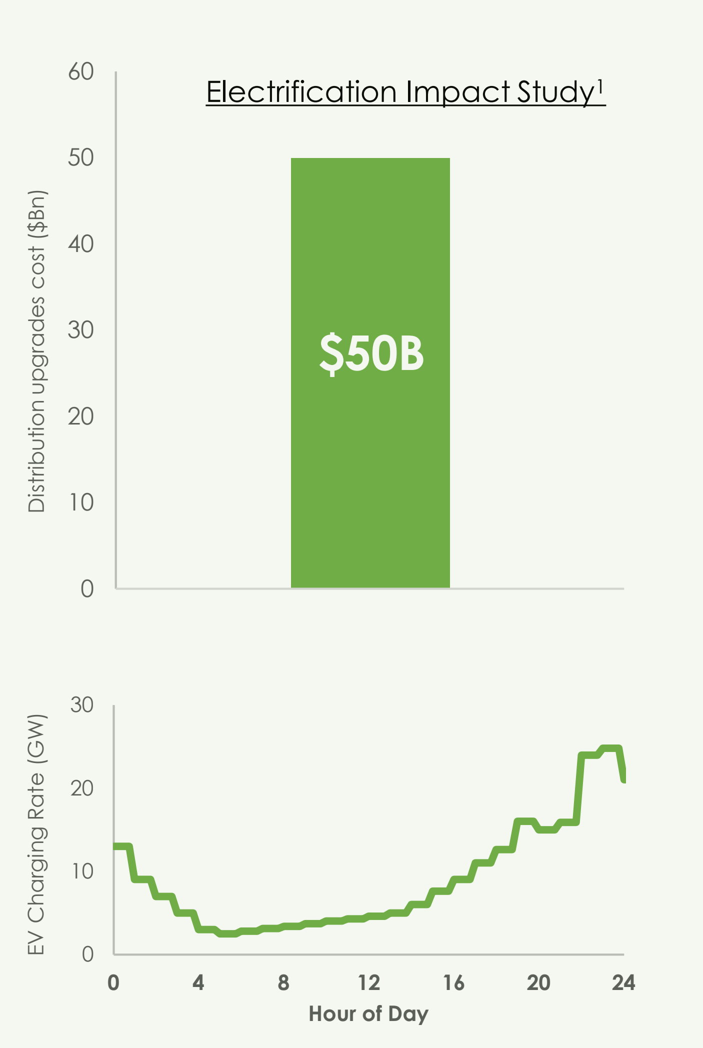


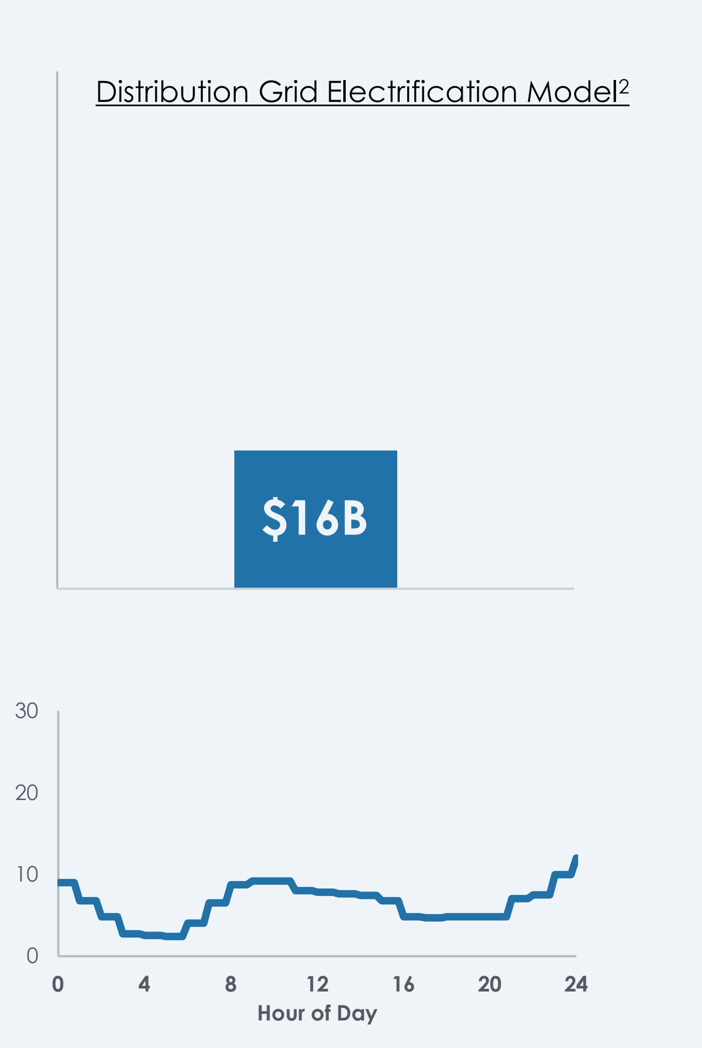
The answer to each of these questions has significant implications for power system planning and cost, particularly for distribution networks.

Rightsizing upgrades

Need to balance cost and pace of distribution upgrades under uncertainty

Two studies looking at California, show vastly different costs…





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

1. Kevala, 2023. 2. Public Advocate's Office, 2023

Prioritizing Grid Planning Actions to Take Today

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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

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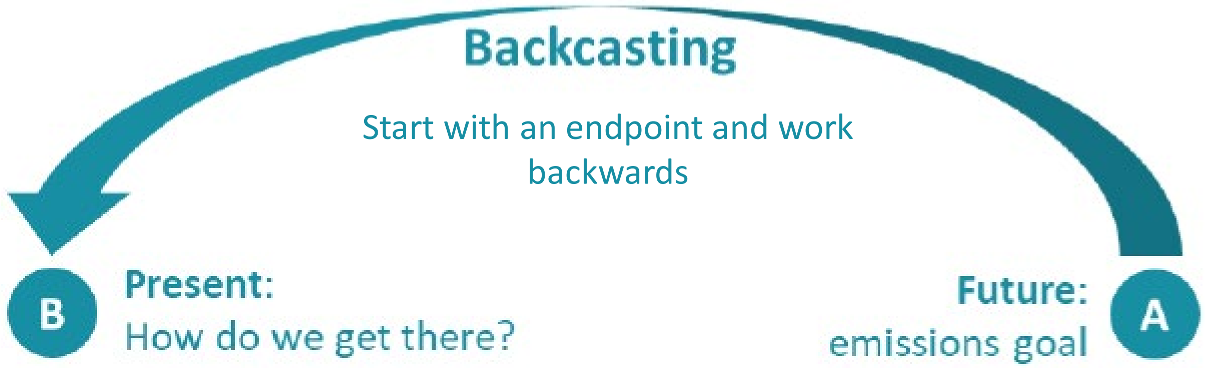
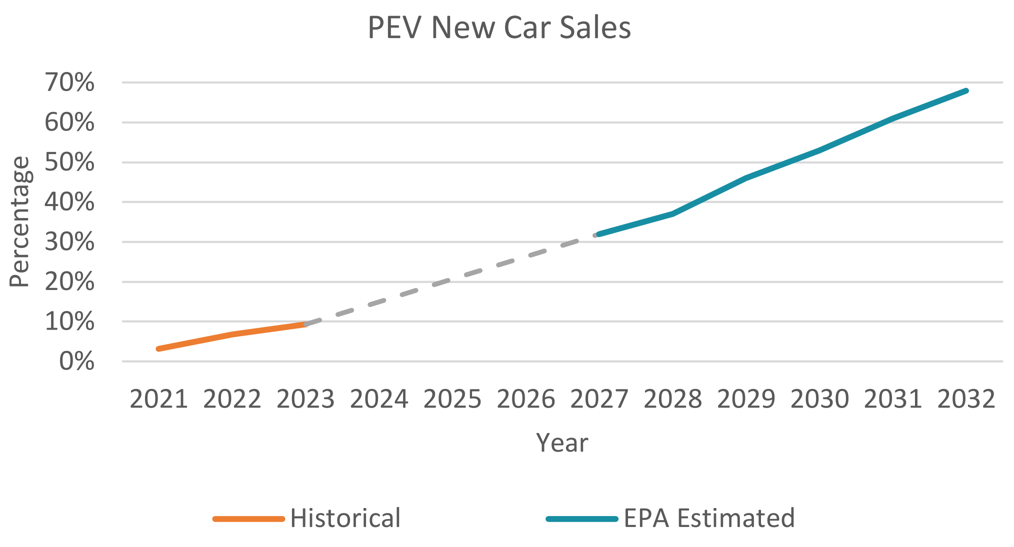
Forecast at a granular level by capturing the key variables

- **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



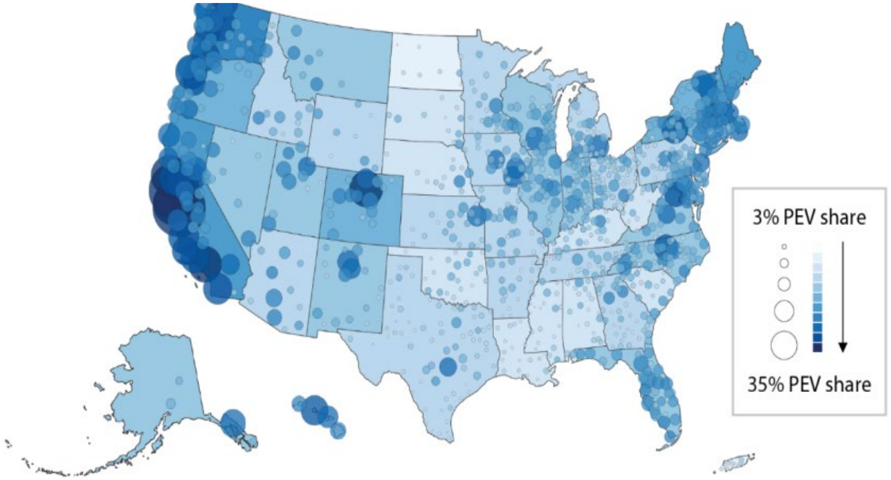


Sources: Data bottom: EPA Final Rule Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light- Duty and Medium-Duty Vehicles. Federal Register /Vol. 89, No. 76.

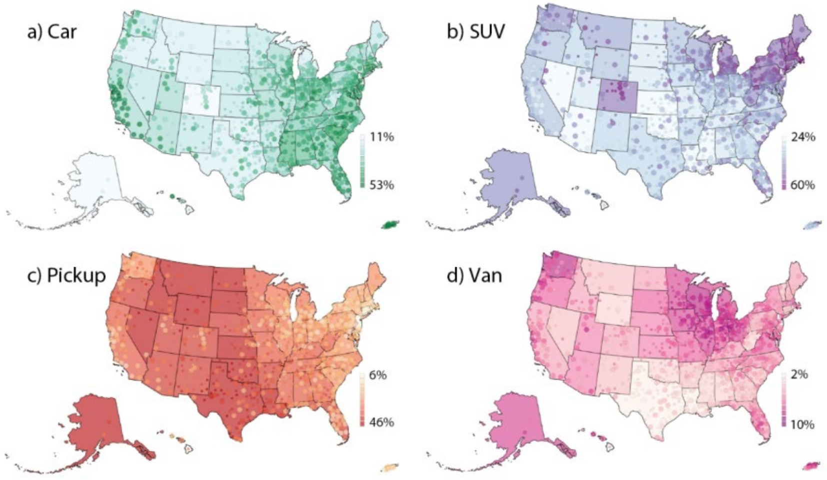
Improving Forecasting:

Getting to location through Use Cases

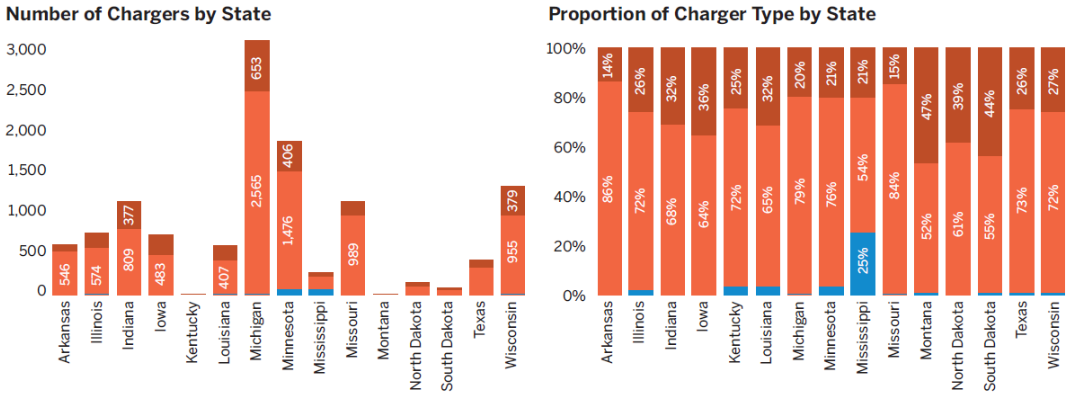
2030 EV National Adoption[1]



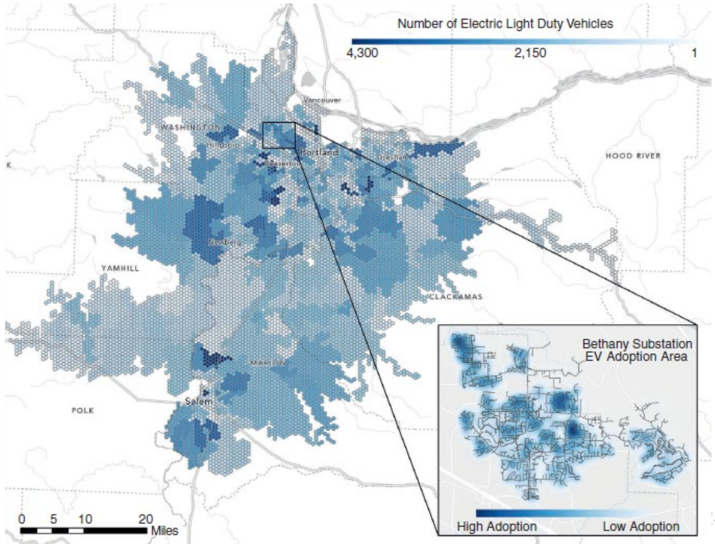
Use Cases – Current LDVs[1]



MISO Changes By State[2]



Within a service territory (Portland, Oregon)[3]

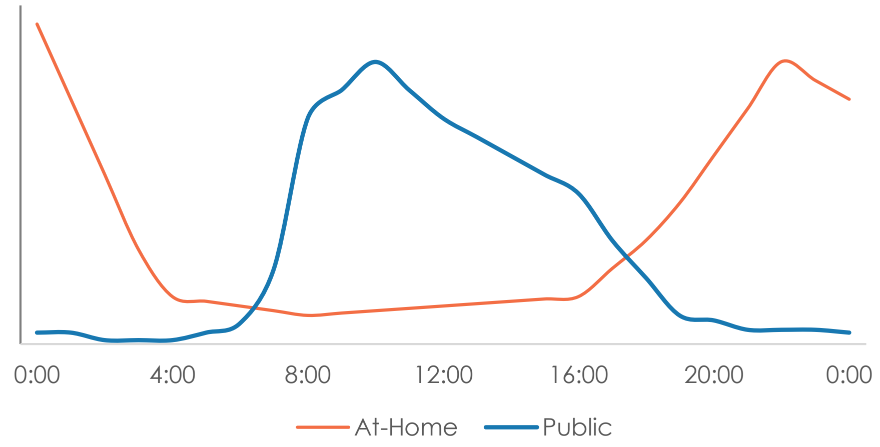


[1]NREL. 2023. *The 2030 National Charging Network*
[2]*MISO. 2023.*Based on EIA data with participation rates applied.
[3]PGE. 2023.

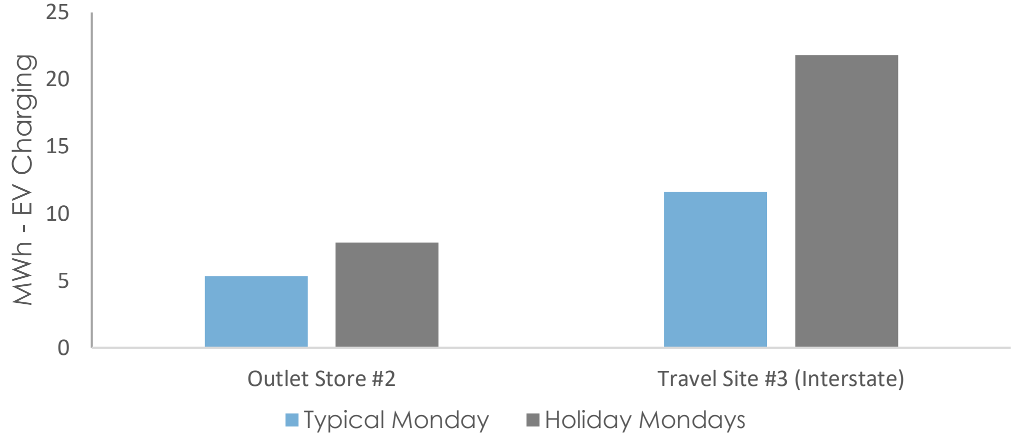
Improving Forecasting:

Getting to Timing

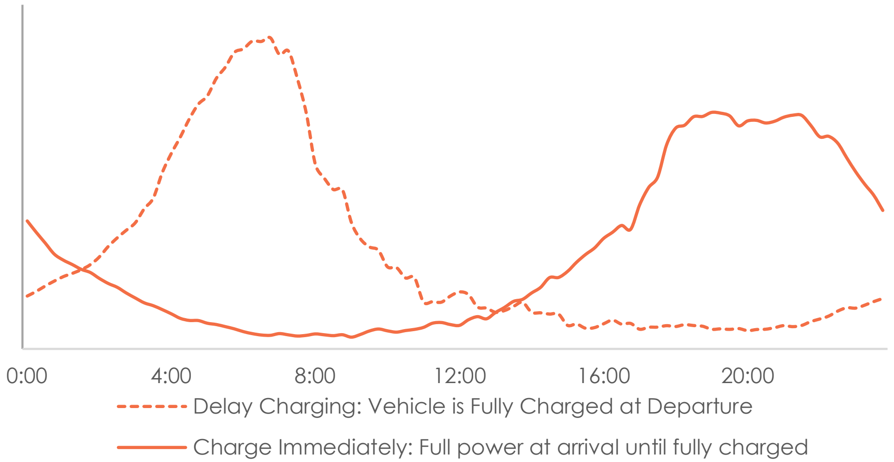
At Home Vs Public Charging[1]



Public Charging: Holidays vs Workdays[3]

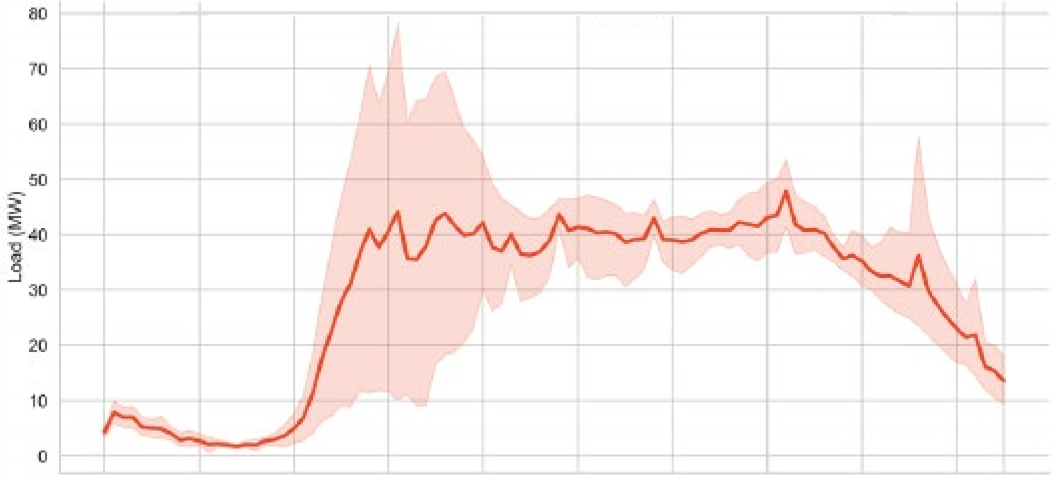


At Home Charging: Immediate vs Delayed[2]



Charging Profiles Vary by Location and time of year[4]

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.

Embrace Smart Charging:

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

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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]

A 2024 DOE study found: **Managed charging techniques can decrease incremental grid investment needs by 30%.**[4]

- While the analysis uses modeled load shapes and distribution circuits and charging profiles that are agnostic to other loads, it indicates the magnitude of reduced grid investments that are possible with smart charging.

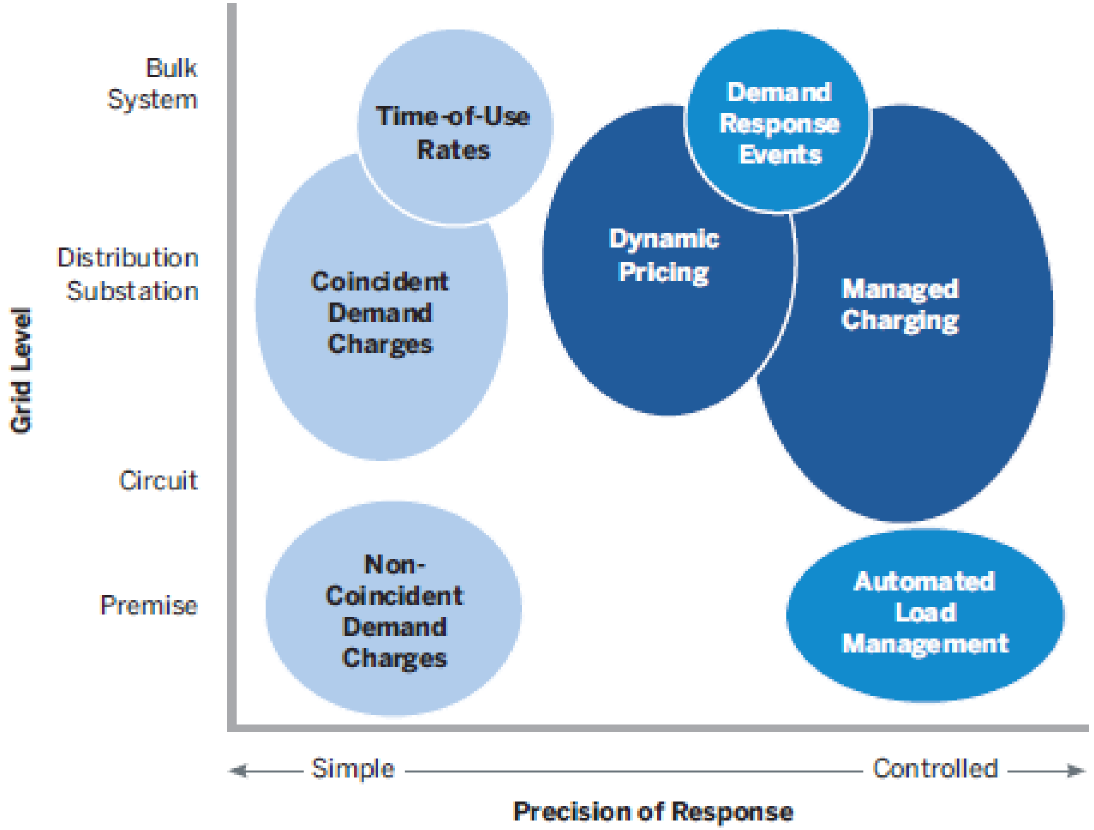

Image Sources. Energy Systems Integration Group. 1. Cutter et al., 2021. 2. Badtke-Berkow et al., 2015. 3. Octopus Energy, 2019. 4. DOE, Multi-State Transportation Electrification Impact Study, 2024.

Embrace Smart Charging:
Can address multiple grid needs simultaneously

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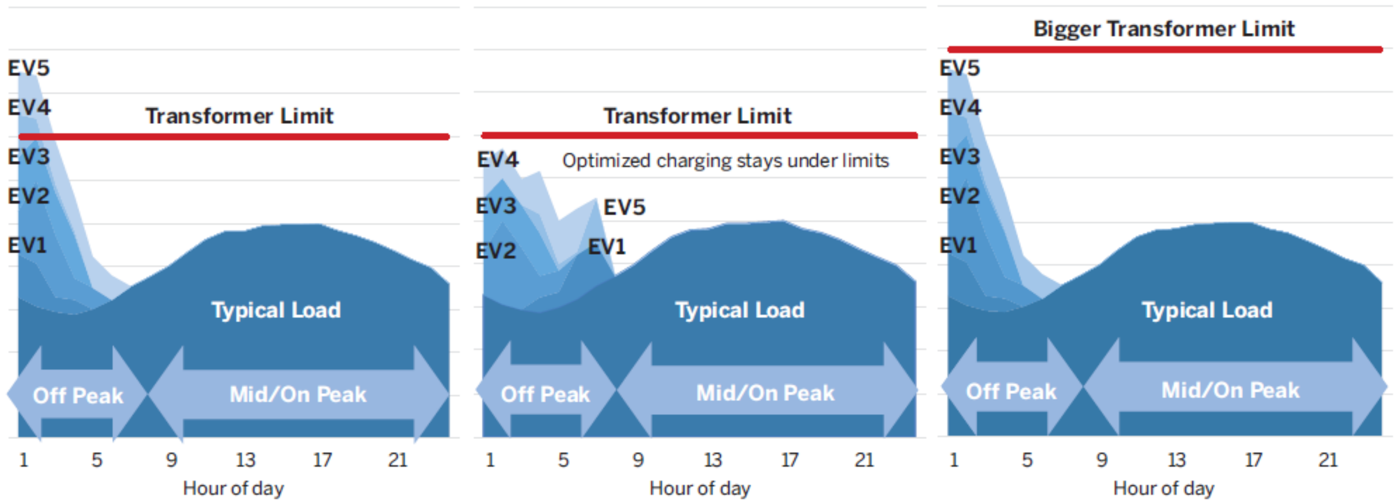
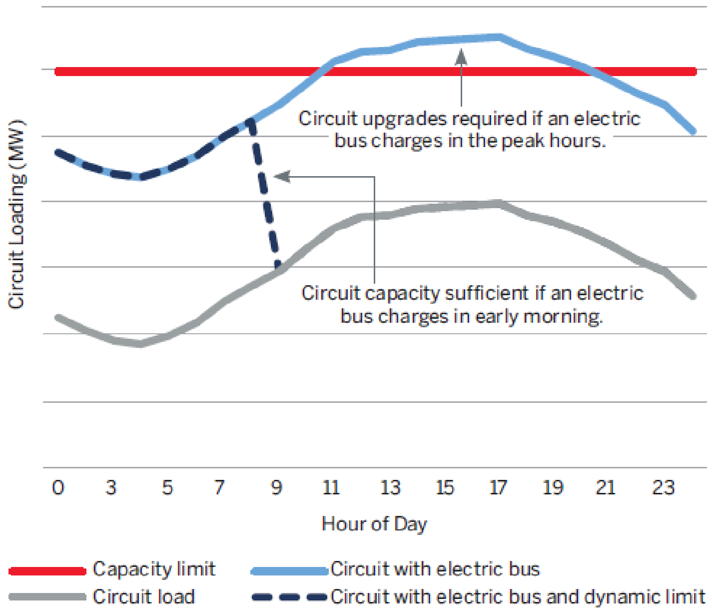
Care should be given to avoid unintended consequences in the design of programs, with costs evaluated against traditional upgrades



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

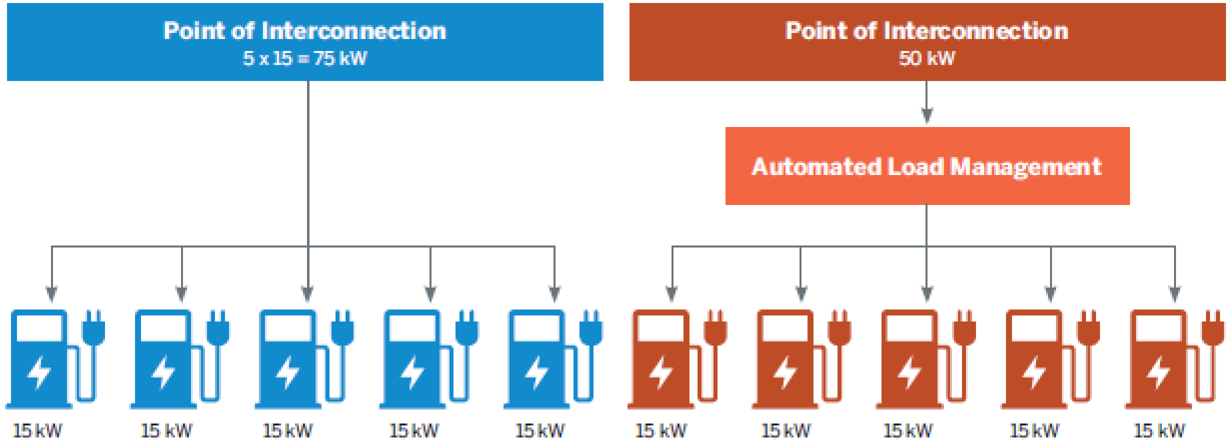


Inspiration for image left: PGE/Weavegrid. Right: ESIG

Embrace Smart Charging:

Solve Site-Level Constraints with Automated Load Management

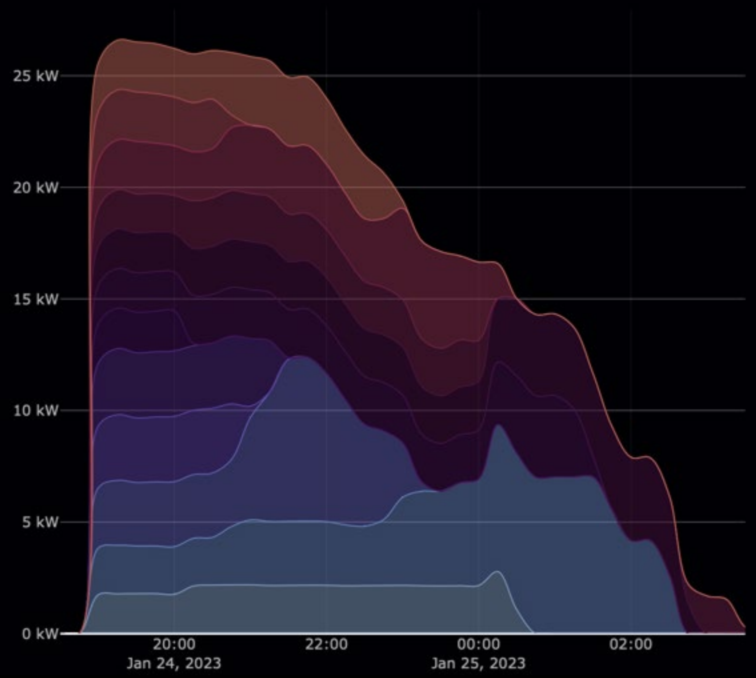
Automated Load Management (ALM) is software that schedules and prioritizes EV demand at a given point of interconnection (POI) to remain within a specified range over time.



- 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.



Source . 1. Decision Authorizing Pacific Gas and Electric Company's Electric Vehicle Charge 2 Program, 2022; 2. Opening Brief of Pacific Gas and Electric Company, 2022; Image right courtesy The Mobility House AG

Incorporate Future-Ready Equipment:

Use Infrastructure that can support the future

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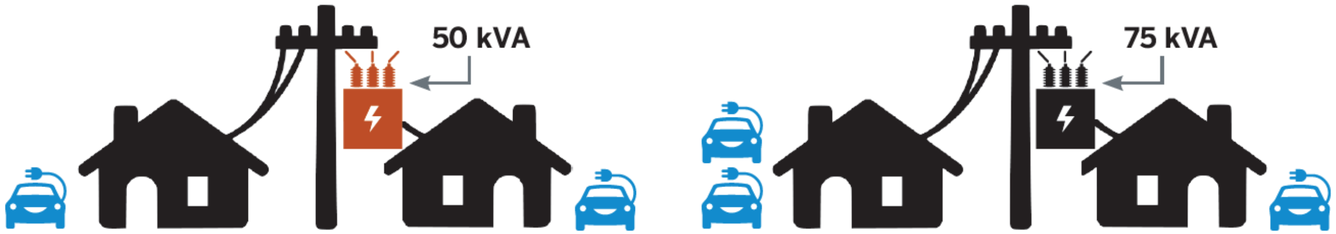
Equipment Standards



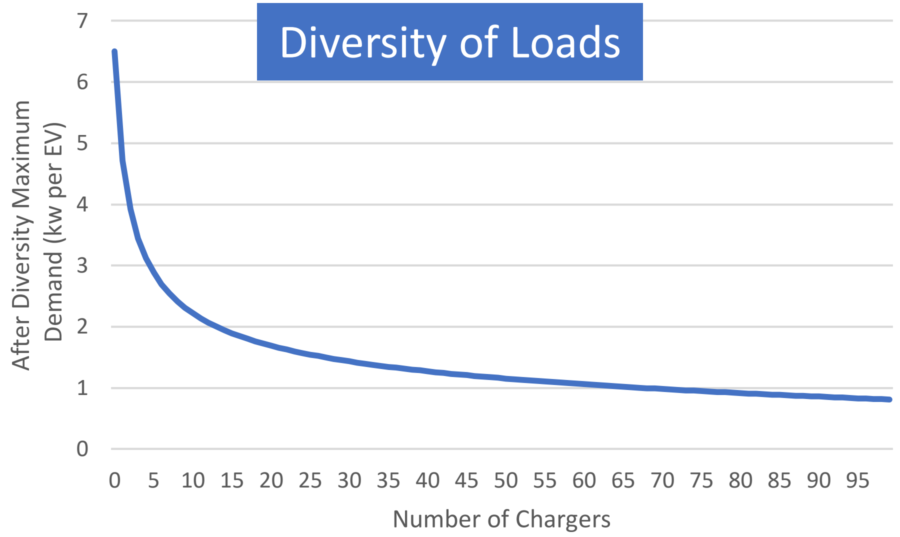
Exegol Utility District

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.

Diversity of Loads



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 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

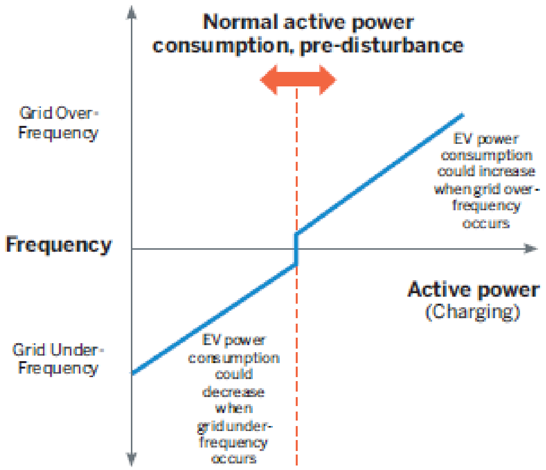
Image Sources: Top: ESIG; Bottom: Data from Vector

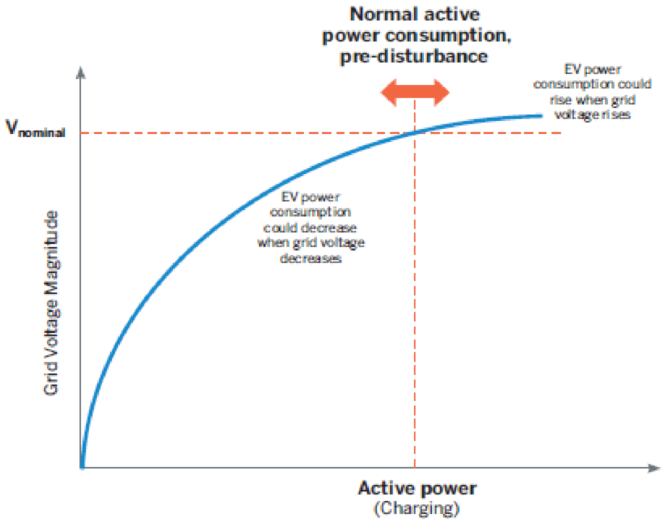
Lessons Learned from BTM PV

Learn from recent developments in rooftop PV

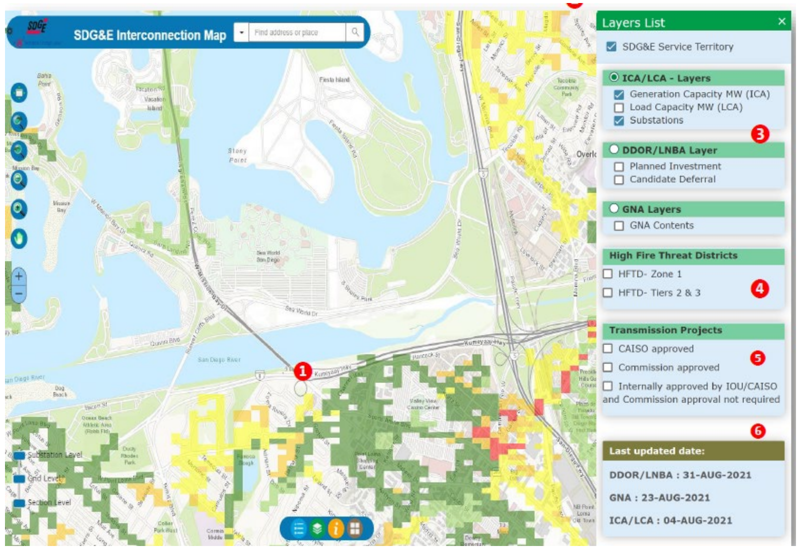
At the charger level

In the digital infrastructure





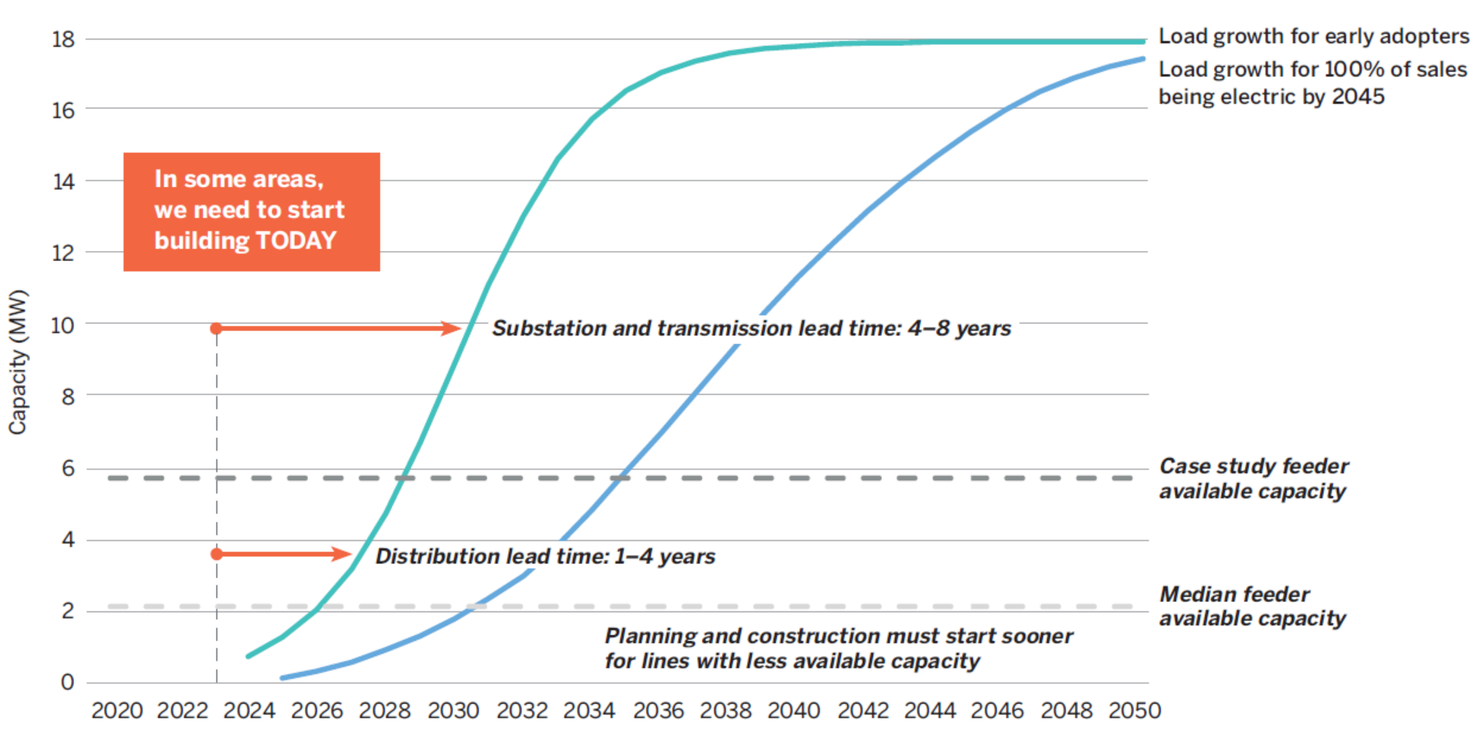
Define Grid Friendly Behavior



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

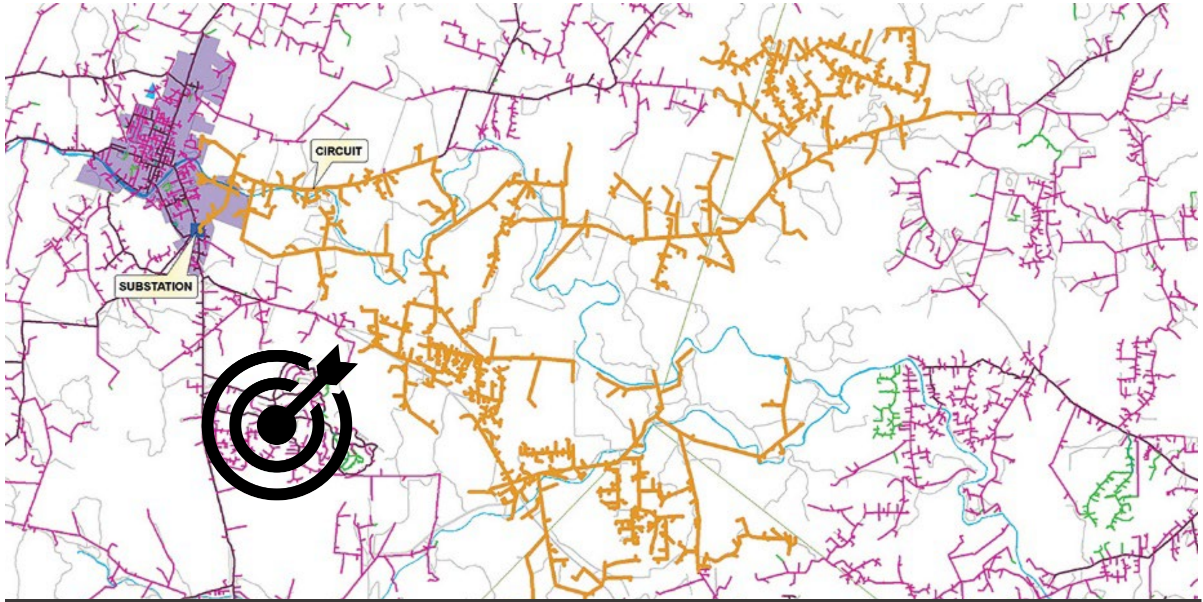
Risks:

- Expensive underutilization
- Inequitable burden of costs

Sources: Image left : National Grid. The Road to Transportation Decarbonization: Readying the Grid for Electric Fleets. 2023. Image Right: ESIG

Promote Proactive Upgrades:

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

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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

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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 consider-ations 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 unknowns, 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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Transportation Electrification and Distribution System Planning

July 9, 2024 | New Mexico Public Regulation Commission Workshop

Hanna Terwilliger| Analyst Coordinator - Distribution System Planning

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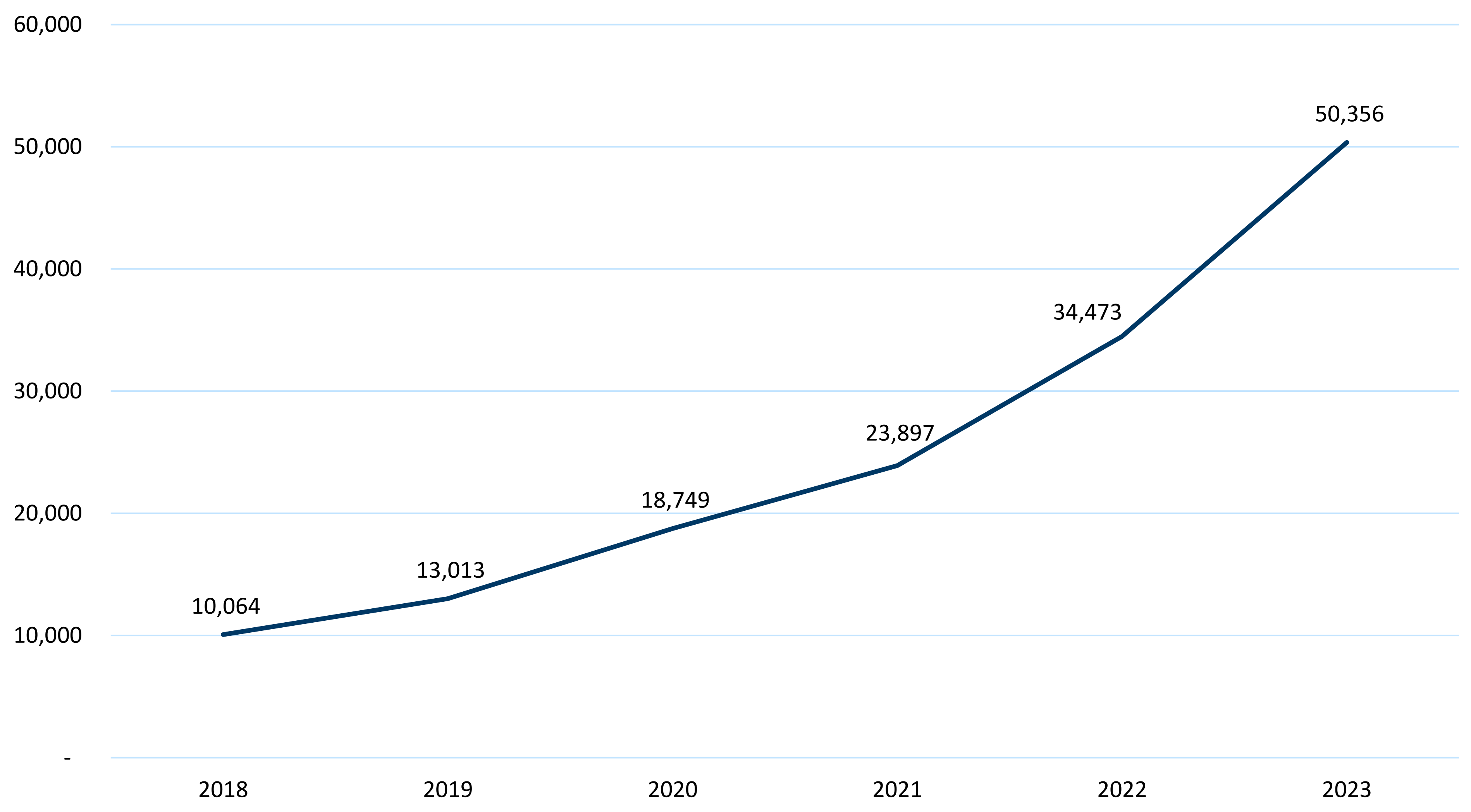
The ideas expressed are the views of the presenter, and not the Minnesota Public Utilities Commission.

EV Registrations in Minnesota



Distribution Planning Objectives

The Commission is facilitating comprehensive, coordinated, transparent, integrated distribution plans to:

- Maintain and enhance the safety, security, reliability, and resilience of the electricity grid, at fair and reasonable costs, consistent with the state's energy policies;
- Enable greater customer engagement, empowerment, and options for energy services;
- Move toward the creation of efficient, cost-effective, accessible grid platforms for new products, new services, and opportunities for adoption of new distributed technologies; and,
- Ensure optimized utilization of electricity grid assets and resources to minimize total system costs.
- Provide the Commission with the information necessary to understand Xcel's short-term and long-term distribution system plans, the costs and benefits of specific investments, and a comprehensive analysis of ratepayer cost and value.

Commission review of distribution system plans are not meant to preclude flexibility for utilities to respond to dynamic changes and on-going necessary system improvements to the distribution system; nor is it a prudency determination of any proposed system modifications or investments.

(Source: IDP Filing Requirements as adopted in 2018)

Integrated Distribution Plan Filing Requirements

IDP Requirements

1. **Timing**
2. **Stakeholder Process**

Utilities must hold at least 1 stakeholder meeting prior to filing, covering DER Forecasts, 5-Year Investment Plan and System Capabilities

3. **Filing Requirements**

A. Baseline Data
  - System
  - Financial
  - DER

B. Hosting Capacity and Interconnection

C. DER Futures Analysis (Scenario Planning)

D. Long-Term Distribution System Investment Plan *(5 & 10 year)*

E. Non-Wires Alternatives Analysis

F. Transportation Electrification Plan (IOUs only)

Transportation Electrification Plans

Transportation Electrification Plan Genesis

February 1, 2019 Order in Docket 17-879 (Commission's EV Inquiry)

- Series of findings defining transportation electrification as in the public interest and defining the utility's role in encouraging electrification
- Required utilities to file EV program and pilots
- Required utilities to file Transportation Electrification Plans that ID'd EV initiatives over the next two years and the extent to which they would:
  - Facilitate availability and awareness of public charging infrastructure and residential charging options for both single family and multiple unit dwellings, including programs or tariffs in development to address flexible load or reduce metering and data costs;
  - Educate customers on the benefits of EVs;
  - Assist in the electrification of vehicle fleets with a focus on medium and heavy-duty trucks and buses;
  - Offer DCFC specific tariffs and which tariffs are currently in use;
  - Optimize EV benefits by, for example, aligning charging with periods of lower customer demand and higher renewable energy production and by improving grid management and overall system utilization/efficiency; and
  - A discussion of current and planned charging practices/tariffs for public charging stations along with a discussion of any concerns related to those charging practices.

2020-2022 TEPs: Evolution of Filing Requirements

- Number of EVs in service territory, by type where possible
- Number of customers and vehicles on each off peak or managed charging rate, energy consumed, and average hourly load profiles by month.
- Level of demand resulting from EVs during each hour of the day, or during each time period in a utility's time-differentiated tariff
- Hourly EV consumption or if not yet available, during each time period in a utility's time-differentiated tariff, for each EV tariff offered by the utility.
- Number and capacity of known Level 2, DCFC Stations
- System upgrades to accommodate EV charging; total costs paid by utility & by customer; average cost per upgrade by customer group

- EV adoption and load forecast (energy and capacity) forecast scenarios by sector.
- Summary of ongoing transportation electrification efforts, including existing programs and projects in development over at least the next 2 years.
- How the utility plans to facilitate public charging infrastructure; residential charging options for both single family and multiple unit dwellings; flexible load; and fleet electrification.
- A summary of customer EV education initiatives
- How the utility plans to optimize EV benefits, including alignment of charging with periods of lower customer demand and higher renewable energy production and by improving grid management and overall system utilization/efficiency.

- Summaries of any proposals or pilots submitted to other regulatory agencies or jurisdictions
- Attachments or links to the most recent reports for any ongoing EV pilots or programs.
- 5-year budget for future and historical expenditures by budget category
- an estimate for each system upgrade needed to accommodate EV charging, and an estimate of the expenditures on other investments that improve a utility's ability to serve EV load
- non-pilot EV program evaluations that examine the cost-effectiveness of the programs as currently designed and potential changes that could improve their cost-effectiveness.

TEP/IDP Merge

MN PUC Docket No. 17-879, Dec 8, 2022, Order

- Combined Transportation Electrification Plans with Integrated Distribution Plans
- "Combining utility TEPs with IDPs is likely to improve the administrative efficiency of each regulatory proceeding, as transportation electrification and related utility distribution system planning functions are substantially linked to one another, and over time, they are likely to become inextricably linked."

TEP/IDP Merge

- Quantitative information incorporated into existing IDP sections:
  - Baseline Data
  - Financial Data
  - DER Scenario Analysis
- New TEP section for qualitative data:
  - Summary of new and ongoing programs
  - Facilitation of specific EV initiatives
  - Optimization of EV benefits
  - Education and awareness initiatives

2023 TEP Legislative Change

- May 2023 – Minn. Stat. 216B.1615: ELECTRIC VEHICLE DEPLOYMENT PROGRAM
  - Requires investor-owned utilities to file Transportation Electrification Plans which Commission must approve, modify, or reject
  - Change from acceptance of TEPs to approval of TEPs
- Shift how TEP/IDPs are evaluated together
  - TEPs include programmatic approvals for EVs, different review process than IDP or original TEPs
  - Still examine grid impacts, budget, and forecasts as part of broader IDP

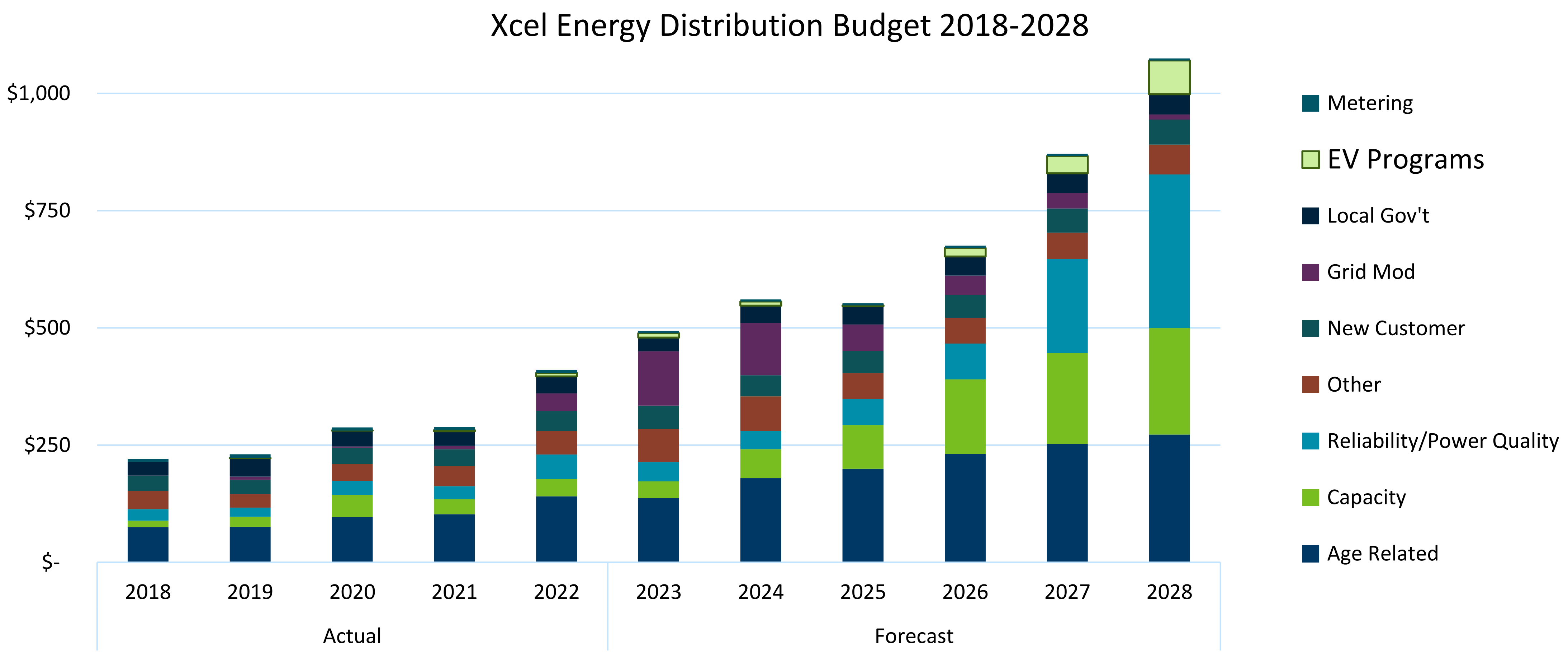
2023 IDP/TEPs

Dockets 23-258; 23-380; 23-452

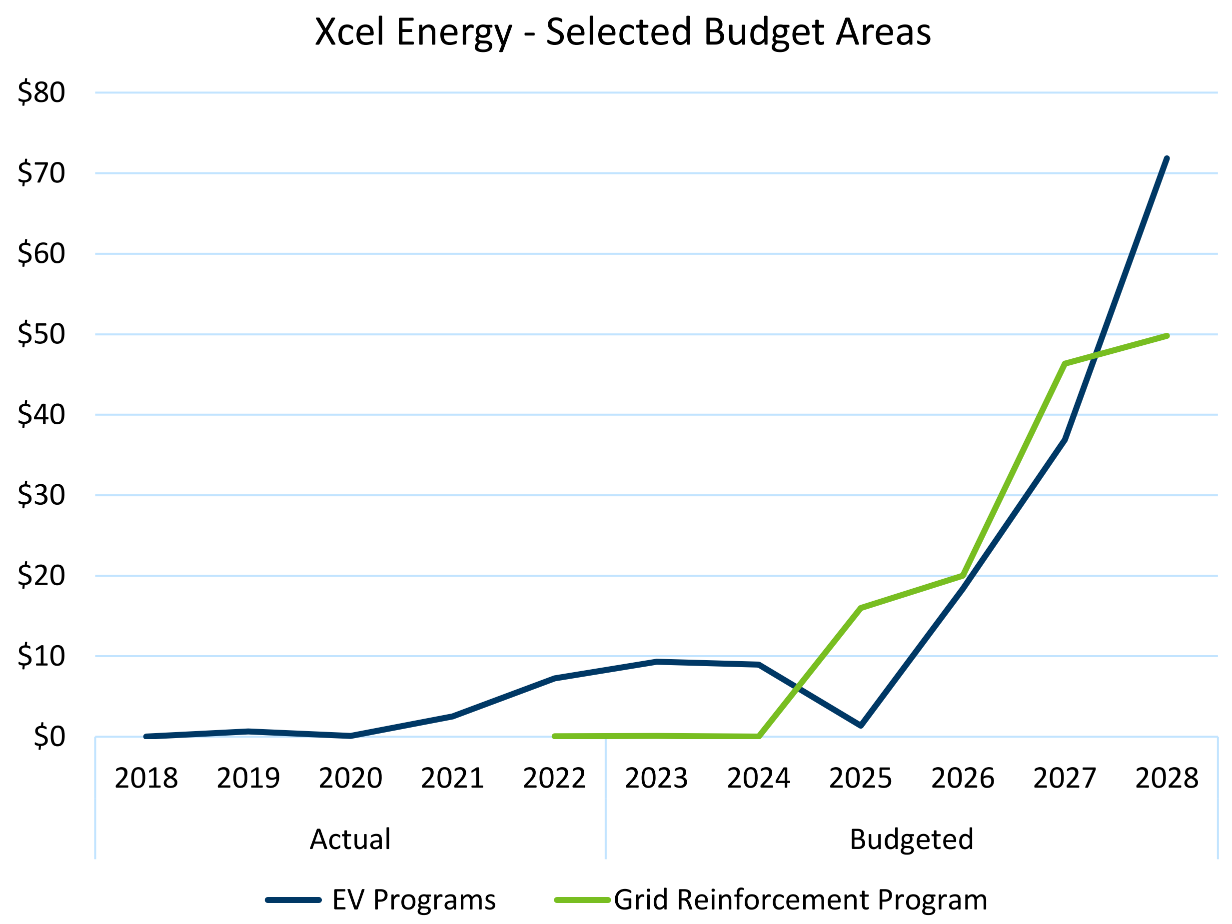
- First combined IDP/TEPs
- Only Xcel Energy filed for program approvals
  - Considered on faster timeline than overall IDP
  - Approved with modifications - May 9, 2024, Order
- Minnesota Power and Otter Tail Power did not have programs ready – plans looked at current programs, upcoming filings
  - Approved with overall IDPs verbally last week
- Next IDP/TEPs due November 1, 2025

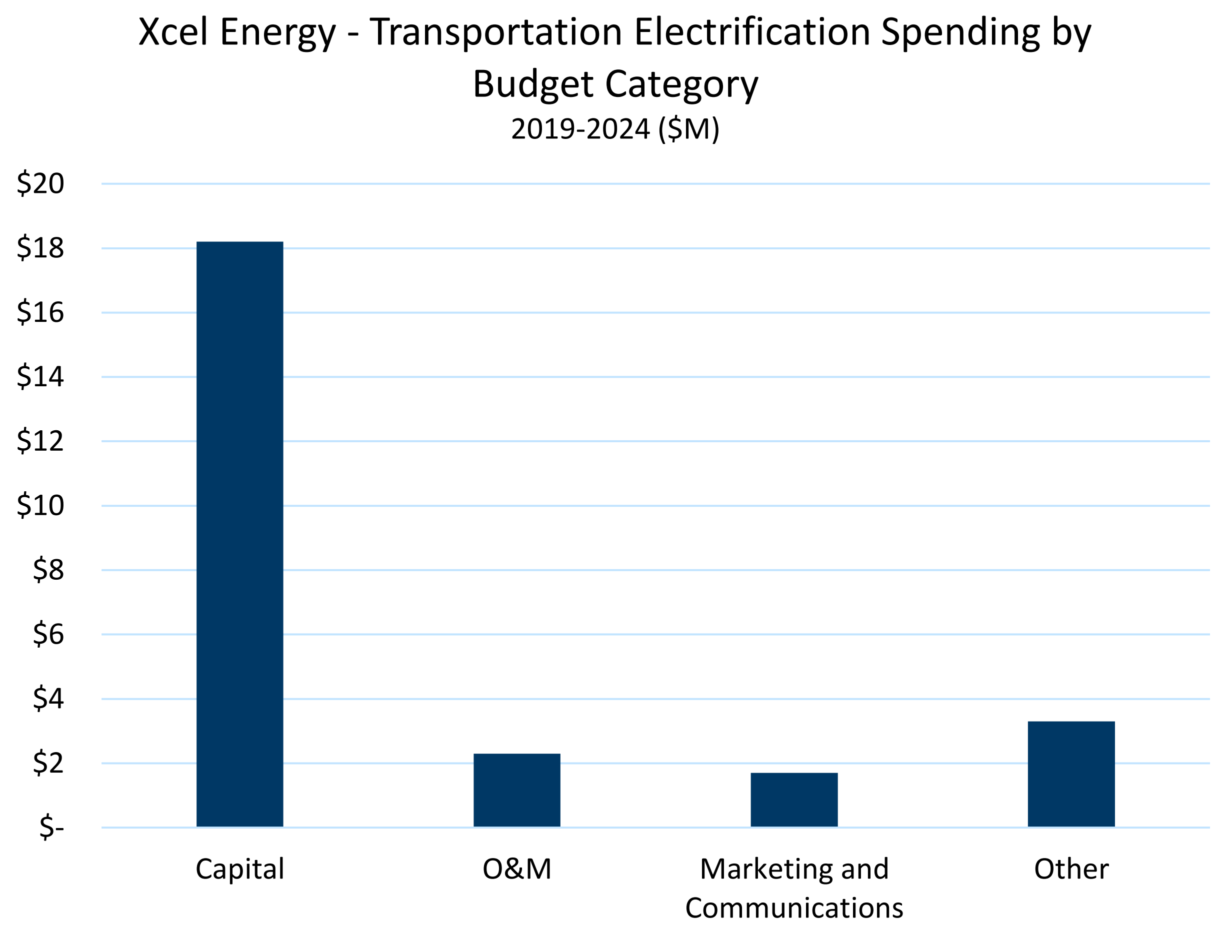
Benefits of Merged TEP/IDPs

Holistic Budget Overview



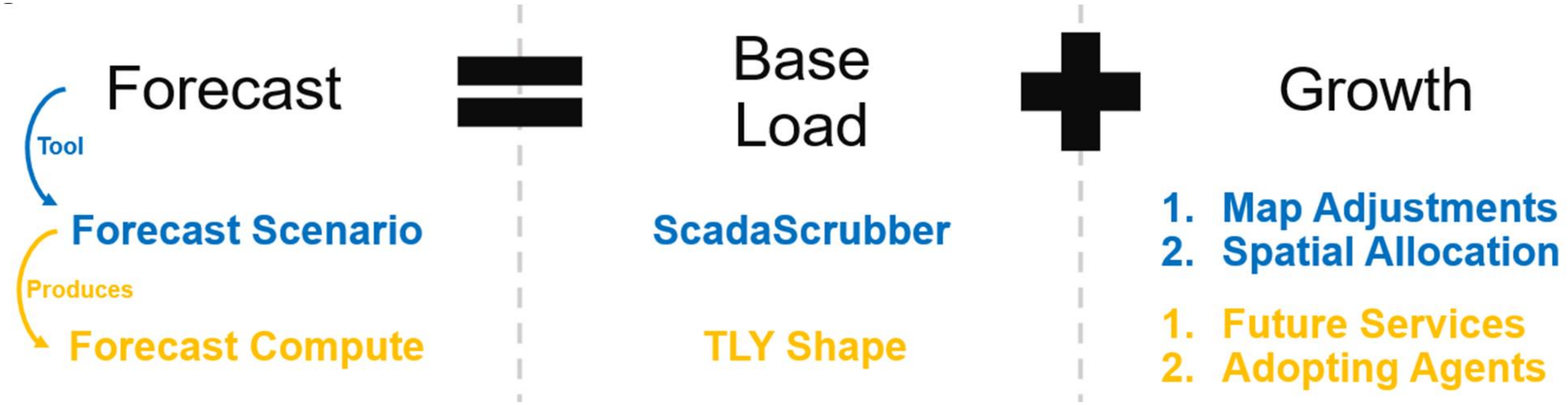
Comparison to related programs



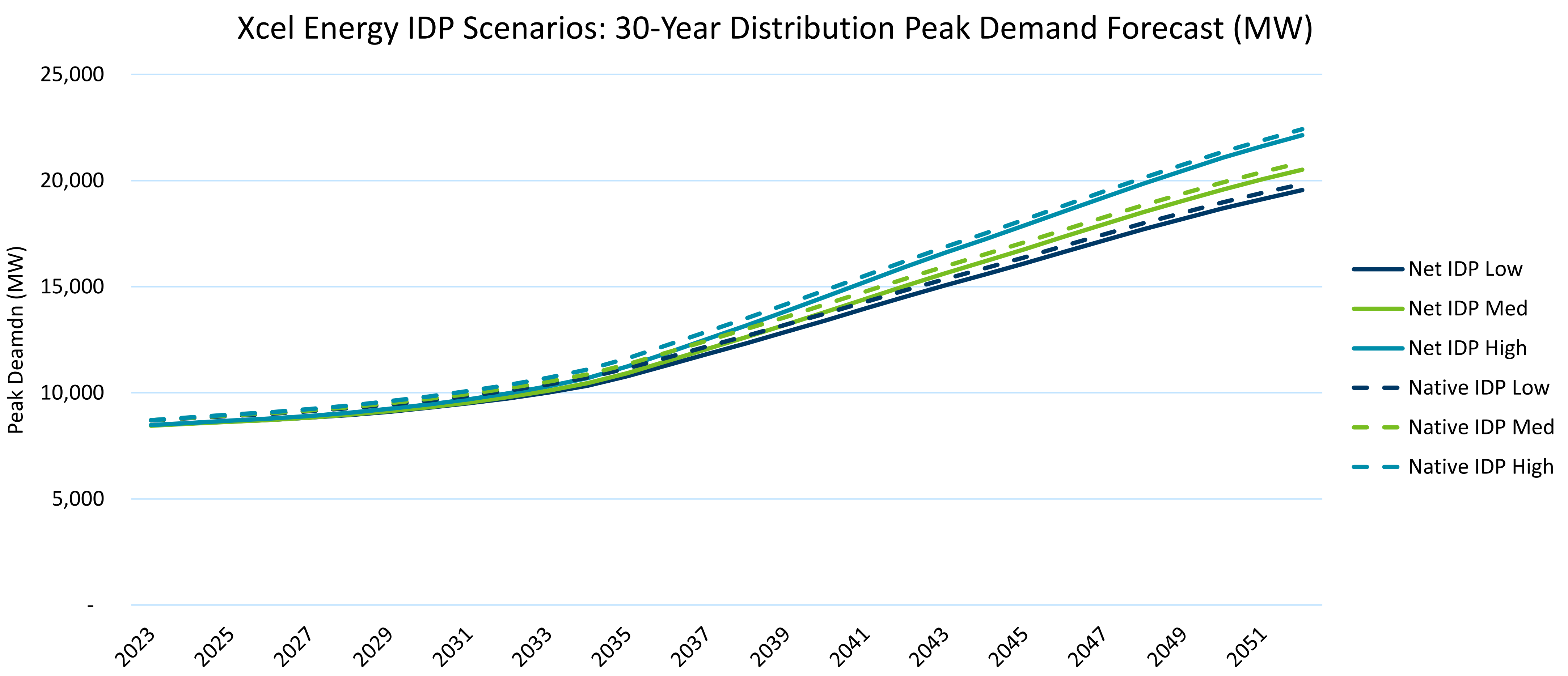


Forecasting – view in context of overall load changes

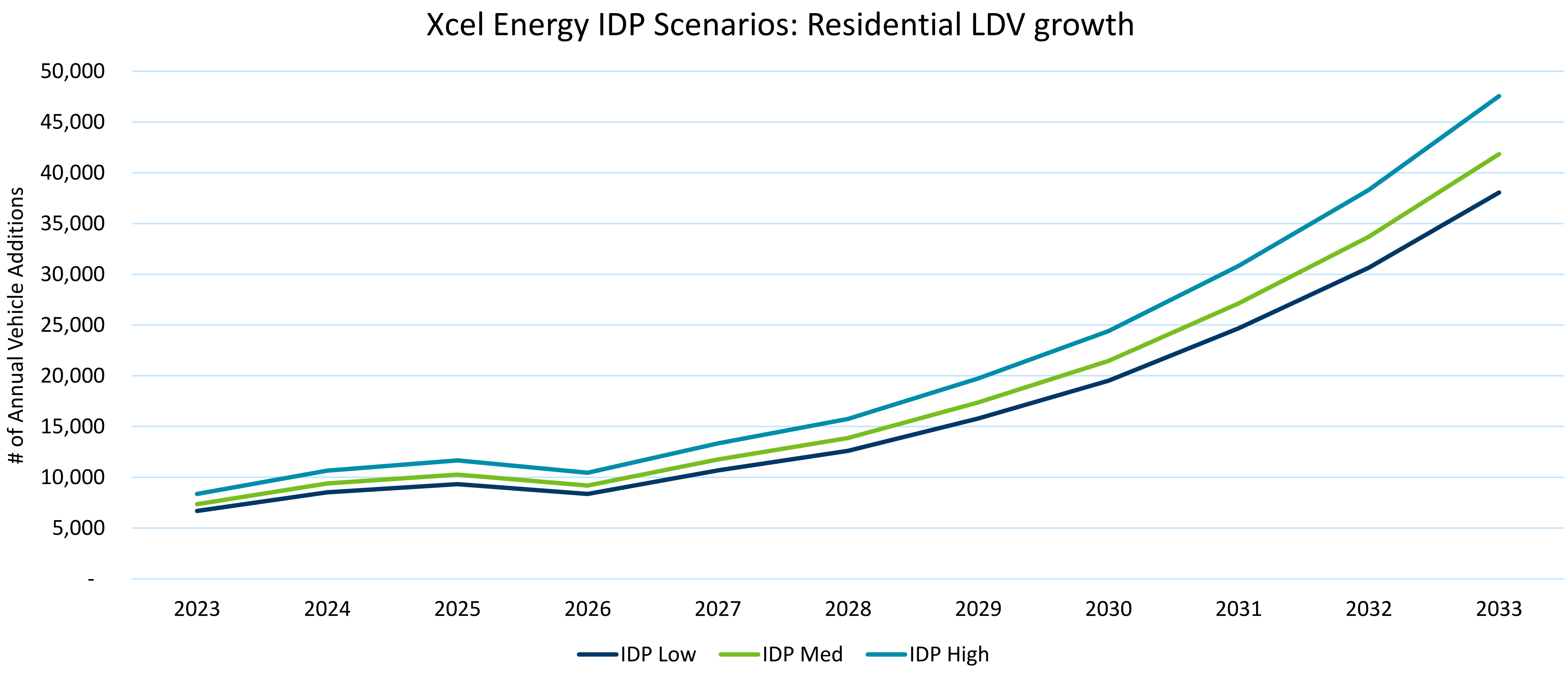
- First IDP for Xcel Energy to use LoadSEER - allows for spatial forecasting of DERs, EVs, electrification on the distribution grid



Load Forecasting – large overall load growth



View EV contribution to load forecast



Cost Allocation and Upgrades

	Proactive Upgrades	Reactive Upgrades
Shared Cost Allocation	• Build distribution budgets around DER and electrification forecasts. • Assign incremental infrastructure costs via typical class cost allocation methods, e.g., in next rate case. • Benefits customers adopting DER and electrification by reducing or eliminating wait time and cost of interconnection. • Risks include deploying assets that are not used and useful if forecasts are not accurate, the potential for shifting costs of upgrades onto non-benefitting customers, and risk of inequitable investments.	• Grid upgrades are made in response to individual customer requests. • Costs assigned via typical class cost allocation methods, e.g., in the next rate case. • Benefits customers adopting DER and electrification by eliminating the cost of interconnection; benefits ratepayers by ensuring upgrades are used and useful. • Risks include continued wait-times in the interconnection process, the potential for shifting costs of upgrades onto non-benefitting customers, and risk of inequitable investments.
Individually Allocated Costs	• Build distribution budgets around DER and electrification forecasts. • Individual customers, where appropriate, pay a fee to cover their share of the upgrade at time of interconnection. • Benefits customers adopting DER and electrification by reducing or eliminating wait times for interconnection; benefits ratepayers by reducing the costs of upgrades via reimbursement over time. • Risks include deploying assets that are not used and useful if forecasts are not accurate, and the potential for shifting costs of upgrades onto non-benefitting customers if forecasts or reimbursement fees are not accurate.	• Grid upgrades are made in response to individual customer requests. • Individual customers, where appropriate, pay a fee to cover their share of the upgrade at time of interconnection. • For the most part the model in place today • Benefit is ensuring upgrades are used and useful. • Risks include wait time and interconnection costs for DER and electrification customers.

Cost Allocation and Upgrades

July 2, 2024 Verbal Decision – Commission led workgroup on establishing a framework for cost allocation and proactive upgrades for electrification and DERs, goal completion date July 1, 2025

Topics to address include:

- How to allocate the costs of proactive upgrades
- How to ensure any proactive upgrades are distributed in an equitable manner throughout a utility's service territory
- If costs are socialized among ratepayers, whether portions of the upgraded capacity should be reserved for certain customer classes
- How a proactive upgrade program would integrate with a utility's planned distribution investment programs
- How a utility's other capacity programs and changes to distribution standards impact available hosting capacity
- How to determine where and when there is a need for proactive upgrades using forecasted DER and load adoption
- Whether there should be changes to any of a utility's service policy provisions such as Contributions In Aid of Construction (CIAC).

MINNESOTA PUBLIC UTILITIES COMMISSION

Thank You!

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