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

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How big of a change is this?

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:
2. SEPA, 2023.
3. SEIA/CRU, 2023. Energizing American Battery Storage Manufacturing
Transportation electrification continues to accelerate

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

**Tesla vehicles delivered and public chargers**

- **Tesla Vehicles Delivered**: 103% CAGR
- **Tesla Public Chargers**: 61% CAGR

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.

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

- **33 million EVs = 1200+ GWh**

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...

Electrification Impact Study¹

$50B

Distribution Grid Electrification Model²

$16B

Right-Sizing under High Uncertainty

Underbuilt Grid

Overbuilt Grid

Risks:
• Unreliable grid
• Stunted public interest in EVs
• Long waits for charger installs

Risks:
• Expensive underutilization
• Inequitable burden of costs

2. Public Advocate’s Office, 2023
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.
Improving Forecasting:
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 Adoption

MISO Changes By State

Use Cases – Current LDVs

Within a service territory (Portland, Oregon)

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1 NRRL. 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 Charging¹

- **At Home**
- **Public**

At Home Charging: Immediate vs Delayed²

- Delay Charging: Vehicle is Fully Charged at Departure
- Charge Immediately: Full power at arrival until fully charged

Public Charging: Holidays vs Workdays³

- Outlet Store #2
- Travel Site #3 (Interstate)

Charging Profiles Vary by Location and time of year⁴

Cambridge, MA has ~10% higher winter traffic

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¹Data: 2022, Powell, Cezar, & Rajagopal
²Data: EVI-lite-Pro
³Data: Provided to ESIG
Embrace Smart Charging:
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.\(^3\)

Cost and ease to implement smart charging measures are characterized relative to each other and should be evaluated against alternatives, such as infrastructure improvements.
Embrace Smart Charging: 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.
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.”
- When using ALM, PG&E observed cost savings ranging from $30,000 to $200,000 per project.

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 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
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
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.

**Promote Proactive Upgrades:**

**Getting Proactive, but intelligently**

Right-Sizing under High Uncertainty

**Underbuilt Grid**
- **Risks:**
  - Unreliable grid
  - Stunted public interest in EVs
  - Long waits for charger installs

**Overbuilt Grid**
- **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

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.

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.
Practice and Process Adaptations
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

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.

**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
## When to Use Which Process

Shading indicates suitability of process to address EV Need

### Managed Charging of Light-Duty Vehicles

<table>
<thead>
<tr>
<th>Existing processes</th>
<th>Customer-collaborative processes</th>
<th>Proactive processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Daily-routine charging</td>
<td>• Perceived charging deserts</td>
<td>• High vehicle deployment</td>
</tr>
<tr>
<td>• Demand for L1 charging</td>
<td>• Service provider requests</td>
<td>• Heavily loaded distribution</td>
</tr>
<tr>
<td>• Elastic demand</td>
<td>• Inflexible demand</td>
<td>• Inflexible demand</td>
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### Charging Along Highways and Corridors

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<th>Existing processes</th>
<th>Customer-collaborative processes</th>
<th>Proactive processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Minimal highway usage</td>
<td>• Along private highways</td>
<td>• Grid limitations along highways</td>
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<tr>
<td></td>
<td></td>
<td>• Regional EV growth</td>
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<td></td>
<td></td>
<td>• Interregional trucking</td>
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### Charging of Vehicle Fleets

<table>
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<tr>
<th>Existing processes</th>
<th>Customer-collaborative processes</th>
<th>Proactive processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Small fleets</td>
<td>• Inflexibility in timing and location</td>
<td>• Multiple fleets competing for capacity</td>
</tr>
<tr>
<td>• Sufficient highway charging</td>
<td>• Large fleets</td>
<td>• Limited land availability</td>
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### Charging in Underserved Communities

<table>
<thead>
<tr>
<th>Existing processes</th>
<th>Customer-collaborative processes</th>
<th>Proactive processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Equity considerations included</td>
<td>• New multi-family housing</td>
<td>• Insufficient opportunity for charging</td>
</tr>
<tr>
<td>• Incentives for EV purchase and smart charging</td>
<td></td>
<td>• MHD vehicles near communities</td>
</tr>
</tbody>
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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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