EVs and Distribution System Planning

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Agenda

- **Background and context**
- **Trends** in distribution system planning
- **Assessment needs** for EVs in grid and distribution system planning
    - EV forecasts
    - Infrastructure programs
    - Grid needs

Background – relevant reports

- Presentation today based on report: Electric Distribution System Planning with DERs – High Level Assessment of Tools and Methods
  - Focuses on tools and methods in distribution system planning
  - Identifies data needs and gaps in current tools
- Trainings to state public utility commissions on distribution systems and planning with Lawrence Berkeley National Laboratory
  - Southeast Regional Training on Distribution System Planning
- Other reports of interest:
  - Summary of Electric Distribution System Analyses with a Focus on DERs
  - State Engagement in Electric Distribution System Planning – PNNL 27066
  - Distribution System Planning – State Examples by Topic.

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Drivers for improved distribution system planning

- More DERs deployed — costs down, policies, new business models, consumer interest
- Resilience and reliability (e.g., storage, microgrids)
- More data and better tools to analyze data
- Aging grid infrastructure and utility proposals for grid investments
- Need for greater grid flexibility in areas with high levels of wind and solar; increasing number of electric vehicles
- Interest in conservation voltage reduction and volt/VAR optimization
- Non-wires alternatives to traditional solutions may provide net benefits to customers

Other potential benefits from improved distribution planning

- **Framework for looking at** distribution system investments holistically
- Provides **opportunities for meaningful engagement**
  - Can improve outcomes
- Establish the **hosting capacity** of circuits and makes information available
- Points to potentially **valuable locations** for distributed energy resources (DERs)
- Enables consideration of **alternatives to traditional investments**
- Considers **uncertainties** under a range of possible futures
- Considers **all solutions** for least cost/risk
- **Motivates utilities** to choose least cost/risk solutions
- Enables **consumers and third-party providers to propose grid solutions** and participate in providing grid services

Foundational elements in distribution system planning

- ► Validated and calibrated feeder models
- ► Accurate and granular data
- ► Grid Architecture

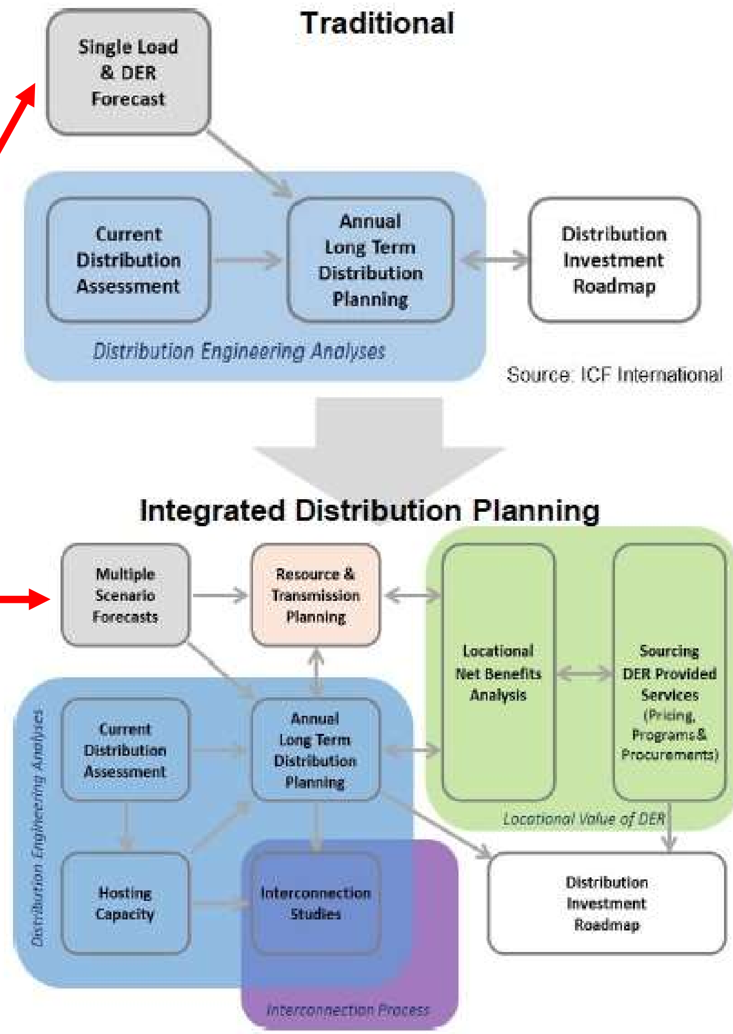
For advanced distribution planning, utilities and commissions need to make **data collection, data management**, and **maintaining validated and calibrated feeder models** priorities.

Data Types Useful for Distribution Planning with DERS

- Granular (in time and space) load growth projections
- System capacity planning studies—from distribution transformer to bulk system sub-transmission
- Existing and projected distributed generation deployment and production by location and time of day and year
- Line loss studies
- System reliability studies (including voltages, protection, phase balancing)
- System-wide and location-specific cost information
- System-wide and location-specific peak demand growth rates
- Embedded and marginal cost of service studies

Load and DER forecasts

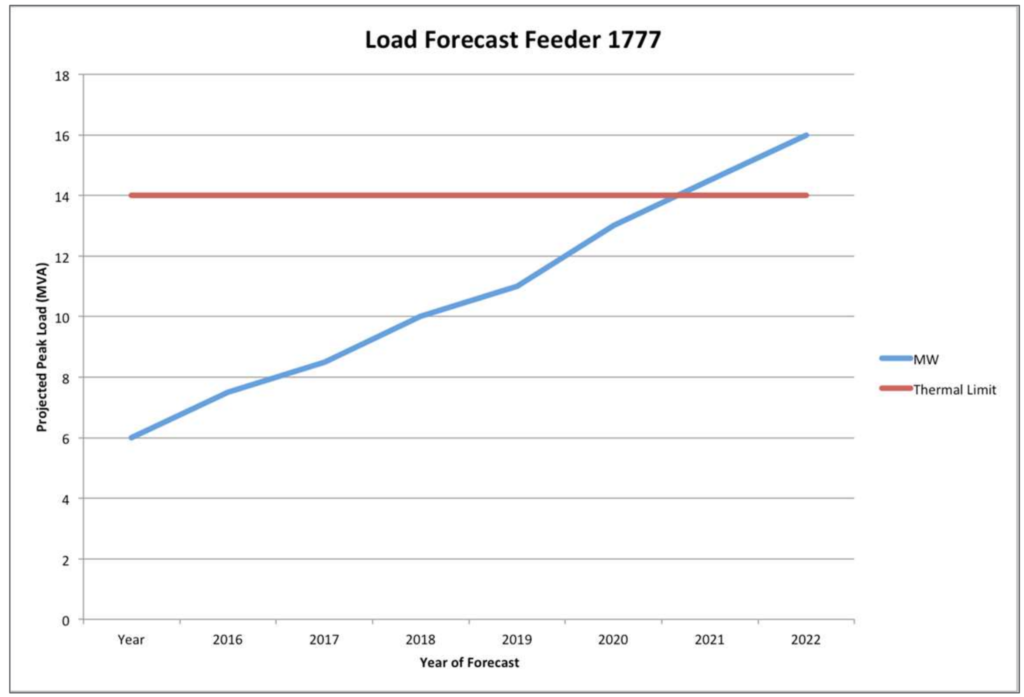
It all starts with **load** and **DER** forecasts



Source: Paul De Martini (ICF) for Minnesota Public Utilities Commission, *Integrated Distribution Planning*, 2016

Traditional load forecasting

- Track peak loads (using SCADA data)
- Evaluate each distribution feeder for annual growth and new loads
- Feeder load forecasts aggregated to show substation status, need for expansion
- Substations may require upgraded transformers, new transformer banks, transmission, distribution equipment
- Traditional load growth projections are commonly included in utility tools (e.g., Cyme, Synergi, Milsoft)

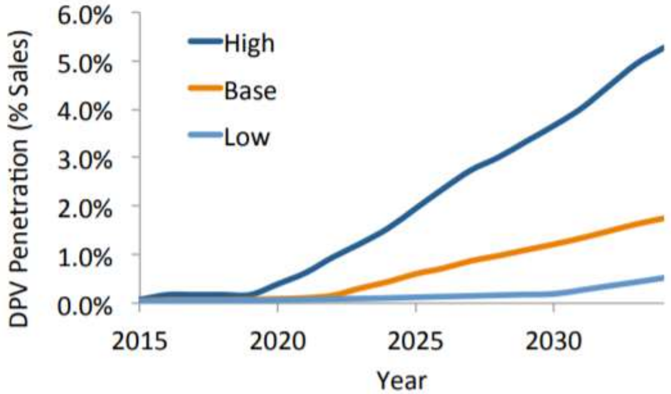


Traditional DER forecasting

- Even understanding baseline or current DER energy production is difficult – utilities don't have visibility or data on customer-owned systems
- Traditional DER forecasting has been based on:
  - Historical trends
  - Specific targets set by policy or program goals
  - Regression-based approaches applied at the service area level
  - Planners judgement
- These rely on few or no quantifiable predictive factors and may not be sufficiently robust for planning purposes going forward.
- Forecasting load and DER often happens in a "top-down" way, separately forecasting load and quantity of DER at the system level, and then allocating that system forecast down to more granular levels.

More advanced load and DER forecasting

- There is a move to more granular load forecasts in time and space, such as annual hourly load forecasts by feeder and/or by customer class.
- Multi-scenario forecasts of DER penetration and gross load can support understanding *potential* effects of DERs on a distribution system
- Scenarios may include:
  - a business-as-usual case
  - varying DER growth projections
    - (EE, DR, CHP, DG, EV and storage)
  - scenarios that reflect cost decreases for certain DERs
  - scenarios that reflect specific policies, including carbon/sustainability scenarios
  - scenarios that explore different energy service provider landscapes, such as a high community choice aggregation scenario.



- Market analysis reports, potential studies, procurement requirements, and internal company analysis can be used to develop different DER growth scenarios.

Load and DER forecasting tools

- Load Forecasts
  - LoadSEER - integrates geospatial and AMI data along with historical and forecasted weather information to develop regularly updated multi-scenario load forecasts.
  - CYME, Snergi, Milsoft - have add-on modules for developing multiple-scenario forecasts.
  - NREL's dsgrid - creates detailed electricity load data sets.
- DER Adoption forecasts
  - dGen forecasts technical and economic potential but does not project customer adoption in the short term.
  - Utility specific tools based on Bass Diffusion Models

Challenges and Gaps – Load and DER Forecasts

- Commercial/mature tools are needed that use customer adoption modeling and machine learning to project customer adoption rates of DERs and net load in a granular way, taking into consideration policies, and existing deployment rates
  - WattPlan Grid, a tool currently in development, plans to use machine learning and advanced analysis for project customer adoption

Hosting capacity and interconnection studies

- Hosting capacity analysis and interconnection studies are increasingly important as part of distribution planning and both require a similar approach
  - Hosting capacity analysis evaluates the amount of DERs that can be connected to a feeder or circuit without affecting feeder power quality or reliability
  - Interconnection studies cover the same technical issues, but for a single DER project
- Hosting capacity analysis typically consists of a set of automated distribution system analyses repeated for increasing amounts of projected interconnected DERs, until one or more of the analysis results exceeds a predetermined threshold
  1. voltage (reliability and service quality)
  2. power quality (harmonics)
  3. protection (reliability)
  4. thermal limits (loading and reliability)
- Challenges:
  - Coordinating data between utility systems
  - The large amount of information required, including feeder models, loads, and DER characteristics
  - Expertise needed to conduct hosting capacity analysis can also be a gap

Hosting capacity and interconnection studies

- Tools
  - EPRI DRIVE – a hybrid stochastic-streamlined approach available as an add-on to existing distribution system analysis tools
  - CYME and Synergi have add-on modules that use the iterative approach
  - GridLab-D and OpenDSS can be used to conduct hosting capacity analysis studies
  - EDD/NISC/DEW software

Challenges and Gaps – Hosting Capacity and Interconnection Studies

- Tools are needed that include:
  - Automatic determination of optimum resource combinations to mitigate hosting capacity exceedances
  - Analysis associated with protection coordination
  - Real-time updating and semi-automated approach to evaluating interconnection requests

EV assessment tools for distribution system planning

- LoadSEER includes agent-based modeling of EVs & provides information on how EVs will change future peak coincident load hours
- Kevala's EV Assessor can be used to optimize EV charging infrastructure, inform rate design, and evaluate the impact of given EV projections
- Electric Vehicle Infrastructure Projection Tool (EVI-Pro) by NREL projects consumer demand for electric vehicle charging infrastructure; can be used to identify the number, type and location of needed EV charging infrastructure
- BEAM, developed by LBNL, includes the ability to analyze energy impacts of changing mobility trends generally, as well as the potential impacts of EV adoption and the benefits of managing charging
- POLARIS is an open-source, agent-based tool developed by Argonne National Laboratory that can evaluate the energy impact of vehicle and transportation technologies, including EVs from a small neighborhood to metropolitan area scale.

EVs in distribution system planning

Functionality Provided	Analysis Tools/Methods*	Advanced Functionality Needed
EV battery charging is a significant new load that distribution planners need to plan for. Eventually vehicle to grid services can support the distribution system.	• LoadSEER includes agent-based modeling of EVs. • Kevala EV Assessor supports design of EV charging infrastructure. • EVI-Pro provides guidance of charging infrastructure needs. • BEAM and POLARIS are mobility focused tools that can be used to address impacts of different EV levels. • Utilities are developing customized Bass-Diffusion models to project EV adoption. • Research tools also exist.	• Commercial tools for projecting EV adoption and charging behavior that can be used for distribution system planning and operations with EVs. • Specific EV manufacturer information that can be used in modeling.

*Not an exhaustive list

From PNNL report: Electric Distribution System Planning with DERs – High Level Assessment of Tools and Methods

Assessment needs for integrating EVs into distribution system and grid plans

Critical Element	Implications for Grid	Quantitative Factors
EV Forecasts	Planning for potential new load growth, capacity needs, grid needs	Assessing magnitude - model assumptions Forecast accuracy - commitment or ability to execute EV policies
Infrastructure Programs	Residential EV charging stations can be treated as DER; Fleet charging may face capacity challenges	Symbiotic relationship with EV forecasts; Assessing barrier removal
Grid Needs	Transmission and distribution upgrades will need to be managed	Finding cost-effective solutions for utilities and rate payers

EV forecasts

- Many major utilities include EV growth in their load forecasting

- Many utilities understand the need to manage the adoption of EVs both in terms of :
  - Meeting their transportation emission goals with adequate EV adoption and corresponding charging equipment
  - Managing load with DER charging equipment

EV forecast methodology

- Most of the utilities reviewed for this analysis hire consultants to forecast growth in their service territory

- BASS Diffusion is common – approximating a logistic curve (‘S’ shape) driven by two factors or types of adopters, innovators and imitators:

$$P(t) = p + \left(\frac{q}{m}\right) N(t)$$

  - *p – coefficient of innovation* (independent actors, propensity to innovate)
  - *q – coefficient of imitation* (susceptible to social pressure)

  *Where **m = maximum penetration**, N(t) is cumulative sales, P(t) is the probability that a purchase is made in time, t*

  Maximum penetration is often driven by utility transportation electrification goals, since they exceed baseline forecasts.

EV forecasting methodology example

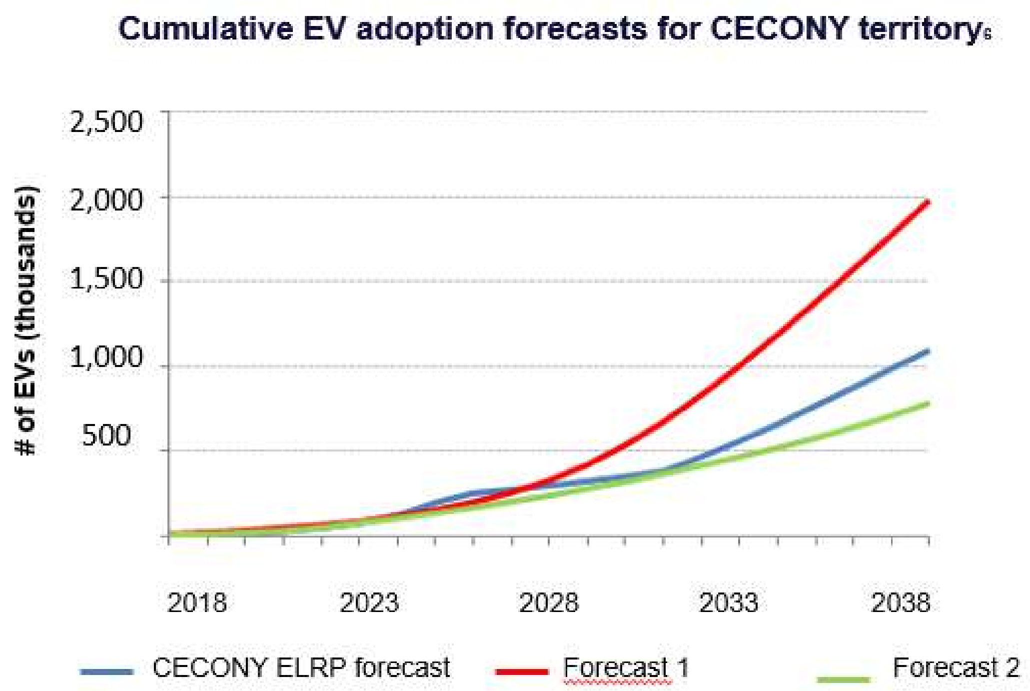
- PG&E – uses a linear growth model between current sales and a terminal assumption; provide much detail regarding what goes into their forecast. 2 Scenarios:
  - Scenario 1: Based on California's zero emissions vehicle (ZEV) standard
  - Scenario 2: Based on modeling plug-in EV (PEV) affordability; do not provide details of terminus

PG&E - EV growth rate scenarios as a percentage of total light duty vehicle sales

Year	Scenario 1: total PEVs	Scenario 2: total PEVs
2015	3.0%	3.2%
2016	3.1%	5.0%
2017	3.0%	9.6%
2018	3.0%	14.1%
2019	4.8%	13.5%
2020	6.7%	13.8%
2021	8.5%	14.3%
2022	9.8%	14.6%
2023	10.8%	15.0%
2024	11.8%	15.3%
2025	12.6%	15.7%

EV forecasting methodology example

Consolidated Edison – longer-term growth based on NY state's ZEV mandate



CECONY = Consolidate Edison Company of New York
ELRP = Electric Long-Range Plan

Infrastructure program examples

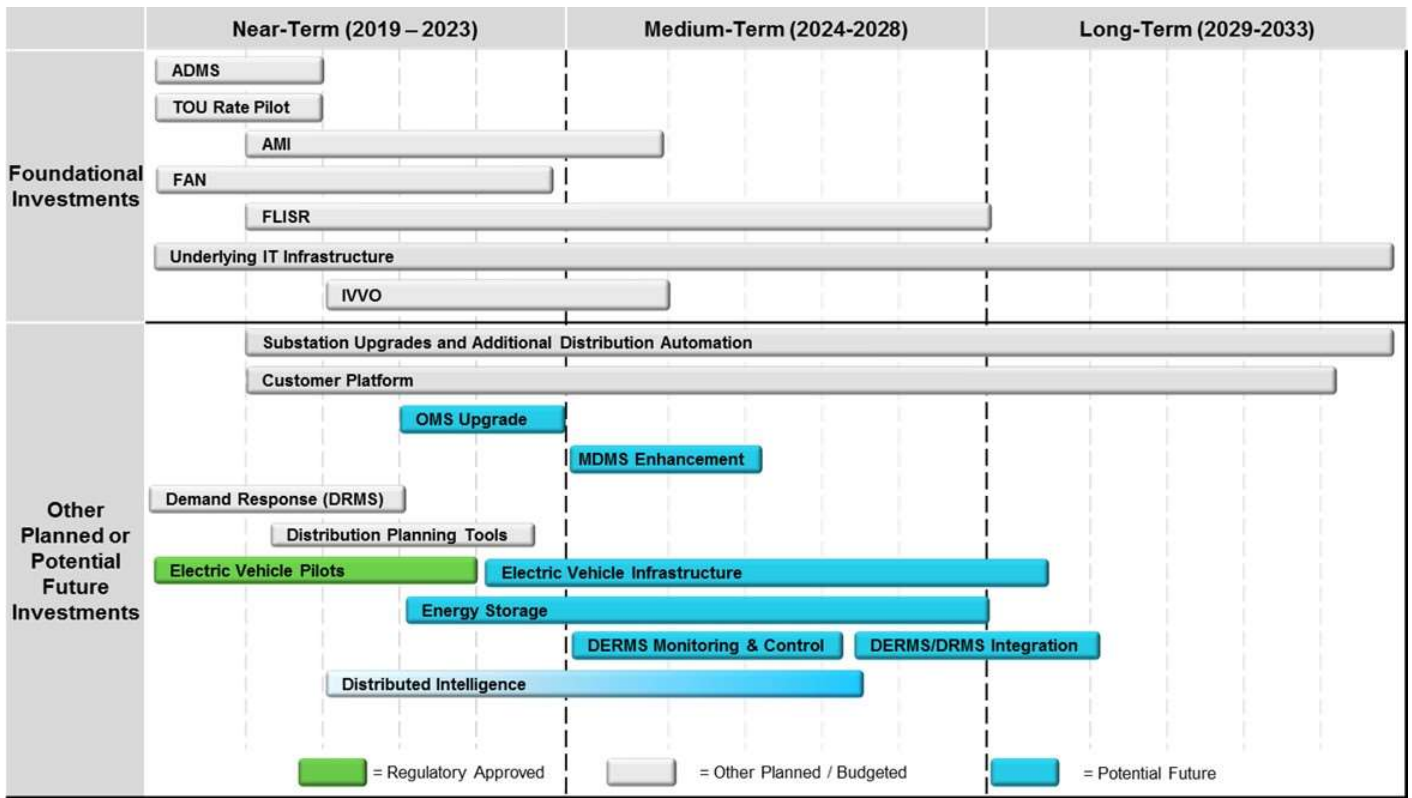
- SDG&E study finding – time of use (TOU) alone creates twin peak loads
  - one peak during evening peak
  - second peak at midnight when the super off-peak begins
  - potential to shift capacity constraint
- PG&E is researching optimal siting to mitigate DC Fast Charging expense. Identify location where:
  - there is available upstream capacity to likely lower installation cost
  - there is substantial charger utilization to help spread fixed demand charge
- Duke approved $76 MM EV Pilot Program
  - Majority of pilot, $34.4MM is going to DC fast charging network
  - $26.6 MM towards public and school bus fleet

Infrastructure programs examples

XCEL – spending $25 MM in Grid Modernization and Pilots associated with EVs

4 EV Pilots:

1) Residential Service – provides EV service equipment
2) Residential Subscription Service – provides attractive off-peak set fee
3) Fleet Service – install, own, maintain fleet infrastructure; requires fleet to take TOU
4) Public Charging – aid in installation and maintenance for developers of public stations



Grid needs related to EVs

- Some studies show impact of EVs on T&D upgrades and retail rates (up to 12% increase) could be substantial depending on charging patterns (Sahoo et al. 2019)
- Additional revenue from electricity sales for EV charging will offset investment costs but utilities may need to recoup some costs through higher retail rates
- Optimizing charging timing & location may decrease EV related T&D costs by 70%
- Suggestions for planning to meet EV demand at reasonable cost:
  - Use detailed network maps to identify sites where anticipate material demand for EV charging infrastructure is anticipated
  - Segment sites into those that would require minimal or no upgrades and those that would need substantial upgrades
  - Develop a plan that both minimizes extent of grid upgrades required at all sites and meets the requirements of the sites that need major upgrades
  - Deploy metering technology that allows for charging different rates at different times and potentially in different locations

Grid needs related to EVs

Hawaii will include 2 sensitivity analyses during their grid assessment simulations. Assess the value of customers charging their cars to better inform future rate design:

1) Unmanaged EV Charging
2) Managed EV Charging

Conclusions

- A variety of methods are being used for forecasting
- Price differential assumptions, between traditional vehicles and EVs, are a major driver for forecasts
- Utilities understand the need to ‘get in front’ of residential charging
- Availability of charging infrastructure can impact EV numbers
- Managing charging location and timing can lead to significant cost reductions and should be a focus of planning

Thank you

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