Forecasting load on distribution systems with distributed energy resources

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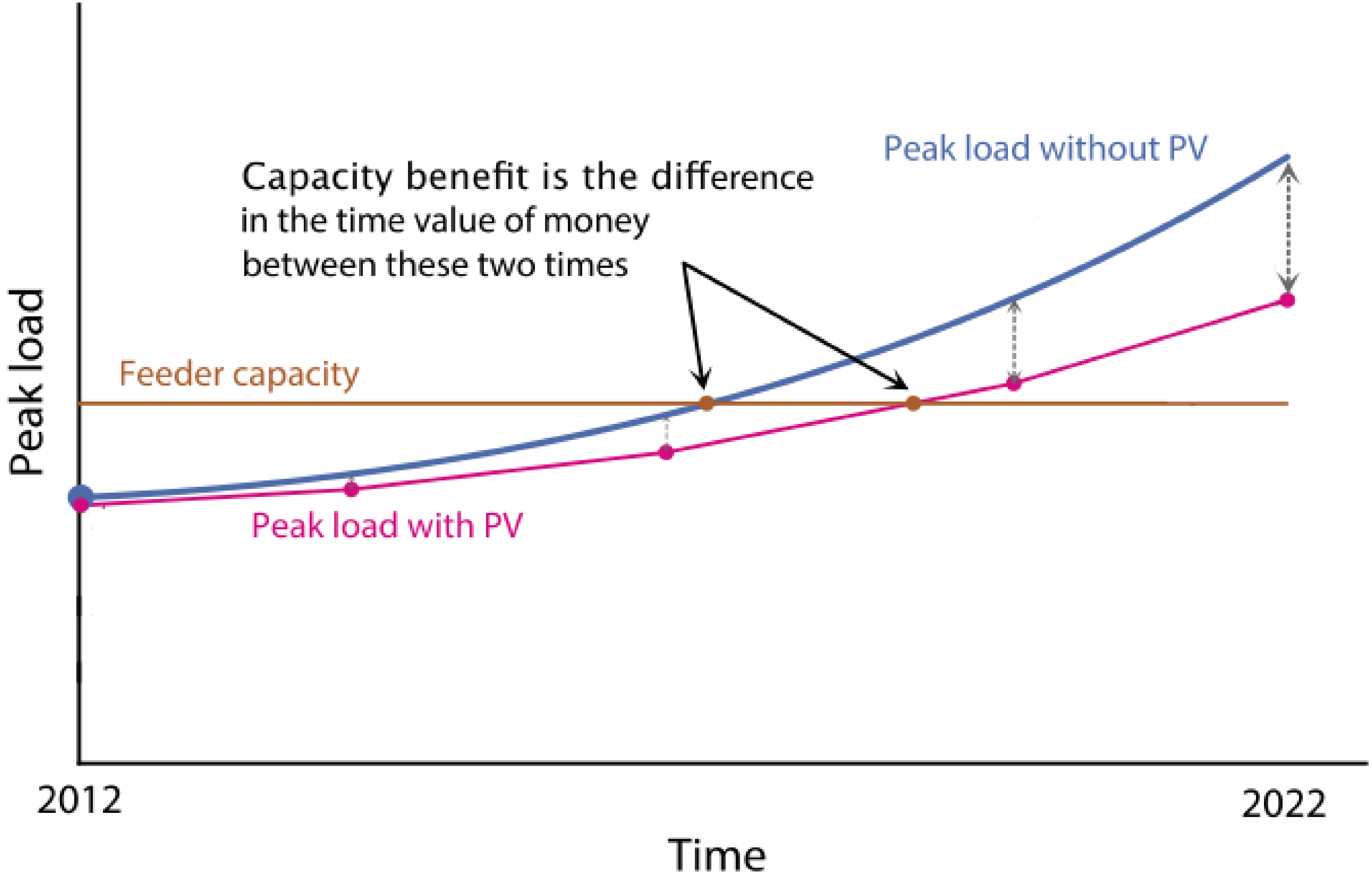
Importance of Including Distributed Energy Resources in Load Forecasts

- Distribution system investments: replacing aging infrastructure and distribution expansion
- Procurement of generating capacity to meet peak demand
- Proactive investments to increase hosting capacity
- Evaluating the costs and benefits of incentives or policies to promote distributed energy resources (DER)

Impact of DPV on T&D Investments: Potential Deferral Value



Source: Adapted from Cohen et al. 2016

Increasing Adoption of DER Increases the Importance of Accurate Forecasts in Planning

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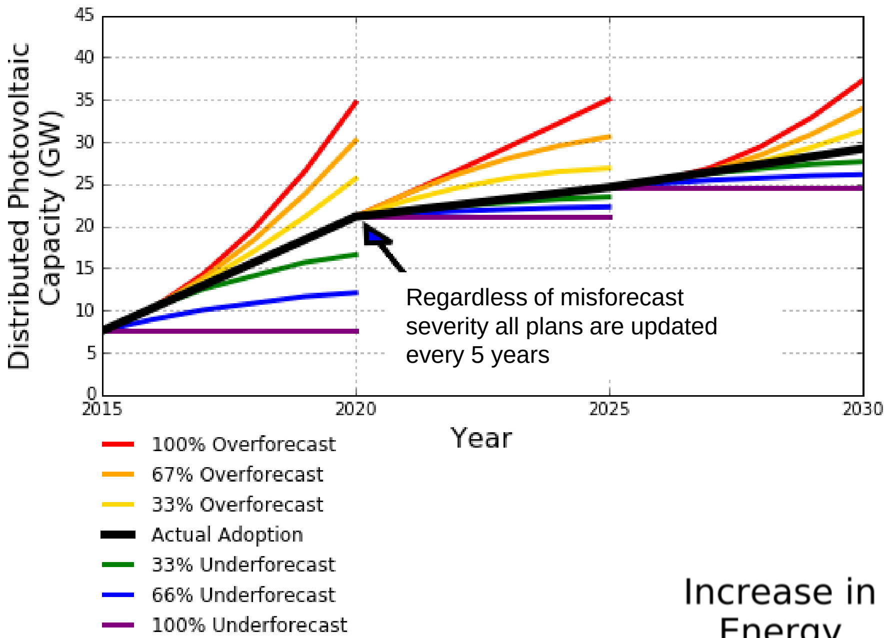
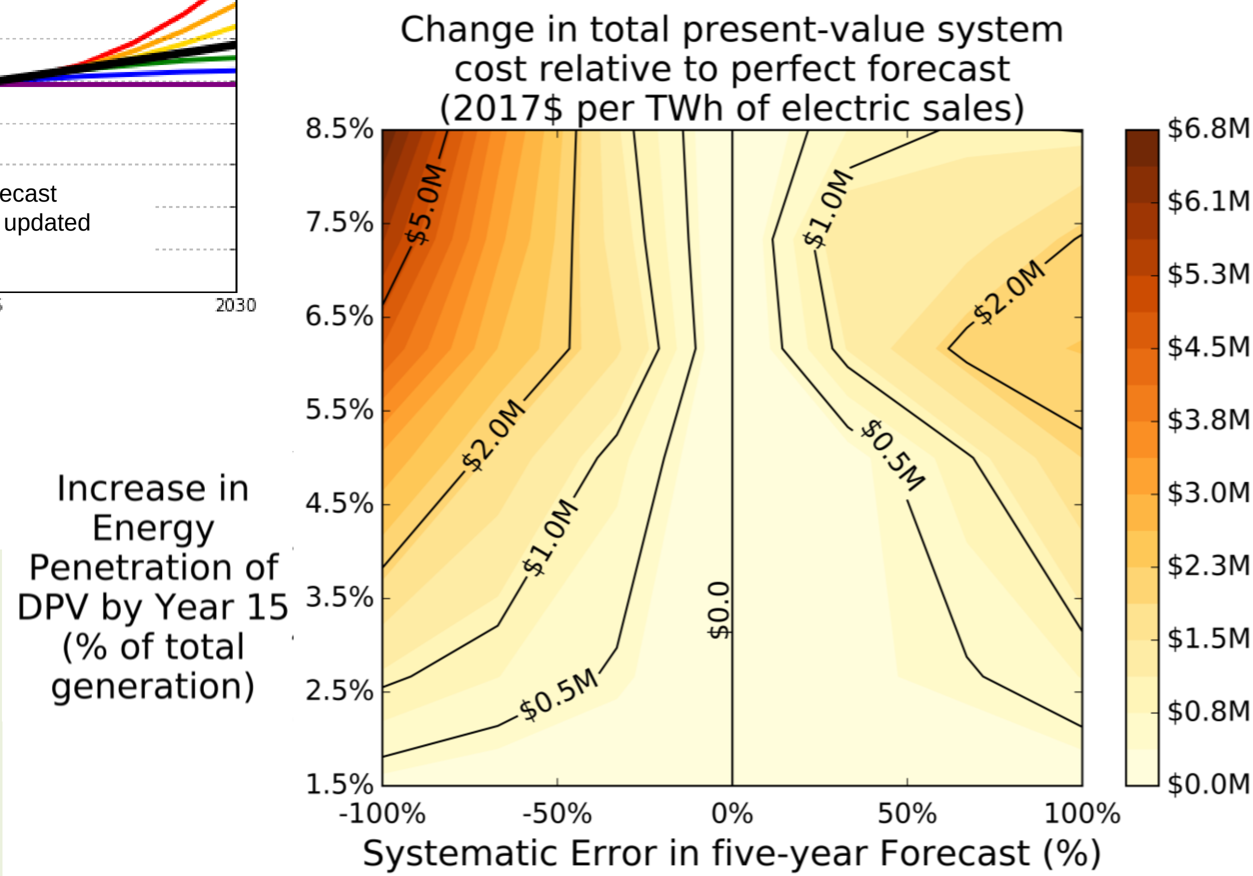




Costs of roughly **$70 million from severe underforecasting** and **$20 million from severe overforecasting** for a utility with sales >10TWh/yr and with up to 8.5% of sales from DPV by the end of a 15-year period

Source: Gagnon et al. (2018)

Planning for a Distributed Disruption: Innovative Practices for Incorporating Distributed Solar into Utility Planning

Context

- Analysts project that distributed solar photovoltaics (DPV) will continue growing rapidly across the United States.
- Growth in DPV has critical implications for utility planning processes, potentially affecting future infrastructure needs.
- Appropriate techniques to incorporate DPV into utility planning are essential to ensuring reliable operation of the electric system and realizing the full value of DPV.

Approach

- Comparative analysis and evaluation of roughly 30 recent planning studies, identifying innovative practices, lessons learned, and state-of-the-art tools.

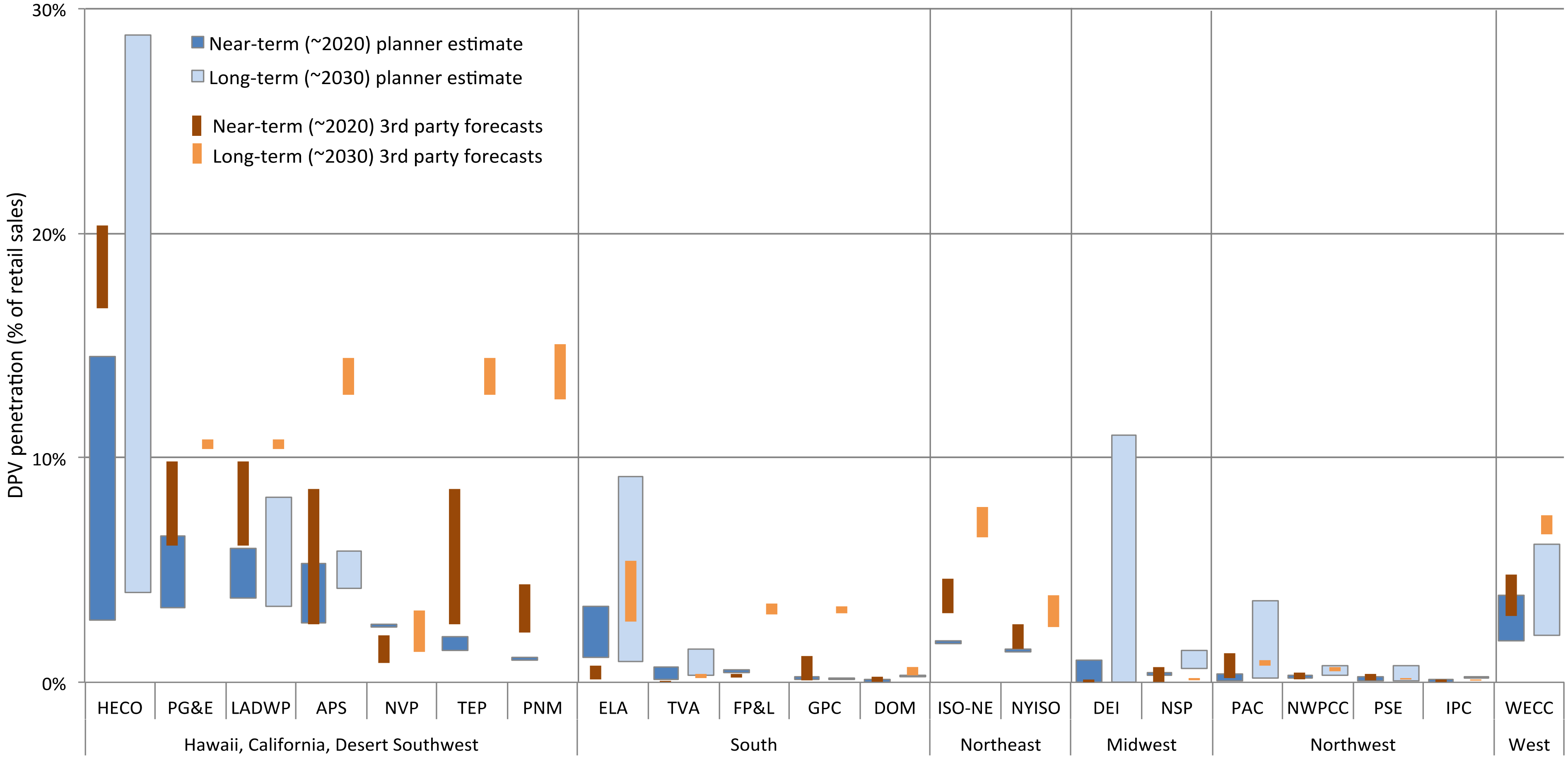
Scope

- Electric infrastructure planning (IRPs, transmission, distribution).
- Focus on the treatment of DPV, with emphasis on how DPV growth is accounted for within planning studies.

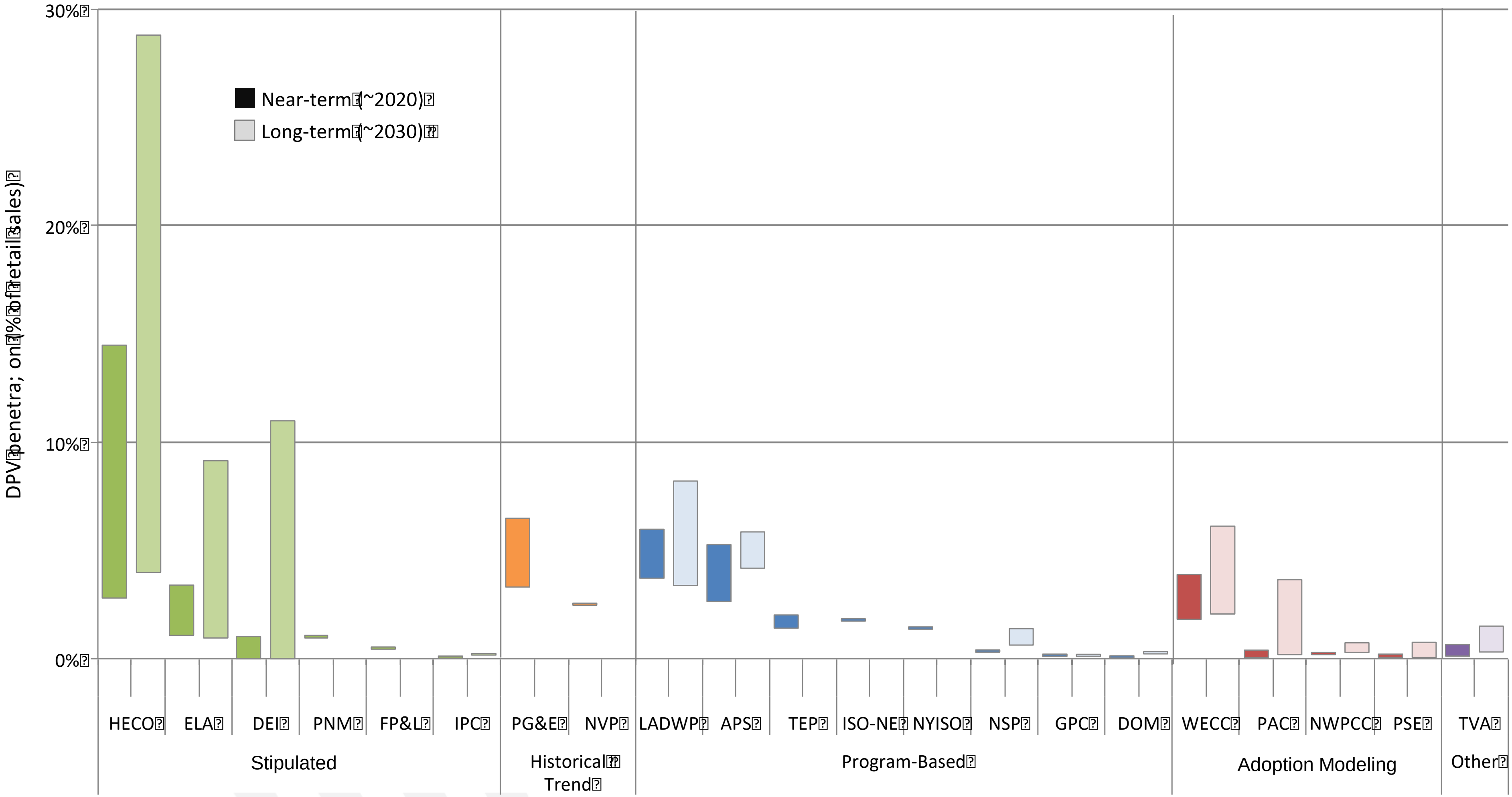
Key Findings

- Forecasting load with DER is often “top-down”: separately forecast load and quantity of DER at the system level, allocate that system forecast down to more granular levels.
- Many factors affect customer decisions to adopt DER, including the cost and performance of DER, incentives, customer retail rates, peer-effects, and customer demographics. Customer-adoption models can help account for many of these factors.
- Forecasts are uncertain: It may be valuable to combine various approaches and to benchmark against third-party forecasts.

High End of 3rd Party Forecasts Suggests More DPV Than Considered By Utilities



A Variety of Methods Are Used to Develop DPV Forecasts



Customer-adoption Modeling Brings Customer Decisions Into DPV Forecast

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Method	Description	Explanatory Factors Used				
		Recent installation rates	Incentive program targets	Technical potential	PV economics	End-user behaviors
Stipulated Forecast	Assumes end-point DPV deployment					
Historical Trend	Extrapolates future deployment from historical data	X				
Program-Based Approach	Assumes program deployment targets reached		X			
Customer-Adoption Modeling	Uses adoption models that represent end-user decision making	X		X	X	X

Some Planners Use Customer-adoption Models for DPV Forecasting

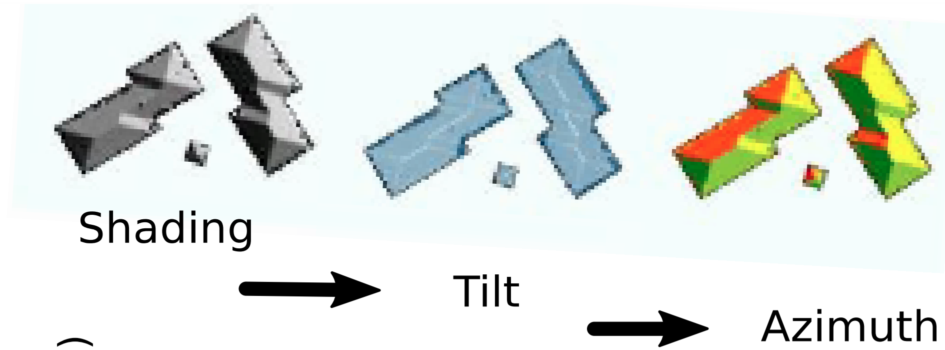
Technical Potential

↓

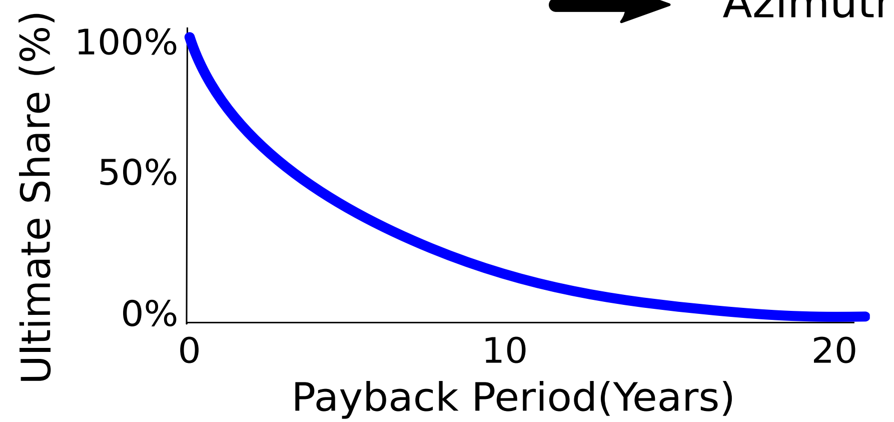
Willingness-to-adopt

↓

Diffusion



Adapted from: Gagnon et al. 2016



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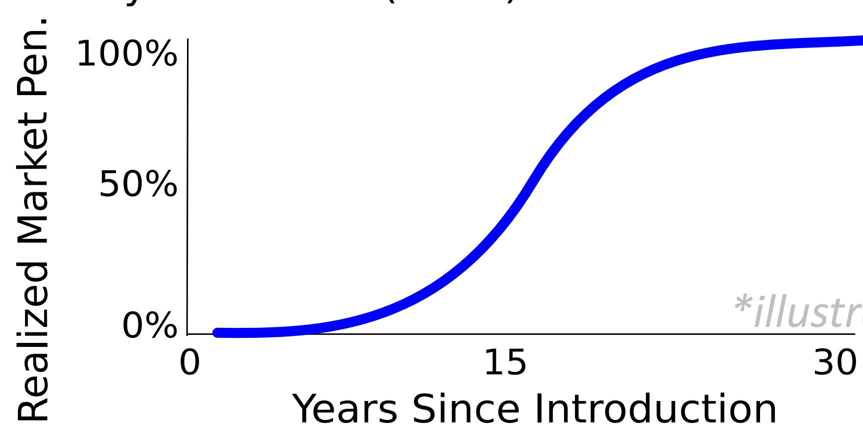
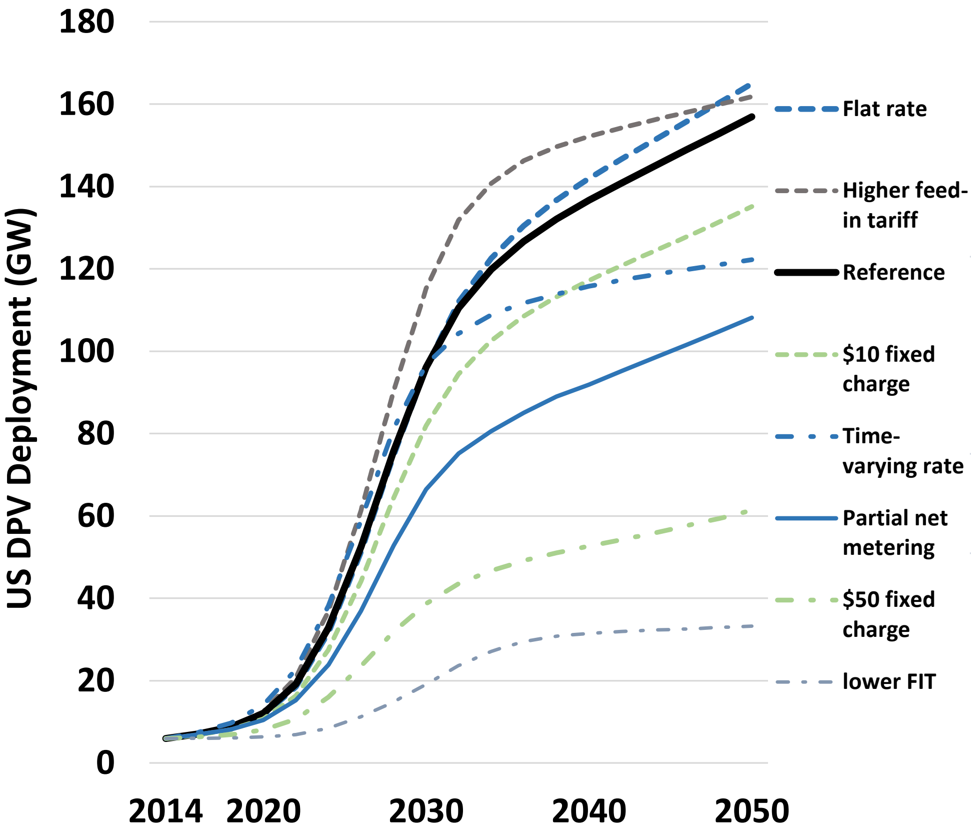


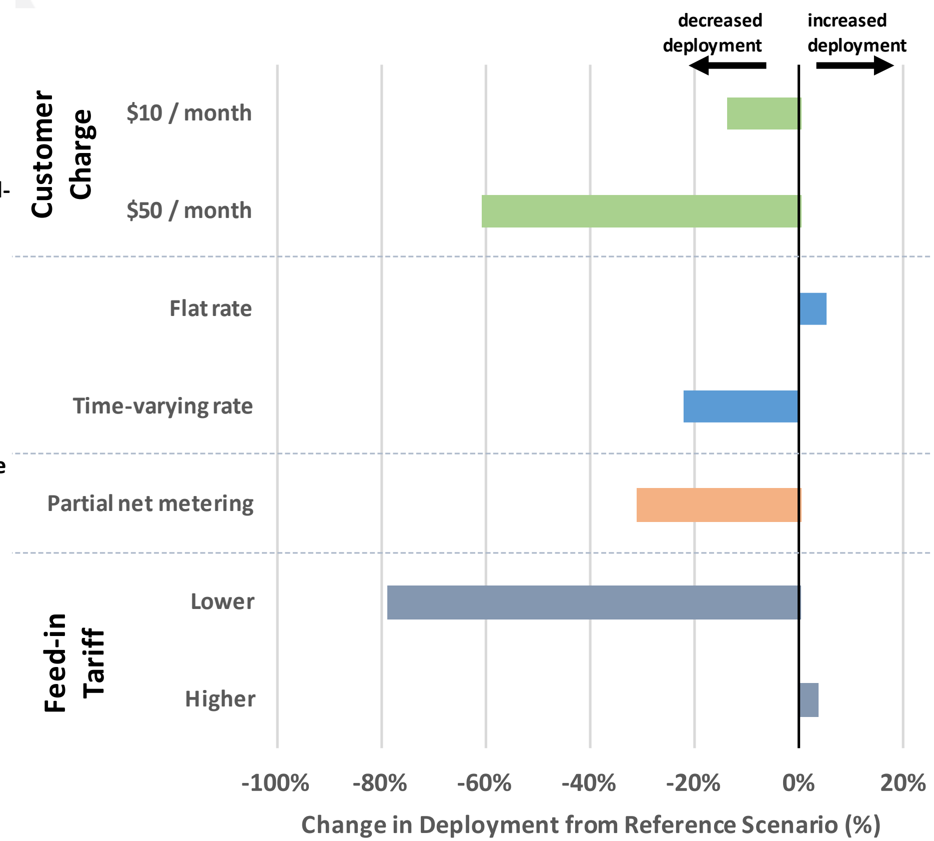
*illustrative

Technical Potential Estimates Are Typically Based on Customer Count and Rooftops

- Technical potential studies used by utilities in our sample of studies were based primarily on customer counts and floor space surveys
  - Rooftop space is based on average number of floors and assumptions about the density of PV arrays
- New emerging tools like Light Detection and Ranging (LiDAR) imaging can refine technical potential estimates:
  - Infer shading, tilt, and azimuth from rooftop images
  - Apply availability constraints to exclude unsuitable orientations or insufficiently large contiguous areas
- Can also refine with permitting and zoning restrictions, if applicable
- May overestimate suitability without consideration of roof condition, building age, electric code compliance, and building ownership

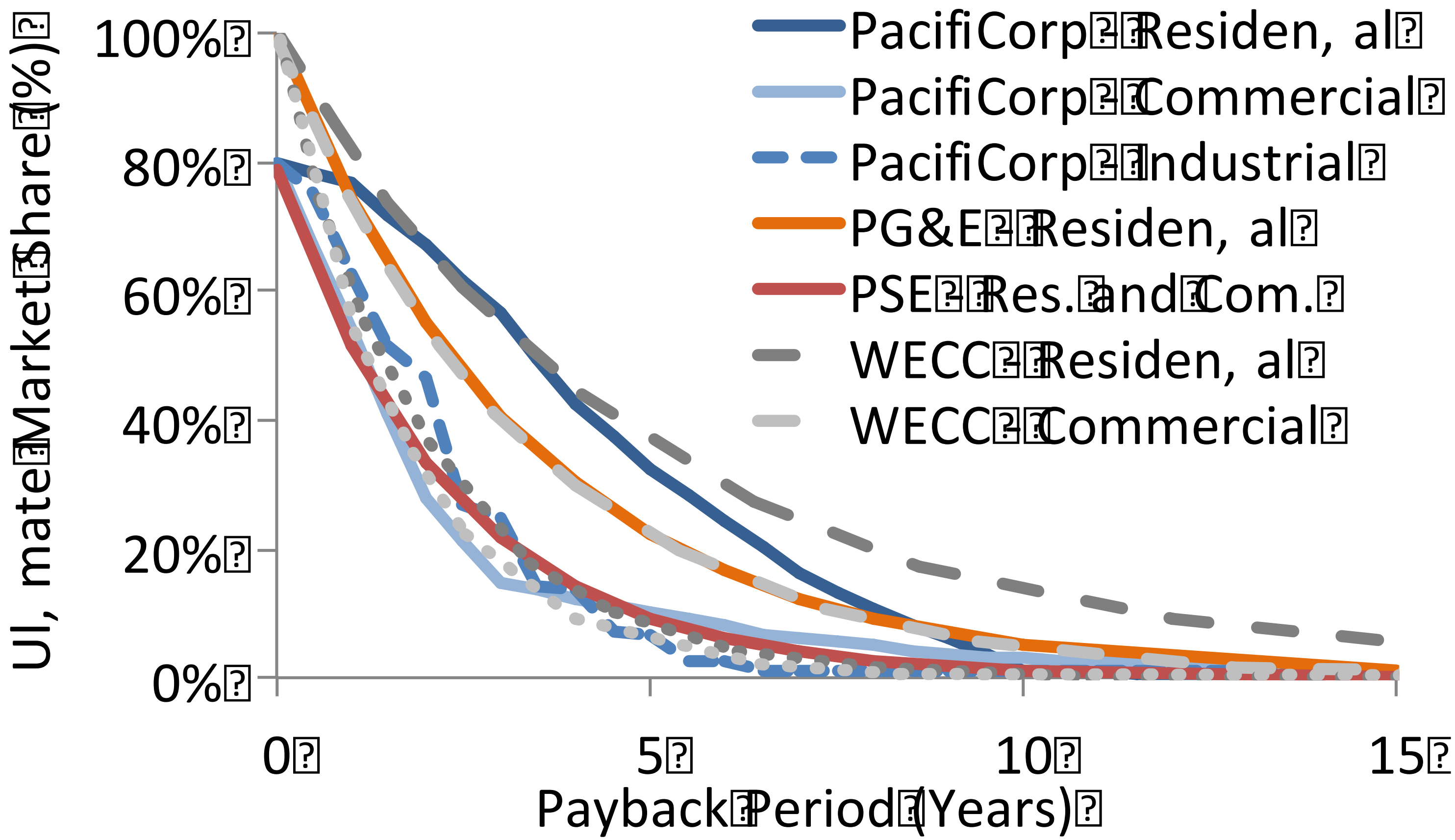
Economic Factors, Especially Rate Design, Significantly Affect Adoption Projections





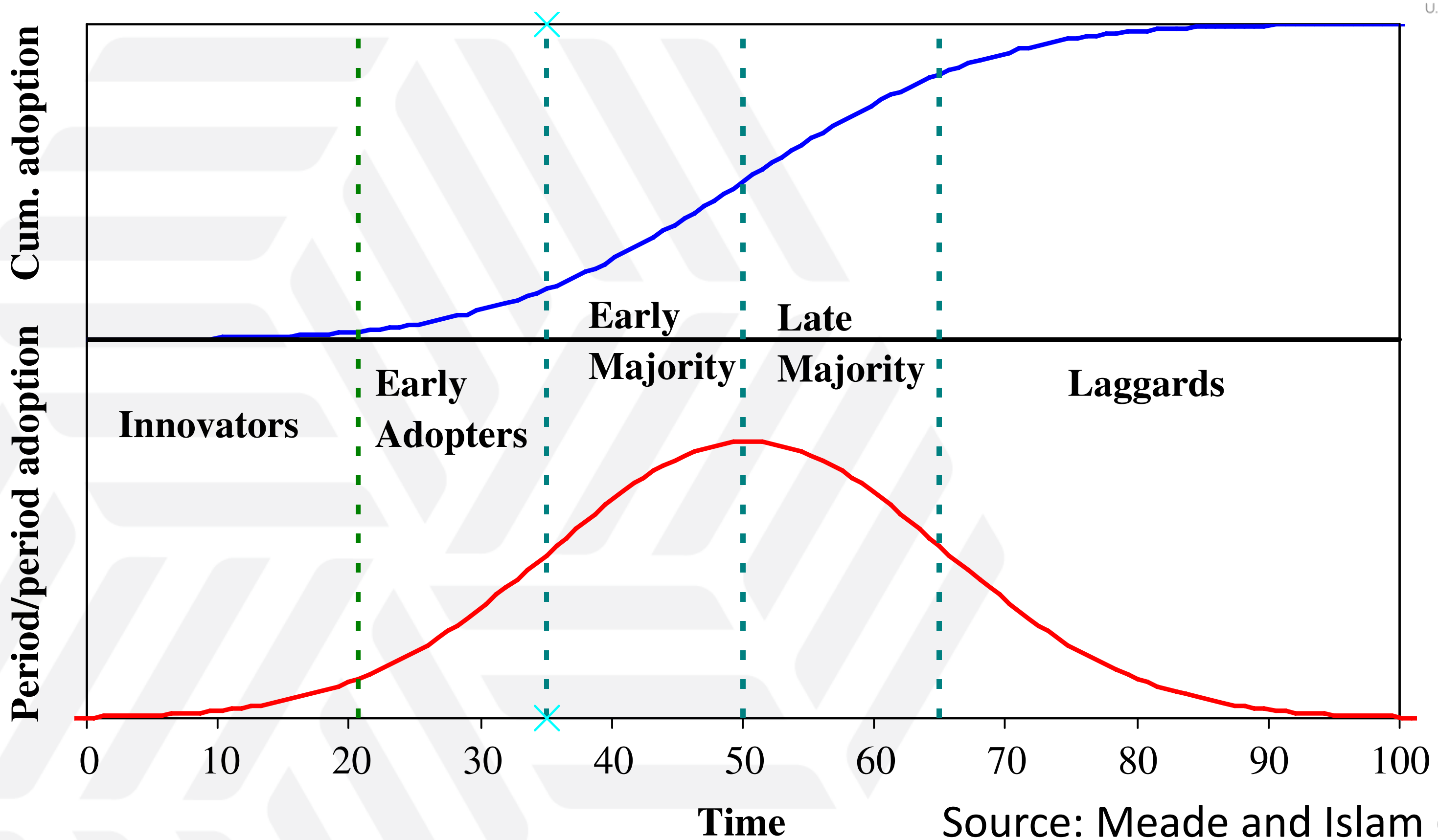
Source: Darghouth et al. 2016

Forecasters Tend to Rely on Similar Willingness-to-adopt Curves



Note: Dashed gray lines (WECC) are for existing buildings, and dotted gray lines are for new buildings.

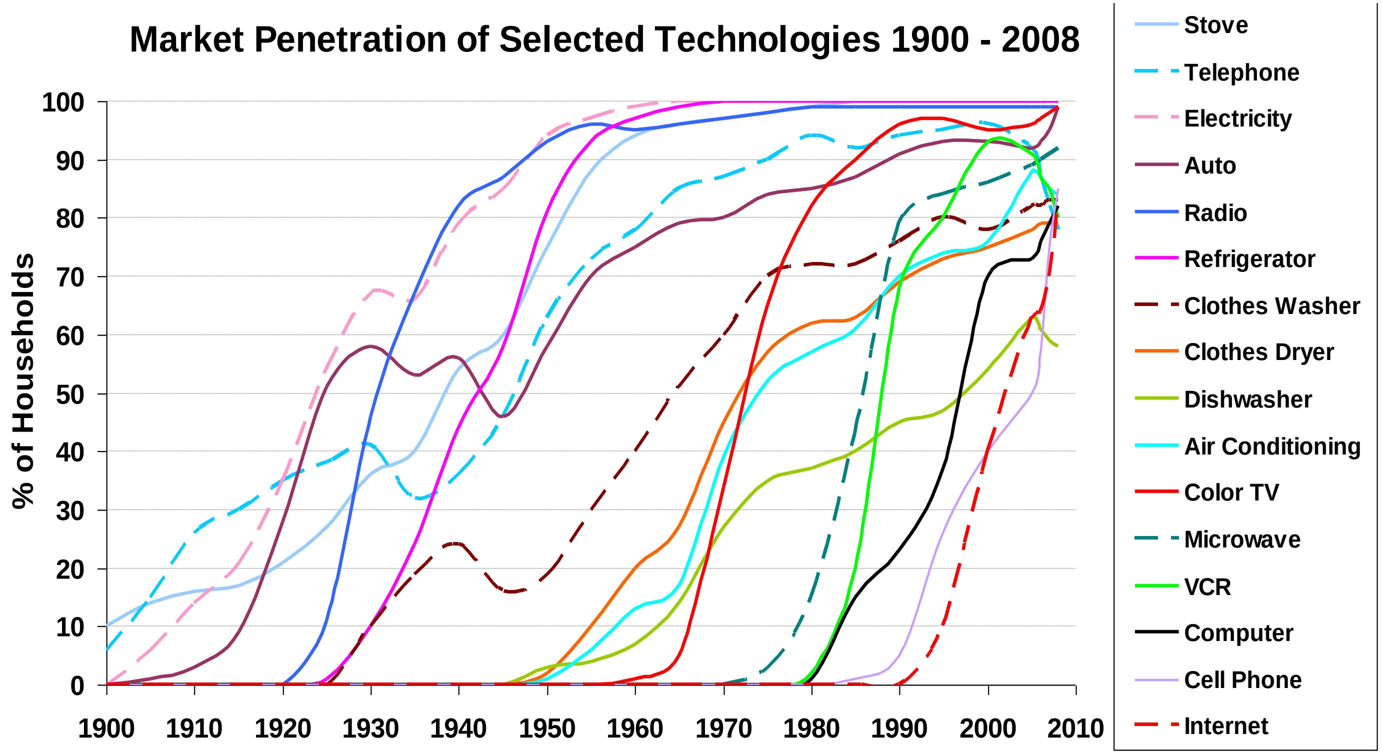
Diffusion of Technology Impacts: Time to Achieve Ultimate Market Share



Source: Meade and Islam (2006)

- The Bass diffusion model and Fisher-Pry model are two common choices that produce the characteristic “S-Curve” in adoption.

Diffusion Curves for DPV Forecasts Are Often Based on Fits to Data, and Can Vary Widely



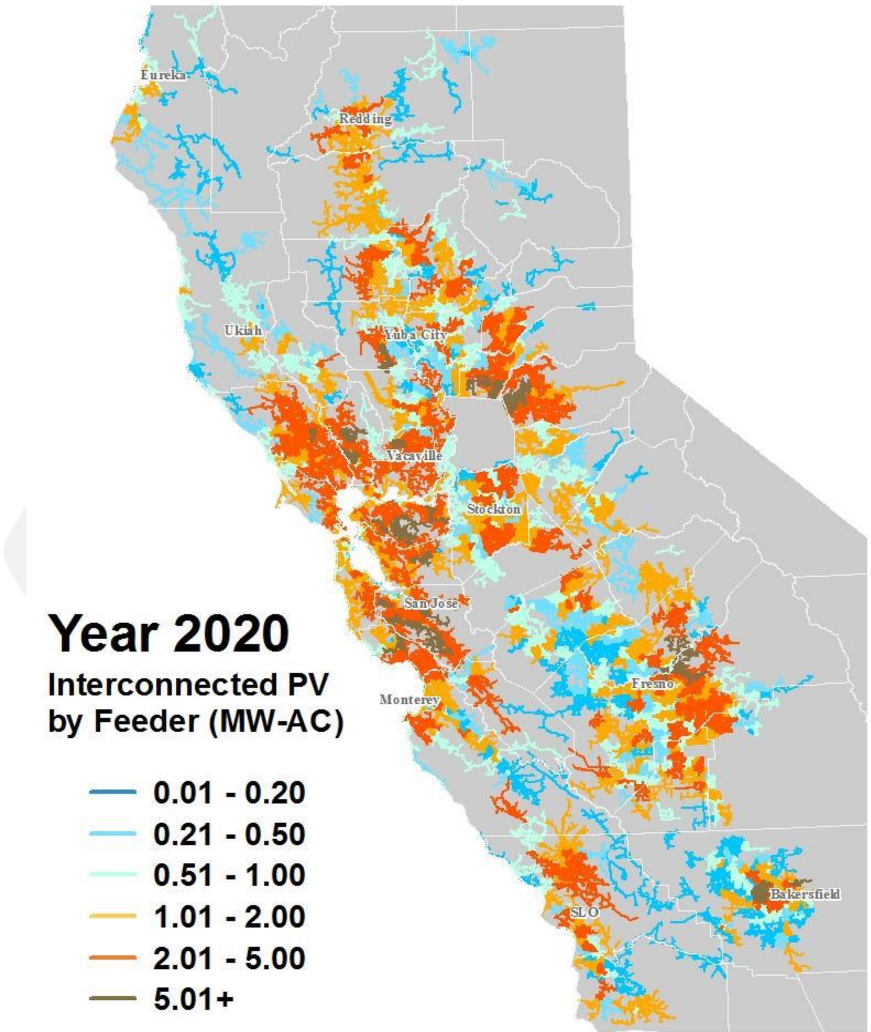
Source: Federal Reserves of San Francisco and Dallas (Sean Ong, NREL)

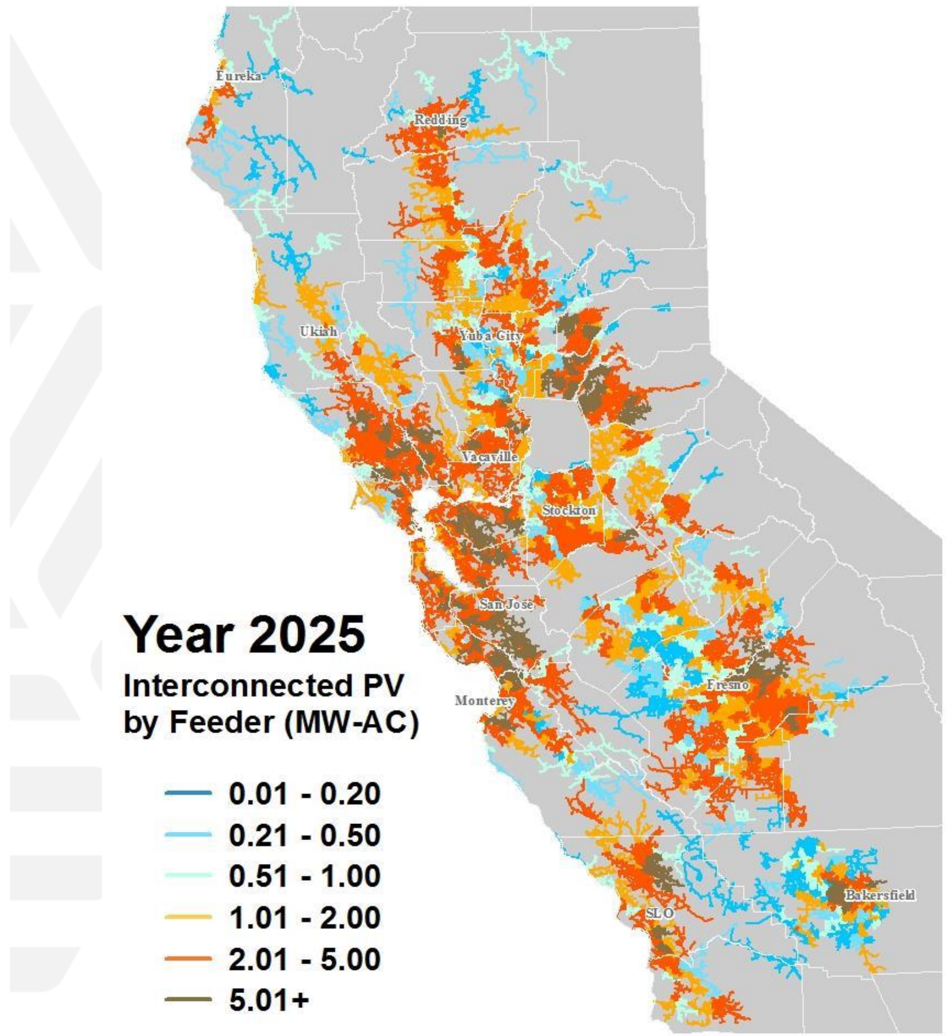
- Precedent for S-curve in diffusion of other technologies
- Highly variable time to saturation, but typically measured in decades.
- Parameter fit (time-to-saturation) is sensitive to observed data; initial studies typically benchmarked to other regions/technologies

Propensity to Adopt Accounts for Factors Like Customer Demographics

Method	Description	Predictive Factors Used		
		Location of existing load or population	Location of existing DPV	Detailed customer characteristics
Proportional to Load	Assumes DPV is distributed in proportion to load or population	X		
Proportional to Existing DPV	Assumes DPV grows in proportion to existing DPV		X	
Propensity to Adopt	Predicts customer adoption based on factors like customer demographics or customer load	X	X	X

Predicting the Location of DPV Adoption Using Propensity to Adopt





Source: PG&E 2015 DRP

Factors Considered in PG&E's Propensity to Adopt Metric

- Residential Customers:
  - Home ownership
  - Electricity usage
  - Income
  - Credit
  - Building characteristics (area, number of stories)
- Non-Residential Customers:
  - Property ownership
  - Electricity usage
  - Retail rate
  - Business type (NAICS)
  - Building characteristics (area, number of stories)

- Propensity to adopt metric is then used to allocate system forecast down to customers.

Source: PG&E presentation to DRPWG (4/2017)

Additional Challenges: Removing DER from Historical Load to Create Accurate Load Forecasts

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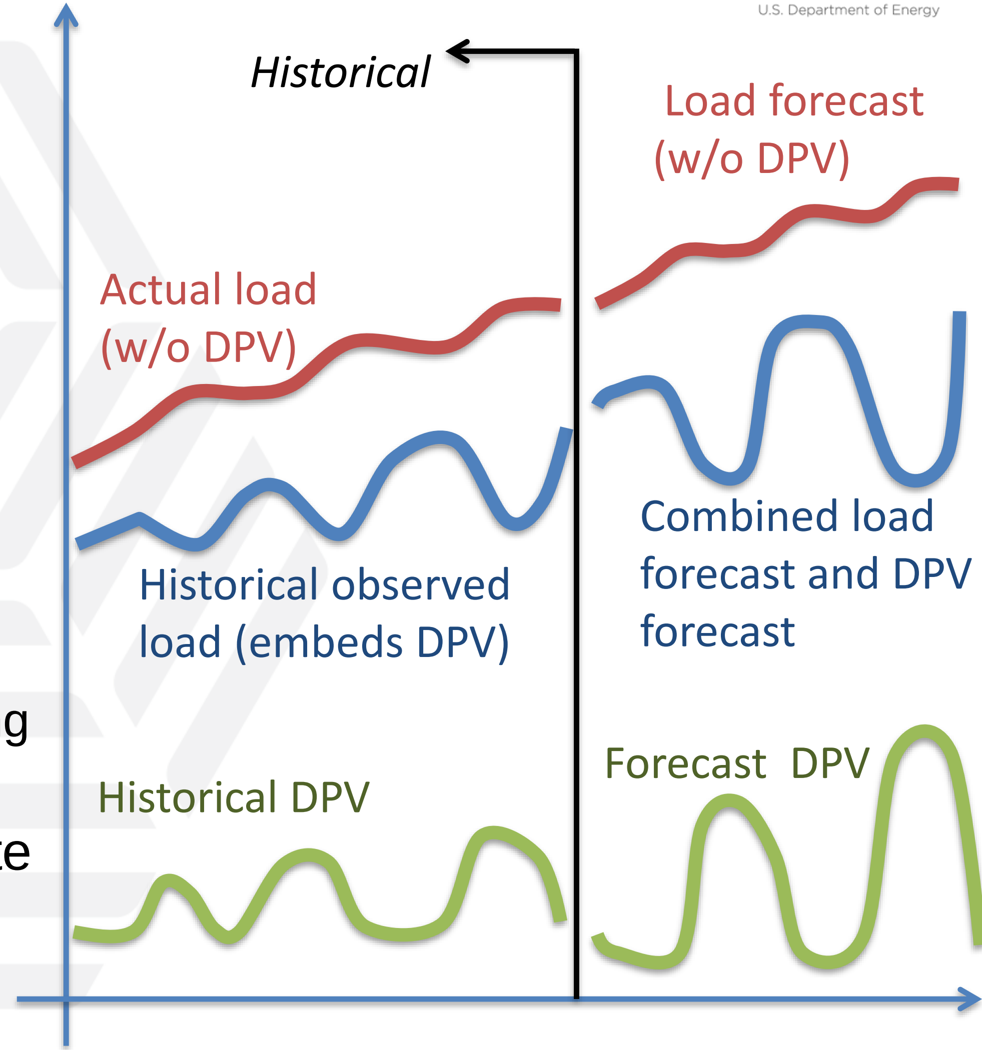
- PJM recently adjusted load forecasting methodology to better account for behind-the-meter PV
- Original approach used the observed load to forecast future load, without adjusting for effect of behind-the-meter DPV on the observed load
  - Load reductions from behind-the-meter DPV were being attributed to new end uses in the load forecasting model
- Revised approach removes estimate of historical PV before forecasting load, then adds back in forecast of DPV to new net load forecast



Additional detail: Falin (2015)

Public Tools Coming Soon to Develop Forecasts

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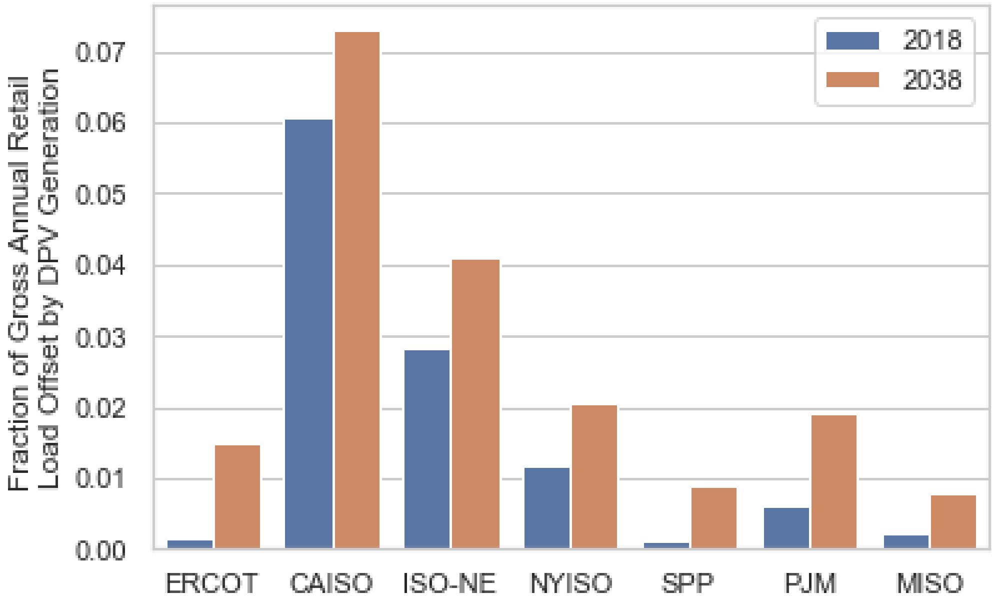
- NREL is funded by U.S. DOE to open-source the dGen DER customer adoption model

- Working with planning staff from all seven ISO/RTOs to develop joint forecasts, develop capacity, and improve methodology

- Beta Model release in July 2020
  Full model in September 2020

http://www.nrel.gov/analysis/dgen

- Looking for additional partners for 2020 - 2021



Projected DPV penetration rate by ISO/RTO for 2038

(Sigrin 2020 - Under Review)

Open-Sourcing the dGen Model

The Resilient Planning for DERs (RiDER) project has four objectives:

- ► Open-source the dGen model so that utilities, PUCs, state energy offices, etc. can easily develop customized DER adoption scenarios themselves
- ► Develop scenario-based forecasts of DER adoption to facilitate long-term planning and load forecast. Download the data yourself, or use the interactive web application
- ► Advance the state-of-art and standardize methodologies for forecasting, as this is quickly becoming an essential part of energy planning
- ► Improve capabilities at ISO/RTOs to incorporate DERs into their market modeling

Key Questions for Regulators About DER Forecasts

- What are the primary factors that drive your forecast of DER adoption? How do you consider customer economics and factors that might affect customer economics within the forecasting horizon?
- How do you account for the tendency for adoption of technologies to follow an S-shaped curve?
- How does your forecast compare to forecasts from third parties for the same region?
- How do you account for factors that might be uncertain such as availability of future incentives, technology cost, or customer choice?
- Do you use a top-down method to forecast DER adoption at the system level? If so, how do you allocate that forecast down to the distribution level? Do you account for differences in customer demographics?

Questions?

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