Forecasting load on distribution systems with distributed energy resources

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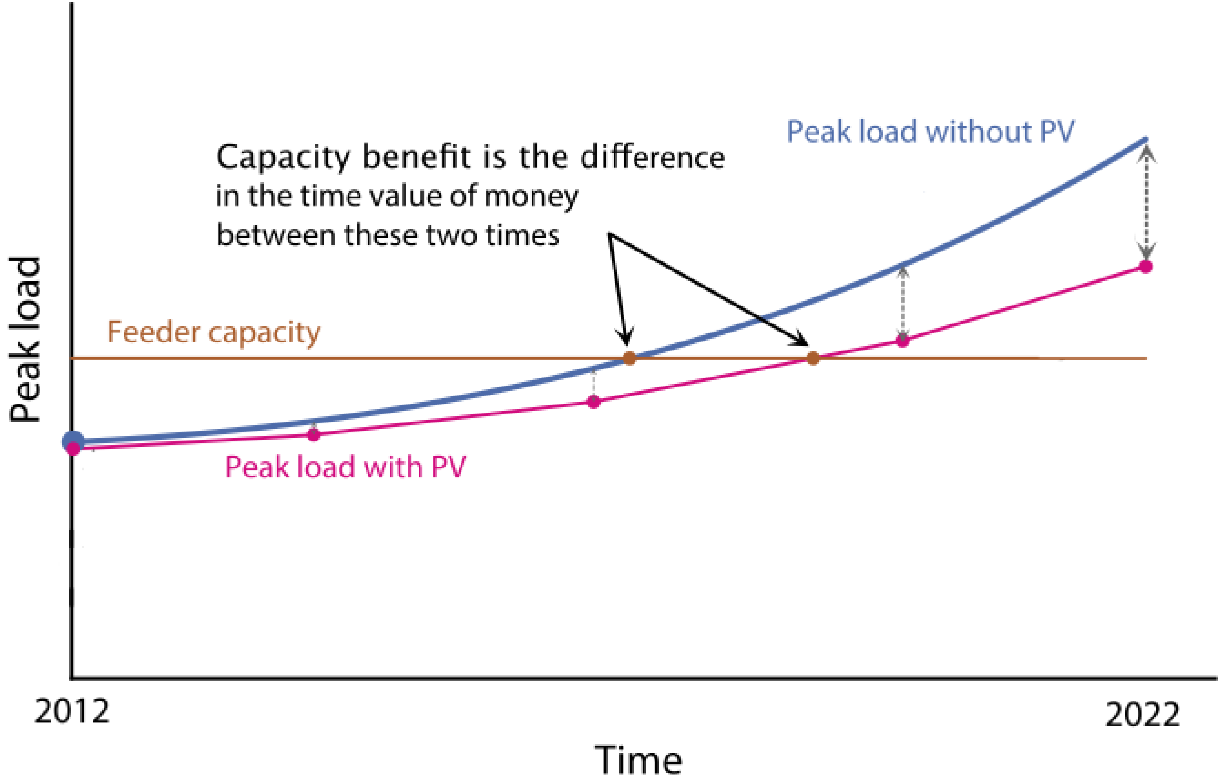
Importance of Including Distributed Energy Resources in Load Forecasts

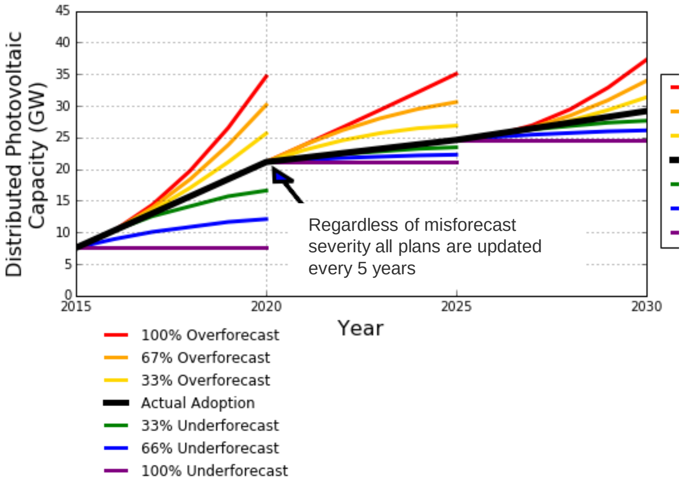
- Distribution system investments: replacing aging infrastructure and distribution expansion
- Procurement of generating capacity to meet peak demand
- Proactive investments to increase hosting capacity
- Evaluating the costs and benefits of incentives or policies to promote distributed energy resources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

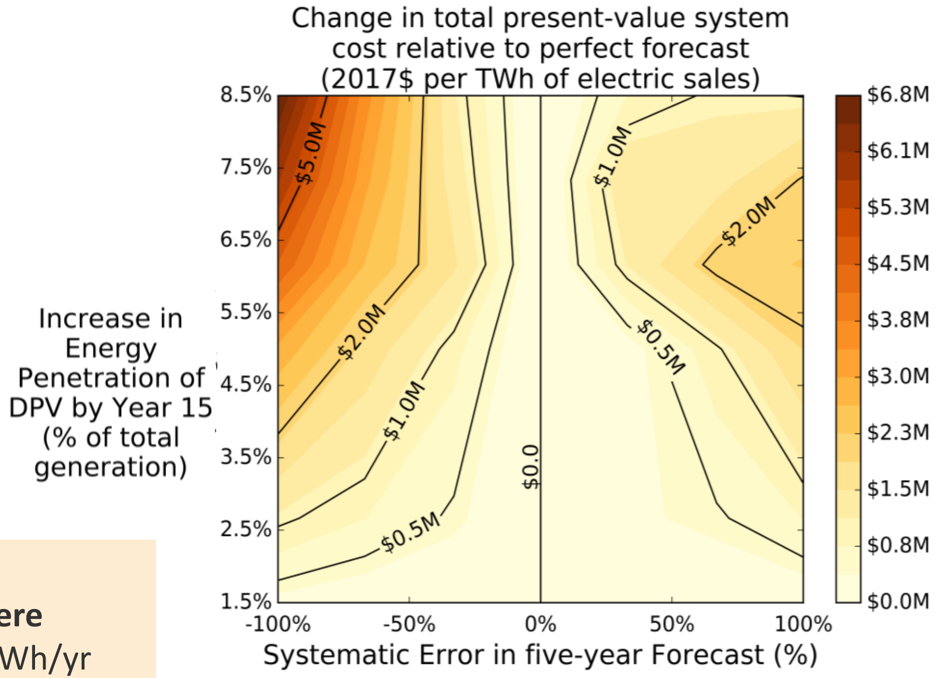
Impact of DPV on T&D Investments: Potential Deferral Value



Source: Adapted from Cohen et al. 2016

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





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.

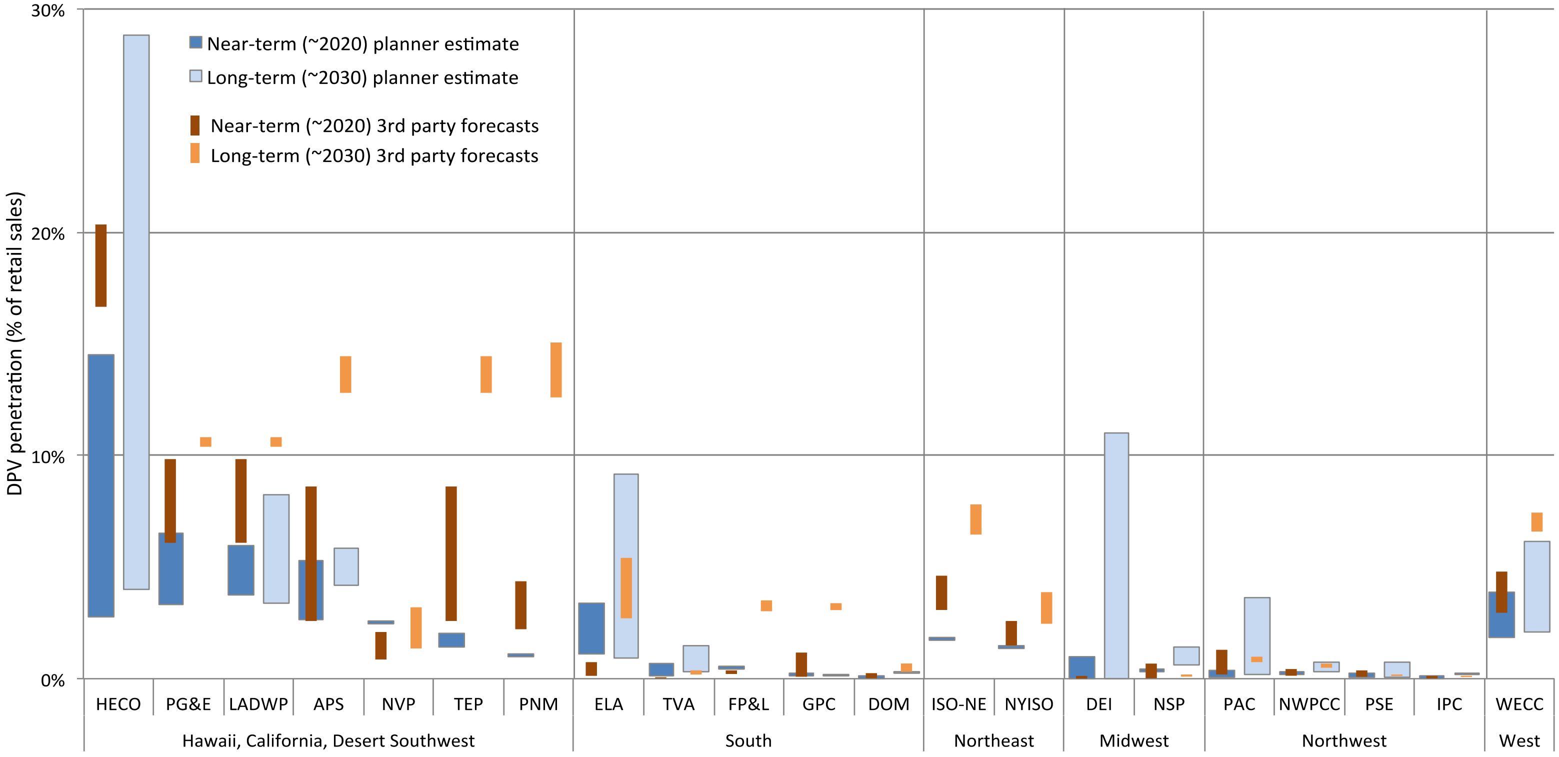
Scope

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

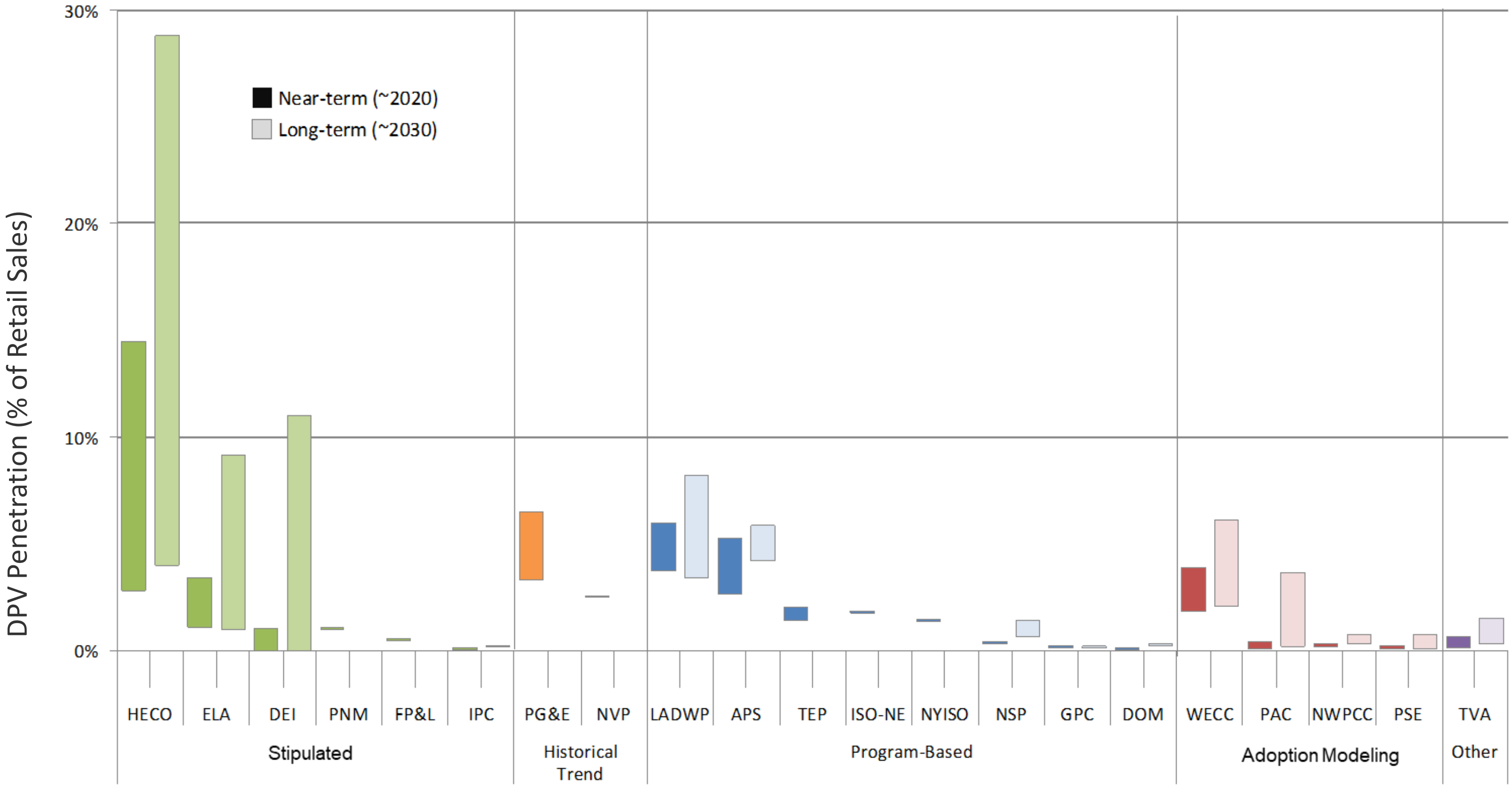
Key Findings

- 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



DPV Deployment Drivers

DPV economics:

- DPV technology cost and performance
- Federal and state incentives
- New business models (e.g., third party ownership)
- Electricity prices
- Rate design (including the availability of Net Energy Metering)

Public policy:

- Renewable Portfolio Standards and environmental requirements
- CO_2 regulation

Customer preferences:

- DPV deployment may be shaped by interest in increased customer choice

Macro factors:

- Economic growth, load growth, oil prices, and cost and availability of complementary technologies (e.g., storage and electric vehicles)

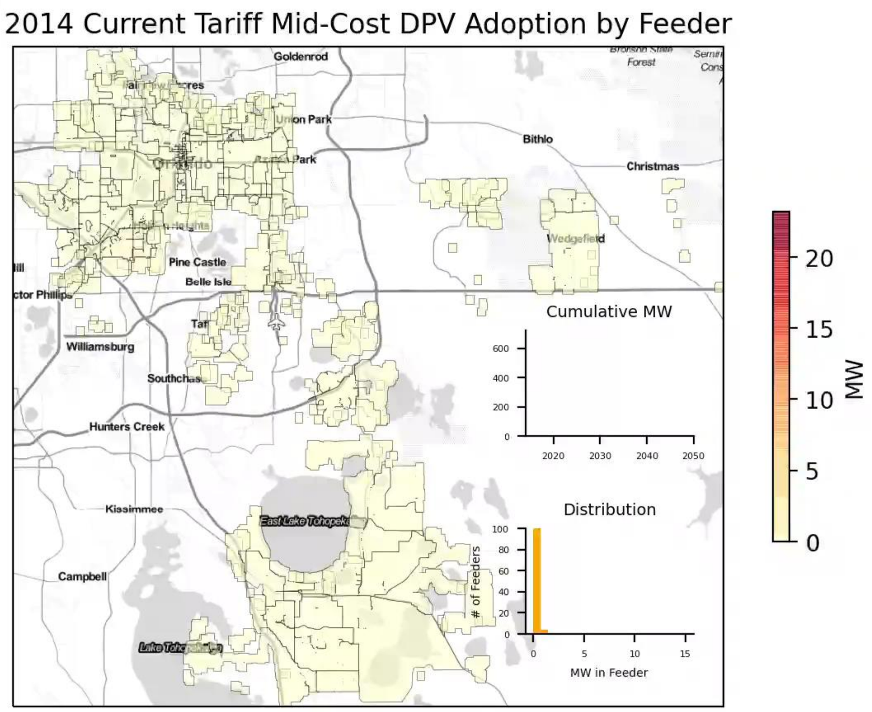
Customer-adoption Modeling Brings Customer Decisions Into DPV Forecast

		Explanatory Factors Used				
Method	Description	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

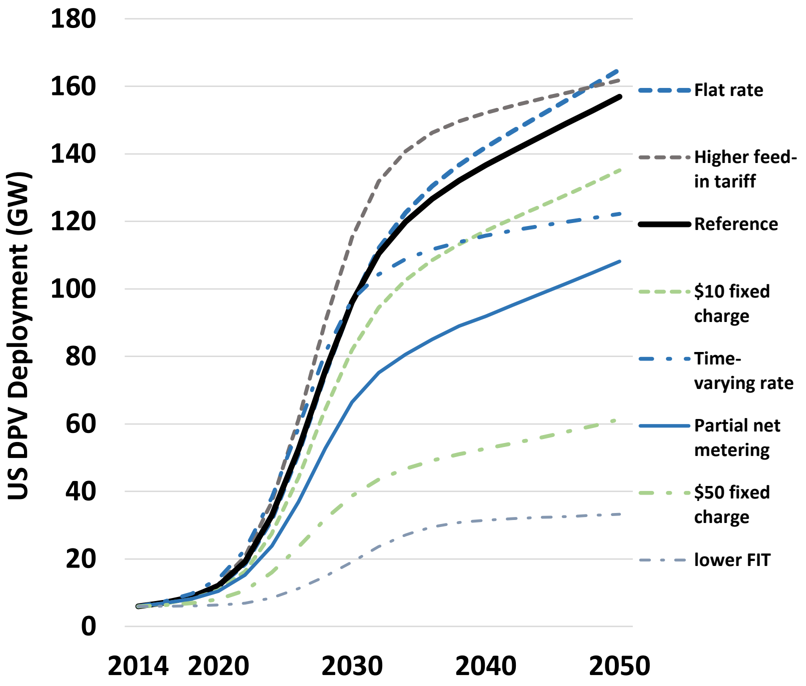
The dGen model can be used to explore forward-looking topics, such as understanding:

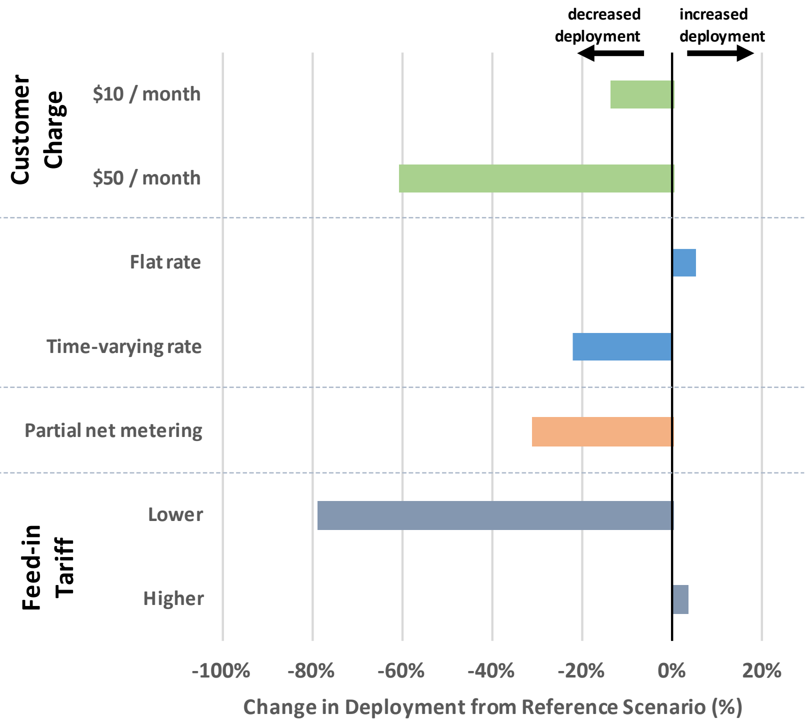
- Infrastructure needs for distribution grids to accommodate DER deployment
- How DERs influence retail electricity prices
- The impact of an electrifying economy
- Synergy between distributed-scale resources and transmission-scale resources.



Source: Koebrich et al. (2018)

Economic Factors, Especially Rate Design, Significantly Affect Adoption Projections





Source: Darghouth et al. 2016

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

Advances in Customer Adoption Modeling

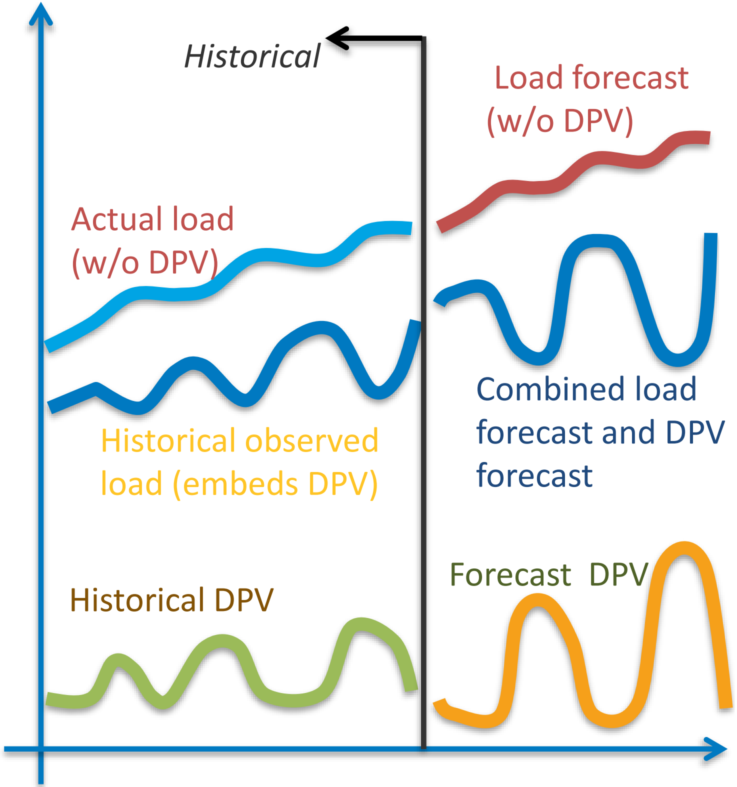
- Agent based models simulate actions and interactions of agents to assess their individual effects on a larger system.
  - Allow for better representation of heterogeneity of customers and more complex decision-making criteria

- Discrete choice models have a well-defined methodology for soliciting customer preferences and can model competition between several options
  - Provide framework for empirically derived forecasts

- Modeling co-adoption of technologies, e.g., solar + storage

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

- 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)

More Examples of DER in Transmission Plans

- Evaluating DPV as a resource option:
  - CAISO transmission planning process identifies transmission needs to meet reliability criteria, then examines feasibility of meeting needs with DPV.
  - If CAISO finds it is feasible to meet needs with increased DPV, information is passed onto CPUC and utilities to determine if programs to encourage additional DPV would be cost-effective.
- Locating DPV within the system:
  - ISO-NE and NYISO use the load-zone-level DPV forecast in their capacity markets and transmission planning. PJM adjusts the load-zone peak demand by the on-peak contribution of DPV for its capacity market and transmission planning.
- Peak demand reduction (i.e., transmission level capacity credit):
  - ISO-NE and PJM use a stricter definition of peaks in transmission planning than for the capacity market.
- Consistent scenarios across planning forums:
  - CAISO/CPUC/CEC coordination, NYISO Gold Book, ISO-NE 10-year regional planning process to coordinate assumptions

Forecasting Other Distributed Energy Resources

- Some DER are similar to DPV :
  - Systems can be installed either in-front-of- or behind-the-meter
  - Adoption can occur for residential, commercial, or industrial customers
- These technologies have yet to see significant adoption due to higher cost or other barriers, but adoption might increase in the future. Similar forecasting tools and models can be used for these emerging technologies.
- Other DER systems are different in that the system cost, performance, and design are specific to individual customers and systems tend to be larger (e.g., CHP units)
- In these cases, local knowledge from distribution planners might be more useful than the top-down methods described here.

Public Tools to Develop Forecasts

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

- NREL is funded by U.S. DOE to maintain and develop the dGen DER customer adoption model
- Working with planning staff from all seven ISO/RTOs to develop joint forecasts, develop capacity, and improve methodology
- Open-Source Model released https://github.com/NREL/dgen
- Winner of R&D 100 Awards in 2021
- Additions to model ongoing - in addition to solar, wind, energy storage we are now adding electric vehicles, energy-efficiency adoption.

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Thank You

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