Developing Forecasts – Distributed Energy Resources

Margaret Pigman (LBNL)
Shibani Ghosh (NREL)

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The authors are solely responsible for any omissions or errors contained herein.

Webinar Series Overview

1) Overview of Webinar Series and Connections to State Planning Efforts
    - October 14, 2:30-3:30 p.m. Eastern
    - Juliet Homer & Eran Schweitzer (PNNL)
2) Developing Forecasts - General Overview
    - October 23, 4-5 p.m. Eastern
    - Brittany Tarufelli & Allison Campbell (PNNL) and J.P. Carvallo (LBNL)
3) Developing Forecasts – Load Expansion
    - October 29, 4-5 p.m. Eastern
    - Sean Murphy & J.P. Carvallo (LBNL) and Christine Holland (PNNL)
4) Developing Forecasts – Distributed Energy Resources
    - November 6, 2-3 p.m. Eastern
    - Sean Murphy & Margaret Pigman (LBNL) and Shibani Ghosh (NREL)

Webinar Series Overview

Resource Adequacy Analysis – Basics

- November 10, 3-4 p.m. Eastern
- Jose Lara, Sebastian Machado, & Rafael Monge (NREL) and Allison Campbell & Eran Schweitzer (PNNL)

6) Transmission and Distribution System Planning – Basics

- November 13, 3-4 p.m. Eastern
- Jose Lara & Vincent Westfallen (NREL)

7) The Evolution of Resource Accreditation

- December 2, 3-4 p.m. Eastern
- Travis Douville (PNNL)

Topics – Distributed Energy Resources (DERs)

- Energy efficiency and demand flexibility – Margaret Pigman
- Distributed solar and storage – Shibani Ghosh

Energy efficiency and demand flexibility

Margaret Pigman (LBNL)

Agenda

- Two approaches to forecast energy efficiency (EE) and demand flexibility (DF)
  - Load modifier – decrement to a gross load forecast
  - Competitive resource – analogous to supply-side resources in a capacity expansion model
- Interactions between potential studies and load forecasts
- Questions states can ask

Resource potential assessments

- The objective of EE and DF potential assessments is to provide accurate and reliable information on:
  - Quantity of EE and DF available
  - Timing of availability (e.g., new construction, stock turnover)
  - EE and DF measure cost
  - Load or savings shape

NIPSCO estimated four types of potential in their 2024 Demand Side Management Market Potential Study for Electric Energy Efficiency Potential

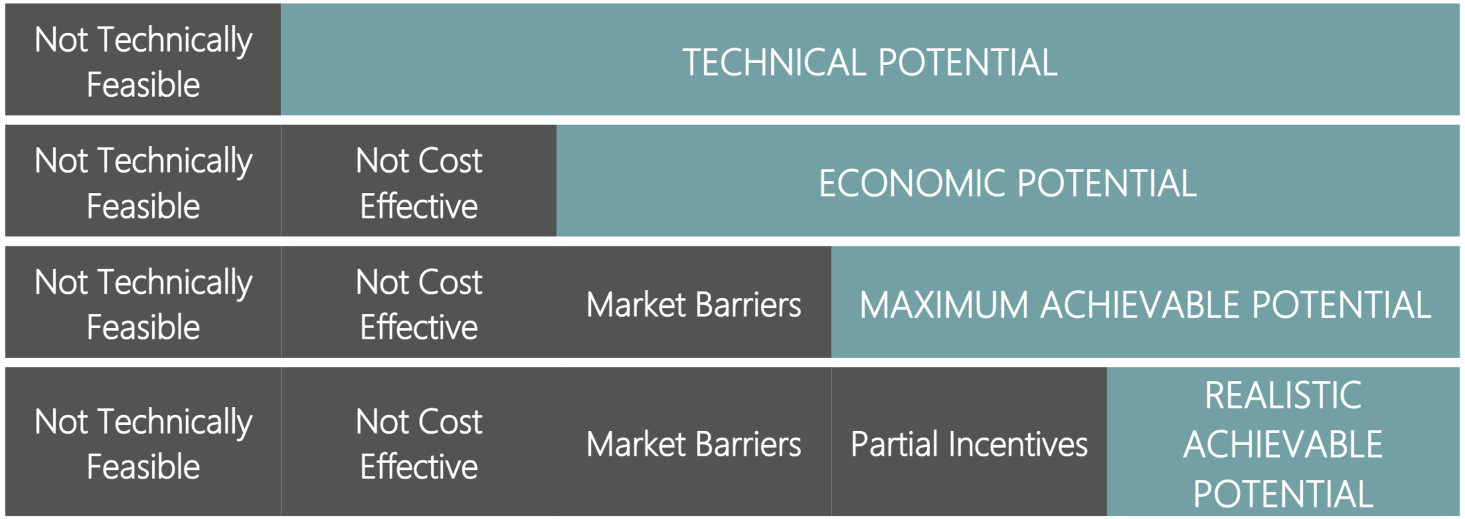
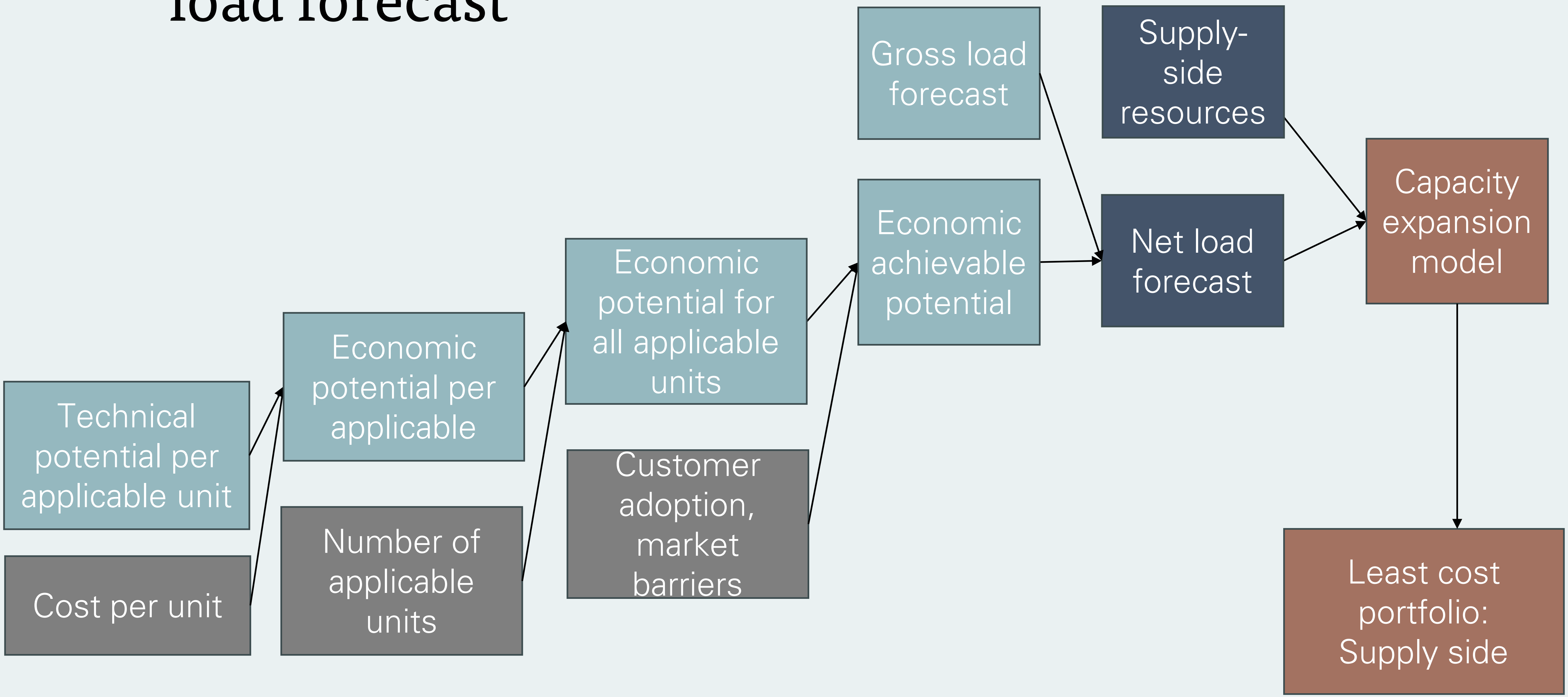


FIGURE 3-2 TYPE OF ENERGY EFFICIENCY POTENTIAL

Source: NIPSCO

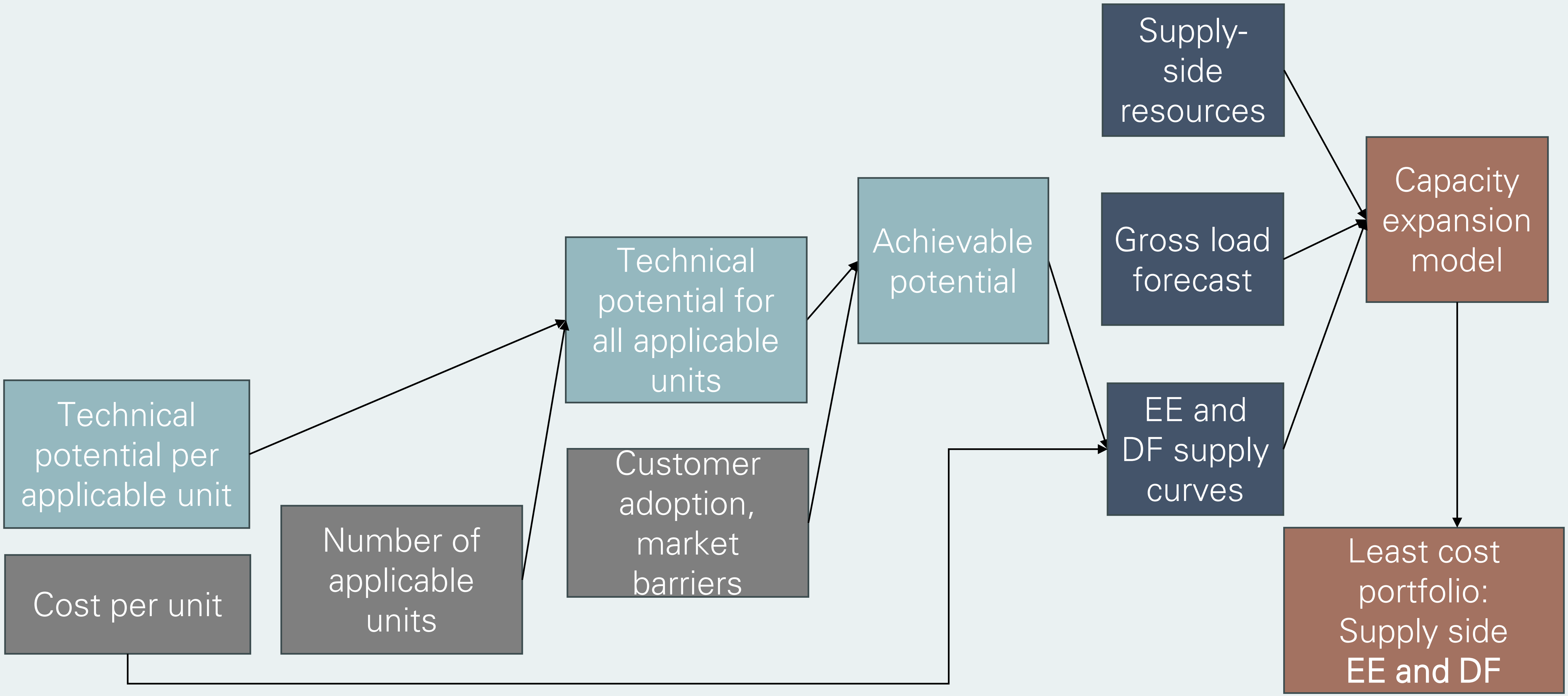
EE / DF as a decrement to the gross load forecast



An alternative to forecasting EE and DF from potential studies is to consider them as selectable resources

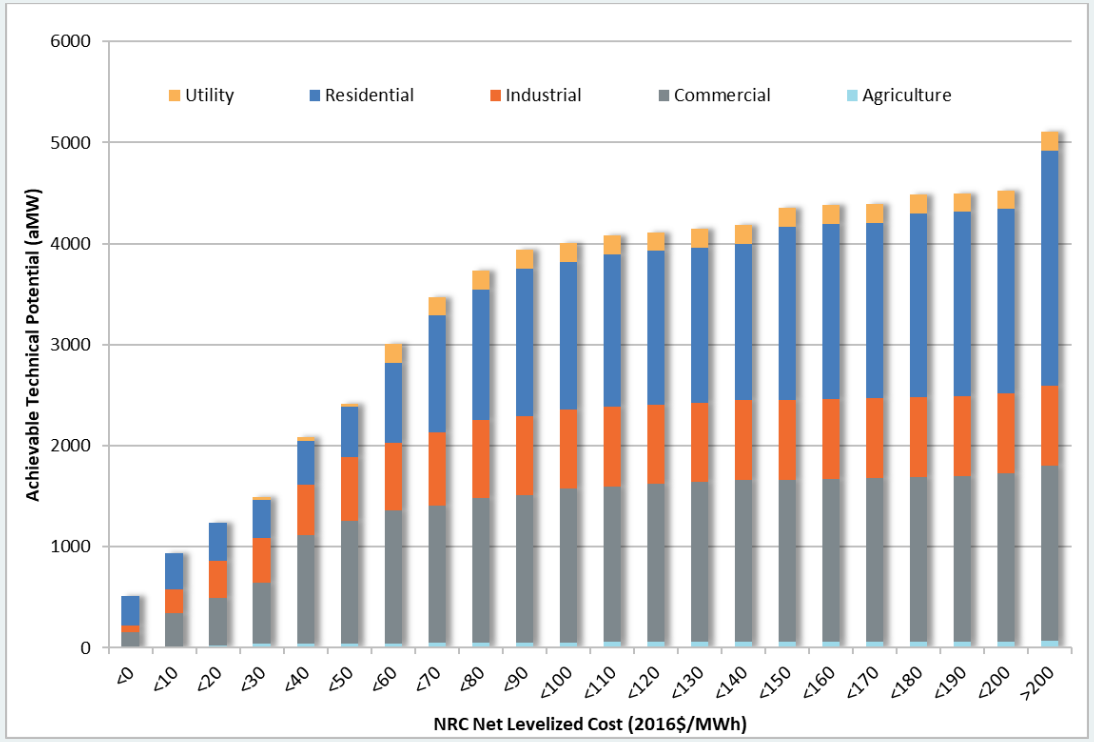
- Integrated Resource Planning (IRP) is intended to evaluate multiple resource portfolio options in an organized, holistic, and technology-neutral manner and normalize solution evaluation across generation, distribution, and transmission systems and demand-side resources.
- In this framework, efficiency and flexibility are decision variables directly comparable to amounts and timing of generation options. This allows for consideration of relative cost and risk across the broadest array of potential solutions.
- Modeling energy efficiency and demand flexibility as resource options for bulk power systems can support many state objectives, including greater reliability and resilience, reduced electricity costs, achieving energy efficiency and renewable energy targets, and lower air pollutant emissions.

EE / DF as selectable resources



What is an efficiency supply curve?

- EE potential is comprised of hundreds of measures.
- IRP models cannot simulate individual efficiency measures, so they are grouped together.
- Supply curves for EE (and other DERs) are usually represented as the amount of resource potential available in discrete "bundles" or "bins."



Source: NWPC 8th Plan

Example: Georgia Power EE bundling approaches

Commercial Load Shape-Based Bundles

Bundle Number	Number of Measures	Total Potential (MWh)	Weighted Avg. Levelized Cost ($/MWh)	Mean Levelized Cost ($/MWh)	Range of Levelized Cost ($/MWh)
21	2	21	0	0	$0-$0
11	2	8	0	0	$0-$0
14	1	1	0	0	$0-$0
4	343	87,593	16	17	$0-$43
19	323	32,363	18	18	$0-$49
2	160	97,414	20	19	$0-$43
9	157	12,452	22	30	$0-$73
13	183	30,355	54	57	$36-$87
10	34	2,700	59	39	$18-$128
18	3	46	78	56	$0-$167
0	150	76,169	78	74	$48-$130
16	89	10,862	118	117	$75-$167
3	107	31,497	122	121	$89-$160
20	1	0	195	195	$195-$195
15	23	376	200	228	$142-$361
5	101	43,549	205	197	$159-$240
8	95	55,907	212	200	$139-$231
17	47	5,139	246	223	$173-$277
1	112	10,863	272	270	$243-$326
12	42	7,142	309	332	$286-$387
7	42	7,781	378	376	$330-$461
6	47	6,234	432	442	$387-$497

Commercial Value Based Bundles

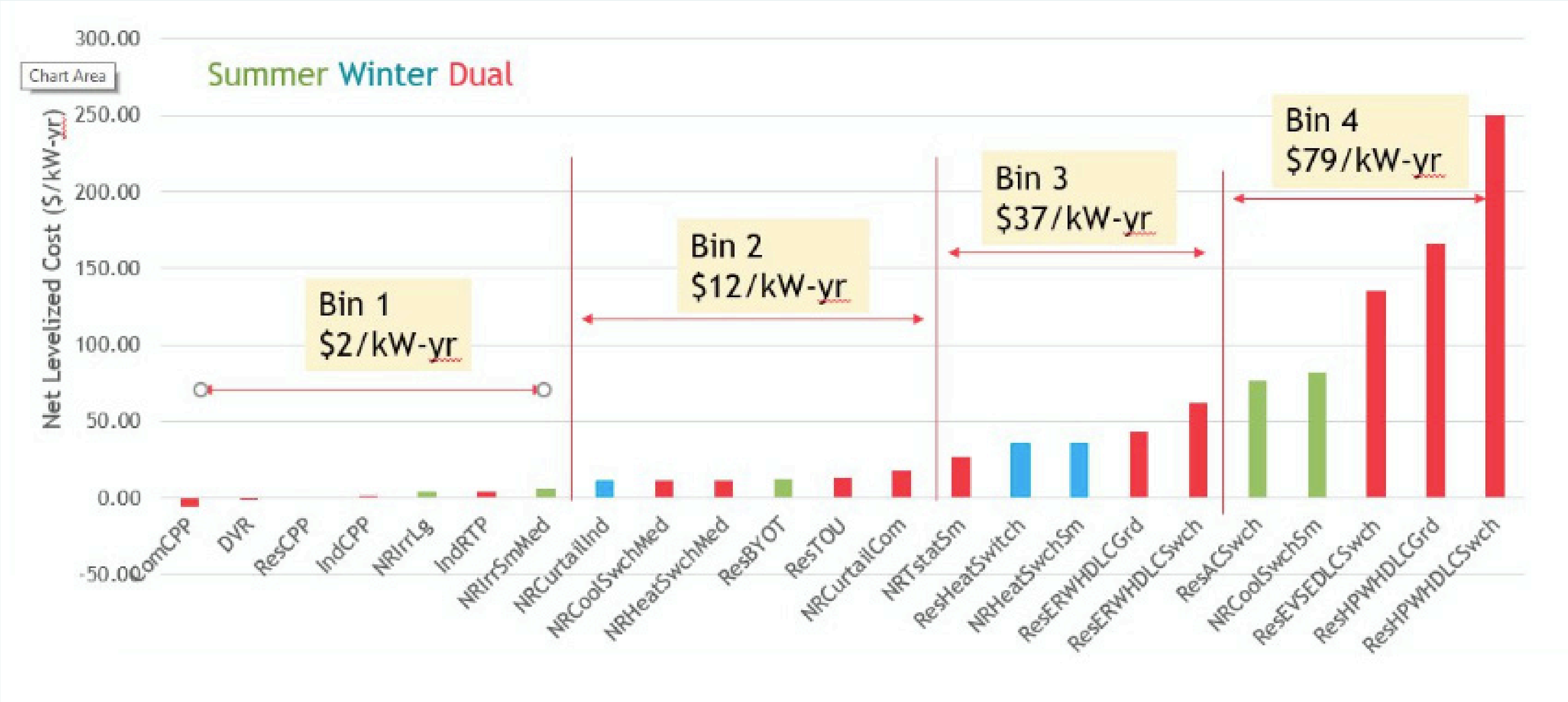
Bundle Number	Number of Measures	Total Potential (MWh)	Weighted Avg. Levelized Cost ($/MWh)	Mean Levelized Cost ($/MWh)	Range of Levelized Cost ($/MWh)
12	3	22	$0	$0	$0-$0
6	2	8	$0	$0	$0-$0
13	340	56,611	$7	$6	$0-$14
1	446	148,971	$20	$21	$14-$29
15	231	32,718	$36	$37	$29-$45
10	146	33,509	$55	$54	$46-$62
4	139	14,604	$70	$71	$63-$80
19	82	56,404	$87	$90	$81-$101
14	85	20,333	$111	$112	$103-$122
0	52	12,239	$135	$135	$124-$146
11	53	11,535	$159	$159	$147-$173
8	109	13,847	$192	$192	$176-$202
3	78	78,154	$214	$212	$202-$222
18	49	5,731	$238	$236	$225-$250
7	93	9,620	$265	$264	$250-$277
17	35	7,287	$295	$297	$282-$315
2	25	3,364	$333	$334	$318-$350
16	44	6,102	$376	$372	$353-$388
9	17	3,697	$402	$407	$391-$430
5	35	3,716	$457	$459	$436-$497

Commercial Cost Based Bundles

Bundle Number	Number of Measures	Total Potential (MWh)	Weighted Avg. Levelized Cost ($/MWh)	Mean Levelized Cost ($/MWh)	Range of Levelized Cost ($/MWh)
8	344	56,631	7	6	$0-$13
2	453	149,882	20	21	$14-$29
14	225	31,817	36	37	$29-$45
5	146	33,509	55	54	$46-$62
6	139	14,604	70	71	$63-$80
13	89	58,291	87	91	$81-$104
0	110	25,676	117	118	$106-$136
10	73	16,545	153	154	$136-$173
4	128	17,543	194	194	$176-$207
11	93	78,377	215	220	$208-$240
1	110	11,631	263	262	$241-$283
9	46	8,854	301	305	$285-$331
3	52	5,956	365	364	$336-$383
12	20	5,358	396	402	$385-$422
7	36	3,799	456	458	$430-$497

Source: Georgia Power

Example: Northwest Power and Conservation Council DR supply curve



Source: [NWPCC 8th Plan]

Several states and utilities considering efficiency as a selectable resource in long-term electricity planning*

- California
  - 2021 Energy Efficiency Potential and Goals Study
  - Staff Proposal for Incorporating Energy Efficiency into the SB 350 Integrated Resource Planning Process
- Georgia
  - Georgia Power - Supply-Side Representation of Energy Efficiency Resources in the Georgia Power IRP Model
- Hawaii
  - Hawaiian Electric Company Integrated Grid Plan
- Idaho
  - Idaho Power – 2nd Amended 2019 IRP
- Indiana
  - Duke Energy – 2020 IRP
  - Vectren
  - IPL/AES – 2019 IRP
  - NIPSCO – 2024 IRP
  - I&M
- Louisiana
  - Entergy New Orleans - 2018 IRP
- Missouri
  - Ameren 2020 IRP
- Minnesota
  - Xcel Energy /Northern States Power 2020 IRP
- Northwest Power and Conservation Council
  - Draft 8th Power Plan
- PacifiCorp (CA, OR, WA, WY, UT)
  - 2021 IRP
- Tennessee
  - Tennessee Valley Authority - 2019 IRP
- Washington
  - Puget Sound Energy – 2021 IRP
  - Avista – 2021 IRP

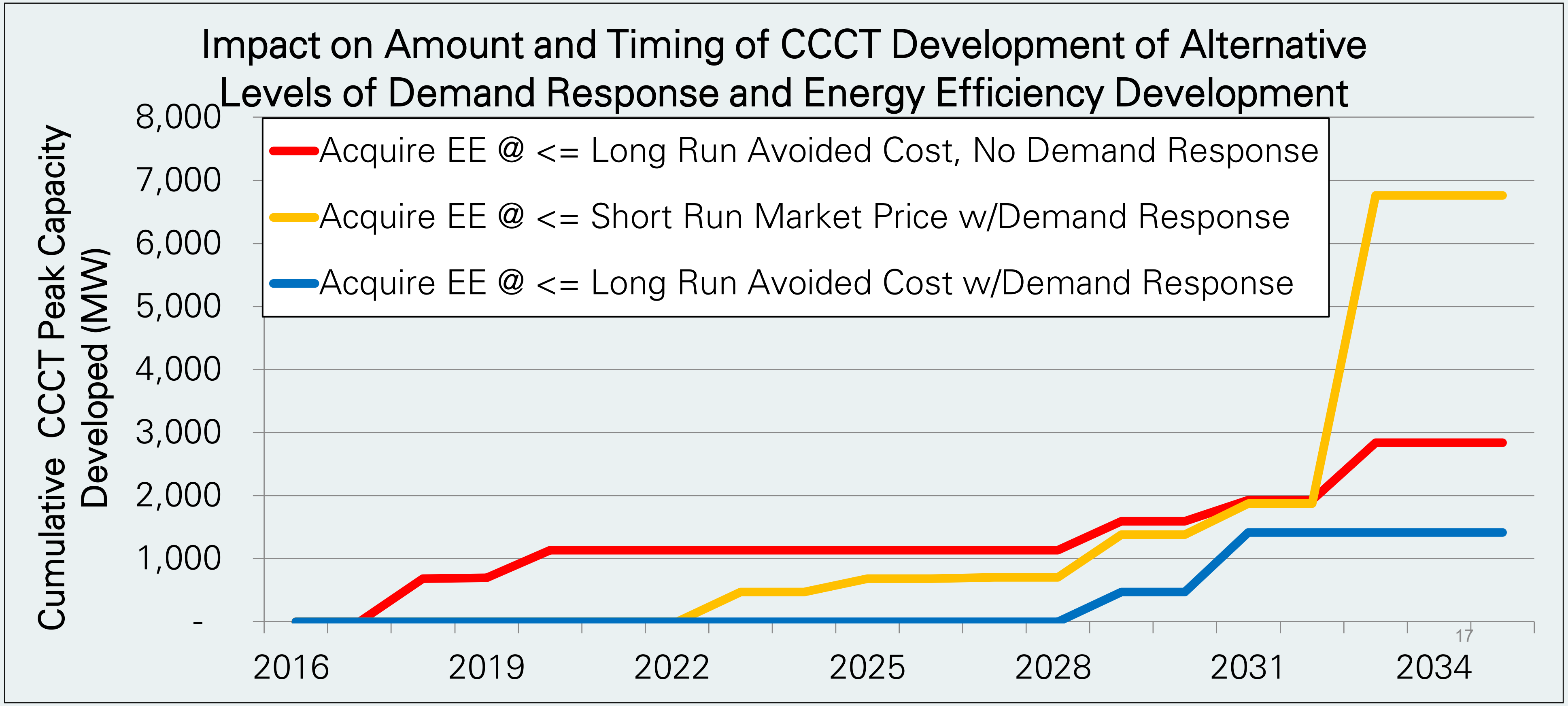
*These are the states/utilities that I am aware of - please let me know if you see an omission.

Challenges with potential studies

- Data inputs to the potential study must be robust. Common shortcomings with potential studies include:
    - Not accounting for variations in interactions between EE / DF and existing and future utility system resources
    - Not accounting for variations in interactions between EE and DF
    - Not using accurate load shapes
    - Not accounting for all benefits, including distribution and transmission system capacity impacts

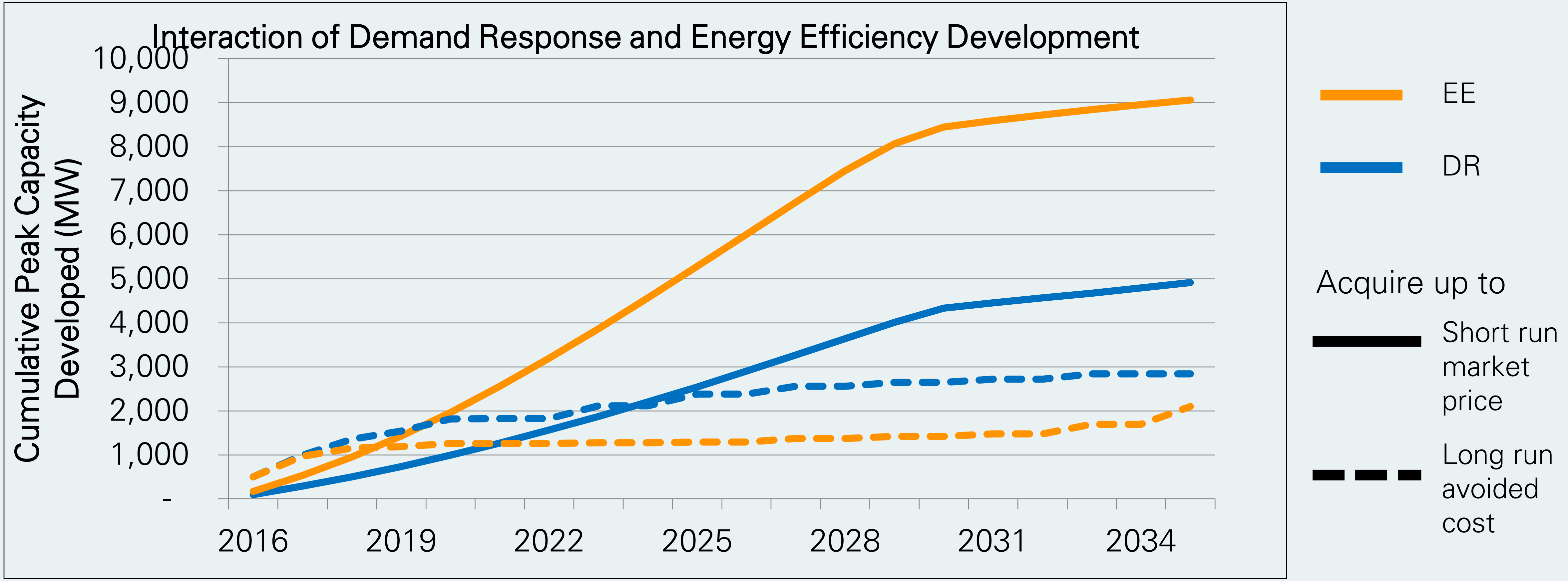
- Using efficiency and other DERs as selectable resources can help overcome the first two.

Treating EE and DF as selectable resource options in a capacity expansion model permits optimization *across supply side and demand side resources*



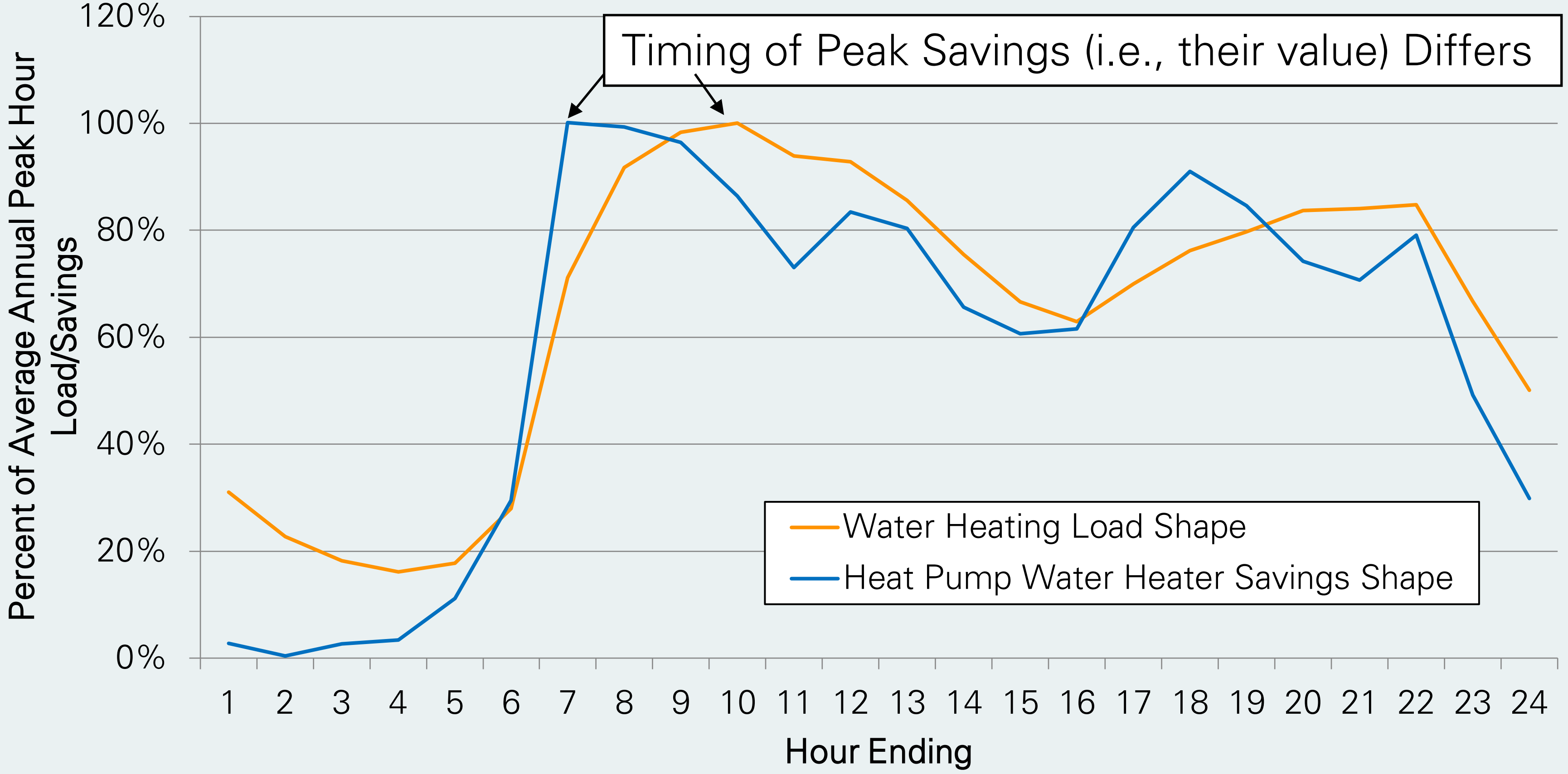
Source: Northwest Power and Conservation Council, [7th Power Plan]

Treating EE and DR as selectable resources in a capacity expansion model permits optimization *between these resources*



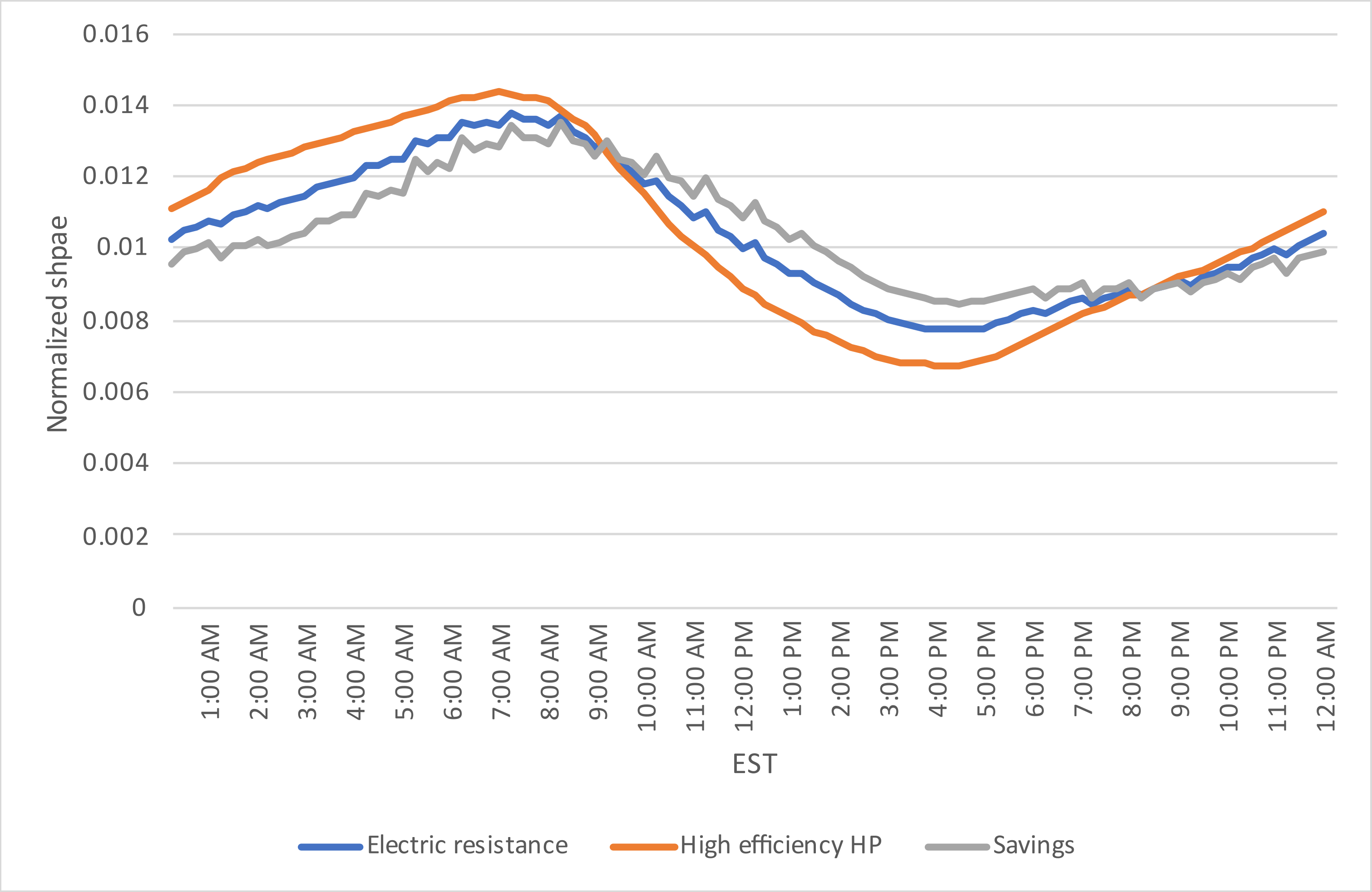
Source: Northwest Power and Conservation Council, 7th Power Plan

Each measure assigned the applicable energy savings load shape or end use load shape



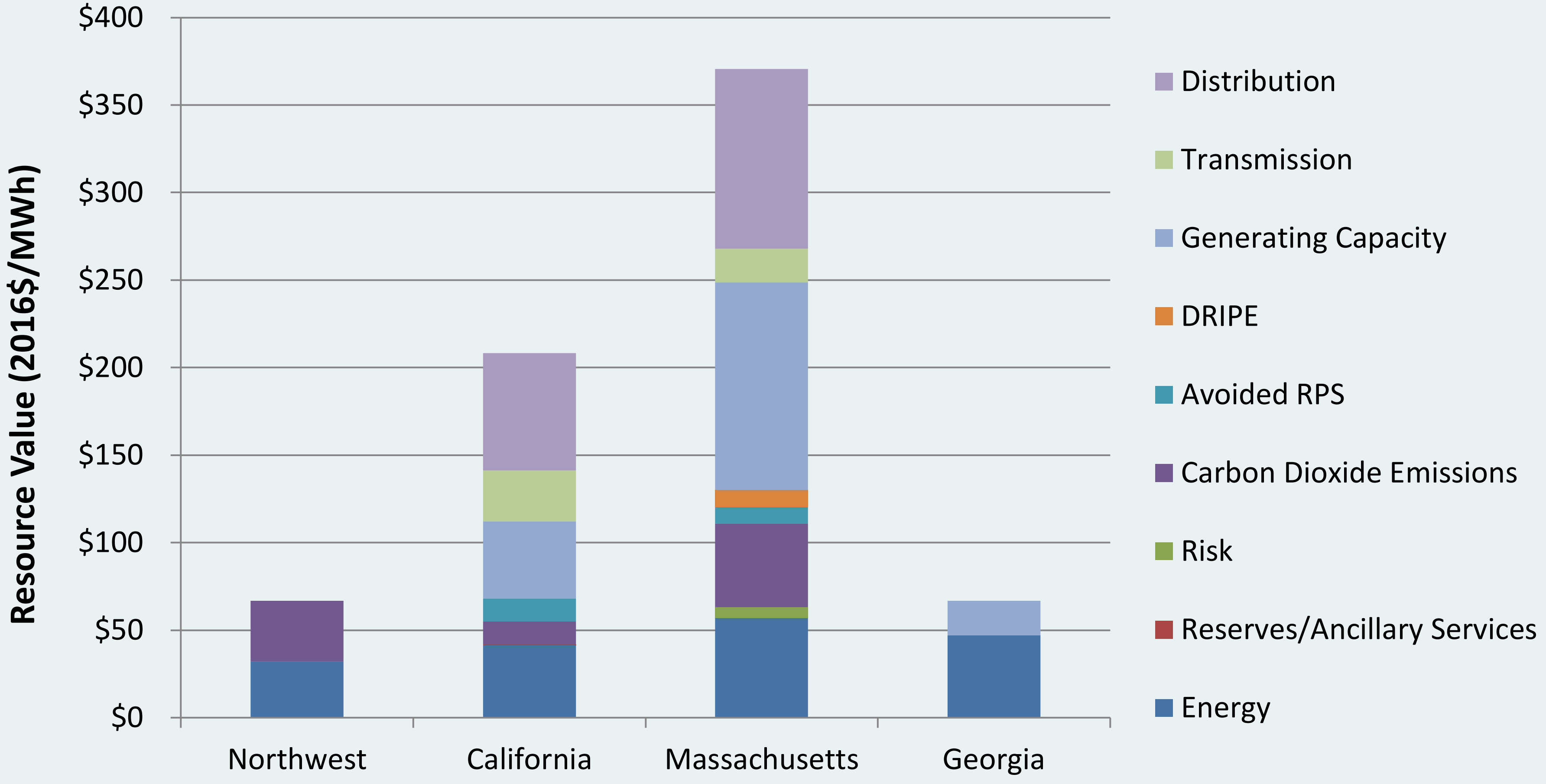
Source: [LBNL]

Example: Illinois residential heating load profiles



Source: [ResStock]

Example: Value of residential air-conditioning measure varies based on avoided costs included in analysis



Source: LBNL

EE and DF potential interact with the load forecast

- EE and DF forecast interact with the load forecast in both approaches.
  - The more common approach uses the EE or DF potential to reduce the load forecast.
  - Considering EE or DF as a selectable resource requires planners to know the quantity of the resource in the load forecast and the quantity the model can select.
- Internal consistency between the load forecast and EE and DF potential assessments is necessary to avoid the potential for *over* or *under* estimating remaining EE and DF potential.
  - Baseline use and efficiency assumptions should be equivalent.
  - "Units" (e.g., houses, commercial floor space, appliance counts) should be identical.
- Emerging issues such as electrification impact the load forecast.
  - Replacing an electric resistance heater with an air source heat pump that is more efficient will reduce electricity consumption.
  - Replacing a gas heater with an air source heat pump will increase electricity consumption.
  - It is important to understand where this data is used in the analysis (e.g., load forecast, potential study, both, neither) for consistency.

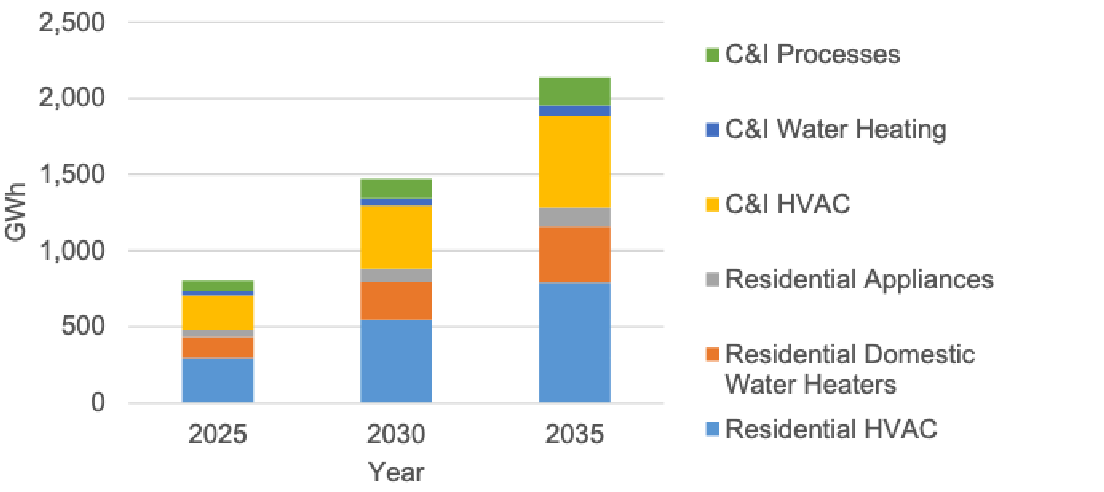
Example: NIPSCO includes building electrification in their load forecast, but not their potential study.

- NIPSCO considers the impact of efficient HVAC in their potential study for electric and gas customers, but there is no consideration of fuel switching.
- NIPSCO considers the impact of building electrification in load forecast scenarios, but the achievable EE potential does not change.

Table 5-10: Achievable Residential Sector Annual Energy Efficiency Potential and Annual Utility Budgets

	Maximum Achievable			Realistic Achievable		
	Cumulative Annual			Cumulative Annual		
Year	MWh	MW	Budget	MWh	MW	Budget
2027	64,672	19.3	$23,192,756	50,575	12.6	$10,519,160
2028	108,667	35.2	$27,937,935	78,203	20.4	$12,296,863
2029	153,581	51.9	$30,160,372	106,311	28.4	$13,235,799
2030	199,056	69.5	$32,016,573	134,931	36.8	$14,207,522
2031	242,779	84.8	$33,868,763	163,391	44.6	$15,117,341
2032	289,272	101.4	$37,655,268	194,012	53.1	$16,739,498
2033	336,339	119.5	$43,912,595	226,058	62.5	$19,300,726
2034	387,042	137.9	$51,128,069	261,135	72.2	$22,736,831
2035	440,263	157.2	$55,380,771	298,430	82.5	$24,439,390

Figure 3-45: Electrification Impact on NIPSCO Energy Sales (AI Scenario)



AI = Accelerated Innovation

Source: NIPSCO 2024 IRP

Example: Unitil includes building electrification in their EE and DR potential study

Figure 4-9. EE CECP Scenario Lifetime Achievable Potential, Top Electricity Measures, 2025-2027, MMBtu (all sectors)

#	Measure	Core Initiative	LT Savings
1	Insulation	A2a - Residential Coordinated Delivery	919,500
2	Ductless MSHP Partially Displacing Oil Boiler	A2c - Residential Retail	311,400
3	ER Baseboard to DMSHP	A2c - Residential Retail	189,120
4	Air Sealing	A2a - Residential Coordinated Delivery	153,640
5	Insulation	B1a - Income Eligible Coordinated Delivery	145,620
6	Heat Pump Water Heater	A2c - Residential Retail	138,540
7	Central Heat Pump	A2c - Residential Retail	130,080
8	Air Sealing	C2a - C&I Existing Building Retrofit	92,680
9	ER Baseboard to DMSHP	B1a - Income Eligible Coordinated Delivery	79,010
10	Central ASHP Partially Displacing Oil Furnace	A2c - Residential Retail	74,090
11	W2W GSHP Replacing Oil Boiler	A2c - Residential Retail	54,190
12	Air Sealing	B1a - Income Eligible Coordinated Delivery	51,520
13	Manual Thermostat to Programmable Thermostat	A2c - Residential Retail	47,880
14	Custom Large C&I	C2a - C&I Existing Building Retrofit	46,980
15	Heat Pump Water Heater	B1a - Income Eligible Coordinated Delivery	44,440
16	Ductless MSHP Partially Displacing Oil Boiler	B1a - Income Eligible Coordinated Delivery	44,110

CECP = Clean Energy and Climate Plan

Source: MA EEAC

Questions states can ask

- How are utilities in your state modeling EE and DF today?
- Are the assumptions in the EE and DF potential studies clearly provided? Are the load forecast and the potential studies aligned?
- What state policy or regulatory changes are needed to facilitate consideration of EE and DF as selectable or competitive resources in electricity planning?

Resources for more information

Berkeley Lab's research on time- and locational-sensitive value of DERs

Bruce Biewald, Devi Glick, Shelley Kwok, Kenji Takahashi, Juan Pablo Carvallo, and Lisa Schwartz. 2024. Best Practices in Integrated Resource Planning

U.S. Department of Energy. 2021. A Roadmap for Grid-interactive Efficient Buildings. Prepared by Andrew Satchwell, Ryan Hledik, Mary Ann Piette, Aditya Khandekar, Jessica Granderson, Natalie Mims Frick, Ahmad Faruqui, Long Lam, Stephanie Ross, Jesse Cohen, Kitty Wang, Daniela Urigwe, Dan Delurey, Monica Neukomm and David Nemtzow

Natalie Mims Frick, Tom Eckman, Greg Leventis, and Alan Sanstad. 2021. Methods to Incorporate Energy Efficiency in Electricity System Planning and Markets

State and Local Energy Efficiency Action Network. 2020. Determining Utility System Value of Demand Flexibility from Grid-Interactive Efficient Buildings. Prepared by Tom Eckman, Lisa Schwartz, and Greg Leventis, Lawrence Berkeley National Laboratory.

Natalie Mims Frick, Snuller Price, Lisa Schwartz, Nichole Hanus, and Ben Shapiro. 2021. Locational Value of Distributed Energy Resources

Natalie Mims Frick, Juan Pablo Carvallo and Lisa Schwartz. 2021. Quantifying reliability and resilience impacts of energy efficiency: Examples and opportunities

Natalie Mims Frick, Juan Pablo Carvallo and Margaret Pigman. 2022. Time-sensitive Value of Efficiency Calculator

Fredrich Kahrl, Andrew D Mills, Luke Lavin, Nancy Ryan, Arne Olsen, and Lisa Schwartz (ed.). The Future of Electricity Resource Planning. 2016. Berkeley Lab's Future Electric Utility Regulation report series.

Berkeley Lab and NREL's End Use Load Profiles for the U.S. Building Stock project

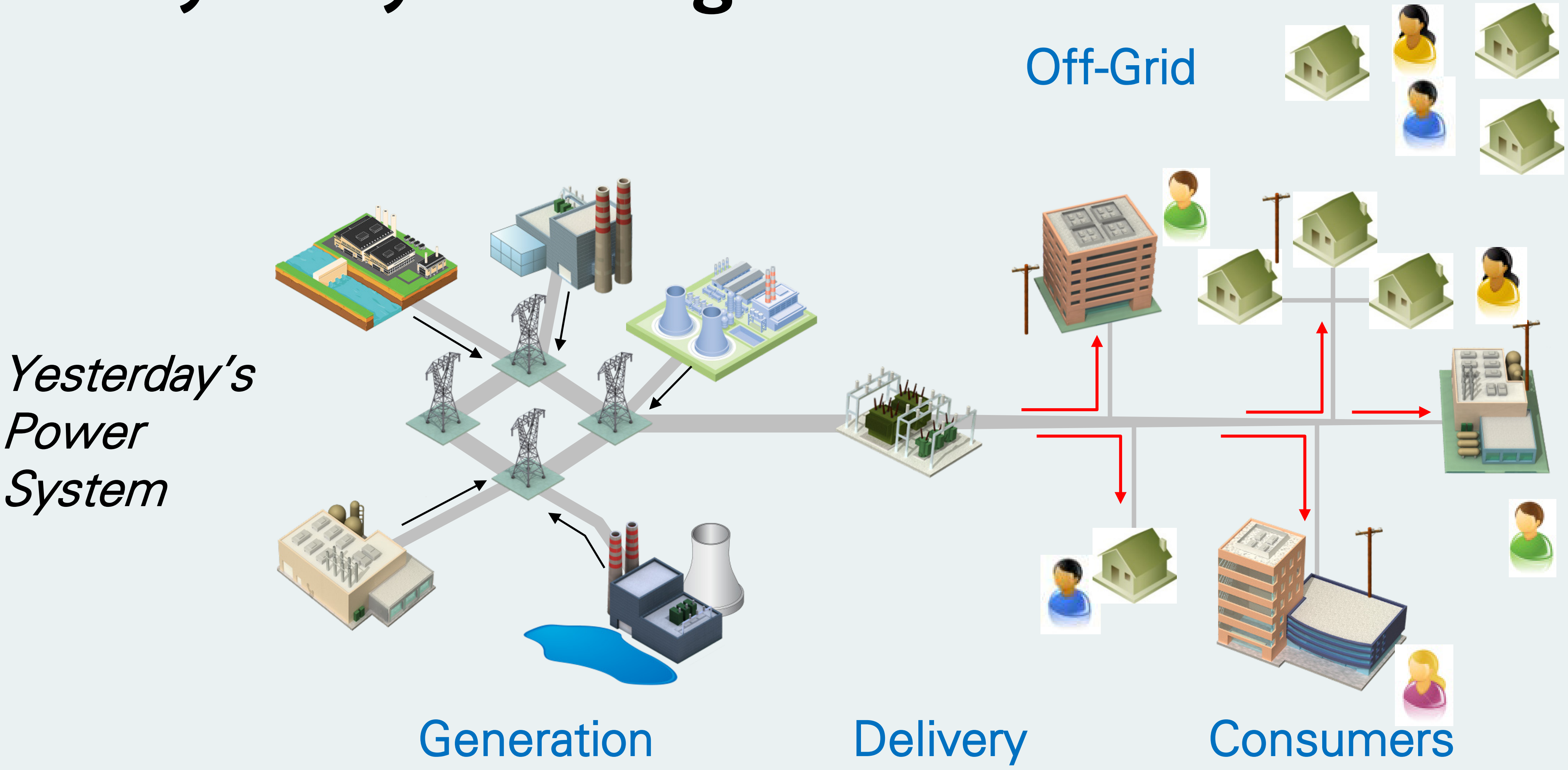
Distributed solar and battery storage

Shibani Ghosh (NREL)

Topics

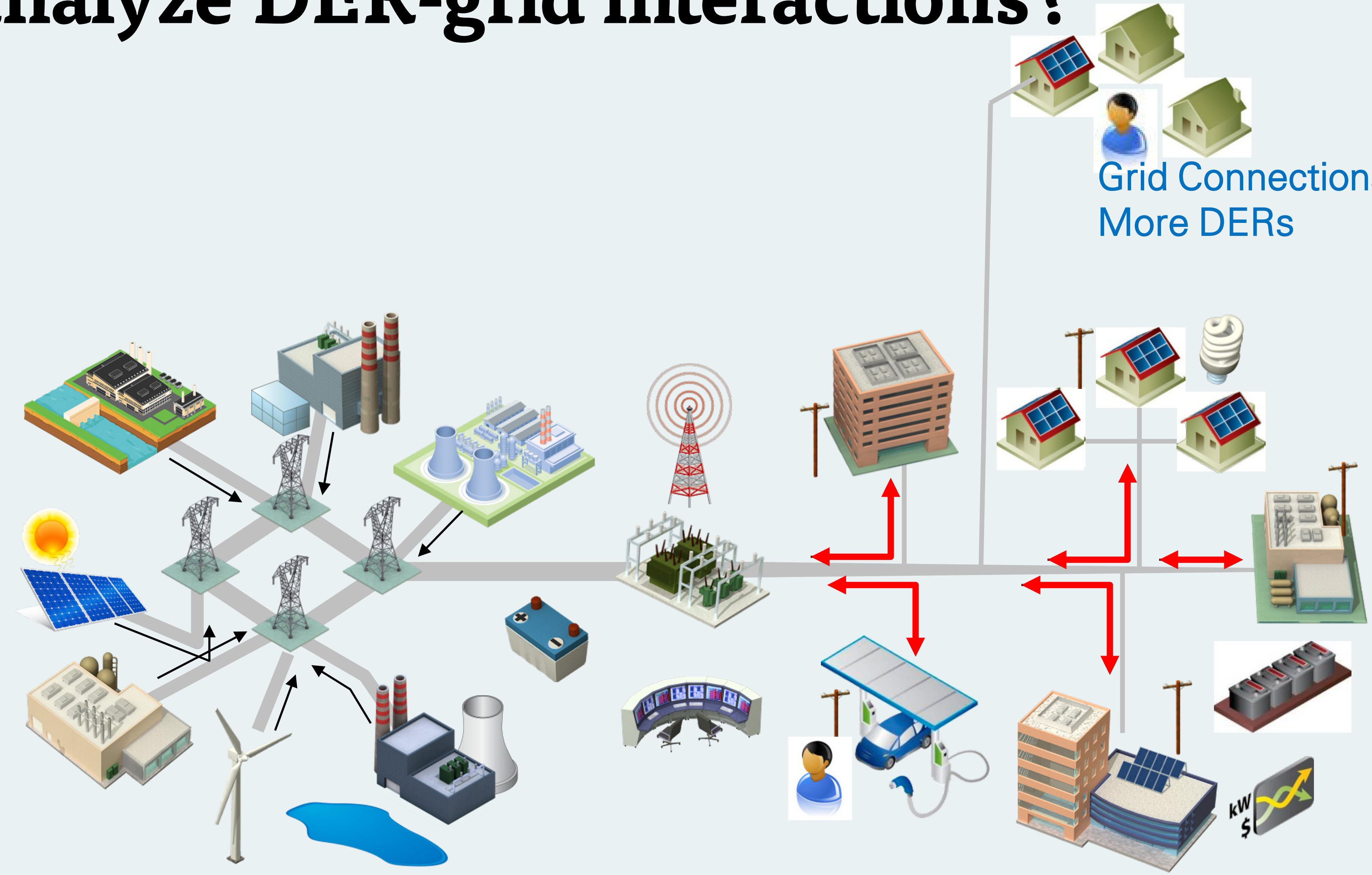
- Evolution of distributed energy resources (DERs)
- Forecasting distributed solar and storage
- Case study – CEC x NREL

Why analyze DER-grid interactions?



Why analyze DER-grid interactions?

Distributed resources are changing how power and data is flowing in a grid



Distributed wind

Solar photovoltaics (PV)

Battery Energy Storage System (BESS)

Electric vehicles

- Benefits of deploying batteries with a solar system
    - Distributes energy load at times when electricity demand is high, flattening the load curve
    - Energy resilience benefit—back-up during power outages
- However, batteries increase the cost of the system – both upfront costs, as well as O&M

Benefits of Distributed Solar

SOLAR ACCESS AND CONSUMER CHOICE

- Contract terms that enhance consumer choice
- Engage with the local community
- Financial products are accessible to all households

AFFORDABILITY AND HOUSEHOLD SAVINGS

- Guaranteed bill and/or household savings
- Wealth building opportunities
- Indirect multifamily affordable housing tenant benefits

RELIABILITY, RESILIENCE, AND SECURITY

- Household and community-level resilience strategies
- Grid strengthening strategies
- Improved health outcomes through reduced or shortened power outages

LOCAL ECONOMIC DEVELOPMENT

- Project ownership opportunities for local individuals or organizations
- Securing support from local leaders
- Support for local entrepreneurs and small businesses

SOLAR WORKFORCE AND ENTREPRENEUR-SHIP

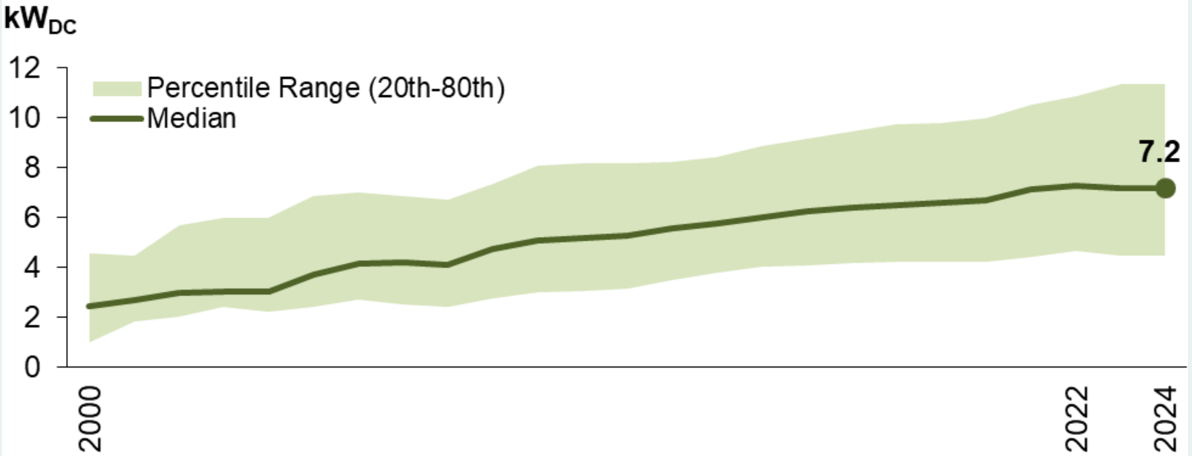
- Strategies to ensure local job creation and competitive wages
- Training and apprenticeship programs

Challenges to the Current Energy Landscape

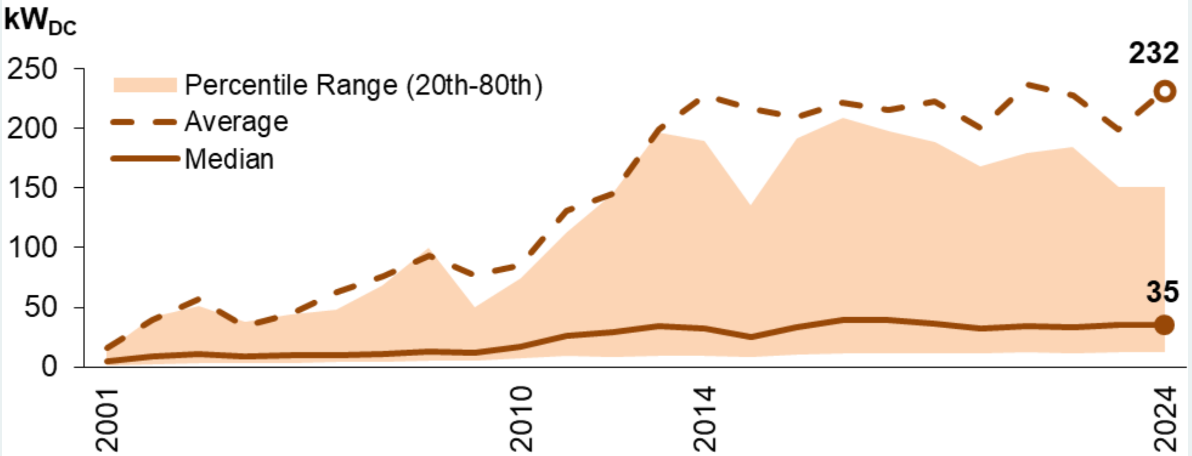
- Practical issues
  - Solar resource limitations
  - Cost of land / Site control
  - Topography
  - Rooftop/infrastructure repairs & restrictions
- Interconnection Process
  - Varies by state/utility
  - Can take between 0-30+ days (depending on various factors)

PV System Sizing Trends

Residential



Non-residential



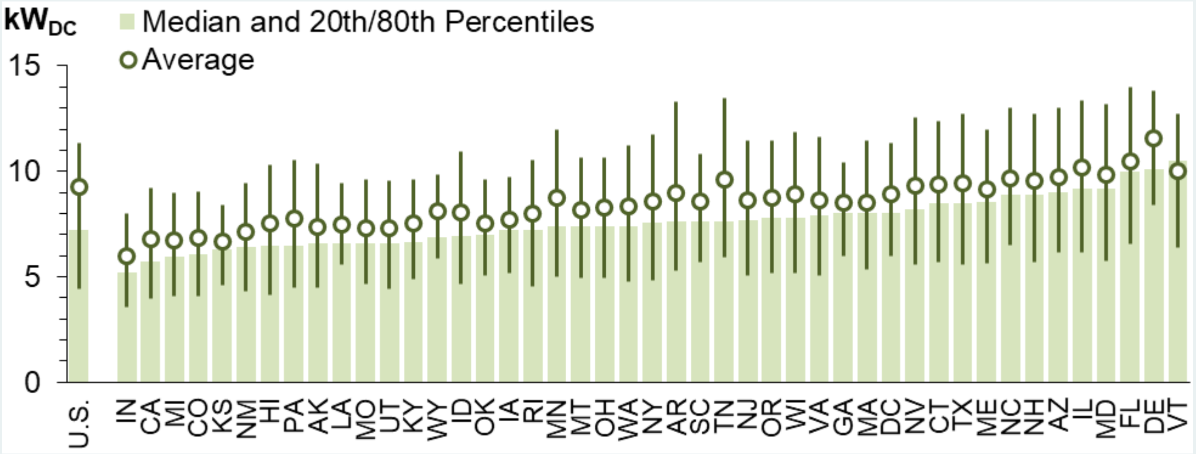
- Median residential system sizes rose steadily over the last two decades by ~5% per year, but the trend has been flat from 2022-2024; corresponds to trends in module efficiencies
- Non-residential system sizes vary widely (e.g., from roughly 10-150 kW between the 20th and 80th percentiles in 2024), but the sizing distribution has remained fairly stable since 2014 (e.g., with average sizes fluctuating between 200-235 kW in each year)
- This contrasts with the years immediately prior to 2014, which saw a rapid increase in the prevalence of relatively large non-residential systems, as indicated by the sharp rise in average sizes (rising from 85 kW to 230 kW between 2010-2014)

Source: U.S. Distributed Solar and Storage 2025 Data Update, October 2025

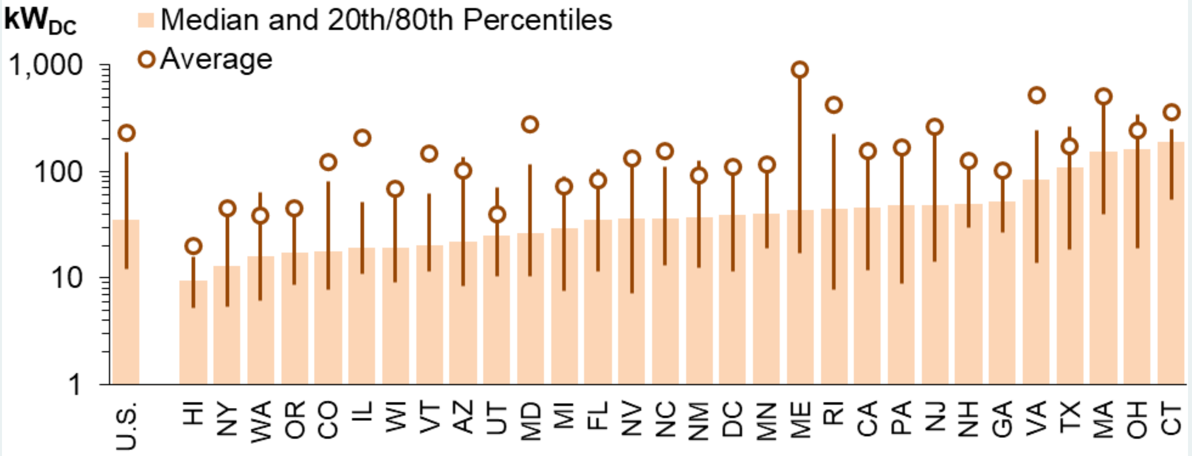
Accompanying dataset and data visualization available at: trackingthesun.lbl.gov

PV System Sizing Distributions (2024 Installs)

Residential



Non-residential



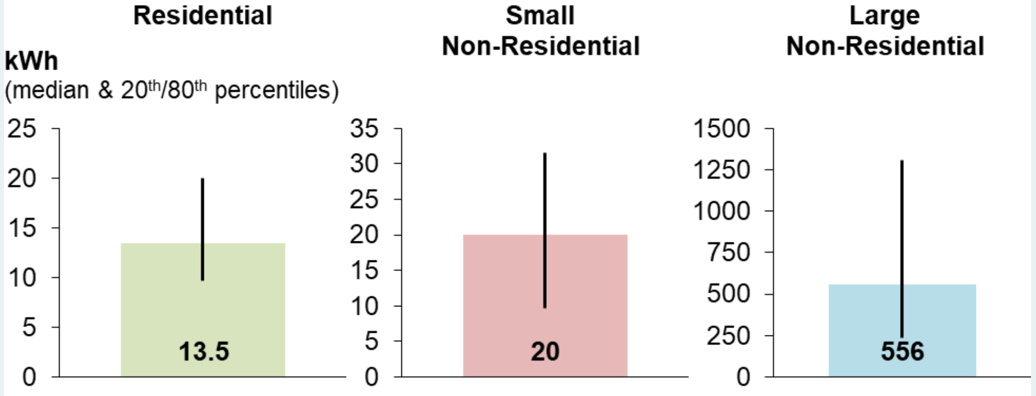
- The median U.S. residential system size was 7.2 kW in 2024, with most systems ranging from roughly 4-11 kW, averaging 9.3 kW
- Non-residential systems (roof-mounted any size + ground-mounted <7 MW) had a median size of 35 kW in 2024, but a long upper tail and an average size of 232 kW (note logarithmic y-axis)
- The composition of the non-residential PV market can vary considerably from state to state, contributing to the wide variation in system sizing observed in 2024

Source: U.S. Distributed Solar and Storage 2025 Data Update, October 2025

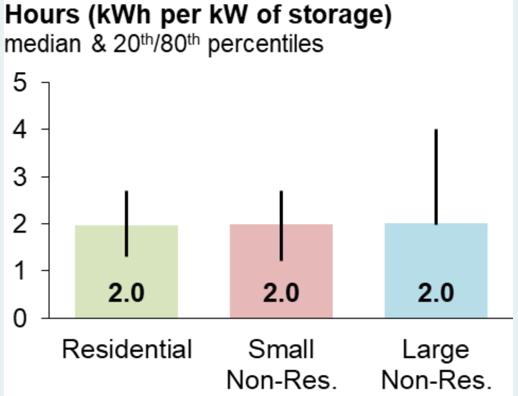
Accompanying dataset and data visualization available at: trackingthesun.lbl.gov

Storage System Sizing (2024 Installs)

Battery Energy Storage System Capacity (BES, kWh)



Storage Duration (hours)

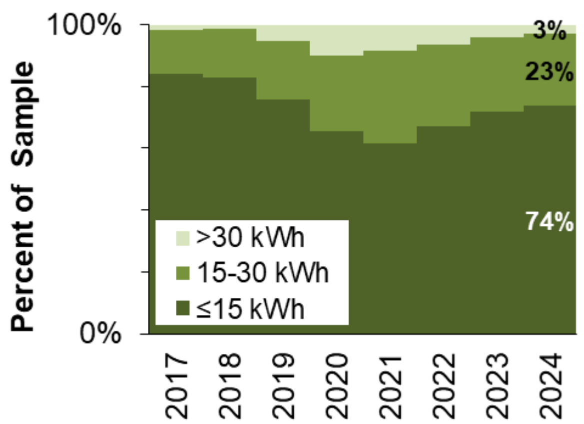


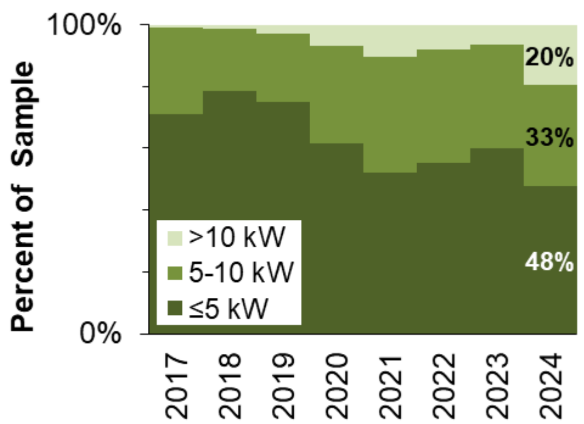
- Residential BESSs had a median size of 13.5 kWh in 2024 (the size of single PowerWall), with most systems ranging from 10-20 kWh. With small non-res. PV systems, they were slightly larger (20 kWh), while those installed with large non-res. PV systems had a median size of ~550 kWh
- Across all three customer segments, median storage duration was 2 hours (i.e., 2 kWh per kW of storage), but large non-residential systems had a larger contingent of longer duration batteries, with at least 20% of paired systems having 4+ hours of storage
- For residential and small non-res. systems, storage kW capacity was roughly equal to the paired PV capacity, but large non-res. systems had smaller batteries relative to their PV capacity

Source: U.S. Distributed Solar and Storage 2025 Data Update, October 2025; Accompanying dataset and data visualization available at: trackingthesun.lbl.gov

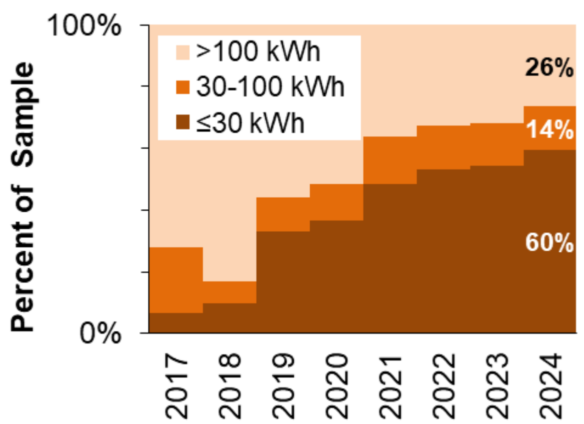
Paired PV+Storage System Sizing Trends

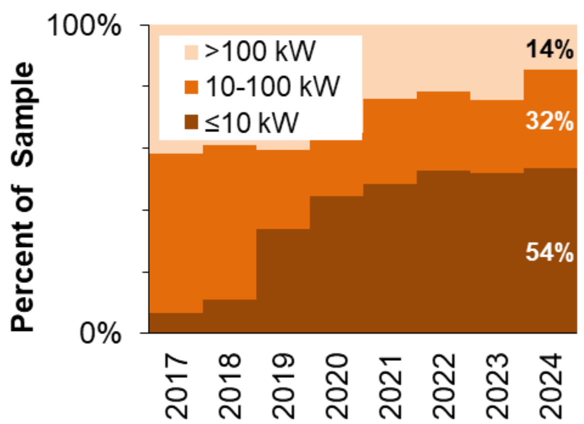
Residential





Non-residential



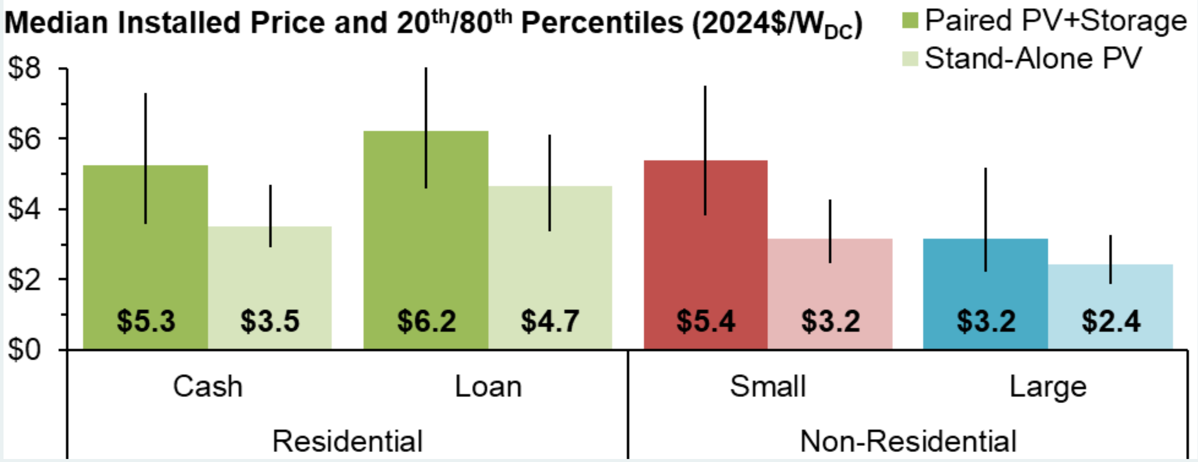


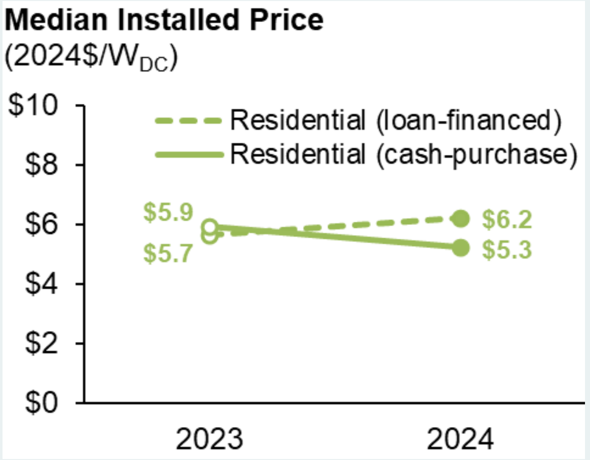
- The residential market had been trending toward systems with larger amounts of energy (kWh) capacity until 2021, but reversed course since then; however, the residential market has continued its trend toward increasing battery power (kW) capacity
- Paired PV+storage systems in the non-residential market have been steadily progressing toward smaller system sizes, as seen in both the storage energy (kWh) and power (kW) capacity trends
- Sizing trends can reflect changes in battery product designs (power to energy ratios) and in customer use-cases (e.g., solar self consumption vs. battery backup power vs. demand charge management)

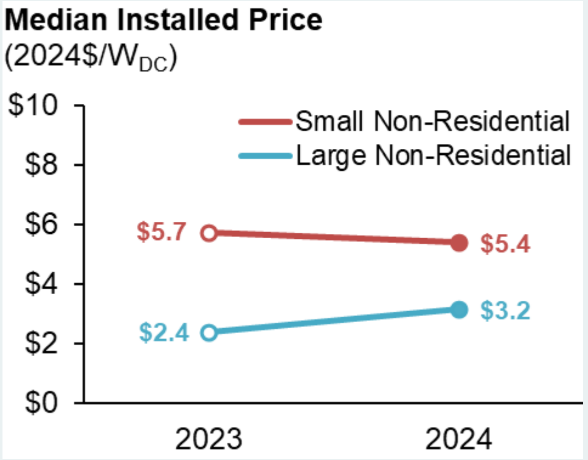
Source: U.S. Distributed Solar and Storage 2025 Data Update, October 2025; Accompanying dataset and data visualization available at: trackingthesun.lbl.gov

Installed Prices for Paired PV+Storage Systems

Paired PV+Storage vs. Stand-Alone PV (2024 Installs, $ per kW)







- The median cash price of paired residential systems in 2024 was $1.7/W higher than for stand-alone systems, while the corresponding differentials were $2.2/W for small non-res. systems and $0.8/W for large non-res.
- Median cash-purchase price for paired residential systems fell by $0.6/W from 2023 to 2024, in inflation adjusted terms, but rose by $0.5/W for loan-financed systems
- Median prices fell for paired small non-res. systems and rose for large non-res. systems

Source: U.S. Distributed Solar and Storage 2025 Data Update, October 2025; Accompanying dataset and data visualization available at: trackingthesun.lbl.gov

Forecasting Distributed Solar and Storage

Forecasting horizons for solar PV systems

Nowcasting (~6 hrs)

- Satellite data, sky cameras, machine-learning models; used for real-time grid balancing

Short-term (6-48 hrs)

- Numerical weather models, statistical/local corrections; used for day-ahead market scheduling

Medium-term (2-7 days)

- Ensemble forecasts; used for planning and unit commitment

Long-term (weeks-months)

- Climate models, historical patterns/seasonal averages; used for maintenance and resource planning

How utilities address solar forecasting

Southern California Edison (SCE)

- Variable Renewable Energy such as solar will need to be forecasted and managed to ensure generation, and load are balanced on the distribution & transmission network
- >100GW of new resources needed from now to 2045 (as of mid-2024), with biggest capacity growth Solar: Expected to increase from 23 GW to 63 GW
- Nearly half the solar capacity (31 GW) is BTM, representing around 50 TWH per year.
- Inaccurate forecasts can lead to:
  - Reliability issues or incur significant costs for SCE to secure energy contracts within a short period of time
  - Canceled maintenance operations (customers require a 2 weeks notice, so any cancellation is significant to operations).

Source: DOE SETO solar forecasting workshop, 2024, https://www.energy.gov/sites/default/files/2024-07/SETO%20-%20Solar%20Forecasting%20Workshop%20-%20Day%202.pdf

SOUTHERN CALIFORNIA EDISON

How utilities address solar forecasting

SCE's Grid Management System (GMS)

2021	2022	2023	2024	2025+
D-SCADA Upgrade	Extensible FEP	Distribution State Estimation	Adaptive Protection Analytics	Day Ahead Planning
	IEEE 2030.5	Advanced Distribution Analysis Apps	Look-Ahead Analysis	Multi Interval Optimization
	DER Provisioning	Advanced Distribution Control Apps	High Impedance Faults	Adv Microgrid Orchestration
	DER Registration & Enrollment	FLISR	Adv. ADMS Enhancements	Demand Response Integration
	Microservice-based T&D Architecture	Enhanced Outage Management	Resource Scheduler	Sub-Transmission Level Outages
	Operational Service Bus	Storm Assist	Single-interval Optimization	
	Network Connectivity Analytic	AMI Pre-Filtering Engine	DER Forecasting	
		Mobile Outage Management	Net & True Load Forecasts	
		Consolidated Distr. Operations UI/UX Exp.	Device Management	

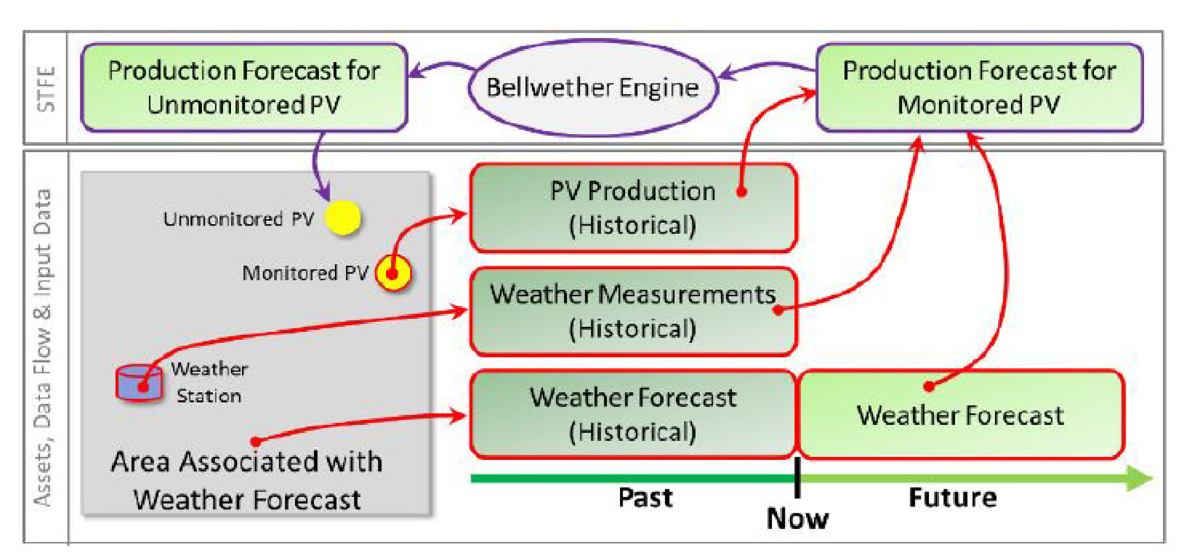
SOUTHERN CALIFORNIA EDISON

Source: DOE SETO solar forecasting workshop, 2024, https://www.energy.gov/sites/default/files/2024-07/SETO%20-%20Solar%20Forecasting%20Workshop%20-%20Day%202.pdf

How utilities address solar forecasting

SCE's Short-term forecasting engine (STFE)

- STFE provides information of real-time system generation and demand conditions so Grid Operators can take informed actions toward proactively preventing or mitigating adverse system conditions, thereby ensuring system reliability.
- Forecasting unmonitored PV: STFE's Bellwether Methodology forecasts production of each unmonitored PV by associating it with a monitored PV of similar size and location. First value of STFE's 5-minute time series production forecast used as an estimate of each unmonitored PVs real-time production.
- STFE does not forecast BESS behavior



Source: DOE SETO solar forecasting workshop, 2024, https://www.energy.gov/sites/default/files/2024-07/SETO%20-%20Solar%20Forecasting%20Workshop%20-%20Day%202.pdf

Policy implications and themes

Regulatory objectives

- Technical aspects of distributed solar and storages
- Economics such as rate design components, valuation of benefits and utility cost recovery

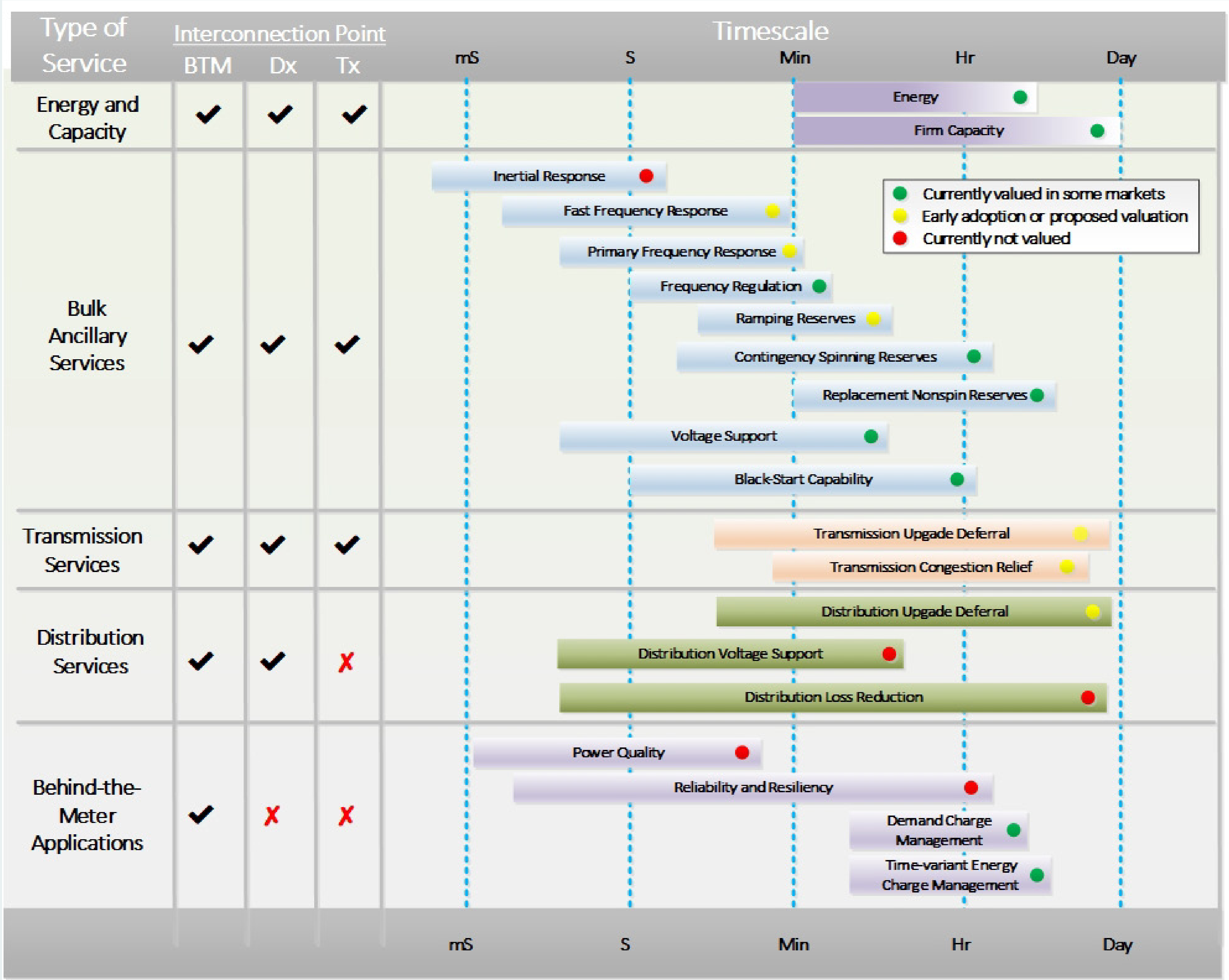
Metering and technical configurations

- Driving factor to design a reasonable interconnection timeline/costs
- Local construction permitting and standards

Key Technical Characteristics (BESSs)

Rated Power Capacity	Total possible instantaneous discharge capability (in kilowatts [kW] or megawatts [MW]) of the battery energy storage system (BESS), or the maximum rate of discharge that the BESS can achieve, starting from a fully charged state.
Energy Capacity	Maximum amount of stored energy (in kilowatt-hours [kWh] or megawatt-hours [MWh]) a battery can hold (capacity may also be represented as 'Usable Energy Capacity' or 'Operating Energy Capacity' that reflects the highest percentage of the total energy capacity recommended to preserve battery performance).
Energy/Power Density	Measure of the energy or power capacity of a battery relative to its volume (kW/L, kWh/L).
Specific Energy/Power	Measure of the energy or power capacity of a battery relative to its weight (kW/g, kWh/g).
Storage Duration	Amount of time storage can discharge at its rated power capacity before depleting its energy capacity.
Cycle Life/Lifetime	Amount of time or cycles a battery storage system can provide regular charging and discharging before failure or significant degradation.
Round-trip Efficiency	Ratio of the energy charged to the battery to the energy discharged from the battery.
Self-discharge	Reduction of stored energy of the battery (% of charge/time) through internal chemical reactions, rather than through discharging to perform work.

https://docs.nrel.gov/docs/fy20osti/75283.pdf

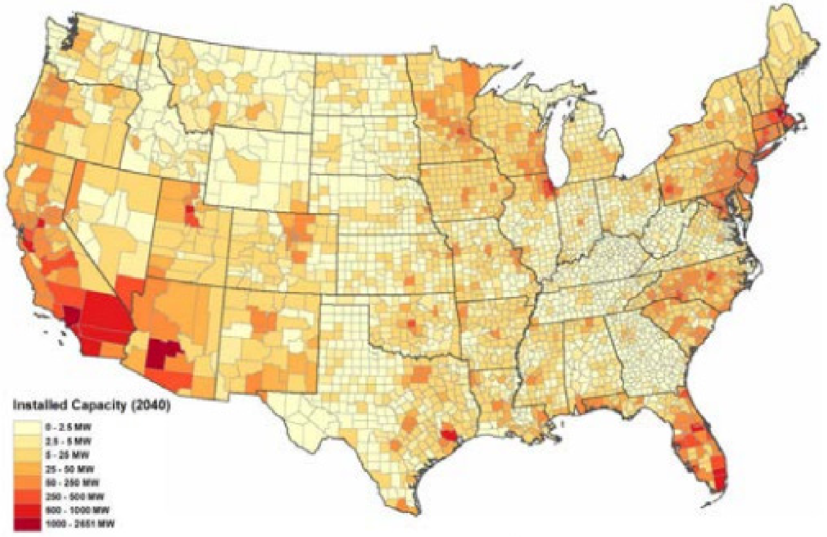


https://docs.nrel.gov/docs/fy20osti/75283.pdf

Tools

Distributed Generation Market Potential (dGen™)

Distributed PV Adoption Example Scenario Analysis – Mid-Cost Scenario – Projected Installed Capacity by the Year 2040



Source: NREL, The North American Renewable Integration Study: A U.S. Perspective, 2021, URL: https://docs.nrel.gov/docs/fy21osti/79224.pdf

The Distributed Generation Market Demand (dGen™) model by NREL forecasts adoption and operation of DERs at high spatial fidelity for power system planning in the United States or other countries through 2050.

- Incorporates detailed spatial data to distinguish individual and regional adoption trends
- Consumer decision-making based on cost-effectiveness of technology
- Identification of drivers of adoption by analysis of multiple scenarios
- U.S. open-source tool available for download at :

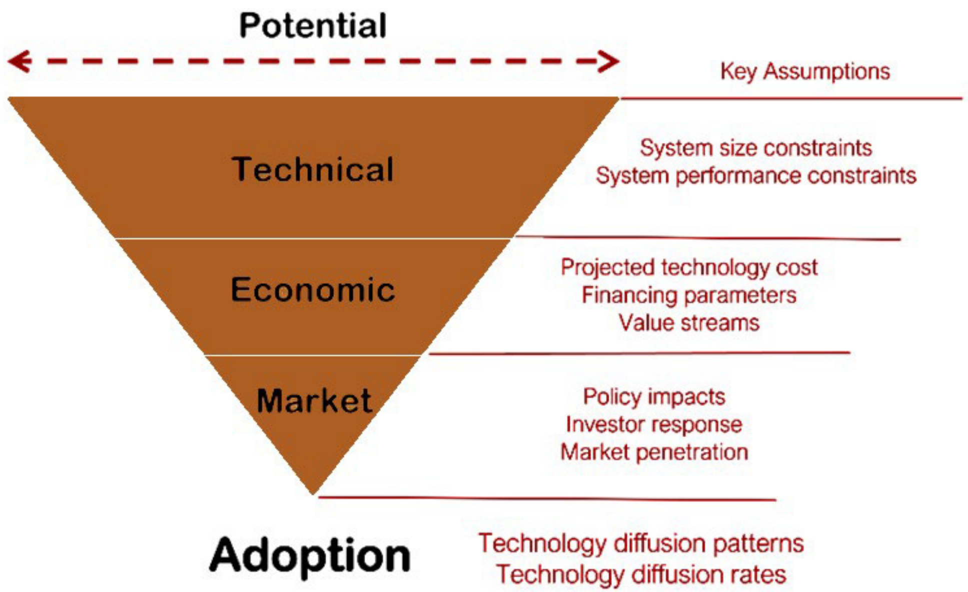
  https://github.com/NREL/dgen

- International dGen code base:

  https://github.com/NREL/dgen_globetrotter

Modeling Methodology

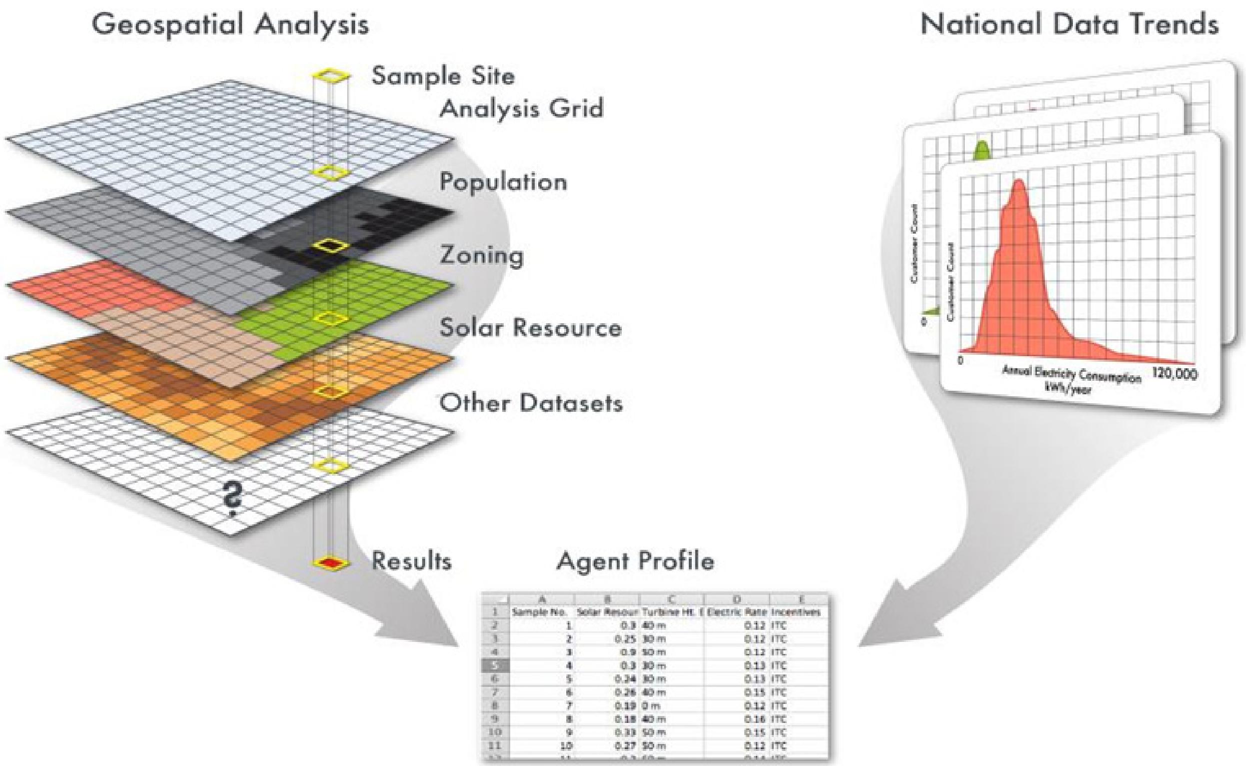
- **Technical potential**: The maximum amount of technically feasible capacity of PV-only and PV + energy storage systems, with PV system size limited by customer's rooftop area in addition to energy consumption, and storage capacity capped as a fraction of the optimal PV capacity at a specific site.
- **Economic potential**: A subset of technical potential, economic potential is estimated as the total capacity that has a positive return on investment or a positive net present value (NPV). Economic potential can also be interpreted as the total capacity of systems that are cost-effective in a specific year.
- **Market potential**: The fraction of economic potential representing the customer's willingness to invest in a technology given a specified payback period.
- **Adoption**: Adopted capacity is the capacity projected to be purchased by residential, commercial, and industrial building owners and installed at the customer premises in a behind-the-meter configuration. Adoption is based on applying a Bass diffusion function where the upper limit of adoption is set to the market potential.



Data Requirements

Input parameters:

- LiDAR roof scans/Building data
- Electricity consumption and profiles by region/sector
- Historic deployments
- Technology costs
- Financing costs
- Solar/Storage incentives and policies by region/sector
- Retail rates by region/sector



CEC Case Study

2024 report

Sekar, A., Das, P., Prasanna, A., Sizemore, M., & McCabe, K. (2024). Modeling Distributed Generation in California. https://doi.org/10.2172/2491424

Key Data Used

Geospatial Resolution	Residential Sector: Building type (single-family), tenure (owner-occupied)
	Commercial sector: United States Department of Energy reference of 16 commercial building types

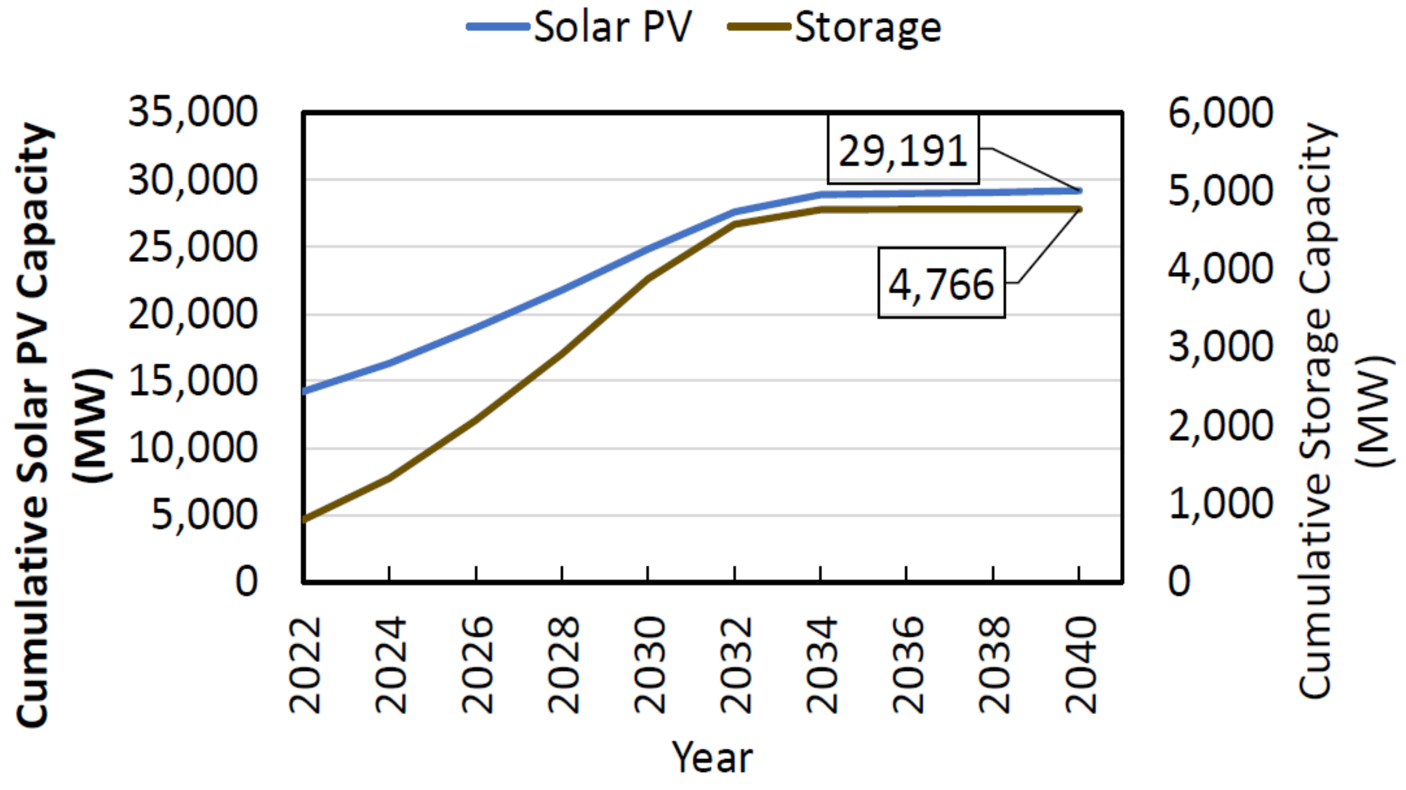
Key Data Used

Building Stock	Solar-suitability levels of the buildings
	Updated based on the 2021 American Community Survey
Electrical Loads	NREL's ResStock and ComStock model and calibrated the load data with county-level data from CEC
Solar Resource	TMY3 solar profiles for 4,229 locations

Key Data Used

Retail Rates	OpenEI utility rate database https://openei.org/apps/USURDB/
Policies and Incentives	Database of state incentives for renewable and efficiency; https://www.dsireusa.org/
Technology Costs	Most-recent annual technology base

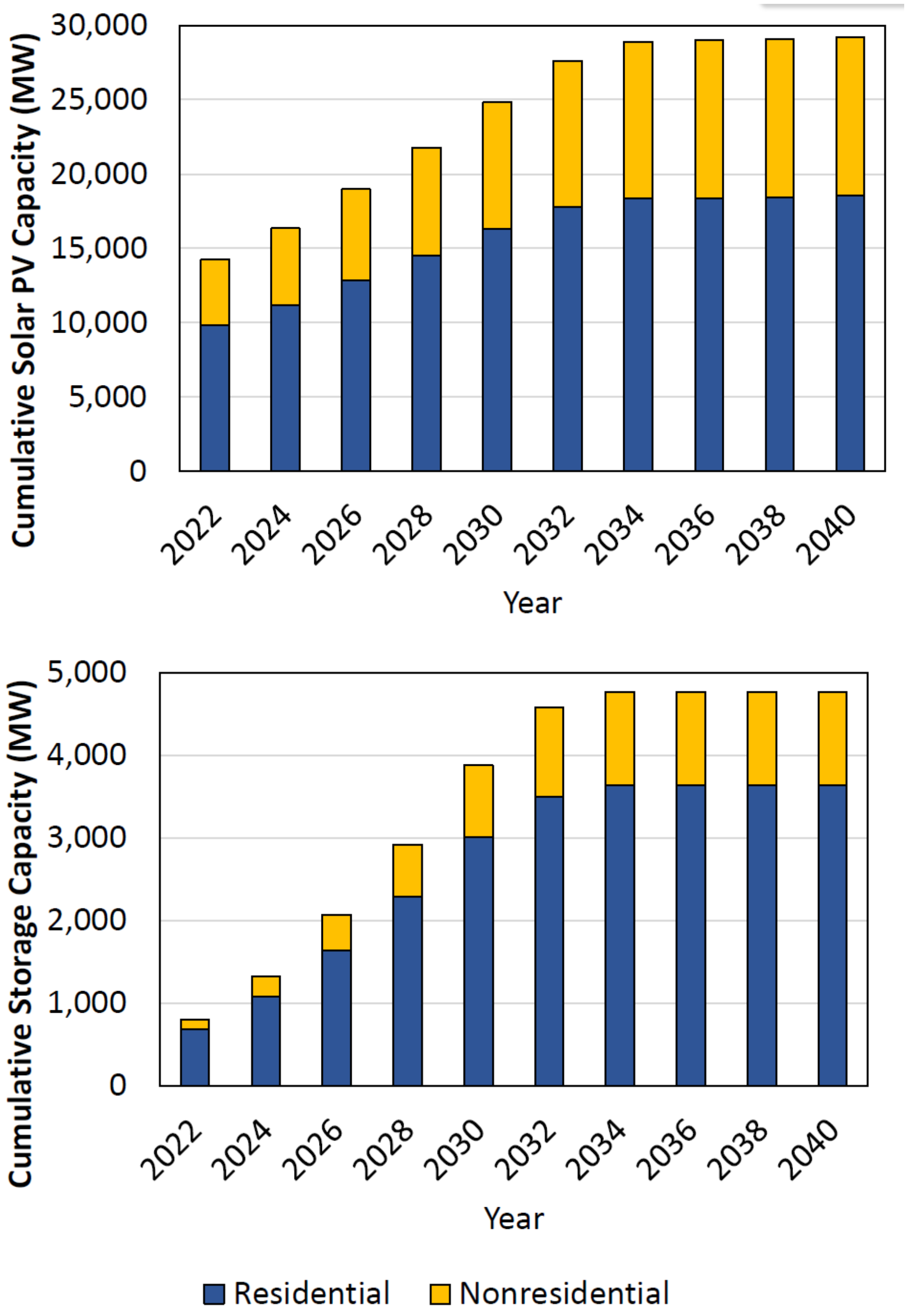
Cumulative Solar Forecast from dGen (CA)



- The results produced by the Distributed Generation Market Demand model forecast a significant growth in solar photovoltaic and storage capacity through retrofits in California - a roughly **twofold** increase in the amount of PV capacity and a **fivefold** increase in the amount of storage capacity from Calendar Year 2023 to the end of the forecast in 2040.

- Increased solar PV and storage adoption can be attributed to a **decrease** in **payback** period, as well as an increase in monthly bill savings throughout the forecast. These changes are due to several factors that were updated for the model, mainly increased electricity rate escalation, decreased system cost, and an extended tax credit.

CA paired solar + storage forecasts



- Because the CPUC's updated net billing tariff (NBT) pushed payback periods upward, a decrease in adoption had been anticipated.
- However, because of other factors that decrease payback period, such as lower installation cost and electricity rate increases, the model shows an overall decrease in payback period, resulting in an increase in forecast adoption.
- As with solar, storage additions are forecast to significantly decrease following the original expiration of the ITC in 2034 (the plateau may become visible earlier since the expiration date has been accelerated to 2025).

Questions states can explore

- What solar forecasting tools are being used by utilities?
- What counter measures do the utilities have in place to account for uncertainty and error margins in these forecasting models?
- How are they keeping track of behind the meter solar and storage adoption?

DOE-funded Resources and Assistance for State Energy Offices and Regulators Program

https://StateTAProgram.lbl.gov

Help Desk

- Online intake form w/ rolling review
- SME provides up to **4 person-hours of support**
- Intake form and support available now

Expert Match

- Online intake form w/ rolling review
- SME provides up to **100 person-hours of support**
- Intake form and support available now

Deep Dive

- Detailed application form in planned ~6-month cycle
- Team of SMEs provide **100+ person-hours of support**
- Detailed online application available soon

BERKELEY LAB

Sean Murphy| SMurphy@lbl.gov

Margaret Pigman | MPigman@lbl.gov

NREL

Shibani Ghosh | shibani.ghosh@nrel.gov