Considering Time-Sensitive Value of Energy Efficiency When Shaping Program Incentives

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National Association of State Utility Consumer Advocates 2023 Mid-Year Meeting

July 18, 2023

This work was funded by the U.S. Department of Energy Building Technologies Office, under Contract No. DE-AC02-05CH11231.

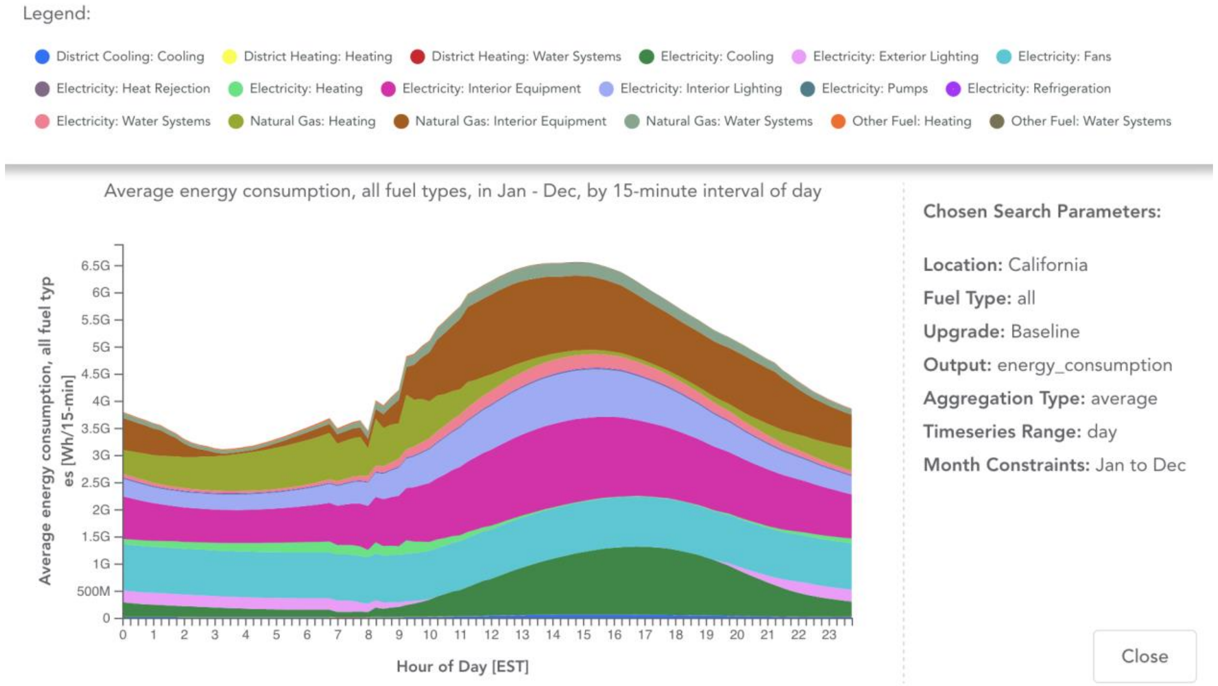
Presentation Agenda

- Time-sensitive value of efficiency and it's importance
- Identifying *when* efficiency savings occur
- Identifying the *value* of efficiency
- Examples of using time and locational value in planning and programs
- Time-sensitive value calculator
- Questions

Time-sensitive value of energy efficiency and other DERs

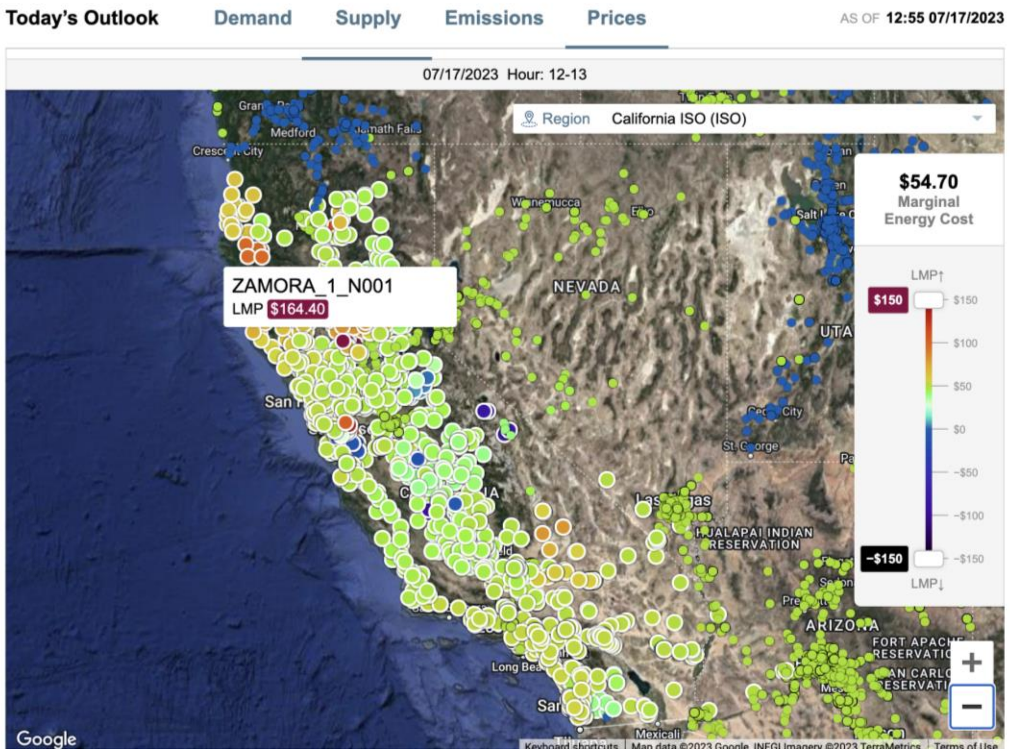
- Time-sensitive value of energy efficiency considers *when* energy efficiency occurs and the *economic value* of the energy or demand savings to the electricity system at that time.

Savings Shape



Source: ComStock

Economic Value

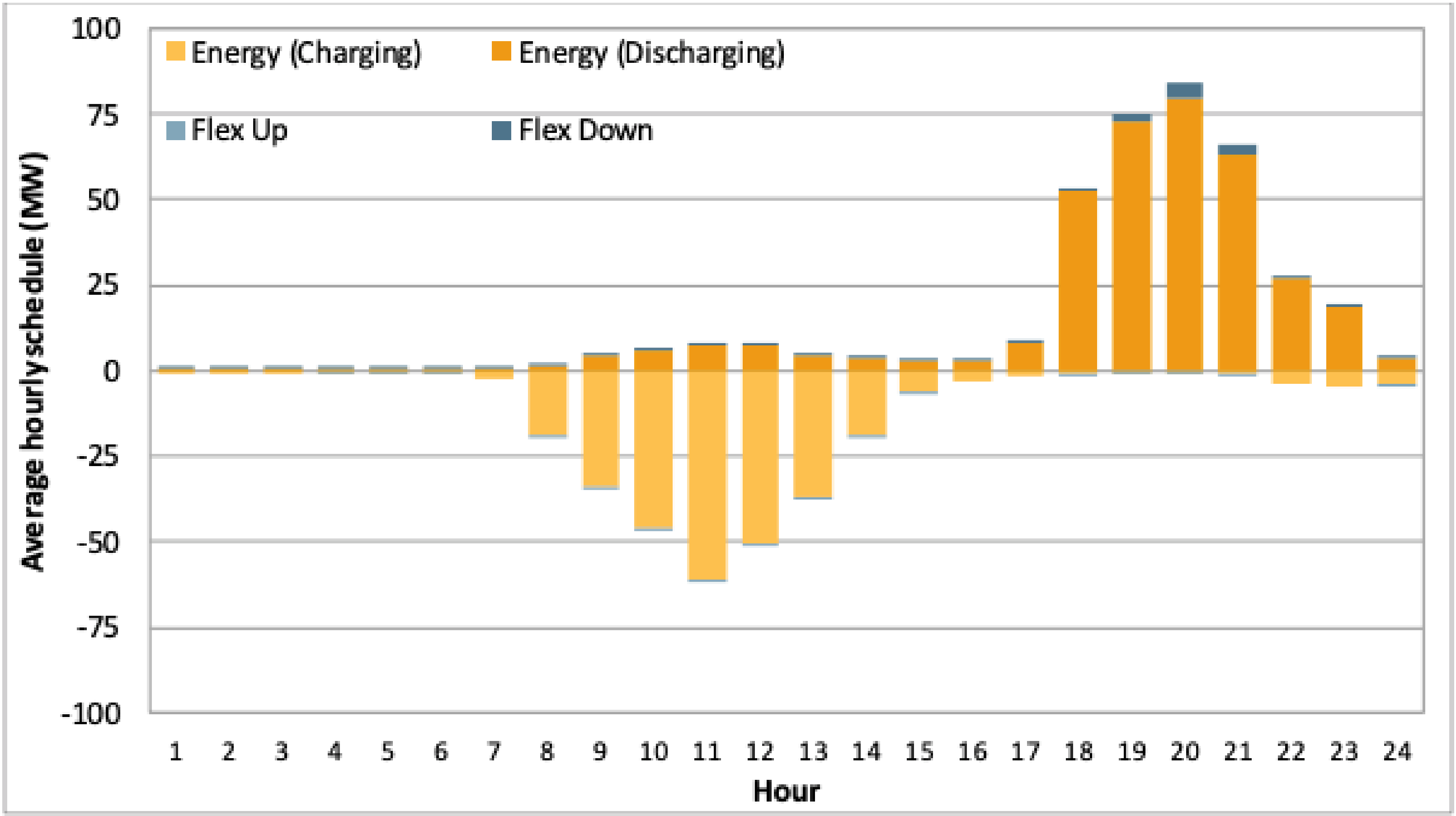


Source: CAISO

Why do we care about it?

- The electricity system is changing, requiring changes in grid operations and greater consideration of the timing, quantity and location of DERs.
- Energy efficiency (with controls) and other DERs can help provide flexibility to the grid.
- Demand flexibility can help meet grid needs and policy goals, including:
  - Integration of growing shares of renewable energy
  - Defer distribution system investments
  - Reduce carbon dioxide and other air pollutants
  - Provide grid and building occupant benefits

Western Energy Imbance Market average hourly battery schedules (2022)



Source: [CAISO 2023]

DERs must be in the right place and operate at the right time to meet system needs.

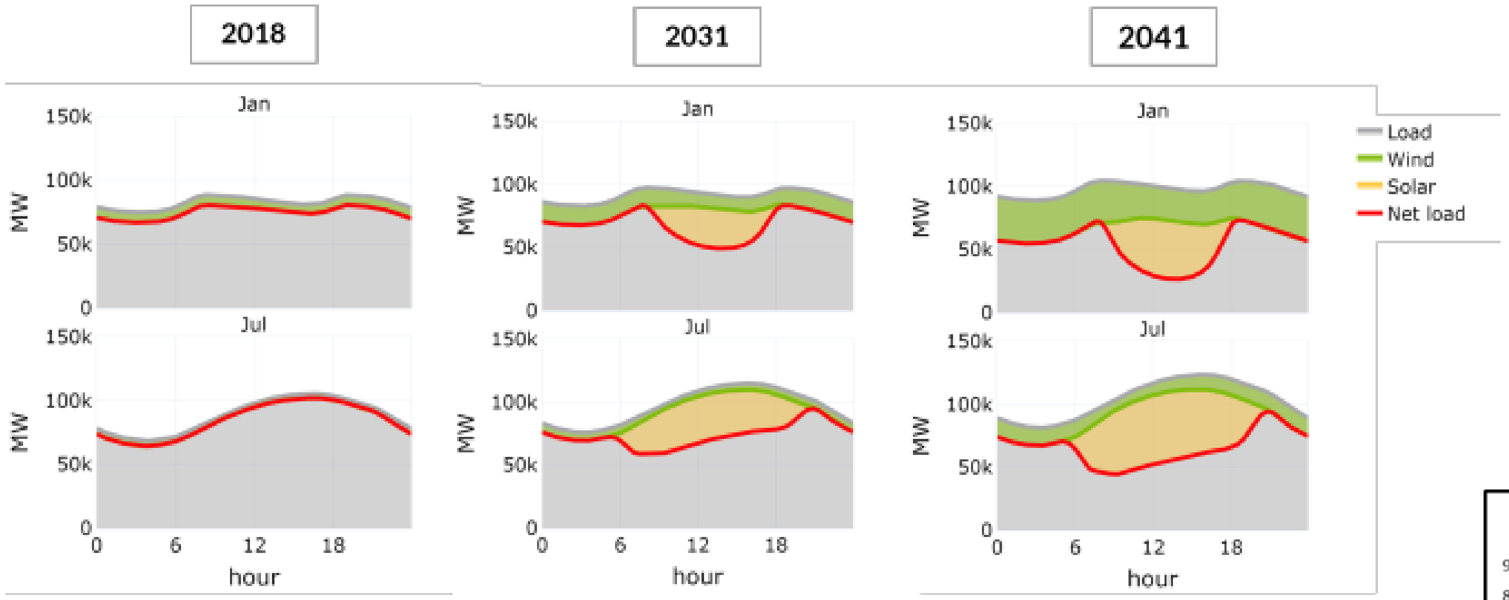
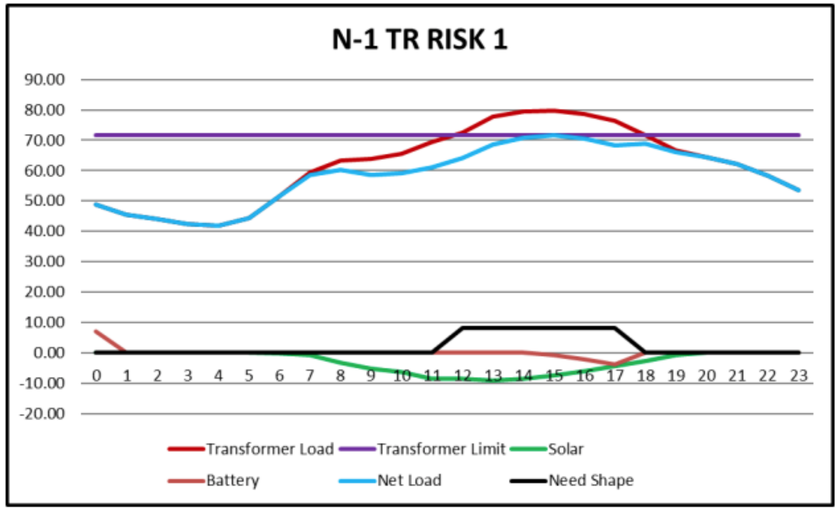


Figure 19: Monthly averages of diurnal net load components for January and July

DERs must operate at the ***right time*** to ensure they will relieve the identified constraint and provide generation or load reduction during the *peak day.*

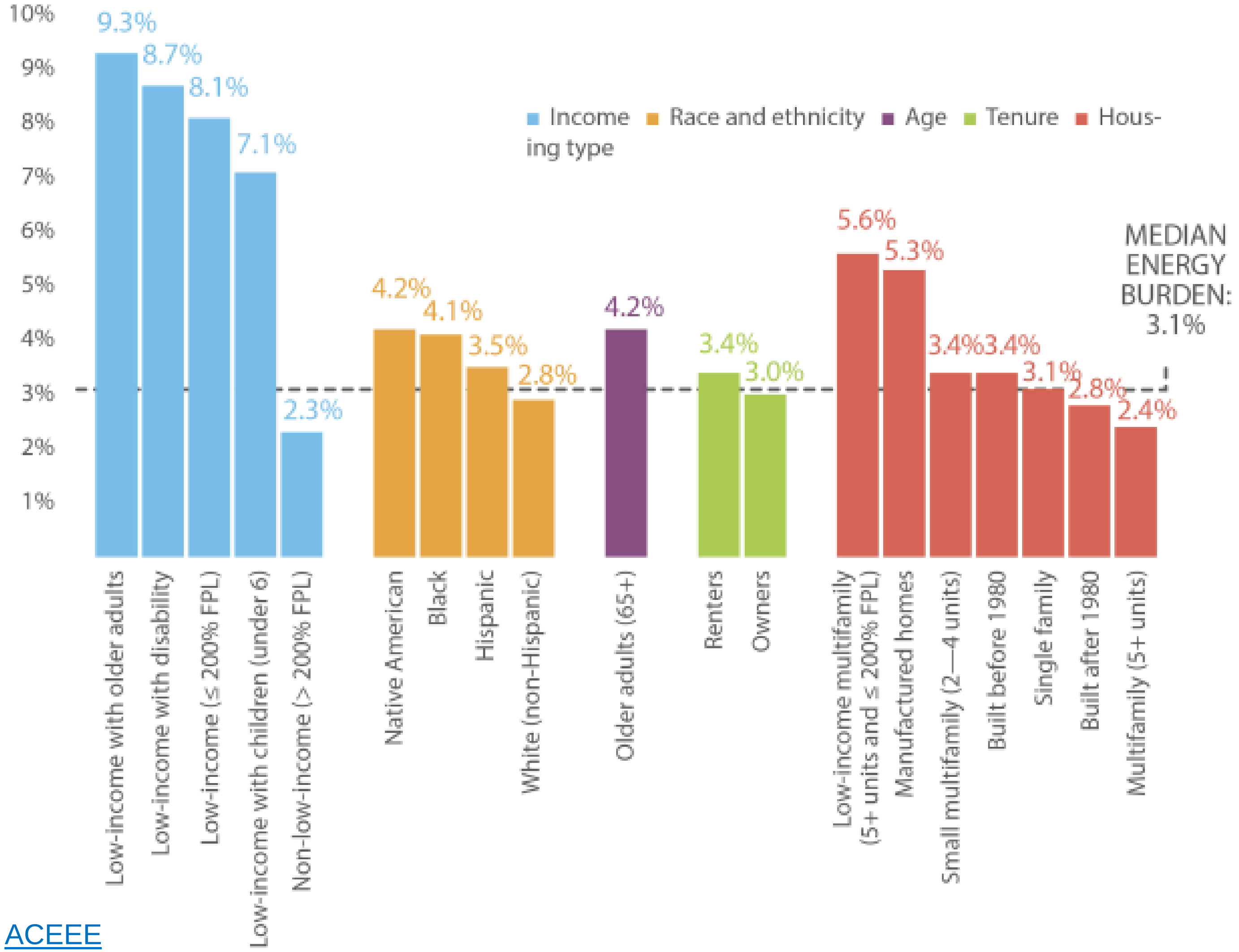


Value of DERs for the distribution system ***depends on location***.

- Value may be associated with a distribution substation, individual feeder, section of feeder, or a combination of these components.
- Avoided distribution costs vary by area. DERs must be targeted to capture the highest value.

Sources: MISO Regional Resource Assessment 2022, Xcel MN 2022 IDP

Efficiency can support an *equitable* clean energy transition.



- Low-income, Native American, Black, and Hispanic and renter households have a higher than average energy burden.
- Energy efficiency, including weatherization can reduce household energy burdens.

Source: ACEEE

Identifying *when* savings occur

End-Use Load Profile and Savings Shape Reports

[Market Needs, Use Cases and Data Gaps](#)

[Methodology and Results of Model Calibration, Validation and Uncertainty Quantification](#)

[Practical Guidance on Accessing and Using the Data](#)

[End-Use Savings Shapes: Residential Round 1](#)

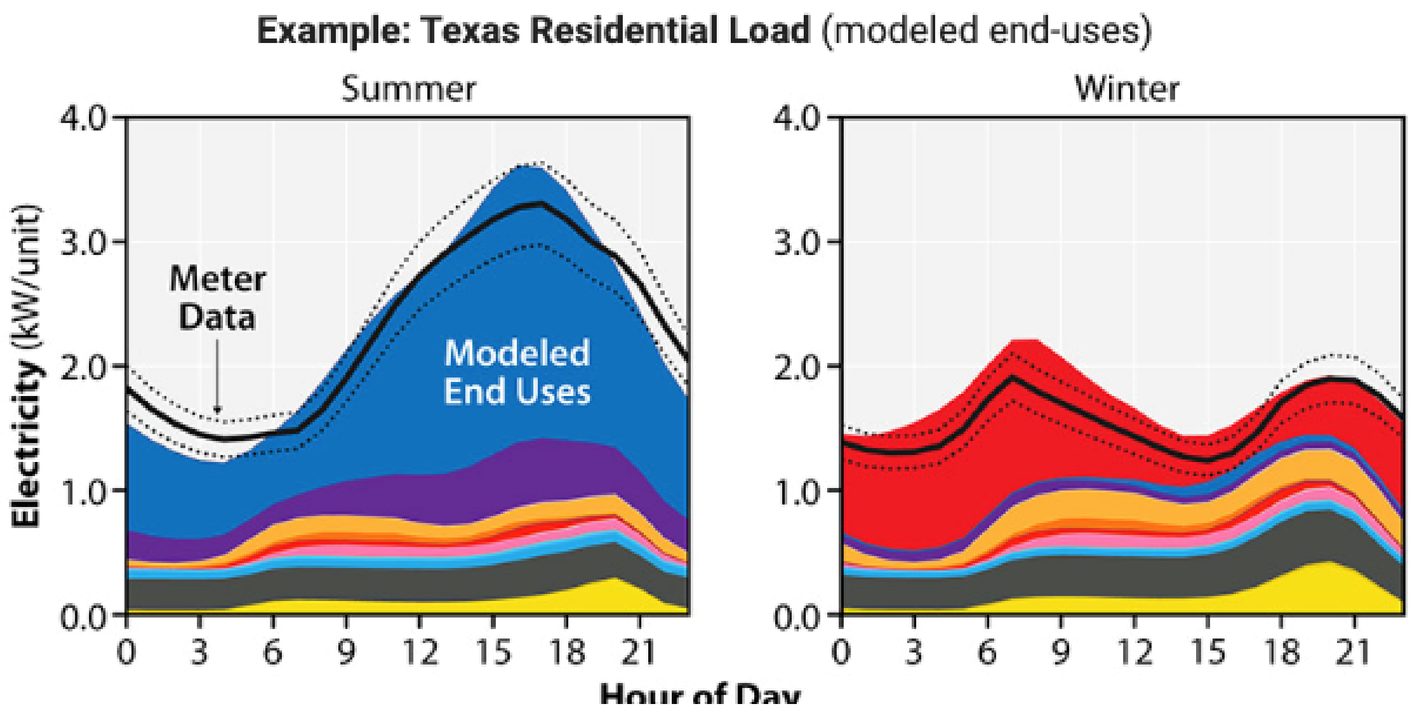
Access all datasets on the project website https://www.nrel.gov/buildings/end-use-load-profiles.html

Foundational Dataset of ~1 Million End-Use Load Profiles for the U.S. Residential and Commercial Building Stock

ComStock ResStock

Building stock models calibrated through 70+ model updates, supported by data:

- Electric load data from 11 utilities and 2.3 million meters
- 15 end-use metering datasets



- The end-use load profile dataset is the output of approximately 900,000 (550,000 ResStock plus 350,000 ComStock) building energy models.
- The output of each building energy model is 1 year of energy consumption in 15-minute intervals, separated into end-use categories.
- Simulation results, building characteristics, energy models are available

Source NREL

Practical Guidance on Accessing and Using End-Use Load Profiles

- Accessing the End-Use Load Profiles and Savings Shapes
- Considerations and Limitations
- Use Cases

Use Case	Application of End-Use Load Profiles
Integrated resource planning	Develop load forecast or energy efficiency supply curves
Long-term load forecasting	Analyze the impact of particular equipment adoption scenarios statewide, across a utility area, or a smaller geographic area; improve baseline building energy consumption assumptions
Transmission planning	Disaggregate the load into components that behave differently during and after a fault
Distribution system planning	Analyze the value of solar and wind as well as different types of energy efficiency based on the location and timing of the generation or savings
Electrification planning	Understand how electrification could affect annual electricity consumption and how the increase in consumption could be spread across hours of the year
Demand-side management	Use as an input to cost-benefit analysis to understand the time-value of energy efficiency; in potential assessments to understand the available amount and timing of energy efficiency (e.g., improving baseline building energy consumption assumptions); and in program design
Bill impacts and rate design	Estimate how electricity bills may increase or decrease with adoption of DERs or switching to a new time-based electricity rate for individual buildings with realistic load profiles, and aggregations of buildings

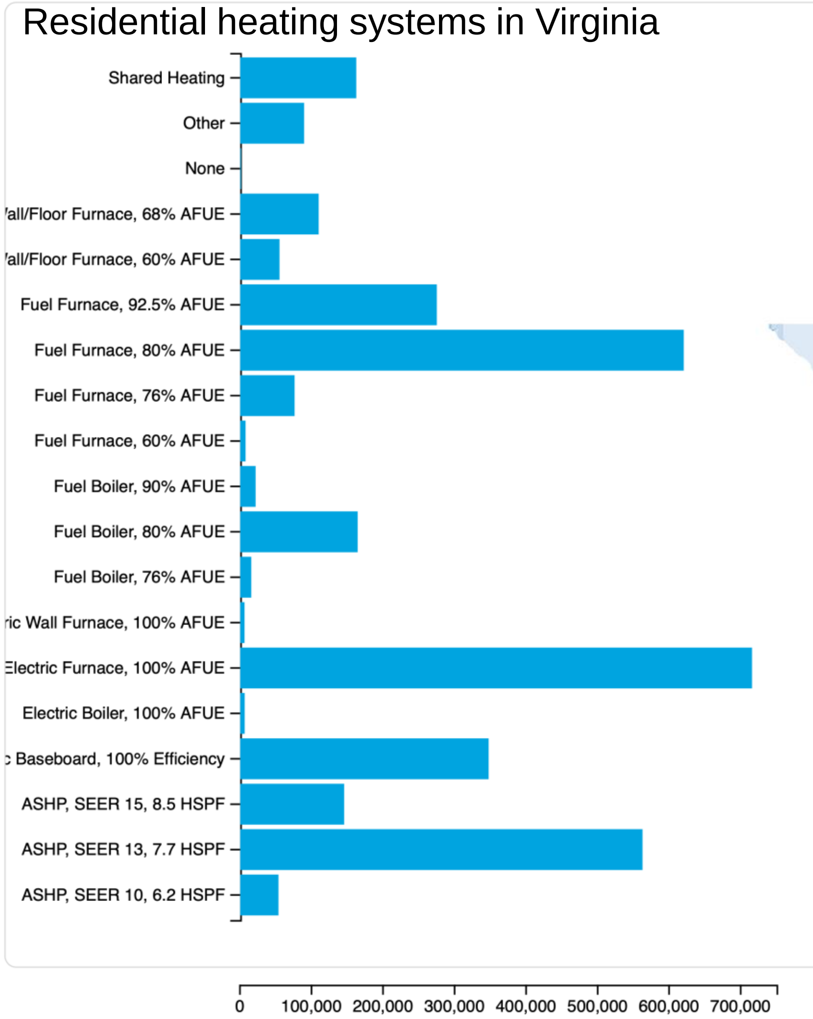
Options to Access the End-Use Load Profiles: Contents of the Dataset

	Commercial	Residential
Models Run (per weather year and upgrade)	350,000 buildings	550,000 dwelling units
Representing	64% of U.S. commercial floor area per CBECS	137 million U.S. homes Excludes AK, HI, territories
Building Types	14	5
End Uses	19	49
Upgrades	Coming soon	10 packages
Weather years	TMY (typical meteorological year), AMY 2018 (actual meteorological year)	TMY, AMY 2012, AMY 2018

Source: EULP webinar

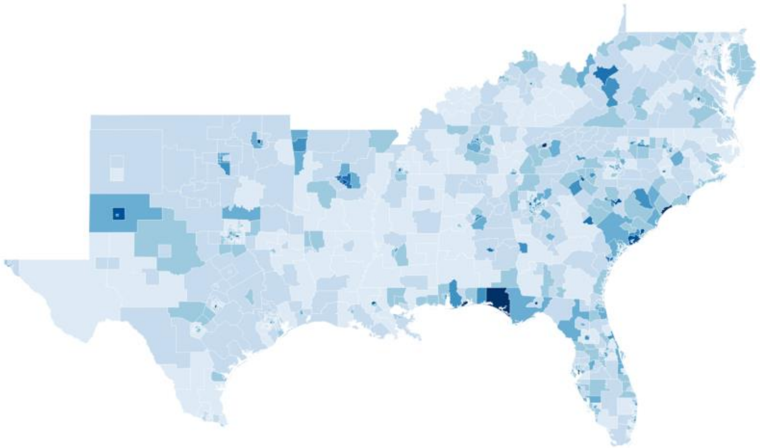
Three Strengths of ResStock and ComStock End-use Load Profiles

Building stock



Source: EULP webinar

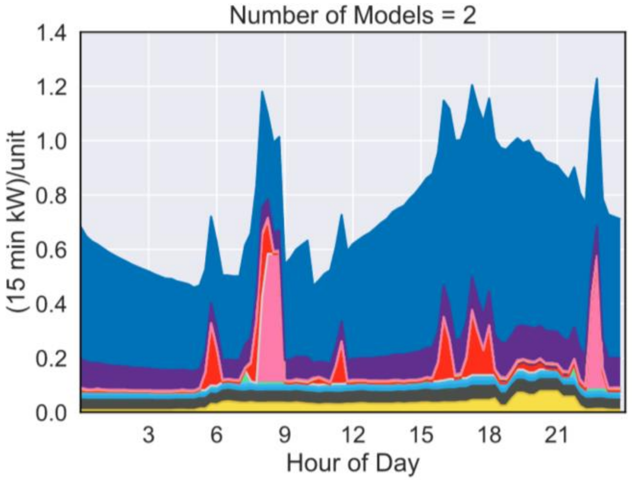
Geographic granularity

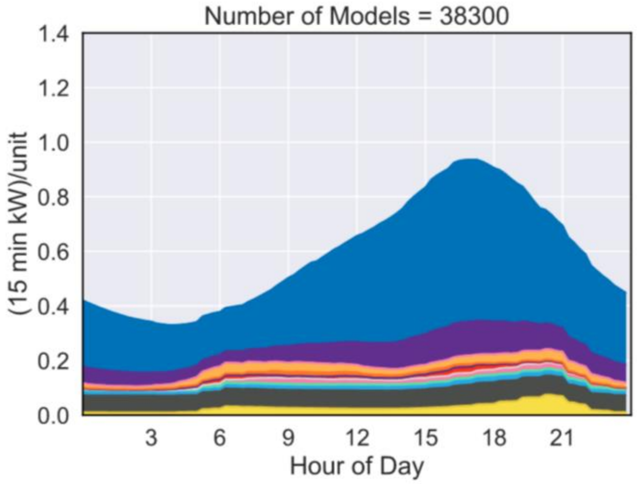


Example of Public Use Microdata Area* (PUMA) resolution:
~200k people; ~2,400 in U.S.

* https://www.census.gov/programs-surveys/geography/guidance/geo-areas/pumas.html

Behavioral diversity





Wilson et al. 2022 Figure 368 (subset)

Overview of access options

ResStock and ComStock

- Web viewer
  - Annual and timeseries graphs
  - 15-minute end-use consumption for a custom set of buildings
  - Compare baseline and efficiency upgrades (ResStock only for now)

OpenEI Data Lake

- Aggregate files
  - 15-minute end-use consumption by building type and geography (e.g. state, county)

- Individual buildings
  - 15-minute end-use consumption for individual buildings and dwelling units
  - Building energy model files

How much are savings worth?

Value = Avoided cost

- Traditionally, the economic value of energy efficiency, demand response, and other DERs has been determined using the "avoided cost" of conventional resources that provide the identical utility system service.

- The underlying economic principle of this approach is that the *value* of a resource can be estimated using the *cost of acquiring the next least expensive alternative resource* that provides comparable services (i.e., the *avoided cost* of that resource).

Source: Determining Utility System Value of Demand Flexibility From Grid-interactive Efficient Buildings

Primary valuation task

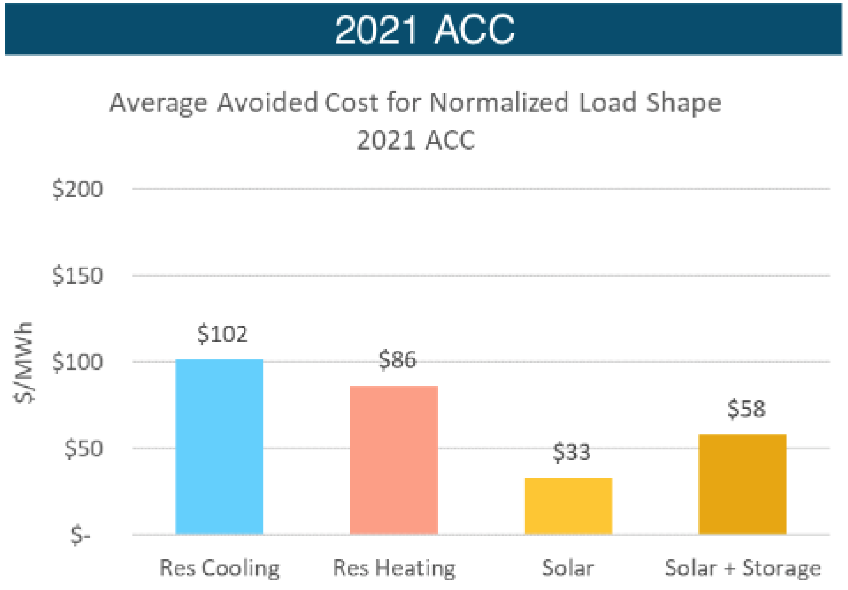
- The primary task required to determine the value of demand flexibility based on avoided cost is to *identify the alternative (i.e., “avoided”) resource* and *establish its cost*.

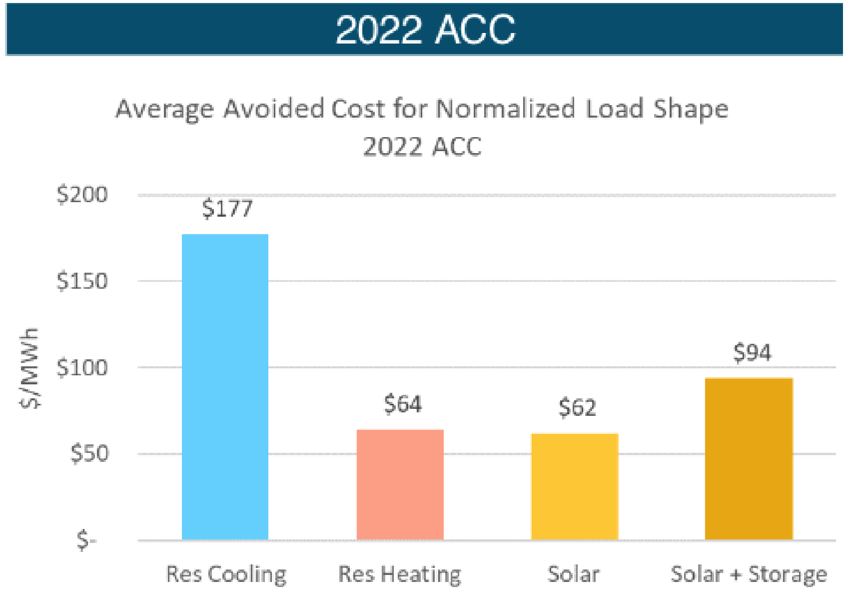
- Methods used to establish avoided cost vary widely across the United States due to differences in:
  - electricity market structure
  - available resource options and their costs
  - state energy policies and regulatory context

There is no single economic value of DERs for utility systems.

- The value of a single “unit” (e.g., kW, kWh) of grid service provided by EE and other DERs is a function of **the *timing* of the impact (temporal load profile)**

Energy efficiency or solar will see an increase in avoided costs if they can capture high-capacity hours in summer and high midday energy prices

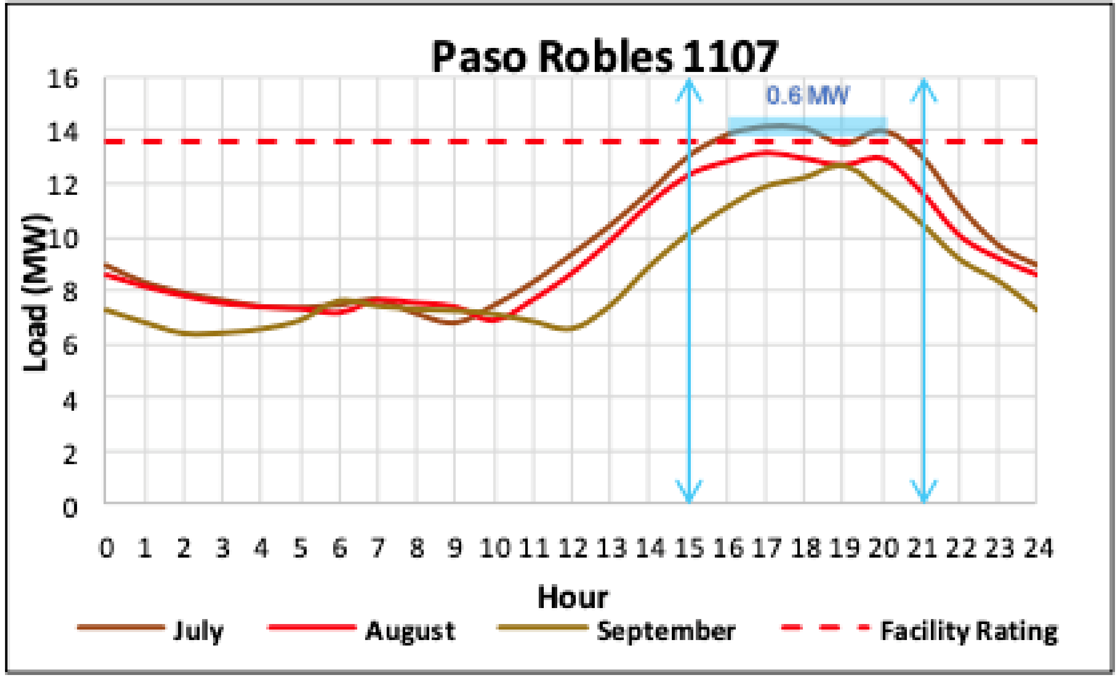


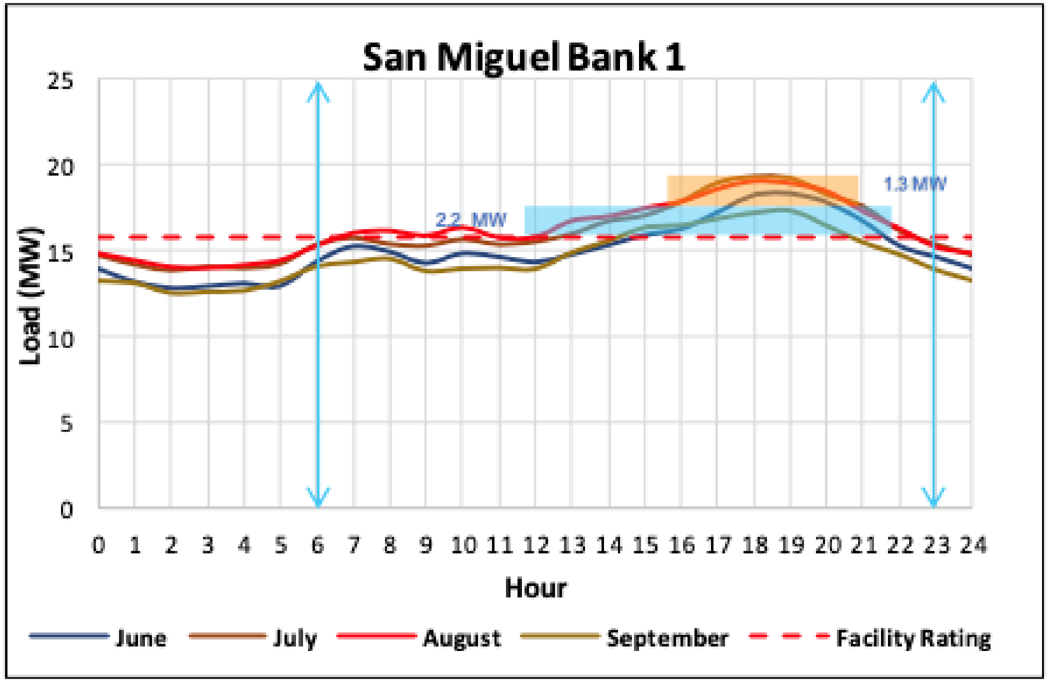


Source: 2022 CPUC Draft Avoided Cost Calculator Workshop

Location of resource

- The value of a single "unit" (e.g., kW, kWh) of grid service provided by EE and other DERs is a function of **the *location* in the interconnected grid**

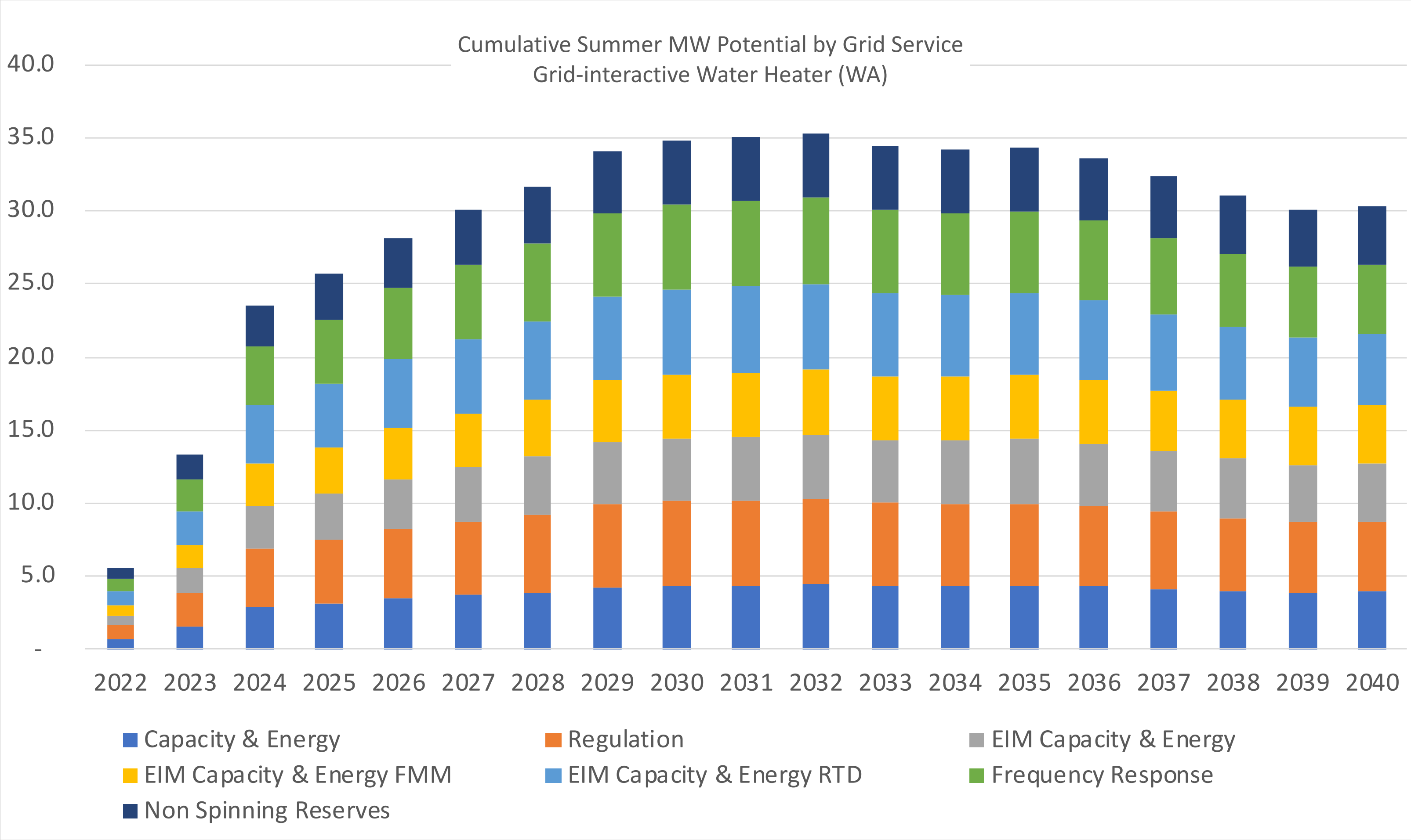




Source: PG&E's Participants Webinar – Distribution Investment Deferral Framework, 2021

Grid service provided by resource

The value of a single “unit” (e.g., kW, kWh) of grid service provided by EE and other DERs is a function of **the *grid services* provided**



Source: PacifiCorp 2021 Conservation Potential Study, Appendix I

Expected useful lives

- The value of a single “unit” (e.g., kW, kWh) of grid service provided by EE and other DERs is a function of **the *expected service life* (persistence) of the impact**

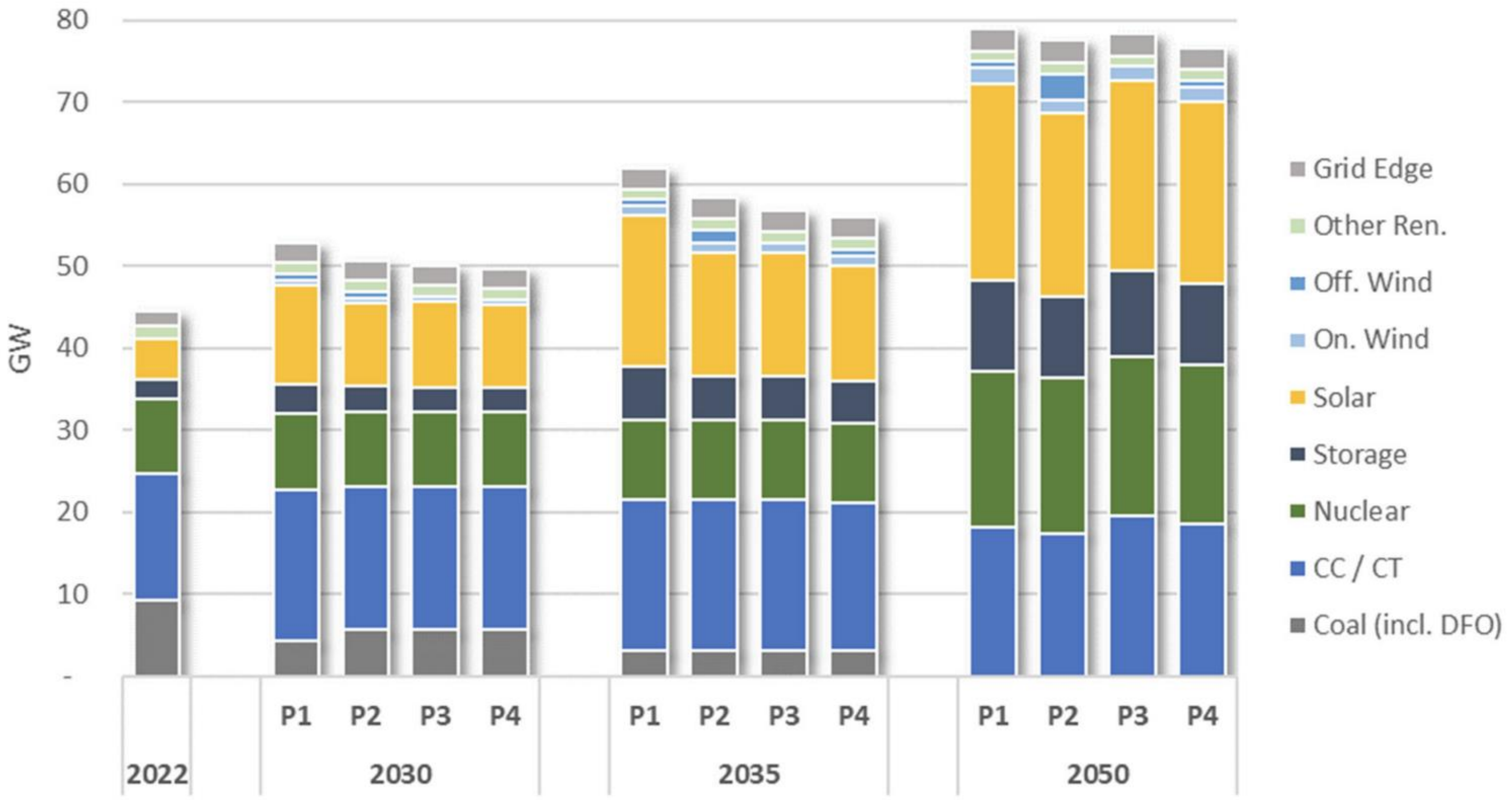
- Expected useful lives (EULs), determined independently of policy or program decisions regarding the length of time compensation is offered for the grid services they provide, should be used in calculating the economic value of DERs providing demand flexibility.

- Demand flexibility that defers or avoids capital expenditures, ongoing fuel costs, or O&M costs throughout their EULs need to be valued (and perhaps compensated) differently than resources that only reduce near-term fuel costs or O&M costs, as well as demand flexibility that is forecasted to have variable and uncertain impacts through time.

Avoided cost of least-expensive resource alternative

- The value of a single "unit" (e.g., kW, kWh) of grid service provided by EE and other DERs is a function of **the *avoided cost of the least-expensive resource alternative* providing comparable grid service.**

Figure 3-4: Capacity Mix by Portfolio, Combined Carolinas System (GW basis)



Source: [Duke Carbon Plan]

Primary methods for valuing energy efficiency and other DERs

- **System capacity expansion and market models**
  - *Most prevalent practice* – Reducing the growth rate of energy and/or peak demand in load forecasts input into the model, then let it optimize the type, amount, and schedule of new conventional resources (generation, transmission or distribution)
  - *Less prevalent practice* - Directly competing DERs with conventional resources in the model to determine DERs' impact on existing system loads, load growth, and load shape—and thus dispatch of existing resources—and the type, amount, and timing of conventional resource development

- **Competitive bidding processes/auctions:** Use "market mechanisms" to select new DERs, currently limited to energy efficiency (EE) and demand response (DR)

- **Proxy resources:** Use the cost of a resource that provides grid services (e.g., a new natural gas-fired simple-cycle combustion turbine to provide peaking capacity) to establish the cost-effectiveness of DERs (i.e., determine the amount to develop) that provide these same grid services

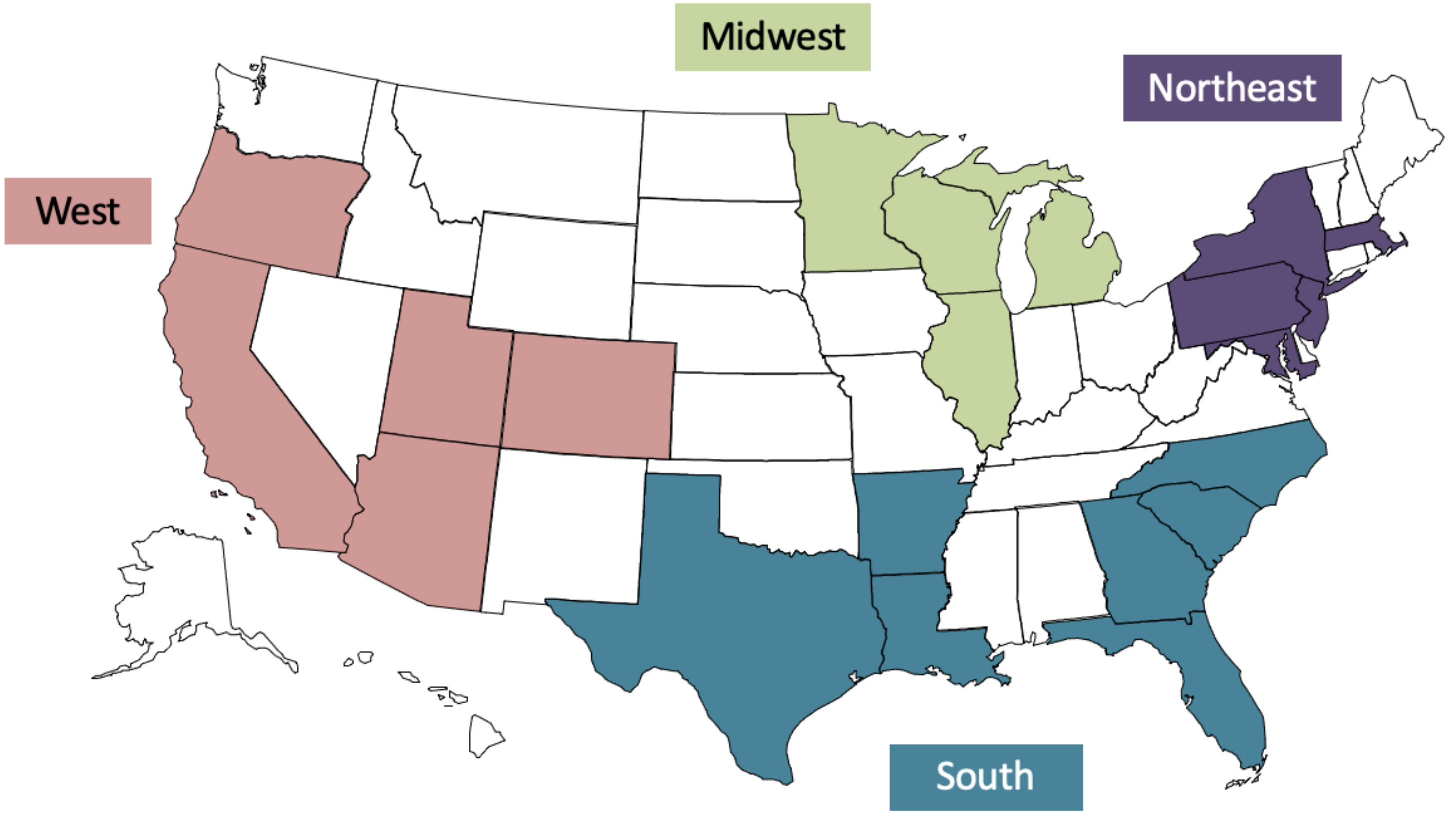
- **Administrative/Public policy**: Use legislative or regulatory processes to establish development goals (e.g., Renewable Portfolio Standards and Energy Efficiency Resource Standards)

**Also used for utility scale resource options analysis*

Examples of using time and locational value in planning and programs

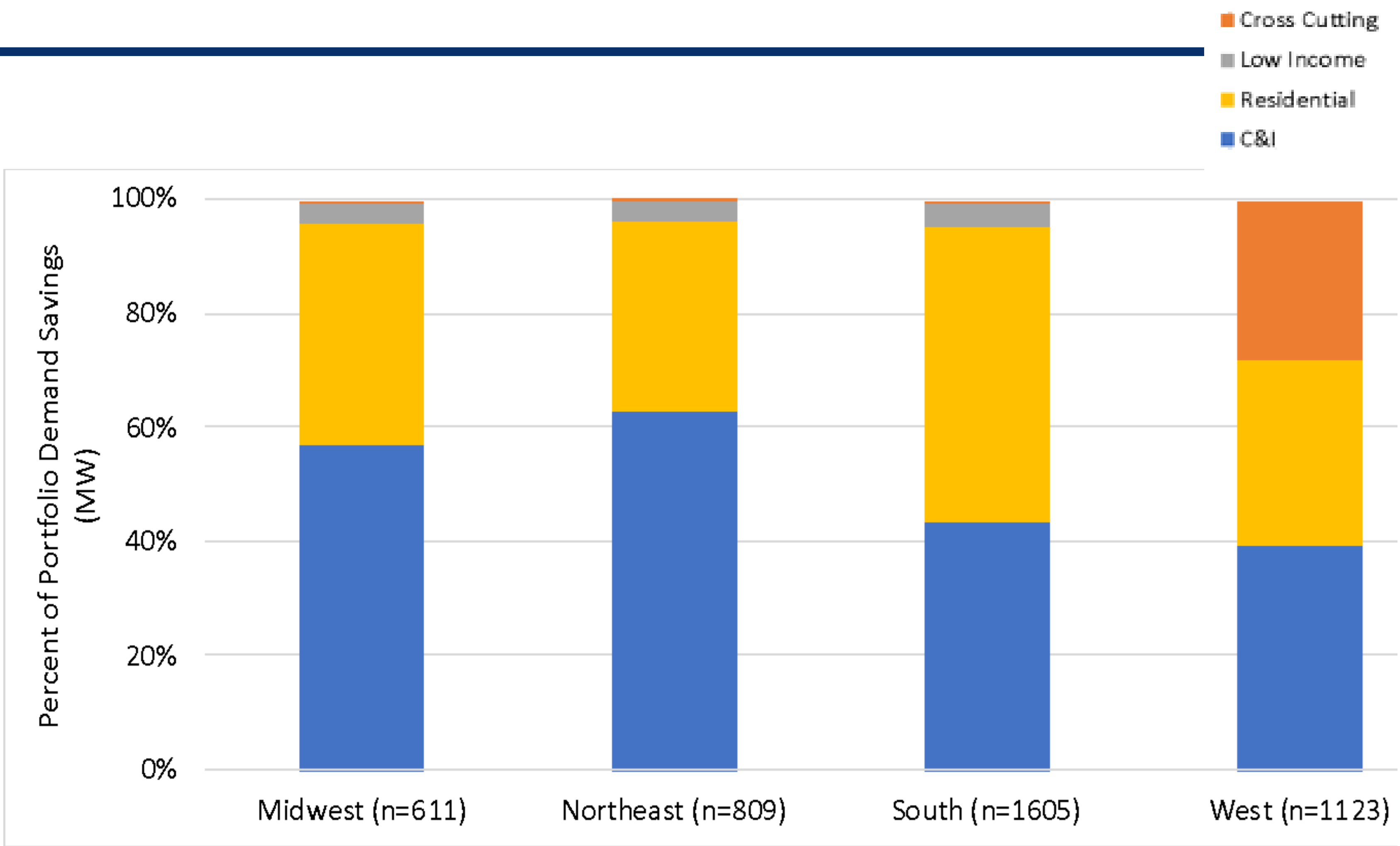
States in Cost of Saving Peak Demand analysis

- Cost of Saving Peak Demand is a subset of Cost of Saving Electricity data.
  - Collection period: 2014-2018
- Data in 2018 represents
  - 67 program administrators in 21 states
  - 92% of reported efficiency spending
  - 84% of reported demand reductions
- For regional analysis, states are categorized into four regions shown by color on the map



Peak demand savings by region for 67 program administrators (2014-2018)

- The C&I sector provided 57% of peak demand savings across all programs in our 2014-2018 study period.
- Results varied by region. C&I provided the majority of savings in the Midwest (57%) and Northeast (63%). Residential provided the majority of savings in the South (55%).



Cross cutting programs apply to all market sectors. They include multi-sector rebates, codes and standards, education, outreach, workforce development and R&D.

Cost of Saving Peak Demand findings

- The cost of saving peak demand analysis spans a 5 year period (2014-2018). Findings include:
  - The program administrator cost of saving peak demand for all programs ranged from $59 to $449 per kW over the course of the study period. The range was greater for our time trend dataset, which is a subset of all of the programs that we have data on.
  - The program administrator cost of saving peak demand decreased over time during the study period. Average cost of programs over the 2014-2018 study period by market sector: C&I - $145/kW, Low Income - $386/kW, and Residential - $147/kW.
  - Four programs contribute more than 40% of the portfolio demand savings for the period studied: residential consumer products, C&I custom, C&I prescriptive, and C&I All Other Programs
  - The comparison of COSE and CSPD “cost curves” for program categories demonstrate the similar relative costs of various types of efficiency programs and the savings contribution of each program type.

The cost of saved electricity has remained relatively constant over 8 years and is a low-cost energy resource.

	2010 - 2018	2018 Results
	Levelized CSE ($/kWh)	**Levelized CSE ($/kWh)**
Residential	0.027	0.029
C&I	0.023	0.020
Low Income	0.091	0.102
Midwest	0.017	0.020
Northeast	0.031	0.027
South	0.030	0.028
West	0.027	0.020

Dispatchable technologies	$/kWh
Ultra-supercritical coal	0.073
Combined cycle	0.037
Combustion turbine	0.107
Advanced nuclear	0.063
Geothermal	0.345
Biomass	0.089
Battery storage	0.119

Non-dispatchable technologies	$/kWh
Wind, onshore	0.037
Wind, offshore	0.121
Solar, standalone	0.030
Solar, hybrid	0.045
Hydroelectric	0.055

Excerpt from EIA, Estimated unweighted levelized cost of electricity and levelized cost of storage for new resources entering service in 2026 (2020 dollars per kWh). Full table found here (table 1b).

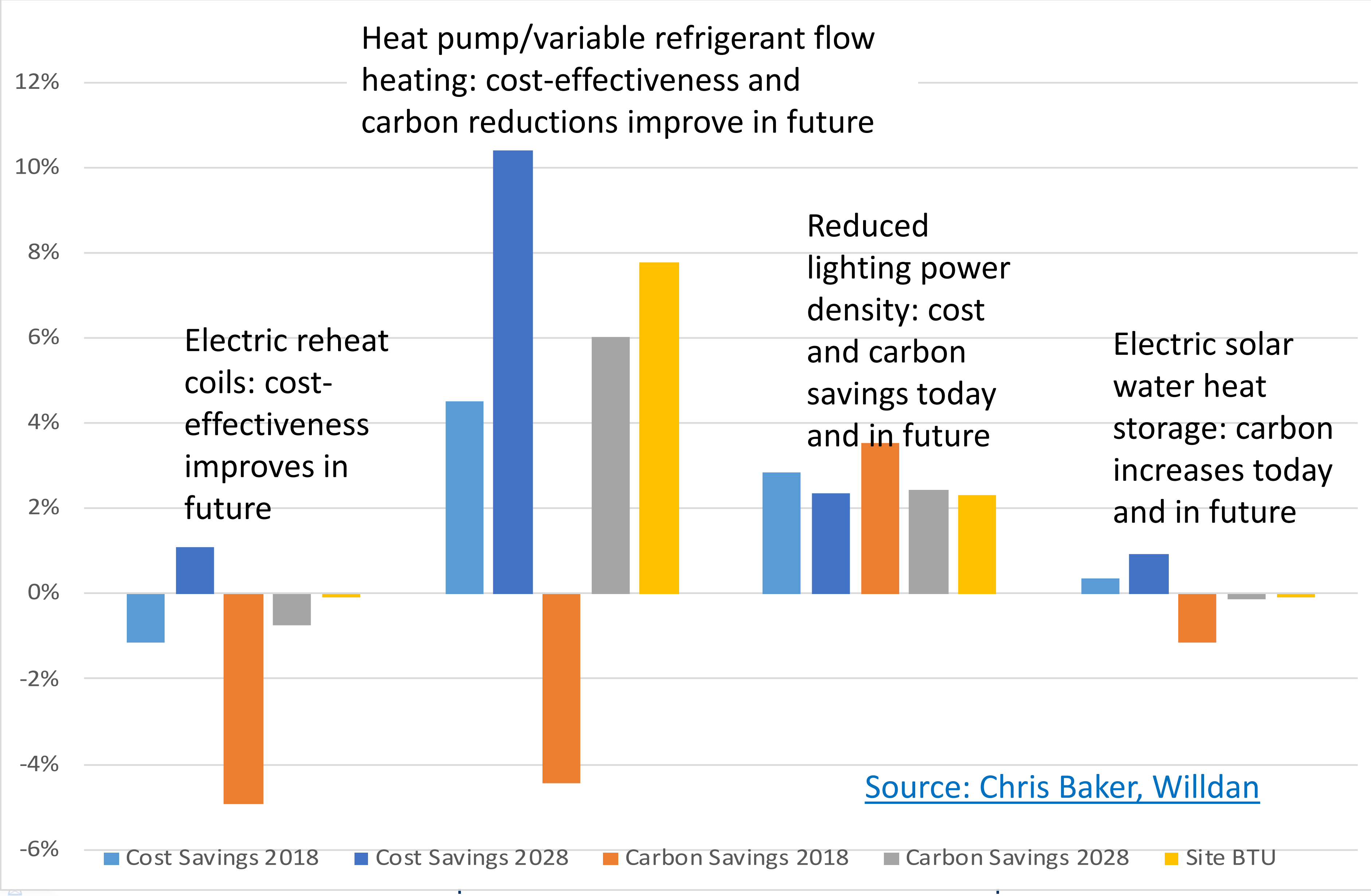
In some cases, efficiency resources do not provide the same services as power generating technologies, making comparisons complex. Adding controls enables active management of efficiency resources, offering additional grid services.

Select *Time-Sensitive Value of Efficiency: Use Cases in Electricity Sector Planning and Programs* Observations

Each of the 5 use cases showcase several examples of how the time-sensitive value of efficiency can be used for more effective planning or programs.

Use Case	Outcomes Enabled by Using the Time-Sensitive Value of Efficiency
Energy efficiency program planning	• Prioritize measures or programs that save energy during high or low demand periods • Inform new program design, or existing program and measure incentive or rebate levels, to achieve efficiency portfolio goals at least cost
Distribution System Planning	• Identify lower-cost non-wires alternatives to traditional distribution system expansion needs • Integrate distributed energy resources
Electricity Resource Planning	• Identify the optimal amount of energy efficiency for a reliable electricity system at least cost (e.g., reduced reserve margins (MW) and system revenue requirements)
Rate Design	• Promote the efficient use of electricity • Create increased value proposition for consumers to install efficiency that lowers energy use during periods of peak demand or high price
State Policy	• Achieve state goals at least cost (e.g., building energy codes) • Inform policy development to align policies with state goals (e.g., energy efficiency resource standards)

Example: Prioritizing efficiency measures



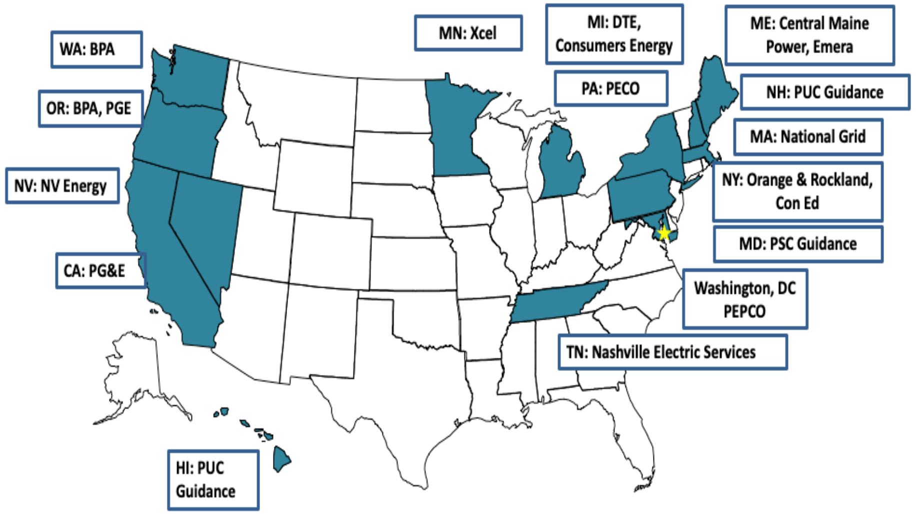
Example: Peak demand reductions from efficiency

As of Q4 2022	Participants	Non-Active Summer Capacity Savings (kW)	Non-Active Winter Capacity Savings (kW)	Active Summer Capacity Savings (kW)	Active Winter Capacity Savings (kW)	Total Summer Capacity Savings (kW)	Total Winter Capacity Savings (kW)
Expand All							
Electric							
Actual	**963,517**	**50,494**	**53,116**	**75,722**	**-**	**126,216**	**53,116**
⊟ Residential	917,618	12,386	13,613	17,985	-	30,371	13,613
⊞ Residential New Buildings	6,194	622	1,617	-	-	622	1,617
⊞ Residential Existing Buildings	911,424	11,764	11,997	17,985	-	29,749	11,997
⊞ Residential Hard-to-Measure	-	-	-	-	-	-	-
⊟ Income Eligible	26,278	2,894	4,480	311	-	3,205	4,480
⊞ Income Eligible Hard-to-Measure	-	-	-	-	-	-	-
⊞ Income Eligible Existing Buildings	26,278	2,894	4,480	311	-	3,205	4,480
⊟ Commercial & Industrial	19,621	35,214	35,022	57,426	-	92,640	35,022
⊞ C&I New Buildings	177	2,657	2,459	-	-	2,657	2,459
⊞ C&I Existing Buildings	19,444	32,557	32,563	57,426	-	89,983	32,563
⊞ C&I Hard-to-Measure	-	-	-	-	-	-	-

Data from Mass Save Data at https://www.masssavedata.com/Public/PerformanceDetails,

Targeted adoption of resources to meet distribution system needs

- Non wires solutions (or non-wires alternatives) are options for meeting distribution system needs related to load growth, reliability and resilience.
    - Single large DER (e.g., battery) or portfolio of DERs that can meet the specified need
  - Objectives: Provide load relief, address voltage issues, reduce interruptions, enhance resilience, or meet local generation needs
- Potential to reduce utility costs
    - Defer or avoid infrastructure upgrades
    - Implement solutions *incrementally,* offering a flexible approach to uncertainty in load growth and potentially avoiding large upfront costs for load that may not show up.



Case studies featured in Berkeley Lab report, *Locational Value of Distributed Energy Resources*

- Typically, the utility issues a competitive solicitation for NWA for specific distribution system needs and compares these bids to planned traditional grid investments to determine the lowest reasonable cost solution.
- Jurisdictions that require NWA consideration include CA, CO, DE, DC, HI, ME, MI, MN, NV, NH, NY and RI. Other states have related proceedings, pilots or studies underway.

Example: Non-wires alternative

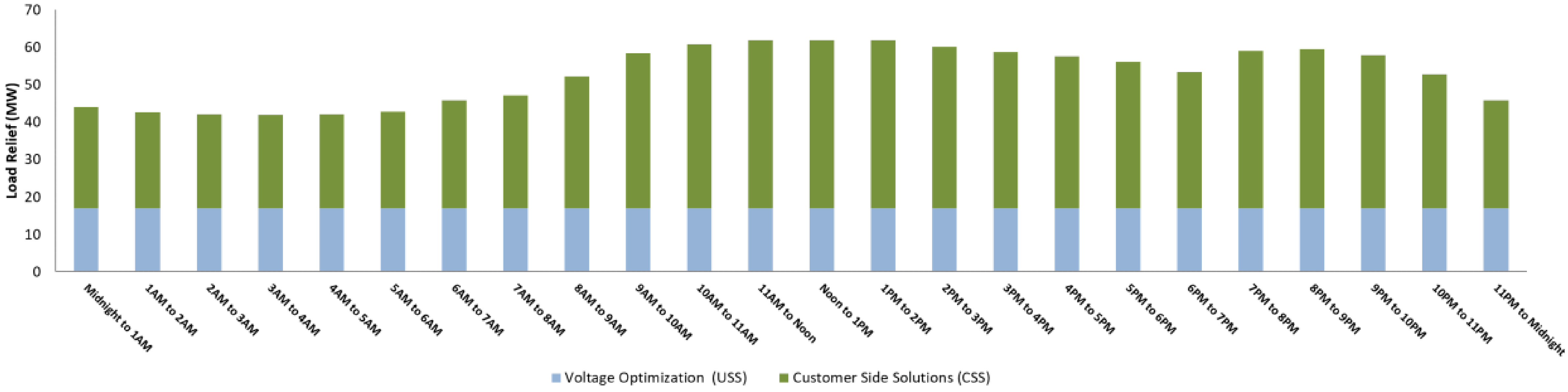
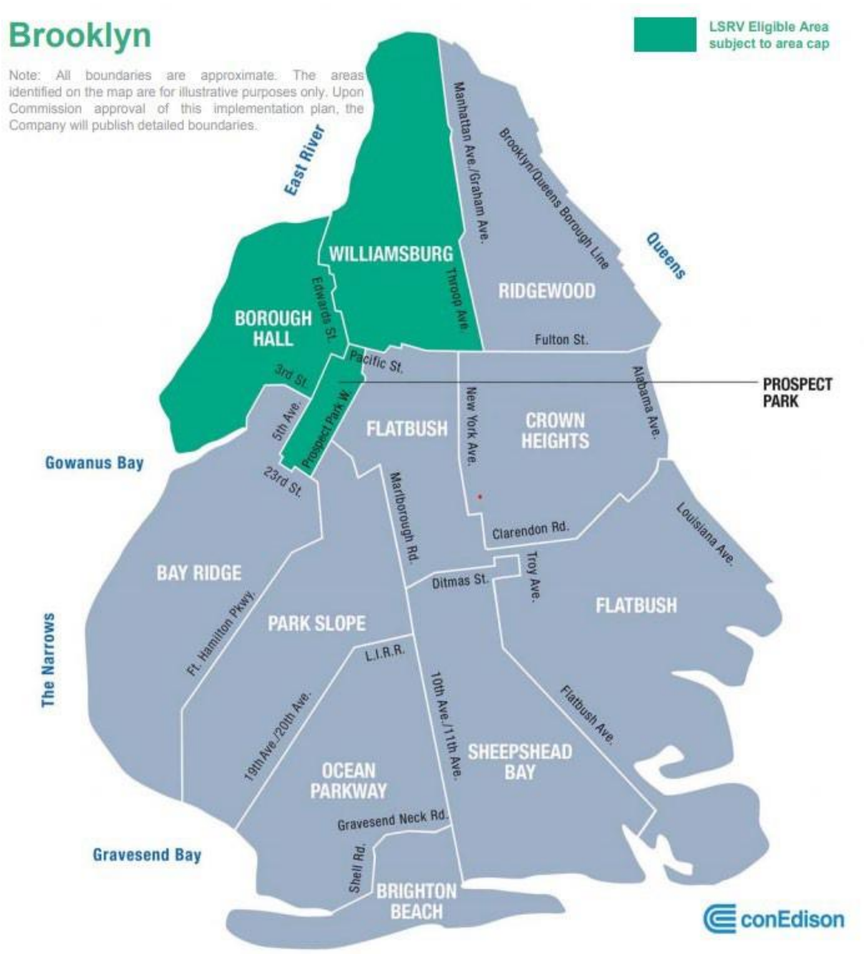


Figure 1: Hourly Load Profile of Operational BQDM Customer-Side Solutions and Non-Traditional Utility-Side Solutions. *Note: A 1.5 MW 4-hour utility-side battery energy storage system is not depicted in the load profile as its dispatch varies.*

Source: [Consolidated Edison]

Example: Locational charges aligned with system needs

- DER payments based on Value of DER
  - New York Value Stack tariff compensates DER based on location, in addition to energy, capacity, environmental and demand reduction values
  - Locational specific relief value (LSRV) zones are identified by each utility
  - Response to event calls in LSRV zones results in additional DER compensation
  - Net energy metering still an option for onsite residential and commercial DG <750 kW



Source: Con Edison LSRV Zone map

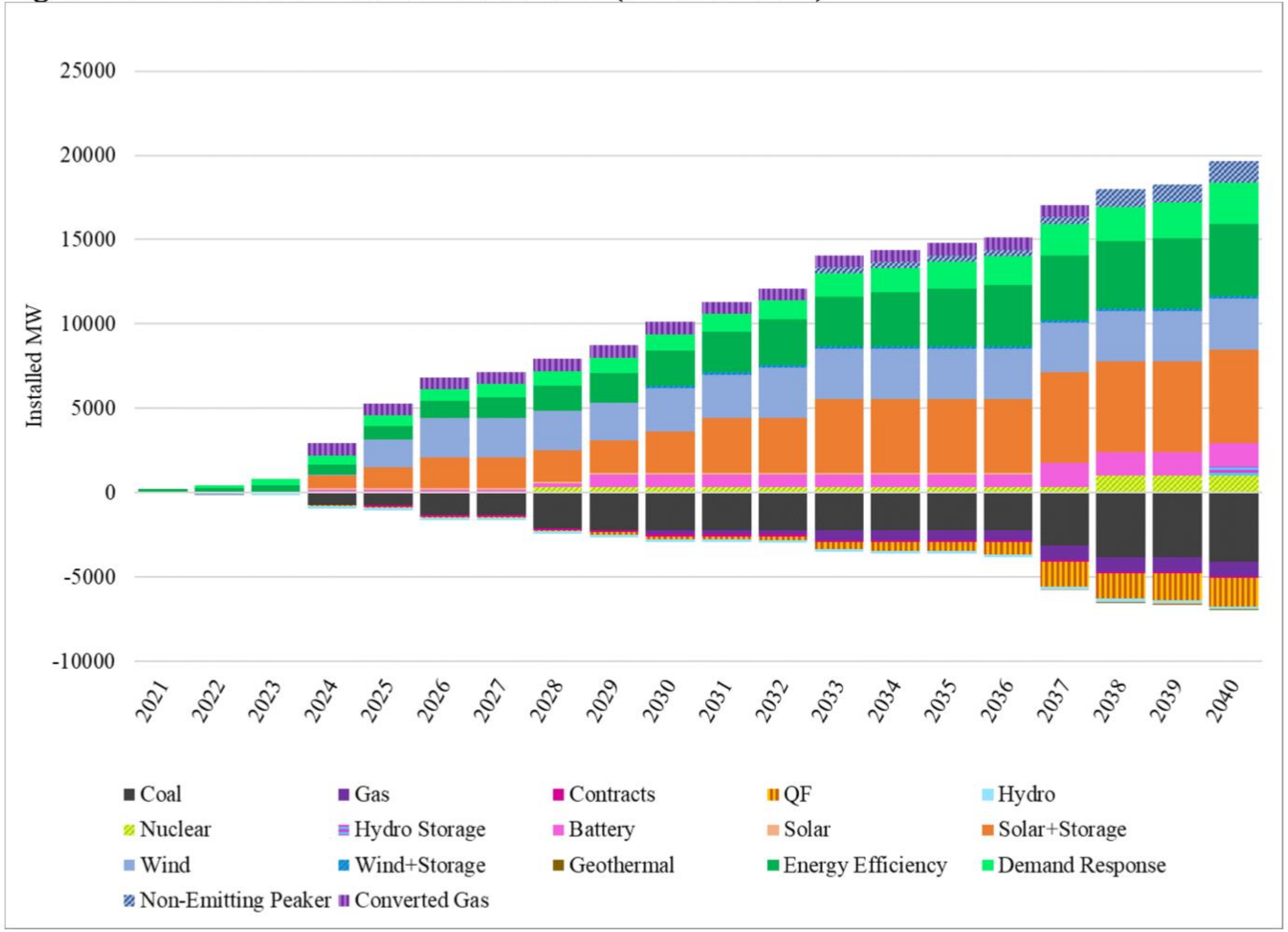
Example: Integrated resource plans and time-sensitive value of efficiency

- Oregon PUC requires modeling EE and DR on a par with other resources (Order 07-047)
- South Carolina (HB 3659, 2019) requires utilities to include EE and DR in IRPs and provide opportunities for customer measures to reduce or manage electricity consumption to reduce utility peak demand and other drivers of electric utility costs
- Hawaii PUC requires demand-side resources to be treated on a consistent and comparable basis with supply-side resources, in part by developing supply curves for EE; modeling supply curves as portfolio options that compete with supply-side options; and explicitly analyzing cost and risk (Order 37419; Order 37730)

Example: Efficiency in a least-cost, least-risk portfolio

"The least-cost, least-risk resource portfolio—defined as the "preferred portfolio"—is the portfolio that can be delivered through specific action items at a reasonable cost and with manageable risks, while considering customer demand for clean energy and ensuring compliance with state and federal regulatory obligations."

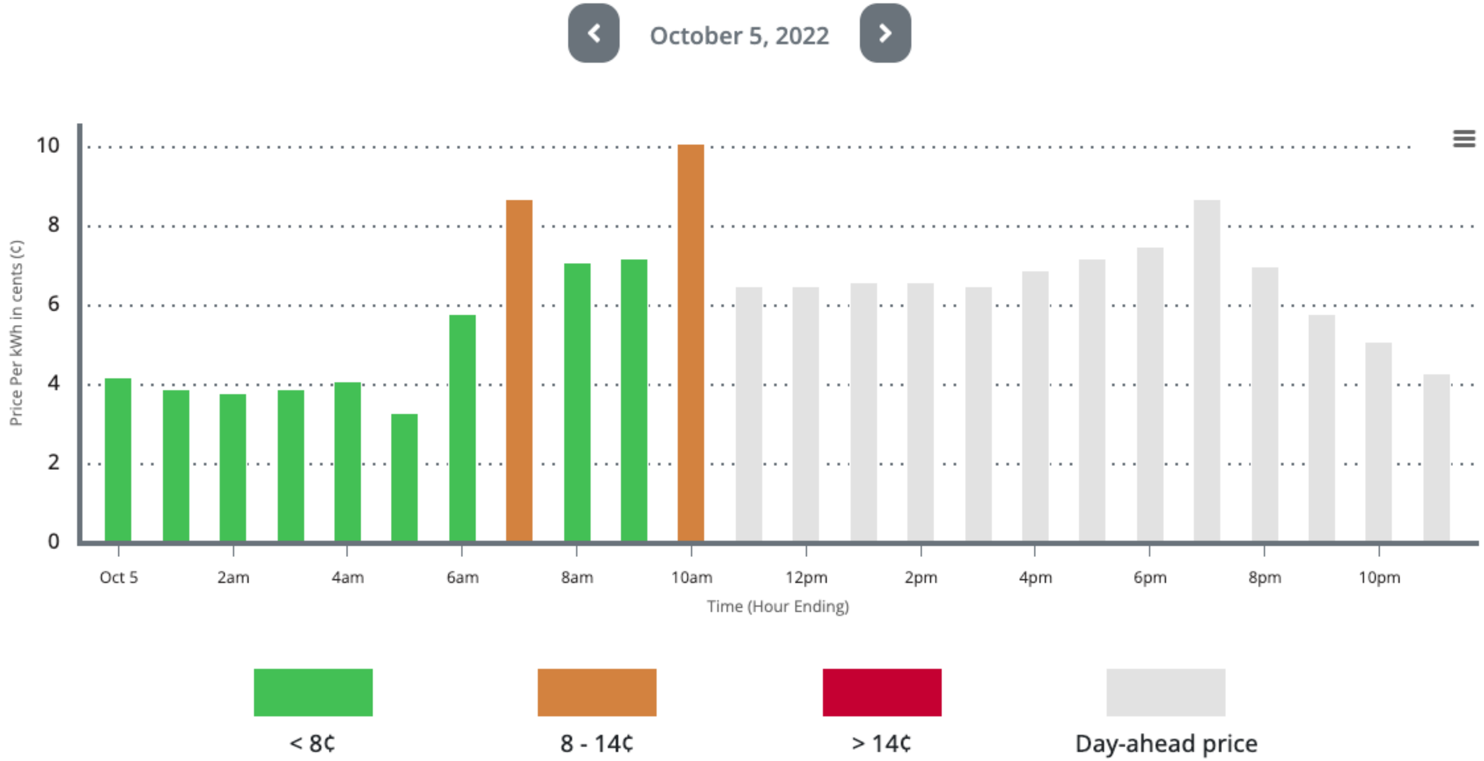
Figure 9.31 – 2021 IRP Preferred Portfolio (All Resources)



Source: [PacifiCorp 2021 IRP]

Example: Rates that are more reflective of hourly electricity system cost

- Commonwealth Edison offers a Residential Real Time Pricing (RRTP) rate.
- On average, customers that participate in it save ~20% on their energy supply costs as compared to Com Ed's fixed price energy supply rate. Source: [ICC Order]



- Participants in the program can see day-ahead and real-time prices through Com Ed's website.
- Participants manage their energy consumption through conservation, energy efficiency investments, shedding and shifting their load.

Source: [Com Ed]

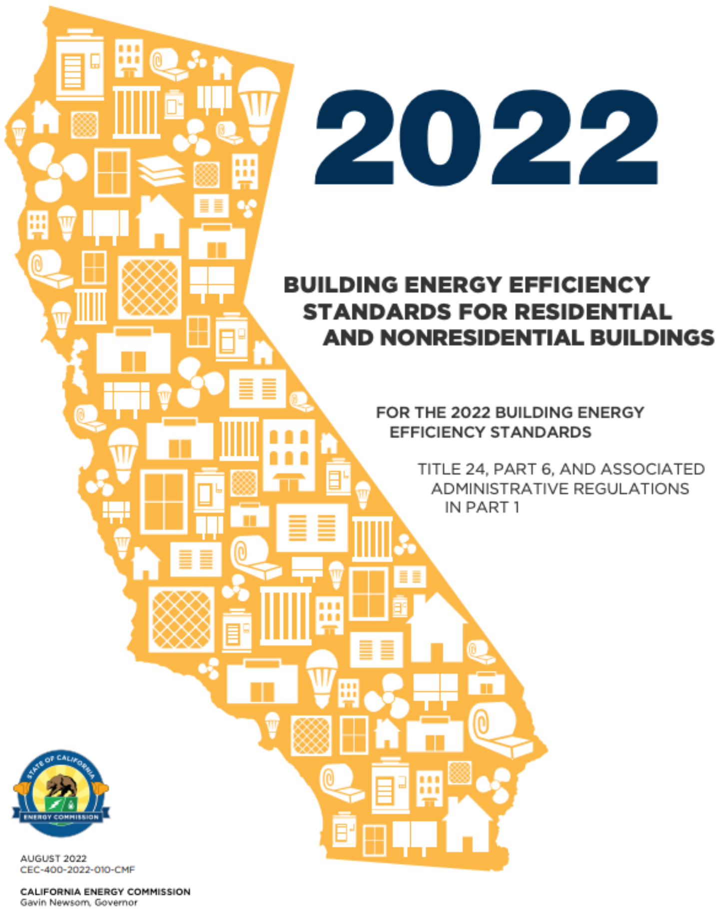
Example: Demand charges aligned with utility system peak

Rate Options for Business Customers				
Rate Option	**Energy Demand**	**Time-Of-Use (TOU) Energy Charge**	**Facilities Related Demand Charge**	**Time-Related Demand Charge (TRD)**
TOU-GS-1-A	20kW or below	$ per kWh	N/A	N/A
TOU-GS-1-B	20kW or below	$ per kWh	Year-round $ per maximum kW during the entire month	June-September $ per kW during On-Peak and Mid-Peak
TOU-GS-2-A	Between 20kW and 200kW	$ per kWh	Year-round $ per maximum kW during the entire month	N/A
TOU-GS-2-B	Between 20kW and 200kW	$ per kWh	Year-round $ per maximum kW during the entire month	June-September $ per kW during On-Peak and Mid-Peak

Source: SCE

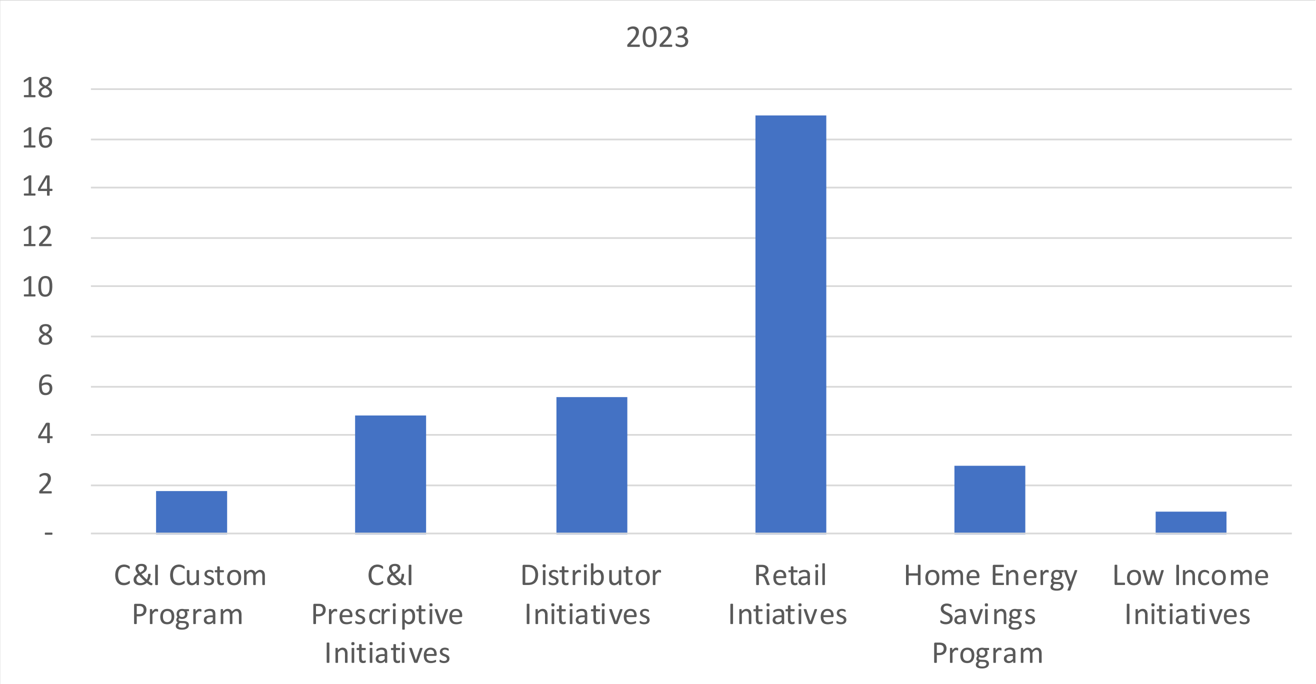
Example: Code values EE measures based on when savings occur

- California's Title 24 building energy code includes a Time Dependent Valuation (TDV) compliance metric (section 100.2).



Example: Energy efficiency resource standards include peak demand target

- Colorado (HB 1227, 2017) required the Public Utilities Commission (PUC) to set goals for DSM programs to achieve ≥5% peak demand reduction from 2019-2028, compared to a 2018 baseline
- Efficiency Maine is required to reduce "peak-load demand for electricity by the maximum achievable cost-effective amount" (MRS 35-A §10104 (4)).



Efficiency Maine Summer Peak Electric Load Reduction (MW)

Time-sensitive value of efficiency

Time-Sensitive Value Calculator

- Time-sensitive value of energy considers when energy is used and its economic value to the electricity system at that time.

- The Time-Sensitive Value Calculator is a publicly-available, free tool that estimates the value of measures using hourly electricity system cost estimates.
- The Calculator takes hourly profiles of up to six measures and monetizes their value for five hourly value streams and one annual value stream, producing outputs in tabular and graphical formats.
- The Calculator was designed for public utility commissions, state energy offices, utilities and stakeholders to estimate the value of measures under future electricity system conditions.

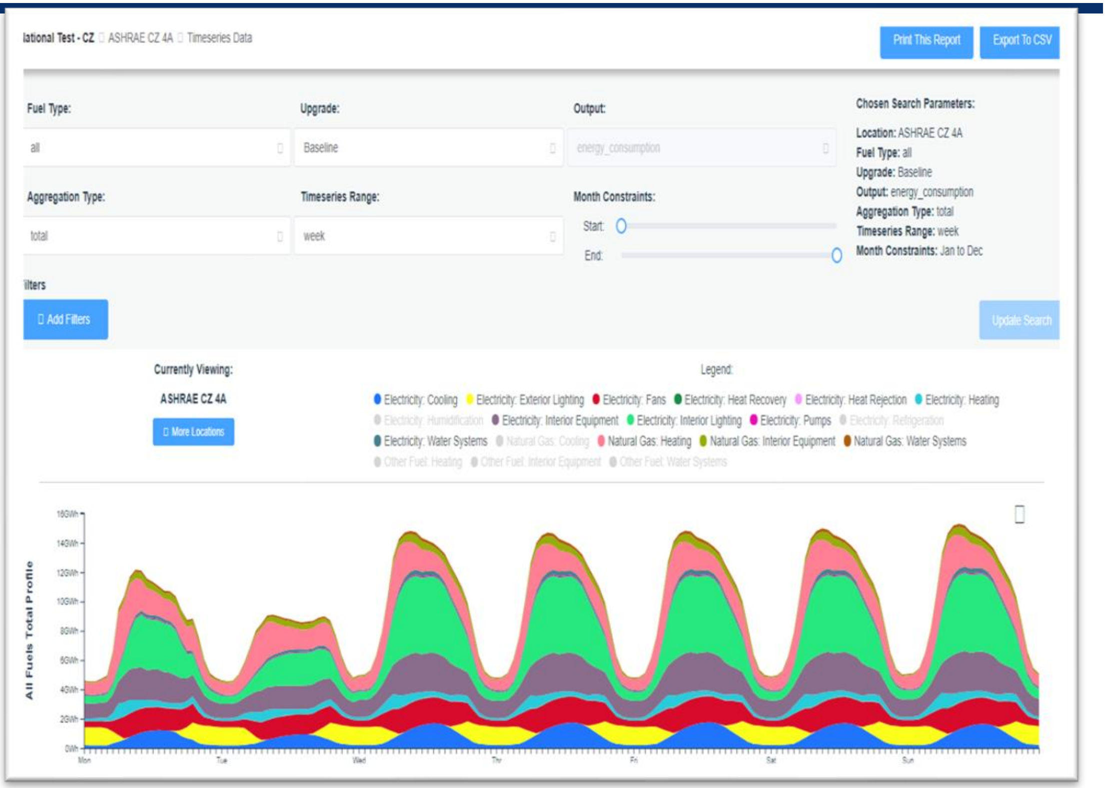
Conceptual overview

Value Streams

- Avoided Electric Energy
- Deferred Electric Generation Capacity
- Deferred Electric Transmission Capacity
- Deferred Electric Distribution Capacity
- Avoided CO2 Emissions
- System Risk Mitigation (annual)

Measures

- Can be consumption, savings, generation
- Hourly shapes – can come from end use load profiles
- Lifetimes



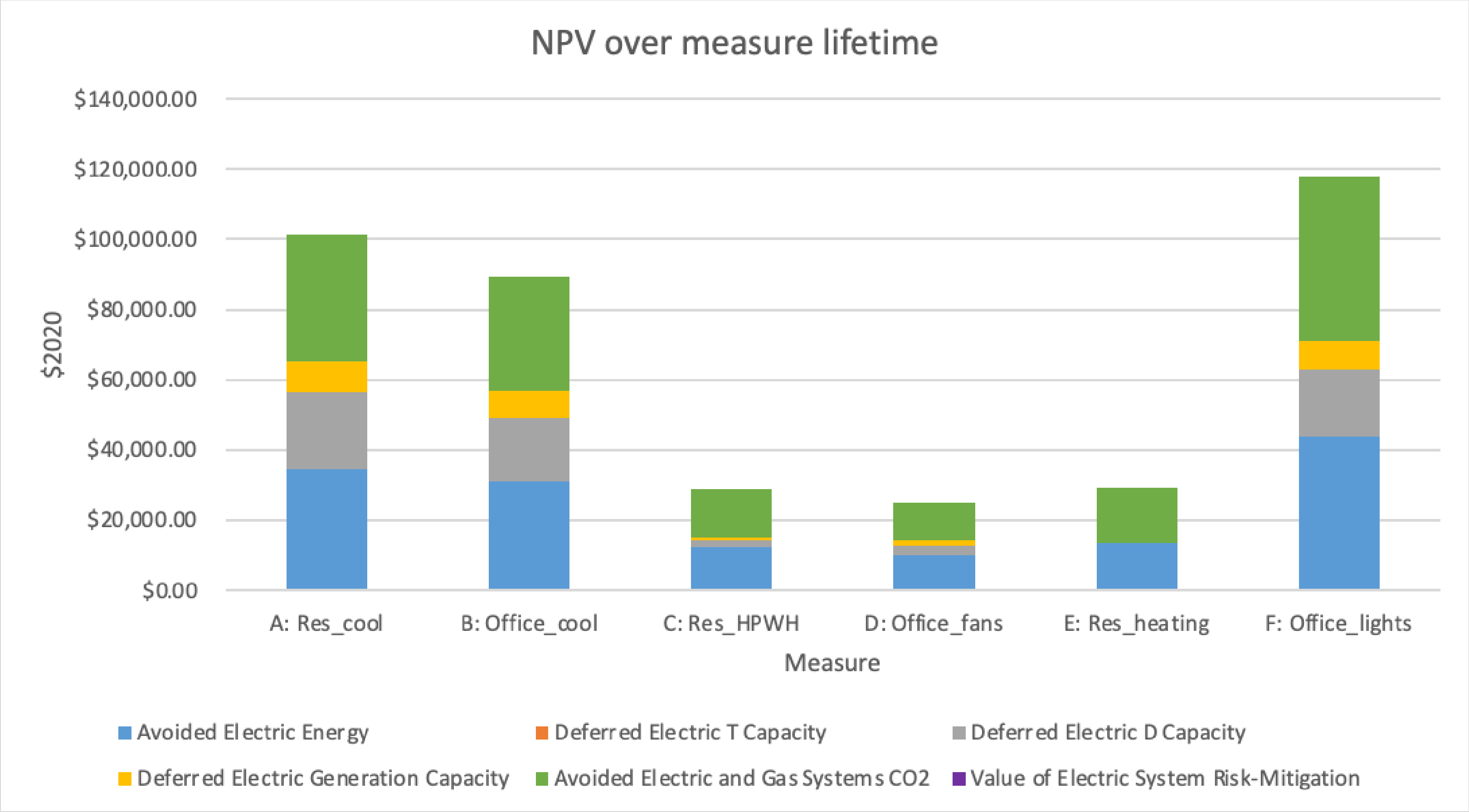
Source: [Residential and Commercial End-Use Load Profiles]

The Calculator file does not contain inputs – the user can enter any hourly costs or measure shapes that are useful. For example, the costs could represent an electricity system with an increasing penetration of renewables.

Calculator features

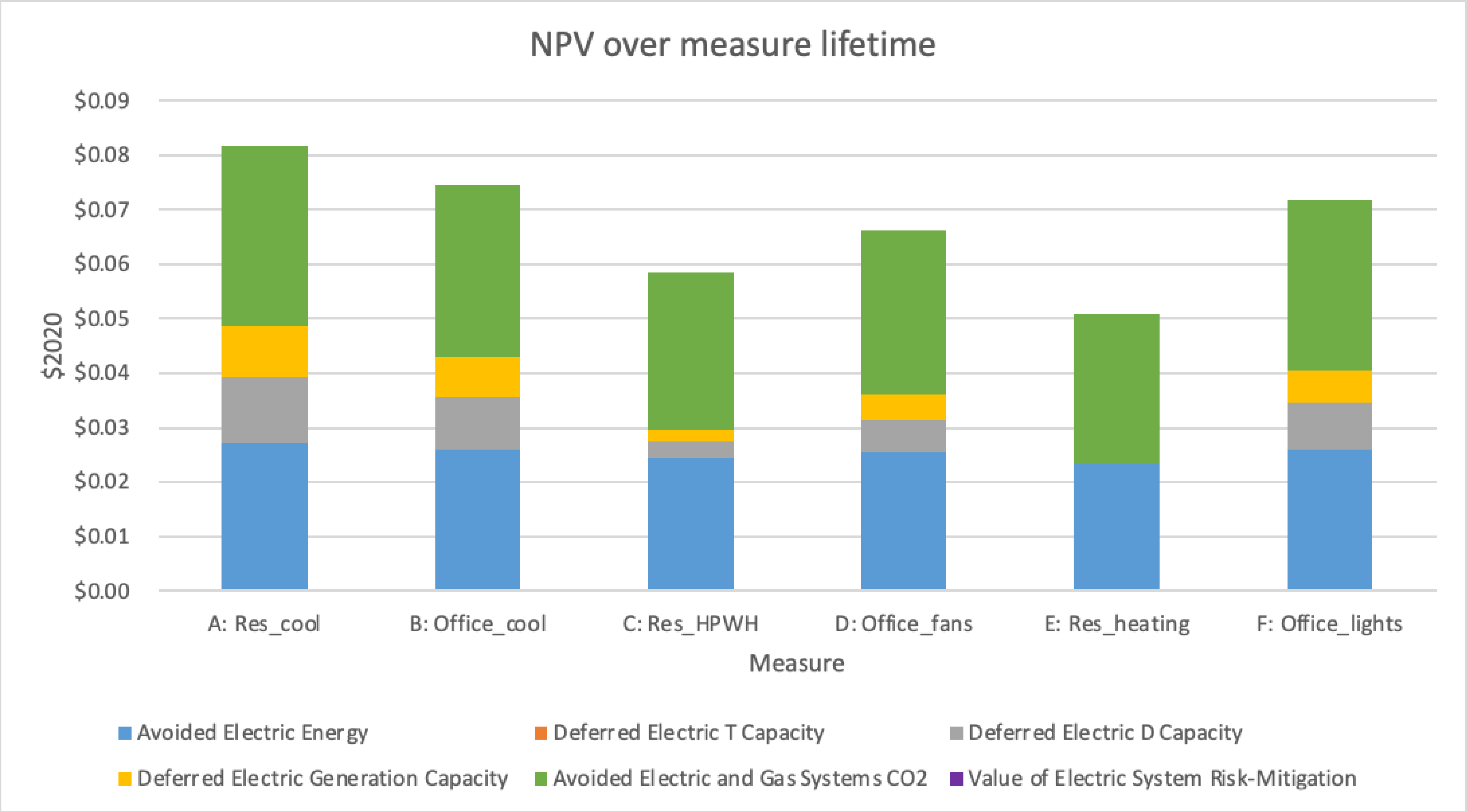
- At a high level, the Calculator monetizes one year of a measure shape by multiplying each hour's demand by the corresponding hour's cost from each hourly value stream and then applying the annual factors. It does this for each of the eight analysis years chosen by the user and then estimates the net present value (NPV) of the total value of each measure over its lifetime.
- Users can select years with different generation mixes and avoided costs to compare the value of measures in diverse resource portfolios. Users can also include or exclude avoided cost values to compare the value of a measure with and without inputs (e.g., avoided cost of carbon).
- The Calculator can create a variety of results. We focus on two of them here, and in the user manual.
  1. Comparison of the value of savings from different measure shapes and impact, taking into consideration the life of the measure – *Shape+*
  2. Comparison of the value of savings from different measure shapes by isolating the timing of the measure impact – *Shape Only*

Example of Shape+ analysis



Measure	Savings (kWh/year)	Measure lifetime (years)
A: Residential cooling	100,000	17
B: Office cooling	100,000	15
C: Residential heat pump water heater	50,000	13
D: Office fans	50,000	9
E: Residential heating	50,000	17
F: Office lights	150,000	15

Example of Shape Only analysis



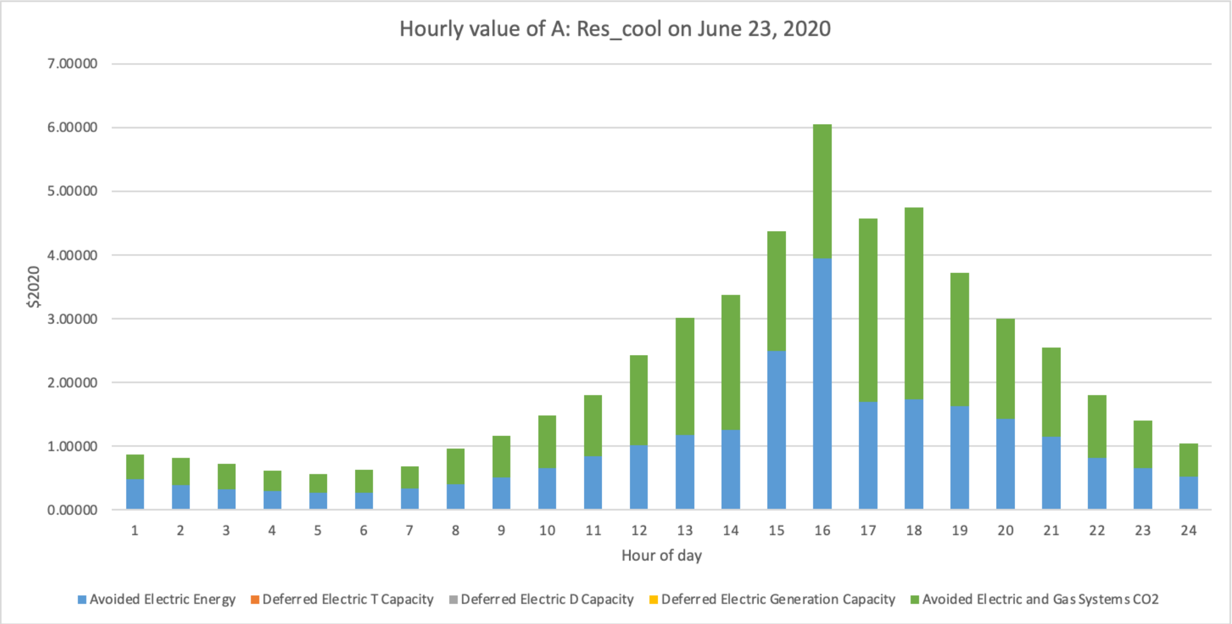
Measure	Savings (kWh/year)	Measure lifetime (years)
A: Residential cooling	1	1
B: Office cooling	1	1
C: Residential heat pump water heater	1	1
D: Office fans	1	1
E: Residential heating	1	1
F: Office lights	1	1

Calculator Demo Results – Savings for a Specific Date

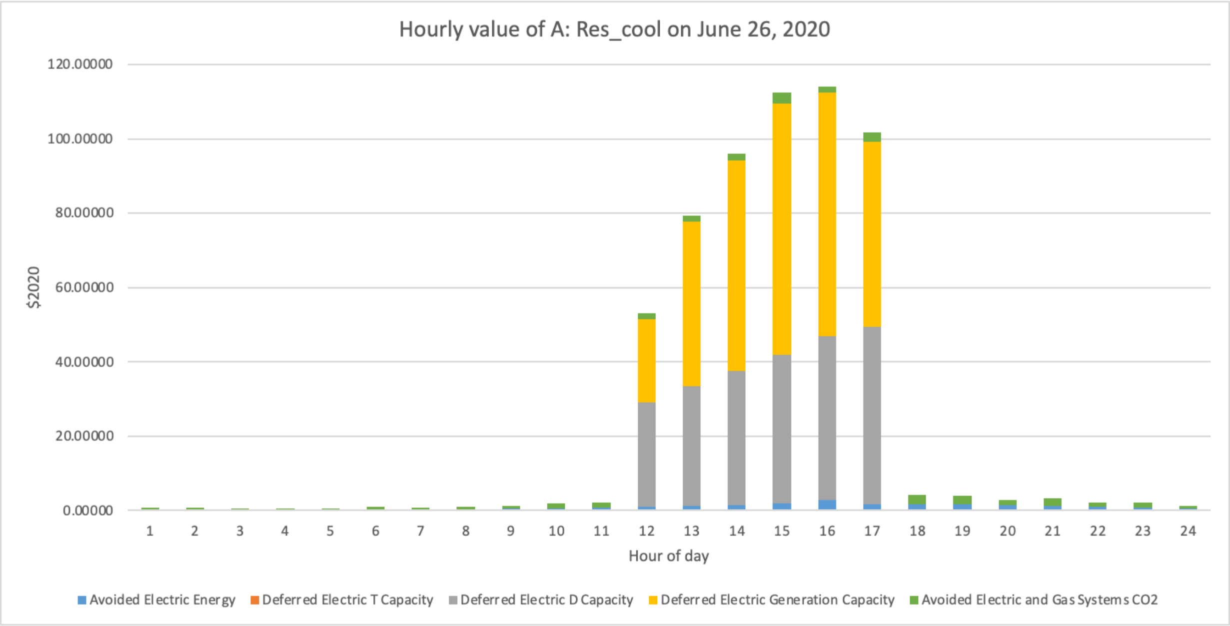
Savings for a specific day/month/year

	Start
Year	2020
Month	June
Day	23
Measure	A: Res_cool

Refresh this chart



Results are also provided in a table format



Calculator Demo Results – Hourly System Shape for a Specific Day

Shapes for a specific day/month/year		
	Start	End
Year	2030	
Month	November	
Day	24	

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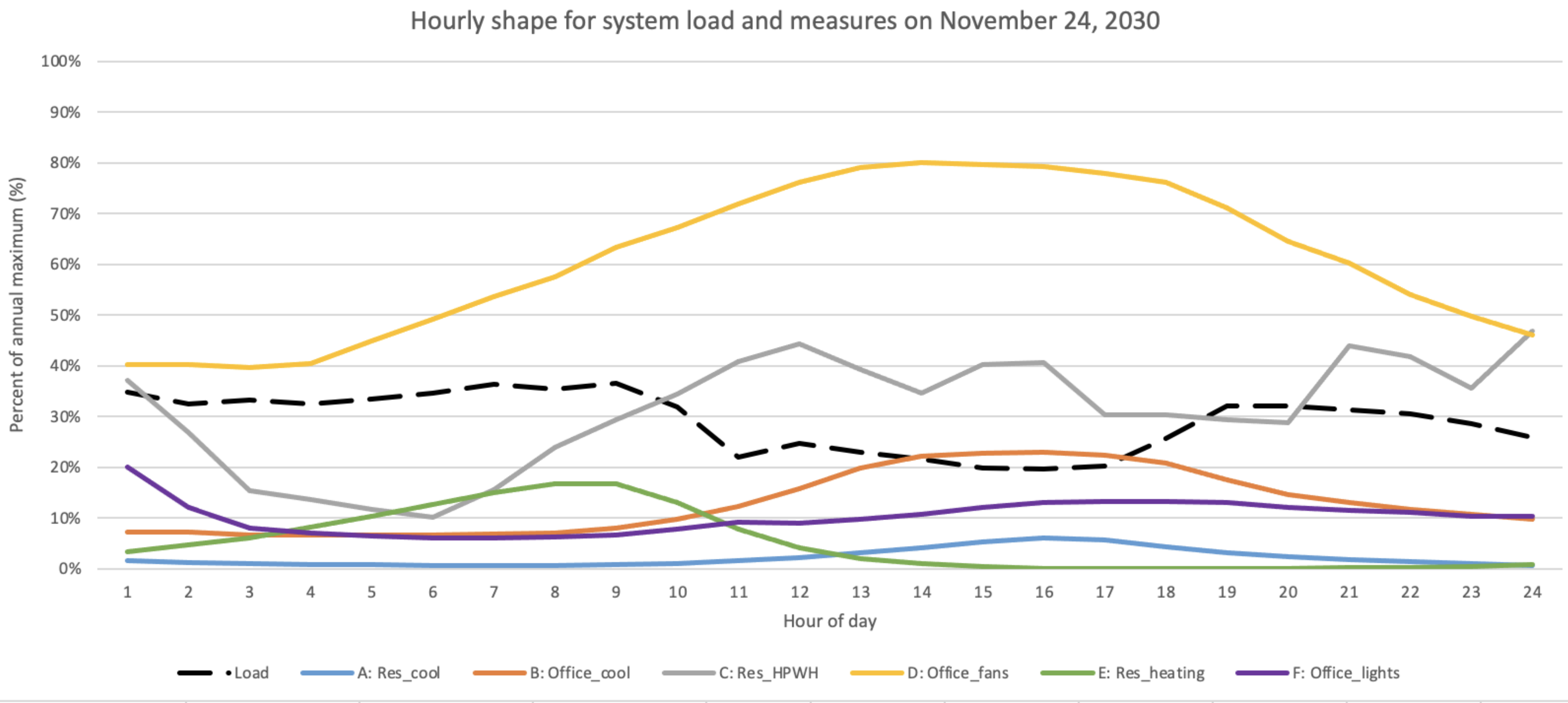
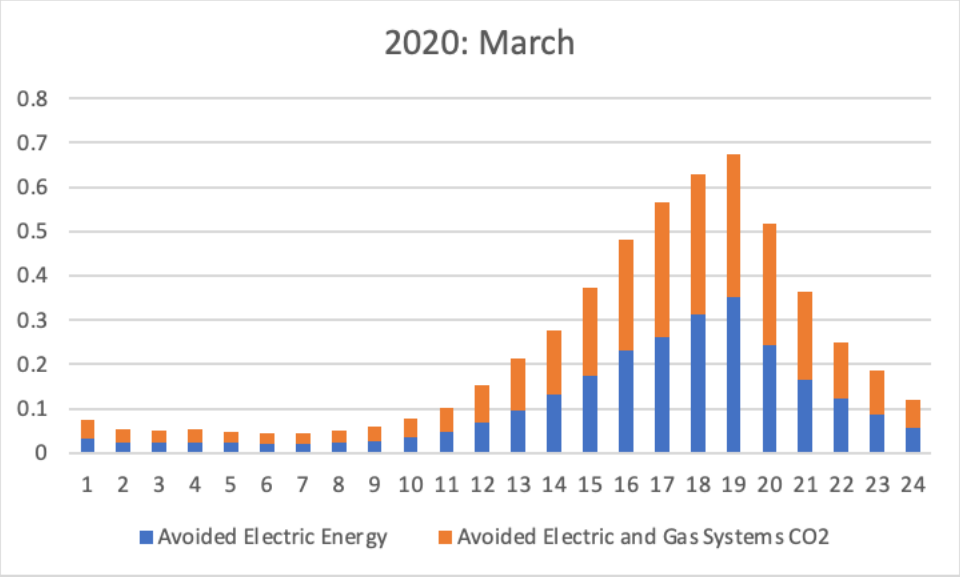
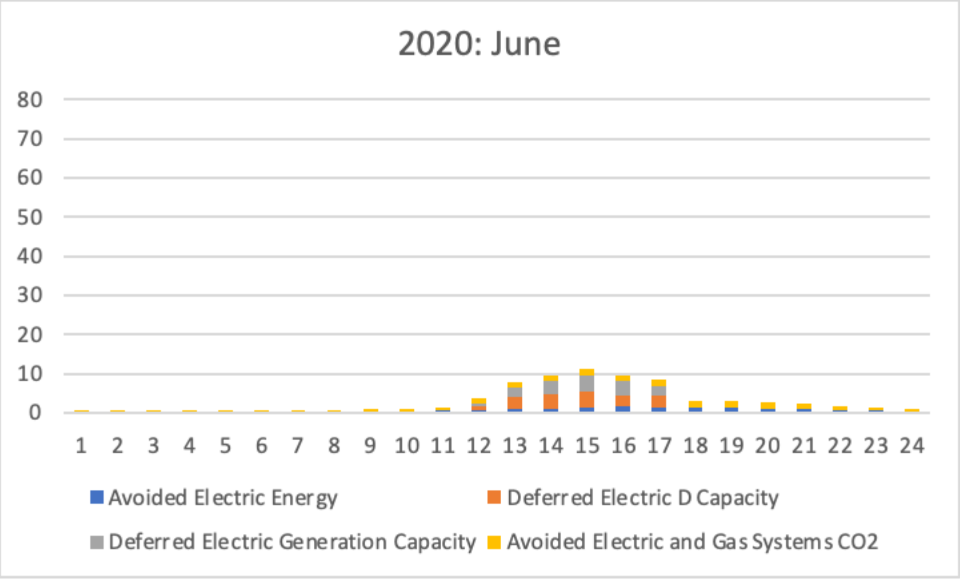
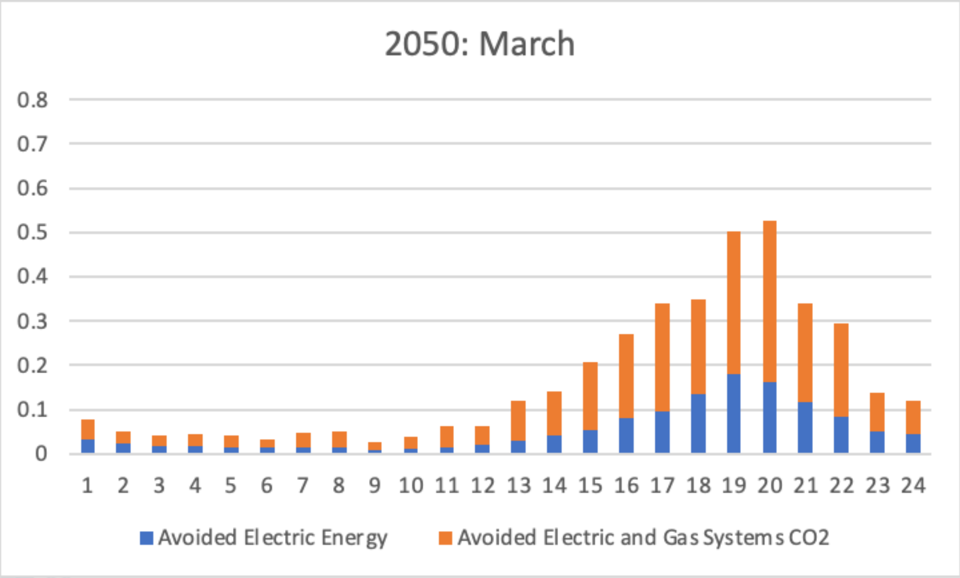
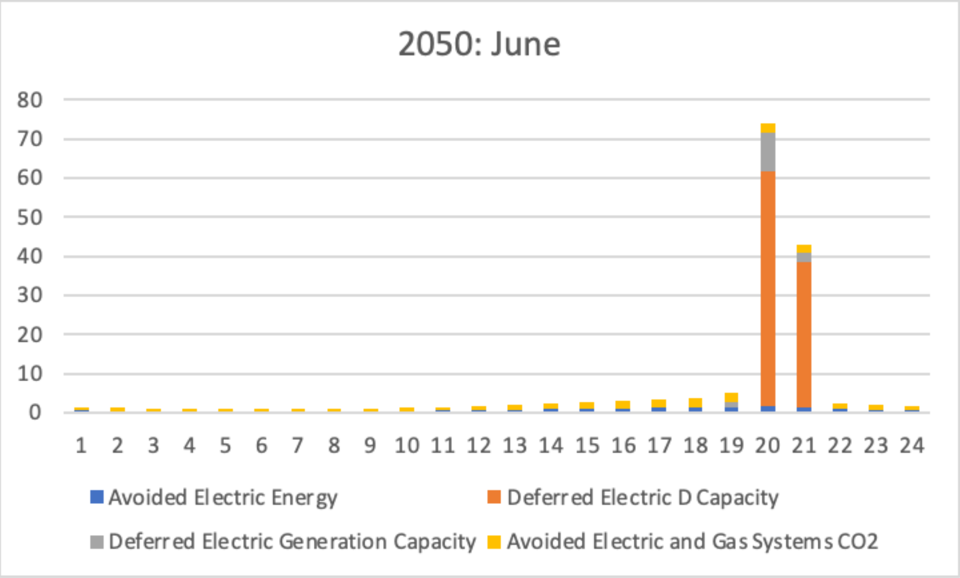


Use Case: Texas Residential Cooling Value Over Time









Select Resources

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

Margaret Pigman, Natalie Mims Frick, Eric Wilson, Andrew Parker and Elaina Present. 2022. End-Use Load Profiles for the U.S. Building Stock: Practical Guidance on Accessing and Using the Data.

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. Methods to Incorporate Energy Efficiency in Electricity System Planning and Markets.

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

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

Alan Cooke, Juliet Homer, Lisa Schwartz, *Distribution System Planning – State Examples by Topic*, Pacific Northwest National Laboratory and Berkeley Lab

Juliet Homer, Alan Cooke, Lisa Schwartz, Greg Leventis, Francisco Flores-Espino and Michael Coddington, *State Engagement in Electric Distribution Planning*, Pacific Northwest National Laboratory, Berkeley Lab and National Renewable Energy Laboratory

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

U.S. Department of Energy's (DOE) Modern Distribution Grid guides

Regional distribution system planning trainings for PUCs and state energy offices: Southeast, New England, MISO footprint, West, Mid-Atlantic

Berkeley Lab's Future Electric Utility Regulation reports

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

Upper Midwest Integrated Resource Plan 2020-2034, Xcel Energy, Docket No. E002/RP-19-368, 2019. Appendix G1: The Potential for Load Flexibility in Xcel Energy's Northern States Power Service Territory

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