Title

Consumer Impacts of A Clean Energy: Energy Efficiency

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Consumer Benefits of Clean Energy: Energy Efficiency

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This paper is an overview of a series reports on **Consumer Benefits of Clean Energy.**

Clean energy offers many benefits to consumers, including reducing consumers' electricity bills, lowering total electricity system costs, and providing health and resilience benefits. States can accelerate consumers' access to these benefits with policies that support energy efficiency, demand flexibility, renewable energy and storage. Berkeley Lab developed a series of briefs that explore these consumer benefits of clean energy, and identify actions states can take to promote them.

1. ***Contribute to a least-cost electricity system*** by using low-cost resources such as end-use efficiency, demand flexibility, behind-the-meter solar PV and storage, and utility-scale renewable energy.
2. ***Greenhouse gas emissions reductions and improved outdoor air quality*** from consumers shifting their home energy consumption from direct combustion of natural gas to efficient electric appliances, taking into account increased electricity generation due to demand growth.
3. ***Improved resilience*** of homes to grid outages due to installation of BTM solar PV coupled with storage.

Together, these briefs highlight how investments in clean energy technologies can provide benefits to all electricity system customers – not just those who invest in these technologies for their homes. The series also outlines options that state policymakers can pursue to facilitate the beneficial outcomes discussed.

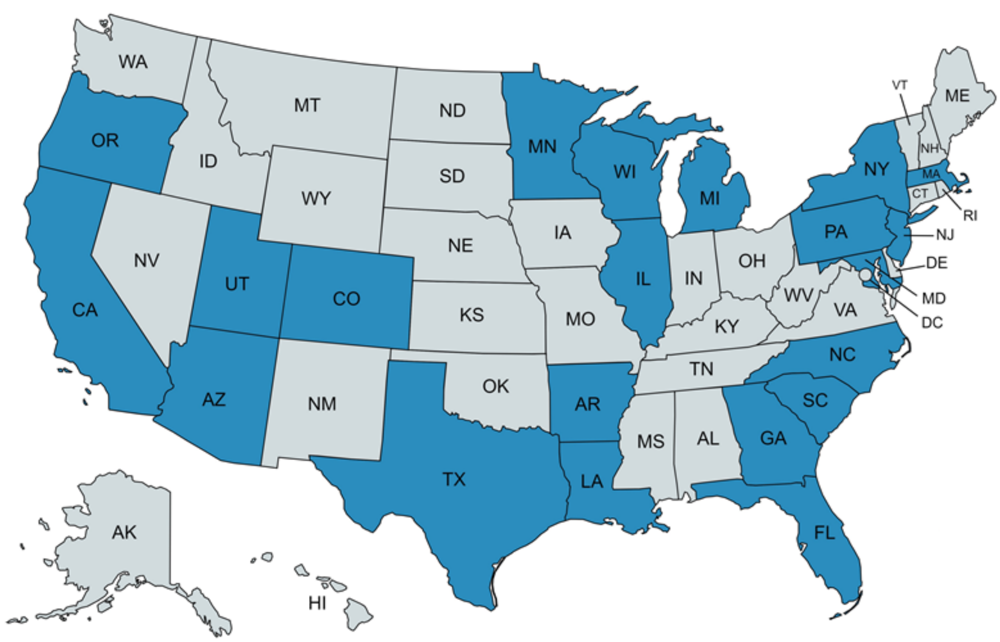
Download the reports here.

This brief builds on prior analysis from Berkeley Lab's Cost of Saved Energy database. We show that energy efficiency remains a low-cost energy and capacity resource; the levelized cost of saving energy for the programs included in the analysis is $0.02/kilowatt-hour and the cost of saving peak demand is less $120/kilowatt. Understanding the impact of the program mix, portfolio size, and duration of implementation for customer-funded energy efficiency portfolios can guide regulatory oversight of these programs, help utilities better utilize energy efficiency as a resource, and inform building energy decarbonization policies. The brief concludes with actions states can take to capture consumer benefits of clean energy.

Energy efficiency can reduce both annual energy consumption and peak demand for electric power systems, and there is increased interest in the ability of efficiency to reduce peak demand. This interest is driven by: (1) state-level policy drivers, (2) design of centrally organized wholesale energy and capacity markets, and (3) adoption of distributed energy resources and their impact on distribution system needs, as well as on the bulk power system. With the increasing need for a more flexible and resilient electricity system, as well as changing generation costs, utilities and other efficiency program administrators must account for all the characteristics of efficiency programs — including peak demand reduction — to ensure a reliable system at the most affordable cost.

In this study, we collected data on costs, energy savings, and peak demand savings for electricity efficiency programs from 64 investor-owned utilities and other program administrators in 21 states for 2021 (Figure 1). We selected a single year for the analysis due to the anomalies that COVID-19 created in the 2020 data, recognizing that some of the program implementation impacts may have carried into 2021. Prior work by Berkeley Lab[1] explores the cost of saved energy and peak demand from 2009-2018 (Frick et al 2021a). As in our prior analysis, we characterize the cost of saved electricity (CSE) and peak demand (CSPD) from the economic perspective of a utility (program administrator) by amortizing the cost of the efficiency programs over the expected lifetime of the installed measures. Together, these program administrators account for 36% of U.S retail electricity sales (Energy Information Administration 2021). The electricity savings values we use in this analysis are ex-ante estimates of gross savings claimed by program administrators. They do not include the results of any evaluation, measurement, and verification activities that occur following the initial claims.

The program administrator CSE and CSPD are each calculated based on the costs incurred by program administrators for individual programs. This means the results cannot be combined because it would double the program cost. Each metric must be considered separately. This *levelized* cost of electricity and peak demand allows us to compare the cost energy efficiency program investments to those of generation assets.



¹ Berkeley Lab's cost of saved energy work is available at: https://emp.lbl.gov/projects/what-it-costs-save-energy

Figure 1. States with energy efficiency program administrators included in analysis

Approach

We used the same approach to calculating the CSE (Equation 1) and CSPD (Equation 2) as in previous Berkeley Lab research (Frick et al 2021a). We used a 6 percent real discount rate as an approximation of the weighted-average cost of capital for an investor-owned electric utility.[2] We adjusted to 2022 dollars program spending that was reported in nominal dollars. We used gross savings to calculate the program administrator CSE and CSPD, primarily because net savings are not universally reported or uniformly defined.[3] As in previous Berkeley Lab CSE and CSPD reports, when we reported the CSE and CSPD at the portfolio level, we included costs of cross-cutting programs (e.g., spending in such areas as market research and planning, and programs that reported costs but not savings).

Equation 1:

Program Administrator Levelized Cost of Saving Electricity =

$$\frac{\textit{Capital Recovery Factor} * \textit{Program Administrator Costs}}{\textit{Annual Electricity Savings (in kWh)}}$$

where the Capital Recovery Factor (CRF) is:

$$CRF = \frac{r(1+r)^N}{(1+r)^N - 1}.$$

and

r = the discount rate

N = estimated program lifetime in years and calculated as the savings-weighted lifetime of measures or actions installed by participating customers in a program.

We also calculated the lifetime levelized program administrator CSPD in constant 2022 dollars per kilowatt saved (Equation 2). The CSPD for efficiency is the cost of achieving peak demand savings in the over the expected lifetime of the peak demand savings.

Equation 2:

Program Administrator Levelized Cost of Saving Peak Demand =

*Capital Recovery Factor * Program Administrator Costs ($)*

[2] We use a real discount rate because inflation already is accounted for in the use of constant dollars (2022$). Our real discount rate is a proxy for a nominal rate in the range of 7.5 to 9 percent, typical values for a utility weighted-average cost of capital (WACC). A utility WACC is the average of the cost of payments on the utility's debt (bonds) and its equity (stock), weighted by the relative share of each in the utility's funds available for capital investment. The utility WACC is often used by investor-owned utilities in their economic screening of efficiency programs.

[3] In addition, inconsistencies in defining and estimating net savings add more uncertainty to those already embedded in estimates of energy savings and peak demand impacts. See Billingsley et al. (2014) and Goldman et al. (2018) for a more in-depth discussion of our rationale for using gross savings estimates.

Annual Peak Demand Savings (kW)

Results

The savings-weighted, levelized average CSE is $0.021/kilowatt-hours (kWh), and CSPD is $120/kW. Across the 21 states included in this study, the levelized CSE ranges from $0.01 to $0.11, and the levelized CSPD values range from ~$50/kW to ~$1300/kW . In Figure 2, we show the levelized CSE and CSPD by market sector and Census region in 2022 dollars. The levelized CSE and CSPD varies more between market sectors than between Census regions. In particular, programs that serve residential and commercial and industrial (C&I) customers have similar CSE and CSPD.

In contrast, the cost of low-income programs is much higher due to program designs that often cover the full cost of energy efficiency measures. Additionally, cross-cutting programs, which serve multiple market sectors, have the lowest cost, largely as a result of codes and standards programs that operate in California. These programs also drive down the cost of saved electricity and peak demand in the West. Differences in labor costs and program scale may also explain the observed regional variation (Murphy and Frick 2023).

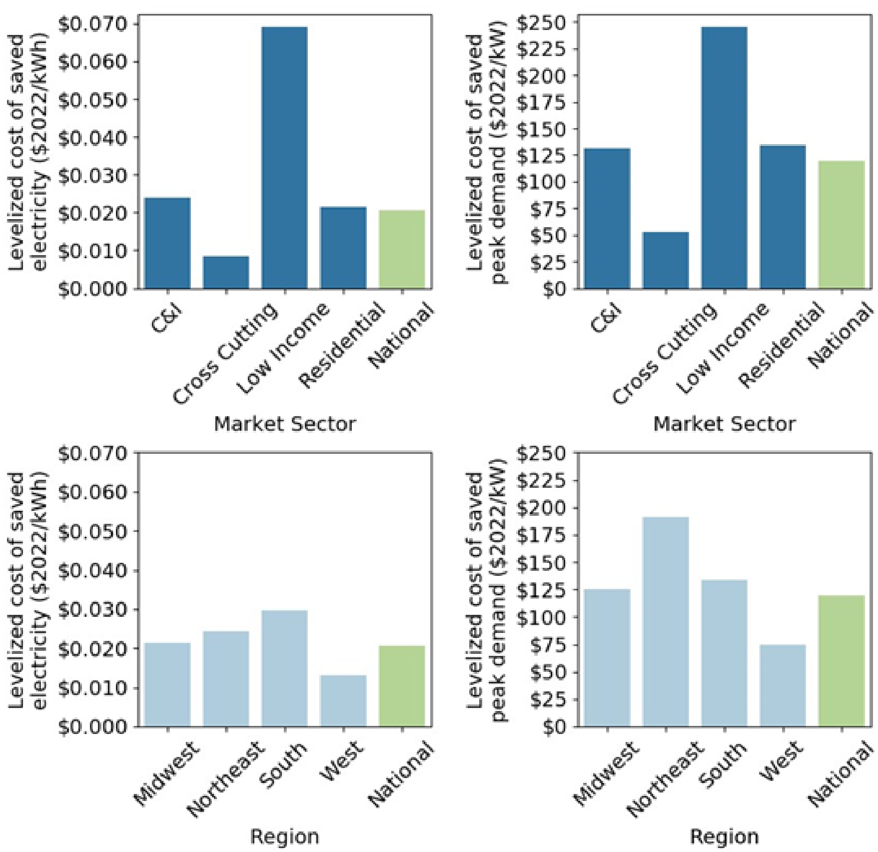


Figure 2. Cost of saved electricity and peak demand by market sector and Census region

Due in part to the codes and standards programs and low-cost residential and commercial energy efficiency programs, program administrators acquired slightly more than half of their 2021 annual energy savings and peak demand reductions for less than $0.015/kWh and $90/kW respectively. While some programs do provide energy and demand reduction at much higher costs, they comprise a small share of energy efficiency portfolios. Three program types accounted for 44% of reported annual electricity savings and 40% of reported annual peak demand savings in 2021: codes and standards, C&I custom, and residential lighting.

When compared to electricity generation, these energy efficiency programs stand out as a least-cost resource. About 80% of energy savings and demand reductions cost less than $0.035/kWh and $150/kW (Figure 3) which is less than the lowest levelized generation costs reported by Lazard ($27/MWh utility onshore wind, Figure 4).

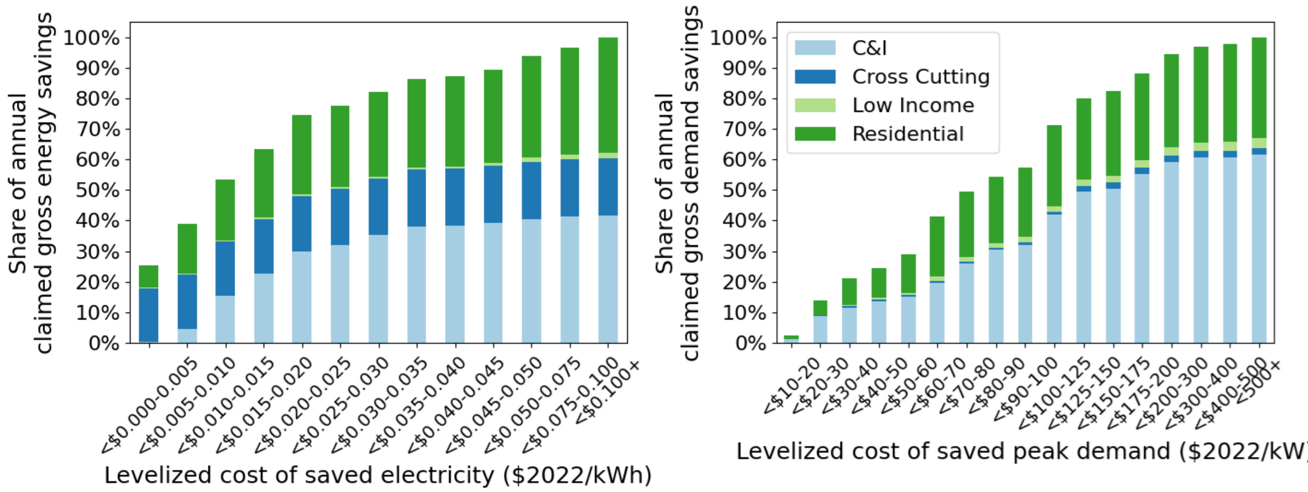


Figure 3. Levelized CSE and CSPD

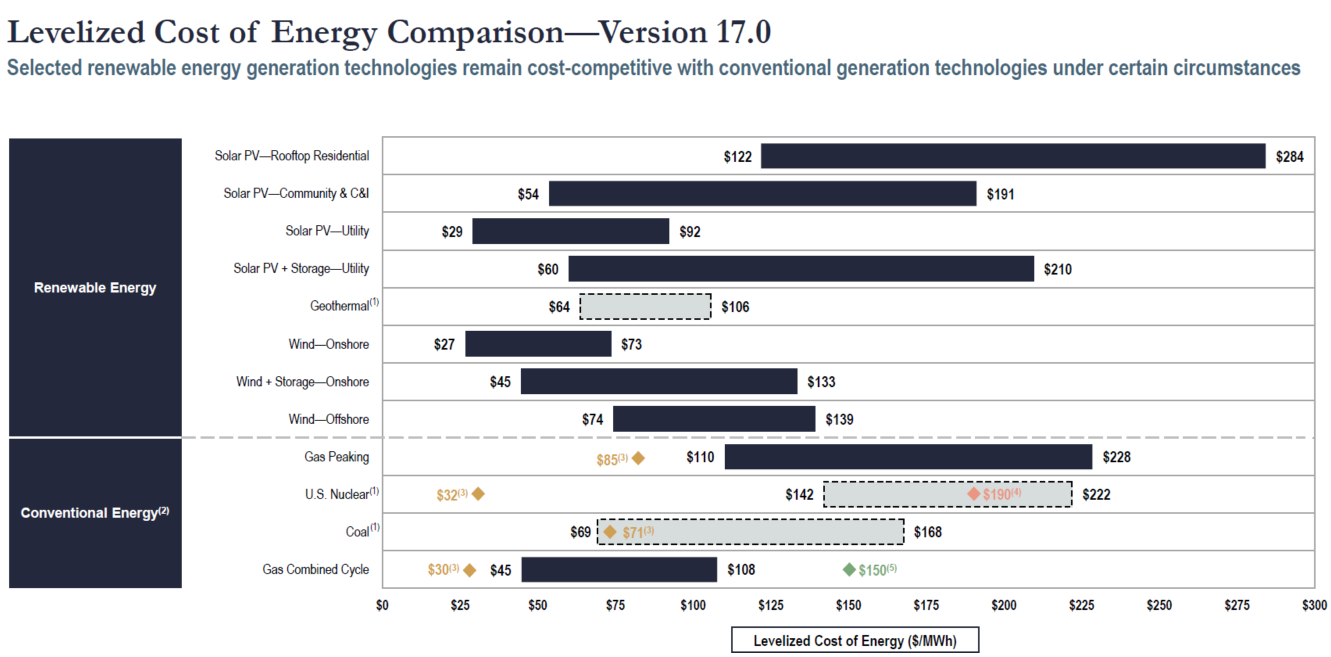


Figure 4. Levelized Cost of Energy (Lazard 2024).

State Actions to Promote Energy Efficiency

Energy efficiency can generate benefit for all electricity customers by reducing energy usage and peak demand. In many states, utilities conduct bulk power system planning to identify an optimal portfolio of resources to meet future electricity needs and policy and regulatory requirements. Best practices consider cost, risk, and uncertainty and include both supply- and demand-side resources—energy efficiency, demand response, distributed generation and storage, microgrids and managed electric vehicle charging (Biewald et al. forthcoming). Energy efficiency, from traditional measures to more time- and location-sensitive approaches, provides important grid benefits for bulk power and distribution systems. Among the many benefits of energy efficiency, it may:

- Reduce the cost and economic risk of meeting consumer needs for energy services
- Be acquired across a wide and nearly continuous range of costs
- Provide both energy and peak demand savings
- Be developed in quantities that more closely align with resource needs and reduce the risk of overbuilding the electricity system in the short-term
- Defer or reduce investments in distribution and transmission infrastructure and the need to acquire additional ancillary services (e.g., reserves)
- Be used to support many objectives, including reliability and resilience of the power grid, reduced electricity cost, energy efficiency targets, and lower air pollutant emissions
- Reduce the risk of a portfolio of resource options because it is not subject to fuel or market price risks, and does not emit air pollutants that may be subject to future regulatory changes (Frick et al. 2021b).

Based on Berkeley Lab's analysis on the cost of saved energy and peak demand, efficiency remains a low-cost resource that can reduce the need to acquire more expensive generation (Figure 3). For example, in PacifiCorp's 2023 integrated resource plan update, where energy efficiency competes with new generation and wholesale market purchases, the preferred portfolio includes almost 5,000 megawatts of cost-effective energy efficiency during the planning period (in addition to approximately 1,000 megawatts from demand response) (PacifiCorp 2024).

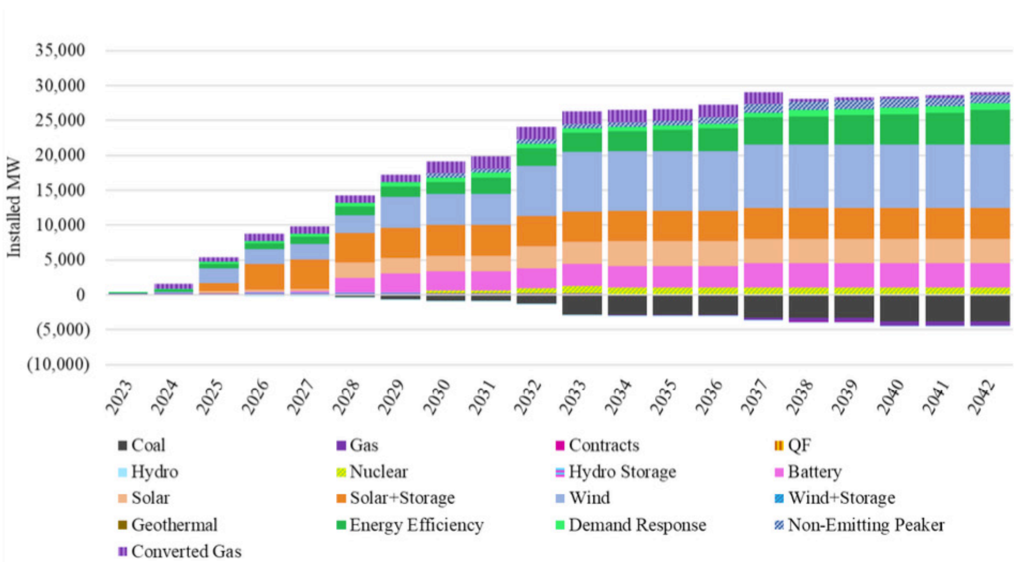


Figure 5. PacifiCorp 2023 Integrated Resource Plan Preferred Portfolio (PacifiCorp 2024)

By reducing load growth and peak demand, energy efficiency can also defer or avoid transmission and distribution system investments (Frick et al. 2021c). For example, Bonneville Power Administration (BPA) avoided building a $1 billon transmission project in 2017 (Potter et al. 2018).

BPA used energy efficiency and demand response to reduce generation south of the transmission constraint and bilateral contracts to provide additional generation north of the transmission need. The non-wires solution avoided building 79 miles of 500 kilovolt transmission lines. Similarly, in New York Commonwealth Edison deferred a $1 billion distribution system investment with a mix of customer and supply side resources, including energy efficiency. The Brooklyn Queens Demand Management project began in 2014, and has achieved 61 megawatts of demand reduction, at a cost of approximately $130 million (Figure 6) (ConEd 2024). Residential and multi-family energy efficiency programs have contributed more than 10 megawatts of demand reduction since the project began.

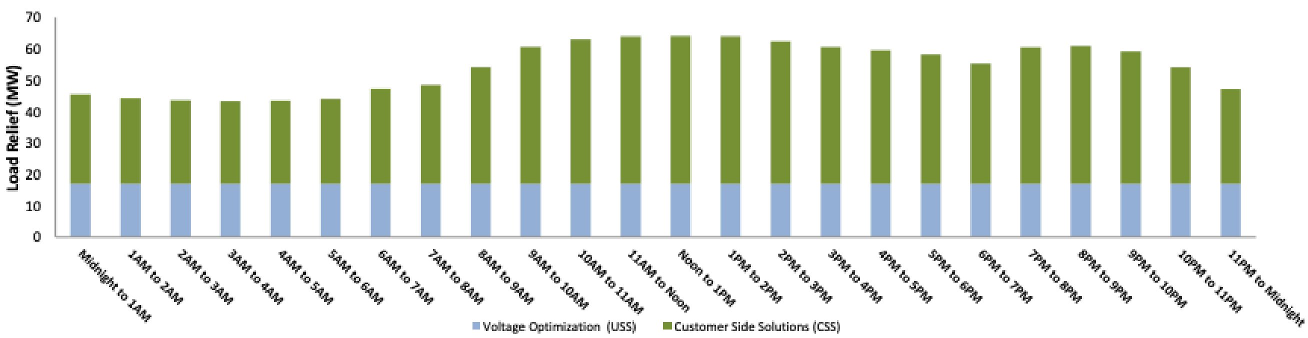


Figure 6. Hourly Load Profile of Operational Brooklyn Queens Demand Management Customer-Side Solutions and Non-Traditional Utility-Side Solutions (ConEd 2024).

Importantly, the benefits accrue to all electricity customers, not just those who invest in energy efficiency. Some example actions states can take capture these benefits are grouped below into three categories: policy, planning and programs.

Policy

- Develop or refine utility performance incentives to remove disincentives to investing in efficiency and other DERs (Schwartz et al. 2021)
- Encourage or require utilities to procure all cost-effective energy efficiency (Long et al. forthcoming)
- Establish or refine energy efficiency program goals to prioritize peak demand reductions (Schwartz et al. 2021)
- Develop grid planning objectives and goals that include energy efficiency as a resource (Schwartz et al. 2024a)[4]
- Consider performance based regulation to align utility performance with state goals (Satchwell and Hledik 2022)

Planning

- Establish or improve grid planning processes, such as distribution system and integrated resource planning (Schwartz et al. forthcoming, Biewald et al. forthcoming)

[4] See Berkeley Lab's compilation of state distribution planning requirements, as well as training materials and publications on the [Integrated Distribution System Planning website](#).

- Provide guidance to utilities about modeling and analyzing demand side resources (e.g., energy efficiency, demand flexibility, solar PV and storage) in grid planning to support development of a least-cost portfolio, such as:
  - Model DERs, including energy efficiency and demand response on par with other resources, allowing for consideration of the interaction between DERs, and between DERs and other resources, to identify a least cost, reliable electricity portfolio (as shown in the Figure 5) (Frick et al. 2021b, Carvallo and Schwartz 2023)
  - Consider all DER benefits and costs in planning analyses, including the time and locational value of DERs as non-wires alternatives for load relief, voltage support and reducing outages (Frick et al. 2021c)
  - Model aggregated DERs or virtual power plants to evaluate the capability of the resources to meet grid needs (Downing et al. 2023)

Programs

- Develop financial programs to maximize efficiency savings, including on-bill financing and revolving load funds (Deason et al. 2024, Pitkin et al. 2024)
- Consider braiding funding from IIJA and IRA with utility efficiency program offerings or refocusing utility program measures (Malinowski et al. 2023)
- Pilot or implement full-scale geotargeted energy efficiency programs to defer or avoid location specific grid investments (Schwartz et al. forthcoming)

References

Biewald, Bruce, Bob Fagan, Devi Glick, Shelley Kwok, Jack Smith, Kenji Takahashi, Rose Anderson, Juan Pablo Carvallo, Lisa C. Schwartz. Best Practices in Integrated Resource Planning. https://emp.lbl.gov/energy-planning-procurement (Forthcoming).

Billingsley, Megan A., Ian M. Hoffman, Elizabeth Stuart, Steven R. Schiller, Charles A. Goldman, and Kristina Hamachi LaCommare. The Program Administrator Cost of Saved Energy for Utility Customer-Funded Energy Efficiency Programs. https://emp.lbl.gov/publications/program-administrator-cost-saved (2014).

Carvallo, Juan Pablo, Lisa C. Schwartz. The use of price-based demand response as a resource in electricity system planning. https://emp.lbl.gov/publications/use-price-based-demand-response. (2023).

Consolidated Edison (Con Ed). BQDM Quarterly Expenditures and Program Report. Case number 14-E-0302. Filed May 30, 2024. https://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=14-E-0302&CaseSearch=Search (2024).

Deason, Jeff, Sean Murphy, Greg Leventis. Participant outcomes in residential Pay As you Save ® programs. https://live-etabiblio.pantheonsite.io/sites/default/files/berkeley_lab_pays_final.pdf (2024).

Downing, Jennifer, Nicholas Johnson, Mailinh McNicholas, David Nemtzow, Rima Oueid, Joseph Paladino, Elizabeth Wolfe. Pathways to Commercial Liftoff: Virtual Power Plants. https://liftoff.energy.gov/wp-content/uploads/2023/10/LIFTOFF_DOE_VVP_10062023_v4.pdf (2023).

Energy Information Administration. Annual Electric Power Industry Report, Form EIA-861 Detailed Data Files. https://www.eia.gov/electricity/data/eia861/ (2021).

Frick, Natalie Mims, Sean Murphy, Chandler Miller, and Margaret Pigman. 2021. Still the One: Efficiency Remains a Cost-Effective Electricity Resource. https://emp.lbl.gov/publications/still-one-efficiency-remains-cost (2021a).

Frick, Natalie Mims, Tom Eckman, Greg Leventis, Alan Santad. Methods to Incorporate Energy Efficiency In Electricity System Planning and Markets. https://emp.lbl.gov/publications/methods-incorporate-energy-efficiency (2021b).

Frick, Natalie Mims, Snuller Price, Lisa Schwartz, Nichole Hanus, Ben Shapiro. Locational Value of Distributed Energy Resources. https://emp.lbl.gov/publications/locational-value-distributed-energy (2021c).

Goldman, Charles A., Sean Murphy, Ian M. Hoffman, Natalie Mims Frick, Greg Leventis, and Lisa C. Schwartz. The Future of U.S. Electricity Efficiency Programs Funded by Utility Customers: Program Spending and Savings Projections to 2030. https://emp.lbl.gov/publications/future-us-electricity-efficiency (2018).

Lazard. Levelized Cost Of Energy. https://www.lazard.com/research-insights/levelized-cost-of-energyplus/ (2024).

Long, Angela. Natalie Mims Frick, Ted Light, Anthony Sandonato. Energy Efficiency Resource Standards. (Forthcoming)

Malinowski, Matt., Vivian Cox, David Farnsworth, Max Dupuy, Jessica Shipley, Raphael Breit and Mark LeBel. Accelerating Heat Pump Adoption through Inflation Reduction Act (IRA) and Complementary Policies. https://www.raponline.org/wp-content/uploads/2024/01/rap-clasp-accelerating-heat-pump-adoption-through-IRA-and-complementary-policies-2023-december.pdf (2023).

Murphy, Sean, and Natalie Mims Frick. "Estimating the Drivers of the Cost of Saved Electricity in Utility Customer-Funded Energy Efficiency Programs." *Energies* 16 (5): 2177. (2023).https://doi.org/10.3390/en16052177.

PacifiCorp. 2023 Integrated Resource Plan Update. https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/integrated-resource-plan/2023_IRP_Update.pdf (2024).

Pitkin, Jeff, Jeff Deason, Greg Leventis. Leveraging State Clean Water Revolving Funds to Expand Clean Energy Financing. https://emp.lbl.gov/publications/leveraging-state-clean-water (2024)

Potter, Amanda, Thad Roth, Hannah Kramer, Susan Jowaiszas, and Becky Engel. *Distribution Systems and Energy Efficiency*. Energy Trust of Oregon. https://www.energytrust.org/wp-content/uploads/2018/05/Board_Learning_Topic_Distribution_Systems_and_EE.pdf (2018).

Satchwell, Andrew, Ryan Hledik. Making Grid-interactive Efficient Buildings a "Win" for Both Customers and Utilities. https://emp.lbl.gov/publications/making-grid-interactive-efficient (2022)

Schwartz, Lisa C., Guillermo Pereira, Paul De Martini, Josh Schellenberg, Jason Ball, Natalie Mims Frick, Lawryn Kiboma, David Narang, Jeremy Keen and Michael Ingram. Interactive Decision Framework for Integrated Distribution System Planning. https://emp.lbl.gov/state-distribution-planning-requirements (2024a).

Schwartz, Lisa C., Natalie Mims Frick, Sean Murphy, Guillermo Pereira, Grace Relf, Jessica Shipley, and Josh A. Schellenberg. State Requirements for Electric Distribution System Planning https://emp.lbl.gov/publications/state-requirements-electric (forthcoming).

Schwartz, Lisa C., Cesca Miller, Sean Murphy, Natalie Mims Frick. State Indicators for Advancing Demand Flexibility and Energy Efficiency in Buildings. https://live-etabiblio.pantheonsite.io/sites/default/files/ee_market_progress_indicators_20211221_v2_0.pdf (2021).

Synapse Energy Economics, Resource Insight, Les Deman Consulting, North Side Energy, and Sustainable Energy Advantage. "Avoided Energy Supply Components in New England: 2021 Report." https://www.synapse-energy.com/sites/default/files/AESC%202021_20-068.pdf. (2021).

Wiser, Ryan, Mark Bolinger, Matt St. Clair. Easing the Natural Gas Crisis: Reducing Natural Gas Prices through Increased Deployment of Renewable Energy and Energy Efficiency. https://emp.lbl.gov/publications/easing-natural-gas-crisis-reducing (2005).

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