
Executive Summary

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This report marks the most comprehensive effort yet to quantify the cost of saving electricity through efficiency programs funded by customers of the investor-owned utilities that serve nearly 70% of U.S. electricity needs (EIA 2016). Cost-effective efficiency programs are an important tool used by utilities to provide reliable service at least cost.

Policymakers, regulators, utility resource planners, and efficiency program administrators and implementers rely on cost performance metrics, such as the cost of saved electricity, to assess energy savings potential, to design and implement programs in a cost-effective manner, and to help ensure electricity system reliability at the most affordable cost as part of resource adequacy planning and implementation processes. In addition, declining costs for some supply-side resource alternatives (e.g., wind, solar and natural gas) have sharpened discussion on the composition and market share of clean energy investments. Thus, accurate assessments of energy efficiency program costs and performance are an increasingly important policy and regulatory priority.

Electricity efficiency programs funded by utility customers are offered in nearly every state. These programs target all market segments (residential, commercial, industrial and agriculture) and include financial incentives, technical assistance, education and energy audits. Building on Berkeley Lab’s earlier work, this report analyzes cost performance of efficiency programs implemented between 2009 and 2015 which were funded by customers of 116 investor-owned utilities and other program administrators in 41 states (see Figure ES - 1).
We quantify the levelized program administrator cost of saved electricity (PA CSE) and the levelized total cost of saved electricity (Total CSE)—based on costs and savings reported by program administrators—on national, regional and state scales and at the program level (see Key Definitions text box). States, utilities and regional planning entities rely on these cost metrics for many purposes: to project efficiency’s impact on load forecasts, model resources to meet future electricity needs, benchmark local programs against regional and national estimates to improve efficiency portfolios, assess how to meet state resource targets, and evaluate how program costs are likely to change over time with funding levels and participation.

**Key Definitions**

**Program administrator costs** include costs for administration, marketing and outreach, incentives paid to customers (or contractors, retailers, manufacturers), technical assistance (e.g., energy audits), and evaluation, measurement and verification (EM&V).

**Net participant costs** include the consumer purchase costs of energy-efficient equipment, measures or appliances net of any incentives paid by the program (e.g., rebates).

**Total costs** include program administrator costs plus costs incurred by participating customers.

**Program savings** are primarily based on claimed gross savings reported by the program administrator unless indicated otherwise. Savings values are based on savings at the end-use site. Lifetime electricity savings, when not reported by the program administrator, were calculated per the approach described in Appendix D.

The levelized PA CSE is the cost incurred by the program administrator for achieving electricity savings over the economic lifetime of the measures installed by customers participating in a program, amortized over that lifetime and discounted back to the first year.

The levelized Total CSE includes costs incurred by the program administrator and participants for achieving electricity savings over the economic lifetime of the measures installed by customers participating in a program, amortized over that lifetime and discounted back to the first year.

**Nomenclature: Cost of saved energy vs. cost of saving electricity**

We use two related terms in this report:

- **Cost of saved energy** – This broad term refers to how much it costs to save a unit of energy — for example, a kilowatt-hour of electricity or a therm of natural gas — through energy efficiency programs.

- **Cost of saving electricity** – This more specific term refers to how much it costs to save a kilowatt-hour of electricity. This cost performance metric, expressed in dollars or cents per kilowatt-hour, is the focus of this report.

These metrics are useful for comparing the relative costs of various efficiency programs, as well as for comparing an energy efficiency option to other demand and supply choices for serving energy needs. See the “Key Definitions” box below for additional terms used in this report.

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**The Program Administrator Cost of Saved Electricity**

The PA CSE for the national “portfolio” of all programs and related activities between 2009 and 2015 is $0.025/kWh in constant 2016 dollars (see Figure ES - 2).
*The sample size for the full portfolio includes programs for which savings are not claimed, but which support the efficiency activities of the program administrator (e.g., planning, research, evaluation and measurement). Costs for these programs are included in our calculation of PA CSE at the portfolio and market sector level.

Figure ES - 2. Program administrator cost of saved electricity for efficiency programs by market sector: savings-weighted averages

Programs in the residential sector had a savings-weighted PA CSE of $0.021/kWh, excluding low-income programs (see Figure ES - 3). Residential lighting rebate programs had an average PA CSE of $0.011/kWh. Lighting programs were a key driver of the low values in the residential sector as they accounted for 45% of the sector’s lifetime savings. Appliance and consumer electronics rebate programs had an average CSE of $0.029/kWh and accounted for 10% of the sector’s lifetime savings. Whole-home retrofit programs typically have a higher cost of savings ($0.069/kWh) because projects are more comprehensive in scope, often including heating and air-conditioning system replacements. In cold climates, air sealing and insulation are common measures. Further, the full cost to participating customers of these measures, not the incremental cost (the cost above standard practice), is typically used for most cost estimates.
Behavioral feedback programs rapidly proliferated among program administrators from 2009 to 2015. These programs use mailed and online messages to customers to persuade them to reduce their consumption by comparing their energy use to that of similar households. These behavioral feedback programs appear to be among the costlier sources of residential electricity savings ($0.066/kWh) during our study period. Nearly all program administrators assumed that savings from behavioral feedback programs lasted one year, and we rely on reported lifetimes from program administrators in calculating the CSE. However, a growing number of evaluations suggest that participants’ efficiency behaviors last longer.¹ If we had assumed that all behavioral feedback programs had an effective useful lifetime of three years, then the savings-weighted average CSE for these programs would have been much lower—$0.028/kWh.

The average PA CSE for programs that targeted commercial, industrial and agricultural customers (collectively “C&I” sector) was $0.025/kWh. Three types of C&I programs—rebates for custom retrofits;

¹ One meta-analysis (Khawaja and Stewart 2014) of evaluations of the five longest-running behavior feedback programs recommends using a measure lifetime of 3.9 years.
prescriptive rebates for installation of high-efficiency lighting, HVAC equipment and controls, refrigeration and motors; and new construction—accounted for 74% of the C&I sector’s annual and lifetime savings. Average CSE values for these three program types are quite attractive, ranging between $0.019/kWh and $0.026/kWh (see Figure ES – 4). Programs that specifically target small C&I customers contributed 10% of the lifetime electricity savings in the C&I sector with an average CSE of $0.038/kWh.

![Figure ES - 4. Program administrator CSE for the C&I sector and select programs: savings-weighted averages](image)

Programs aimed at low-income households were costlier at $0.105/kWh, but accounted for a modest share of spending (9%). These programs also accounted for a small share of overall savings (2%). Program administrators typically pay the full cost of measures for these programs and often incur costs to address issues related to the poor condition of older homes and health and safety issues (e.g., asbestos removal, old wiring) before efficiency measures can be installed. Low-income programs also often have aims beyond energy savings (e.g., lower energy bills, improved health and safety of occupants, better comfort).
Trends in PA CSE over time

We also examined trends in the cost of saved electricity over time. Our sample of 116 program administrators includes program-level data for 51 administrators for the entire study period. That enables a comparable longitudinal analysis as well as separating out the potential impact of new administrators who may be ramping up efficiency programs in the later years of the study period. The average CSE for this sample trends upward over time from $0.022/kWh in 2010 to $0.026/kWh in 2015. This translates into a compound annual growth rate of about 3.5% (accounting for inflation).

Further, we segmented the 51 program administrators into three equal groups, by annual energy savings, which tends to be correlated with the size of the utility (i.e., its retail electricity load). The increase in the savings-weighted PA CSE for this sample was driven primarily by the 3.5% increase in the PA CSE for the largest program administrators, accounting for almost two-thirds of annual savings. In contrast, the savings-weighted PA CSE declined slightly (-0.6% per year) for the generally smaller and newer program administrators, accounting for just 7% of annual savings among the 51 PAs.

Regional and State Trends

The cost of saving electricity varied significantly among U.S. Census regions ranging from a low of $0.015/kWh in the Midwest to $0.033/kWh in the Northeast. The CSE values were comparable in the South and West ($0.025/kWh).

Figure ES - 5 shows average CSE values for all 41 states in our dataset with the dotted red line showing the national savings-weighted average value. CSE values for 16 states were less than or equal to $0.02/kWh during the 2009-2015 study period. These states tended to be concentrated in the Midwest, South and Intermountain West. Some of these states were relatively new to energy efficiency, were just ramping up their programs with a heavy focus on lighting, or had program design restrictions that limited savings acquisition (e.g., caps on customer payback periods).

Five states had average CSE values that exceeded $0.04/kWh during the study period. Four of these are Northeast states (CT, VT, MA, NH) with relatively high electricity prices, extensive histories in pursuing energy savings and strong policy commitments (e.g., statutory mandates to acquire all cost-effective energy efficiency or meet specified energy savings targets). Thus, they tend to have greater market saturation for efficiency measures and have mined more of the lowest cost savings opportunities.

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2 A previous LBNL study (Hoffman et al. 2017) examining such trends involved a smaller dataset and shorter timeframe (2009-2013).
Figure ES - 5. Program administrator CSE by state for 2009–2015: savings-weighted averages
A Multi-Program Cost Curve for Electricity Efficiency

We developed an aggregate “cost curve” for electricity efficiency programs implemented between 2009 and 2015. Figure ES - 6 provides a composite portrait of the electricity efficiency resource across market sectors (residential and C&I) and program types. Programs are arrayed along the x-axis in ascending order based on their relative CSE. The width of each bar on the x-axis is scaled to represent the lifetime savings of that program type. The values at the top of each bar show the percentage of total lifetime savings for all programs for which savings were claimed between 2009 and 2015.

![Composite cost curve for electricity efficiency programs funded by utility customers (2009-2015)](image)

Utility customer-funded programs aimed at supporting more stringent building energy codes are the least-cost efficiency resource, but these programs are only offered in a few states (e.g., CA, MA). Residential lighting and other consumer product rebate programs provide the most lifetime savings at the lowest cost. Moving up the cost curve are C&I custom and prescriptive programs disaggregated by market sector (e.g., industrial and agricultural customers) and mixed (programs serving a mix of commercial, industrial and agricultural customers).

We draw two major implications from the cost curve. First, residential efficiency portfolios are highly dependent on low-cost savings from rebates for lighting and other residential consumer products. Federal and state energy efficiency standards are substantially raising the energy performance of those products. Further, the performance of light-emitting diodes (LEDs) continues to improve and unit costs continue to decline. As market penetration of LEDs increases, program administrators may have
reduced opportunities to acquire low-cost savings through residential lighting programs because an increasing number of consumers may be adopting LED technology irrespective of efficiency programs. If there are significant changes to the costs of residential lighting programs or savings potential decreases, the cost of savings could increase for the overall portfolio.

Second, C&I programs—specifically, rebates for C&I custom retrofits, prescriptive measures and new construction—deliver nearly half of the national portfolio savings on a lifetime basis, and the CSE values for these programs are attractive. The bulk of these savings come from large C&I customers. However, in recent years, more states have allowed large C&I customers to opt out of utility efficiency programs or choose self-direct program options. Where customers can opt out, between 10% and 30% of a utility’s load typically no longer participates in the efficiency programs offered. If this trend continues, it will likely shift reliance for savings in the C&I sector onto market sectors dominated by small to mid-size C&I customers, which have higher PA CSE values in our sample and lower savings potential. Thus, a shrinking C&I market for program administrators may put upward pressure on CSE values in the C&I sector and the overall portfolio.

The Total Cost of Saved Electricity

A subset of our sample—27 states—included sufficiently granular data to calculate the Total CSE. The Total CSE for 2009-2015 programs in our sample was ~$0.05/kWh (Figure ES - 7). The total CSE for programs that targeted residential customers was $0.039/kWh, while the Total CSE for programs that focus on low-income households was $0.145/kWh. The average value for Total CSE for the C&I sector was $0.055/kWh.

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3 States vary in their criteria for customers eligible to opt out or self-direct. Many states set criteria at greater than 1 megawatt peak demand. In some jurisdictions, industrial customers may choose to opt out of the efficiency programs and may not pay for the costs of energy efficiency programs or receive any of the benefits (e.g., incentives).
Figure ES - 7. Total cost of saved electricity for efficiency programs by sector: national savings-weighted averages

Figure ES - 7 presents the Total CSE as stacked bar charts, with the program administrator cost component on the bottom (darker shade) and the participant cost component on the top (lighter shade). From a resource investment perspective, the program administrator cost can be regarded as the cost of leveraging investment by participants. To acquire savings across the full portfolio of programs, program administrators contributed about 54% of total costs while participants contributed about 46%.

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4 Because Total CSE can be calculated for only a subset of our total sample, PA CSE values in this figure are slightly different than those for the full sample.
Figure ES - 8. Total CSE by state: savings-weighted averages and program administrator (PA) vs. participant costs
The Total CSE varies significantly from region to region and state to state, as illustrated in Figure ES - 8. The Total CSE varies by more than a factor of three among states, from a low of ~$0.026/kWh to more than $0.08/kWh. One-third of states in our 27-state sample had a Total CSE less than $0.04/kWh. These states were regionally diverse: three in the West (NM, AZ, NV), three in the Midwest (SD, IN, WI), two in the South (SC, NC) and one in the Northeast (ME). The Total CSE for 15 states in this sample was below the national average of $0.05/kWh. Adjusting for inflation, the Total CSE appears to have increased very little during the last several years in those 27 states.

Progress, Challenges and Future Directions

Over the 2009 to 2015 period, we have witnessed continuation of the expansion in reliance on efficiency programs as a core electricity resource. Program-level reporting of efficiency costs and impacts is increasing and more program administrators are reporting information on customer cost contribution which allows us to calculate the Total CSE.

At the same time, we found that many program administrators do not provide a complete picture of the impacts or costs of efficiency investments at the program level. For example, program average measure lifetimes are essential for calculating the CSE. Yet only 27% of program administrators reported measure lifetime, lifetime savings or both. This data limitation means that we had to impute program average measure lifetime for over half of the program years based on average values from the programs where program administrators reported this information. Public utility commissions may also wish to consider requiring program administrators to report information on participant costs and improve the consistency of estimated lifetimes of installed measures located in similar climate regions across states.

In 2018, we are broadening our analysis of the cost of saved energy to include the cost of saving electricity for public power utilities and the cost of reducing peak electricity demand. We also are conducting a limited update of the cost of saving natural gas. Additional potential areas of exploration include improving our understanding of the cost of saved energy by cost category (e.g., administration vs. incentive costs) and comparing cost performance trends of efficiency and supply-side resources.

Steps such as these will fill in crucial information gaps for efficiency as a cost-effective resource and inform sound decision-making on meeting energy needs reliably and at least cost and risk.