The Best Value for America's Energy Dollar: A National Review of the Cost of Utility Energy Efficiency Programs

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Executive Summary

After a decades-long history, U.S. energy efficiency programs have expanded rapidly in recent years. As program administrators face rising energy efficiency targets that require more comprehensive portfolios, they have an increasing concern about the impact on program costs. This creates the need for high-quality, comprehensive, and consistent data metrics on energy efficiency program costs and cost effectiveness. To this end, the American Council for an Energy-Efficient Economy (ACEEE) has undertaken an assessment of utility-sector energy efficiency program costs and cost effectiveness in 2009-2012.

The results of our analysis clearly demonstrate that energy efficiency programs are holding steady as the least-cost energy resource option that provides the best value for America's energy dollar. Data from a large number of diverse jurisdictions across the nation show that energy efficiency has remained the lowest-cost resource even as the amount of energy efficiency being captured has increased significantly. At an average cost of 2.8 cents per kilowatt hour (kWh), electricity efficiency programs are one half to one third the cost of alternative new electricity resource options such as building new power plants. Natural gas energy efficiency programs also remain a least-cost option at an average cost of 35 cents per therm as compared to the national average natural gas commodity price of 49 cents per therm in 2013. In addition, both electricity and natural gas efficiency costs have remained consistent over the past decade. This consistency shows the reliability of efficiency as a long-term resource.

METHODOLOGY

The goal of the current ACEEE analysis is to collect and aggregate recent data on energy efficiency program costs and cost effectiveness from jurisdictions across the United States. Our focus is on the costs to utilities or other program administrators to run efficiency programs, but we also include some data on the broader costs and benefits to participants and to society. We do not aim to compare one state's efficiency portfolio results to others, but instead to present overall results.

We collected data for 20 states for electricity programs and 10 states for natural gas efficiency programs from 2009 to 2012, pulling from utilities' and other program administrators' program results. We collected the necessary data (annual program costs, net energy savings, and measure lifetime) to calculate the levelized utility cost of saved energy (CSE). By levelized we mean that upfront costs are amortized over the lifetime of a measure at an assumed real discount rate. The levelized CSE is the best measure for comparing energy efficiency to other energy resource options.

Our definition of utility energy efficiency costs includes

- Direct program costs incurred by administrators, including incentives to participants and all non-incentive costs such as the direct installation of measures, program design and administration, marketing, education, and evaluation
- Shareholder incentives or performance fees, which reflect the rate of return utilities earn in some states to meet or exceed certain thresholds of energy savings levels

We also collected some data on participant costs; however these data are much more sparsely reported and therefore the data set includes only seven states.

Our task of data collection and comparison was complicated by numerous challenges, including inconsistent reporting formats, nomenclature, and frequency; variation in energy savings evaluation approaches and in the accounting of demand response programs; and structural differences in program portfolios. We tried to make the data as consistent as possible in the face of these challenges. We consistently calculated the CSE based on a 5% real discount rate, we used net energy savings values and measure lifetimes as reported by the program administrator, and we used energy savings reported at the meter rather than at generation. We converted all data to real 2011 dollars.

RESULTS

As shown in figure S1, the CSE for electricity energy efficiency programs ranged from $0.013 to $0.056 per kWh across the 20 states from 2009 to 2012.

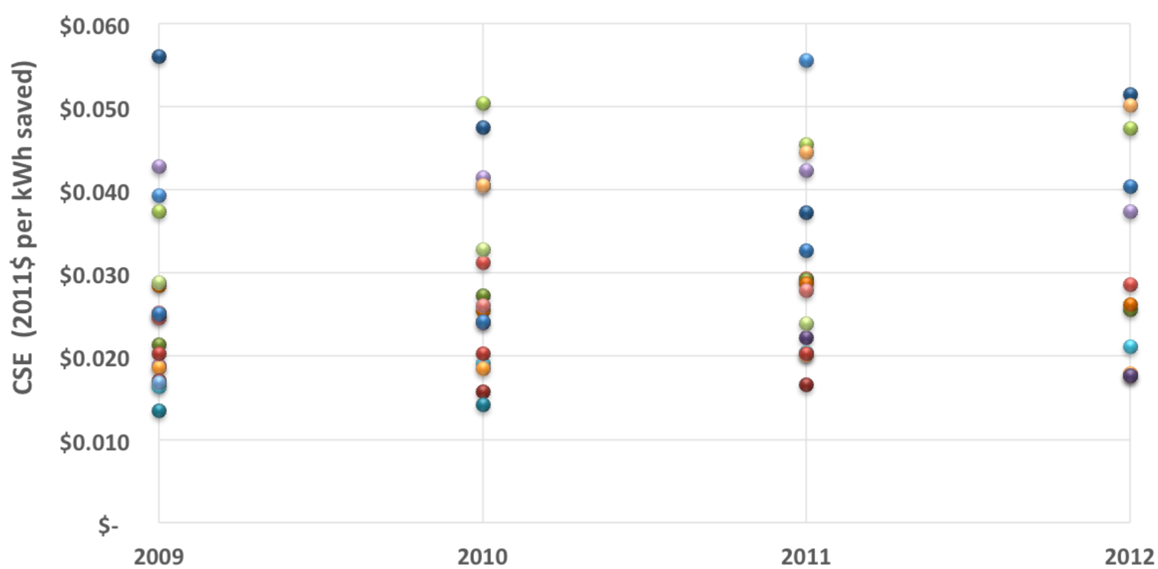

Figure S1. Electricity energy efficiency program CSE by year. Each dot represents average costs for each state in a given year. 2011$ per levelized net kWh at meter. Assumes 5% real discount rate.

We calculated four-year averages (2009-2012) for each of the 20 jurisdictions (and 10 jurisdictions for gas programs), and display the average, median, minimum, and maximum for the dataset in table S1. The simple average utility CSE was $0.028 per kWh for electricity programs and $0.35 per therm for gas programs.

Table S1. Summary of results for four-year averages (2009-2012) for all states in dataset

	Electricity programs ($ per kWh)	Natural gas programs ($ per therm)
Average	$0.028	$0.35
Median	$0.026	$0.37
Minimum	$0.016	$0.10
Maximum	$0.048	$0.59

2011$ per levelized net kWh or therm at meter. 5% real discount rate. Each state's four-year average is a distinct data point. The complete data set for individual years (Figure S1) has lower minimum and higher maximum values.

We also reviewed energy savings and CSE by customer class. Among the 17 states that readily reported electricity savings by customer class, the average portfolio included 45% savings from residential customers and 55% from business (commercial and industrial) customers. We calculated electricity CSE values by customer class for nine states (complete data was not readily available for the other jurisdictions), and identified an average CSE of $0.037/kWh for residential portfolios and $0.027/kWh for business portfolios.

While this study focused on the utility costs to deliver energy efficiency programs, we also examined some results of the total resource cost (TRC) test, which involves a system-wide perspective.[1] TRC test results from nine states show benefit-cost ratios ranging from 1.24 to 4.0 for electricity portfolios. In other words, in these jurisdictions, each dollar invested by utilities and participants in energy efficiency measures yields $1.24 to $4.00 in benefits.

Many analysts have hypothesized that program CSE will increase over time as administrators increase energy savings levels. An initial correlation analysis in this study finds only a very weak correlation between CSE values and energy savings levels. This analysis casts doubt on the claim that higher savings levels are associated with higher costs.

While comparisons of efficiency program costs to current levelized costs for new electricity resource options or natural gas commodity prices provide useful context, they do not tell the complete cost-effectiveness story for energy efficiency. For example, in addition to the avoided energy- and capacity-related costs to all customers, energy efficiency programs also result in utility benefits such as avoided transmission and distribution (T&D) costs, peak demand benefits, price mitigation effects in wholesale markets, and reduced pollution. Program participants can also benefit from lower water and fuel usage and improved comfort. In addition, energy efficiency programs result in reinvestment of local dollars in local jobs and industries. Also, these indicators of current avoided energy costs do not reflect future expected avoided energy costs and future price volatility. Including higher levels of low-cost energy efficiency in long-term planning can hedge against volatile and/or rising costs of supply resources.

In summary, the results of this analysis clearly demonstrate that energy efficiency programs are the least-cost resource option available to utilities. As shown in figure S2, electricity

[1] A complete and balanced TRC test should include benefits both to participants and to the system.

efficiency programs, at a range of about 2 to 5 cents per kWh and an average of 2.8 cents per kWh, are about one half to one third the levelized cost of alternative new electricity resource options.

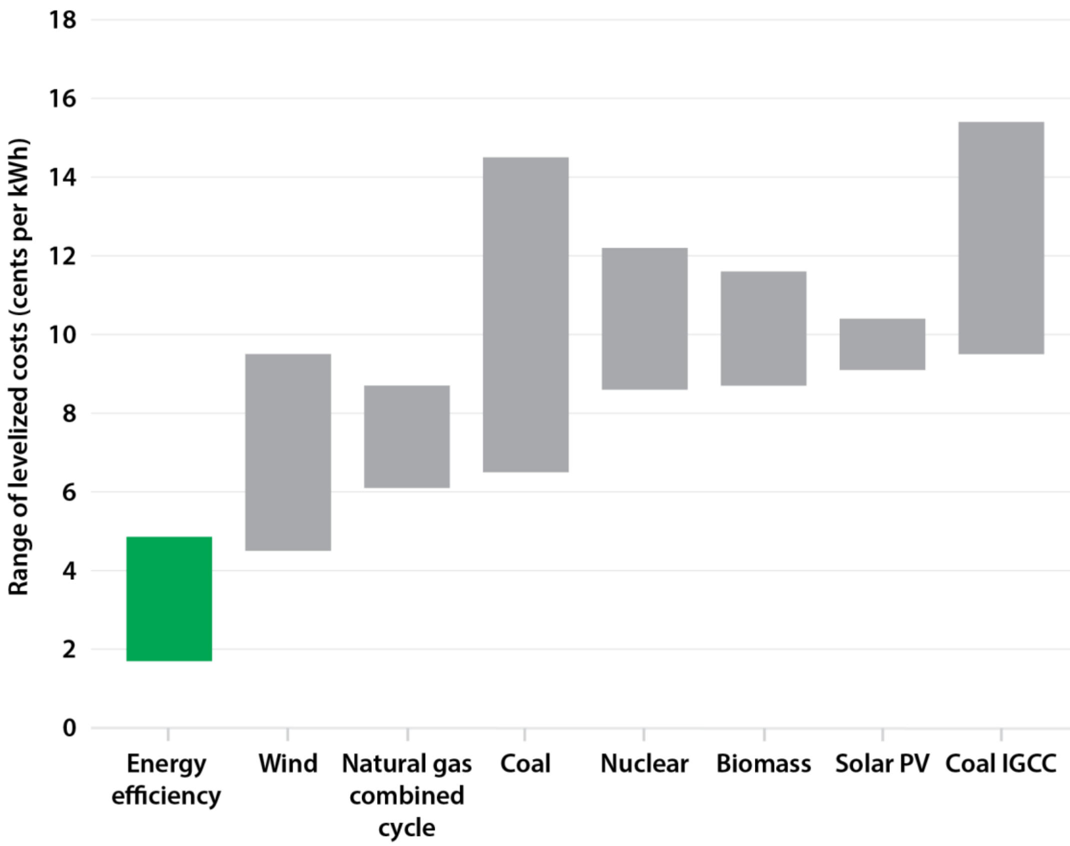

Figure S2. Levelized costs of electricity resource options. *Source:* Energy efficiency data represent the results of this analysis for utility program costs (range of four-year averages for 2009-2012); supply costs are from Lazard 2013.

RECOMMENDATIONS AND FURTHER RESEARCH

Given the inconsistency in efficiency program report formatting, nomenclature, and frequency, we recommend that utilities, regulators, and program administrators in each state discuss these issues, perhaps also at a regional and national level, and work toward adopting best reporting practices. We offer several specific recommendations to improve consistency and transparency in reporting.

In this review we discuss numerous metrics that may have a direct impact on the cost of efficiency, e.g., the share of savings by customer class, or the types of programs offered. Further research is needed on the relative impact of these different variables on CSE values and on the broader set of benefits to customers. Trends in CSE over time may be another fruitful area of study. Correlation analyses of CSE trends over time across jurisdictions are difficult and may produce incomplete results because of differences among program portfolio structures and reporting consistency. Further research should delve into this question, perhaps examining individual jurisdictions or regions.

Introduction

The energy future of the United States has entered an era of increasing change and uncertainty. While oil and gas production have increased in recent years, ongoing challenges include the environmental impacts of power generation, difficulty in siting new energy facilities and infrastructure as well as their high capital cost, and the continuing risk of fuel price volatility. In the face of these challenges and the need for economic development strategies, an increasing number of states have turned to energy efficiency as a significant component of their long-term energy resource planning.

Energy efficiency has long been demonstrated to be a low-cost and low-risk strategy. The American Council for an Energy-Efficient Economy (ACEEE) has conducted two reviews of utility-sector energy efficiency programs to document their cost effectiveness (Kushler, York and Witte, 2004; Friedrich, Eldridge, and York 2009). Both studies found that energy efficiency programs are the least-cost resource option compared to supply-side energy options.

ACEEE's 2004 and 2009 efficiency program cost reviews found the following:

- Examining data from seven states, the 2004 review identified a range of levelized cost of saved energy (CSE) from $0.023 to $0.044 per kilowatt hour (kWh), with a median value of $0.03 per kWh (Kushler, York, and Witte, 2004).
- The 2009 review of 14 states identified CSEs ranging from $0.016 to $0.033 per kWh, with an average cost of $0.025 per kWh. Six natural gas efficiency program portfolios covered in the report had an average CSE of $0.37 per therm (Friedrich, Eldridge, and York 2009).

Utility-sector energy efficiency programs have a decades-long history in the U.S., but have expanded significantly in recent years, which means the availability of new data sets and the increasing visibility of efficiency.[1] As states face rising energy savings targets, some stakeholders are concerned that energy efficiency programs' cost of saved energy will increase as they ramp up to hit their targets. These recent trends and concerns suggest the need for an updated and expanded review of energy efficiency program costs.

From 2006 to 2011, national annual electricity efficiency program spending tripled from $1.6 billion to about $4.8 billion (Downs et al. 2013). Although budgets for natural gas efficiency

[1] This report focuses exclusively on utility-sector energy efficiency programs that aim to reduce overall customer energy usage. We do not include demand response programs, which aim to reduce or shift energy usage only during times of peak demand. By "utility-sector energy efficiency programs," we mean programs funded through utility rates (whether embedded in rates or as a separate tariff rider or surcharge) or through associated public benefits charges and administered by utilities, government agencies, or third-party organizations.

programs have been much smaller, they have gained popularity in recent years and increased from $0.3 billion in 2006 to $1.1 billion in 2011.

This rapid growth stems largely from the increasing adoption of energy efficiency resource standards (EERS) and other regulatory mechanisms that reduce barriers to efficiency and encourage utilities to pursue it cost effectively.[2] States have also increasingly recognized energy efficiency as a low-cost economic development tool that attracts new businesses, creates jobs, and stimulates the economy. Twenty-six states now have EERS policies, and many others have other short-term energy efficiency planning processes.

These recent trends open up a wider set of utilities and states that collect data on efficiency program costs. Similarly, as efficiency programs gain traction as a true resource that planners can use in long-term forecasting, the need increases in step for high-quality and uniform data metrics on energy efficiency program costs and benefits.

Numerous utilities and statewide program administrators are now facing rising energy efficiency targets as part of their EERS policies, and they must hit these targets within firm cost-effectiveness requirements. Some stakeholders are concerned that the cost of efficiency programs is rising and that it is becoming more difficult to realize savings as federal appliance and equipment standards raise the baseline. It is true that program costs increase in the short term as programs target the uptake of higher-cost technologies, e.g., as they move from CFLs to LEDs. But, continuing with this example, costs are quickly declining for LEDs, which can counterbalance the initial higher program costs. Similarly, utilities are developing new, highly cost-effective program strategies such as large customer reverse auctions and strategic energy management. They are also identifying market gaps such as multifamily buildings. Still, much uncertainty and many misconceptions remain about the costs and cost trends of efficiency programs.

The goal of this analysis is to collect and aggregate recent data on energy efficiency program costs and cost-effectiveness metrics from jurisdictions across the U.S. as a comprehensive source of information for stakeholders. Our primary focus is on the costs incurred by utilities or other program administrators to run efficiency programs, but we also include some data on the broader costs and benefits to participants and society. We collected data by reviewing utilities' and other program administrators' program results to calculate CSE values. We do not aim to compare states' efficiency portfolio results, but instead to present overall results. We also would like to advance the discussion on how to improve protocols and consistency in the reporting of efficiency programs.

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[2] EERS policies establish specific, long-term (3+ years) energy efficiency targets that utilities or non-utility program administrators must meet through customer energy efficiency programs. See http://www.aceee.org/topics/eers for more information.

Measuring Cost Effectiveness: Practices and Challenges

Since the 1980s, energy efficiency programs have gained traction as a true resource option that utilities and states can scale up and rely on within their resource plans. As a demand-side resource, however, efficiency is fundamentally different from supply options such as power plants and wind turbines. This difference calls for a unique set of methodologies to quantify efficiency as a resource by measuring its energy savings and cost effectiveness.

Since the 1970s and 80s, regulators have adopted particular practices to evaluate the costs and energy savings from efficiency programs. States have adopted these practices with varying degrees of consistency, and this creates a challenge for reviewing efficiency program costs across states. Some regions of the country have begun to coordinate methodologies and reporting guidelines through efforts such as the Regional Technical Forum in the Pacific Northwest and the Northeast Energy Efficiency Partnership (NEEP) Regional Evaluation, Measurement, and Verification Forum.[3] However most states continue to use a diverse set of methodologies and reporting structures.

This section presents our approach to reviewing the costs, savings, and cost effectiveness of efficiency programs, addressing the following questions:

1) What is typically included in the definition of energy efficiency program costs?
2) How are energy savings evaluated, measured, and verified (EM&V)?
3) How are costs expressed relative to energy savings? For example, what is the relationship between levelized costs, first-year costs, and measure lifetimes?
4) How are energy efficiency cost-effectiveness tests currently applied?

We discuss practices and challenges for each topic in this background section, as well as the approach we took to these issues in our review. The subsequent section on methodology goes into further detail on our approach to some of these topics.

ENERGY EFFICIENCY COSTS

Program Costs

What types of values should be attributed to the cost of delivering energy efficiency as a utility resource? We include two broad categories of energy efficiency resource costs: (1) direct program costs and (2) shareholder incentives (also called performance incentives or performance fees) earned by utilities or third-party program administrators for reaching or exceeding certain energy savings thresholds.[4] From a utility or program administrator perspective, the sum of efficiency program costs and performance incentives comprises the total cost of energy efficiency resources.

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[3] For more information, see http://rtf.nwcouncil.org/ and http://neep.org/emv-forum/.

[4] For more information on performance incentives, see http://aceee.org/sector/state-policy/toolkit/utility-programs/performance-incentives.

The following types of costs are commonly incurred by energy efficiency program administrators as the direct costs to administer programs:

a. direct rebates or incentives to customers
b. engineering or technical support
c. program administration, planning, and delivery
d. evaluation, measurement, and verification (EM&V)
e. marketing and education[5]

The second general category is performance incentives, which are either utility shareholder incentives or performance management fees for non-utility program administrators. Both are typically established as a way to encourage greater levels of efficiency, and typically they are earned only if certain thresholds of energy savings are met or exceeded. While utilities earn the incentives for good performance and may not perceive them as a direct cost of efficiency programs, ratepayers foot the bill for performance incentives, so they need to be accounted for in calculating the overall cost of delivering energy efficiency resources. Not all jurisdictions, however, adopt performance incentives: currently 28 states have them in place for at least one major utility (Downs et al. 2013). We have chosen to include performance incentives as a cost component of delivering energy efficiency resources because they are a direct way to encourage energy efficiency performance, and they are equivalent to a rate of return that utilities would earn on a supply-side investment.[6]

Participant Costs

In addition to the program costs incurred by administrators, program participants may spend additional money to purchase or install energy efficiency upgrades. Depending on the type of cost-effectiveness test used (as discussed later in this section), participant costs may or may not be included as a component in cost-effectiveness screening. The total resource cost (TRC) test, for example, includes participant costs, while the utility or program administrator cost test (UCT/PACT) assumes the perspective of the utility planner and so does not take participant costs into account.

The best way to directly compare efficiency costs to supply-side options is to take the perspective of the UCT/PACT and focus on the cost of energy efficiency programs as a resource option to utility planners. Since this is how we focused our analysis, we did not conduct an extensive review of participant costs. Although we did collect some limited data, most annual program administrator reports do not include participant cost estimates and benefits. Participant costs are used as an input to the TRC calculations, however, and therefore embedded in the results of any TRC test. See the Methodology and Results sections for further details on participant cost estimates and TRC test results.

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[5] For all of these cost types, the nomenclature and reporting vary across jurisdictions.

[6] Including this factor in comparisons with the cost of supply-side resources is only appropriate if those supply cost estimates include all associated utility "incentives" (e.g., rate of return).

Decoupling and Lost Fixed Cost Recovery

Symmetrical decoupling is a way to remove the throughput incentive to utilities, which otherwise links utility profits to increased energy sales. While the decoupling mechanism is a critical component of a regulatory approach that puts efficiency on a level playing field with supply resources, it should not be considered a cost of delivering energy efficiency programs. Rather, it is used to improve regulatory certainty in ratemaking. Decoupling was widely adopted in the gas utility industry, for example, during the era of declining energy sales.

Mechanisms to directly compensate utilities for lost fixed cost are a different approach than decoupling.[7] These mechanisms allow utilities to recover fixed-cost revenues that are "lost" due to energy savings from efficiency, but they do not adjust rates downward if revenues are greater than authorized.

Neither decoupling nor lost fixed cost adjustments are costs of delivering efficiency services, because they do not increase total revenue requirements. Rather, they are rate tools designed to reallocate fixed costs in different ways, i.e., to recover the same fixed costs that would have been recovered anyway. For these reasons, neither mechanism is included in our analysis of efficiency costs.

It is noteworthy that these policy mechanisms are being used as a way to improve the business case for energy efficiency. Currently 13 states have full revenue decoupling for at least one major electric utility in the state, and 19 states have lost fixed cost mechanisms for at least one utility (Downs et al. 2013). Recent literature has explored the impact of decoupling on rates and found that most rate adjustments (64%) are within plus or minus 2% of the retail energy rate, which amounts to about $2.30 for the average electric residential consumer (Morgan 2012).

EVALUATION, MEASUREMENT, AND VERIFICATION (EM&V) OF ENERGY SAVINGS

Dating back to the 1970s and 1980s, EM&V of energy efficiency results aims to assess the performance and implementation of programs, document and measure their effects, help program planners improve performance, and ensure that programs are cost effective. The State and Local Energy Efficiency Action Network (SEE Action) defines EM&V as the

> collection of approaches for determining and documenting energy and non-energy benefits resulting from end-use energy efficiency activities and programs. Effective EM&V can confirm energy savings, verify cost-effectiveness, and guide future energy efficiency investment decisions.[8]

Various international, national, and regional groups have been working to improve consistency and standardization in the EM&V process. For example, the International

[7] These are often called lost revenue adjustment mechanisms (LRAM) or lost contribution to fixed costs (LCFC).

[8] See http://www1.eere.energy.gov/seeaction/evaluation.html.

Performance Measurement and Verification Protocol (IPMVP), published by the Energy Valuation Organization, defines standard terms and provides a framework for verifying project-specific energy efficiency savings. In the United States, the Department of Energy's SEE Action network, the NEEP EM&V Forum, and the Regional Technical Forum (RTF) of the Northwest Power and Conservation Council all have initiatives to develop common standards and approaches to verify and evaluate efficiency savings.

While efforts to improve consistency in energy savings EM&V have expanded, in practice states still use a diverse set of methods to document savings. Not only do they use a variety of cost-effectiveness tests, as discussed below, but they also have various approaches to the energy savings calculations themselves. For example, whereas most states use deemed savings (i.e., predetermined engineering estimates of savings per measure, or savings estimates verified in past EM&V studies), some states use different methodologies to calculate savings after measures are installed.[9] Similarly, states have different approaches to achieving consistency in evaluation. Many adopt their own technical resource manual (TRM) as a way to specify engineering calculations for estimating savings. Others in regions such as the Northeast or Northwest may share resources, and still others do not have standard methodologies.

Net Versus Gross Savings

Another key methodological difference among states in evaluating energy savings is whether they estimate net or gross energy savings impacts from efficiency programs (or both). The definition of these terms, methodology used, and application for use also vary. Gross energy savings impacts are "changes in energy consumption that result directly from program-related actions taken by participants in an energy efficiency program, regardless of why they participated" (NREL 2013). Net energy savings are "changes in energy use attributable to a particular energy efficiency program. These changes may implicitly or explicitly include the effects of factors such as freeridership, participant and non-participant spillover, and induced market effects" (NREL 2013).[10] In practice, net savings calculations typically account for freeridership, but only sometimes account for spillover and induced market effects.

A recent national review by ACEEE examines and documents state practices, precedents, and issues regarding net and gross savings (Kushler, Nowak, and Witte 2014). The study finds that the majority (54%) of the 43 states that responded to the survey estimate net energy savings using specific values for programs, another 5 states apply a uniform net-to-gross (NTG) ratio, another 4 states estimate both net and gross, and the final 11 states estimate gross savings only. The study's review of states and national experts makes it clear that both net and gross savings can serve useful purposes. For example, estimates of net savings help program improvement as they provide information toward minimizing

[9] ACEEE's 2012 survey of EM&V practices found that 36 of the 42 states that responded used deemed savings values to calculate energy savings (Kushler, Nowak, and Witte 2012).

[10] Freeriders are participants who would have adopted efficiency measures in the absence of the program.

freeriders, while gross savings are more straightforward and less expensive to estimate. Overall, there is a need and often regulatory pressure to understand the net impacts attributable to programs, especially as a way to calculate things like cost effectiveness and lost revenue adjustments in order to protect ratepayer interests.

For our CSE calculations, we chose to use net energy savings figures, which most jurisdictions reported. We recognize that methodologies for calculating net savings can vary by state and jurisdiction, making it difficult to directly compare results. However, because the focus of this review is on energy efficiency as a resource for utility planners, and since stakeholders by and large are most interested in the net impacts of efficiency programs on energy usage, we decided to focus on cost effectiveness based on net savings.

Electricity Savings at Site or Generation Level

Another variation in reporting of energy savings (for electricity only) is that some entities report "at-site" savings, i.e., at the customer meter, whereas others report "at-generation" savings, which add in estimated transmission and distribution (T&D) line losses that are avoided. The at-generation approach is an attempt to directly compare the energy savings to the electric generation that would otherwise be needed to offset the efficiency gains. It is useful in integrated resource planning (IRP) because it puts efficiency on a level playing field with supply-side resources.

At-generation savings are most appropriate for comparing efficiency costs to electric supply resources, and perhaps the appropriate framework for this analysis. However at-site savings are more useful for comparing efficiency gains to overall electricity sales, and they are the most common and longstanding approach to measuring and evaluating energy savings. Moreover most state EERS are established as a percentage of retail sales. For these reasons, this analysis presents energy savings data at site or meter. In the Results section, we also examine the implications of using generation-level energy efficiency savings.

While this range of diversity in methodology among states makes it challenging to compare cost values, our review tries to make the differences across states transparent. See the Methodology section for more details.

LEVELIZED COSTS VERSUS FIRST-YEAR COSTS

Program managers and regulators typically use two general approaches to express the costs of energy efficiency portfolios relative to energy savings: (1) levelized CSE and (2) first-year "acquisition" costs. Since both approaches provide meaningful information to planners, we review them both. However, ACEEE finds that levelized costs are the best way to compare efficiency program costs to supply options, and therefore we place more emphasis on this metric. By levelized, we mean that upfront investments are annualized over the life of the investment assuming a real discount rate.

Energy planners commonly use levelized costs as a way to express the costs of long-term energy supply investments. For electricity generation technologies, for example, the levelized cost represents the per-kWh cost expressed in real dollars of building and operating a power plant over an assumed financial life, duty cycle, and capacity factor.[11] Similarly, levelized cost is an appropriate metric for energy efficiency resources, which continue to save energy over several years of their effective useful lifetime. A full description of the cost-of-saved energy approach is included in the Methodology section.

A second approach to expressing efficiency program costs relative to their savings is to use first-year costs, which are representative of the annual costs to administer an efficiency portfolio divided by the energy savings in the first year only. These are sometimes called energy efficiency acquisition costs, and they can be useful for program budgeting purposes. Program administrators and regulators tend to focus on first-year costs when they are faced with one-year savings targets. These costs, however, do not take into account the full value of efficiency investments because they capture only the first-year savings, whereas the measures continue saving energy throughout their useful lifetime.[12] (We present data on typical measure lifetime in the Results section.) In other words, higher first-year costs do not necessarily mean higher levelized CSE values. First-year costs thus misrepresent the full benefits of efficiency. Furthermore, supply-side investments are not typically assessed based on the full upfront costs.

COST-EFFECTIVENESS TESTS

Regulators typically predicate energy efficiency programs on the fact that they are cost-effective compared to their avoided costs.[13] This adds a layer of rigor to the requirements for energy efficiency program review, necessitating detailed analysis to evaluate how efficiency costs and benefits accrue to various parties with different perspectives.

Utilities and other program administrators use some combination of various cost-effectiveness tests. These tests have evolved from the first California Standard Practice Manual in 1983, which has been periodically revised since then, most recently in 2011. Representing various perspectives, the five standard cost-effectiveness tests are

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[11] See http://www.eia.gov/forecasts/aeo/er/electricity_generation.cfm

[12] For example, two measures can have identical levelized costs, while the first-year cost for a measure with a shorter lifetime (e.g., CFLs) appears lower than that of a measure with a much longer lifetime (e.g., insulation).

[13] The term "avoided costs" originated with federal laws designed to encourage independent power production. They refer to the costs that utilities would incur to produce one more unit of electricity (kWh) and/or capacity (kW) or one more unit of natural gas (therm). For energy efficiency cost-effectiveness evaluation, avoided costs refer to the energy-related and capacity-related costs that would have been incurred by utilities if the energy efficiency measures had not been adopted. Thus they are used as a reference point against which efficiency programs are compared. The methodology for calculating avoided costs can vary significantly across jurisdictions.

- Utility/Program Administrator Cost Test (UCT/PACT)
- Total Resource Cost (TRC) test
- Societal Cost Test (SCT)
- Participant Cost Test (PCT)
- Ratepayer Impact Measure (RIM) test

Numerous resources are available on the topic of cost-effectiveness tests (e.g., National Action Plan for Energy Efficiency 2008; Woolf et al. 2012; Kushler, Nowak, and Witte 2012).[14] A recent national review by ACEEE found that most states use a combination of the tests, with the TRC being the most widely used as the primary test and the RIM rarely being used (Kushler, Nowak, and Witte 2012). For information on each state's approach to cost-effectiveness tests, see the ACEEE State Energy Efficiency Policy Database.[15]

From a utility resource planning perspective, the UCT is the preferred approach for evaluating energy efficiency as a resource for utility planners, and thus is the focus of this report. A handful of states use the UCT as their primary test: Connecticut, Michigan, New Mexico, Texas, and Utah. The TRC, although most widely used as the primary test, can be challenging to implement properly because it takes a system-based approach that requires all costs and benefits to be fully accounted. While costs to utilities and customers are relatively straightforward to count, the benefits are less straightforward, particularly for customers, and as a result they are often underreported (Kushler and Neme 2010).

Given the diversity of cost-effectiveness tests used across the states as well as methodological differences such as discount rates, the results of these tests can be difficult to compare across jurisdictions. While the focus of this review is on the cost of saved energy, we also collected the benefit/cost (B/C) ratio results of the TRC when they were available.

ENERGY EFFICIENCY VALUATION IN INTEGRATED RESOURCE PLANNING

Energy efficiency program costs are typically evaluated differently than other energy resources: they are evaluated against the avoided costs of supply options. In other words, regulators want to know how the cost of procuring additional energy efficiency compares to the prevailing cost of the next marginal unit of supply that would otherwise be incurred. Efficiency resources that cost less than avoided costs are deemed cost effective.

As efficiency gains traction as a resource option, efficiency programs should be incorporated into integrated resource plans (IRP) and other planning tools that truly optimize efficiency as analogous to a supply-resource option. Although many states began to do this in the 1980s and many continue today, efficiency is typically treated through scenarios of the demand curve rather than as an explicit resource option. Improved analysis of energy efficiency program costs and impacts in terms of procured energy (kWh) and demand (kW)

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[14] Resources are available from the Regulatory Assistance Project (RAP), the SEE Action Network (and its predecessor the National Action Plan for Energy Efficiency), and ACEEE.

[15] http://www.aceee.org/sector/state-policy

savings will be crucial to the incorporation of efficiency into multi-objective resource planning tools. For more information, see the resources offered by the Regulatory Assistance Project (RAP) on best practices for the incorporation of energy efficiency into IRP processes (e.g., RAP 2013).

Methodology

This section describes the data collection process for this study, the challenges and caveats attendant on processing the data, and the various calculations used to estimate the CSE and first-year acquisition costs.

DATA COLLECTION AND PROCESSING

For this review, we collected data on energy efficiency program costs and energy savings from secondary sources including annual reports, EM&V reports, and in some cases individual requests to contacts at public utility commissions (PUCs), utilities, and state agencies. ACEEE's 2009 review collected data from 14 states. Now, with more states developing comprehensive energy efficiency portfolios and reporting their results, we were able to collect data for 20 states for electricity programs, as shown in table 1, and 10 states for natural gas efficiency programs, as shown in table 2. We chose the states for two reasons: (1) they were included in the last study and thus were good candidates to include again, and/or (2) they had readily available cost data in consistent reporting formats. Other states or utilities may have had data on energy efficiency program cost effectiveness, but if they did not have consistent and transparent metrics reported in a common location, they were not good candidates for this study. ACEEE hopes to continue conducting reviews of this sort and to expand the data set in the next update.

Table 1. States and program administrators covered in the review: electricity programs

	State	Program administrator covered		State	Program administrator covered
1	Arizona	Arizona Public Service Company (APS)	11	New Mexico	Public Service of New Mexico
2	California	IOUs	12	New York	NYSERDA
3	Colorado	Xcel Energy	13	Nevada	NV Energy
4	Connecticut	CEEF (all IOUs)	14	Oregon	Energy Trust of Oregon
5	Hawaii	Hawaii Energy	15	Pennsylvania	IOUs
6	Illinois	Ameren and Com-Ed	16	Rhode Island	National Grid
7	Iowa	IOUs	17	Texas	IOUs
8	Massachusetts	IOUs	18	Utah	Rocky Mountain Power
9	Michigan	All utilities	19	Vermont	Efficiency Vermont

	State	Program administrator covered		State	Program administrator covered
10	Minnesota	Xcel Energy	20	Wisconsin	Focus on Energy

IOUs are investor-owned utilities.

Table 2. States and program administrators covered in the review: natural gas programs

	State	Program administrator covered
1	California	IOUs
2	Colorado	Xcel Energy
3	Connecticut	CEEF
4	Iowa	IOUs
5	Massachusetts	IOUs
6	Michigan	All utilities
7	Minnesota	Xcel Energy
8	Oregon	Energy Trust of Oregon
9	Rhode Island	National Grid
10	Wisconsin	Focus on Energy

IOUs are investor-owned utilities.

We collected 10 data points for 2009 to 2012 annual program years as available. Some states did not yet have 2012 data available, and others only had one or two years available. Not all data points were available for all states. Note that in many cases we had to manipulate the data to permit consistent comparison among programs, e.g., by subtracting out demand response or renewable energy program costs. We provide some details here for each of the data points collected and processed, and we further discuss key challenges and caveats in the next section.

1. *Annual total program costs by program year*. We included energy efficiency program portfolio costs only, not renewable energy or demand response.

2. *Annual program costs by customer class (residential and business)*. Most states categorize classes by residential and business, whereas only a couple of jurisdictions disaggregate business customers into commercial and industrial. Low-income programs are often categorized separately; however we chose to include these programs in the residential category for convenience in reporting.

3. *Shareholder or performance incentives awarded annually as applicable*. We collected data for those states with performance incentives that had been approved for the applicable program

year. In a couple of cases (e.g., Wisconsin), performance incentives are awarded on a cumulative-year basis, and so they were not yet approved and were not included in our estimates.

4. *Annual costs by type (customer incentives, non-incentive program costs, and shareholder/performance incentives).* Several of the jurisdictions in our review reported customer incentives as a distinct category, and some reported numerous other categories of spending such as administrative, research and development, education, and marketing. In these cases, we combined all non-incentive costs into one category. Other states may have reported program costs as distinct from administrative or EM&V; however it was unclear whether the definition of program costs included both customer incentives and other program-related costs.

5. *Annual participant cost estimates.* Only a handful of states explicitly and readily report participant contributions to energy efficiency measures, or at least report full incremental measure costs. It is possible to derive participant cost contributions by subtracting incentives from full incremental measure costs.

6. *Gross and net energy (kWh and therms) savings reported, both total and by customer class.* We collected both gross and net electricity and natural gas savings from efficiency programs, and by customer class if available. For electricity savings, we noted whether savings were reported at site or at generation. We also collected some data on electricity demand (kW) impacts, but not comprehensively enough to report here.

7. *Applicable electricity sales within jurisdiction.* We collected electricity sales for the jurisdictions included in the state for 2010, which is the most readily accessible data point from the Energy Information Administration (EIA) for all jurisdictions. We collected electricity sales data in order to normalize savings as a percentage of sales and to compare this metric to CSE values.

8. *Measure lifetimes by customer class.* As available, we collected measure lifetimes by customer class and in aggregate for the entire portfolio as an input to CSE calculations.

9. *Cost-effectiveness test ratios.* We collected these for TRC tests and UCT/PACT, as available.

10. *Weighted average cost of capital assumed in cost-effectiveness calculations.* In some cases, program administrators reported their own utility CSE values. We collected the weighted average cost of capital (WACC) that was assumed for these calculations, along with aggregate measure lifetimes, in order to derive first-year cost assumptions. Also, we were interested in this metric in general to compare to our own assumptions, and so we also collected WACC and social discount rate assumptions for other states as available.

CHALLENGES AND CAVEATS

As previously discussed, there are a number of challenges involved in the collection and comparative review of national energy efficiency cost-effectiveness data. In light of these, the goal of this report is not to compare one state's efficiency portfolio results to others, but to present overall information and trends in energy efficiency program costs and cost effectiveness—and also to improve the transparency of key data issues. This section explores several of the challenges and discusses our approach to improving consistency within the dataset.

Variation In Reporting Formats, Frequency, And Timing

Most utilities and program administrators prepare annual reports on the impacts of efficiency programs, and some prepare reports more frequently, e.g., semiannually or quarterly. The frequency and formats are usually based on regulator requirements; however this varies by state. In some limited cases, annual reports present only cumulative data for multiple years and not distinct annual results.

The location and consistent availability of reports vary significantly by state. Some utilities and program administrators post reports on their own websites, others file them on commission websites or within commission dockets, some states have a separate website hosted by an advisory group, or there may be combination of these approaches. Program administrators who do not produce reports that are readily available in a common location were less likely to be included in this study.

Most program administrators are required by their regulators to calculate cost and energy impacts separately for electricity and natural gas programs (and they may also present combined results). A few states combine electricity and natural gas programs in their reporting. In some cases, on request, program administrators suggested a methodology for disaggregating program costs; in other cases we were unable to disaggregate the data and so these jurisdictions were not good candidates for this type of review. Similarly, renewable energy programs or demand response programs were sometimes combined in the overall reporting of cost-effectiveness metrics. In these cases we backed out these program costs and savings impacts to isolate the energy efficiency programs.

Variation In Reporting of Net or Gross Energy Savings, and At-Site or At-Generation Electricity Savings

As discussed earlier, we chose to calculate and report CSE values based on net energy savings. The great majority of jurisdictions in this review reported net energy savings values. A couple of states or program administrators explicitly assume that net and gross savings are equivalent, i.e., that there is a 100% NTG ratio. Only a couple of states in our data set (Minnesota and Nevada) do not estimate net savings; in those cases we adjusted gross savings figures by an NTG ratio of 0.9 to estimate net savings and make them more comparable to net savings figures reported by other states.[16] An NTG ratio of 0.9 falls within the range of factors used by several states in calculating net energy efficiency savings.

As discussed earlier, some states report electricity savings at the customer or site level while others report savings at the generation level. At-site savings appear to be the most common and longstanding approach to measuring and evaluating energy savings; moreover most

[16] This methodology is consistent with ACEEE's *State Energy Efficiency Scorecard* (Downs et al. 2013).

state EERS are established as a percentage of retail sales. For these reasons, this review presents at-site energy savings data. In some cases we converted at-generation savings to at-site savings assuming the same line loss factor used by the reporting entity.

Demand Response

Many program administrators combine their reporting of energy efficiency (EE) and demand response (DR) programs in their overall demand-side management reports and evaluations.[17] While EE aims to reduce overall energy usage (kWh), DR aims to curtail demand (kW) only during peak hours or to shift usage from peak hours to off-peak hours. As demand-side resources, EE and DR have documented synergies; for example, EE can contribute on-peak demand reductions, and DR can produce some kWh savings. However they remain fundamentally different resources. This review focuses exclusively on EE costs and energy (kWh) savings. In some cases we had to subtract out DR costs from reported spending to focus on EE costs and benefits.

Structural Differences in Program Portfolios

In addition to variations in reporting and evaluation methods, numerous differences in the structure of efficiency programs can affect efficiency costs. The type of programs offered, the relative share of program savings from different customer classes, and the range of eligible efficiency measures can all affect program cost effectiveness. These factors can also impact the balance of incentive versus non-incentive program costs. While this study does not tease out costs by program type, we do classify costs by customer class and try to identify trends. For trends in costs at the program level, readers should review an analysis by the Lawrence Berkeley National Laboratory (LBNL 2014).

Differences In Program Cost Type Definitions

As discussed earlier, energy efficiency program administrators commonly incur the following types of costs as the direct costs to administer programs, with the nomenclature and reporting often inconsistent across jurisdictions:

a. direct rebates or incentives to customers
b. engineering or technical support
c. program administration, planning, and delivery
d. EM&V
e. marketing and education

In particular, the definition of cost categories such as "administrative" varies by state, and sometimes categories are not disaggregated. Nor is this an exhaustive list of current or future cost types. Emerging programs such as behavioral and loan programs may require new cost-type definitions.

In addition, whether a program administrator earns a shareholder or performance incentive can increase the cost of energy efficiency resources. Also, we note that some states have an

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[17] Demand response is also referred to as load management; however "demand response" is the more modern term.

incentive mechanism in place but they award it on a cumulative basis. If the award had not yet been finalized for program years 2009-2012, we did not include it in this analysis. Future work on CSE values could develop a methodology for estimating average annual values in such instances.

CALCULATIONS AND ASSUMPTIONS

After the data collection process, we first converted all cost data by program year to 2011$ using GDP deflators from the Bureau of Economic Analysis (BEA).

Utility CSE

In the 2009 review, ACEEE presented the CSE as reported by the state in many cases, while calculating the CSE for some states. Reported values have the limitation that input assumptions may not be clear, which create inconsistencies in the data set. For this update, to attempt a more consistent review and methodology, we instead calculate the CSE for each state, as shown below.

To calculate the CSE, we multiply annual energy efficiency program costs (C) by a capital recovery factor and then divide by the annual energy savings (D). The calculation for the capital recovery factor, which is used as a way to levelize or spread the costs over a specified period of time and assumed interest rate, is shown below. For consistency, we use the same real discount rate (A) for all jurisdictions. We use each state's estimated measure lifetime (B), program costs (C), and net energy savings (D). We discuss each of these elements in further detail below.

The CSE calculation is:

CSE in $/kWh = (C) x (capital recovery factor)/(D)

where:
A = Real discount rate (5%)
B = Estimated measure life in years
C = Total annual program cost in 2011$
D = Incremental net annual energy (kWh or therms) saved by energy efficiency programs
Capital recovery factor = [A*(1+A)^(B)]/[(1+A)^(B)-1]

DISCOUNT RATE The discount rate for energy efficiency cost-benefit analysis depends on the cost-effectiveness test used. For the utility cost test and TRC, jurisdictions typically use the utility's WACC. The SCT takes a societal perspective and should use a lower social discount rate to appropriately value long-term societal perspective. We collected some utility data on WACC rates, and found that they ranged from 7% to 8% over the 2009-2012 period. It was not always clear whether these values were nominal or real; however we presumed them to be nominal rates because they were used for annual reporting and in some cases they were confirmed as nominal.[18] We also collected some data on assumed social discount rates used for cost-effectiveness screening and found they ranged widely from about 1.2% to 6.0% (real).

The current practice of assuming the WACC for energy efficiency cost-effectiveness screening, however, has been criticized as undervaluing the reduced risk of energy efficiency program expenditures versus supply-side investments (Woolf et al. 2012). To reflect the lower financial risk of efficiency investments, some jurisdictions have adopted alternative discount rates for energy efficiency valuation in the UCT and TRC tests, such as a societal discount rate or a risk-adjusted discount rate. In Massachusetts, for example, regulators have acknowledged that energy efficiency resources are a low-risk investment and that a low-risk discount rate is most appropriate for the TRC test (Woolf et al. 2013). In the Northwest, the preferred approach is to use a risk-free discount rate for both supply resource and energy efficiency, and then to explicitly model resource risk (i.e., fuel price, environmental regulation, capital cost, and so forth) in the analysis of resource options (Northwest Power and Conservation Council 2010). This approach improves transparency by requiring that the type and magnitude of risk estimates for each resource are displayed.

For this analysis, we assume a real discount rate of 5% (value A in our CSE calculation) for the overall presentation of the results.[19] This is meant to be fairly consistent with the weighted average utility cost of capital in real terms, and is consistent with the approach in the 2009 ACEEE review of energy efficiency costs. We also report the aggregate CSE values (for all states) in the Results section using a 3% real discount rate and 7% real discount rate to show the impact of this assumption on the results.

MEASURE LIFETIME The estimated measure lifetime in years (B) is based on data from the program administrator, if available. For some states (Colorado, Illinois, Michigan, Nevada, Pennsylvania, and Texas), we were unable to track down average measure lifetime estimates for the entire portfolio. In some cases these states did report program- or measure-specific measure lifetimes; however, due to time constraints, we were unable to go through all program data to develop an average portfolio-wide estimate ourselves. Instead, for these states we assumed an overall 11-year measure lifetime, which was the average of states that did provide data. Similarly, to estimate CSE values by customer class, if state-specific data were not available, we assumed an 8-year measure lifetime for the residential class and 12.5 years for the business class, which were the average values for states that did provide data.

COSTS AND SAVINGS Total program costs (C) and incremental net annual energy savings (D) are based on data collected from the program administrators, as previously discussed and defined. Note that we used net savings (D) as available. Some states assume that net savings

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[18] Real discount rates do not include inflation, whereas nominal discount rates do. Assuming 1% inflation, these nominal WACC rates of 7-8% would range from 6% to 7% in real dollar terms. Assuming 2% inflation, they range from 5% to 6%.

[19] In deciding whether to use a nominal or real discount rate, the key is consistency. This analysis examines energy efficiency program costs in real (2011$) terms, and therefore we apply a real discount rate.

equal gross savings (i.e., a 100% NTG ratio); a couple of states do not estimate net savings, in which case we estimated net savings using an NTG ratio of 0.9.

First-Year Acquisition Costs

We also calculate the first-year acquisition costs ($ per kWh-net or $ per therm-net), as shown below:

First-year cost in $/kWh net or $ per therm net = C / D

where:
C = Total annual program cost in 2011$
D = Incremental net annual energy (kWh or therms) saved by energy efficiency programs

Energy Savings Relative to Sales

For the electricity data set, we collected data on actual electricity sales in each applicable jurisdiction for one year (2010). We then were able to calculate energy savings as a percentage of applicable energy sales in the given jurisdiction. This allowed for a direct comparison of energy savings thresholds to energy costs.

Results

This section presents the results of the review. Data sources for each state can be found in Appendix A.

ELECTRICITY

The review includes electricity energy efficiency program data for the 20 states listed in table 1 above.

Cost of Saved Energy

Our results are focused on the CSE values as presented in figure 1 and table 3 below. We emphasize again that the goal is not to compare results among states, but to present an overall picture of the range and typical values across many different jurisdictions, each of which has its own factors that bear on the costs of efficiency programs. For example, note that the costs in figure 1 range from $0.013/kWh to $0.056/kWh, a spread of about $0.042/kWh.

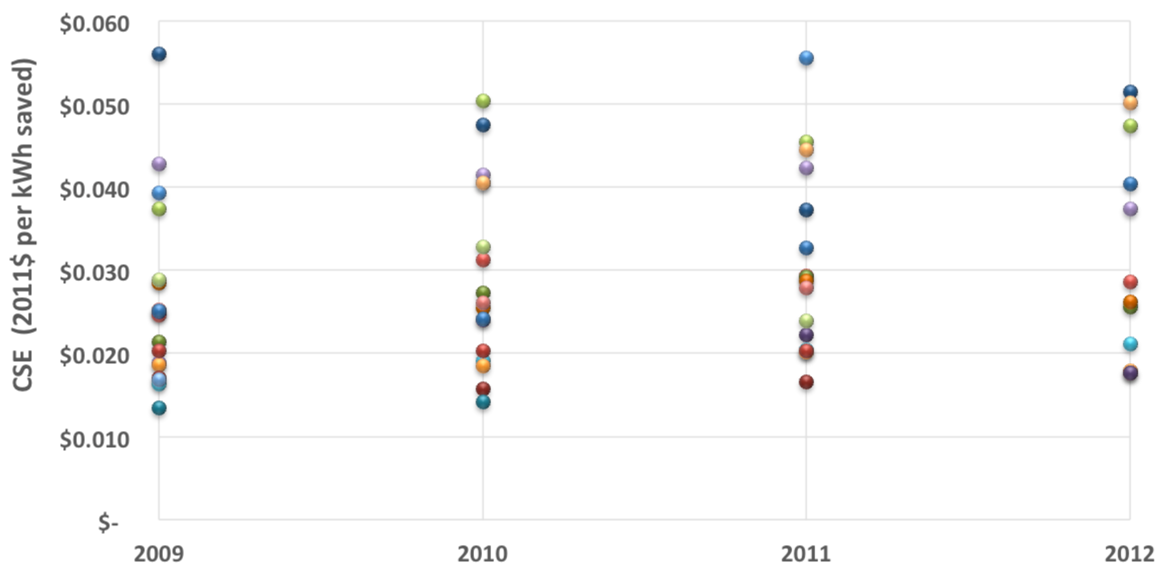

Figure 1. Electricity energy efficiency program CSE by year. Each dot represents average costs for each state in a given year. 2011$ per levelized net kWh at meter. Assumes 5% real discount rate.

Table 3 presents the average for each state for each year, and the state's four-year average from 2009 to 2012. We were unable to calculate data for every state for each year due to missing data points, which means that the overall average for each year represents a varying number of jurisdictions.

Table 3. CSE in $ per levelized net kWh at meter

State	2009	2010	2011	2012	4-year average (2009-2012)
Arizona	$0.016	$0.019	$0.020	$0.021	$0.019
California	$0.039	$0.041	$0.056	n/a	$0.045
Colorado	$0.023	$0.029	$0.027	$0.027	$0.027
Connecticut	$0.037	$0.050	$0.045	$0.047	$0.045
Hawaii	$0.025	$0.024	$0.033	$0.040	$0.031
Illinois	n/a	n/a	$0.019	n/a	$0.019
Iowa	$0.019	$0.018	$0.020	$0.018	$0.019
Massachusetts	$0.056	$0.048	$0.037	$0.051	$0.048
Michigan	$0.017	$0.016	$0.017	$0.018	$0.017
Minnesota	$0.021	$0.027	$0.029	$0.026	$0.026
New Mexico	$0.025	$0.024	$0.022	$0.018	$0.022
Nevada	$0.013	$0.014	$0.016	$0.020	$0.016

State	2009	2010	2011	2012	4-year average (2009-2012)
New York	$0.020	$0.020	$0.020	n/a	$0.020
Oregon	$0.028	$0.025	$0.029	$0.026	$0.027
Pennsylvania	n/a	n/a	$0.017	n/a	$0.017
Rhode Island	n/a	$0.040	$0.044	$0.050	$0.045
Texas	$0.025	$0.026	$0.028	n/a	$0.026
Utah	$0.029	$0.033	$0.024	$0.029	$0.029
Vermont	$0.043	$0.041	$0.042	$0.037	$0.041
Wisconsin	n/a	n/a	$0.022	$0.015	$0.019
Average	**$0.027**	**$0.029**	**$0.028**	**$0.030**	**$0.028**
Median	**$0.025**	**$0.026**	**$0.026**	**$0.026**	**$0.026**
Minimum	**$0.013**	**$0.014**	**$0.016**	**$0.015**	**$0.016**
Maximum	**$0.056**	**$0.050**	**$0.056**	**$0.051**	**$0.048**

2011$. 5% real discount rate. N/A means that we were unable to track down sufficient data for the calculation. Average for each year represents a varying number of states, so they are not directly comparable.

For the four-year average values in the column furthest to the right, we find an overall national average of $0.028/kWh, and a range of $0.016 to $0.048/kWh. As pointed out in the Discussion section, these typical efficiency program costs compare very favorably to the typical costs of new electricity generation.

The values in table 3 vary among states due to numerous factors such as structural differences in program types and share of savings by customer class. For example, portfolios with a larger share of savings from residential programs or low-income programs tend to have higher overall CSE values. (We present some data by customer class for several states later in this section.) On the other hand, program portfolios that rely heavily on low-cost lighting programs, or that have lower shares of savings from low-income programs, tend to have lower CSE values. An analysis by LBNL provides further insight into specific CSE values and ranges for different types of programs (LBNL 2014).

In addition, the eligibility and attribution of non-electricity savings from programs differ by jurisdiction, which can affect the cost of saved electricity. For example in Massachusetts, electric ratepayer funds are used to support investments in oil and propane energy savings. Because the values in table 3 are developed using total electric spending (without adjusting for spending on oil and propane savings) and total electric savings, the cost per unit of electricity savings appears higher than it would if spending were adjusted for non-electricity savings.

The CSE values in figure 1 and table 3 represent costs per net electricity savings, and they assume a 5% real discount rate. This rate is meant to be roughly consistent with the typical nominal utility WACC of about 7%. We also wanted to calculate and compare the values under different real discount rate assumptions. Table 4 presents values for 3%, 5%, and 7% real discount rates.

Table 4. CSE values under various real discount rate assumptions

	3% real discount rate	5% real discount rate	7% real discount rate
Average	$0.025	$0.028	$0.031
Median	$0.023	$0.026	$0.029
Minimum	$0.014	$0.015	$0.018
Maximum	$0.043	$0.048	$0.054

These values represent aggregate 4-year averages (2009-2012) for all states.

Table 4 shows that a difference of 2% in the discount rate assumption can impact the CSE values by about 10-12%, which is minimal compared to the wide margin between energy efficiency portfolios and alternative energy options. For specific programs on the margins, however, the assumed rate can have an impact on whether programs are deemed cost effective.

From a utility resource planning perspective, it is important that analysts use appropriate discount rates for energy efficiency and supply side resources, considering their relative risks and other characteristics, in any levelized cost analyses. As discussed earlier, planners should also consider explicitly modeling resource risk in their analysis of resource options.

All these results reflect energy savings reported at the meter, which is how most states report energy efficiency savings. However, as discussed earlier, the more appropriate metric for comparing costs to supply-side resources may be savings at the generator level, which account for T&D line losses that are avoided by efficiency. EIA estimates a national average line loss factor of 7%.[20] If we convert the savings values at the meter level to the generator level, the average CSE value of $0.028/kWh would decrease by 7% to $0.026/kWh. No matter which method is chosen, the most important thing is that the assumptions be transparent and that avoided T&D line losses be factored into the cost-effectiveness analysis in some way.

First-Year Acquisition Costs

In addition to the CSE values, in figure 2 and table 5 we present the first-year program costs (non-amortized), which are often called acquisition costs. As noted earlier, first-year costs

[20] See http://www.eia.gov/tools/faqs/faq.cfm?id=105&t=3

can be useful for program budgeting purposes, but we caution that this metric is not reflective of the full resource value of efficiency.

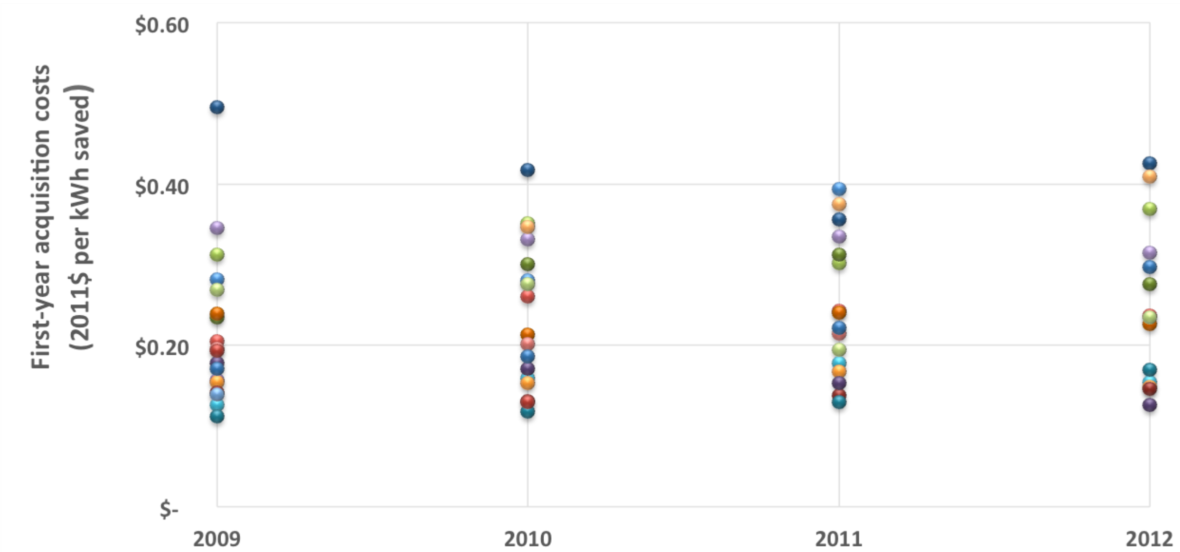

Figure 2. Electricity energy efficiency program first-year acquisition costs by year

Table 5. First-year acquisition costs

State	2009	2010	2011	2012	4-year average (2009-2012)
Arizona	$0.13	$0.16	$0.18	$0.15	$0.15
California	$0.28	$0.28	$0.39	n/a	$0.32
Colorado	$0.20	$0.26	$0.24	$0.24	$0.24
Connecticut	$0.31	$0.35	$0.30	$0.37	$0.33
Hawaii	$0.17	$0.19	$0.22	$0.30	$0.22
Illinois	n/a	n/a	$0.16	n/a	$0.16
Iowa	$0.15	$0.15	$0.17	$0.15	$0.16
Massachusetts	$0.49	$0.42	$0.36	$0.43	$0.42
Michigan	$0.14	$0.13	$0.14	$0.15	$0.14
Minnesota	$0.23	$0.30	$0.31	$0.28	$0.28
New Mexico	$0.18	$0.17	$0.15	$0.13	$0.16
Nevada	$0.11	$0.12	$0.13	$0.17	$0.13
New York	$0.21	$0.21	$0.21	n/a	$0.21
Oregon	$0.24	$0.21	$0.24	$0.23	$0.23
Pennsylvania	n/a	n/a	$0.14	n/a	$0.14
Rhode Island	n/a	$0.35	$0.37	$0.41	$0.38

State	2009	2010	2011	2012	4-year average (2009-2012)
Texas	$0.20	$0.20	$0.22	n/a	$0.20
Utah	$0.27	$0.28	$0.20	$0.23	$0.24
Vermont	$0.35	$0.33	$0.34	$0.31	$0.33
Wisconsin	n/a	n/a	$0.19	$0.13	$0.16
Average	$0.23	$0.24	$0.23	$0.24	$0.23
Median	$0.21	$0.21	$0.21	$0.23	$0.21
Minimum	$0.11	$0.12	$0.13	$0.13	$0.13
Maximum	$0.49	$0.42	$0.39	$0.43	$0.42

2011$ per first-year net kWh at meter. N/A means that we were unable to track down sufficient data for the calculation. Average for each year represents a varying number of states, so they are not directly comparable. Values vary among states due to numerous factors such as structural differences in program types and share of savings by customer class.

Participant Costs

Program administrators use estimates of participants' costs for energy efficiency measures as inputs to the TRC test and the SCT.[21] Program administrators typically estimate participant costs either through deemed measure costs or for custom-based programs through actual reporting by customers.

Unfortunately most program administrators do not explicitly include participant cost estimates or participant benefits in their annual reporting. However they are implicit in their TRC outcomes. It might be possible to use TRC values as compared to UCT values to derive estimates of participant costs, but this approach has obvious caveats: cost-benefit tests do not make transparent all the annual values or discount rate assumptions, and they use a net present value basis. Further work should more fully explore participant cost and associated participant benefit estimates.

Several program administrators did report estimates of annual participant contributions, or made it possible to derive participant costs as the difference between incremental measure costs and incentives paid to participants. Although limited, we report these estimates along with program costs for the states listed in table 6 below, but we caution that there are significant caveats.

[21] Participant costs are the additional costs incurred by program participants net of any incentives paid to them by program administrators.

Table 6 shows that the ratio of participant costs to program costs varies significantly by state. The ratio depends largely on the nature of the programs, e.g., the level of participant rebates versus non-financial incentives including technical assistance and marketing.

Table 6. Combined program and participant cost estimates

State	Program cost estimate	Ratio of participant costs to program costs	Participant cost estimate	Combined program and participant cost estimate
Hawaii	$0.033	149%	$0.049	$0.076
Illinois	$0.016	115%	$0.018	$0.041
Iowa	$0.019	159%	$0.030	$0.049
New York	$0.020	262%	$0.053	$0.073
Pennsylvania	$0.018	159%	$0.029	$0.043
Rhode Island	$0.045	25%	$0.011	$0.056
Wisconsin	$0.019	118%	$0.022	$0.041
Average for this dataset	**$0.024**	**141%**	**$0.030**	**$0.054**

2011$ per kWh levelized

For these seven states, the ratio of participant costs to program costs ranges from 25% to 262%, and the simple average is 141%. In other words, for every $1 invested by the program administrator, participants are estimated to spend on average an additional $1.41 on efficiency upgrades.

The sum of program costs and participant costs on average for these states is $0.054 per kWh levelized. However, given the limited dataset, this figure is highly uncertain and does not represent a national average. It is also important to recognize that this metric is not an appropriate comparison to the utility cost of supply-side resources, because it captures participant costs which are not incurred by utilities.[22]

The 2009 ACEEE review similarly collected participant costs for about six program portfolios and found that on average participants contributed $0.83 for every $1 invested by program administrators. Again, these values varied significantly across jurisdictions. The states included in the 2009 review were different from the ones in this review (only three states were included in both reviews), which explains the large difference between the 2009 results and those presented in table 6. Overall, much caution is warranted in making comparisons among jurisdictions about participant costs.

[22] The inclusion of participant costs in a cost-effectiveness test also requires incorporating participant non-energy benefits for a systematically balanced calculation. For example, see http://www.nhpci.org/publications/NHPC_EE-Screening-Coalition-Position-Paper-final_20131118.pdf.

Benefit-Cost Ratios

Next we present the benefit-cost (B/C) ratios as reported by program administrators. While the CSE values represent only the cost side of the cost-effectiveness equation, the B/C ratios represent a more complete picture of how program costs compare to program benefits. It is important to note that the benefits side of the equation can also vary significantly from state to state. Benefits include avoided energy, capacity, and T&D costs for the UCT, as well as participant and other system-wide non-energy benefits for the TRC test. Moreover, as noted earlier, implementation of the TRC test is incomplete in many states, i.e., the range of benefits calculated can vary significantly.

As in our review of CSE values, our goal is not to directly compare B/C ratios, but to present overall trends. Although most states conduct the TRC test when evaluating energy efficiency cost effectiveness, the results are not always presented clearly in reports. Therefore the TRC results presented in table 7 reflect only 9 of the 20 states. The results show that energy efficiency benefits in these states exceed costs by a factor of 1.24 to 4.0. In other words, each dollar invested by program administrators and customers in energy efficiency measures yields $1.24 to $4.00 in benefits to all customers.

Table 7. Benefit-cost ratios for TRC tests

State	2009	2010	2011	2012
California	1.83	1.61	1.24	n/a
Colorado	3.66	2.87	2.47	2.09
Hawaii	n/a	1.40	1.60	2.60
Illinois	2.15	2.84	2.24	n/a
Iowa	2.54	2.06	2.10	2.34
Massachusetts	3.28	3.11	4.00	3.50
New Mexico	1.57	2.20	1.78	2.63
Utah	1.99	1.68	1.95	2.00
Wisconsin	n/a	n/a	2.84	3.26
Minimum	**1.57**	**1.40**	**1.24**	**2.00**
Maximum	**3.66**	**3.11**	**4.00**	**3.50**

Savings by Customer Class

Figure 3 displays the results of electricity savings in several jurisdictions by customer class for 2009-2012. (17 states readily reported savings by customer class.[23]) Jurisdictions with the highest share of savings from residential customers are on the left, and those with the highest share of savings from business customers are on the right.

[23] Some of the other jurisdictions reported savings at the program level, but did not aggregate by customer class.

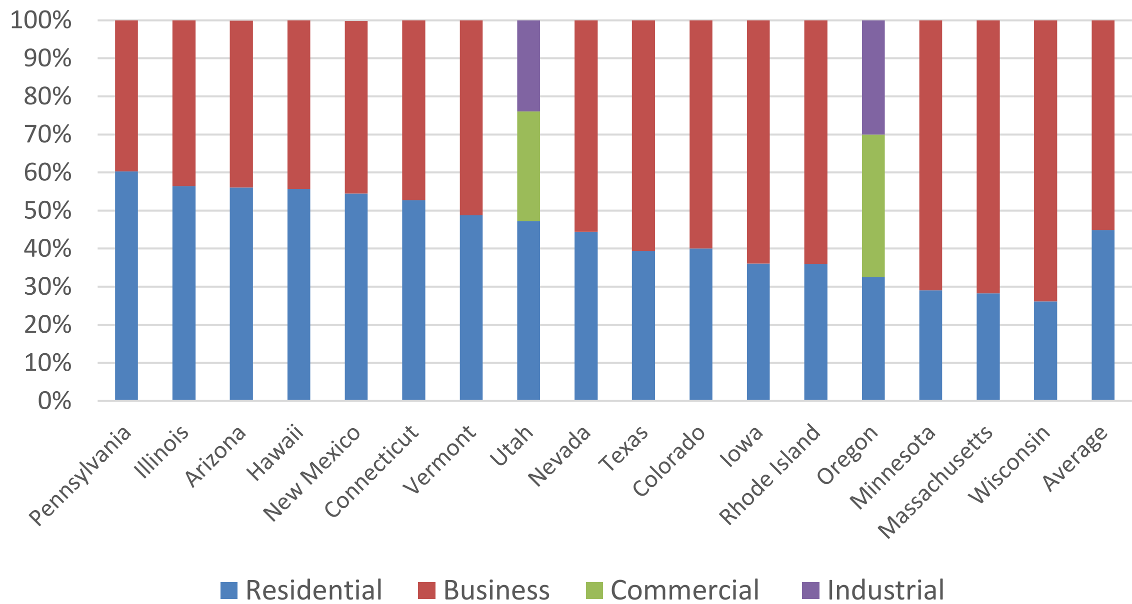

Figure 3. Electricity savings by customer class. Program administrators often report low-income programs as a separate category; we include these with residential savings. Most jurisdictions report savings in aggregate for residential customers and for business customers. Only Utah and Oregon readily reported commercial and industrial customer categories separately.

As shown in the column furthest to the right, the average savings by customer class amount to 45% from residential customers and 55% from business customers. However this ratio varies significantly by state; for example, the share of savings from residential programs ranges from 60% to 26%. There are several likely reasons for this variation. For example, the relative size of energy savings potential by customer class itself can differ from state to state, or regulators may require that a specific share of savings come from specific customer classes.

In general it appears that jurisdictions that are newer to broad-scale energy efficiency portfolios (e.g., Pennsylvania, Illinois, Arizona, and New Mexico) have a higher share of savings from residential customers, while states with more mature portfolios (e.g., Minnesota, Massachusetts, Oregon, and Rhode Island) have a higher share of savings from business customers. New program development tends to start with a large portion of funding to mass residential lighting and appliance programs, and a smaller portion to business programs, before launching into more comprehensive programs for business customers.

There is no optimal mix of savings by customer class because it may vary significantly by jurisdiction. Also, stakeholders must consider a number of factors in addition to cost effectiveness (e.g., equity) to ensure that all customer segments benefit from efficiency programs. In sum, these data show that the portion of savings by customer class can vary significantly by state, and this is a likely factor in the overall average CSE values. See the section on Costs by Customer Class for further discussion.

Measure Lifetime Estimates

Energy efficiency upgrades continue saving energy over the lifetime of the measure installed. The estimate of measure lifetime is an important factor in calculating the cost of energy efficiency resources. As with many metrics, states vary in their explicit reporting of this figure. Table 8 presents the average electricity measure lifetimes by customer class (if available) for several jurisdictions, either as they were explicitly reported or as we derived them by dividing lifetime energy savings estimates by annual energy savings estimates. For these jurisdictions, the average measure lifetime for residential programs is 8 years, for business programs, about 13 years, and for the overall portfolio, about 11 years.

Table 8. Average electricity measure lifetimes by state and customer class

State	Residential	Commercial/business	Industrial	All sectors
Arizona	7.3	13.4	n/a	9.8
California	n/a	n/a	n/a	9.1
Connecticut	6.5	12.8	n/a	9.6
Hawaii	6.7	12.3	n/a	9.2
Massachusetts	8	13	n/a	11.6
Minnesota	n/a	n/a	n/a	13.8
New Mexico	8	10	n/a	8.9
Oregon	10.6	13.5	9.5	11.2
Rhode Island	9.1	12.3	n/a	11.1
Utah	n/a	n/a	n/a	11.3
Vermont	7.7	13.1	n/a	11
Wisconsin	9	12.4	n/a	11.4
Average	**8.1**	**12.5**	**9.5**	**10.6**

Values for each state typically represent the average over the 2009-2012 program period, although data were not available for all years in each state.

Costs by Customer Class

We can discern some trends from the CSE results of electricity efficiency resources by customer class. First-year costs are comparable for both residential and business (commercial and industrial) programs at about $0.22/kWh. However, because business energy efficiency measures tend to have longer measure lifetimes (an average of 12.5 years in this electricity data set) than residential measures (8.1 years), the levelized CSE is on average lower for business program portfolios than for residential portfolios. We calculated electricity CSE values by customer class for 9 states as shown in figure 4 and table 9, and identified an average CSE of $0.037/kWh for residential portfolios and $0.027/kWh for business portfolios.[24]

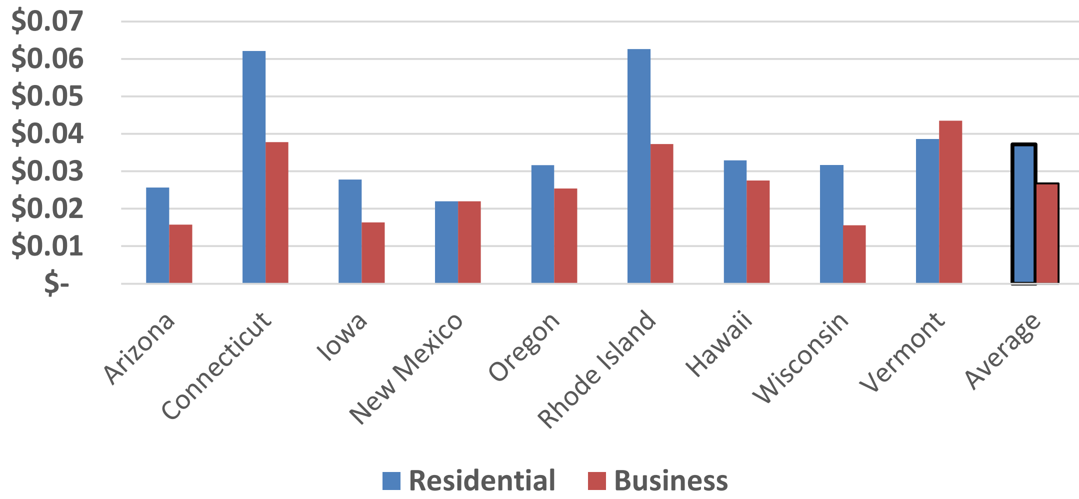

Figure 4. Electricity CSE by state and customer class, and average

Table 9. Electricity CSE by state and customer class

State	Residential	Business	All Sectors
Arizona	$0.026	$0.016	$0.019
Connecticut	$0.062	$0.038	$0.045
Iowa	$0.028	$0.016	$0.019
New Mexico	$0.022	$0.022	$0.022
Oregon	$0.032	$0.025	$0.027
Rhode Island	$0.063	$0.037	$0.045
Hawaii	$0.033	$0.028	$0.031
Wisconsin	$0.032	$0.016	$0.019
Vermont	$0.039	$0.044	$0.041
Average	**$0.037**	**$0.027**	**$0.030**

$ per kWh levelized

We selected states that had readily available data for all three components of this calculation: savings, costs, and measure lifetime by customer class. While the average difference between customer class portfolio costs is about $0.01/kWh higher for residential programs, figure 4 demonstrates that it can vary significantly by state. A couple of states

[24] Note that the overall average CSE for this limited set of states is $0.030/kWh, which is slightly higher than the complete data set average value of $0.028/kWh.

have cost differences of about $0.02/kWh higher for residential programs, while other states exhibit very negligible differences, and a few states have business programs that cost more than residential portfolios. Note also that the residential portfolio includes low-income programs, which tend to have higher CSE values and therefore (depending on the size of the programs) will have an impact on the overall residential CSE values.

We did not review individual program CSE values; however it is worth noting that there is significant variation in CSE value by program type. A report by LBNL provides information at the program level (LBNL 2014). These results again demonstrate the significant variation among jurisdictions in CSE trends by customer class. The estimates of measure lifetime values in particular are a large factor in determining CSE values.

Costs by Type

Figure 5 breaks down efficiency program costs by type, including customer incentives, performance incentives, and non-incentive program costs such as marketing, EM&V, and administrative costs.

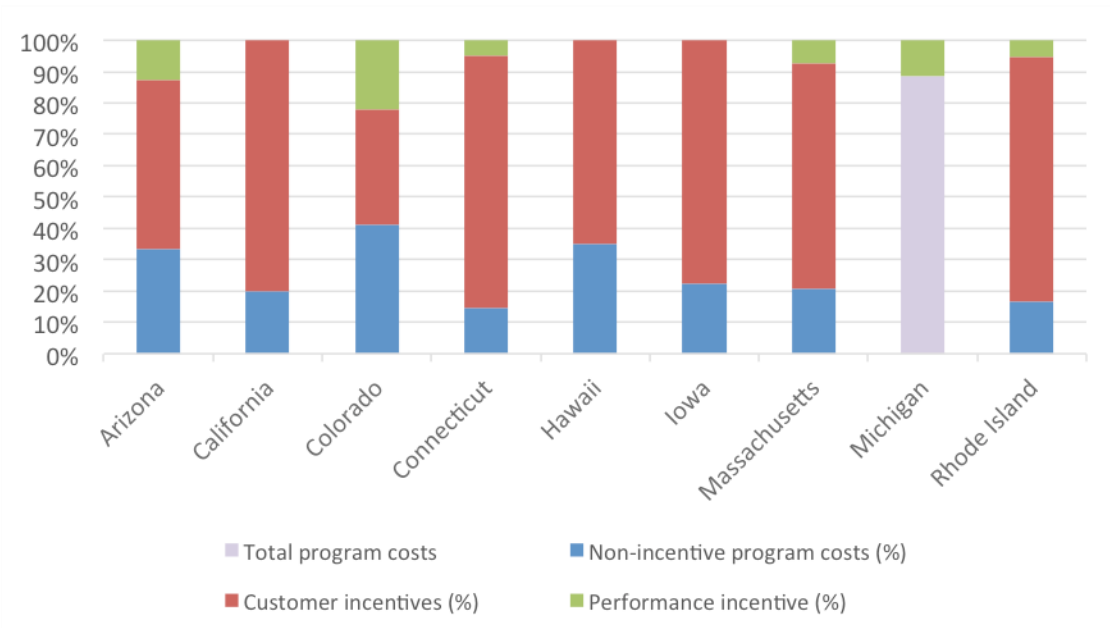

Figure 5. Electricity energy efficiency program costs by type. Some states did not explicitly define costs as customer incentives; for example, California uses the term "direct implementation costs" and Connecticut, "direct program costs." However we took these to mean customer incentives.

Since definitions of cost types vary from state to state, there is significant uncertainty in directly comparing states. In particular, the types of costs included in the non-incentive program category can vary significantly. For the 8 states shown in figure 5, for instance, non-incentive program costs range from about 15% to 40%. One example that might help explain this range is mass marketing-based programs. As programs ramp up marketing and outreach as a way to increase participation and spur market transformation, this type of spending would fall into non-incentive costs. However it might have the same if not higher energy savings impact as spending on direct incentives. Spending categories may need to shift as next-generation efficiency programs develop.

CSE Relative to Electricity Savings Thresholds

The hypothesis that programs with higher savings also have higher CSE values has been suggested but not readily demonstrated. This idea is especially relevant because as program administrators face increasing energy savings targets, they fear that program costs will rise as they go after higher savings. To test this hypothesis, we compare CSE values for each jurisdiction with relative electricity savings thresholds, i.e., savings as a percentage of applicable retail electricity sales. Figure 6 shows the scatter plot of these results, where each dot represents an individual jurisdiction for an individual year. Note that we were not able to present these data for all states.

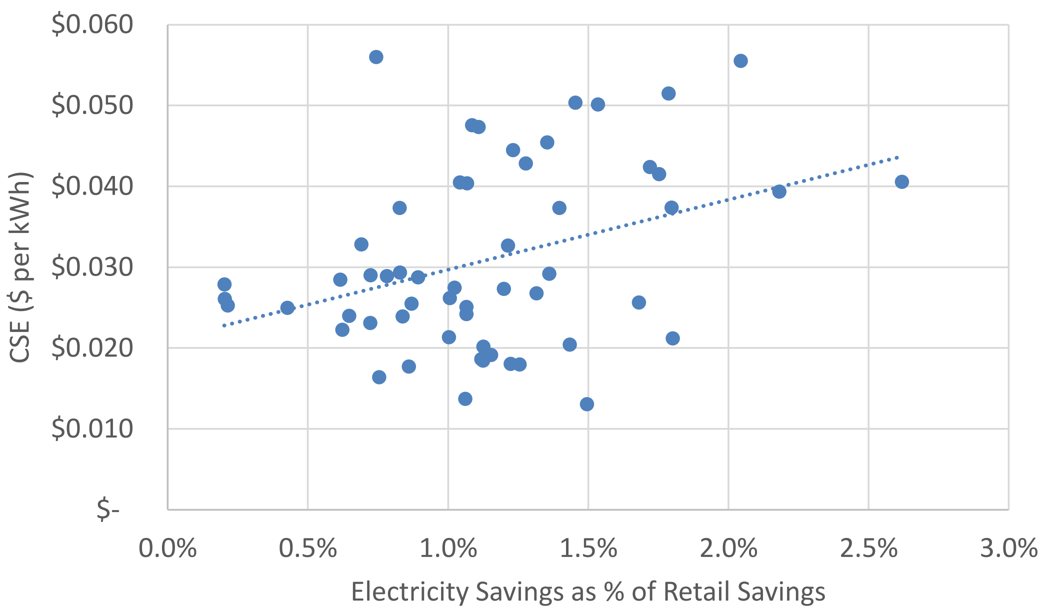

Figure 6. CSE values relative to electricity savings as a percentage of sales

We calculated the Pearson correlation coefficient (r) for this data set in Excel. This correlation coefficient is a measure of how well two data arrays are linearly related or dependent. Correlation tests do not indicate a causal relationship between two variables; rather, they measures the strength of a linear association. The correlation coefficient may range from +1.0 to -1.0, where 1 is a total positive correlation, 0 is no correlation, and -1 is a total negative correlation. An r value of greater than 0.7 is generally regarded as strong, whereas an r value of less than 0.3 is generally regarded as weak. Values in between are considered moderate. However these general guidelines should not be regarded as strict rules; the strength ascribed to a particular value depends on the context and purpose of the calculation. Studies that use scientific data, for example, may require much higher values than social science data to indicate strength in correlation.

The r value for the data set in figure 6 is 0.27, which indicates a positive, but low or weak correlation between CSE and electricity savings as a percentage of sales. These findings cast doubt on the hypothesis that programs with higher electricity savings levels are associated with higher CSE values. In fact, other analysis suggests that CSE values may decrease as savings levels increase, due to factors such as economies of scale (Takahashi and Nichols 2008). Our findings indicate that many robust program portfolios can exceed and are exceeding 1% or 1.5% savings as a percentage of sales while maintaining a cost-effective portfolio.

While these general findings are notable, there are many differences in the data points. For example, individual jurisdictions may have different program types or share of savings by customer class. Future work should examine trends over time for individual jurisdictions and within regions.

NATURAL GAS

The review includes natural gas energy efficiency program data for 10 states as shown in table 2 above.

Cost of Saved Energy

Figure 7 shows CSE results by jurisdiction and year.

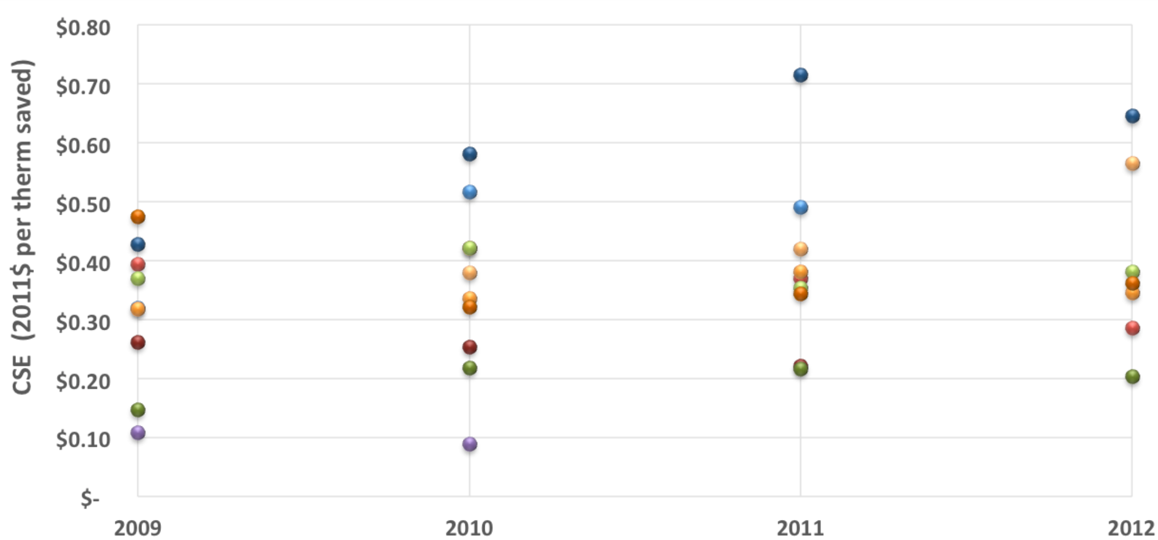

Figure 7. Natural gas CSE results by year. Each dot represents average costs for each state in a given year. 2011$ per levelized net therm at site. Assumes a 5% real discount rate.

Table 10 shows CSE values by state for each year, as well as the average, median, minimum, and maximum values for each year across the 10 jurisdictions, and for the average of 2009-2012. The CSE ranges from $0.15 per therm to $0.71 per therm across the time period, with a four-year average of $0.35 per therm.

Table 10. Natural gas efficiency CSE results by state

State	2009	2010	2011	2012	4-year average (2009-2012)
Colorado	$0.39	$0.42	$0.37	$0.29	$0.37
Connecticut	$0.37	$0.42	$0.35	$0.38	$0.38
California	$0.32	$0.52	$0.49	n/a	$0.44
Iowa	$0.32	$0.34	$0.38	$0.34	$0.34
Massachusetts	$0.43	$0.58	$0.71	$0.64	$0.59
Michigan	$0.26	$0.25	$0.22	n/a	$0.25
Minnesota	$0.15	$0.22	$0.22	$0.20	$0.20
Oregon	$0.47	$0.32	$0.34	$0.36	$0.37
Rhode Island	n/a	$0.38	$0.42	$0.56	$0.45
Wisconsin	n/a	n/a	$0.11	$0.09	$0.10
Average	**$0.34**	**$0.38**	**$0.36**	**$0.36**	**$0.35**
Median	**$0.34**	**$0.38**	**$0.36**	**$0.35**	**$0.37**
Minimum	**$0.15**	**$0.22**	**$0.11**	**$0.09**	**$0.10**
Maximum	**$0.47**	**$0.58**	**$0.71**	**$0.64**	**$0.59**

2011$ per therm at site. 5% real discount rate. N/A means that we were unable to track down sufficient data for the calculation. Average for each year represents a varying number of states, so they are not directly comparable. Values vary among states due to numerous factors such as structural differences in program types and share of savings by customer class.

First-Year Acquisition Costs

Figure 8 shows the results of the first-year costs by jurisdiction and year.

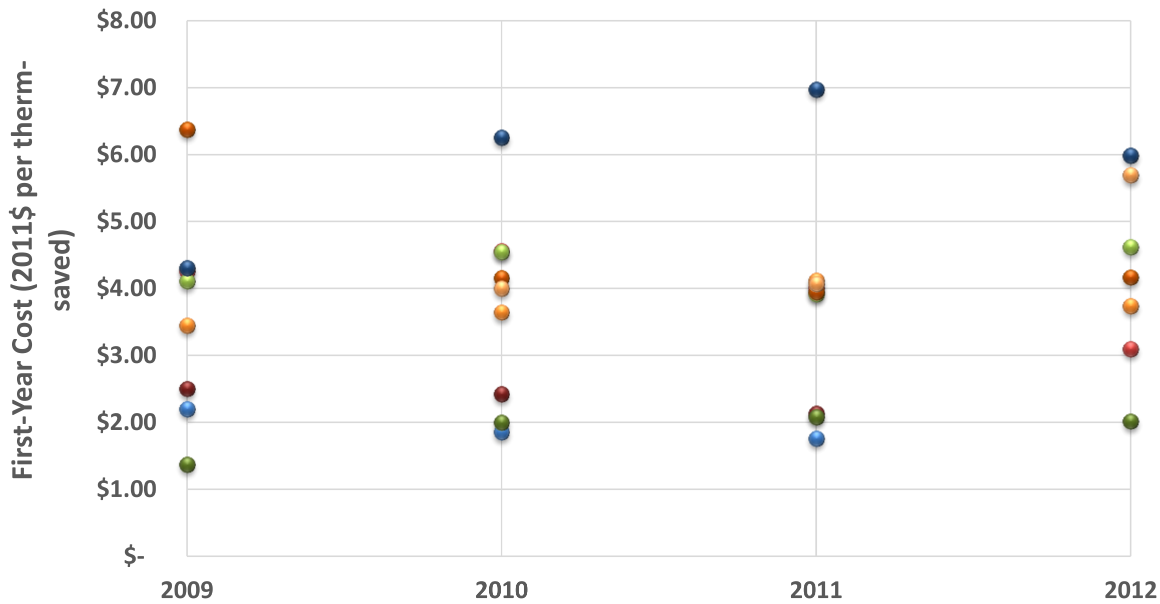

Figure 8. Natural gas first-year acquisition costs by year. Each dot represents average costs for each state in a given year.

Table 11 shows the average, median, minimum, and maximum values for each year across the 9 jurisdictions, and for the average of 2009-2012. The first-year acquisition cost ranges from $1.37 per therm to $6.97 per therm across the time period, with an overall average of $3.73 per therm.

Table 11. Natural gas efficiency first-year cost results

	2009	2010	2011	2012	4-year average (2009-2012)
Colorado	$4.26	$4.56	$4.00	$3.1	$3.98
Connecticut	$4.11	$4.55	$3.92	$4.6	$4.30
California	$2.20	$1.86	$1.76	n/a	$1.94
Iowa	$3.45	$3.64	$4.12	$3.74	$3.74
Massachusetts	$4.30	$6.25	$6.97	$5.99	$5.88
Michigan	$2.84	$2.75	$2.40	n/a	$2.66
Minnesota	$1.37	$1.99	$2.08	$2.01	$1.86
Oregon	$6.37	$4.16	$3.95	$4.17	$4.66
Rhode Island	n/a	$4.00	$4.07	$5.69	$4.59
Wisconsin	n/a	n/a	$1.13	$0.95	$1.04
Average	**$3.61**	**$3.75**	**$3.70**	**$4.19**	**$3.73**

	2009	2010	2011	2012	4-year average (2009-2012)
Median	$3.78	$4.00	$3.95	$4.17	$3.98
Minimum	$1.37	$1.86	$1.76	$2.01	$1.86
Maximum	$6.37	$6.25	$6.97	$5.99	$5.88

$ per therm. N/A means that we were unable to track down sufficient data for the calculation. Average for each year represents a varying number of states, so they are not directly comparable. Values vary among states due to numerous factors such as structural differences in program types and share of savings by customer class.

Measure Lifetimes

We also collected gas efficiency measure lifetimes overall and by customer class, as presented in table 12.

Table 12. Average natural gas measure lifetimes by state and customer class

State	Residential	Commercial/business	Industrial	All sectors
California	n/a	n/a	n/a	17.6
Connecticut	18.0	13.9	n/a	17.1
Massachusetts	13.2	12.9	n/a	13.1
Minnesota	n/a	n/a	n/a	13.2
Oregon	23.1	18.2	14.0	19.8
Rhode Island	19.1	12.1	n/a	14.4
Vermont	18.1	17.6	n/a	18.0
Wisconsin	24.2	13.3	n/a	15.4
Average	**19.3**	**14.7**	**14.0**	**16.1**

Average values for each state typically represent the average over the 2009-2012 program period, although data were not available for all years in each state. For example Massachusetts data represent 2012 only, and Wisconsin data represent 2011-2012 average.

The average measure lifetime is about 16 years overall. Unlike electricity measures, which tend to have longer lifetimes for business than for residential measures, natural gas efficiency measure lifetimes tend to be longer for residential measures. This is likely due to the prevalence of equipment replacement and residential building shell measures for residential programs.

Due to the limited available data, we did not calculate CSE values by customer class for natural gas efficiency programs.

Discussion and Recommendations

The results of this review provide a large data set that we can draw on for a discussion of energy efficiency program costs. First we discuss program costs in terms of cost effectiveness and as compared to supply-side options. Second, we discuss issues related to the consistency and transparency of energy efficiency reporting, and we make recommendations for improvements. Third, we discuss areas for further research that can build upon the findings of this review.

ENERGY EFFICIENCY COSTS COMPARED TO SUPPLY-SIDE OPTIONS

This review finds that energy efficiency programs are clearly the least-cost resource option compared to new energy supply resources. Here we discuss the results of our efficiency program cost review compared to typical costs for supply-side resource. A couple of important caveats are worth noting. First, we do not try to conduct a new cost-benefit analysis here; rather, we aim to provide a high-level discussion. Energy efficiency offers multiple benefits to utilities and program administrators—as well as to society and to participants—which we do not analyze for this study. Second, this discussion compares efficiency program costs to indicators of current avoided energy- and capacity-related costs. A complete cost-benefit analysis compares the costs of efficiency programs to *forecast* avoided energy costs, because efficiency measures continue to provide energy savings over their useful lifetimes. Examining forecasted avoided energy costs would show additional benefits if avoided energy costs are expected to increase in future years.

Electricity

Figure 9 shows the CSE results from this analysis alongside data from Lazard, an energy industry analysis firm, for national averages of new electricity generation options (Lazard 2013). On a levelized cost basis, new electricity energy efficiency programs cost about one-half to one-third as much as new electricity generation resources.

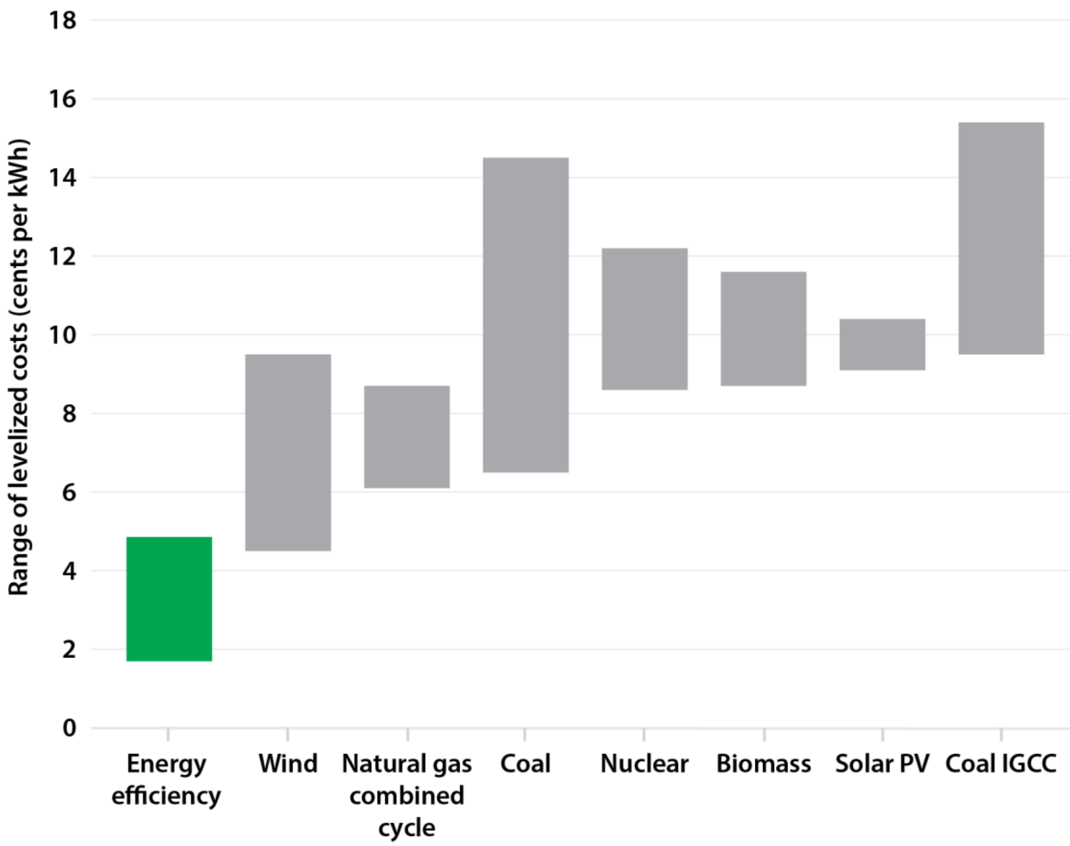

Figure 9. Levelized costs of electricity resource options. *Source:* Energy efficiency data represent the results of this analysis for utility program costs (range of four-year averages for 2009-2012); supply costs are from Lazard 2013.

The costs for all resources in figure 9 are presented as a range, which is indicative of the variability and uncertainty implicit in any energy resource option for new electricity generation. The results of our energy efficiency program cost review may at first seem to display an overly wide variation across states; however, when seen next to supply-side options, this variation is not unlike what we find in other resource options.

Comparing efficiency program costs to other new electricity resource options on a levelized cost basis provides useful context. However it does not tell the complete cost-effectiveness story for energy efficiency. When done properly, efficiency cost-benefit analysis should be more comprehensive. The utility cost test, for example, compares efficiency costs to the utility's avoided energy-related costs and capacity-related costs (as well as avoided T&D and other benefits to utilities). States use different methodologies for calculating avoided costs. Due to differences in methodology, economics, and market structures, avoided costs can vary significantly by jurisdiction, and may represent various mixes of the resources shown in figure 9. A complete utility cost-test analysis should consider additional benefits to utilities such as avoided T&D, wholesale price mitigation impacts, avoided environmental compliance costs, and other non-energy benefits.

In addition, levelized annual costs as shown in figure 9 do not reflect the added value of energy efficiency resources at certain periods of time during the year. For example, avoided energy costs can vary significantly between seasons and between peak and non-peak hours. Energy efficiency measures that reduce demand during peak periods can result in higher benefits.

The TRC and societal cost-effectiveness tests also include the broader benefits that efficiency provides to participants and to society, which are significant and present an even more complete view of the benefits of efficiency. (However as discussed earlier, in practice the TRC test is often incomplete when it does not include full participant benefits.) Our review of the TRC ratios reported by several states finds that the benefits of efficiency exceed costs by a factor of about 1.2 to 4.0. These results further demonstrate that the benefits of efficiency far exceed the costs.

Natural Gas

Average natural gas commodity prices have fallen significantly in recent years, which has put pressure on gas program administrators to keep costs below avoided costs. Our analysis finds that natural gas energy efficiency programs remain a low-cost and cost-effective resource at an average portfolio cost of $0.35/therm across 10 states. This average value is lower than the average citygate price of natural gas of $0.49/therm nationally in 2013 (EIA 2014).[25] However the avoided gas commodity cost does not tell the complete story of gas energy efficiency benefits. In addition to the commodity cost of gas, avoided costs to utilities can also include avoided distribution and transmission costs, peak demand benefits, hedging against fuel price volatility, and environmental benefits. Adding these benefits of efficiency savings further tilts the scale in favor of efficiency as a cost-effective resource.

In addition, natural gas avoided costs vary significantly across the country due to methodology and market structure differences, and they are subject to the uncertainty around future gas prices. For example, we collected a sample of recent (2012 and 2013) avoided natural gas costs, both current values and forecasts, for a handful of jurisdictions across the country. We identified a range of $0.37/therm to $1.019/therm for current and forecasted avoided gas costs. In comparison, we identified a range of natural gas efficiency portfolios of about $0.10 to $0.70/therm, very favorable values compared to avoided costs. And looking at the average gas efficiency program CSE of $0.35/therm, we can see that energy efficiency remains cost effective compared to average gas prices.

Efficiency Cost Trends

Energy efficiency program costs appear to be holding steady as the least-cost resource. The average utility CSE value in this review ($0.028/kWh) is only slightly higher than the average CSE 2009 review value ($0.025/kWh), and slightly lower than the 2004 value ($0.030/kWh). Similarly, the average natural gas efficiency program cost in the current data set ($0.35/therm) is comparable to the 2009 review value of $0.37/therm. Figure 10 displays

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[25] Per EIA, the citygate price is the "point or measuring station at which a distributing gas utility receives gas from a natural gas pipeline company or transmission system."

the annual results from the 2009 review and from this analysis for average, minimum, and maximum CSE values. Annual results from the 2004 review were not available.

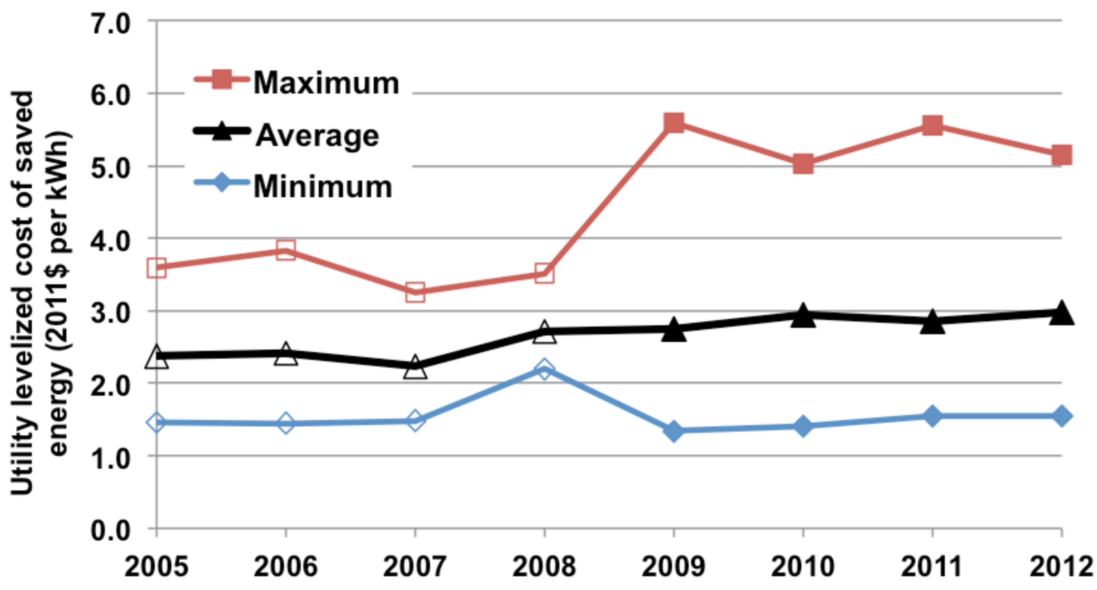

Figure 10. Utility cost of saved energy 2005-2012. *Source:* Data for 2005-2008 are from Friedrich et al. 2009 (designated by unfilled markers). Data for 2009-2012 are from this analysis.

Some caution is warranted in drawing direct comparisons between the results of the two studies, since they used different data sets (i.e., the number and specific jurisdictions included) and slightly different methodologies. For example, the 2009 study did not review whether the CSE captured net or gross energy savings, and it did not include utility shareholder incentives, both of which we addressed in the current analysis. In addition, the current review calculates all CSE values, whereas the 2009 study relied on a combination of reported and calculated values. As discussed in the next section, there is a need for further analysis on CSE trends.

What is clear, however, is that the available data refute the claims that the low-hanging fruit has been picked and that the future availability and cost effectiveness of energy efficiency are in doubt. Data from a large number of diverse jurisdictions across the nation show that energy efficiency has consistently remained the lowest-cost resource for the past decade, even as the amount of captured energy efficiency has increased significantly.

CONSISTENCY AND TRANSPARENCY IN ENERGY EFFICIENCY REPORTING

Throughout this report we have discussed the challenges in energy efficiency reporting around the country. All states should take steps toward improving consistency and transparency in reporting. To this end, we recommend that utilities, regulators and program administrators in a given state (and perhaps also at a regional and national level) discuss these issues and work toward adopting best reporting practices. Guidelines are already available for program administrators interested in improving the transparency and consistency of their reporting metrics. For stakeholders interested in detailed guidelines and templates for reporting, we suggest the NEEP *Common Statewide Energy Efficiency Reporting Guidelines* and *Regional Energy Efficiency Database (REED)* (NEEP 2010, 2013), and *Energy Efficiency Program Typology and Data Metrics: Enabling Multi-State Analyses through the Use of Common Terminology* (LBNL 2013).

Rather than offering detailed guidelines, the following section makes recommendations around several common issues that program administrators should address to improve consistency and transparency.

Regularize Location and Frequency of Reporting

First and foremost, annual program reports and evaluations should be easily accessible on a common website. They should also follow a consistent annual schedule if possible, or provide public notification of schedule and availability. The website may be an individual program administrator's site, a common docket established by the commission, or an independent advisory group website. Regulators or advisory groups should require at least some minimum threshold of reporting and provide sample templates that build on best practices such as those laid out by NEEP. In cases where there are multiple utilities or program administrators reporting, it makes sense and is in the interest of all stakeholders to have one dedicated entity to aggregate key metrics across all territories.

Improve Transparency of Energy Efficiency Metrics and Assumptions

To improve overall transparency, we recommend that program administrators and regulators adopt or improve on measures such as the following:

- Report energy efficiency program portfolio spending and impacts separately from demand response and renewable energy impacts.
- Separate electricity and natural gas program spending and savings. For combined programs, develop methodologies for attributing spending and savings to gas or electric.
- Report estimated participant costs by customer class.
- Indicate whether electricity savings are reported at site or at generation. If at generation, make clear the assumption of T&D line losses so they can be converted to site.
- Identify whether energy savings are net or gross, and what assumptions are used.
- Provide a succinct but transparent description of the methodologies used to estimate gross and/or net savings, with links to more detailed information.
- If the emphasis is on cumulative (i.e., multiyear) energy savings and cost-effectiveness impacts, provide incremental annual impacts to indicate trends over time and facilitate comparisons with other jurisdictions.

Expand Reporting and Disaggregation of Key Metrics

More often than not, energy efficiency reporting leaves out critical metrics or assumptions that are necessary to calculate the cost of saved energy, or at least does not report aggregate values across customer classes. We recommend reporting measures such as the following:

- Report both net and gross energy savings values.
- Report measure lifetime estimates.
- Disaggregate all data by customer class (e.g., residential, commercial, and industrial). Most jurisdictions currently disaggregate business customers into commercial and industrial; however we recommend that programs disaggregate data in a way that furthers program development (e.g., commercial versus industrial customers, or small versus large business customers).
- Disaggregate cost data at least by the following: customer incentives, non-incentive program costs, and performance/shareholder incentives.

FURTHER RESEARCH

This review presents a large quantitative dataset combined with qualitative findings on energy efficiency cost-effectiveness metrics and reporting practices. However we offer only a very limited initial statistical analysis of trends. Further analysis is needed to discern trends in CSE values over time and the relative impact of various metrics on CSE values. As for trends over time, many analysts have hypothesized that the cost of saved energy for programs will increase as program administrators raise energy savings levels. Yet an initial correlation analysis in this study (for electricity programs only) finds only a weak correlation between CSE values and electricity savings levels and therefore casts doubt on the broad notion that high savings are associated with high CSE values.[26] However correlation analyses of CSE trends over time across jurisdictions are difficult and may provide incomplete results because of fundamental differences among program portfolio structures and reporting consistency. Further research should delve into this question, perhaps examining individual jurisdictions or regions.

The relative impact of different variables on CSE values is also an important area for further statistical and qualitative research. In this review we present numerous metrics that may have a direct impact on the cost of efficiency, e.g., the share of savings by customer class, or the types of programs offered. Also of interest is the impact of avoided costs on CSE within a jurisdiction, which we hypothesize should be a significant indicator of CSE values. (We did not conduct this analysis because we did not collect avoided costs data.) If program administrators must pass cost-effectiveness screening up to the point that efficiency programs cost more than the marginal unit of energy supply (i.e., avoided costs), that would allow for a higher ceiling on program costs in jurisdictions with higher avoided costs. Similarly, labor and capital costs may have a direct influence on the cost of energy efficiency programs.

Conclusion

This analysis finds that energy efficiency is clearly holding steady as the least-cost energy option that provides the best value for America's energy dollar. At an average cost of 2.8 cents per kWh, electricity efficiency programs are one half to one third the cost of the

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[26] Note that this is different from the notion that total program dollar costs will increase to meet higher savings levels. Total program costs may increase, but the levelized CSE for the efficiency resources can hold steady.

alternative of building new power plants. Natural gas energy efficiency programs also remain a least-cost option at an average cost of 35 cents per therm, which is less than the average natural gas commodity price of 49 cents per therm in 2013. These data represent a large number of diverse jurisdictions across the nation.

The data show that energy efficiency has remained consistent as the lowest-cost resource over the past decade even as the amount of energy efficiency being captured has increased significantly. Energy efficiency also provides additional benefits beyond avoided energy costs, including reductions in water and fuel usage, avoided T&D costs, price mitigation effects in wholesale markets, and non-energy benefits to society such as reduced pollution and job creation. As utility and state planners face increasing uncertainty and rising supply costs in their long-term planning (including fuel-price volatility and the need to address the environmental impacts of power generation), they should look to energy efficiency as a reliable and consistent "first fuel" in their loading order of energy options.

The need increases for high-quality and consistent data across the country as efficiency gains even wider adoption and traction as the least-cost energy resource option. In this analysis we found that jurisdictions collect and report a wealth of data and information on efficiency programs. However we also found that the collection and comparison of energy efficiency cost data across the nation face numerous challenges, including variation in reporting formats, nomenclature, and frequency. All states should take steps toward improving consistency and transparency in reporting. Finally, further work should explore the relative impact of different variables on CSE values, as well as trends over time for individual jurisdictions.

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Appendix A. Data Sources by State and Program Administrator

State and administrator	Data sources
Arizona: Arizona Public Service Company (APS)	DSM semiannual reports with annual data for 2009, 2010, 2011, and 2012. Published in March each year.
California: Southern California Gas; Southern California Edison; Pacific Gas & Electric; San Diego Gas & Electric	Utility annual reports available for 2009, 2010, and 2011 from http://eega.cpuc.ca.gov/. Published in May.
Colorado: Xcel Energy	Xcel Energy Colorado *Demand-Side Management (DSM) Annual Status Reports.* Published in April. http://www.xcelenergy.com/About_Us/Rates_&_Regulations/Regulatory_Filings/CO_DSM
Connecticut: Connecticut Energy Efficiency Fund	*CEEF Annual Legislative Reports* for 2009, 2010, 2011, and 2012. Published from February to April. http://www.ctenergyinfo.com/about/eeboard/annualreports
Hawaii: Hawaii Energy	*Hawaii Energy PY12 Annual Report,* October 1, 2013. also PY11, PY10, and PY9 reports. http://www.hawaiienergy.com/information-reports
Illinois: Ameren Illinois Utilities; ComEd, and DCEO	Ameren: *ActOnEnergy Energy Efficiency and Demand Response Results* (PY 1). *Portfolio Cost-Effectiveness Evaluation* (PY 3). ComEd: Evaluation Reports Prepared by Summit Blue/Navigant for PY 1 (2009), PY 2 (2010), and PY 3 (2011) (savings data and TRC ratios). ComEd PY3 annual report to ICC (cost data for 2011). Some reports available at http://ilsag.org/.
Iowa: MidAmerican Energy and Alliant Energy/Intrastate Power & Light	Energy Efficiency Annual reports for 2009, 2010, 2011, and 2012. Published in May. http://www.state.ia.us/government/com/util/energy/energy_efficiency/ee_plans_reports.html
Massachusetts: All investor-owned utilities	2011 data: Northeast Energy Efficiency Partnership's Regional Energy Efficiency Database (REED). 2012, 2010, and 2009 data: individual utility reports available from www.ma-eeac.org 2011 and 2012 TRC results: "Statewide Electric Results Master Summary" spreadsheets. www.ma-eeac.org
Michigan: All utilities	Michigan PSC. 2012. *Report on the Implementation of P.A. 295 Utility Energy Optimization Programs.* November 30, 2012. Data for 2009, 2010, and 2011. Michigan PSC. 2013 *Report on the Implementation of P.A. 295 Utility Energy Optimization Programs.* November 26, 2013.
Minnesota: Xcel Energy	Xcel Energy annual Status Reports available from https://www.edockets.state.mn.us/EFiling/home.jsp for 2009, 2010, 2011, and 2012 program years

State and administrator	Data sources
New Mexico: Public Service Company of New Mexico (PNM) and Southwestern Public Service Company (SPS)	PNM: *PNM Energy Efficiency Program Annual Report* (available for 2009, 2010, 2011, and 2012), published annually from March-June. SPS: *SPS 2009 Energy Efficiency and Load Management Annual Report* (August 1, 2010). Only 2009 report was readily available. Note: New Mexico's TRC results reported only for PNM.
Nevada: NV Energy (merger of Nevada Power Company (NPC) & Sierra Pacific Power Company (SPPC); but separate EE reporting still)	NPC: DSM Status Update Reports for 2009, 2010, 2011, and 2012 SPPC: DSM Status Update Reports for 2009, 2010, 2011, and 2012
New York: NYSERDA	Cumulative data for 2006-2011: NYSERDA, *New York's System Benefits Charge Programs Evaluation and Status Report: Year Ending December 31, 2011 Report to the Public Service Commission* (March 2012) (Revised April 2012)
Oregon: Energy Trust of Oregon	ETO Annual Reports for 2009, 2010, 2011, and 2012 http://energytrust.org/About/policy-and-reports/Reports.aspx
Pennsylvania: Electric Distribution Companies (EDCs)	Act 129 Market Potential Study, with impacts for PY 1 (June 2009-May 2010) and PY 2 (June 2010–May 2011) http://www.puc.pa.gov/electric/pdf/Act129/Act129-PA_Market_Potential_Study051012.pdf
Rhode Island: National Grid Electric and Natural Gas	National Grid Year-End Reports for 2010, 2011, and 2012. Also for 2011 data: Northeast Energy Efficiency Partnership Regional Energy Efficiency Database (REED).
Texas: Electric IOUs	Frontier Associates; *Energy Efficiency Accomplishments of Texas Investor-Owned Utilities.* Annual reports for 2009, 2010, and 2011 http://www.texasefficiency.com/index.php/publications/reports
Utah: Rocky Mountain Power (PacifiCorp)	PacifiCorp, *Annual Energy Efficiency and Peak Reduction Report: Utah.* Annual reports for 2009, 2010, 2011, and 2012
Vermont: Efficiency Vermont (Vermont Energy Investment Corporation)	Annual Savings Claim Reports http://www.efficiencyvermont.com/about_us/information_reports/annual_reports.aspx
Wisconsin: Focus on Energy	Focus on Energy evaluation reports for 2011 and 2012: *Calendar Year 2011 Evaluation Report* (October 31, 2012), *Calendar Year 2012 Evaluation Report* (April 30, 2013)