Demand-Side Energy Efficiency Technical Support Document
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1. Introduction

This chapter provides information on demand-side energy efficiency (EE) as a measure for reducing carbon dioxide (CO_2) emissions from fossil fuel-fired electric generating units (EGUs). Specifically, this chapter supports the discussion of demand-side EE as a non-BSER compliance measure in section V, "The Best System of Emission Reduction (BSER) and Associated Building Blocks," and section VIII, "State Plans," of the preamble. In addition, support is provided for the magnitude, timing, and cost of demand-side EE measures included in the illustrative demand-side EE plan scenario developed as a basis for the Regulatory Impact Analysis (RIA) and related discussion in section X, "Impacts of this Action," of the preamble.

The chapter is organized as follows:

2. Background

3. History of EE Policies in the United States

4. EE Programs

5. Other EE Strategies

6. Utility Business Models

7. Experience with EE Certificates

8. Demand-Side EE Plan Scenario: Magnitude and Timing of Savings

9. Demand-Side EE Plan Scenario: Assessment of Costs

10. Analysis Considerations

Sections 2 through 7 provide support for both the preamble sections cited above as well as background for the illustrative demand-side EE plan scenario presented in sections 8 and 9. Sections 8 and 9 provide details on the approach, inputs, calculations, and results for the magnitude and timing of savings and the assessment of associated costs for the demand-side EE plan scenario. Lastly, section 10 discusses considerations relevant to sections 8 and 9.

2. Background

Demand-side EE policies and programmatic efforts have existed for decades and are now used in all 50 states. These strategies are intended to help states achieve energy savings goals, reduce the environmental impacts (including CO_2 emissions) of meeting energy service needs, save energy and money for consumers, and provide a significant resource for meeting power system capacity requirements (EPA 2015). EE policies currently in place are generally considered by states to be cost-effective strategies for contributing to these policy objectives.[1] Moreover, states – through their utilities, primarily – have been rapidly increasing their funding of EE programs in recent years, more than tripling budgets in the five years from 2006 to 2011, from $1.6 billion to $5.9 billion (ACEEE 2014c). In 2012, the utility-reported cumulative impacts of these programs represented a 3.7% reduction in national electricity demand (EIA 2012a). And, EE spending is projected to continue to grow at a substantial rate. A recent study by Lawrence Berkeley National Laboratory (LBNL) projects EE program spending to reach $8.1 billion to $12.2 billion ("Medium Case" and "High Case," respectively) in 2025 (Barbose et al. 2013).

2.1 EE Technologies and Practices

EE is using less energy to provide the same or greater level of service. Demand-side EE refers to an extensive array of technologies, practices and measures that are applied throughout all sectors of the economy to reduce energy demand while providing the same, or better, level and quality of service. Utilities employ an array of strategies in implementing EE programs, these include financial incentives such as rebates and loans, technical services such as audits and retrofits, and educational campaigns about the benefits of EE improvements. The purpose of these EE programs is to induce EE investments and practices that would not otherwise occur due to market failures and behavioral impediments. In the residential sector, examples of EE activities include the purchase of more efficient products and equipment (e.g., ENERGY STAR labeled), the upgrading of insulation in attics and walls, sealing of air leaks, and undertaking home energy audits leading to customized whole home retrofits. Opportunities for cost-effective EE in commercial buildings can include optimization of heating, ventilation, and air conditioning (HVAC) systems, upgrades of windows, and use of more efficient office equipment at replacement. In the industrial sector key EE strategies include motor upgrades and maintenance programs, recovery of waste heat streams, and optimization of processes through modern instrumentation and controls systems.

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[1] See below for discussion of cost-effectiveness and related cost tests used by states to evaluate EE programs.

The opportunity presented for economic investment in EE is dynamic, growing over time as technologies and practices advance, as populations grow, and as investment occurs in the construction of new homes, buildings, and industrial facilities. After decades of experience implementing policies to accelerate investment in cost-effective EE, states are finding renewed opportunities as they develop more sophisticated and effective strategies, evolving from a focus on individual end-uses and products to whole-building and systems-based strategies that account for the interactions between the many energy end-uses in buildings and industry (ACEEE 2013). As will be discussed, the experience in the U.S. has been that, on balance, a persistent and large potential for achievable and cost-effective EE is expected to remain even as the impact of past and ongoing efforts have accumulated.

2.2 Barriers to EE Investment

Despite the persistent and large potential for electricity savings through investment in EE technologies and practices, market failures, as well as non-market barriers and behavioral impediments, limit the realization of the many benefits of these investments. Several market failures that lead to inefficiencies in the investment in energy efficiency are widely recognized by analysts and practitioners, and are discussed extensively in the literature (Levine et al. 1995; Gillingham et al. 2009;Gerarden et al. 2015). In the presence of market failures, users of electricity, or those making EE investments, face prices or incentives that prevent them from weighing the full social benefits and costs of their investments and thus under-invest in approaches to reduce electricity consumption. The behavioral impediments provide another explanation for why individuals do not always make EE investments that are seemingly in their own best interest. Some of the most common examples of these market failures include:

- *Pollution externalities.* Fossil energy consumption is associated with negative externalities, such as emissions of CO_2, SO_2, and NO_x that cause human health and environmental damages. Energy prices that do not correctly reflect the externalities associated with energy use would lead to investments in EE below the socially optimal levels.
- *Imperfect information.* Energy users often lack accurate information about energy savings and other attributes of energy efficient products or practices to understand the costs and benefits of EE investments.

- *Split incentives (or the "principal-agent problem").* Incentives of individuals who make EE investment decisions are not always aligned with incentives of those who use and pay for energy. Examples include misalignment between landlords and tenants, between builders and homeowners, and within organizations and institutions (DeCanio 1998; McKinsey 2007).
- *Credit constraints*. Limited access to credit may prevent some consumers, especially low-income consumers, from making cost-effective EE improvement with higher upfront cost.
- *Under-provision of research and development (R&D).* Because of the public good nature of knowledge, firms involved in technology development may be less willing to invest in R&D, leading to sub-optimal levels of EE investments from a social perspective (Jaffe et al. 2003).
- *Supply market imperfections.* Markets for energy efficient products are often incomplete and fragmented, leading to underinvestment in innovation and limited EE supplied by the manufacturers. In addition, supply chain fragmentation may also add complexity to the purchase and installation of otherwise economically rational investments, thereby slowing the adoption of EE technologies (Fischer 2005).
- *Behavioral impediments*. Behavioral economics and psychology have identified potential behavioral phenomena that lead to consumers to deviate from the standard theory of welfare maximizing in consumption and other decisions, including EE investments (Gillingham and Palmer 2014).

Other factors, such as hidden costs, risk and uncertainty experienced by both consumers and suppliers of energy efficient products, and heterogeneity among consumers, may also influence EE investment decisions.[2] Examples of such barriers include:

- *Risk and uncertainty*. Adopting an unfamiliar, typically more expensive EE technology can be an uncertain undertaking given the lack of credible information on

[2] It has been recognized that there is a difference between cost-effective energy efficiency investment levels, based on cost-minimizing consideration, and observed levels of energy efficiency. This phenomenon, also termed 'energy paradox,' or 'energy efficiency gap,' has been discussed extensively in the academic literature, although a full explanation of the gap remains elusive, likely because it differs by setting and energy efficiency investment. See, for example, Jaffe and Stavins 1994, DeCanio 1998, Sanstad and Howarth 1994, DeCanio and Watkins 2008, Allcott and Greenstone 2012, and Gerarden et al. 2015.

product performance and future energy prices, and the irreversibility of the investment. Imperfect or asymmetric information can exacerbate the perceived risk of EE investments and help explain why consumers and firms do not always invest in EE measures. Suppliers also face risk and uncertainty, without perfect information of consumer preferences for EE. In the presence of risk and uncertainties, consumers and suppliers alike will invest less in EE.

- *Transaction costs*. Consumers face transaction costs in searching, assessing and acquiring energy efficient technologies and services. It can be time-consuming and difficult for consumers to estimate lifetime operating costs of a product. The complexity of the search process may put more efficient products at a disadvantage relative to better-known less-efficient products with, sometimes, lower upfront costs.
- *Capital market barriers*. Consumers sometimes face higher interest rates to finance EE investments compared to other investments. Lenders can be reluctant to invest in EE loan portfolios in part because EE loans may lack standardization and financial markets have difficulty ascertaining the likely payoff from such investments.

EE policies and programs can play an important role in correcting market failures and addressing the barriers to the investment and adoption of socially beneficial EE opportunities. Examples of effective EE policies and programs include public funding of R&D, information programs (such as energy labeling, the ENERGY STAR program, and consumer education), rebates for high-efficiency products, product energy performance standards, financing and loan programs, and technical assistance.

2.3 EE Policies

2.3.1 Objectives and Role in Reducing CO_2 Emissions from the Power Sector

EE policies are implemented by states to meet a number of closely related policy goals, including:

- Reducing costs to electricity customers,
- Providing a significant resource for meeting power system capacity needs,
- Meeting energy savings goals,

- Stimulating local economic development and new jobs,
- Reducing the environmental impacts of meeting electricity service needs, and
- Improving the health of lower-income households (EPA and DOE 2006; EPA 2015).

EE policies currently in place are considered by states to be cost-effective strategies for contributing to each of these policy objectives (EPA and DOE 2006). While each of these objectives, and others, contribute to the motivation of policymakers and utilities to pursue EE policies and programs, reducing energy costs to consumers over the long term is a primary purpose in pursuing these policies. In addition, EE policies are central to meeting state objectives for reducing CO_2 emissions from the power sector. EE policies are a leading tool for achieving CO_2 reductions from power plants, accounting for 35% to 70% of reductions of sector emissions in ten states with statutory requirements for greenhouse gas reductions (EPA 2015).[3] Many evaluations of the economic potential for carbon dioxide reductions from the United States' power sector identify demand-side EE as the lowest cost strategy (typically, as noted above, with positive net present value) as well as the strategy having the greatest reduction potential. For example, McKinsey found that EE accounted for more than 60% of their mid-range potential for greenhouse gas reductions from the U.S. power sector and that it was available at positive net present value if "persistent barriers to market efficiency" could be addressed (McKinsey 2007).

Similarly, economy-wide studies of climate mitigation scenarios confirm that EE can play a critical role in reducing the costs and enhancing the flexibility of meeting long-term climate stabilization targets (Clarke et al. 2014; Kriegler et al. 2014). An analysis by the International Energy Agency (IEA) suggested that in order to stabilize the carbon concentration in the atmosphere at 450 ppm, as much as 44% of the estimated global abatement potential in 2035 derives from greater EE in the world economy (IEA 2012b). Several recent Energy Modeling Forum (EMF) studies have investigated the role of technology in achieving climate policy objectives in the U.S. ("EMF 24" and "EMF 25" studies) and globally ("EMF 27" study).[4]

[3] States with GHG reduction laws include: California, Connecticut, Hawaii, Maine, Maryland, Massachusetts, Minnesota, New Jersey, Oregon, and Washington.

[4] Energy Modeling Forum (EMF) is a consortium of energy economists and energy economic modeling teams that was established in 1976. Through ad hoc working groups, the EMF has focused on a series of energy and environmental topics that are of interest to policy decisions. In recent years, the EMF is recognized for its contribution to the advancement of economics of climate change and the reports of the Intergovernmental Panel on Climate Change (IPCC).

These studies concluded that compared to business-as-usual EE, improvements in EE in various economic sectors would slow the increases of GHG emissions in the short run, substantially reduce the costs of GHG mitigation (on average, by about 50%), and ease the technology transformation pathways to achieve long-term carbon reduction goals (Kriegler et al. 2014; Kyle et al. 2011).

Several economic studies (including EMF25 studies) examined the role of EE policies (such as EE standards and subsidies) in relation to other climate policy instruments (such as carbon taxes). These studies found that when EE policies address market failures, they are welfare improving and can complement climate policy (Comstock and Boedecker 2011; Fischer 2005; RFF 2010). In addition, EE policies are recognized to be an appropriate response to demonstrated market failures and behavioral impediments, particularly in contexts where these failures have broader societal implications such as environmental externalities (Gillingham et al. 2009).

In addition to providing cost-effective opportunities for reducing GHG emissions, EE is recognized to provide other co-benefits, including air quality and public health benefits, waste reduction from energy generation, energy security, energy system reliability, community economic and social development, and consumer amenities (RAP 2012). EE investments and policies that apply to industry have been found to spur productivity growth, technology learning and innovation (Boyd and Pang 2000; Worrell et al. 2003). Recently, more attention has been paid to developing methods for recognizing these co-benefits and integrating them into the cost-benefit analysis framework used by state utility commissions and administrators of EE programs. These co-benefits have not been fully accounted for in the EPA analysis.

2.3.2 Policy Types

EE policies come in many forms. The most prominent and impactful EE policies in most states include those that drive development and funding of EE programs, and building energy codes. Other policies that are leading to significant impacts in some states include state appliance and equipment standards, "lead by example" strategies targeting energy use in state operations through energy services performance contracting, and "volt-VAR optimization." See section 5 for further description of these policies, their history, and potential for achieving significant electricity savings. Comparing the relative impact (potential or achieved) of the different policy types is challenging, particularly to do so comprehensively, across all states, and at the national level. EE programs are the only state EE approach that has comprehensive and detailed reporting of impacts, costs, and other characteristics from all 50 states.[5] This information is generally based upon measurement and verification studies submitted annually, most commonly to state utility commissions, and reported to the Energy Information Administration (EIA) for all program administrator types (including all utility types, third-parties, and government agencies). EE program data reported to EIA includes: incremental savings (also referred to as "first-year" savings), cumulative savings, peak demand savings, program costs broken down by component, and composition by end-use sector (residential, commercial, industrial). As of 2013 EIA ended their collection of cumulative savings data. In 2013, utilities and other program administrators in all 50 states and the District of Columbia states reported savings from EE programs to EIA through form EIA-861. At a national level, the EPA is not aware of a comprehensive dataset reported by states of the achieved impacts of strategies other than those that lead to investment in EE programs. However, state and regional-level information does exist. For example, the Northwest Power and Conservation Council (NPCC) has been compiling the impacts of EE policies (including utility and third-party EE programs, state building energy codes, and federal appliance standards) across their member states (ID, MT, OR, WA) for more than three decades. For the past decade, EE programs have accounted for more than 75% of the cumulative energy savings from state EE policies for NPCC, with building energy codes accounting for the remaining savings (NPCC 2010).

Another representation of the relative opportunity provided by different state EE strategies is presented by evaluations of EE achievable potential or projections of the impacts of EE policies. The results from two recent evaluations at a national level are presented in Table 1. EE programs account for 77% and 82% of achievable savings in studies by ACEEE and Georgia Tech, respectively (ACEEE 2014a; Wang and Brown 2013). These studies indicate that the substantial majority of potential savings from state EE efforts are available through EE programs, and that state and local building energy codes can make a significant additional

[5] In 2011, EIA began collecting data from third-party administrators of programs. Prior to 2011, this was a significant shortcoming in the breadth of the data collected. The breadth and quality of information collected through Form EIA-861 has improved over time, however, outside entities (e.g., ACEEE and CEE) have found that the data can be improved through expert review and supplementation with other data sources. While now fairly comprehensive, the EIA data can be improved further with regards to data quality and consistency. See section 10 for further discussion.

contribution. Massachusetts provides a state example of the impacts of EE programs relative to other state EE policies. The Massachusetts Global Warming Solutions Act of 2008 established statewide limits on greenhouse gas (GHG) emissions of 25 percent below 1990 levels by 2020. To achieve this target, Massachusetts is relying upon an integrated portfolio of clean energy policies. State EE policies are expected to provide the largest contribution to meeting the 25 percent target with utility-sponsored EE programs and state building energy codes accounting for 76% and 17%, respectively, of those policies (Massachusetts EOEEA 2010). In their 2013 progress report, Massachusetts indicates that they are generally on track for meeting or exceeding these projections (Massachusetts EOEEA 2013).

Table 1. Relative Opportunities Provided by Key EE Programs and Building Codes

Study	Year	EE Programs	Building Codes	Other
ACEEE	2030	77%	13%	10%
Georgia Tech	2035	82%	18%	0%

Source: ACEEE 2014a, and Wang and Brown 2013

The next section reviews the lengthy history of EE policies in the U.S. In the following section, the focus returns to the EE programs highlighted here for an in-depth review of this important strategy.

3. History of EE Policies in the United States

Demand-side EE has been repeatedly supported through federal policies and market innovations over the past four decades, in recognition of its multiple benefits, including increased energy security, reduced emissions from the power sector, lower customer energy bills, enhanced economic development and job creation, and improved reliability and resiliency of the electricity system. Following the 1973 Organization of Petroleum Exporting Countries (OPEC) oil embargo, the Nixon administrated established the Federal Energy Administration, imposed oil price regulations, and created Project Independence to put the U.S. back on the path toward improved energy security.

The 94th Congress took the first major U.S. legislative action on energy through the 1975 Energy Policy and Conservation Act (EPCA). Among other provisions, EPCA authorized the creation of vehicle fuel economy standards, and labeling requirements and efficiency standards for major household appliances (Congress 1975). Also in 1975, the American Society of

Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) developed the first national model building energy code, 90-75 “Energy Conservation in New Building Design,” for residential and commercial buildings (BCAP n.d.).

Continuing this trend of energy policy initiatives, Congress passed the Energy Conservation and Production Act in 1976, which authorized the creation of mandatory national building energy performance standards (BEPS). BEPS, which were repealed in the 1980s, provided loan guarantees for saving energy in public and commercial buildings, authorized grants to states for low-income weatherization and state energy conservation programs, and encouraged the development of electric utility rate structures designed to save energy.

Federal energy efficiency policy action continued during the Carter administration. President Carter’s 1977 National Energy Plan included energy efficiency as “the quickest, cheapest, and most practical source of energy In the same year President Carter also issued the first executive order on energy efficiency, Energy Policy and Conservation E.O. 12003 requiring federal agencies to develop energy conservation plans (Woolley and Peters n.d.). Other policy actions in 1977 included the creation of the U.S. Department of Energy, thereby consolidating multiple federal agencies and programs, including many that support energy efficiency, into one cabinet-level department.

In 1978, partly in response to the Administration’s new energy plan, Congress enacted the National Energy Act, including the National Energy Conservation Policy Act (NECPA), which made EPCA’s provisions for federal efficiency standards mandatory and pre-emptive of state law; established the Residential Conservation Service (RCS), which required utilities to provide home energy audits; and authorized the Institutional Conservation Program (ICP), a grant program for schools and hospitals. NECPA also provides the core authority for the federal government’s energy management goals and requirements, which have been updated and amended since 1978 (Congress 1978a). Congress also passed the Public Utility Regulatory Policies Act (PURPA) in 1978 which, among other provisions, introduced competition into generation markets, and required state utility commissions to consider ratemaking practices that encourage energy efficiency (Congress 1978b). As state commissions pursued PURPA-related requirements as well as their own related policy interests, integrated resource planning became more widely used, and the concept of demand-side management (DSM) emerged, in which utilities implement programs to influence customer loads through energy efficiency and other demand-side initiatives (RAP 2011).

The energy service company (ESCO) business model also emerged during the 1970s and 1980s. Leaders in the Federal Energy Administration, such as Roger Sant, defined the term "energy services" in the 1970s as the services people want from energy, such as lighting and comfort, and distinct from energy commodities such as fuels and electricity. This concept gave rise to the energy services business, in which ESCOs could reduce energy service costs through energy efficiency. The ESCO industry's growth was supported by utilities paying ESCOs for services such as utility-supported energy audits, and by helping federal agencies implementing federal energy management goals (NAESCO 2011). ESCOs also succeeded in contracting with state and local and institutional customers, whose limited ability to finance energy improvements matched up well with ESCOs' ability to bring private capital to energy improvement projects.

Federal policy support for energy efficiency declined dramatically in the 1980s under the Reagan Administration as energy supplies improved, prices stabilized, and a less favorable climate for federal regulation emerged. The BEPS and RCS programs were repealed, and a "no-standard" standard was issued under NECPA appliance standards authority. Some states acted to fill these policy vacuums, enacting their own building codes, appliance standards, and utility programs. Appliance manufacturers, concerned about the proliferation of multiple, different state standards, supported a compromised effort that resulted in the 1987 National Appliance Energy Conservation Act (NAECA) (Congress 1987). NAECA, which was further amended in 1988, established the first national home appliance efficiency standards by amending NECPA. During the 1980s, state and local residential and commercial building energy codes were also adopted to achieve greater energy savings in new construction (BCAP n.d.).

As integrated resource planning and DSM practices continued to spread in the 1980s, and electric utilities began to offer customers DSM programs under formal regulatory processes, including programs to incentivize more efficient technologies and practices. These DSM programs sometimes resembled utility conservation programs launched in the 1970s, but signified a larger shift to integrate energy efficiency into broader utility planning and operations (ACEEE 2012b). The rapid growth of DSM in the 1980s was the result of the 1970s' increased energy prices, energy security concerns, and the environmental consequences of electricity generation. Rising power plant capital and fuel costs resulted in rate increases, rising customer dissatisfaction, and new requirements for utilities to pursue IRP to manage electricity demand, supply and risk (LBNL 1996). By the end of the decade, 41 states had made some progress towards implementing a rule to require integrated resource planning by electric utilities (Synapse 2011). Utilities also played a key role in supporting ESCO projects into the 1990s by providing incentives that offset energy efficiency project costs, as integrated resource plans found that investments in energy efficiency were lower-cost alternative to new power plants.

The 1990s began with the Clean Air Act Amendments and the Pollution Prevention Act of 1990, each of which in their own ways recognized the role energy efficiency can play in protecting human health and the environment. The Clean Air Act amendments provided the authority to use demand-side energy efficiency as a compliance option that gives utilities flexibility to obtain needed sulfur dioxide emission reductions through programs that encourage customers to conserve energy. In 1992, EPA introduced the ENERGY STAR label for office products which manufacturers voluntarily design to perform at superior levels of energy savings. President Clinton signed Executive Order 12845 in 1993 requiring federal agencies to purchase ENERGY STAR qualified products. The Pollution Prevention Act gave EPA new authority to reduce emissions via voluntary and other approaches that reduce pollution sources.

The Energy Policy Act (EPAct) of 1992 also advanced energy efficiency through a broad suite of policies, including federal appliance and equipment efficiency standards, requirements for states and the Department of Energy on model building codes, new requirements for federal energy management, new provisions on least-cost planning for federal electric utilities, and new research and development authorizations. EPAct 1992 also included provisions to encourage states to adopt policies to support energy savings through electric utility regulatory reforms (Congress 1992). In 1996, DOE and EPA signed a joint Memorandum of Understanding to cooperate in delivering the growing suite of ENERGY STAR programs, increasing the number of products and markets covered and leveraging expertise and resources across the federal government.

During the early 1990s, electric utility DSM programs grew rapidly, with energy savings exceeding 50 billion kilowatt-hours (kWh) and utility spending at $2.7 billion in 1994 (ACEEE 2000). About 95 percent of the reported energy savings, though only slightly over half of the spending, was attributed to programs reported as targeting energy efficiency (ACEEE 2000). These utility programs accelerated the commercialization of advanced energy efficiency technologies, often by partnering with federal energy efficiency programs like ENERGY STAR (ENERGY STAR 2012a, 2012b). By the late 1990s, funding for utility-sponsored energy efficiency programs fell to less than one-third of its 1994 peak, as about half of the states from a wave of electricity restructuring policies, accompanied by increased political and regulatory pressures to hold down electricity prices (EPA and DOE 2006). Some restructured electric utilities shifted their focus away from regulated DSM programs to unregulated power marketing and ESCO businesses to deliver energy sales and services directly to customers. However, the business model for these market-based ESCOs limited their ability to reach all but the largest industrial, commercial and institutional customers. Recognizing the limits of private-market delivery of EE, and seeking to preserve the benefits of EE programs, as the more states restructured their electricity markets in the 1990s, some 20 states adopted public benefit funds (PBFs) to ensure continuation of ratepayer-funded programs. Several states and local governments also expanded the authorized use of ESCO services in public facilities via lead-by-example policies.

Following the year 2000, energy efficiency policies and programs gained increased attention and, supported by decades of implementation experience, began to be widely recognized as a legitimate, measureable, and low-cost option to serve the nation's energy and environmental goals. Congress displayed a strong commitment to energy efficiency in the Energy Policy Act (EPAct) of 2005, which included sweeping energy efficiency provisions: it authorized $250 million over five years to provide energy efficiency appliance rebates, $1.8 billion over three years for weatherization services, included direct enactment of federal efficiency standards, and authorized a national consumer education campaign on energy efficiency (Congress 2005). At the same time, however, the ESCO market declined due to an authorization lapse for the federal Energy Savings Performance Contracting (ESPC) program and loss of market confidence for industrial financing mechanisms (NAESCO 2011). This trend was soon reversed as ESCOs increased focus on state and local public buildings and innovated in order to provide customers new technologies and financial models. Eventual resolution of the ESPC authorization program, and executive orders by both President Bush and President Obama have also required more aggressive energy savings in federal facilities (White House 2007, 2009, 2015).

By the mid-2000s, the electric utility and regional electricity markets also solidified the validity of rate-payer funded energy efficiency programs as system resources. In 2006, the National Action Plan for Energy Efficiency Leadership Group of more than 60 leading gas and electric utilities, state agencies, energy consumers, energy service providers, environmental groups, and energy efficiency organizations released five policy recommendations recognizing energy efficiency as a high-priority energy resource. States, utilities, and key stakeholders across 49 states joined in making aggressive commitments to energy efficiency and endorsing the Action Plan recommendations (EPA and DOE 2006).

In the years following the Action Plan's efforts, about half the states enacted Energy Efficiency Resource Standards (EERS), which are long-term, quantified energy savings targets designed to drive ratepayer-funded program plans. These policy drivers lead to the evaluation, planning, and adoption of EE programs and associated budgets, which are supported through different funding mechanisms. Funding for utility electricity energy efficiency programs has in turn increased rapidly, from $1.6 billion in 2006 to $6.3 billion in 2013 (ACEEE 2014c).

At the regional level, the wholesale electricity market operator in New England began to allow energy efficiency to participate in regional capacity markets as part of a 2006 settlement agreement with their regulator, the Federal Energy Regulatory Commission (FERC). Since 2009, energy efficiency providers have been compensated for its measureable contribution to meeting New England's regional capacity needs, helping to ensure sufficient electricity will be available in the future to reliably meet demand across the region. PJM, the wholesale electricity market operator across 13 states around the Mid-Atlantic region, also integrated energy efficiency into this capacity market rules in 2009 (Booz Allen 2012).

In 2007, the Energy Independence and Security Act (EISA) passed due to growing concerns over both energy prices and climate change. EISA included several new, and strengthened existing, appliance and equipment standards including a major incandescent lamp efficiency standard, authorized industrial energy efficiency programs, and included a provision for states to consider adopting policies to support greater energy efficiency. EISA also enacted the federal agency savings goals of President Bush's 2007 Executive Order 13423, Strengthening

Federal Environmental, Energy and Transportation Management, which required even more aggressive building energy savings than previous Executive Orders.

The American Recovery and Reinvestment Act of 2009 (ARRA 2009) recognized energy efficiency for its economic benefits, including job creation, bill savings and economic development. ARRA 2009 allocated DOE around $16 billion for energy efficiency programs, including appliance rebates, grants to local governments, state energy programs, weatherization assistance, and smart grid grants (DOE 2012c). These investments brought results: for example, ARRA's weatherization program helped more than 650,000 low-income families nationwide, exceeding the original target of 600,000 homes. These retrofits improved the energy efficiency of the homes, saving families an average of $437 a year on their energy bills (DOE 2012c).

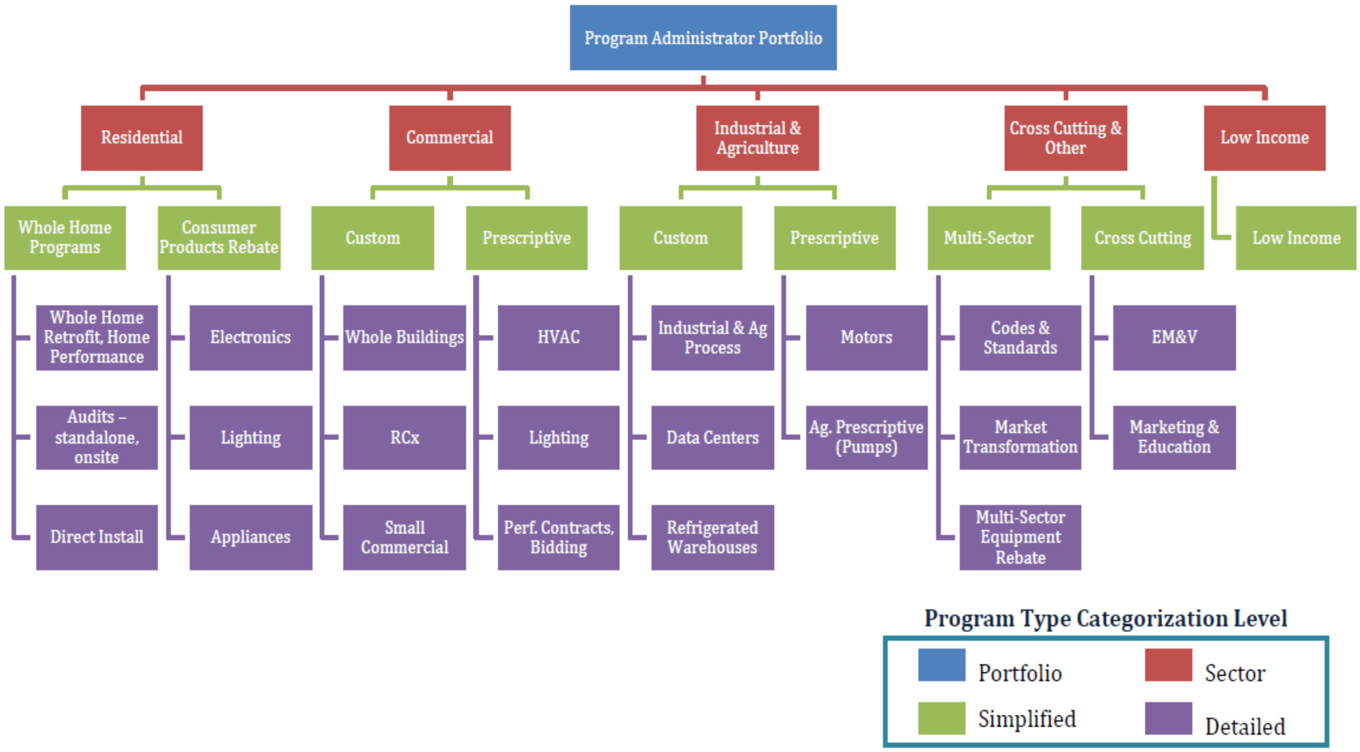
4. EE Programs

4.1 EE Programs

Portfolios of EE programs are comprised of numerous measures and measure types that are applied across all sectors of electricity end-users. Figure 1 illustrates the multi-level composition and breadth of EE program portfolios (LBNL 2013b). The diversity represented by a typical portfolio of EE programs implemented by a utility (or other program administrator) is an important characteristic relevant to analysis of EE policies. Every detailed program type (as illustrated in the lower half of the figure) represents a unique set of characteristics including costs of energy saved, ratio of program to participant costs, investment life, scale, M&V approach, etc.[6]

[6] See following sections for discussion of these factors.

Figure 1. EE Program Portfolio[7]



Source: LBNL 2013b

4.1.1 <u>Administrators</u>

EE programs are administered by a variety of entities ("program administrators") including utilities of all ownership types (investor-owned, municipals, and cooperatives), non-profit and for-profit third-parties (e.g., Vermont Energy Investment Corporation), and state and local government agencies (e.g., NYSERDA). Most EE programs (including all investor-owned utilities which account for more than 75% of reported savings[8]) are overseen by state utility commissions, which review and approve program plans, projected impacts, and associated budgets; and establish annual reporting and M&V requirements (EIA 2013).

4.1.2 <u>Policy Drivers</u>

EE programs result from a number of different policy approaches or "drivers." These include EE resource standards (EERS) (26 states), system benefit charges (14 states), integrated

[7] The "EM&V" box is not comparable to the other program types and is not relevant to this discussion. It was included in the referenced source to indicate that EM&V is a key activity within a program portfolio.
[8] EPA calculation using EIA-861 2013 data.

resource planning (IRP) requirements (34 states), demand-side management plan or multi-year EE budget (28 states), and statutory requirement to acquire "all-cost-effective EE" (6 states) (ACEEE 2014c; Barbose et al. 2013).[9] EERS is a more recently developed strategy and has quickly become the leading driver of the rapid growth in EE programs due to their clear goals and proven success as a policy tool (ACEEE 2011). These policy drivers lead to the evaluation, planning, and adoption of EE programs and associated budgets, which are supported through different funding mechanisms.

4.1.3 Funding Sources

Funding sources for EE programs are varied but for most states are dominated by revenues collected from ratepayers through electricity surcharges, typically ranging from $1 to $4 per megawatt-hour (ACEEE 2014c). More recently adopted funding sources include proceeds from the auction of allowances in the Regional Greenhouse Gas Initiative (RGGI) states and from EE resources bid into the forward capacity market operated by the New England Independent System Operator (NE-ISO). Ratepayer-funding accounts for more than 90% of total EE program support nationally.

4.2 The Demand-Side EE Opportunity

As discussed, states are employing a number of EE strategies with EE programs yielding the most significant impacts both historically as well as in terms of future potential. Furthermore, EE programs are unique among state EE strategies in the comprehensiveness and transparency of their reported impacts, funding, and other characteristics. In this section we address the rapid growth in EE programs, estimated impacts of EE programs to-date and projections of the impacts of existing EE programs and trends, and the electricity savings potential achievable through expanded use of EE policies and programs. Finally, we will discuss the costs and cost-effectiveness of EE programs, specifically.

4.2.1 Rapid Growth in Demand-Side EE

Funding for EE programs has increased rapidly in recent years driven by recent policy innovations and increasing evidence of the effectiveness of these new strategies. Table 2 presents

[9] The number of EERS states is from ACEEE 2014c and includes states with explicit EERS, those with long-term energy savings targets for individual program administrators, and those with EE incorporated as an eligible resource in a renewable portfolio standard. The numbers for the other policy approaches are from Barbose et al. 2013.

levels of EE program funding in the U.S. since 2006 (ACEEE 2014c). In the previous five years, funding increased by more than 250%, from $1.6 billion in 2006 to $5.9 billion in 2011.

Table 2. U.S. Electric Utility EE Program Funding (2006-2013)

	Year							
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Electric Efficiency Program Budgets (billions of $s, nominal)	1.6	2.2	2.6	3.4	4.6	5.9	5.9	6.3

Source: ACEEE 2014c

Key new state policies that have helped to drive these rapid increases in EE program funding include EERS, electricity savings goals, and "all cost-effective EE" requirements. The adoption of EERS, in particular, increased through this period and clearly has been the primary driving force behind the increasing success of and investment in EE programs. Table 3 shows the number of states adopting EERS by year (ACEEE 2014c).

Table 3. U.S. State Adoption of EE Resource Standards

Year	States Adopting an EERS	Total
1997-2004	California, Hawaii, Texas, Vermont	**4**
2005	Nevada, Pennsylvania	**2**
2006	Rhode Island, Washington	**2**
2007	Colorado, Connecticut, Illinois, Minnesota, North Carolina	**5**
2008	Maryland, Michigan, New Mexico, New Year, Ohio	**5**
2009	Arizona, Indiana, Iowa, Maine, Massachusetts	**5**
2010	Arkansas, Oregon	**2**
2011	Wisconsin	**1**
1997-2011		**26**

Source: ACEEE 2014c

4.2.2 EE Program Impacts

4.2.2.1 Impacts to-date

The primary sources for EE program information (including costs and impacts) are annual EE program reports required by utility commissions, or cooperative or municipal utility boards of directors. Program impact results provided in these reports are based on evaluation, measurement, and verification (EM&V) procedures and methods used to estimate the electricity savings from EE programs within the program portfolio. The EIA has been collecting data on EE programs through Form 861, "Annual Electric Power Industry Report," for more than three decades.[10] The data collection reflects an increasing degree of breadth and detail over time. For example, third-party-administered programs were not initially required to report but were added beginning in 2011. Data fields have been added over the years to reflect industry trends (e.g., EE programs are now reported separately from load management programs). Outside organizations have taken the EIA data, supplemented it with additional sources including surveys of utility commissions and program administrators, and published their own annual reports that capture EE program impacts (ACEEE 2014c; CEE 2015).

The EPA has relied on the EIA Form 861 dataset for identifying historical impacts of EE programs by state, tribe and territory. Specifically, the reported sales data and incremental electricity savings in the 2013 EIA 861 dataset are used to estimate electricity EE impacts by state.[11] EIA data is reported by program administrator (e.g., utility, third-party, or state agency) and requires the disaggregation of reported data by state for administrators with programs in multiple states (e.g., multi-state investor-owned utilities). Program administrators in 50 states and the District of Columbia reported savings in 2013. The EPA has compiled this information to derive aggregate electricity sales and incremental electricity savings at the state, tribal and territorial levels.[12]

Three tribal areas (Navajo, Ute, and Fort Mojave) and two territories (Puerto Rico and Guam) have affected EGUs under the final rule. The 2013 EIA form 861 data contain information to identify historical electricity sales and EE activities in these tribal areas and territories. The tribes are located in three states – Arizona, New Mexico, and Utah. Electricity sales within the tribal areas are taken out of the total sales within these three states and reported separately. For Arizona, this includes utility sales in the "Navajo Tribal Utility Authority" (Navajo tribe) and the "Aha Macav Power Service" (Fort Mojave tribe). For New Mexico, this includes utility sales in the "Navajo Tribal Utility Authority" (Navajo tribe). For Utah, this

[10] More information on EIA Form 861 can be found at *http://www.eia.gov/electricity/data/eia861/*.
[11] The analysis uses 2013 EIA 861 data, available at *http://www.eia.gov/electricity/data/eia861/*.
[12] The sub-form "Retail Sales 2013" is used to calculate electricity sales. The sub-form contains details on utility electricity sales by service type (energy, delivery, and bundled) and by sector, within each state and territory. In addition, while EIA's 861 survey encompasses most of each state's utility sales, EIA makes an adjustment to account for the small remainder of data not included in each utility's entry. The adjusted data for "delivery" and "bundled" sales from all sectors are used to calculate sales at the state and territory levels.

includes utility sales in the "Navajo Tribal Utility Authority" (Navajo tribe) and the "Moon Lake Electric Assn, Inc." (Ute tribe).

Table 4 provides a summary of the estimated electricity savings data by state, tribal area and territory for the latest year of available data. At the national level, incremental electricity savings[13] in 2013 was 0.66% of retail sales with individual state values ranging from 0.00% to 2.00%. Cumulative electricity savings[14] (representing the remaining impacts of programs from all prior years) reported at the national level for 2012 represent 3.73% of retail sales with individual state values ranging from 0.0% to 15.44%.[15] 2012 was the most recent year that EIA Form 861 included cumulative savings data, which has been discontinued in the 2013 version of the form.

Table 4. Aggregate Electricity Savings by State, Tribal Area and Territory

State	Incremental Savings as a Percent of Retail Sales (%) 2013	Cumulative Savings as a Percent of Retail Sales (%) 2012
Alabama	0.10%	0.78%
Arizona	1.59%	5.43%
Arkansas	0.49%	0.39%
California	1.16%	13.67%
Colorado	0.92%	4.67%
Connecticut	1.00%	13.39%
Delaware	0.01%	0.00%
District of Columbia	0.45%	0.57%
Florida	0.17%	3.60%
Georgia	0.26%	0.67%
Idaho	0.54%	6.20%
Illinois	1.06%	2.15%
Indiana	0.93%	1.72%
Iowa	1.18%	7.80%

[13] Incremental savings (also known as first-year savings) represent the reduction in electricity use in a given year associated with new EE activities in that same year, either new participants in DSM programs that already existed in the previous years, or new DSM programs that existed for the first time in the current year.
[14] Cumulative savings (also known as annual savings) represent the reduction in electricity use in a given year from EE activities in that year and all preceding years, taking into account the lifetimes of installed measures.
[15] EPA recognizes concerns associated with consistency and quality of 861 data that different reporting entities may have used different methodologies to estimate savings and the EIA 861 data are self-reported. Over time, there has been increased standardization in data reporting. We believe his dataset remains the most comprehensive publically available dataset. See section 3.10 for further discussion.

State	Incremental Savings as a Percent of Retail Sales (%) 2013	Cumulative Savings as a Percent of Retail Sales (%) 2012
Kansas	0.01%	0.24%
Kentucky	0.38%	1.04%
Louisiana	0.03%	0.00%
Maine	1.14%	5.42%
Maryland	1.07%	2.47%
Massachusetts	1.06%	6.27%
Michigan	1.15%	2.77%
Minnesota	1.13%	13.10%
Mississippi	0.23%	0.50%
Missouri	0.49%	0.55%
Montana	0.54%	5.85%
Nebraska	0.15%	0.99%
Nevada	0.48%	6.19%
New Hampshire	0.15%	4.90%
New Jersey	0.70%	1.04%
New Mexico	0.57%	1.87%
New York	1.20%	6.89%
North Carolina	0.60%	1.26%
North Dakota	0.02%	0.22%
Ohio	1.04%	3.20%
Oklahoma	0.26%	0.70%
Oregon	1.20%	7.72%
Pennsylvania	0.91%	3.08%
Rhode Island	2.00%	11.22%
South Carolina	0.46%	1.12%
South Dakota	0.13%	0.33%
Tennessee	0.31%	1.76%
Texas	0.20%	1.54%
Utah	0.82%	6.70%
Vermont	1.77%	15.44%
Virginia	0.02%	0.30%
Washington	1.00%	7.37%
West Virginia	0.25%	0.20%
Wisconsin	1.32%	6.61%

State	Incremental Savings as a Percent of Retail Sales (%) 2013	Cumulative Savings as a Percent of Retail Sales (%) 2012
Wyoming	0.17%	0.71%
Navajo	0.00%	0.00%
Ute	0.00%	0.00%
Fort Mojave	0.00%	0.00%
Continental U.S. Total	0.66%	3.76%
Alaska	0.05%	0.15%
Hawaii	0.04%	0.33%
Puerto Rico	0.00%	0.00%
Guam	0.00%	0.00%
U.S. Total and Territories	0.66%	3.73%

Source: EPA calculation based EIA 2013 and EIA 2012a

4.2.2.2 Projected Impacts

In 2013, Lawrence Berkeley National Laboratory (LBNL) published an update to a 2009 analysis and projected future spending levels and savings through 2025 from EE programs funded by electric and gas utility customers in the United States under three scenarios (high, medium, and low cases) (Barbose et al. 2013). The scenarios represent "a range of potential outcomes under the current policy environment" and were based on detailed, bottom-up analysis of existing state EE policies. Significantly, the study presumes no new major policy developments such as a "national EE standard, clean energy standard, or carbon policy" and specifies that such policy changes could "result in customer-funded EE program spending and savings that exceed the values in our High Case."

The study concludes that efficiency programs are "poised for dramatic growth over the course of the next 10 to 15 years" with the most significant increases occurring in regions with lower levels of program spending, historically, including the Midwest and South. For example, under the medium scenario total U.S. spending on electric efficiency programs increase by 40% to $8.1 billion in 2025 from 2012 levels. Under the high scenario, spending more than doubles from 2012 levels to $12.2 billion in 2025. Incremental savings levels grow commensurately, to 0.8% and 1.1% of sales under the medium and high scenarios, respectively. The study results indicate that under the high scenario 20 states would be achieving 1.5% or higher levels of incremental savings, with 11 of those reaching or exceeding 2.0%.[16] Table 5 summarizes the results of the LBNL analysis.

Table 5. Summary of Impacts: Scenarios of Future Utility Customer-Funded Electric EE Programs

Case	2025		
	Incremental Savings (% of Sales)	**Program Costs (billions of $, nominal)**	**Programs Costs (% of Revenues)**
Low	0.5%	5.5	1.1%
Medium	0.8%	8.1	1.7%
High	1.1%	12.2	2.7%

Source: Barbose et al. 2013

4.2.3 EE Potential

4.2.3.1 Evaluations of EE Potential

EE potential studies are a common tool for informing the development of EE program plans and budgets, as well as supporting the development of electricity savings targets, required savings levels under an EERS, or "all cost-effective" EE requirement. In conducting these studies, states and utilities have developed a methodology that is often described as a "bottom-up, engineering-based" approach (EPA and DOE 2007a). EE potential studies are conducted at various geographic scopes (national, regional, state, and utility service territory level) and at different degrees of aggregation (e.g., economy-wide, sectoral, and program), and can be broadly grouped into a few types: technical, economic, market, and program.[17]

- **Technical potential** represents the theoretical maximum amount of energy use that could be displaced by efficiency, without regard to non-engineering constraints such as costs and the willingness of energy consumers to adopt the efficiency measures. It often assumes immediate implementation of all technologically feasible energy saving measures, with additional efficiency opportunities assumed as they arise.
- **Economic potential** refers to the subset of the technical potential that is economically cost-effective. Definition of "economic potential" can vary to some degree by study. Some estimate economic potential by evaluating technology upfront cost, operating

[16] LBNL provided these unpublished results from their analysis.
[17] The definitions discussed below largely follow that outlined in EPA and DOE 2007a.

costs that considers energy prices, product lifetime and discount rate, compared to a conventional alternative or the supply-side energy resources. Others incorporate consideration of consumer preferences in addition to consumers' out-of-pocket expenditure when evaluating the economic potential. Both technical and economic potential estimates assume immediate implementation of efficiency measures without regard to technology adoption process or real-life program implementation. In addition, these estimates do not always reflect market failures or barriers that impede EE and often fail to capture transaction costs (e.g., administration, marketing, analysis, etc.) beyond the costs of efficiency measures. Another key factor determining economic potential is the level of aggregation at which the cost-effectiveness evaluation is applied. Applying the cost test at lower levels of aggregation (e.g., at the measure or program level, rather than the sector level) will typically lead to lower economic potential when evaluating a portfolio of programs.

- **Market potential (or "achievable" potential**) refers to the subset of economic potential that reflects the estimated amount of energy savings that can realistically be achieved, taking into account factors such as technology adoption process, market failures or barriers that inhibit technology adoption, transaction costs, consumer preferences, social and institutional constraints, and possibly the capability of programs and administrators to ramp up program activity over time.
- **Program potential** refers to the subset of market potential that can be realized given specific program funding levels and designs. Program potential studies can consider scenarios ranging from a single program to a full portfolio of programs.[18]

As mentioned, the EE industry standard for potential studies is the bottom-up, engineering evaluation of EE potential of individual end-use technologies and measures (EPA and DOE 2007a). Bottom-up analyses all employ a similar methodology but can vary significantly in key assumptions (e.g., breadth of sectors and end-uses considered, aggregation level at which cost tests are applied, study period, discount rate, pattern of technology penetration, whether economically justified early replacement of technologies is allowed for, and

[18] Each subsequent potential estimate described above is a subset of the previous potential estimate, e.g., the market potential is a subset of the economic potential, and the economic potential is a subset of the technical potential.

whether continued improvement in efficiency of technology is provided for). As a result, estimated efficiency potential can vary significantly among studies.[19]

4.2.3.2 Overview of Results

EE potential studies have been conducted for decades and in recent years numerous studies have been conducted at utility, state, regional, and national levels. This section presents a summary of more than 50 recent studies (2009 through 2014) collected by EPA. Further detail on the collection of studies is provided in Appendix 1, including a database of study sources and results. Studies were identified by reviewing three recent meta-studies (Sreedharan 2013; ACEEE 2014b; and EPA 2014a) and supplementing those reviewed studies with more recent or overlooked studies. By focusing on studies conducted after 2008, the potentially significant effects of the lighting provisions of the Energy Independence and Security Act of 2007 (Congress 2007) are accounted for. The collected studies cover all major end-use sectors (residential, commercial and industrial) and all regions of the U.S.

To normalize results of analyses addressing different study periods, we present average annual achievable potential by dividing cumulative percentage savings in the last year of the study by the duration (in years) of the study period. This is a common method of normalization for EE potential studies and allows for comparison with results from the EPA's demand-side EE plan scenario later in this chapter (section 8) (Sreedharan 2013; ACEEE 2008, 2014b). Many studies provided multiple estimates of achievable potential. Some studies use the terms "high," "medium" and "low" achievable potential, while others used terms such as "high achievable" and "achievable" potential or, in some cases "achievable" and "programmatic" potential. For studies that provided multiple levels of achievable potential, the highest value was classified as high potential and the lowest value was classified as low potential. If a study provided just a single value, it was used as both the high and low potential value for that study. In many instances, low potential values in the studies were arrived at using assumptions of limited budgets or other limiting factors. To be conservative, the EPA has included these low values but

[19] Because of the complex consumer behavior, energy market and macroeconomic drivers of energy use and energy efficiency, and in some cases due to the lack of consistent data, quantifying energy efficiency potential and energy savings from policies and programs remains a challenging analytical task. Assumptions about consumer technology adoption behavior, market barriers and failures, and how technology diffusion occurs can also affect estimated potential.

generally consider the high achievable values to be the more appropriate point of comparison in evaluating the magnitude and timing of savings represented in the illustrative EE plan scenario.

Table 6 provides summary results of EPA's review of recent EE potential studies. Across all sectors for all studies, average annual achievable potential ranges from 0.9% to 1.3% per year for low to high potential estimates, respectively. Results vary between end-use sectors with the industrial sector showing less potential than residential and commercial sectors. Results for all sectors indicate very substantial opportunity for achievable EE savings.

Table 6. Summary of EE Potential Studies (2009 to 2014)[20]

Sector	Average Annual Achievable Potential (% per year)			
	High		Low	
	Median	Mean	Median	Mean
Residential	1.0%/year	1.2%/year	0.7%/year	0.8%/year
Commercial	1.3%/year	1.3%/year	0.8%/year	0.9%/year
Industrial	0.9%/year	1.0%/year	0.5%/year	0.7%/year
All	1.3%/year	1.2%/year	0.9%/year	0.9%/year

Source: Appendix 1

4.3 Costs and Cost-Effectiveness of State EE Policies

4.3.1 EE Cost-Effectiveness

States enact EE policies to meet multiple policy objectives including reduction of customer electricity bills, lower costs of meeting electricity supply needs, energy reduction, environment and health benefits, and local economic development benefits (EPA and DOE 2006). Most states evaluate their EE policy options through the application of cost tests, weighing the projected benefits with the costs of the EE technologies and practices (EPA and DOE 2008; RAP 2012). Each state determines their own policies for the specific costs and benefits to include in these tests. The costs and benefits are compared on an equal footing by using present value analysis. This is necessary because EE typically requires primarily upfront expenditures (e.g., a whole home retrofit) while the economic benefits (e.g., electricity bill savings) accrue over the life of the investment ("measure life") which can range from a few to

[20]All 53 of the studies reported results for all sectors but many did not report results for one or more of the individual sectors. At least 30 studies reported results for each sector shown in the table. Because of this, the median value for the "low" data for all sectors is higher than the median value for any of the three sectors.

twenty or more years. As such, the choice of discount rate and the estimation of measure life are significant determinants of the cost-effectiveness results. Most states employ multiple tests, adjusting cost and benefit categories depending upon the economic perspective of interest (e.g., utility, ratepayer, program participant, society), and consider the results from each one, usually with an identified primary test type. Policies that are selected are those that are found to be cost-effective, with benefits greater than costs, as determined by the utility applying methods defined by their state utility commission.

There are five primary cost-effective tests used in the U.S.:

1. *Participant cost test* from the perspective of the customer installing the measure. Costs may include incremental equipment and installation costs; benefits include incentive payments, bill savings, and applicable tax credits or incentives.
2. *Utility/program administrator cost test* from the perspective of utility, government agency or third-party implementing the program. Costs may include program incentive, installation, and overhead costs; benefits may include avoided energy and capacity costs - including generation, transmission and distribution - by the utility.
3. *Ratepayer impact measure test* from the perspective of utility ratepayers not participating in available EE programs. This text includes the costs and benefits that will affect utility rates, including program and administration costs, as well as "lost revenues" to the utility; benefits include avoided energy and capacity costs, and additional resource savings.
4. *Total resource cost test* from the perspective of all utility customers in the service area. Costs may include the full incremental cost of the measure, program installation and overhead costs; benefits may include avoided energy and capacity costs, and additional resource savings.
5. *Societal cost test* from the social perspective. In addition to benefits considered in total resource cost test, may also include non-monetized benefits such as environmental and health benefits.

While many states consider more than one cost test in evaluating EE programs, the most commonly used (29 states) primary test is the total resources cost test. This test is considered to be the best measure of the interests of all utility customers. The utility and societal cost tests are the next most commonly used primary tests, used by five states each. The utility cost test is considered to be the most comparable metric to compare with supply-side resource investments from a utility resource planning perspective.

4.3.2 Costs of Saved Energy

A common metric for comparing alternative electricity resource options within utility resource plans is the levelized cost of energy (LCOE) or, for EE resources, the levelized cost of saved energy (LCSE) (EPA and DOE 2007b).[21] LCSE EE is often compared favorably with LCOE of alternative new generation sources such as fossil-fueled or nuclear power plants, or renewable energy resources like wind or solar-power generation. In these comparisons, typically only utility (or program) costs are considered, not the total costs of saved energy that are discussed later in this chapter. The EE analysis literature reports average LCSE in the range of 1-6 cents/kWh based on program administrator cost.[22] A recent review by ACEEE examined studies across 20 states between 2009 and 2012, and estimated LCSE for electricity EE programs in the range of 1.3-5.6 cents/kWh, with a mean value of 2.8 cents/kWh (ACEEE 2014d). Earlier reviews of utility EE programs identified a similar range of LCSE. In 2009 ACEEE reviewed 14 utility studies of LCSE and found a range from 1.6 to 3.3 cents/kWh, with a mean value of 2.5 cents/kWh (ACEEE 2009). An earlier ACEEE study reviewed cost-effectiveness analysis results in nine states and suggested that reported utility LCSE ranged between 2.3-4.4 cents/kWh, with a mean value of 3 cents/kWh (ACEEE 2004). In 2014, an LBNL analyzed the program cost of saved energy based on data from their DSM Program Impacts Database. The database includes program results reported to state regulators by more than 100 program administrators in 31 state, primarily for the years 2009-2011 (LBNL 2014b). LBNL found a national average LCSE of 2.1 cents/kWh of gross savings.

The economic literature also evaluates the LCSE from EE measures using other techniques (e.g., econometrics, top-down modeling), although this body of studies is much smaller compared to the bottom-up, engineering-based analysis. The economic literature has varying treatment of the free ridership, EE program endogeneity, and the rebound effect. The

[21] "Negawatt" or "negawatt-hour" is a term sometimes used to refer to electricity demand or energy reductions achieved through energy efficiency.

[22] Unless otherwise noted, estimates of LCSE discussed in this section refer to program administrator cost (also known as utility cost). The discount rates, average measure lives, and other assumptions affecting the calculation of LCSE were not always consistent or reported in all studies.

different assumptions used in these analyses make direct comparison challenging, but overall these empirical analyses present a wider range of estimates of cost of saved energy. For example, a 2008 study in the Energy Journal examining utility DSM programs estimated the average utility cost of saved energy in the range of 5.1 to 14.6 cents per kWh (Auffhammer et al. 2008). Some other studies in the economic literature suggest estimated LCSE in a similar range as from the bottom-up analyses. RFF calculated an average cost of 3.4 cents per kWh saved from utility EE programs, based on the utility-reported savings in the EIA Form 861 (Gillingham et al. 2006). A 2012 econometric analysis of utility rate-payer funded demand-side management and EE programs between 1992 and 2006 found that the estimated energy savings in electricity consumption were achieved at an expected average cost to utilities of approximately 5 cents/kWh (Arimura et al. 2012). In 2011, using a top-down approach that evaluates the savings potential of EE investments using state- and region-specific price elasticity, an RFF study estimated that electricity savings of 1 to 3 percent were available at a marginal cost of 5 cents/kWh and a corresponding average cost of 2.5-3.5 cents/kWh (RFF 2011).

A number of analytical and data considerations related to LCSE estimation are also discussed in the literature, including the issue of “free riders” in EE programs, and the accuracy of utility reported costs and energy savings (Train 1994; Joskow and Marron 1992). EE practitioners also recognize the need to consider “free rider” and “spillover” effects in program evaluation (Gillingham et al. 2006). A slight majority of states adjust for free ridership in energy savings estimates, leading to higher LCSE values than otherwise would be the case (ACEEE 2012a). A smaller number of states adjust for spillover effects which reduce LCSE values when addressed.

Another consideration related to LCSE estimation is the rebound effect. The economic literature has extensive discussion of the potential rebound effect, market interactions and economy-wide response of EE policies and investments. An improvement in EE would effectively reduce the cost of a service or production input, potentially boosting its demand or production output thus increasing energy use (“direct” rebound). In addition, money saved from EE can be used for consumption or investment that can increase energy consumption for other goods and services in the economy (two forms of “indirect” rebound). Reviews suggest that both direct and indirect rebound effects exist and the size of such effects varies among different studies, technologies, sectors and income groups (UKERC 2007). Overall, however, rebound effects are found to be relatively modest in most markets and settings (Greening et al. 2000; Davis 2008; Gillingham et al. 2013; UKERC 2007).

5. Other EE Strategies

In addition to ratepayer-funded EE programs, many other strategies are available to increase investment in EE and realize associated energy savings, emissions reductions and other benefits. In this section we address a few of the more significant opportunities for realizing additional EE potential: building energy codes, state appliance standards, energy service performance contracting, and volt/VAR optimization.

5.1 Building Energy Codes

5.1.1 Overview

Building energy codes establish minimum efficiency requirements for new and renovated residential and commercial buildings. Building energy codes lock in long-term energy savings at a low cost during the building design and construction phase; some of which would not be feasible or cost-effective as building retrofits. The primary policy rationale for energy codes is the need to overcome large and persistent market barriers, the largest of which is the concern over split-incentives or "principal-agents," in which builders' incentives to minimize the initial costs of constructing a building are misaligned with occupants' incentives to minimize total occupancy costs. Building energy codes are designed to eliminate inefficient technologies and building practices, minimizing total ownership and operating costs over the life of the building. Additional co-benefits of implementing building energy codes include pollution prevention, improved electric system reliability, avoidance of new energy supply investment, and improved occupant comfort and health. Energy building code requirements are also designed to overcome the complexity of advanced codes, lack of local-level implementation resources, and a shortage of empirical data on the costs and benefits of codes.

Building energy codes specify thermal performance[23] criteria for building thermal envelope components such as walls, ceilings, floors, and windows, and also set air leakage and duct leakage standards. They also address lighting system efficiency, hot water system efficiency, and heating and cooling equipment efficiency in cases where federal standards do not

[23] The thermal performance of a building refers to how well the temperature of a building is insulated from the outside environment.

cover the affected equipment or system types. For the residential sector, the International Energy Conservation Code (IECC) is the prevailing model code, and ASHRAE 90.1 is the model code for the commercial sector (EPA 2014b). Various versions of these model codes are adopted and enforced at the state and local government levels.

5.1.2 Authority / Obligated Parties

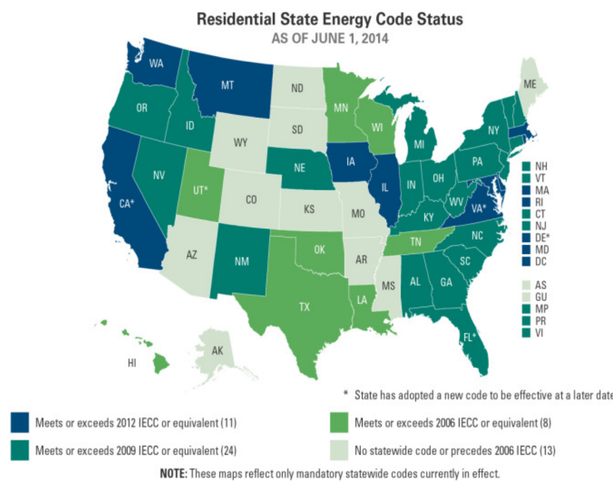
Model energy building codes are typically developed at the national or international level, adopted at the state or local level, and administered and enforced locally. Local building industry parties, such as developers and property owners requiring building permits, are the most common obligated parties (EPA 2014b). Federal authority affecting state code adoption was established in the Energy Policy Act (EPAct) of 1992 (Congress 1992); its provisions require the U.S. Department of Energy to review each new version of the IECC and ASHRAE 90.1, released about every three years, to determine whether they save energy compared to the previous version (EPA 2015). When DOE concludes that a new version of the code would improve energy efficiency, states must review and consider adopting the new code. However, since EPAct 1992, not all states have adopted or updated residential and commercial building energy codes per the current DOE determination.

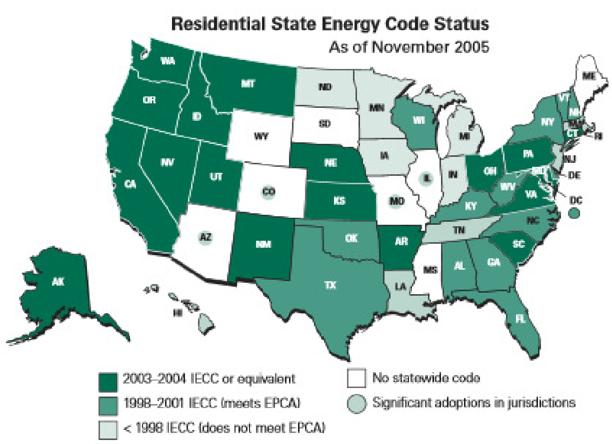
5.1.3 Building Code Regulations Over Time

Federal authority for building codes was established in Energy Conservation and Production Act of 1976 (ECPA), which authorized DOE to create national Building Energy Performance Standards (BEPS) that would be legally binding nationwide. The BEPS provision was repealed by Congress in the early 1980s. States, however, continued to develop energy codes. In 1978, California became the first state to include energy requirements in its code (EPA 2015). Other states, such as New York, Massachusetts, Florida, and Minnesota, developed their own energy codes during the 1980s.

In response to the EPAct 1992 requirements, most states adopted various versions of the IECC and ASHRAE 90.1. Over the last decade, the number of states adopting residential and commercial energy codes has remained relatively stable at about 40 (EPA 2006, 2015). Figure 2 shows this consistency for residential energy codes, as the states with the lightest shading are the ones that had either not adopted or recently updated their energy codes. However, the stringency of these codes has been updated multiple times since 2005 in most states. Eleven of the 40 states with residential building codes are using the 2012 IECC version, which DOE has determined would improve the energy efficiency of residential buildings by approximately 30 percent compared to the 2006 IECC (EPA 2015). A recent study estimated that upgrading the energy efficiency of a typical new home in Arizona from the 2006 IECC would save homeowners an average of $3,245 over 30 years with the 2009 IECC and $6,550 over 30 years with the 2012 IECC (DOE 2012b). DOE estimates that currently-adopted building energy codes across the country will result in a financial benefit of nearly $2 billion annually by 2015 and over $15 billion annually by 2030 (DOE 2014).

Figure 2. Residential Energy Building Code Adoption (2005 to 2014)





Source: EPA 2006 and EPA 2015

5.1.4 Remaining Market Potential

There is still significant potential for savings from building energy code adoption. From 1992 to 2012, building energy codes in the U.S. saved a cumulative 4 quadrillion Btu and reduced greenhouse gas emissions by 300 million metric tons (ACEEE 2015a). From 2013 to 2040, the continued adoption of increasingly stringent building energy codes in the U.S. is expected to save 40.1 quadrillion Btu (ACEEE 2015a). A recent study by ACEEE also found that for residential and commercial building codes, the potential for energy savings by 2030 was 155 million megawatt-hours (MWh) annually, or 4.2 percent of annual electricity consumption relative to 2012 (ACEEE 2014a).

5.2 State Appliance Standards

5.2.1 Overview

State appliance standards establish minimum energy efficiency levels for those appliances and other energy-consuming products that are not already covered by the federal government. These standards typically prohibit the sale of less efficient models within a state. States are finding that appliance standards offer a cost-effective strategy for improving energy efficiency and lowering energy costs for businesses and consumers, though these standards are superseded when federal standards are enacted for new product categories (EPA 2014b).

The key objectives of appliance efficiency standards are to:

- Raise the efficiency of a range of residential and commercial energy-consuming products, where cost-effective.
- Overcome market barriers, such as split incentives between homebuilders and homebuyers and between landlords and tenants, and panic-purchase[24] situations in which appliances break and must be replaced on an emergency basis.
- Ensure energy use reductions to prevent criteria air pollution and greenhouse emissions, improve electric system reliability, and reduce consumer energy bills (EPA 2015).

[24] In a panic purchase, customers usually do not have the time to consider a range of models, features, and efficiency levels, and the full range may not be available from all suppliers.

While state appliance standards can be useful in testing and exploring the effectiveness of standards for new products, many state appliance standards have been preempted or superseded by existing federal standards. States may apply to DOE for a waiver to implement more stringent standards. This is sometimes granted if a certain period of time has passed since the federal standard has been updated (EPA 2015).

5.2.2 Authority / Obligated Parties

Establishing efficiency standards in a state typically requires enabling legislation from the state legislature. However, once legislation is enacted, it may allow an executive agency to set further standards administratively (EPA 2015).

State energy offices, which typically administer the federal state energy program funds, have generally acted as the administrative lead for implementing standards. In contrast, inspection and enforcement of appliance standards regulations has typically involved self-policing among industry. Manufacturers of products being sold in a given state are typically obligated to ensure their appliances meet the appropriate energy efficiency standards (EPA 2014b).

5.2.3 Appliance Standards over Time

California's appliance standards program dates to the 1970s, when the state began to pursue standards before the enactment of federal legislation. When the federal government opted not to issue standards under its legislative mandate in 1982, other states joined California in developing state standards. These state initiatives helped create the impetus for new federal legislation in 1987 (the National Appliance Energy Conservation Act or NAECA), the Energy Policy Acts (EPActs) in 1992 and 2005, and the Energy Independence and Security Act (EISA) in 2007 (EPA 2015). These federal laws have established appliance efficiency standards for more than 50 products, representing about 90% of home energy use, 60% of commercial building energy use, and about 30% of industrial energy use (DOE 2015a). Bolstered by new standards contained in the EPAct 2005, EISA 2007, and additional DOE rules,[25] these savings rose to 278 terawatt-hours (TWh), or 7% of U.S. electricity use in 2010. By 2025, total electricity savings from existing federal standards are projected to increase to 682 TWh per year, or 14% of the

[25] DOE is required to review federal appliance standards and test procedures periodically, and initiate a process to set new standards provided that improvements to energy efficiency are "technically feasible and economically justified" (DOE 2015b).

projected annual U.S. electricity use. Net savings to consumers and businesses are also expected to increase from $27 billion in 2010 to $61 billion in 2025 (ASAP 2012).

While the NAECA effectively preempted state action on federally covered consumer products, California has continued to develop efficiency standards for other products and technologies that aren't included in the Act. California's standards program has contributed to substantial improvements in energy efficiency. Since its inception, the program has saved consumers over $75 billion on electricity bills (CEC 2013).

Since 2001, 15 states and the District of Columbia have enacted appliance efficiency standards. While most of these individual standards have been superseded by federal standards, as of February 2014, 12 states[26] and the District of Columbia have one or more appliance efficiency standards for products not covered by federal standards (ASAP 2014).

5.2.4 Remaining Market Potential

While federal appliance standards continue to expand, the direct economic and environmental benefits of state standards are still substantial. California draft regulations for 15 new appliance standards are expected to save 50 billion gallons of water, 1,400 MW of peak electricity, 9.8 TWh of electricity, and 162 million therms of natural gas per year. This is expected to result in annual savings of $2 billion (CEC 2014).

From a national perspective, there is still untapped potential for states to move into product areas not yet covered by federal standards. Table 7 shows potential energy savings from products that do not currently have federal standards. The three products with the greatest potential in the residential, commercial and industrial, and lighting sectors are shown, along with a summary line for each sector. Some of the greatest potential savings in 2035 are in the residential sector, specifically improvements in water heater efficiency. Implementing all of these standards through federal regulations would result in annual savings of 212 TWh in 2025, or 5% of projected national electricity consumption (ASAP 2012; EIA 2015).

[26] These states include Arizona, California, Connecticut, Georgia, Maryland, Nevada, New Hampshire, New York, Oregon, Rhode Island, Texas, and Washington.

Table 7. Estimated Energy Savings Potential of State Appliance Standards

	Annual savings in 2025			Annual savings in 2035		
	Electricity savings	Peak demand	Natural gas	Electricity savings	Peak demand	Natural gas
Products	**(TWh)**	**(GW)**	**(Tbtu)**	**(TWh)**	**(GW)**	**(Tbtu)**
RESIDENTIAL STANDARDS						
Water heaters	18.2	2.5	—	43.0	5.9	—
Set top boxes and digital communication equipment	14.7	2.0	—	14.7	2.0	—
Air handlers	13.7	5.6	—	29.1	11.9	—
Total (14 products)	**98.5**	**16.8**	**51.6**	**142.3**	**27.0**	**51.6**
COMMERCIAL AND INDUSTRIAL STANDARDS						
Walk-in coolers and freezers	14.7	3.4	—	14.7	3.4	—
Distribution transformers	10.9	1.5	—	22.4	3.1	—
Electric motors	9.0	1.4	—	18.6	2.9	—
Total (13 products)	**62.4**	**15.5**	**74.2**	**98.5**	**24.5**	**139.9**
LIGHTING STANDARDS						
Incandescent reflector lamps	20.2	5.0	—	20.2	5.0	—
Outdoor lighting fixtures	10.3	0.7	—	26.1	1.8	—
General service fluorescent lamps	6.9	1.7	—	6.9	1.7	—
Total (7 products)	**50.8**	**9.3**	**—**	**65.6**	**15.6**	**—**
ALL PRODUCTS	**212**	**42**	**126**	**306**	**67**	**235**

Source: ASAP 2012

5.3 Energy Service Performance Contracting

5.3.1 Overview

Energy service performance contracting (ESPC) uses cost savings from reduced energy consumption to repay the cost of installing energy conservation measures (HUD 2014). Under an EPC program, an Energy Service Company (ESCO) first conducts an energy audit. The ESCO then designs and constructs a project that achieves the building owner’s energy efficiency needs and arranges for the project’s financing, usually through a third party. The third party is repaid by the building owner/operator from the savings in their energy costs. In this type of ESPC arrangement, the builder owner/operator does not need to incur upfront expenses, and will experience the benefits of the upgrades, including monetary savings once the financer’s costs have been repaid (ICF 2007).

ESPC programs have been used extensively by state, federal, and local facilities to reduce utility and operating costs and to help meet environmental and energy efficiency goals, which can include the use of combined heat and power (CHP). Forty-nine states have implemented performance contracting activities, primarily through legislation, covering a combination of entities that include public agencies, school districts, municipalities, state colleges and universities, counties, or the state as a whole (ORNL 2015).[27] While ESPC programs are already widespread, states have found that they can further utilize this approach by extending eligibility to all public facilities in the state (EPA 2015).

While ESCOs deliver ESPC projects, and the ESPC market is the main driver for ESCOs, the two markets do not overlap completely. Since 2006, the share of the ESCO market consisting of ESPC projects has remained stable at about 70 percent (ICF 2007; LBNL 2014a). The other 30 percent of the market is comprised of design/build services; engineering, procurement, and construction services; consulting services; and operation and maintenance contracts. These services are not considered to be EPC projects since the project financial performance risk is not incurred by the ESCO or potential third party lenders (ICF 2007).

5.3.2 History of ESPC Programs and the ESCO Business Model

The ESCO business model emerged during the 1970s, supported in part by utilities paying ESCOs a fee for services such as energy audits provided to customers via their electric utilities and implementing federal energy management goals (NAESCO 2011). EPC activities emerged in the mid-1980s as power plants became more expensive to build and utilities were ordered to produce Integrated Resource Plans (IRPs) where energy efficiency measures could be used to meet projected demand. ESCOs were used to deliver energy savings from projects implemented at industrial and institutional sites, relying on advances in energy efficiency monitoring and verification techniques (ICF 2007).

By the late 1990s, funding for utility-sponsored energy efficiency programs was reduced in about half of the states due to changed regulatory structures and increased political and regulatory pressures to maintain lower electricity prices (EPA 2006). Many restructured electric utilities shifted their focus away from sponsoring programs to starting new affiliated ESCOs to deliver energy services directly to customers. However, the business model for these market-based ESCOs was limited in reach to mainly larger industrial, commercial and institutional customers. Several states and local governments also turned to EPC activities to provide services

[27] Wyoming currently has no performance contracting legislation.

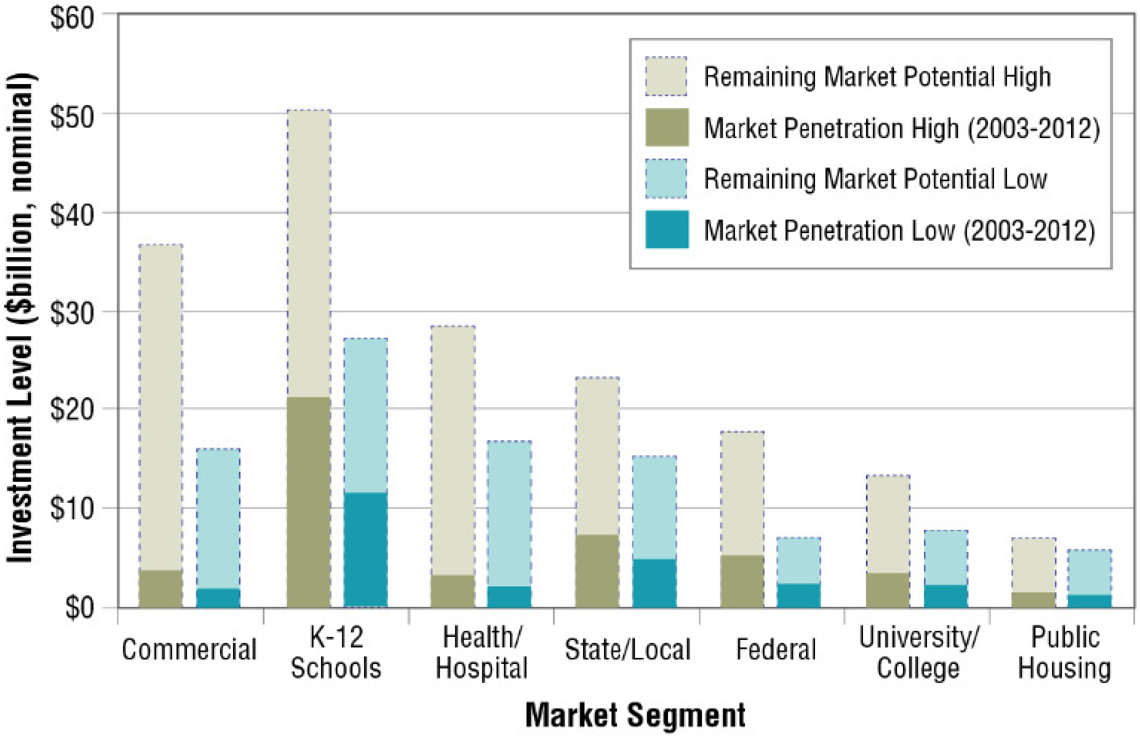
in public facilities via lead-by-example policies (see section 3). These governments also saw the benefits of addressing capital equipment and maintenance projects that would not have otherwise been addressed through the capital budget process (ICF 2007). Commercial lenders also became involved in EPC funding, lowering the cost of projects through competition and paving the way for new financing vehicles (ICF 2007).

During the early 2000s, however, the growth of the EPC and ESCO market declined due to loss of both performance contracting in federal buildings and market confidence for industrial financing mechanisms (NAESCO 2011). This trend reversed in 2005 as the EPC and ESCO market increased focus on state and local public buildings and innovated program offerings to provide customers new technologies and financial models (see section 3 and ICF 2007).

5.3.3 Remaining Market Potential

The market potential for EPC programs and ESCOs remain significant. Annual revenues for the U.S. ESCO market was expected to increase from $5.3 billion in 2011 to about $6.4 billion in 2013 (LBNL 2014a). An analysis by Lawrence Berkeley National Lab estimated the investment opportunity for ESCOs ranged between $71 billion and $133 billion (LBNL 2013a). Figure 3 shows a breakdown of investment opportunity by market segment. Commercial buildings, K-12 schools, and the health and hospital sectors have the highest remaining potential for ESCOs. Commercial buildings in particular have high barriers to implementing energy efficiency under EPC activities, as the private sector is generally averse to financing energy efficiency activities and has more stringent requirements for a lower payback period on projects (LBNL 2013a). While the two markets do not overlap completely, the potential for ESCO investments provide a strong indicator for the remaining potential of EPC activities.

Figure 3. Remaining Market Potential for ESCOs



Source: LBNL 2013a

5.4 Volt/VAR Optimization

5.4.1 <u>Overview</u>

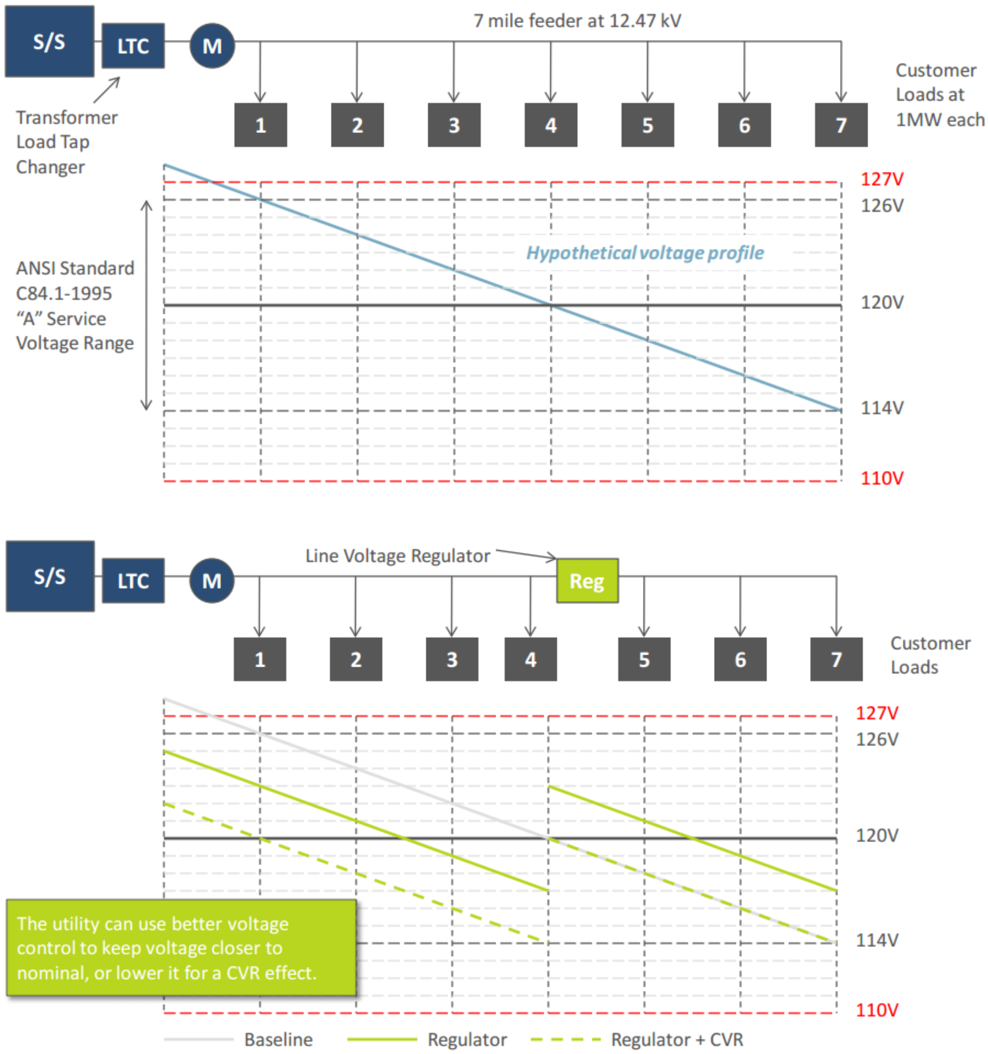
Volt/VAR optimization (VVO) refers to coordinated efforts by utilities to manage and improve the delivery of real and reactive power[28] in order to increase the efficiency of electricity distribution. VVO is accomplished primarily through the implementation of Smart Grid technologies that improve the real-time response to the demand for real and reactive power. Technologies for VVO include load tap changers and voltage regulators, which can help manage voltage levels, as well as capacitor banks, which allow for the delivery of reactive power. By using local capacitor banks to respond to reactive power demand, rather than adjusting the output of remote generators, systems can achieve reductions in transmission line loss. The U.S. Energy Information Administration (EIA) estimates that on average, 7.5% of generated electricity is lost

[28] Reactive power is an inherent feature of alternating current systems, and is related to the phase shift between the current and voltage. Reactive power does no work, but is important for circuits that include capacitive and inductive loads, most notably motors. It is measured in Volt-Ampere Reactive (VAR).

in transmission and distribution, a number that could be reduced by effective use of VVO (EIA 2012b).

VVO efforts are often closely related to conservation voltage reduction (CVR), which are actions taken to reduce initial delivered voltage levels in feeder transmission lines while remaining within the 114 volt to 126 volt range required at the customer meter (based on ANSI C84.1 standards). Like VVO, CVR relies on the use of Smart Grid technologies in order to more effectively manage voltage levels across all loads in a system. A simple presentation of these benefits are shown in Figure 4, where the implementation of VVO technologies allows electricity distributors to deliver electricity initially at a lower voltage, thus decreasing the generation fuel requirements, while still delivering within the acceptable range to all 7 loads. The combination of VVO and CVR can lead to a range of benefits, including reductions in peak electricity demand, reductions in energy requirements necessary to meet a certain level of demand, and a reduction in line loss.

Figure 4. Hypothetical Voltage Profiles with and without VVO Technologies



Source: DOE 2011

5.4.2 History of VVO Programs

VVO and CVR efforts were first introduced with partial implementation in California in 1977 (UNLV 2014). In 1987, the Snohomish Public Utility District instituted a pilot CVR project that demonstrated the possibility of reducing voltage and energy requirements by approximately 2.1% (NRECA 2013). More recently, the advent of Smart Grid technology with increased availability of energy use data, has led to a renewed interest in VVO and CVR as the potential for increased efficiency has become more apparent. Of the 99 projects funded by the Smart Grid Investment Grant program under the American Recovery and Reinvestment Act of 2009, 26 included the implementation of VVO technologies. These projects, which target reduced voltage during peak demand, electricity conservation due to reduced voltage, and reduced losses from feeder lines, are expected to achieve a 1% reduction in energy consumption for every 1% reduction in voltage level (DOE 2012a).

There is no formal state requirement directing implementation of Volt/VAR optimization. However, in 2012, the National Association of Regulatory Utility Commissioners published a resolution in support of VVO implementation at the state-level. The resolution encouraged public utility commissions to work with state legislature to include deployment of VVO technologies as part of energy efficiency resource standards (NARUC 2012).

5.4.3 VVO Market Potential

Large market potential currently exists for the implementation of VVO. The Pacific Northwest National Laboratory estimates that implementing VVO nationwide could potentially yield as much as a 3.2% annual reduction in energy consumption (PNNL 2012). The Bonneville Power Administration estimates that the cost-benefit ratio for transmission and distribution optimization is positive and well understood, and that CVR is a key component of these positive effects (BPA n.d.). McKinsey estimates that VVO could provide $43 billion in gross annual benefits in 2019 in the U.S., with CVR comprising the largest share of these benefits (McKinsey 2010). IHS Technology estimates that the shipments of VVO technology devices will double between 2013 and 2018, with a quadrupling of revenue over the same time period (IHS 2013). The Institute of Electrical and Electronics Engineers estimates that CVR has the potential to save approximately 750 trillion BTUs of electricity, equivalent to 5.4% of total U.S. electricity generation, at a total cost of $3.3 billion dollars (IEEE 2014). While these estimates vary in level of impact, they display the strong market potential that exists for VVO projects.

6. Utility Regulatory Models for Supporting Demand-Side EE

The electricity sector widely recognizes that state utility regulatory models for supporting energy efficiency are key to expanding utility investments and higher energy savings from programs (IEI 2014). Further, all states which regulate investor-owned utilities have adopted or modified one or more policies in order to better align utility incentives with the delivery of cost-effective energy efficiency (IEI 2014). States with the highest per capita spending on energy efficiency programs have the most comprehensive regulatory models for energy efficiency in place (NRDC 2012).

The most common regulatory models for incentivizing energy efficiency through electric utilities include decoupling revenue from sales volumes, ensuring program cost recovery, and providing shareholder incentives linked to program performance. The Edison Foundation reports on the adoption of these policies across states through its Institute for Electric Innovation, as shown in Table 8.

Table 8. Summary of State Regulatory Frameworks: December 2014

Energy Efficiency Incentive Mechanism		Number of States	Pending
Fixed-Cost Recovery Mechanisms	**Lost Revenue Recovery**	19	0
	Revenue Decoupling	14	1
Performance Incentives		29	2
Program Cost Recovery		46	0

Source: IEI 2014

These approaches have been widely used for over a decade, with performance incentives approved by Connecticut as early as 1988 (IEI 2014). In 2006, the need for such policies was recognized by the National Action Plan for Energy Efficiency Leadership Group of gas and electric utilities, state agencies, energy consumers, energy service providers, environmental groups, and energy efficiency organizations. Over 100 states, utilities, and key stakeholders across 49 states made aggressive commitments to energy efficiency under the Action Plan and endorsed the Action Plan five key policy recommendations which included modifying utility incentives (EPA and DOE 2006). In 2014, the Edison Electric Institute (EEI) and the Natural Resources Defense Council (NRDC) issued a joint statement urging state utility regulators to adopt a number of policies to sustain utility financial health given the greater investment being made in both energy efficiency and customer-sited electricity generation (NRDC 2014).

The need for states to adopt utility financial incentive policies is due in part to how traditional ratemaking allows utilities to recovery costs based on the volume of electricity sold. This creates an incentive to maximize the volume of sales (often referred to as the “throughput incentive”), which in turn creates a disincentive to invest in energy efficiency since such programs will reduce sales volume. A decoupling policy counteracts the financial incentive to increase sales by fixing a utility's revenue for a specific term, in order to match the amount of anticipated costs incurred plus an appropriate profit. If the utility can reduce its costs during the term through energy efficiency, the utility will be able to increase its profits. Alternately, lost revenue adjustment mechanisms may be used to diminish the throughput incentive by allowing utilities to directly recover the lost revenue associated with not selling energy due to energy efficiency programs.

Reduced electricity sales may affect utility finances in additional ways, including reducing the utility's opportunity to earn additional profit from the regulated rate of return on new capital projects which would otherwise be needed to meet higher load growth, such as new generators and transformers upgrades. As an alternative, performance incentive policies are used to allow utilities to earn a profit for achieving high levels of energy savings, recognizing that multiple benefits of energy efficiency resources that are not otherwise explicitly accounted for in traditional regulatory models. Performance incentive policies come in different forms, such as earning bonuses and allowing a utility to earn a higher rate of return on capital invested in energy efficiency.

The level of capital investment made by a utility is often informed by electricity resource planning. Most states require one or more forms of electricity resource planning, such processes used to inform long-term integrated resources plans (IRPs) and regulatory approvals for large projects often referred to as Certificates of Public Convenience and Necessity (CPCNs). IRPs are required or present in more than 30 states, including most vertically integrated states, and at least 19 states have some form of CPCN (EPA 2015). Incorporating energy efficiency into electricity resource planning enables the utility to consider a broad range of electricity resource options and avoid capital investment in more expensive electricity supply or delivery infrastructure.

Due in part to the shifts in long-term incentives from regulators, utilities are also increasingly seeing energy efficiency as part of their business model. According to a 2015 survey of utility executives, 71% of utilities are developing new business models for energy efficiency and demand response (UtilityDIVE 2015). A significant number of the utilities surveyed see their business model changing from a traditional vertically integrated utility, to an energy services or smart integrator businesses model. Further, states such as New York and Hawaii have initiated actions at their public utility commissions to examine and encourage changes to the utility business model.[29] Both of these state are experiencing growth in distributed electricity generation and can build upon their existing energy efficiency regulatory frameworks which include energy efficiency program cost recovery, decoupling, and performance incentives.

7. Energy Efficiency Certificates

In the U.S., extensive consideration of tradable energy efficiency credits (EEC) developed almost a decade ago, most often framed as a potential compliance mechanism for state energy efficiency resource standards (EERS), a widely adopted and effective policy mechanism for achieving cost-effective electricity savings through utility energy efficiency programs.[30] State EERS as a key policy strategy and the use of EECs for compliance were concepts borrowed from the earlier adoption of renewable portfolio standards (RPS) and the use of renewable energy credits (RECs) for compliance.

Building from the successful experience with EERS/RECs, several significant policy papers discussed how the generation, tracking, and trading of energy efficiency credits could work as a means for supporting compliance with EERS or as a mechanism for achieving greenhouse gas reductions (NREL 2008; CRS 2007; IEA 2012a). A few states put regulations in place that allowed for the use of EECs for EERS or RPS compliance.[31] Consistent with these developments, several of the regional tracking systems developed to support the use of RECs for compliance with state RPS also included a capability to perform the same functions for the use of EECs for potential compliance with state policies.[32] However, these capabilities have yet to be widely used as significant levels of EEC transactions have not developed in the U.S.

There are, however, some voluntary markets for energy savings credits. For example, North American Renewable Registry extended its certificate tracking system to energy efficiency, and registered the first voluntary energy efficiency certificates for IBM Corporation

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[29] For more information, see the New York Reforming Energy Vision proceeding (*http://www3.dps.ny.gov/W/PSCWeb.nsf/All/26BE8A93967E604785257CC40066B91A?OpenDocument*) and Summary from Hawaii PUC of the Commissions Inclinations on the Future of Hawaii's Electric Utilities (*http://puc.hawaii.gov/wp-content/uploads/2014/04/Commissions-Inclinations.pdf*).

[30] Many terms have been used or suggested including energy efficiency certificates, energy savings certificates, white tags, and white certificates.

[31] These states include Connecticut, Michigan, and North Carolina.

[32] NEPOOL Generation Information System issues energy efficiency certificates for CT. PJM Generation Attribute Tracking System issues energy efficiency certificates for PA. NC Renewable Energy Tracking System allows energy efficiency to count towards compliance with the NC RPS.

in March 2010 (NARR 2010). Sterling Planet, a retailer of RECs and carbon offsets, also offers White Tags® trading instruments that recognize the meter-measured, performance-based results of energy efficiency projects. In June 2012, Sterling Planet completed the first White Tags transaction by purchasing Michigan's Selfridge Air National Guard Base's 2011 White Tags in order to fulfill energy efficiency compliance requirements for a Michigan utility (Sterling Planet 2012). The Climate Registry has a program called "Cool Planet Energy Efficiency" which provides assistance to utility company business customers with measuring and managing their energy and carbon outputs (TCR 2015).

Even though experience with EECs in the U.S. is limited, their use internationally has been significant. Nine energy efficiency policies across seven countries outside of the United States allow for trading of the energy savings used for compliance (IEA 2012a). Trading has been incorporated in the design of these policies to help identify cost-effective opportunities from a broader pool of participating projects and parties. Table 9 summarizes the types of energy savings and trading included in policy design. Over half of these policies allow for trading through the creation and sale of EECs.

Table 9. International Examples of Trading Energy Savings

Country (Jurisdiction)	Eligible Energy savings	Type of Trading
Australia (New South Wales)	Preapproved projects implemented by obligated and accredited non-obligated parties	EECs
Australia (South Australia)	Activities undertaken by, or on behalf of, obligated energy retailer	Limited transfer of credits among obligated parties
Australia (Victoria)	Installation of preapproved energy efficiency products by obligated and accredited non-obligated parties	EECs
China	Achieved by grid companies and energy service companies subsidiaries of grid companies	Obligated parties may purchase savings from customers and ESCOs under bilateral contracts
Denmark	Distributors must engage third parties to achieve energy savings across energy types	Energy savings may only be traded among obligated energy distributors
France	Produced by obligated parties, local authorities, and social housing landlords	Over-the-counter trading of EECs
Italy	Produced by obligated distributors ad accredited energy service providers	Over-the-counter and spot market trading of EECs
Poland	Projects selected through annual auctions	EECs fully tradable on the Polish Power Exchange
United Kingdom	Projects implemented by obligated parties or their contractors	Transfers of emissions reductions and trading of obligations allowed among obligated parties

Source: IEA 2012a

Two good international examples are provided by programs in Italy and in Australia (New South Wales) that have been trading EECs successfully and at significant scale over the past decade (Pavan 2008; NSW 2015). Italy uses EECs as part of its White Certificates system, a key policy supporting their international climate commitments (Italy 2014). In implementing this policy, electricity and gas distribution utilities use EECs to meet established energy savings targets. These utilities may either generate their own EECs or buy from third parties through the market. Approximately one-third of EECs are generated by third parties and subsequently trade on the open market. EECs are also exchanged between energy efficiency providers and utilities through bilateral contracts.[33] The majority of energy savings from the Italian White Certificates system are realized from reducing electricity usage through a set of pre-established eligible project types (IEA 2012a).

[33] From 2005-2009, electricity savings met 77% of the overall energy savings targets, as reported in The Fifth National Communication under the UN Framework Convention on Climate Change, submitted by Italy in November 2009.

In Australia, the state of New South Wales initially incorporated EEC trading as part of their Greenhouse Gas Emissions Trading scheme. In 2009, New South Wales began trading EECs via the Energy Savings Scheme recognizing that unique barriers to energy efficiency persisted. Obligated parties, which include electric utilities, are required to acquire and surrender EECs to meet the energy savings targets of the Energy Savings Scheme. Other organizations also use EECs to voluntarily reduce their greenhouse gas emissions. Energy efficiency projects across residential, commercial and industrial sectors are used to create EECs in New South Wales.

Active trading of EECs also exists in New South Wales. Trading markets have been established by the private sector with some organizations, such as the Australian Financial Markets Association and individual brokers of environmental commodities, providing regular updates on EEC wholesale market prices (NSW 2015). Even though most EECs are traded via bilateral contracts, trading of EECs has also developed across spot, forward, and options contracts. Since any party who is an "Accredited Certificate Provider" may create EECs, the Energy Savings Scheme policy has fostered the development of a robust energy services industry of firms implementing energy efficiency projects supported in part by revenues from the sale of associated EECs.

8. Demand-Side EE Plan Scenario: Magnitude and Timing of Savings

8.1 Approach

Chapter 3 of the Regulatory Impacts Analysis (RIA) presents illustrative analysis of the final rule by making assumptions about the approaches that states might pursue as they develop their state plans. These approaches are embodied in the illustrative plan scenarios developed by EPA for the RIA and used to estimate the costs, benefits, and impacts of the final rule. The final CPP provides the states the flexibility to use demand reductions resulting from demand-side EE as a component of their state plan strategy, either directly recognized towards compliance with a rate-based goal or as a complimentary approach for achieving a mass-based goal (see section VIII, State Plans, of the final rule preamble for details). The EPA has included in the illustrative plan scenarios (both rate- and mass-based) a level of demand reduction that could be achieved, and the associated costs incurred, through implementation of demand-side EE measures. In this section, the EPA provides the basis for the illustrative demand-side EE plan scenario that is included as a component of the plan scenarios presented in the RIA and, then, in the following section, the basis for associated EE cost estimates are provided.

The demand-side EE plan scenario is derived from state and utility experience with ratepayer-funded EE programs and the resulting energy savings, as described in preceding sections of this TSD. Demand-side EE is included in the illustrative analysis contained in the RIA for several reasons including the current use of such programs in every state, the substantial savings relative to other opportunities to reduce CO_2 emissions from the power sector, overall cost-effectiveness, and the quality of available information on their impacts and associated costs. The ratepayer-funded EE programs are the basis for the levels of demand-side EE that are included as part of the RIA, although there are other strategies and measures that states may employ for purposes of the final CPP. For example, the final rule provides states the flexibility to use building codes, appliance standards, and energy service performance contracting (to name a few examples), and those strategies also offer substantial, low-cost opportunities to reduce CO_2 emissions from affected EGUs.

8.2 Inputs

The following steps were taken to establish the inputs for development of the illustrative demand-side EE plan scenario for each state, tribal area, and territory:

- *Step 1: Determine current level of demand-side EE performance*
- *Step 2: Determine EE plan scenario level of performance*
- *Step 3: Determine start year for EE plan scenario*
- *Step 4: Determine start year level performance*
- *Step 5: Determine pace of improvement from start year to EE plan scenario level of performance*
- *Step 6: Determine average portfolio measure life and distribution of measure lives*
- *Step 7: Determine sustainability of EE plan scenario level of performance*

8.2.1 <u>Step 1: Determine Current Level of Demand-Side EE Performance</u>

A fundamental indicator of the level of EE program performance is incremental annual savings (also known as first-year savings) as a percent of retail sales. This is a common metric defining savings levels for state EERS and is readily calculated from EIA Form 861 data for each state, tribal area and territory (hereafter, just referred to as "states"). Incremental annual savings are also more directly estimated and evaluated than are cumulative savings.[34] To determine the current level of demand-side EE performance, the EPA aggregated the most recent (2013) EIA Form 861 data to the state level to establish their current level of performance. Estimated incremental savings results are presented in Table 4.

8.2.2 Step 2: Determine EE Plan Scenario Level of Performance

As discussed previously (section 4.2.3), achievable demand-side EE potential exists at significant and comparable levels (on the basis of total cumulative potential over a period of ten to twenty years) in all regions of the country. While varied regional characteristics (e.g., avoided power system costs, economic growth, sectoral mix, climate, and level of past EE efforts) affect estimates of achievable potential, ongoing improvements in energy-efficient technologies and practices, economic growth, population increases, and continually improving strategies for program delivery have resulted in persistent and substantial levels of achievable potential regardless of specific regional characteristics.

Direct indicators of the achievable incremental levels of energy savings performance is provided by past performance at the state and utility levels, and by requirements states have put in place for levels of savings to be achieved by 2020. As discussed, these requirements are often in the form of EERS or similar savings goals that are applied to utilities in the state.

Table 10 summarizes incremental savings levels as a percentage of retail sales from EIA Form 861 (2013) data, aggregated to the state level, and categorized into four ranges of savings levels (< 0.5%, 0.5% to 0.99%, 1.0% to 1.49%, and >= 1.5%). As shown, three states achieved the highest level of performance (> 1.5%) and an additional fourteen states achieved the second highest level of performance (1.0% to 1.49%).

[34] Estimates of cumulative savings impacts in a given year are derived from incremental savings values and information on measure lives. Information on measure lives is less consistently gathered than is information on incremental savings values.

Table 10. 2013 State Levels of Incremental Annual Savings

Incremental Savings as % of Retail Sales	# of States	States
>= 1.5%	3	AZ, RI, VT
1.0% to 1.49%	14	CA, CT, IL, IA, ME, MD, MA, MI, MN, NY, OH, OR, WA, WI
0.5% to 0.99%	9	CO, ID, IN, MT, NJ, NM, NC, PA, UT
< 0.5%	25	AL, AK, AR, DE, DC, FL, GA, HI, KS, KY, LA, MS, MO, NE, NV, NH, ND, OK, SC, SD, TN, TX, VA, WV, WY

Source: EPA calculation using EIA 2013

In addition to the state levels of performance represented in Table 10, numerous utilities of all ownership types and in all regions of the country have achieved significant levels of incremental savings. Tables 11, 12, and 13 provide examples of investor-, cooperative-, and municipal-owned utilities and their incremental savings levels for 2013 based on EIA Form 861 data.

Table 11. 2013 Incremental Annual Savings – Investor-Owned Utilities

Investor-Owned Utility	State	Incremental Savings as % of Retail Sales
Arizona Public Service Company	AZ	1.6%
Commonwealth Edison Company	IL	1.2%
DTE Electric Company	MI	1.3%
Niagara Mohawk Power Corporation	NY	2.2%
Pacific Gas & Electric Company	CA	1.7%
Potomac Edison Company	MD	1.8%

Source: EPA calculation using EIA 2013

Table 12. 2013 Incremental Annual Savings – Cooperative-Owned Utilities

Cooperative-Owned Utility	State	Incremental Savings as % of Retail Sales
French Broad Electric Membership Corporation	NC	2.2%
Jackson Electric Cooperative Inc.	WI	2.6%
KEM Electric Cooperative Inc.	ND	1.6%
Southern Maryland Electric Cooperative Inc.	MD	1.4%
Southern Pine Electric Power Association	MS	2.4%
Umatilla Electric Cooperative Association	OR	1.5%

Source: EPA calculation using EIA 2013

Table 13. 2013 Incremental Annual Savings – Municipal-Owned Utilities

Municipal-Owned Utility	State	Incremental Savings as % of Retail Sales
Austin Energy	TX	0.9%
City of Fort Collins	CO	2.2%
City of Oberlin	OH	2.6%
City of Seattle	WA	1.5%
City of Saint Peter	MN	2.1%
Jacksonville Electric Authority	FL	0.8%
Los Angeles Department of Water & Power	CA	0.9%

Source: EPA calculation using EIA 2013

Table 14 summarizes incremental savings levels required by state EERS and categorized into the same four ranges as Table 10 (ACEEE 2015b). Seven states are required to achieve the highest level of performance (> 1.5%) and an additional eight states are required to achieve the next highest level of performance (1.0% to 1.49%).

Table 14. Levels of Incremental Savings Required by State EERS

Incremental Savings as % of Retail Sales	# of States	States
>= 1.5%	7	AZ, ME, MA, MN, RI, VT, WA
1.0% to 1.49%	8	CO, CT, HI, IA, MD, MI, NY, OR
0.5% to 0.99%	4	AR, CA, IL, WI
< 0.5%	1	TX

Source: ACEEE 2015b

For the illustrative demand-side EE plan scenario level of performance, the EPA has determined that a 1.0% incremental savings, as a percentage of retail sales, is appropriate. This level was achieved by seventeen states and by numerous utilities of all ownership types in 2013. An additional two states (CO and HI), accounting for overlap, are expected to achieve this level by 2020 as shown in Table 14. Thus, nineteen states have either achieved or are required to achieve this level of performance.

8.2.3 Step 3: Determine Start Year for EE Plan Scenario

For construction of the EE plan scenario, the EPA has determined that 2020 is appropriate as the first year for state demand-side EE efforts. The EPA believes this is reasonable for the illustrative plan scenario as efforts are ramped up in advance of the 2022-2029 interim plan performance period. This allows sufficient time – more than four years – after issuance of the final rule for planning of these efforts. This reflects a three year delay from the 2017 start year used for the proposal.

8.2.4 Step 4: Determine Start Year Level of Performance

For construction of the best practices scenario, the EPA has set each state's level of performance in the start year (2020) to the level of performance observed in 2013, based on the aggregate state-level incremental electricity savings based on EIA Form 861 data (Table 4). This reflects the experience of states and utilities in ramping up EE program efforts over time, with less experienced program administrators requiring time to increase savings from current levels.

8.2.5 Step 5: Determine Pace of Improvement from Start Year to EE Plan Scenario Level of Performance

To determine a reasonable trajectory of incremental savings levels from the 2020 level to the EE plan level of performance, the EPA considered past performance of individual program administrators[35] as well as requirements of existing state EERS. For the past performance of individual program administrators, the EPA first screened the data and divided them into moderate and high performing sub-groups. The moderate group (47 entities) was defined as programs that achieved from 0.8% to 1.5% maximum incremental savings levels and the high group (26 entities) was defined as programs that achieved greater than 1.5% maximum incremental savings levels. The EPA then calculated the rate at which each entity had increased savings over time and calculated average values for each sub-group. For the moderate group, the average rate of improvement of incremental annual savings rate was 0.30% per year. For the high group, the average rate of improvement of incremental annual savings rate was 0.38% per year. See Appendix 2 for supporting data and analysis.

[35] EIA 861 was the primary data source; however, EIA 861 data was supplemented with data for third-party program administrators. Prior to 2011 EIA did not collect data from third-party program administrators.

EPA also considered requirements of existing state EERS and evaluated the rate at which their incremental savings levels increase over time. For several EERS, the EPA was unable to clearly identify ramp-up schedules. The EPA identified ten states with clear schedules and calculated the average rate of improvement for each. The average rate of improvement of incremental annual savings rate required for these ten states is 0.21% per year. See Appendix 2 for supporting data and analysis.

Based on these results, the EPA has chosen 0.2% per year for the demand-side EE plan scenario rate of improvement. These values are at the low end of the range in comparison with our analysis of past state performance and state requirements.

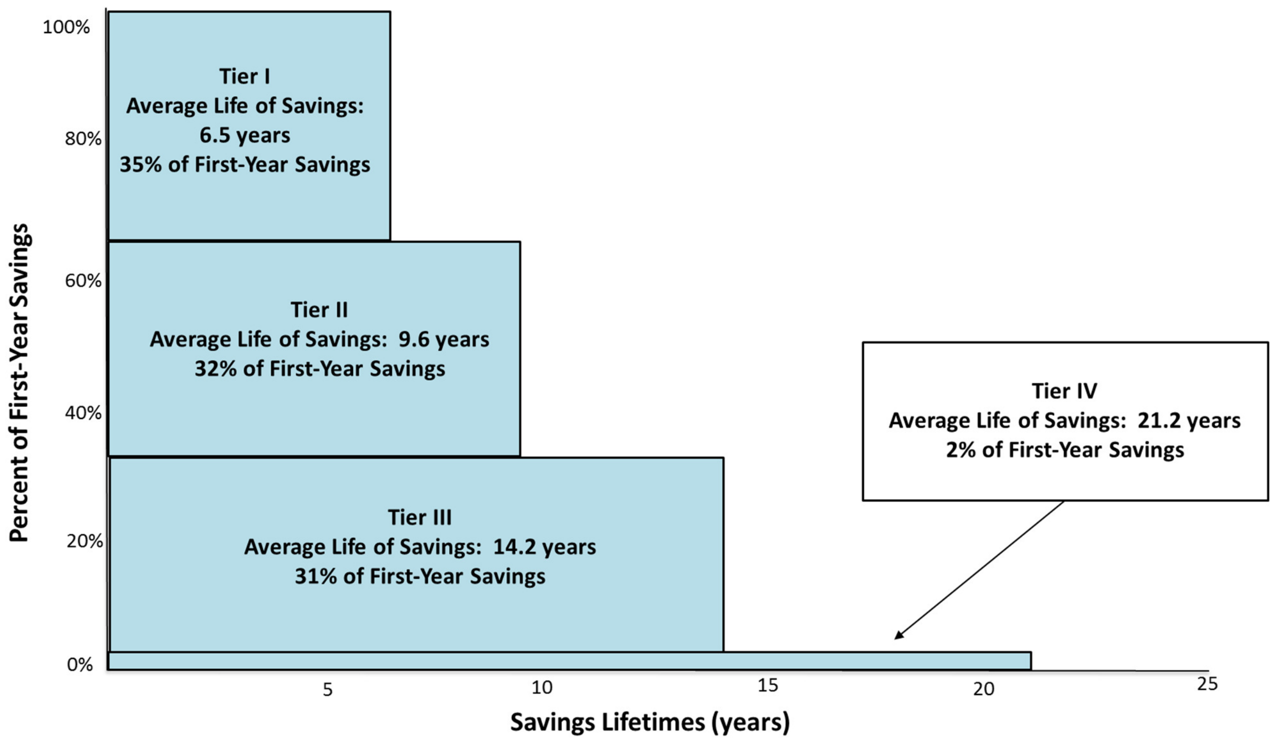
8.2.6 Step 6: Determine Average Portfolio Measure Life and Distribution of Measure Lives

The next step in defining the EE plan scenario entails projecting the cumulative future impacts of the annual incremental savings levels for each state. The incremental (or first-year) savings impacts in a year reflect the savings from EE measures put in place in that year. The cumulative incremental savings in a given year represents the total impacts of all EE measures, those put in place in that year and all prior years, that still have remaining savings impacts in the given year. The cumulative savings account for the continuing impacts of EE measures that remain in place for a period of time (the "measure life") before being replaced. For example, the purchase of a high-efficiency refrigerator may lead to savings for twelve years, before being replaced with a new model. To estimate cumulative impacts of a series of years of incremental savings, the industry uses the concept of an average measure life for the entire portfolio of EE programs being administered. Rather than use a single, average measure life to represent a diverse portfolio of programs, that range in measure lives from less than ten years (e.g., commercial lighting technologies and applications, residential behavioral feedback) to as long as twenty years or more (e.g., residential HVAC, residential building insulation), the EPA is assuming a distribution of measure lives around the average to account for future impacts of incremental savings levels.

To approximate a distribution of measure lives across a portfolio of EE programs represented by the EE plan scenario, EPA relied on a recent analysis by the Lawrence Berkeley National Laboratory (LBNL) of the distribution of EE program lifetimes (LBNL 2015a). The analysis was based on the LBNL DSM Program Database. The database consists of program-level data, including first-year savings and program savings lifetimes, reported directly by the EE program administrators since 2009. Across the database of nearly 6,000 program years of data, program savings lifetimes are available for about 1,600 program years (27% of the program years). More than 50 utilities and other EE program administrators in 25 states contributed to those data through their regulatory filings, statewide databases, and other sources. The weighted average of EE measure lifetimes for the entire population in the LBNL analysis is 10.2 years. The LBNL analysis further partitions the measure lifetimes of the EE programs into four tiers based on a cluster analysis – a statistical approach for grouping values based on their similarity.[36] The four-tier distribution of EE program measure lifetimes, as well as the associated weighted-average measure lifetime and the shares of first-year savings of each tier, are used in the analysis. Figure 5 presents LBNL's four-tier distribution of the EE program measure lifetimes, and the associated weighted average measure lifetime and share of first-year savings for each tier.

[36] The method used for the cluster analysis is the *k*-means approach. The method starts with assignment of each data point to a cluster so as to minimize the distance of cluster members from the center of the cluster, which is designated randomly. In essence, the method seeks to minimize differences within each cluster and maximize differences among the clusters. In this case, the programs within each cluster would have similar lifetimes and program types.

Figure 5. The Four-Tier Distribution of Demand-Side EE Program Measure Lifetime



Source: LBNL 2015a

The weighted-average EE program measure lifetime of 10.2 years for the entire population of data in the LBNL analysis is roughly consistent with a 2014 ACEEE study that found an average measure life of 10.6 years based on electricity EE program data across all sectors in 20 states (ACEEE 2014d). A more common approach in other studies is to assume a portfolio with no diversity of measure lives, with the entirety of incremental savings being realized in each year from the first through the full average measure life and then dropping to zero in the following year. By comparison, the approach used here is a conservative one, leading to the same quantity of total energy savings, but with a greater portion of the savings occurring in later years than occur with the more common, simpler approach of using a single average measure life to represent the entire portfolio of EE programs.

8.2.7 Step 7: Determine Sustainability of EE Plan Scenario Level of Performance

For construction of the best practices scenario, once a state achieves the best practices level of performance, the EPA has kept the level of performance constant through the analysis period. Limited empirical data suggests the reasonableness of this approach; however, comprehensive data, across all regions and states, does not exist because these levels of performance have not been achieved and sustained nationwide previously. The Northwest Power Conservation Council (NPCC) provides one such example. NPCC has been conducting the most consistent and long-running series of evaluations of achievable cost-effective potential in the country, updated every five years, as part of their five-state[37] regional energy resource plans (NPCC 2010). These analyses have become more detailed, reliable, and purposeful over time. Since 1998, NPCC's estimates of achievable potential have more than tripled even as evaluated electricity savings from EE programs have increased rapidly, more than quadrupling between 1998 and 2010 (while levelized costs of saved energy achieved have remained flat), and exceeding plan targets every year since 2005. A study of the NPCC results concludes: "our research shows that when programs invest in higher levels of efficiency, this helps drive measurement improvements and technical innovation, resulting in larger and more reliable conservation supply estimates" (NPCC 2008). Table 15 summarizes the NPCC's achievable potential estimates and evaluated savings since 1998 (NPCC 2010).

Table 15. NPCC Achievable EE Potential and Achieved Incremental Savings (1998-2010)

	Year		
	1998	**2005**	**2010**
Achievable Potential over 20 Years (GWh)	13,447	24,651	51,684
Achieved Incremental Savings from EE Programs (GWh)	547	1,184	2,248

Source: NPCC 2010

Additional substantiation of this approach is provided by average annual achievable rates from reviewed studies, as discussed previously, and comparison of those with the rates resulting from the best practices scenario. We address this in a later section, 8.4.2, after presenting those results.

[37] NPCC's resource plans cover Idaho, Oregon, and Washington in their entirety, and western regions of Montana and Wyoming.

8.2.8 Summary of the Demand-Side EE Plan Scenario Construction

Table 16 provides a summary of inputs for the demand-side EE plan scenario. The pace of improvements, average measure life, and distribution of measure lives are each conservative and, therefore, lead to lower cumulative savings than would otherwise result. Similarly, the EE plan scenario, being based solely on results from and requirements of EE programs, is less stringent than a level would be that accounted for potential impacts of other EE strategies such as building energy codes, state appliance standards, or energy services performance contracting.

Table 16. Summary of Demand-Side EE Plan Scenario Inputs

Input	Demand-Side EE Plan Scenario
Current Level of Performance (incremental savings as % of retail sales)	Calculated using data from EIA 861 (2013)
EE Plan Scenario Level of Performance (incremental savings as % of retails sales)	1.0%
Start Year	2020
Start Year Level of Performance	2013 level of performance
Pace of Improvement (increase in incremental savings rate per year)	0.20% per year
Average Measure Life and Distribution of Measure Lives	10.2 years with a 4-tier distribution of measure lifetimes (LBNL database and analysis)
Continued Performance	Once achieved, EE plan scenario savings level is sustained

Source: Section 8.2

8.3 Calculations

This section presents the calculations for determining cumulative savings levels for each state, for each year based on the demand-side EE plan scenario. The cumulative savings levels are derived based upon the key inputs summarized in Table 16.

Calculating the net cumulative savings of the demand-side EE plan scenario involves six steps. For each state, for each year (2020-2030) the following steps are taken:

1. Determine annual business-as-usual (BAU) sales
2. Determine annual incremental EE savings as a percentage of sales
3. Determine annual incremental EE savings (GWh)
4. Determine annual expiring EE savings (GWh)
5. Determine net cumulative EE savings (GWh)

6. Determine sales after net EE (GWh)
7. Determine net cumulative EE savings as a percentage of BAU sales

To illustrate these calculations, each step is described and results provided for one state (using South Carolina as an example) for 2020 through 2027. We truncate the results at 2027 for simplicity, but all calculations and full results are presented for all states for all years in the spreadsheet file included as Appendix 3.

8.3.1 <u>Step 1: Determine Annual Business as Usual (BAU) Sales</u>

BAU sales are derived by aggregating 2013 sales to the state level using EIA Form 861 data and increasing the value for each subsequent year by the average annual growth rate (AAGR) from the AEO 2015 Reference Case for the region corresponding to the state. Specifically, the AAGR from AEO 2015 for 2013-2040 is used to derive BAU sales for 2014 through 2040, and the AAGR from AEO 2015 for 2030-2040 is used to derive BAU sales for 2041 through 2050. For South Carolina the corresponding region is SRVC and the AAGR from 2013-2040 is 0.88% per year and from 2030-2040 is 0.76% per year. The resulting values are provided in Table 17 for South Carolina.

Table 17. BAU Sales for South Carolina

	Year							
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
BAU Sales (GWh)	83,601	84,341	85,087	85,840	86,599	87,365	88,138	88,918

8.3.2 <u>Step 2: Determine Annual Incremental EE Savings as a Percentage of Sales</u>

Next, the 2020 value for annual incremental EE savings as a percentage of sales is set at the 2013 value based upon aggregated EIA-861 reported data (see Table 4). For South Carolina that value is 0.46%. This value is then increased by the pace of improvement of 0.2% per year until the goal level of 1.0% is reached and then held constant. The resulting values are provided in Table 18 for South Carolina.

Table 18. Annual Incremental EE Savings as a Percentage of Sales for South Carolina

	Year							
	2020	2021	2022	2023	2024	2025	2026	2027
Annual Incremental EE Savings (% sales)	0.46%	0.66%	0.86%	1.00%	1.00%	1.00%	1.00%	1.00%

8.3.3 Step 3: Determine Annual Incremental EE Savings (GWh)

Annual incremental EE savings (also known as first-year savings) are calculated by multiplying the annual incremental savings as a percentage of sales times the prior year sales after net EE. The resulting values are provided in Table 19 for South Carolina.

Table 19. Annual Incremental EE Savings (GWh) for South Carolina

	Year							
	2020	2021	2022	2023	2024	2025	2026	2027
Annual Incremental EE Savings (GWh)	385	553	721	834	833	833	832	832

8.3.4 Step 4: Determine Annual Expiring EE Savings (GWh)

As discussed above (section 8.2.6), the annual incremental (or first-year) EE savings of the portfolio decline (or expire) over time according to the four-tier distribution of measure lives. Expiring EE savings are calculated as the sum of all expired savings in a given year from all prior years' incremental (first-year) savings. The resulting values for expiring EE savings are provided in Table 20 for South Carolina.

Table 20. Expiring EE Savings for South Carolina

	Year							
	2020	2021	2022	2023	2024	2025	2026	2027
Expiring EE Savings (GWh)	0	0	0	0	0	0	69	165

8.3.5 Step 5: Determine Net Cumulative EE Savings (GWh)

Net cumulative EE savings in a given year are equal to annual incremental savings for that year minus total expiring savings for that year plus net cumulative savings for the prior year. The resulting values are provided for South Carolina in Table 21.

Table 21. Net Cumulative EE Savings for South Carolina

	Year							
	2020	2021	2022	2023	2024	2025	2026	2027
Net Cumulative EE Savings (GWh)	385	938	1,659	2,493	3.327	4,159	4,922	5,589

8.3.6 Step 6: Determine Sales after Net EE (GWh)

Sales after net EE are calculated by subtracting net cumulative savings from BAU sales. The resulting values are provided in Table 22 for South Carolina.

Table 22. Sales after Net EE Savings for South Carolina

	Year							
	2020	2021	2022	2023	2024	2025	2026	2027
Sales after Net EE Savings (GWh)	83,216	83,403	83,428	83,346	83,272	83,206	83,216	83,329

8.3.7 Step 7: Determine Net Cumulative EE Savings as a Percentage of BAU Sales

Net cumulative EE savings as a percentage of BAU sales are equal to net cumulative savings divided by BAU sales. The resulting values are summarized for South Carolina in Table 23.

Table 23. Net Cumulative EE Savings as a Percentage of BAU Sales for South Carolina

	Year							
	2020	2021	2022	2023	2024	2025	2026	2027
Net Cumulative EE Savings as % of BAU Sales	0.46%	1.11%	1.95%	2.90%	3.84%	4.76%	5.58%	6.29%

8.3.8 Summary of Calculation Formulas and Results by Step for South Carolina

Table 24 provides summaries of the results for South Carolina for each step, respectively.

Table 24. Summary of Results by Step for South Carolina

	Year							
	2020	2021	2022	2023	2024	2025	2026	2027
BAU Sales (GWh)	83,601	84,341	85,087	85,840	86,599	87,365	88,138	88,918
Annual Incremental EE Savings (% sales)	0.46%	0.66%	0.86%	1.00%	1.00%	1.00%	1.00%	1.00%
Annual Incremental EE Savings (GWh)	385	553	721	834	833	833	832	832
Annual Expiring EE Savings (GWh)	0	0	0	0	0	0	69	165
Net Cumulative EE Savings (GWh)	385	938	1,659	2,493	3.327	4,159	4,922	5,589
Sales after Net EE (GWh)	83,216	83,403	83,428	83,346	83,272	83,206	83,216	83,329
Net Cumulative EE Savings as % of BAU Sales	0.46%	1.11%	1.95%	2.90%	3.84%	4.76%	5.58%	6.29%

8.4 Results

8.4.1 Summary of Results

As discussed, the EE plan scenario results in reduced electricity demand in each state, in each year of the plan scenario. Table 25 provides the results for 2020, 2025, and 2030, as electricity demand reduced in gigawatt-hours and as a percentage of BAU sales for the year. Full results are presented for all states for all years in the spreadsheet file included as Appendix 3.

Table 25. Demand-Side EE Plan Scenario: Magnitude and Timing of Net Cumulative Savings

States	Net Cumulative Savings					
	2020		2025		2030	
	GWh	% of BAU Sales	GWh	% of BAU Sales	GWh	% of BAU Sales
Alabama	91	0.10%	3,287	3.37%	7,258	7.13%
Arizona	797	0.99%	4,786	5.65%	7,195	8.09%
Arkansas	241	0.48%	2,519	4.81%	4,279	7.80%
California	2,735	0.99%	16,310	5.70%	24,310	8.19%
Colorado	524	0.91%	3,367	5.58%	5,116	8.06%
Connecticut	305	1.00%	1,805	5.77%	2,658	8.34%
Delaware	1	0.01%	352	2.98%	849	7.06%
District of Columbia	51	0.45%	556	4.81%	938	7.99%
Florida	389	0.17%	9,054	3.69%	18,673	7.31%
Georgia	357	0.26%	5,889	4.07%	11,314	7.48%
Idaho	137	0.54%	1,327	4.98%	2,195	7.91%
Illinois	1,458	1.00%	8,633	5.76%	12,742	8.31%
Indiana	1,006	0.92%	6,347	5.69%	9,459	8.29%
Iowa	484	0.99%	2,878	5.73%	4,270	8.25%
Kansas	2	0.01%	1,265	2.95%	3,080	6.97%
Kentucky	337	0.37%	4,232	4.50%	7,544	7.68%
Louisiana	23	0.02%	2,905	3.02%	6,983	6.92%
Maine	121	1.00%	717	5.77%	1,056	8.34%
Maryland	632	1.00%	3,729	5.78%	5,482	8.36%
Massachusetts	566	1.00%	3,344	5.77%	4,925	8.34%
Michigan	1,055	1.00%	6,232	5.77%	9,176	8.34%
Minnesota	712	0.99%	4,230	5.73%	6,275	8.25%
Mississippi	119	0.23%	2,159	3.95%	4,244	7.40%
Missouri	420	0.49%	4,324	4.89%	7,230	7.97%
Montana	79	0.53%	770	4.98%	1,274	7.91%
Nebraska	49	0.15%	1,205	3.65%	2,500	7.35%
Nevada	176	0.47%	1,862	4.81%	3,162	7.84%
New Hampshire	17	0.15%	425	3.67%	875	7.42%
New Jersey	531	0.69%	4,202	5.40%	6,514	8.24%
New Mexico	138	0.56%	1,300	5.02%	2,140	7.87%
New York	1,477	1.00%	8,637	5.86%	12,537	8.51%
North Carolina	814	0.59%	7,385	5.12%	11,984	7.95%
North Dakota	3	0.02%	517	3.00%	1,244	7.00%
Ohio	1,545	1.00%	9,150	5.76%	13,506	8.31%

States	Net Cumulative Savings					
	2020		2025		2030	
	GWh	% of BAU Sales	GWh	% of BAU Sales	GWh	% of BAU Sales
Oklahoma	168	0.26%	2,744	4.07%	5,276	7.45%
Oregon	500	0.99%	2,986	5.69%	4,460	8.17%
Pennsylvania	1,351	0.90%	8,677	5.70%	12,915	8.33%
Rhode Island	80	1.00%	471	5.77%	693	8.34%
South Carolina	385	0.46%	4,159	4.76%	7,117	7.79%
South Dakota	16	0.13%	464	3.54%	986	7.28%
Tennessee	320	0.31%	4,586	4.26%	8,503	7.57%
Texas	801	0.20%	16,359	3.82%	32,959	7.32%
Utah	257	0.81%	1,823	5.53%	2,789	8.12%
Vermont	57	1.00%	338	5.77%	498	8.34%
Virginia	28	0.02%	3,707	3.02%	8,907	6.94%
Washington	975	0.99%	5,822	5.69%	8,696	8.17%
West Virginia	79	0.24%	1,347	4.06%	2,580	7.59%
Wisconsin	710	1.00%	4,201	5.76%	6,197	8.31%
Wyoming	31	0.17%	700	3.73%	1,433	7.33%
Navajo	0	0.00%	21	2.90%	53	6.85%
Ute	0	0.00%	17	2.91%	41	6.90%
Fort Mojave	0	0.00%	2	2.90%	4	6.85%
Continental U.S.	23,150	0.59%	194,126	4.81%	327,092	7.83%
Alaska	2	0.04%	161	3.13%	376	7.04%
Hawaii	3	0.04%	284	3.10%	668	7.03%
Puerto Rico	0	0.00%	528	2.97%	1,271	7.14%
Guam	0	0.00%	46	2.97%	112	7.14%
U.S. Total	23,156	0.59%	195,145	4.80%	329,518	7.82%

Source: Appendix 3

8.4.2 <u>Results in Context</u>

To provide context for state cumulative savings results provided in Table 26, the average annual savings were calculated for each state through 2030, starting from 2020. Table 22 summarizes the results.

Table 26. Average Annual Savings Rates of Demand-Side EE Plan Scenario

Years	Number of Years	Range of Cumulative Savings (% of Sales) across States in 2030	Range of Average Annual Savings Rates across States	National Average Annual Savings Rate
2020-2030	11	6.92% to 8.36%	0.63%/year to 0.76%/year	0.71% per year

Source: EPA calculations based on Table 25

The state range and national value for the average annual savings rate represented in the demand-side EE plan scenario are below the range of values found in recent utility, state, and regional studies (0.9% to 1.3% per year) as summarized in Table 6. These results provide additional support for the reasonableness and feasibility of the demand-side EE plan scenario and associated state-specific results.

8.4.3 Representation of Demand-Side EE in Modeling of the Illustrative Plan Scenario

To reflect the implementation of the illustrative energy efficiency plan scenario in power sector modeling, as discussed in the RIA (Chapter 3), the IPM base case electricity demand was adjusted exogenously to reflect the estimated future-year demand reductions described and summarized above. State-level demand reductions were scaled up to account for transmission losses and applied to base case generation demand in each model year to derive adjusted demand for each state, reflecting the energy efficiency plan scenario energy reductions. The demand adjustments were applied proportionally across all segments (peak and non-peak) of the load duration curve. This approach to allocating annual electricity reductions is consistent with the significant levels of savings represented in the illustrative demand-side plan scenario. Achieving 1.0% incremental savings typically require robust EE program portfolios, employing a diverse set of measures across all sectors and most end-use categories. The impacts of such comprehensive portfolios occur across the full annual load duration curve with higher periods of demand providing proportionally greater EE potential. In other words, potential demand reductions through EE measures tend to mirror the underlying load duration curve which, in turn, is formed from the demands from all end uses, across all end-use sectors. Appendix 1 provides summary results from more than 50 recent EE potential studies – conducted between 2009 and 2014 – from across the U.S. The detailed results of these studies indicate the breadth of end-uses, across all end-use sectors, which provide cost-effective EE potential.

9. Demand-Side EE Plan Scenario: Assessment of Costs

9.1 Approach

This section provides the basis for estimating the costs that would be incurred to achieve the magnitude and timing of EE savings represented by the EE plan scenario. Chapter 3 of the Regulatory Impacts Analysis (RIA) presents illustrative analysis of the final rule by showing approaches that states might pursue as they develop their state plans. The scenarios used in the RIA are the basis for costs, benefits, and other power sector impacts of the final rule. The final rule allows states to use demand-side EE as a component of their state plan strategy, either directly recognized towards compliance with a rate-based goal or as a complimentary approach for achieving a mass-based goal. The EPA has included in the illustrative plan scenarios (both rate- and mass-based) a level of demand reduction that could be achieved, and the associated costs incurred, through implementation of demand-side EE measures as shown in this TSD. In this section, the EPA provides the basis for the costs of the illustrative demand-side EE plan scenario that is included as a component of the plan scenarios presented in the RIA.

The electricity savings resulting from the demand-side EE methodology was used to adjust electricity demand levels in an exogenous manner, applied to the power sector modeling for the illustrative plan scenarios of the RIA. In other words, the degree to which EE is employed is not determined endogenously within the power sector modeling based upon optimization of costs but, rather, "hard wired" into the illustrative plan scenarios. The electricity savings represented in the demand-side EE plan scenario lead to substantial reductions in power system costs due to the reductions in specified electricity demand. Since EE is not represented endogenously as an abatement measure within the power sector modeling, the costs associated with the EE plan scenario must be estimated outside of the power sector modeling and integrated with the results from that modeling. These EE cost estimates, their basis, and calculations are addressed in the following sections.

9.2 Inputs

The following steps were taken to establish the inputs for development of the EE cost estimates for each state in each year.

- Step 1: Determine incremental electricity savings

- Step 2: Determine first-year program costs and cost factors
- Step 3: Determine the ratio of program to participant costs

9.2.1 Step 1: Determine Incremental Electricity Savings

Results from section 8 provide the starting basis for estimation of EE costs used in the RIA. The resulting incremental savings (MWh) by state and by year provide the first step in calculating EE plan scenario costs.

9.2.2 Step 2: Determine First-Year Program Costs and Cost Factors

First-year program costs refer to the full costs (e.g., incentive payments, administration, technical support, marketing, evaluation, measurement and verification (EM&V), information to consumers, etc.) incurred by a utility or other administrator of EE programs in a given year that lead to EE measures (technologies and practices) put in place in that year, and result in reductions in electricity demand in that and future years (driven by the mix of measure lives across the portfolio of EE programs employed). First-year program costs are represented as these costs divided by the incremental (or first-year) savings for that year. Unlike participant costs, program costs are readily known by the administrator of EE programs and are, therefore, an appropriate starting point for cost analysis of the demand-side EE plan scenario.

Recent studies have collected and analyzed first-year program cost data directly from EE program administrators from across the U.S. In 2009, ACEEE conducted a national review of data on EE program costs from program annual reports, evaluation reports, and information compiled from contacts at program administers in 14 states (ACEEE 2009). The program cost data were compiled from multiple EE program administrators over multiple years in each state. ACEEE found average first-year net[38] program costs of $275/MWh (2011$). Two newer national analyses have found lower program costs than the 2009 ACEEE study. In 2014, ACEEE updated their analysis from 2009, expanding the number of states to 20, and including a greater number of program administrators and years (ACEEE 2014d). In this analysis ACEEE found average first-year net program costs of $230/MWh (2011$). In 2014, an LBNL study presented results from a uniquely comprehensive study of EE program costs (LBNL 2014b). The LBNL analysis reviewed program-level data from over 100 program administrators in 31 states. Data were

[38] "Net costs" refers to costs per electricity saved after accounting for effects of free-ridership on those savings. Depending upon the state, spillover effects may also be accounted for in net costs.

collected from over 1,700 individual programs for up to three years (2009-2011), covering more than 4,000 individual program-years data points. Because of the broad scope of their study and the lack of net savings information for many programs, LBNL focused on gross, rather than net, savings values.[39] LBNL found national average first-year program cost of gross savings of $162/MWh (2012$). Applying an average net-to-gross ratio of 0.9 and deflating costs at 1.8%, results in an estimated national average first-year cost of net savings of $177 (2011$).[40] The results cited from these three studies represent average first-year costs from program administrators across the U.S.

There are two factors that would influence first-year EE costs as higher levels of performance are achieved. Economies of scale in the operation of larger EE programs and larger portfolios of EE programs, and learning and expertise gained over time from the continued implementation of programs, are two factors that would lower costs as programs scale up and expand to realize higher levels of performance (Jaffe et al. 2003). However, the limited supply of EE abatement measures and the need to employ higher cost measures, over time, to reach higher levels of performance, and to sustain high levels of performance, are factors that would increase costs as higher levels of performance are achieved. Several analyses of EE program costs and savings based on empirical data are consistent with this, indicating significantly declining costs up to incremental savings levels of 1.0% or higher, and then level or increasing costs as higher savings levels are achieved (Synapse 2008; GEEG 2012; LBNL 2015b). Based on analysis like these, a recent LBNL study adopted an approach that generically represented declining costs at lower savings levels and increasing costs at higher savings levels (Barbose et al. 2013). Counter to these studies, other analysis of empirical data has indicated only steadily rising costs as savings levels increase even from levels below 0.5% (ACEEE 2014d).

In consideration of the above discussion, the EPA has chosen to use a three-tier approach to generically represent declining first-year program costs through the maximum savings level of 1.0% represented in the EE plan scenario. The first tier is used for incremental savings levels less than 0.5%; the second tier is used for incremental savings levels equal to or greater than 0.5% and less than 1.0%; and the third tier is used for incremental savings levels of 1.0% (the highest

[39] "Gross savings" refers to electricity savings before any accounting for effects of free-ridership or spillover.
[40] Source: BEA National Income and Product Accounts Table 1.5.4 Price Indexes for Gross Domestic Product (version revised on March 27, 2015).

level assumed for demand-side EE plan scenario). To reflect the significantly higher costs found at the lowest savings levels, program costs for the first tier are set at two times the level found in the 2009 ACEEE study. This results in first-year program costs of $550/MWh ($2011) for the first tier. For the second and third tiers, these costs are reduced by 20% and 40%, respectively, resulting in first-year program costs of $440/MWh and $330/MWh. The approach results in reasonable but conservative cost assumptions for analyzing the demand-side EE plan scenario.

9.2.3 Step 3: Determine the Ratio of Program to Participant Costs

As noted above, while program costs are readily known and consistently tracked and reported by program administrators, participant costs are not easily known, and are less consistently estimated and reported. The ratio between program and participant costs will vary significantly from one program to the next within a utility's portfolio. To determine an appropriate ratio for the impacts assessment of the CPP proposed rule, EPA conducted research and analysis of industry data (annual EE program reports from administrators in 22 states) and found that on average program costs represented 53% of total measured costs (with direct participant costs representing the remaining 47%) (EPA 2014a). Based on this analysis, the EPA used a ratio of 1-to-1 for program to participant costs for the EE cost estimates contained in the CPP proposed rule. In April 2015 the Lawrence Berkeley National Laboratory (LBNL) published a technical brief that analyzed program and participant costs for EE programs based on their extensive LBNL DSM Program Database (LBNL 2015b). The database contains information on approximately 1,700 individual EE programs across multiple years from 34 states. The LBNL summary findings indicate a ratio of program to participant costs of 51% to 49%. These results are consistent with the earlier analysis and support the use of the 1-to-1 ratio for the current analysis. This ratio is used to derive participant and total costs based upon program costs.

9.2.4 Summary of Inputs for Demand-Side EE Cost Analysis

Table 27 provides a summary of inputs for the EE cost analysis including incremental electricity savings, first-year costs and cost factors, and ratio of program to participant costs.

Table 27. Summary of EE Cost Analysis Inputs

<table>
<tr><th>Input</th><th colspan="3">Source or Value</th></tr>
<tr><td>Incremental Electricity Savings</td><td colspan="3">Results from demand-side EE plan scenario</td></tr>
<tr><td>First-Year Program Cost</td><td colspan="3">$550/MWh (2011$)</td></tr>
<tr><td>Ratio of Program to Participant Costs</td><td colspan="3">1:1</td></tr>
<tr><td>First-Year Participant Cost</td><td colspan="3">$550/MWh (2011$)</td></tr>
<tr><td>First-Year Total Cost</td><td colspan="3">$1100/MWh (2011$)</td></tr>
<tr><td rowspan="3">Cost Factors and Total Costs by Level of Incremental Savings</td><td colspan="3">Incremental Savings Rate</td></tr>
<tr><td>< 0.5%</td><td>0.5% to < 1.0%</td><td>1.0%</td></tr>
<tr><td>100% of first-year costs
$1100/MWh (2011$)</td><td>80% of base costs:
$880/MWh (2011$)</td><td>60% of base costs:
$660/MWh (2011$)</td></tr>
</table>

Source: Section 9.2

9.3 Calculations

This section addresses the methodology for calculating the cost associated with the EE levels included in the illustrative plan scenarios. Specifically, three values are calculated (annual first-year costs, levelized cost of saved energy (LCSE), and annualized costs); for each, program and participant components are then calculated using the 1:1 ratio (i.e., 50% of total for each) derived above. Specific results from prior sections on timing and magnitude of savings, and costs inputs are used for these calculations. For each state, the following steps are taken for each year:

1. Calculate annual first-year costs of saved energy
2. Calculate levelized cost of saved energy (LCSE)
3. Calculate annualized costs

To illustrate these calculations, each step is described and results are provided for one state (using South Carolina as an example) for 2020 through 2027 (truncated for simplicity). The full national results (for 2020, 2025, and 2030) are presented following the step-by-step example for South Carolina.

9.3.1 <u>Step 1: Calculate Annual First-Year Costs</u>

Annual total first-year costs are calculated by multiplying annual total incremental savings (MWh) (from Table 19) by the first-year total cost of saved energy (from Table 27, using the corresponding incremental savings rate). Program and participant portions of the first-year costs are then calculated as 50% of total first-year costs for each per Table 27.

The resulting values are summarized for South Carolina in Table 28.

Table 28. Calculation of Annual First-Year Costs for South Carolina

	Year							
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
Annual Incremental Savings (GWh)	385	553	721	834	833	833	832	832
First-Year Total Cost of Saved Energy (2011$/MWh)	1100	880	880	660	660	660	660	660
First-Year Total Cost (millions 2011$)	423.4	486.6	634.5	550.6	550.1	549.6	549.2	549.2
First-Year Program (millions of 2011$)	211.7	243.3	317.3	275.3	275.0	274.8	274.6	274.6
First-Year Participant (millions of 2011$)	211.7	243.3	317.3	275.3	275.0	274.8	274.6	274.6

9.3.2 Step 2: Calculate Levelized Cost of Saved Energy

The LCSE calculation algorithm is based on the 2002 California Standard Practice Manual (California GOPR 2002). This approach was adopted in order to appropriately allocate the cost of a single year EE program over declining lifetime savings. The net present value of all savings from a single year's EE activities (i.e., over the entire distribution of program lifetimes) is calculated using the real discount rate rates of 3% and 7%. The levelized cost of saved energy is then calculated by dividing the annual first-year costs (from Table 28) by the net present value of the savings. The resulting values are summarized for South Carolina in Table 29.

Table 29. Levelized Cost of Saved Energy for South Carolina (at 3% discount rate)

	Year							
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
Levelized Savings (GWh)	3,279	4,710	6,141	7,105	7,099	7,092	7,087	7,087
First-Year Total Cost (millions 2011$)	423.4	486.6	634.5	550.6	550.1	549.6	549.2	549.2
Total LCSE (2011$/MWh)	129.2	103.3	103.3	77.5	77.5	77.5	77.5	77.5
Program LCSE (2011$/MWh)	64.6	51.7	51.7	38.7	38.7	38.7	38.7	38.7
Participant LCSE (2011$/MWh)	64.6	51.7	51.7	38.7	38.7	38.7	38.7	38.7

9.3.3 Step 3: Calculate Annualized Costs

Annualized costs are calculated by multiplying the LCSE for each year by the estimated savings of the demand-side EE plan scenario in that year through the full distribution of measure lifetimes. For a given year in the analysis, the total annualized costs resulting from all current and past investments are summed to calculate the total annualized costs for that year. The resulting values are summarized for South Carolina in Table 30.

Table 30. Annualized Costs for South Carolina

	Year							
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
Annualized Total Costs (millions 2011$)	49.7	106.9	181.4	246.0	310.6	375.1	430.7	476.4
Annualized Program Costs (millions 2011$)	24.9	53.4	90.7	123.0	155.3	187.6	215.3	238.2
Annualized Participant Costs (millions of 2011$)	24.9	53.4	90.7	123.0	155.3	187.6	215.3	238.2

9.3.4 Summary of General Formulas and Results by Step for South Carolina

Table 31 provides results for South Carolina for each step.

Table 31. Summary of Results by Step for South Carolina.

	Year							
	2020	2021	2022	2023	2024	2025	2026	2027
Total First-Year Costs (millions 2011$)	423.4	486.6	634.5	550.6	550.1	549.6	549.2	549.2
Total LCSE (2011$/MWh)	129.2	103.3	103.3	77.5	77.5	77.5	77.5	77.5
Annualized Total Costs (millions 2011$)	49.7	106.9	181.4	246.0	310.6	375.1	430.7	476.4

9.4 Results

9.4.1 Summary of National Results

Tables 32 and 33 provide the national first-year and annualized EE costs for the best practices EE scenario for 2020, 2025, and 2030. Table 34 provides the estimated national LCSE for the same years. Each of the three tables includes values for program, participant, and total costs.

Table 32. First-Year Demand-Side EE Costs (billions 2011$) (Continental U.S.)

	Year		
	2020	2025	2030
Program	9.1	12.7	12.7
Participant	9.1	12.7	12.7
Total	18.1	25.4	25.3

Table 33. Annualized Demand-Side EE Costs (3% discount rate, billions 2011$) (Continental U.S.)

	Year		
	2020	2025	2030
Program	1.1	8.4	13.2
Participant	1.1	8.4	13.2

	Year		
	2020	2025	2030
Total	2.1	16.7	26.3

Table 34. Levelized Cost of Saved Energy (3% discount rate, 2011$/MWh) (Continental U.S.)

	Year		
	2020	2025	2030
Program	46.0	43.1	40.3
Participant	46.0	43.1	40.3
Total	92.0	86.3	80.5

Full calculations and results are presented for all states for all years in the spreadsheet file included as Appendix 3. The file includes results for LCSE (total, program and participant, discounted at 3% and 7%), first-year costs (total, program and participant), and annualized costs (total, program and participant, discounted at 3% and 7%).

9.4.2 Results in Context

To provide context for the pace of increase in EE program spending levels represented by the demand-side EE plan scenario, we consider the compound annual growth rate (CAGR) of the recent rapid increase in historic investment (2006 to 2011) and the CAGR from 2013 (the most recent historic value) through 2020, 2025, and 2030 represented by program costs of the plan scenario. Historic data is from Table 2 and EE plan scenario data is from Table 32. Table 35 provides a summary of the results. The CAGRs represented by the EE plan scenario through 2020, 2025, and 2030 vary from 4% to 6%. The historic growth rate reflecting the rapid recent growth in EE program spending is 30%, roughly six times the EE plan scenario values. The pace of increase in EE program spending represented by the demand-side EE plan scenario is modest and much lower than recently achieved performance.

Table 35. Annual Growth Rates of Demand-Side EE Program Spending – Historic and Demand-Side EE Plan Scenario

Time Period (Years)	Compound Average Growth Rate
Historic (2006-2011)	29.8%
Demand-Side EE Plan Scenario (2013-2020)	5.4%

Time Period (Years)	Compound Average Growth Rate
Demand-Side EE Plan Scenario (2013-2025)	6.0%
Demand-Side EE Plan Scenario (2013-2030)	4.2%

9.4.3 Costs per Tonne CO_2 Reduced

For the CPP proposed rule, the EPA analyzed a scenario incorporating the reductions in electricity demand associated with the proposal's "EE scenario" and compared the results with the base case scenario (EPA 2014a). Both analyses were conducted using the Integrated Planning Model (IPM) described in RIA. Combining the resulting power system cost reductions with the energy efficiency cost estimates associated with the EE scenario, net cost impacts were derived for 2020, 2025, and 2030. Dividing these net cost impacts by the associated CO_2 reductions for each year, the average cost of the CO_2 reductions achieved were found to range from $16 to $24 per metric tonne of CO_2. These results confirmed the general cost-effectiveness of demand-side EE at the levels and costs of the proposal, and relative to the IPM base case used at that time (since updated). The final rule incorporates changes to the IPM base case, and the levels (significantly lower) and costs (higher in 2020, lower in 2025 and 2030) of demand-side EE incorporated into the illustrative plan scenario. These changes are likely to result in similar or lower average costs per tonne of CO2 achieved through the demand-side EE plan scenario in the final rule.

10. Analysis Considerations

Two considerations are worth noting in regards to the analysis described in the previous two sections (9 and 10) which characterize the energy savings and costs of the demand-side EE plan scenario: 1) the implicit representation of demand-side EE policies and programs in the base case electric demand forecast and 2) Form EIA-861 as a data source.

10.1 State EE Policies in the Baseline Electricity Demand

The AEO 2015 reference case provides the basis for the base case electric demand forecast used for EPA's power sector modeling of the final rule (as discussed in the RIA) and also serves as a basis for estimates of electricity savings for the demand-side EE plan scenario. The AEO 2015 reference case does not explicitly represent existing EE programs, the continuation of EE programs or policies, or future requirements (e.g., EERS) to achieve savings through such programs. For example, existing state EERS are not evaluated and represented in the AEO 2015 reference case. However, to some degree, AEO 2015 may implicitly reflect a continuation of the effects of past or existing EE programs in the electricity demand projections represented in the reference case. This implicit representation is captured in part through a calibration process that is affected by several historic factors including reported electricity sales and sectoral energy consumption surveys.

As noted, the estimates of electricity savings for the demand-side EE plan scenario do rely on AEO 2015 as a basis for base case electricity demand projections. The underlying mechanics of the calculations are such that modest changes in base case demand growth rates lead to minor impacts on cumulative savings levels relative to other inputs such as 2020 starting savings levels (based on 2013 EIA 861 data), the target savings level (i.e., 1.0% incremental annual savings), and the pace of improvement from the starting to target savings levels (i.e., 0.2% per year). Any implicit representation of the effects of existing EE programs in the base case demand forecast would also, to some degree, affect estimates of the impacts of the final rule in the RIA. The effects of these considerations would have some degree of influence on the assessment of demand-side EE, however, for purposes of the RIA, the methodology for determining levels of demand-side EE, and associated costs, is appropriate in the context of the final rule.

10.2 Energy Information Administration Form EIA-861 as Data Source

Comprehensive national data on electricity savings are limited for evaluating and comparing energy efficiency programs and their effectiveness at the utility, state, and national scale. Issues related to the lack of standardized definitions and reporting, and data quality are noted to limit evaluation of EE programs (MJ Bradley 2011). The EIA Form 861, "Annual Electric Power Industry Report," remains the most comprehensive effort that collects data annually on demand-side management (DSM) programs, including their spending and energy savings impacts, nationally.[41] The form is requested for electric utilities, electric power producers, energy service providers, wholesale power marketers, and all DSM program managers and entities responsible to estimate the DSM activity for the reporting year using their

[41] More information on EIA Form 861 can be found at *http://www.eia.gov/electricity/data/eia861/*.

best available data, including costs and electricity savings from EE and load management programs.

This analysis uses only two EIA-861 data variables. Specifically, we use the 2013 sales data and reported incremental annual electricity savings of EE programs to estimate the current performance of EE programs (aggregated to the state level) to inform the illustrative demand-side EE plan scenario discussed in this chapter.

EPA notes potential concerns associated with consistency and quality of reported DSM program data in Form EIA-861. Specifically, the data are self-reported by utilities and other DSM program administrators. The definitions and data categories may not be consistently applied across different program administrators, utilities, and states, and may vary by data year. Over time, however, the data quality has improved significantly and there is increased standardization in data reporting and more detailed and up-to-date data categories are being reported. For instance, in 2011, EIA began collecting data from third-party administrators of programs and now requires that entities operating programs in multiple states report results disaggregated to the state level. While now comprehensive, outside entities have found that the EIA-861 data can be improved through supplementation with publicly available annual EE program reports.[42]

[42] See, for example, ACEEE 2014c and CEE 2015.

Appendices

Appendix 1:
Summary of Recent Energy Efficiency Potential Studies (2009-2014)

Appendix 2:
Incremental Electricity Savings Pace of Improvement Analysis

Appendix 3:
Demand-Side Energy Efficiency Plan Scenario: Data, Calculations and Results

Appendix 1:
Summary of Recent Energy Efficiency Potential Studies (2009-2014)

The EPA conducted an extensive review of energy efficiency potential studies of electricity savings. Studies were identified from recent published meta-analyses (Sreedharan 2013; ACEEE2014b) and supplemented with additional studies identified through research. Comprising results from more than 50 potential studies conducted between 2009 and 2014, the resulting database of results is one of the most comprehensive of its kind.

See the attached file for detailed information on the sources, data, calculations, and results:

- GHG Abatement TSD – Demand-Side EE Potential Studies.xlsx

Appendix 2:
Incremental Electricity Savings Pace of Improvement Analysis

This appendix summarizes and analyzes data to characterize the pace of improvement of incremental (or first-year) savings as a percentage of retail sales for electricity energy efficiency (EE) programs. We considered two different perspectives: 1) historical data reflecting achieved savings of EE programs and 2) requirements of existing state energy efficiency resource standards (EERS). For the historical perspective, we reviewed data from the Energy Information Administration's Form EIA-861 on EE program electricity savings (supplemented as needed with program administrator reports) and identified the pace at which entities reaching higher savings levels have historically increased energy savings over time.[43] Specifically, we reviewed the historical savings data in the following two groups of energy efficiency program administrators.

1. Top saver 1% - a group with 47 entities that achieved a maximum first-year savings level of 0.8% to 1.5%.
2. Top saver 2% - a group with 26 entities that achieved a maximum first-year savings level of 1.5% to 3.0%.[44]

For the existing state requirements perspective, we reviewed energy savings ramp-up schedules established under EERS for states that provide clear ramp-up schedules. According to ACEEE's 2013 State Energy Efficiency Scorecard, there are a total of 26 states that have mandatory EERS policies (ACEEE 2013a). Our analysis contains 10 states for which clear ramp-up schedules were identifiable.

Our research findings on <u>historical</u> savings performance are:

- The "Top Saver 1%" group (savings between 0.8% and 1.5%) exhibits a trend that these entities took or would take about 3.4 years on average to increase first-year

[43] The EIA 861 was the main data source (EIA 2012a). However, we have supplemented the EIA 861 with third-party program administrator data because the EIA 861 just started to collect third-party administrator data in 2011. The third-party entities included in our analysis are Efficiency Vermont, Energy Trust of Oregon, Efficiency Maine Trust, and Cape Light Compact. In addition, we supplemented the EIA 861 database with additional data for two utilities that we found achieved high energy savings, but did not report savings data in the EIA 861 data for one or two years. These entities are Burlington Electric and Massachusetts Electric Company (now part of National Grid).

[44] In addition to these maximum first-year savings thresholds, we screened program administrators for the following conditions: (a) the maximum savings levels occurs after the minimum savings levels; (b) sufficient amounts of increase in first-year savings are provided to evaluate reasonable ramp-up schedules to gain an incremental 1% first-year savings; and (c) savings data series are continuous between the years for the minimum and maximum savings levels.

savings by 1% (with a range of 1.6 years to 10 years) (see Table 2-1). The entities in this group have increased the level of first-year savings by 0.30% per year on average from their minimum to their maximum first-year savings levels (with a range of 0.10% per year to 0.63% per year).[45]

- The "Top Saver 2%" group (savings between 1.5% and 3%) exhibits a trend that took or would take about 2.6 years on average to increase savings by 1% (with a range of 0.8 years to 7.3 years) (see Table 2-1). The entities in this group have increased the level of first-year savings by 0.38% per year on average from the minimum to the maximum first-year savings levels (with a range of 0.14% per year to 1.28% per year).[46]

Table 2-1. Energy savings ramp-up trends in first-year savings for "Top Saver 1%" and "Top Saver 2%" groups

	Top Saver 1%		Top Saver 2%	
	Average Annual First-Year Savings Increase	**Estimated Years to Gain Incremental 1%**	**Average Annual First-Year Savings Increase**	**Estimated Years to Gain Incremental 1%**
Average	**0.30%**	**3.4**	**0.38%**	**2.6**
Median	**0.29%**	**3.4**	**0.34%**	**3.0**
Max	0.63%	1.6	1.28%	0.8
Min	0.10%	10	0.14%	7.3
# of sample entities	47		26	

Sources: EIA 2012a and third-party program administrator data[47]

Our research findings on incremental electricity savings ramp-up based on existing state EERS policies are:

[45] This is a simple average estimate of the annual average increase in first-year savings from each entity in this group.
[46] This is the simple average estimate of the annual average increase in first-year savings from each entity in this group.
[47] Data sources: The EIA 861 was the main data source (EIA 2012a). However, we have supplemented the EIA 861 with third-party program administrator data because the EIA 861 just started to collect third-party administrator data in 2011. The third-party entities included in our analysis are Efficiency Vermont, Energy Trust of Oregon, Efficiency Maine Trust, and Cape Light Compact. In addition, we supplemented the EIA 861 database with additional data for two utilities that we found achieved high energy savings, but did not report savings data in the EIA 861 data for one or two years. These entities are Burlington Electric and Massachusetts Electric Company (now part of National Grid).

- The states with EERS policies which exhibit savings ramp-up schedules are requiring increases in first-year energy savings at a pace that ranges from 0.11% (Colorado and Oregon) to 0.40% (Rhode Island) as shown in Table 2-2.
- The first-year savings pace of increase averages 0.21% per year across the 10 states. This savings level translates to about 4.7 years to achieve an incremental 1% first-year savings increase.

Table 2-2. First-Year Energy Savings Ramp-up Review of State EERS Policies

State	Minimum Target		Maximum Target		Climb Time (years)	Annual Average % Increase	Years to Achieve 1% Increase
	Min	Year	Max	Year			
	a	b	c	d	e=d-b	f=(c-a)/e	g=1/f
Arizona	1.25%	2011	2.5%	2016	5	0.25%	4.0
Arkansas	0.25%	2011	0.9%	2015	4	0.16%	6.2
Colorado	0.80%	2011	1.7%	2019	8	0.11%	9.3
Illinois	0.20%	2008	2.0%	2015	7	0.26%	3.9
Indiana	0.30%	2010	2.0%	2019	9	0.19%	5.3
Massachusetts	1.4%	2010	2.6%	2015	5	0.24%	4.2
Michigan	0.3%	2009	1.0%	2012	3	0.23%	4.3
Ohio	0.3%	2009	1.2%	2019	10	0.17%	5.9
Oregon	0.8%	2010	1.0%	2013	3	0.07%	15.0
Rhode Island	1.7%	2011	2.5%	2013	2	0.40%	2.5
Average						0.21%	4.8

Sources: ACEEE 2014c and APSC 2013

Appendix 3:
Demand-Side Energy Efficiency Plan Scenario: Data, Calculations and Results

See attached files for comprehensive data, calculations, and results supporting the illustrative demand-side energy efficiency (EE) plan scenario. These files address the magnitude and timing of savings, and the assessment of costs of the demand-side energy efficiency included in the illustrative plan scenario of the Regulatory Impacts Assessment (RIA). The two files reflect costs discounted at 3% and 7%, respectively:

- GHG Abatement Measures TSD – Demand-Side EE @ 3%.xlsx
- GHG Abatement Measures TSD – Demand-Side EE @ 7%.xlsx

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