ELECTRIC POWER RESEARCH INSTITUTE

# State Level Electric Energy Efficiency Potential Estimates

**3002009988**

# State Level Electric Energy Efficiency Potential Estimates

**3002009988**

Technical Update, May 2017

EPRI Project Managers

C. Holmes
S. Mullen-Trento

ELECTRIC POWER RESEARCH INSTITUTE
3420 Hillview Avenue, Palo Alto, California 94304-1338 ▪ PO Box 10412, Palo Alto, California 94303-0813 ▪ USA
800.313.3774 ▪ 650.855.2121 ▪ askepri@epri.com ▪ www.epri.com

THE FOLLOWING ORGANIZATION PREPARED THIS REPORT:

**EPRI**



**This is an EPRI Technical Update report. A Technical Update report is intended as an informal report of continuing research, a meeting, or a topical study. It is not a final EPRI technical report.**

## NOTE

For further information about EPRI, call the EPRI Customer Assistance Center at 800.313.3774 or e-mail askepri@epri.com.

# ACKNOWLEDGMENTS

The Electric Power Research Institute (EPRI) prepared this report with the support of the Office of Strategic Programs in the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. The authors would like to thank the following individuals for their thoughtful review of the document: Danielle Sass Byrnett, Steve Capanna, Alice Dasek, Paul Donohoo-Vallett, Ookie Ma, Alicia Moulton, Kara Podkaminer and Jonah Steinbuck, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy; John Agan and Erin Boyd, U.S. Department of Energy, Office of Energy Policy and Systems Analysis; Colin McMillan and Jack Mayernik, U.S. Department of Energy, National Renewable Energy Laboratory (NREL); Annie Gilleo and Maggie Molina, and American Council for an Energy Efficient Economy (ACEEE).

This publication is a corporate document that should be cited in the literature in the following manner:

*State Level Electric Energy Efficiency Potential Estimates:* EPRI, Palo Alto, CA: 2017. 3002009988.

# ABSTRACT

This report reflects work performed under contract with the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. The research focused on applying the result of EPRI's 2014 US Energy Efficiency Potential Study which was conducted at the Census division level and developing a method to apply the division level results to the state level by customer class and by end-use.

The state allocation shows that every state has a large amount of electric energy efficiency potential that can be utilized as a cost-effective energy resource. This cost-effective electric potential grows over time as equipment reaches the end of its useful life and is replaced by a cost-effective efficient replacement. In total GWh, this energy efficiency economic potential in 2035 ranges from 901 GWh in Vermont to 87,336 GWh in Texas, reflective of the both electric loads and the types electric services in each state.

Finally, to understand the potential to bring additional technologies to market and the impact that added incentives can have on energy efficiency potential, the national model and state allocations were re-run with differing levels of incentives. These results, which vary by state, show both the direct impact of incentives as well as potential opportunities to increase energy efficiency through cost reductions.

**Keywords**
Energy Efficiency Potential
State level EE Potential
Technical Potential (TP)
Economic Potential (EP)
High Achievable Potential (HAP)
Programmatic Energy Efficiency

**Deliverable Number: 3002009988**

**Product Type: Technical Update**

## Product Title: State Level Electric Energy Efficiency Potential Estimates: Product

**PRIMARY AUDIENCE:** UTILITY PLANNING PERSONNEL, RESEARCH ORGANIZATIONS, REGULATORS

**SECONDARY AUDIENCE:** ANYONE INVOLVED IN THE DESIGN, IMPLEMENTATION AND EVALUATION OF ENERGY EFFICIENCY PROGRAMS

### KEY RESEARCH QUESTION

Following the publication of the first U.S. Energy Efficiency Potential Study in 2009, stakeholders have expressed interest in the development of a consistent and comparable state level energy efficiency potential analysis to aid in state-specific energy planning. While more detailed planning and assessment studies occur on a regional, state and utility basis, given the range of approaches that are used as well as the geographical variation and differing time frames of existing studies, the work produced here can serve as a starting point for understanding energy efficiency potential across states using a consistent nationwide methodology.

### RESEARCH OVERVIEW

Understanding growth in demand is key for electric service providers and planners at all levels as they manage resources to meet customers' needs while maintaining reliable operation of the power system. The challenge to provide affordable, reliable and environmentally responsible electricity incents providers and planners to understand all resources available to continue to meet demand. Appropriately, utilities and policy makers increasingly look to energy efficiency (EE) as a cost-effective resource to enable reliable and affordable electric service while at the same time reducing carbon emissions.

### KEY FINDINGS

- Despite the significant energy efficiency activities that have occurred over the past ten years this report identifies areas of potential energy efficiency by customer class and by end-use over the next twenty years using currently available efficiency technologies.
- This report investigates efficiency at the state level rather than the census division levels as in past studies. This improved resolution shows that not all states have the same efficiency potential but that significant potential still exists across states. The levels are driven by technology stock, efficiency available at the measure level and historical energy efficiency implementation activity.
- The EPRI national model and state allocations were re-run with differing levels of incentives. The results vary by state but show that the direct impact of incentives as well as potential opportunities to increase energy efficiency through cost reductions may be significant.

### WHY THIS MATTERS

State level estimates of energy efficiency (electric) potential, by customer class and by end-use provide utilities, regulators and researchers with the information needed to develop cost effective and impactful energy efficiency programs. Energy efficiency programs reduce customer energy costs, mitigate environmental impacts and increase customer and satisfaction with their energy providers.

**HOW TO APPLY RESULTS**

The results of this research helps utility program planners, regulators and efficiency research organizations review their current energy efficiency program offerings and make adjustments in order to maintain program impacts and top produce cost savings. The first step is a technical screening of potential efficiency measures. This report provides guidance on technologies and measures that are costs effective and relevant for their state and service territory.

**LEARNING AND ENGAGEMENT OPPORTUNITIES**

- This research supports the U.S. Energy Efficiency Potential Studies that EPRI conduct on a three to five year cycle. This effort will be applied to the upcoming potential study scheduled for completion in late 2017 or early 2018.
- State regulators, advocacy groups and other policy makers who are interested in maintaining the viability of a strong energy efficiency program within their states will find this information useful.

**EPRI CONTACTS:** Chris Holmes, Principal Technical Lead; Sara Mullen-Trento, Senior Technical Leader

**PROGRAM:** P170 End-Use Energy Efficiency and Demand Response



**Electric Power Research Institute**
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com

# EXECUTIVE SUMMARY

## Overview

The challenge to provide affordable, reliable and environmentally responsible electricity incents electric service providers and planners at all levels to understand all resources available to continue to meet demand. Appropriately, utilities and policy makers increasingly look to energy efficiency (EE) as a cost-effective resource to enable reliable and affordable electric service while at the same time reducing carbon emissions.

In 2014, the Electric Power Research Institute (EPRI) commissioned a study, *U.S. Energy Efficiency Potential Study through 2035,*[1] to assess the potential energy savings achievable through energy efficiency (EE) and demand response programs in the U.S, across the residential, commercial, and industrial sectors. The results are based on a bottom-up, stock turnover approach and were presented at both a national and Census division-level, along with three large, individual states: Florida, Texas and California. The study found a total of 790,639 gigawatt-hours (GWh) of cost-effective electric energy efficiency economic potential economically available from 2012 to 2035, which represents 17.5% of baseline retail sales in 2035.

Following the publication of the national study, stakeholders expressed interest in a consistent and comparable state level energy efficiency potential analysis to aid in state-specific energy planning. While more detailed planning and assessment studies occur on a regional, state and utility basis, given the range of approaches that are used as well as the geographical variation and differing time frames of existing studies, the work produced here can serve as a starting point for understanding energy efficiency potential across states using a consistent nationwide methodology.

The updated analysis shows a total national estimate of 740,985 GWh of cost-effective electric energy efficiency economic potential from 2016 to 2035, which represents 16% of baseline retail sales in 2035, with substantial savings from all three sectors. This national potential was used to determine state-level economic potential and to assess the impact that added incentives can have on energy efficiency potential. Future estimates are forthcoming with a full update in 2017 or 2018.

## EPRI Model and Updates

The model used to determine EPRI's division-level estimates of energy efficiency potential may be found in 2014 its report, U.S. Energy Efficiency Potential through 2035. The model estimates the penetration of and energy savings produced by new more efficient technologies using a bottom-up, stock turnover approach relative to the Energy Information Administration's (EIA) Annual Energy Outlook (AEO) 2012 forecast of electric consumption. These estimates are developed at the class level – residential, commercial and industrial – and aggregated across those groups.

[1] *U.S. Energy Efficiency Potential through 2035*. EPRI, Palo Alto, CA: 2014. 1025477. http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=1025477

[2] Adjusted baseline sales remove existing programmatic and naturally occurring savings from the AEO baseline, as discussed in Section 3.

Given the focus of this project on developing a state-level allocation methodology and the complexity of updating the overall analysis, only a few updates were made to the assumptions for the underlying stock-turnover model from the 2014 EPRI potential study to make results more reflective of the current environment. These modifications include updating avoided costs estimates used in performing the total resource cost test (TRC) based on the AEO2016 fuel cost projections and changing the start year to 2016. The other major assumptions such as technology impacts, technology costs, and end-use stocks, were unchanged from the 2014 study. Due to this approach, the energy efficiency potential reported here does not reflect the changes in energy efficiency technologies that have occurred since the 2014 report, nor the changes in energy codes and standards. However, as addressed below, accounting for the changes that have occurred, the results reported here provide a good first step in establishing a point of reference for state energy efficiency potentials.

The approach developed to allocate division-level potential estimates to the states was constructed using initial division-level estimates of energy efficiency potential and allocating savings based on 2015 EIA state-level electricity consumption by sector. The potential for each state will depend on the concentration of end-uses with efficiency potential and the amount of efficiency they have already implemented. It does not take into account future energy efficiency technology improvements that may occur or potential policy drivers, which could consequently unlock greater potential savings.

In the benchmark analysis, the potential in each state was compared to the savings that could be achieved if states continue to realize the same average level of annual incremental savings as has been achieved in the past 10 years. This benchmark comparison is intended to help gauge the efficiency potential relative to energy savings that states have achieved to date.

Finally, the impact of incentives on the economic potential and the high achievable potential was tested by re-running the total resource cost test with an added incentive ranging from $5 to $20/MWh. This analysis serves to help understand the shape of the energy efficiency supply curve at both the economic and high achievable potential levels as well as understand the potential gains in energy efficiency economic potential that can be achieved by targeted incentives or through further cost reduction.

## Results

The state allocation shows that every state has a large amount of electric energy efficiency potential that can be utilized as a cost-effective energy resource. This cost-effective electric potential grows over time as equipment reaches the end of its useful life and is replaced by a cost-effective efficient replacement. The energy efficiency economic potential in 2035 ranges from 901 GWh in Vermont to 87,336 GWh in Texas, reflective of both the electric loads and the types electric services in each states, as shown in Figure ES-1.

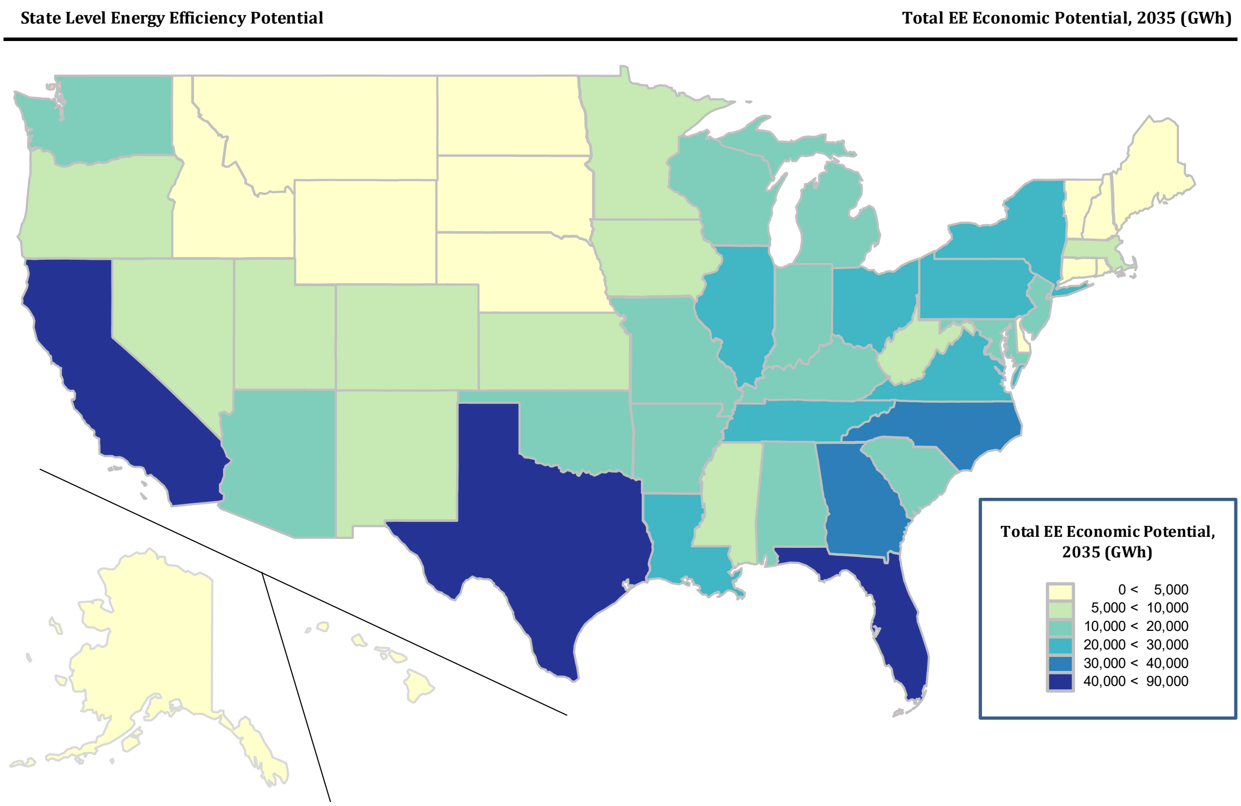



**Figure ES-1**
**Total Energy Efficiency Economic Potential (EP) by State in 2035, in GWh**

State-level energy efficiency potential estimates range from 12% (Missouri) to 21% (Florida) in 2035 relative to the adjusted baseline sales[2] – fluctuating due to sector composition and climate zone. Because the EPRI Census division-level results were used to determined state-level potential, there is a strong similarity by region in the percent savings. Twenty six states show more than 15% savings available cost-effectively between 2016 and 2035 relative to the adjusted baseline sales, as shown in Figure ES-2.

[2] Adjusted baseline sales remove existing programmatic and naturally occurring savings from the AEO baseline, as discussed in Section 3.

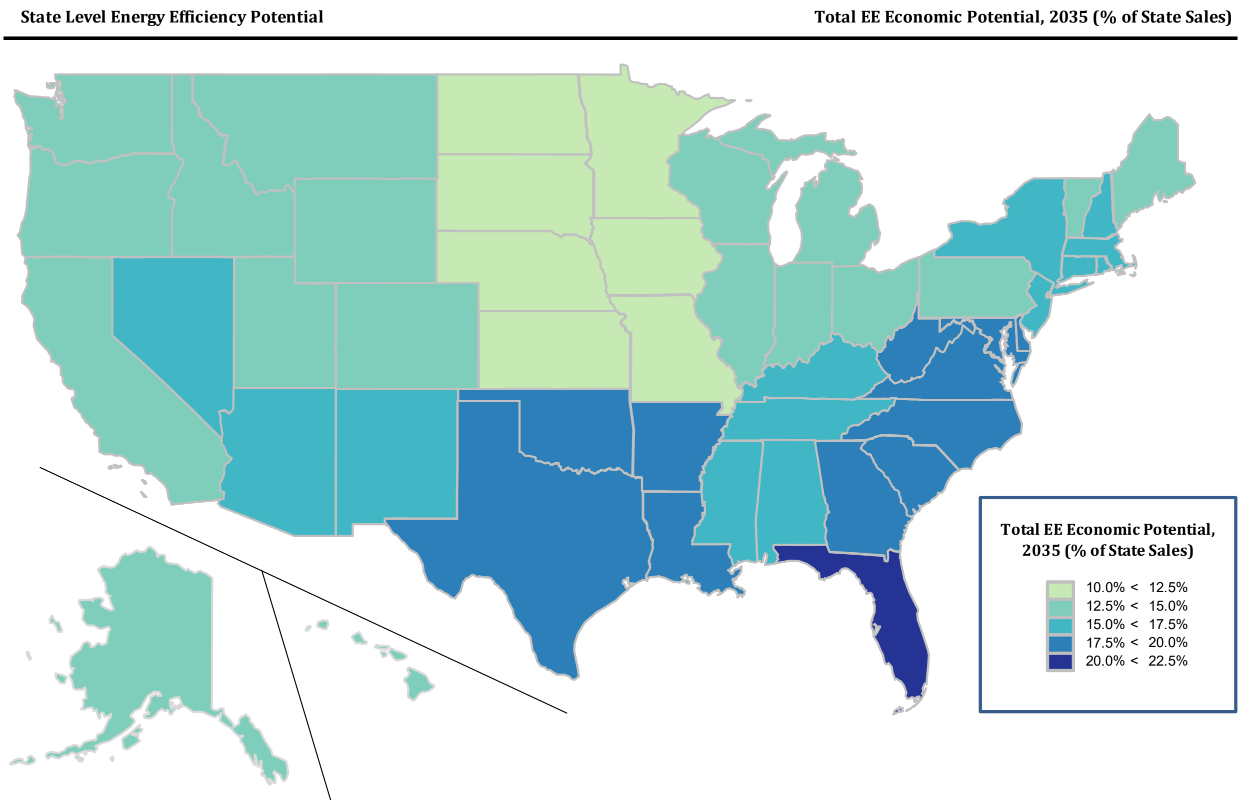



**Figure ES-2**
**Total Energy Efficiency Economic Potential (EP) in 2035, as a Percentage of Adjusted Baseline Sales**

However, the extent to which states are taking advantage of this potential varies. The benchmark analysis compares state-level efficiency potentials to the savings that could be achieved if states continue to achieve their average historical, incremental energy efficiency savings. This analysis gives a sense of which states are already on a trajectory to take advantage of this potential and which states have yet to develop energy efficiency programs and policies to the same degree.

This comparison shows that 22 states that have developed programs that – if they continue at the same pace – would be on track to achieve 100% of the model's projected cost effective savings by 2035. This finding highlights the extent to which annual incremental savings add quickly over time (and thus, this shows that investing in energy efficiency has long-term benefits), but it also points to limitations in the model and methodology (e.g., a lack of modeled energy efficiency opportunities rather than a lack of likely savings available). It also illustrates the significant underinvestment in energy efficiency that still remains in some states. If states continue to utilize energy efficiency at the same historical level, 18 states would have captured less than 50% of the energy efficiency potential identified by the EPRI model, illustrating the remaining cost-effective energy savings potential in their state.

The extent to which states are poised to take advantage of the economic potential identified in this study is shown in Figure ES-3. By continuing to achieve state average historical incremental savings rates, the states with higher percentages (dark blue) will capture most of the identified economic potential; states in yellow and green will capture a smaller fraction of the identified economic potential if those states continue to achieve annual incremental savings at the same average rates as measured in the past.

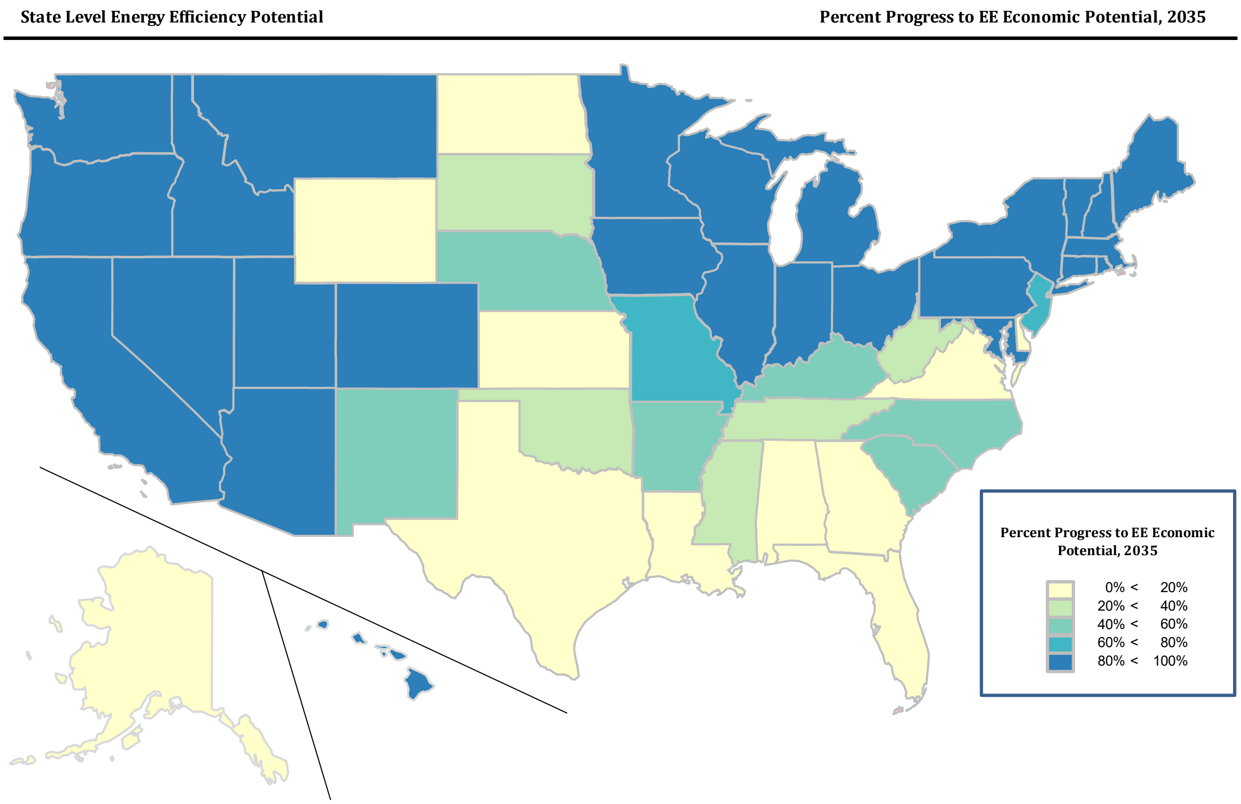



**Figure ES-3**
**Percent Progress to 2035 Energy Efficiency Economic Potential (EP) Based on Extrapolation of Average Historical State Savings**

This benchmark analysis also highlights a limitation of the model in that in the out years of this projection, if states with historically high annual incremental savings continue their progress, those states could exceed the potential that is reported in this study. However, the potential identified here is constrained by the model outputs, which are determined by input factors including the technologies considered, the cost of those technologies, the avoided costs, and the program administration costs. If policies require higher levels of savings than projected in this study, program administrators might implement new or additional efficiency measures in order to reduce costs and achieve more savings, taking advantage of both technological innovation and cost reduction as well as other energy efficiency savings approaches, including behavioral savings, which are not considered here.

Finally, to understand the potential to bring additional technologies to market and the impact that added incentives can have on energy efficiency potential, the national model and state allocation was re-run with differing levels of incentives. The incentive values, from $5-20/MWh, were factored into the total resource cost test when evaluating cost-effective measures. This analysis demonstrates the potential for targeting measures and where additional savings can be gained.

With a \$20/MWh incentive, the EE economic potential increases by 102,848 GWh, an increase of 13% relative to the no incentive case.  Across the residential sector, the highest incentive level leads to 25% more cost-effective energy efficiency potential. In the commercial and industrial sector, \$20/MWh yields 7% more efficiency potential.  These results, which vary by state, show both the direct impact of incentives as well as potential opportunities to increase economic energy efficiency potential though cost reductions.[3]

[3] Subsidies and cost reductions would have the same net impact on economic EE potential; if a \$20/MWh subsidy yields 7% more efficiency potential, a \$20/MWh cost reduction would do the same.

# CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

# 1
# BACKGROUND

The challenge to provide affordable, reliable and environmentally responsible electricity electric service incents providers and planners at all levels to understand all resources available to continue to meet demand. Utilities and policy makers continue to look to energy efficiency as a cost-effective resource to enable reliable and affordable electric service while at the same time reducing carbon emissions.

In 2014 the Electric Power Research Institute (EPRI) commissioned a study to assess the potential energy savings achievable through energy efficiency and demand response programs in the U.S, U.S. Energy Efficiency Potential Study through 2035[4], provides. ¬The results presented in that study were reported at both a national and Census division-level, along with three states: Florida, Texas and California. The goal of this follow-up report is to develop a methodology to disaggregate the Census division-level results to the state-level. While more detailed planning and assessment studies occur on a regional, state and utility basis, given the range of approaches that are used as well as the geographical variation and differing time frames of existing studies, the work presented here serves as a benchmark for energy efficiency potential across the residential, commercial, and industrial sectors using a consistent nationwide methodology.

Following the publication of the national study, stakeholders expressed interest in a consistent and comparable state-level energy efficiency potential analysis to aid in state-specific energy planning. While more detailed planning and assessment studies occur on a regional, state and utility basis, given the range of approaches that are used as well as the geographical variation and differing time frames of existing studies, the work produced here can serve as a benchmark for energy efficiency potential across states using a consistent nationwide methodology.

Given the complexity of updating the overall analysis, this project focuses on developing the state-level allocation methodology and makes only a few updates to the assumptions for the underlying stock-turnover model that drives the EPRI analysis, including updating the avoided costs used in the total resource cost (TRC) test and changing the base year. Due to this approach the energy efficiency potential reported here does not reflect the changes in energy efficiency technologies that have occurred since the 2014 report, nor the changes in energy codes and standards. However, the results reported here provide a good first step in establishing a point of reference for state energy efficiency potentials. This national potential was used to determine state-level economic potential and used to assess the impact that added incentives can have on energy efficiency potential. Future estimates are forthcoming with a full update in 2017 or 2018.

In addition to developing state-level energy efficiency potentials, this state-level potential was compared to the savings that could occur if states continue to achieve average historical incremental energy efficiency savings. This comparison shows many states that have developed

---

[4] *U.S. Energy Efficiency Potential through 2035*. EPRI, Palo Alto, CA: 2014. 1025477. http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=1025477

programs to take advantage of energy efficiency, while also illustrating the remaining potential in states that have not yet captured the energy savings potential to the same extent.

## EPRI Model and Updates

This effort is focused on creating a reasonable allocation of the energy efficiency potential developed by EPRI at the Census division-level to each state for the years 2017, 2020, 2025, 2030, and 2035. EIA state-level electric sales by sector are used to apportion the potential energy savings among states in a given division.

Because the Census division and national level results from the 2014 study are several years old, this analysis re-calculated Census division-level estimates. This analysis also makes several key changes to the 2014 national study. These include:

- Updates to the avoided costs used in performing the total resource cost test (TRC) based on AEO2016 fuel price projections
- Changing the base year for the simulation from 2012 to 2016 (2017 is the first year with energy savings)
- Running scenarios with incentives

Technology assumptions (energy savings and associated equipment costs) and baseline forecasts remain unchanged. While changes have occurred relative to the AEO2012 baseline used in the 2014 study, updating all the inputs was beyond the scope of this project. The current assumptions are unbiased and consistent and a full update is planned for 2017 or 2018.

While the EPRI model does allow for the development of new energy efficient technologies over time (here allowing for new technologies/cost reductions to deploy in 2020), based on the input assumptions the model produces a set technical, economic, and high achievable potential for a given year (see Appendix A). Given the model output, this data set cannot address the question of whether energy efficiency itself is a fixed resource or whether new approaches and new technologies will expand the available savings potential. As such, this state level allocation approach based on state sectoral sales also does not directly account for the progress certain states have made to date in attaining aggressive energy efficiency savings nor the ability to maintain those savings in the future. However, since these sectoral sales values are net of current programmatic efficiency and natural conservation,[5] states that have been more aggressive in developing energy efficiency programs and increasing annual energy savings have lower sales reflective of those efforts and thus receive a smaller percentage of the pool of efficiency potential.

To put these state-level results in context, a secondary comparison was used to highlight the progress of states with robust energy efficiency programs and illustrate the untapped low-cost energy resources that would remain in states that have yet to access the full spectrum of energy efficiency as a resource. For each state, the average historical incremental savings in state-level energy efficiency is used to estimate what level of energy savings could be expected through an extension of existing programmatic efforts. This analysis highlights the states where energy

---

[5] "Electric Power Annual," U.S. DOE EIA, Washington DC, November 2016. Table 2.8. http://www.eia.gov/electricity/annual/

efficiency currently is well-utilized as an energy resource as well as states that could rely on energy efficiency to a greater extent to meet electricity demand.

## EPRI's Efficiency Potential Estimates

While a full description of the model and assumptions is available in the 2014 report, briefly, the EPRI study relies on a stock turnover model in which the number and efficiency of the end-use stock of residential and commercial equipment are used to determine various levels of energy efficiency potential and a top-down approach is used for the industrial sector.

EPRI used the U.S. DOE Energy Information Administration's (EIA) Annual Energy Outlook (AEO) 2012[6] for its forecast of end-use electricity consumption, including detailed stock forecasts for the residential and commercial sectors (not available for industrial). It also uses expert advice from its technology subject matter experts to assess the efficiency measures available today and in the future. EPRI uses end-use stock, energy consumption, and vintage information gathered from the EIA's 2009 Residential Energy Consumption Survey[7] (RECS) and the 2003 Commercial Building Energy Consumption Survey[8] (CBECS) to estimate bottom-up potential in the residential and commercial sectors. Residential consumption is based on unit energy consumption (UEC) in kWh per year when the appliances are present, calculated from the AEO2012 and RECS consumption and equipment stock. Commercial consumption is based on energy use intensity (EUI) in kWh per year per square foot, calculated from the AEO2012 and CBECS consumption and end-use saturation.

Because detailed customer and equipment accounting is not currently available within the industrial sector, nor is there uniformity of equipment size and application, a top-down approach is used to determine the energy efficiency potential in the industrial sector. The industrial model relies on energy consumption data from the EIA's 2010 Manufacturing Energy Consumption Survey[9] (MECS) along with the EIA's model Plant Energy Profiler, or PEP[10] (formerly called QuickPEP), to estimate savings in the manufacturing portion of the industrial sector.

Further details can be found in the appendices and in the 2014 full report.

---

[6] "Annual Energy Outlook 2012 with Projections to 2035," U.S. DOE EIA, Washington DC, DOE/EIA-0383(2012), June 2012. http://www.eia.gov/forecasts/aeo/pdf/0383%282012%29.pdf

[7] "2009 Residential Energy Consumption Survey," U.S. DOE EIA, Washington DC, Oct. 2012. http://www.eia.gov/consumption/residential/

[8] "2003 Commercial Buildings Energy Consumption Survey," U.S. DOE EIA, Washington DC, Sept. 2008. http://www.eia.gov/consumption/commercial/

[9] "2010 Manufacturing Energy Consumption Survey," U.S. DOE EIA, Washington DC, March 2013. http://www.eia.gov/emeu/mecs/

[10] Plant Energy Profiler, U.S. DOE, released Nov. 10, 2011. Available: https://ecenter.ee.doe.gov/EM/tools/Pages/ePEP.aspx

# 2
# STATE LEVEL ALLOCATION METHODOLOGY

## State Level Potential

The EPRI model estimates energy efficiency potential at the Census division-level. In order to disaggregate down to the state-level, the 2015 EIA state-level electric sales by class were used. Because EPRI's estimates of potential include existing programmatic savings, it is necessary to adjust the baseline forecasts to add estimated existing programmatic savings[11] back into the forecast sales before applying the EIA state-level percent sales to EPRI's division-level savings potential estimates.

This calculation, demonstrated in Table 2-1, shows the New England Census division residential economic potential as an example—including Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont:

- Row (a) shows the 2020 EPRI residential EE economic potential for the New England Census division.
- Row (b) shows the 2020 EPRI residential division-level savings as a percentage of baseline sales.
- Row (c) shows the percent of New England Census residential sales by state based on the 2015 EIA state level residential electric sales.[12]
- Row (d) shows the baseline residential sales from the AEO2012 Reference case.
- Row (e) shows the baseline residential sales by state, derived by multiplying the percent annual state residential level sales by the Census division baseline residential sales (c×d).
- Row (f) shows the 2020 adjusted Census division residential baseline sales, which add back in the existing programmatic savings.
- Row (g) scales the state baseline residential sales to the adjusted baseline (e×f/d).
- Row (h) applies the percent division sales to the 2020 adjusted residential baseline sales to show the 2020 residential economic potential, in GWh, derived by the EPRI model for the New England Census division (b×g).

This process was repeated for each sector separately. The sectoral economic potentials and the sectoral adjusted baseline electricity sales were summed separately and the total EE economic potential was divided by the total adjusted baseline sales to determine the total economic potential as a percentage of total adjusted baseline electricity sales.

---

[11] Determined as part of the AEO2012 scenario analyses.

[12] "Electric Power Annual," U.S. DOE EIA, Washington DC, November 2016. Table 2.8. http://www.eia.gov/electricity/annual/. Note that these values are net of current programmatic efficiency and natural conservation.

**Table 2-1**
**Example of Residential Economic Potential State Allocation Approach for the New England Census Division in 2020**

| | | Connecticut | Maine | Massachusetts | New Hampshire | Rhode Island | Vermont | Division Total |
|---|---|---|---|---|---|---|---|---|
| From EPRI results | (a) Census level GWh, no incentives | | | | | | | **3,219 GWh** |
| From EPRI results | (b) EPRI division-level high achievable potential savings in 2020 as a percentage of baseline | 6.9% | 6.9% | 6.9% | 6.9% | 6.9% | 6.9% | **6.9%** |
| Based on EIA 2015 residential annual sales | (c) Annual state level sales share | 27% | 10% | 42% | 10% | 7% | 4% | **100%** |
| | (d) Base Census division residential sales from AEO2012 Reference case | | | | | | | **46,242 GWh** |
| Calculations | (e) Base state residential sales from AEO2012 Reference case (c×d) | 12,556 GWh | 4,540 GWh | 19,648 GWh | 4,409 GWh | 3,054 GWh | 2,034 GWh | **46,242 GWh** |
| | (f) Adjusted Census division baseline | | | | | | | **47,708 GWh** |
| | (g) Adjusted state baseline (e×f/d) | 12,954 GWh | 4,684 GWh | 20,271 GWh | 4,549 GWh | 3,151 GWh | 2,099 GWh | **47,708 GWh** |
| | (h) Total 2020 state level residential economic potential (b×g) | 894 GWh | 323 GWh | 1,398 GWh | 314 GWh | 217 GWh | 145 GWh | **3,219 GWh** |

## Benchmark Analysis

In addition to calculating the total GWh available as economic potential in each state and the percentage of the state's adjusted baseline sales, that EE economic potential was used to assess the progress of existing programmatic savings by state. In this benchmark analysis, EE economic potential as a percent of state sales in a given year was compared to the savings that could be attained by continuing to save energy at the average incremental programmatic estimates of energy efficiency percent annual savings from 2006 to 2015 found by the American Council on an Energy Efficiency Economy (ACEEE).[13]

Termed the "percent progress to economic potential," this metric was calculated by dividing the compounded savings that would be achieved if the average annual incremental savings rate, calculated based on the ACEEE state scorecard data for the last 10 years, was maintained out to a future year, divided by the EPRI identified economic potential as a percent of base sales. Where the compounded average incremental savings exceed the EPRI identified savings, the state savings are capped by the EPRI savings to provide a consistent metric, ranging from 0-100%.

The percent progress to economic potential was calculated using the following equation:

$$\boldsymbol{Percent\ Progress\ to\ Economic\ Potential} = \frac{\boldsymbol{CAS_i}}{\boldsymbol{EPRI_{\ i}}}$$

Where,

$CAS_i$ – the compounded average annual incremental savings rate as a percent of state sales in year *i*, capped by the EPRI estimate of percent economic potential in year *i*

$EPRI_{\ i}$ – EPRI identified economic potential as a percent of total adjusted state sales in year *i*

The resulting percent progress to economic potential indicates the extent to which a continuation of historical savings rates would enable states to achieve the economic potential identified in this study. This calculation is demonstrated in Table 2-2 for the New England region for 2020.

As shown in Table 2-2, Vermont's 2020 extrapolated historical annual savings (row c) exceed the estimate by EPRI (row a). Therefore, in this analysis to determine Vermont's progress to its economic potential, its potential is capped at the EPRI estimate. Rhode Island is on track to capture 96% of its potential savings, and Massachusetts could capture 84% of its identified economic potential. In contrast, Connecticut, Maine, and New Hampshire have lower average historical annual savings rates and thus have additional savings in 2020 that can be attained beyond a continuation of historical savings rates. In subsequent years as the EPRI estimates

---

[13] Average of 2006 through 2015 State Energy Efficiency Scorecard data, representing the customer-funded incremental electric savings as a percent of state retail sales. Data provided by ACEEE, November 2016.

increase, the capped states will grow at their historical programmatic level unless again they exceed the EPRI estimate, and would then be capped at the EPRI estimated level of potential.

This approach has the effect of limiting the energy efficiency potential in a given state based on the level of EPRI-estimated, which represents an upper bound on cost-effective efficiency compared to alternative energy resources based on our assumptions. Advances such as new or lower cost technologies, increases in the avoided costs, or a decline in programmatic costs can increase the available potential.

**Table 2-2**
**Example of Benchmark Analysis Approach to Calculate the Percent Progress to EE Economic Potential for the New England Census Division in 2020**

| Benchmark | | Connecticut | Maine | Massachusetts | New Hampshire | Rhode Island | Vermont |
|---|---|---|---|---|---|---|---|
| From EPRI results | (a) EPRI state level total economic potential savings in 2020 as a percentage of total adjusted baseline | 8.7% | 7.4% | 8.8% | 8.2% | 9.0% | 7.6% |
| From ACEEE state scorecard | (b) Average annual ACEEE incremental programmatic savings | 1.2% | 1.0% | 1.8% | 0.6% | 2.1% | 2.0% |
| | (c) Compounded average incremental historical savings in 2020 based on ACEEE $((1+b)^{(2020-2016)}-1)$ | *4.9%* | *4.2%* | 7.4% | *2.5%* | 8.6% | 8.3% |
| | (d) Capped programmatic savings (minimum of c and a) | 4.9% | 4.2% | 7.4% | 2.5% | 8.6% | 7.6% |
| Calculations | (e) Percent progress to EE economic potential (d/a) | 56% | 56% | 84% | 30% | 96% | 100% |

# 3
# NATIONAL RESULTS

This analysis provides a summary of baseline electricity consumption and potential savings reflecting the updates in the model. The AEO2012 adjusted baseline is net of the impacts of programmatic and naturally occurring energy efficiency impacts, and these savings are captured in the potential savings estimates. The economic and high achievable potential is the focus of the national potential savings calculated in this study.

Table 3-1 presents U.S. economic and high achievable energy efficiency potential estimates for the U.S. in 2025 and 2035. Relative to the adjusted baseline forecast, in 2035:

- High achievable potential is 588 TWh, or a 13% reduction in projected consumption.
- Economic potential is 741 TWh, or a 16% reduction in projected consumption.

Relative to the AEO2012 Reference case, in 2035:

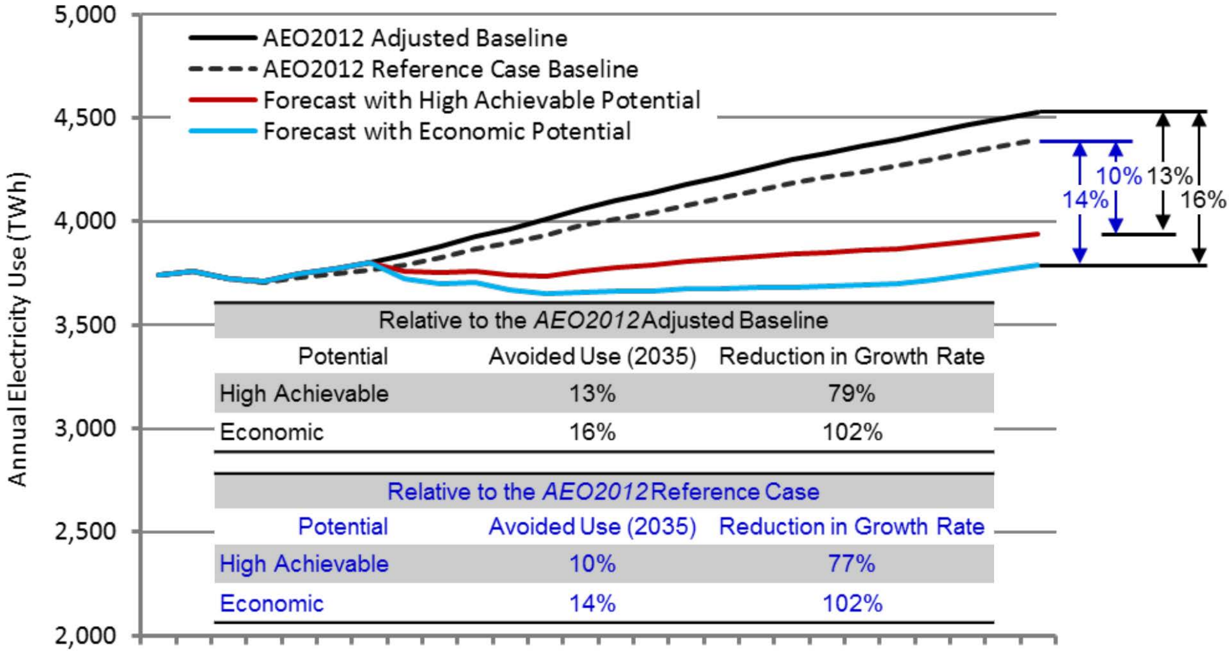
- High achievable potential represents 453 TWh of *additional* non-programmatic energy efficiency savings, or a 10% reduction in projected consumption.
- Economic potential represents 605 TWh of *additional* non-programmatic energy efficiency savings, or a 14% reduction in projected consumption.

- These estimates suggest that energy efficiency programs can realistically reduce the annual growth rate of U.S. electricity consumption from 2016 to 2035 projected by the AEO2012 Reference case by 77%, from 0.82% to 0.19%.

**Table 3-1**
**Energy Efficiency Potential for the U.S.**

| | AEO2012 Reference Case | Adjusted Baseline Forecast | High Achievable Potential | Economic Potential |
|---|---|---|---|---|
| **Forecasts (TWh)** | | | | |
| 2025 | 4,078 | 4,177 | | |
| 2035 | 4,393 | 4,529 | | |
| **Savings Relative to AEO2012 Reference Case (TWh)** | | | | |
| 2025 | - | - | 271 | 405 |
| 2035 | - | - | 453 | 605 |
| **Savings Relative to Adjusted Baseline Forecast (TWh)** | | | | |
| 2025 | - | - | 370 | 504 |
| 2035 | - | - | 588 | 741 |

Figure 3-1 illustrates these economic and high achievable potential savings forecasts along with key summary results. The focus of this analysis is on the potential savings relative to the adjusted baseline, with results shown in the top table (black text).




| Relative to the *AEO2012* Adjusted Baseline | | |
|---|---|---|
| Potential | Avoided Use (2035) | Reduction in Growth Rate |
| High Achievable | 13% | 79% |
| Economic | 16% | 102% |

| Relative to the *AEO2012* Reference Case | | |
|---|---|---|
| Potential | Avoided Use (2035) | Reduction in Growth Rate |
| High Achievable | 10% | 77% |
| Economic | 14% | 102% |

**Figure 3-1**
**U.S Economic (EP) and High Achievable Potential (HAP) Energy Efficiency, 2016-2035**

Although there are savings in a wide range of end uses in the residential, commercial and industrial sectors, Figure 3-2 presents the highest saving end uses in each of the sectors.

Commercial indoor lighting presents significant opportunities for energy savings, more than the sum of the remaining end uses presented in Figure 3-2 , about 57% of the total achievable 2035 energy savings. Lighting opportunities are also present in the end use of industrial facilities, which also includes HVAC, water heating and lighting.[14]

Space cooling is in the top two out of three for residential where more efficient central air conditioners, room air conditioners, and heat pumps present cost-effective energy savings above and beyond what is mandated by codes and standards.

[14] Lighting savings opportunities may be lower now due to changes in the market not captured in the 2014 national study.

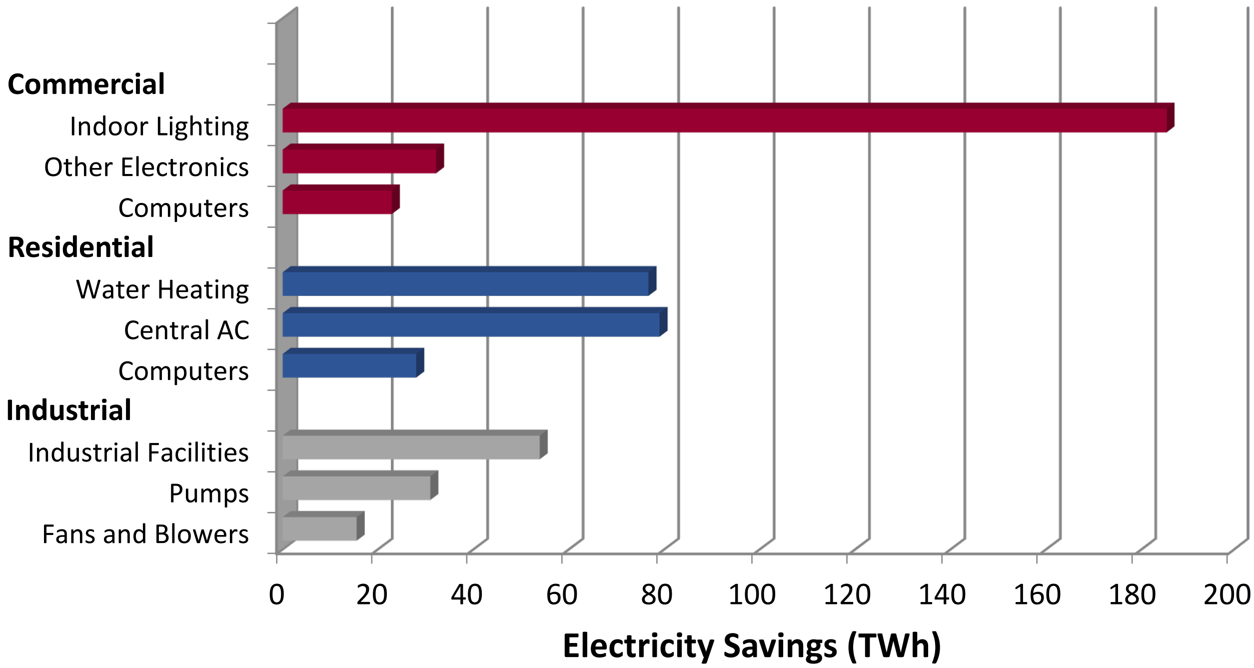



**Figure 3-2**
**Top Three End Uses in Each Sector for Economic Potential (EP) Energy Savings, 2035**

Cumulative energy consumption and potential savings for 2016 through 2035 are provided in Table 3-2. Cumulative savings represent the sum of the annual savings relative to the baseline and provide a more accurate perspective of the magnitude of the efficiency potential when growth is occurring. This is sometimes more reflective of the level of activity rather than focusing on a single year or the end year. In this analysis, the cumulative EP savings are 12.1% of the baseline cumulative forecast usage.

**Table 3-2**
**Cumulative Baseline Electricity Consumption and Technical Potential, with Economic (EP) and High Achievable Potential (HAP) Savings, for 2016 through 2035**

| | 2016-2035 Cumulative Energy | 2016-2035 Savings as a Share of Cumulative Baseline |
|---|---|---|
| AEO2012 baseline consumption | 79,866 TWh | - |
| Technical potential efficiency savings | 18,477 TWh | 23.1% |
| Economic potential (EP) efficiency savings | 9,628 TWh | 12.1% |
| High achievable potential (HAP) efficiency savings | 7,266 TWh | 9.1% |

# 4

# STATE LEVEL POTENTIAL

This section provides summary tables with a breakout of EPRI's Census division economic potential electricity savings estimates broken out by state using the approach described in Section 2. The case without incentives is provided here for the economic potential results, with the breakouts for the four levels of incentives and the high achievable potential provided in separate spreadsheets.

Every state has a large amount of electric energy efficiency potential that can be utilized as a cost-effective energy resource, both in terms of GWh, Figure 4-1, and as a percentage of adjusted state sales, Figure 4-2. This potential grows over time as equipment reaches the end of its useful life and is replaced by a cost-effective efficient replacement. The EE economic potential in 2035 ranges from 901 GWh in Vermont to 87,336 GWh in Texas, reflective of the both electric loads and the types of electric services in each states. Because the EPRI Census division-level results were used to determined state-level potential, there is a strong similarity by region in the percent savings. As a percentage of state sales, the economic potential savings ranges from 1.8% savings in Iowa to 4.4% savings in the District of Columbia in 2017 and from 12.2% potential savings in Missouri to 21.5% savings in Florida in 2035.

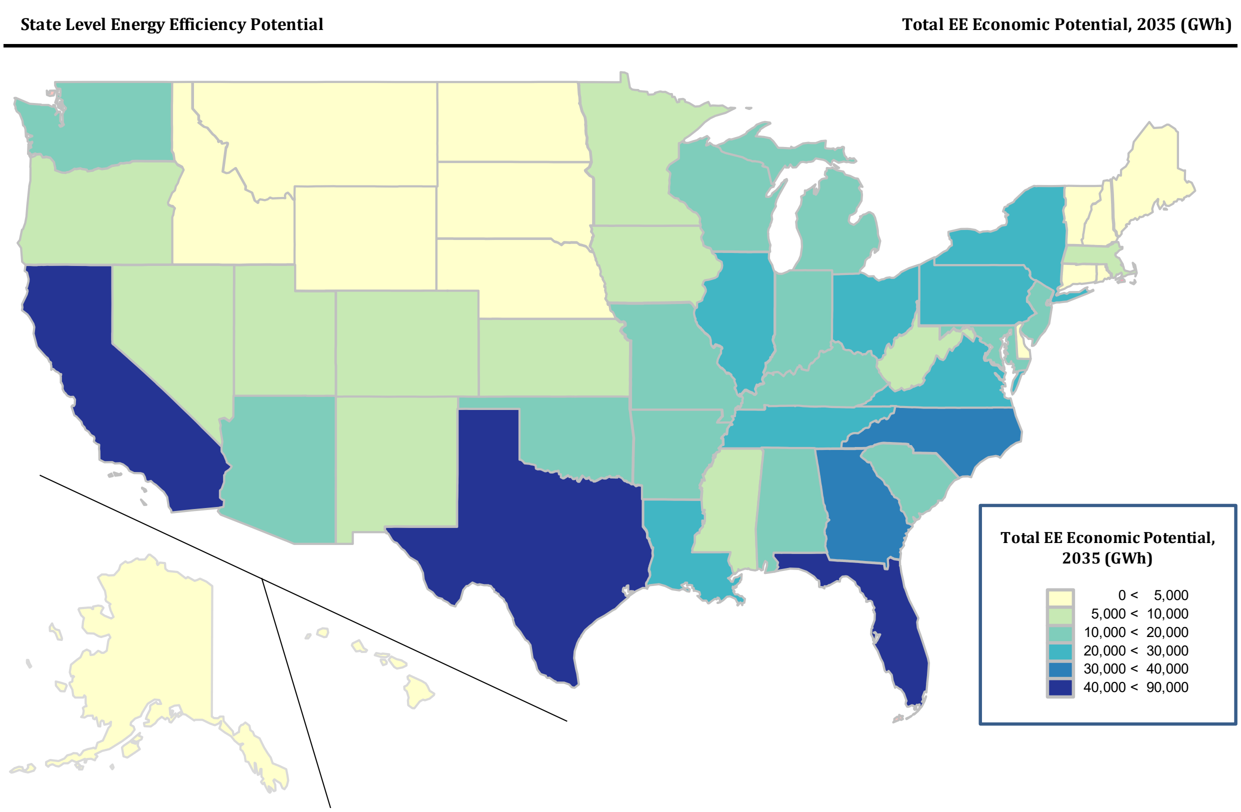



**Figure 4-1**
**Total Energy Efficiency Economic Potential (EP) by State in 2035, in GWh**

For each state and the District of Columbia, the absolute savings (in gigawatt-hours) and the savings as a share of the state's adjusted annual sales are provided for key years in Tables 4-1 through 4-4. Table 4-1 shows the total EE economic potential. Tables 4-2, 4-3 and 4-4 show the economic potential by state for the residential, commercial and industrial sector, respectively.

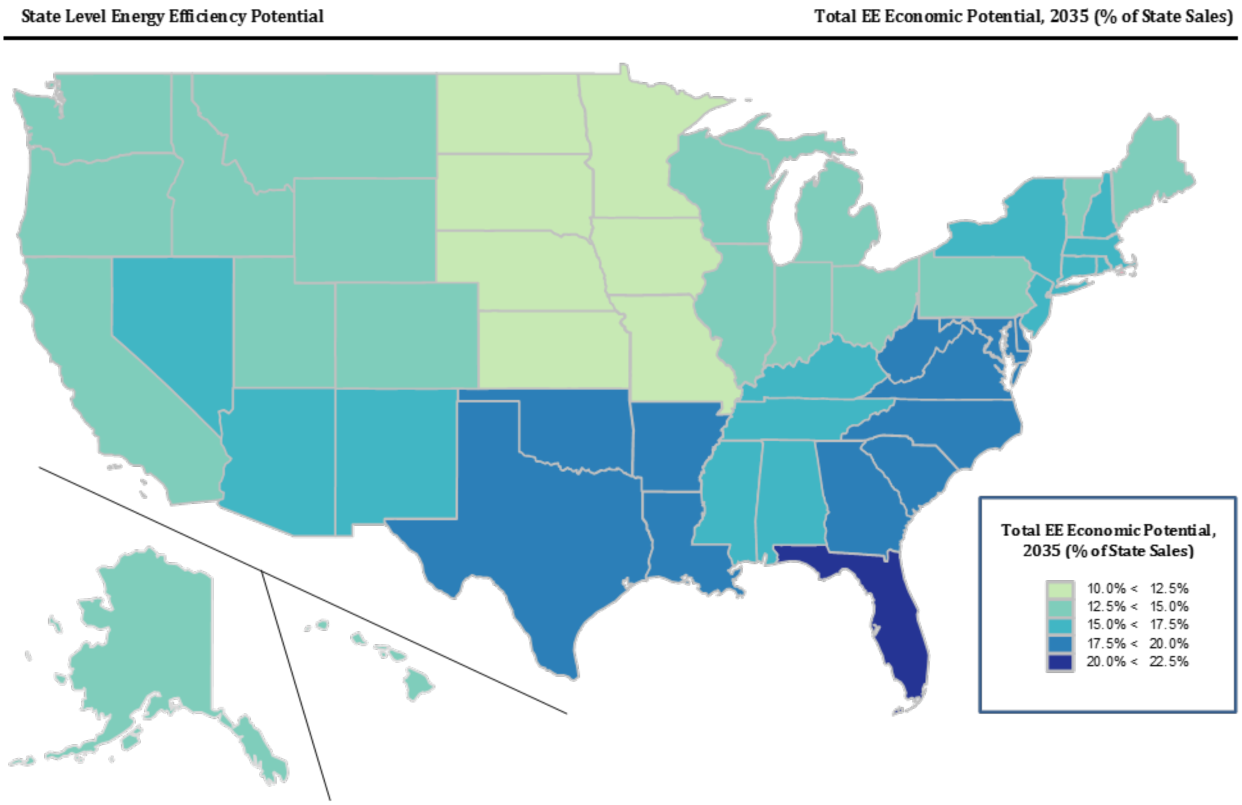



**Figure 4-2**
**Total Energy Efficiency Economic Potential (EP) in 2035, as a Percentage of Adjusted Baseline Sales**

For example, as shown in Table 4-1, Alabama has 2,040 GWh of economic potential in 2017, which is 2.1% of the adjusted annual state sales. 875 GWh of this potential comes from the residential sector, 777 GWh from the commercial sector and 388 GWh from the industrial sector. This potential grows to 18,106 GWh of EE economic potential in 2035, equivalent to 15.7% of the adjusted annual state sales, with 8,059 GWh from residential savings, 4,041 GWh from commercial and 6,005 in industrial. For comparison, Ohio has 23,430 GWh of economic potential 2035 representing 14%, comprised of 5,690 GWh residential, 11,897 GWh commercial and 5,843 GWh industrial indicating both the differences in population, appliance stock, and commercial and industrial electricity use in the state.

**Table 4-1**
**Total Economic Potential across the Residential, Commercial and Industrial Sectors by State by Year, in GWh and as a Share of the Adjusted Annual State Sales**

| | Total Economic Potential, GWh (% of Adjusted Annual State Sales) | | | | |
|---|---|---|---|---|---|
| | 2017 | 2020 | 2025 | 2030 | 2035 |
| Alabama | 2,040 (2.1%) | 5,791 (5.7%) | 11,198 (10.4%) | 16,445 (14.7%) | 18,106 (15.7%) |
| Alaska | 234 (3.2%) | 614 (8.0%) | 998 (12.3%) | 1,166 (13.5%) | 1,246 (13.7%) |
| Arizona | 2,721 (3.2%) | 7,303 (8.1%) | 12,862 (13.0%) | 16,760 (15.8%) | 18,540 (16.3%) |
| Arkansas | 1,200 (2.6%) | 3,461 (7.2%) | 6,578 (12.9%) | 9,614 (18.0%) | 11,031 (19.8%) |
| California | 8,307 (3.3%) | 20,778 (8.0%) | 31,421 (11.4%) | 40,119 (13.8%) | 43,990 (14.4%) |
| Colorado | 1,438 (2.8%) | 3,853 (7.2%) | 6,863 (11.7%) | 8,542 (13.6%) | 9,213 (13.7%) |
| Connecticut | 1,138 (3.8%) | 2,662 (8.7%) | 3,919 (12.6%) | 4,763 (15.2%) | 4,793 (15.3%) |
| Delaware | 368 (3.3%) | 954 (8.1%) | 1,673 (13.2%) | 2,320 (17.1%) | 2,648 (18.4%) |
| District of Columbia | 487 (4.4%) | 1,253 (10.8%) | 2,053 (16.3%) | 2,524 (18.6%) | 2,857 (19.7%) |
| Florida | 9,996 (3.6%) | 27,611 (9.4%) | 49,598 (15.7%) | 68,405 (20.2%) | 77,031 (21.5%) |
| Georgia | 4,212 (3.2%) | 10,960 (8.0%) | 19,329 (13.0%) | 26,949 (17.0%) | 30,735 (18.3%) |
| Hawaii | 298 (2.8%) | 796 (7.3%) | 1,327 (11.5%) | 1,615 (13.3%) | 1,726 (13.6%) |
| Idaho | 550 (2.6%) | 1,459 (6.5%) | 2,576 (10.6%) | 3,310 (12.8%) | 3,579 (13.1%) |
| Illinois | 4,030 (2.9%) | 10,806 (7.6%) | 17,599 (12.0%) | 21,679 (14.4%) | 22,622 (14.8%) |
| Indiana | 2,492 (2.3%) | 6,684 (6.2%) | 11,240 (10.2%) | 14,607 (13.2%) | 15,200 (13.7%) |
| Iowa | 855 (1.8%) | 2,335 (4.9%) | 4,165 (8.5%) | 5,763 (11.5%) | 6,203 (12.2%) |
| Kansas | 845 (2.1%) | 2,244 (5.5%) | 3,871 (9.1%) | 5,123 (11.7%) | 5,561 (12.3%) |
| Kentucky | 1,717 (2.0%) | 4,915 (5.6%) | 9,548 (10.3%) | 14,026 (14.6%) | 15,415 (15.6%) |
| Louisiana | 2,284 (2.5%) | 6,659 (7.1%) | 12,757 (12.8%) | 18,465 (17.7%) | 21,111 (19.5%) |
| Maine | 408 (3.1%) | 994 (7.4%) | 1,542 (11.5%) | 1,940 (14.6%) | 1,925 (14.9%) |
| Maryland | 2,316 (3.8%) | 5,897 (9.1%) | 10,042 (14.3%) | 13,505 (17.8%) | 15,483 (19.1%) |

| | | | | | |
|---|---|---|---|---|---|
| Massachusetts | 2,106 (3.7%) | 5,028 (8.8%) | 7,519 (12.9%) | 9,047 (15.4%) | 9,068 (15.5%) |
| Michigan | 3,037 (2.9%) | 8,138 (7.7%) | 13,220 (12.1%) | 16,226 (14.5%) | 16,936 (14.9%) |
| Minnesota | 1,363 (2.1%) | 3,634 (5.4%) | 6,307 (8.9%) | 8,447 (11.6%) | 9,155 (12.3%) |
| Mississippi | 1,168 (2.2%) | 3,257 (5.9%) | 6,208 (10.6%) | 9,046 (14.8%) | 9,991 (15.8%) |
| Missouri | 1,842 (2.3%) | 4,671 (5.6%) | 7,796 (8.9%) | 10,497 (11.5%) | 11,530 (12.2%) |
| Montana | 364 (2.7%) | 975 (7.0%) | 1,735 (11.4%) | 2,180 (13.4%) | 2,353 (13.5%) |
| Nebraska | 583 (2.0%) | 1,559 (5.2%) | 2,722 (8.7%) | 3,694 (11.6%) | 4,000 (12.3%) |
| Nevada | 1,046 (2.6%) | 2,921 (6.9%) | 5,335 (11.8%) | 7,215 (15.1%) | 7,934 (15.8%) |
| New Hampshire | 408 (3.5%) | 972 (8.2%) | 1,462 (12.2%) | 1,798 (15.0%) | 1,799 (15.1%) |
| New Jersey | 2,547 (3.3%) | 6,653 (8.6%) | 10,057 (12.6%) | 12,037 (14.8%) | 12,358 (15.0%) |
| New Mexico | 733 (2.8%) | 2,063 (7.6%) | 3,791 (12.9%) | 4,922 (15.8%) | 5,366 (16.4%) |
| New York | 4,869 (3.3%) | 12,952 (8.6%) | 19,881 (12.9%) | 23,640 (15.0%) | 24,150 (15.2%) |
| North Carolina | 4,276 (3.3%) | 11,070 (8.1%) | 19,436 (13.2%) | 27,052 (17.1%) | 30,907 (18.4%) |
| North Dakota | 350 (2.0%) | 966 (5.3%) | 1,720 (9.0%) | 2,287 (11.8%) | 2,457 (12.4%) |
| Ohio | 4,149 (2.7%) | 10,970 (7.1%) | 17,881 (11.3%) | 22,428 (13.9%) | 23,430 (14.4%) |
| Oklahoma | 1,689 (2.7%) | 4,859 (7.5%) | 9,216 (13.4%) | 13,139 (18.2%) | 15,092 (20.0%) |
| Oregon | 1,667 (3.1%) | 4,214 (7.5%) | 6,635 (11.2%) | 7,965 (12.8%) | 8,543 (13.1%) |
| Pennsylvania | 3,918 (2.7%) | 10,076 (7.0%) | 15,448 (10.6%) | 19,814 (13.5%) | 20,219 (14.0%) |
| Rhode Island | 303 (3.9%) | 712 (9.0%) | 1,049 (13.0%) | 1,259 (15.4%) | 1,268 (15.5%) |
| South Carolina | 2,172 (2.8%) | 5,785 (7.3%) | 10,484 (12.2%) | 14,912 (16.4%) | 16,902 (17.7%) |
| South Dakota | 269 (2.2%) | 695 (5.6%) | 1,177 (9.1%) | 1,565 (11.6%) | 1,709 (12.3%) |
| Tennessee | 2,568 (2.4%) | 6,960 (6.3%) | 12,951 (11.0%) | 18,624 (15.0%) | 20,676 (16.0%) |
| Texas | 9,615 (2.5%) | 26,935 (6.7%) | 51,977 (12.3%) | 75,725 (17.0%) | 87,336 (18.8%) |
| Utah | 778 (2.8%) | 2,122 (7.2%) | 3,838 (11.9%) | 4,777 (13.9%) | 5,140 (14.0%) |
| Vermont | 193 (3.1%) | 470 (7.6%) | 727 (11.7%) | 907 (14.7%) | 901 (15.0%) |

| | | | | | |
|---|---|---|---|---|---|
| Virginia | 3,868 (3.5%) | 9,968 (8.6%) | 17,211 (13.8%) | 23,378 (17.4%) | 26,696 (18.7%) |
| Washington | 3,099 (3.0%) | 7,852 (7.4%) | 12,403 (11.1%) | 14,976 (12.8%) | 16,064 (13.1%) |
| West Virginia | 813 (2.7%) | 2,187 (7.0%) | 4,009 (11.9%) | 5,750 (16.2%) | 6,501 (17.5%) |
| Wisconsin | 1,927 (2.8%) | 5,200 (7.3%) | 8,544 (11.7%) | 10,604 (14.3%) | 11,051 (14.7%) |
| Wyoming | 299 (2.1%) | 889 (6.0%) | 1,726 (10.9%) | 2,283 (13.8%) | 2,440 (14.2%) |

**Table 4-2**
**Residential Economic Potential by State by Year, in GWh and as a Share of the Adjusted Annual State Residential Sales**

| | Residential Economic Potential, GWh (% of Adjusted Annual State Sales) | | | | |
|---|---|---|---|---|---|
| | **2017** | **2020** | **2025** | **2030** | **2035** |
| Alabama | 875 (2.6%) | 2,147 (6.0%) | 4,095 (10.7%) | 6,957 (16.8%) | 8,059 (18.2%) |
| Alaska | 86 (3.9%) | 157 (7.0%) | 150 (6.3%) | 195 (7.8%) | 220 (8.4%) |
| Arizona | 1,219 (3.4%) | 2,773 (7.4%) | 4,079 (9.7%) | 6,219 (13.4%) | 7,408 (14.6%) |
| Arkansas | 608 (3.2%) | 1,593 (8.0%) | 2,810 (13.2%) | 4,688 (20.5%) | 5,548 (22.7%) |
| California | 3,392 (3.8%) | 5,931 (6.5%) | 6,365 (6.7%) | 10,733 (10.6%) | 12,939 (12.2%) |
| Colorado | 614 (3.1%) | 1,245 (5.8%) | 1,573 (6.6%) | 2,145 (8.2%) | 2,450 (8.5%) |
| Connecticut | 458 (3.6%) | 894 (6.9%) | 1,145 (8.7%) | 1,643 (12.3%) | 1,702 (12.6%) |
| Delaware | 138 (2.7%) | 329 (6.2%) | 623 (10.7%) | 1,056 (16.6%) | 1,254 (18.3%) |
| District of Columbia | 71 (2.7%) | 170 (6.2%) | 321 (10.7%) | 544 (16.6%) | 646 (18.3%) |
| Florida | 4,030 (3.3%) | 11,426 (8.8%) | 22,500 (15.9%) | 35,724 (23.1%) | 41,131 (24.7%) |
| Georgia | 1,601 (2.7%) | 3,831 (6.2%) | 7,246 (10.7%) | 12,285 (16.6%) | 14,591 (18.3%) |
| Hawaii | 112 (3.9%) | 203 (7.0%) | 193 (6.3%) | 252 (7.8%) | 285 (8.4%) |
| Idaho | 269 (3.1%) | 545 (5.8%) | 689 (6.6%) | 940 (8.2%) | 1,074 (8.5%) |
| Illinois | 1,325 (3.0%) | 2,291 (5.1%) | 2,800 (6.1%) | 4,406 (9.2%) | 4,933 (10.0%) |
| Indiana | 963 (3.0%) | 1,664 (5.1%) | 2,035 (6.1%) | 3,202 (9.2%) | 3,585 (10.0%) |
| Iowa | 372 (2.6%) | 694 (4.7%) | 892 (5.7%) | 1,613 (9.7%) | 1,926 (10.8%) |
| Kansas | 358 (2.6%) | 667 (4.7%) | 857 (5.7%) | 1,550 (9.7%) | 1,850 (10.8%) |
| Kentucky | 717 (2.6%) | 1,761 (6.0%) | 3,358 (10.7%) | 5,705 (16.8%) | 6,609 (18.2%) |
| Louisiana | 1,050 (3.2%) | 2,750 (8.0%) | 4,851 (13.2%) | 8,093 (20.5%) | 9,578 (22.7%) |
| Maine | 166 (3.6%) | 323 (6.9%) | 414 (8.7%) | 594 (12.3%) | 616 (12.6%) |
| Maryland | 778 (2.7%) | 1,861 (6.2%) | 3,519 (10.7%) | 5,966 (16.6%) | 7,086 (18.3%) |
| Massachusetts | 716 (3.6%) | 1,398 (6.9%) | 1,791 (8.7%) | 2,572 (12.3%) | 2,664 (12.6%) |
| Michigan | 990 (3.0%) | 1,711 (5.1%) | 2,092 (6.1%) | 3,292 (9.2%) | 3,686 (10.0%) |
| Minnesota | 587 (2.6%) | 1,094 (4.7%) | 1,405 (5.7%) | 2,541 (9.7%) | 3,034 (10.8%) |
| Mississippi | 509 (2.6%) | 1,249 (6.0%) | 2,382 (10.7%) | 4,047 (16.8%) | 4,688 (18.2%) |
| Missouri | 916 (2.6%) | 1,708 (4.7%) | 2,194 (5.7%) | 3,968 (9.7%) | 4,738 (10.8%) |
| Montana | 161 (3.1%) | 327 (5.8%) | 413 (6.6%) | 563 (8.2%) | 643 (8.5%) |
| Nebraska | 258 (2.6%) | 480 (4.7%) | 617 (5.7%) | 1,115 (9.7%) | 1,332 (10.8%) |
| Nevada | 454 (3.4%) | 1,031 (7.4%) | 1,518 (9.7%) | 2,314 (13.4%) | 2,756 (14.6%) |
| New Hampshire | 161 (3.6%) | 314 (6.9%) | 402 (8.7%) | 577 (12.3%) | 598 (12.6%) |
| New Jersey | 953 (3.3%) | 1,669 (5.7%) | 1,597 (5.3%) | 2,814 (9.1%) | 3,244 (10.2%) |

| | | | | | |
|---|---|---|---|---|---|
| New Mexico | 244 (3.4%) | 555 (7.4%) | 817 (9.7%) | 1,245 (13.4%) | 1,484 (14.6%) |
| New York | 1,668 (3.3%) | 2,921 (5.7%) | 2,796 (5.3%) | 4,926 (9.1%) | 5,679 (10.2%) |
| North Carolina | 1,643 (2.7%) | 3,932 (6.2%) | 7,436 (10.7%) | 12,607 (16.6%) | 14,974 (18.3%) |
| North Dakota | 131 (2.6%) | 245 (4.7%) | 315 (5.7%) | 569 (9.7%) | 679 (10.8%) |
| Ohio | 1,529 (3.0%) | 2,642 (5.1%) | 3,230 (6.1%) | 5,082 (9.2%) | 5,690 (10.0%) |
| Oklahoma | 753 (3.2%) | 1,972 (8.0%) | 3,478 (13.2%) | 5,802 (20.5%) | 6,867 (22.7%) |
| Oregon | 773 (3.9%) | 1,403 (7.0%) | 1,338 (6.3%) | 1,744 (7.8%) | 1,970 (8.4%) |
| Pennsylvania | 1,779 (3.3%) | 3,116 (5.7%) | 2,983 (5.3%) | 5,255 (9.1%) | 6,058 (10.2%) |
| Rhode Island | 111 (3.6%) | 217 (6.9%) | 278 (8.7%) | 400 (12.3%) | 414 (12.6%) |
| South Carolina | 853 (2.7%) | 2,041 (6.2%) | 3,860 (10.7%) | 6,545 (16.6%) | 7,773 (18.3%) |
| South Dakota | 124 (2.6%) | 230 (4.7%) | 296 (5.7%) | 535 (9.7%) | 639 (10.8%) |
| Tennessee | 1,142 (2.6%) | 2,804 (6.0%) | 5,347 (10.7%) | 9,084 (16.8%) | 10,524 (18.2%) |
| Texas | 4,351 (3.0%) | 10,787 (7.0%) | 18,388 (11.2%) | 32,592 (18.5%) | 39,181 (20.9%) |
| Utah | 304 (3.1%) | 617 (5.8%) | 780 (6.6%) | 1,063 (8.2%) | 1,215 (8.5%) |
| Vermont | 74 (3.6%) | 145 (6.9%) | 185 (8.7%) | 266 (12.3%) | 276 (12.6%) |
| Virginia | 1,303 (2.7%) | 3,119 (6.2%) | 5,898 (10.7%) | 10,000 (16.6%) | 11,877 (18.3%) |
| Washington | 1,441 (3.9%) | 2,616 (7.0%) | 2,495 (6.3%) | 3,252 (7.8%) | 3,674 (8.4%) |
| West Virginia | 325 (2.7%) | 777 (6.2%) | 1,469 (10.7%) | 2,490 (16.6%) | 2,958 (18.3%) |
| Wisconsin | 630 (3.0%) | 1,088 (5.1%) | 1,331 (6.1%) | 2,094 (9.2%) | 2,344 (10.0%) |
| Wyoming | 89 (3.1%) | 181 (5.8%) | 229 (6.6%) | 312 (8.2%) | 357 (8.5%) |

**Table 4-3**
**Commercial Economic Potential by State by Year, in GWh and as a Share of the Adjusted Annual State Commercial Sales**

| | Commercial Economic Potential, GWh (% of Adjusted Annual State Sales) | | | | |
|---|---|---|---|---|---|
| | **2017** | **2020** | **2025** | **2030** | **2035** |
| Alabama | 777 (3.5%) | 2,054 (8.9%) | 3,385 (13.7%) | 3,758 (14.3%) | 4,041 (14.5%) |
| Alaska | 137 (3.4%) | 414 (9.7%) | 747 (16.3%) | 815 (16.5%) | 860 (16.3%) |
| Arizona | 1,341 (4.0%) | 3,878 (10.8%) | 7,267 (18.5%) | 8,202 (19.4%) | 8,658 (19.2%) |
| Arkansas | 468 (3.4%) | 1,362 (9.3%) | 2,597 (16.8%) | 3,111 (19.0%) | 3,564 (20.5%) |
| California | 4,402 (4.0%) | 12,775 (11.1%) | 20,229 (16.4%) | 21,909 (16.5%) | 23,107 (16.3%) |
| Colorado | 719 (3.6%) | 2,181 (10.3%) | 4,299 (18.4%) | 4,868 (19.4%) | 5,145 (19.2%) |
| Connecticut | 631 (5.3%) | 1,572 (12.8%) | 2,345 (18.3%) | 2,514 (18.7%) | 2,527 (18.2%) |
| Delaware | 213 (5.1%) | 552 (12.5%) | 880 (18.3%) | 1,003 (19.4%) | 1,121 (20.3%) |
| District of Columbia | 415 (5.1%) | 1,076 (12.5%) | 1,716 (18.3%) | 1,954 (19.4%) | 2,184 (20.3%) |
| Florida | 5,508 (5.1%) | 14,307 (12.7%) | 22,703 (18.5%) | 25,910 (19.6%) | 28,813 (20.4%) |
| Georgia | 2,378 (5.1%) | 6,170 (12.5%) | 9,840 (18.3%) | 11,208 (19.4%) | 12,527 (20.3%) |
| Hawaii | 157 (3.4%) | 475 (9.7%) | 858 (16.3%) | 937 (16.5%) | 988 (16.3%) |
| Idaho | 221 (3.6%) | 670 (10.3%) | 1,319 (18.4%) | 1,494 (19.4%) | 1,579 (19.2%) |
| Illinois | 2,331 (4.6%) | 7,017 (13.2%) | 11,435 (20.3%) | 12,307 (20.5%) | 12,704 (20.0%) |
| Indiana | 1,113 (4.6%) | 3,350 (13.2%) | 5,459 (20.3%) | 5,875 (20.5%) | 6,065 (20.0%) |
| Iowa | 312 (2.6%) | 954 (7.7%) | 1,725 (13.3%) | 1,855 (13.6%) | 1,949 (13.7%) |
| Kansas | 398 (2.6%) | 1,216 (7.7%) | 2,198 (13.3%) | 2,364 (13.6%) | 2,482 (13.7%) |
| Kentucky | 650 (3.5%) | 1,717 (8.9%) | 2,829 (13.7%) | 3,141 (14.3%) | 3,377 (14.5%) |
| Louisiana | 962 (3.4%) | 2,801 (9.3%) | 5,341 (16.8%) | 6,399 (19.0%) | 7,330 (20.5%) |
| Maine | 196 (5.3%) | 487 (12.8%) | 727 (18.3%) | 779 (18.7%) | 784 (18.2%) |
| Maryland | 1,511 (5.1%) | 3,920 (12.5%) | 6,252 (18.3%) | 7,121 (19.4%) | 7,959 (20.3%) |
| Massachusetts | 1,275 (5.3%) | 3,178 (12.8%) | 4,742 (18.3%) | 5,082 (18.7%) | 5,109 (18.2%) |
| Michigan | 1,780 (4.6%) | 5,360 (13.2%) | 8,735 (20.3%) | 9,401 (20.5%) | 9,705 (20.0%) |
| Minnesota | 605 (2.6%) | 1,849 (7.7%) | 3,342 (13.3%) | 3,594 (13.6%) | 3,775 (13.7%) |
| Mississippi | 477 (3.5%) | 1,261 (8.9%) | 2,079 (13.7%) | 2,307 (14.3%) | 2,481 (14.5%) |
| Missouri | 790 (2.6%) | 2,414 (7.7%) | 4,363 (13.3%) | 4,692 (13.6%) | 4,929 (13.7%) |
| Montana | 172 (3.6%) | 523 (10.3%) | 1,031 (18.4%) | 1,167 (19.4%) | 1,234 (19.2%) |
| Nebraska | 241 (2.6%) | 736 (7.7%) | 1,330 (13.3%) | 1,430 (13.6%) | 1,502 (13.7%) |
| Nevada | 440 (4.0%) | 1,273 (10.8%) | 2,386 (18.5%) | 2,693 (19.4%) | 2,842 (19.2%) |
| New Hampshire | 219 (5.3%) | 545 (12.8%) | 813 (18.3%) | 871 (18.7%) | 876 (18.2%) |
| New Jersey | 1,531 (3.8%) | 4,735 (11.4%) | 7,916 (18.4%) | 8,449 (18.9%) | 8,390 (18.5%) |

| | | | | | |
|---|---|---|---|---|---|
| New Mexico | 406 (4.0%) | 1,176 (10.8%) | 2,203 (18.5%) | 2,486 (19.4%) | 2,624 (19.2%) |
| New York | 3,044 (3.8%) | 9,417 (11.4%) | 15,741 (18.4%) | 16,802 (18.9%) | 16,685 (18.5%) |
| North Carolina | 2,432 (5.1%) | 6,312 (12.5%) | 10,066 (18.3%) | 11,466 (19.4%) | 12,815 (20.3%) |
| North Dakota | 162 (2.6%) | 496 (7.7%) | 897 (13.3%) | 965 (13.6%) | 1,013 (13.7%) |
| Ohio | 2,183 (4.6%) | 6,571 (13.2%) | 10,708 (20.3%) | 11,525 (20.5%) | 11,897 (20.0%) |
| Oklahoma | 796 (3.4%) | 2,319 (9.3%) | 4,421 (16.8%) | 5,297 (19.0%) | 6,068 (20.5%) |
| Oregon | 792 (3.4%) | 2,398 (9.7%) | 4,333 (16.3%) | 4,728 (16.5%) | 4,987 (16.3%) |
| Pennsylvania | 1,729 (3.8%) | 5,349 (11.4%) | 8,942 (18.4%) | 9,545 (18.9%) | 9,478 (18.5%) |
| Rhode Island | 180 (5.3%) | 449 (12.8%) | 671 (18.3%) | 719 (18.7%) | 723 (18.2%) |
| South Carolina | 1,106 (5.1%) | 2,869 (12.5%) | 4,576 (18.3%) | 5,212 (19.4%) | 5,826 (20.3%) |
| South Dakota | 123 (2.6%) | 375 (7.7%) | 679 (13.3%) | 730 (13.6%) | 767 (13.7%) |
| Tennessee | 1,160 (3.5%) | 3,065 (8.9%) | 5,053 (13.7%) | 5,608 (14.3%) | 6,031 (14.5%) |
| Texas | 4,225 (3.3%) | 11,922 (8.9%) | 23,808 (16.7%) | 27,982 (18.5%) | 32,127 (20.1%) |
| Utah | 409 (3.6%) | 1,242 (10.3%) | 2,447 (18.4%) | 2,771 (19.4%) | 2,928 (19.2%) |
| Vermont | 98 (5.3%) | 244 (12.8%) | 364 (18.3%) | 390 (18.7%) | 392 (18.2%) |
| Virginia | 2,438 (5.1%) | 6,326 (12.5%) | 10,089 (18.3%) | 11,492 (19.4%) | 12,845 (20.3%) |
| Washington | 1,447 (3.4%) | 4,380 (9.7%) | 7,916 (16.3%) | 8,637 (16.5%) | 9,110 (16.3%) |
| West Virginia | 393 (5.1%) | 1,021 (12.5%) | 1,628 (18.3%) | 1,854 (19.4%) | 2,073 (20.3%) |
| Wisconsin | 1,089 (4.6%) | 3,279 (13.2%) | 5,343 (20.3%) | 5,751 (20.5%) | 5,936 (20.0%) |
| Wyoming | 138 (3.6%) | 420 (10.3%) | 827 (18.4%) | 936 (19.4%) | 990 (19.2%) |

**Table 4-4**
**Industrial Economic Potential by State by Year, in GWh and as a Share of the Adjusted Annual State Industrial Sales.**

| | Industrial Economic Potential, GWh (% of Adjusted Annual State Sales) | | | | |
|---|---|---|---|---|---|
| | **2017** | **2020** | **2025** | **2030** | **2035** |
| Alabama | 388 (0.9%) | 1,590 (3.7%) | 3,718 (8.3%) | 5,731 (12.9%) | 6,005 (13.7%) |
| Alaska | 11 (0.9%) | 43 (3.8%) | 101 (8.5%) | 156 (13.2%) | 166 (14.1%) |
| Arizona | 161 (0.9%) | 653 (3.8%) | 1,516 (8.5%) | 2,339 (13.2%) | 2,474 (14.1%) |
| Arkansas | 124 (0.9%) | 506 (3.7%) | 1,171 (8.3%) | 1,814 (12.9%) | 1,919 (13.7%) |
| California | 513 (0.9%) | 2,072 (3.8%) | 4,826 (8.5%) | 7,476 (13.2%) | 7,944 (14.1%) |
| Colorado | 105 (0.9%) | 427 (3.8%) | 991 (8.5%) | 1,529 (13.2%) | 1,617 (14.1%) |
| Connecticut | 50 (0.9%) | 196 (3.8%) | 429 (8.5%) | 606 (13.2%) | 563 (14.0%) |
| Delaware | 18 (0.9%) | 72 (3.7%) | 170 (8.3%) | 261 (12.9%) | 274 (13.7%) |
| District of Columbia | 2 (0.9%) | 7 (3.7%) | 17 (8.3%) | 26 (12.9%) | 27 (13.7%) |
| Florida | 457 (0.9%) | 1,878 (3.7%) | 4,395 (8.3%) | 6,771 (12.9%) | 7,087 (13.7%) |
| Georgia | 233 (0.9%) | 958 (3.7%) | 2,243 (8.3%) | 3,456 (12.9%) | 3,617 (13.7%) |
| Hawaii | 29 (0.9%) | 118 (3.8%) | 275 (8.5%) | 426 (13.2%) | 453 (14.1%) |
| Idaho | 60 (0.9%) | 244 (3.8%) | 568 (8.5%) | 876 (13.2%) | 926 (14.1%) |
| Illinois | 374 (0.8%) | 1,499 (3.3%) | 3,364 (7.5%) | 4,966 (11.7%) | 4,984 (12.4%) |
| Indiana | 416 (0.8%) | 1,669 (3.3%) | 3,746 (7.5%) | 5,531 (11.7%) | 5,551 (12.4%) |
| Iowa | 170 (0.8%) | 686 (3.3%) | 1,548 (7.5%) | 2,294 (11.7%) | 2,329 (12.4%) |
| Kansas | 90 (0.8%) | 362 (3.3%) | 817 (7.5%) | 1,210 (11.7%) | 1,228 (12.4%) |
| Kentucky | 350 (0.9%) | 1,438 (3.7%) | 3,361 (8.3%) | 5,180 (12.9%) | 5,428 (13.7%) |
| Louisiana | 272 (0.9%) | 1,108 (3.7%) | 2,565 (8.3%) | 3,973 (12.9%) | 4,203 (13.7%) |
| Maine | 46 (0.9%) | 183 (3.8%) | 401 (8.5%) | 566 (13.2%) | 526 (14.0%) |
| Maryland | 28 (0.9%) | 116 (3.7%) | 271 (8.3%) | 418 (12.9%) | 437 (13.7%) |
| Massachusetts | 114 (0.9%) | 451 (3.8%) | 987 (8.5%) | 1,393 (13.2%) | 1,295 (14.0%) |
| Michigan | 266 (0.8%) | 1,066 (3.3%) | 2,393 (7.5%) | 3,532 (11.7%) | 3,545 (12.4%) |
| Minnesota | 171 (0.8%) | 691 (3.3%) | 1,560 (7.5%) | 2,312 (11.7%) | 2,347 (12.4%) |
| Mississippi | 182 (0.9%) | 747 (3.7%) | 1,747 (8.3%) | 2,693 (12.9%) | 2,822 (13.7%) |
| Missouri | 136 (0.8%) | 549 (3.3%) | 1,239 (7.5%) | 1,836 (11.7%) | 1,864 (12.4%) |
| Montana | 31 (0.9%) | 125 (3.8%) | 292 (8.5%) | 450 (13.2%) | 476 (14.1%) |
| Nebraska | 85 (0.8%) | 343 (3.3%) | 775 (7.5%) | 1,148 (11.7%) | 1,166 (12.4%) |
| Nevada | 152 (0.9%) | 616 (3.8%) | 1,431 (8.5%) | 2,208 (13.2%) | 2,335 (14.1%) |
| New Hampshire | 29 (0.9%) | 113 (3.8%) | 248 (8.5%) | 350 (13.2%) | 325 (14.0%) |
| New Jersey | 63 (0.9%) | 249 (3.8%) | 544 (8.5%) | 774 (13.2%) | 723 (14.0%) |

| | | | | | |
|---|---|---|---|---|---|
| New Mexico | 82 (0.9%) | 332 (3.8%) | 771 (8.5%) | 1,190 (13.2%) | 1,258 (14.1%) |
| New York | 156 (0.9%) | 614 (3.8%) | 1,344 (8.5%) | 1,913 (13.2%) | 1,786 (14.0%) |
| North Carolina | 201 (0.9%) | 826 (3.7%) | 1,934 (8.3%) | 2,979 (12.9%) | 3,118 (13.7%) |
| North Dakota | 56 (0.8%) | 225 (3.3%) | 508 (7.5%) | 753 (11.7%) | 764 (12.4%) |
| Ohio | 438 (0.8%) | 1,757 (3.3%) | 3,943 (7.5%) | 5,822 (11.7%) | 5,843 (12.4%) |
| Oklahoma | 140 (0.9%) | 569 (3.7%) | 1,317 (8.3%) | 2,039 (12.9%) | 2,157 (13.7%) |
| Oregon | 102 (0.9%) | 414 (3.8%) | 964 (8.5%) | 1,493 (13.2%) | 1,586 (14.1%) |
| Pennsylvania | 410 (0.9%) | 1,611 (3.8%) | 3,524 (8.5%) | 5,015 (13.2%) | 4,682 (14.0%) |
| Rhode Island | 12 (0.9%) | 46 (3.8%) | 100 (8.5%) | 141 (13.2%) | 131 (14.0%) |
| South Carolina | 213 (0.9%) | 875 (3.7%) | 2,048 (8.3%) | 3,155 (12.9%) | 3,303 (13.7%) |
| South Dakota | 22 (0.8%) | 90 (3.3%) | 202 (7.5%) | 300 (11.7%) | 304 (12.4%) |
| Tennessee | 266 (0.9%) | 1,091 (3.7%) | 2,551 (8.3%) | 3,932 (12.9%) | 4,120 (13.7%) |
| Texas | 1,039 (0.9%) | 4,225 (3.7%) | 9,782 (8.3%) | 15,152 (12.9%) | 16,029 (13.7%) |
| Utah | 65 (0.9%) | 263 (3.8%) | 611 (8.5%) | 942 (13.2%) | 997 (14.1%) |
| Vermont | 21 (0.9%) | 81 (3.8%) | 178 (8.5%) | 251 (13.2%) | 233 (14.0%) |
| Virginia | 127 (0.9%) | 523 (3.7%) | 1,224 (8.3%) | 1,886 (12.9%) | 1,974 (13.7%) |
| Washington | 212 (0.9%) | 855 (3.8%) | 1,992 (8.5%) | 3,086 (13.2%) | 3,279 (14.1%) |
| West Virginia | 95 (0.9%) | 390 (3.7%) | 912 (8.3%) | 1,405 (12.9%) | 1,471 (13.7%) |
| Wisconsin | 208 (0.8%) | 833 (3.3%) | 1,869 (7.5%) | 2,760 (11.7%) | 2,770 (12.4%) |
| Wyoming | 71 (0.9%) | 289 (3.8%) | 671 (8.5%) | 1,034 (13.2%) | 1,094 (14.1%) |

NOTE: Because of the way that the industrial sector is modeled here, the same level of resolution is not available as it is in the residential and commercial sectors. As such, the percent of sales is roughly equivalent in each year reported

# 5
# STATE LEVEL HISTORICAL BENCHMARK ANALYSIS

While energy efficiency is a broadly available resource, the extent to which states utilize energy efficiency differs. The benchmark analysis calculates the percent progress to economic potential by comparing the energy efficiency savings that would be attained by maintaining a state's average historical savings rate to the state-level economic potential identified by EPRI. Since it is possible for the state savings to exceed the EPRI identified savings, the state savings are capped by the EPRI savings to provide a consistent metric, ranging from 0-100%.

Given the high annual incremental rates that have been achieved in some states, this benchmark analysis also highlights a limitation of the model. If states with historically high annual incremental savings continue their progress, the compounded savings would exceed the potential that is reported in this study. However, the potential identified here is constrained by the model outputs, which are determined by input factors including the technologies considered, the cost of those technologies and the avoided costs, and the program administration costs. Higher levels of savings can be attained by incorporating new technologies, accelerating the turnover of equipment, reducing program administration costs and finding innovative ways to enable energy efficiency savings. However, these are not included in the results modeled here. If policies mandate higher levels of savings than projected in this study, program administrators might implement new or additional efficiency measures in order to reduce costs and achieve more savings, taking advantage of both technological innovation as well as other energy efficiency savings approaches, including behavioral savings which are not considered here. Further, as modeled, if incentives are available at the state or regional level, more energy efficiency becomes cost effective. Thus, this analysis serves as a benchmark, not as a limiting condition for the potential of energy efficiency.

The percent progress to economic potential for 2035, shown below in Figure 5-1 for each state and serves a benchmark for the extent to which states are in position to utilize energy efficiency as a resource through existing programs, policies and action. If states with a history of achieving high levels of annual energy efficiency savings continue at the average historical savings rate, these states are poised to capture a large portion and in many cases all  (shown in dark blue) of the EE economic potential identified in this study. However, other states, shown in the lighter shades have historically achieved lower rates of savings and would need to increase the annual savings rate to capture all of the energy efficiency identified here.

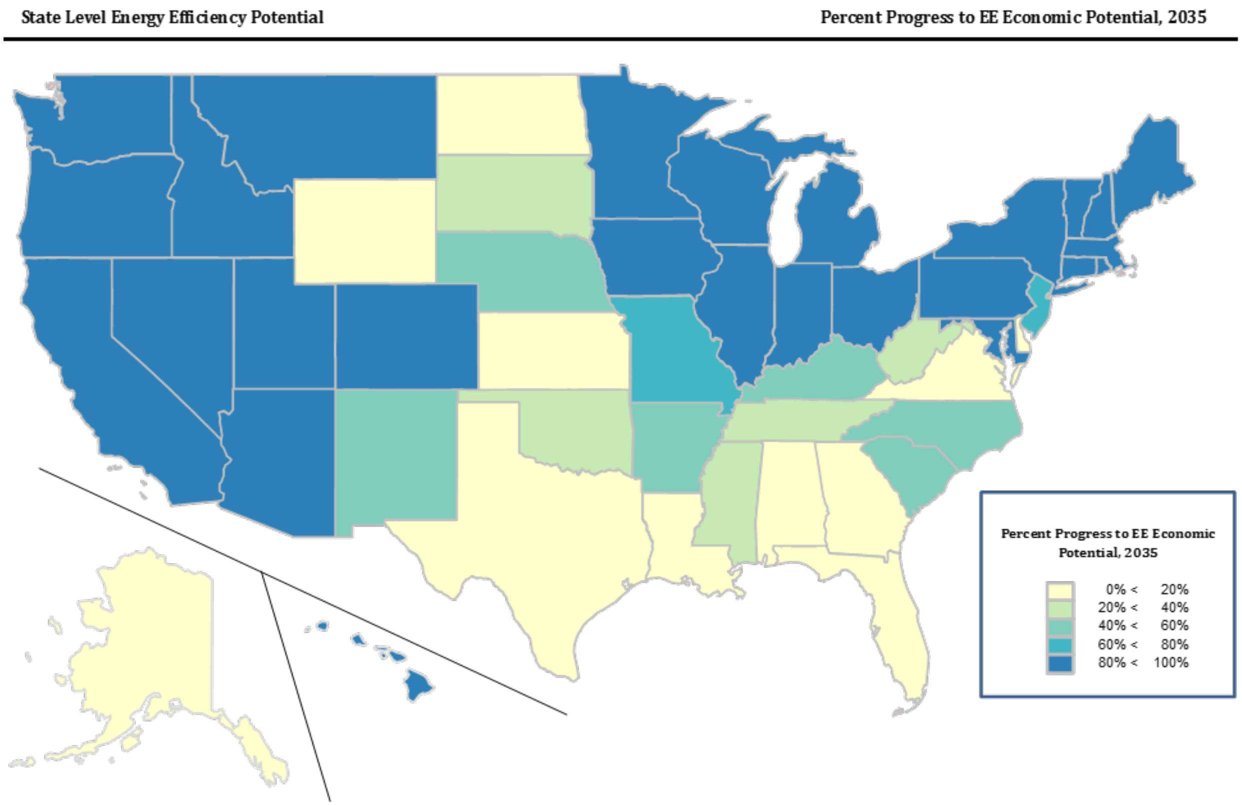



**Figure 5-1**
**Percent Progress to 2035 Energy Efficiency Economic Potential (EP) Based on Extrapolation of Average Historical State Savings**

The calculated percent progress to EE economic potential is shown below in Table 5-1 for each years 2017, 2020, 2025, 2030 and 2035.

**Table 5-1**
**Benchmarked Savings: Percent Progress to EE Economic Potential Based on Extrapolation of Average Historical State Savings for 2017, 2020, 2025, 2030 and 2035**

100% indicates that a continuation of the average historical yearly savings rate will capture all of the EE potential identified by the EPRI model.

| | Percent of Energy Efficiency Captured by Exiting Programs, Policies and Activities, | | | | |
|---|---|---|---|---|---|
| | 2017 | 2020 | 2025 | 2030 | 2035 |
| Alabama | 4% | 6% | 7% | 8% | 10% |
| Alaska | 1% | 1% | 2% | 2% | 3% |
| Arizona | 41% | 66% | 96% | 100% | 100% |
| Arkansas | 17% | 24% | 30% | 34% | 43% |
| California | 41% | 70% | 100% | 100% | 100% |
| Colorado | 25% | 40% | 56% | 77% | 100% |
| Connecticut | 32% | 56% | 90% | 100% | 100% |
| Delaware | 4% | 7% | 10% | 12% | 15% |
| District of Columbia | 11% | 18% | 27% | 37% | 48% |
| Florida | 5% | 8% | 11% | 13% | 17% |
| Georgia | 6% | 9% | 13% | 16% | 20% |
| Hawaii | 50% | 80% | 100% | 100% | 100% |
| Idaho | 30% | 48% | 68% | 90% | 100% |
| Illinois | 32% | 49% | 71% | 93% | 100% |
| Indiana | 28% | 43% | 59% | 73% | 96% |
| Iowa | 53% | 80% | 100% | 100% | 100% |
| Kansas | 3% | 5% | 7% | 8% | 10% |
| Kentucky | 18% | 25% | 32% | 35% | 45% |
| Louisiana | 2% | 3% | 3% | 4% | 5% |
| Maine | 34% | 56% | 84% | 100% | 100% |
| Maryland | 24% | 40% | 58% | 75% | 97% |
| Massachusetts | 48% | 84% | 100% | 100% | 100% |
| Michigan | 38% | 58% | 86% | 100% | 100% |
| Minnesota | 50% | 78% | 100% | 100% | 100% |
| Mississippi | 8% | 11% | 14% | 16% | 21% |
| Missouri | 21% | 34% | 48% | 59% | 76% |
| Montana | 21% | 34% | 48% | 64% | 87% |

| | | | | | |
|---|---|---|---|---|---|
| Nebraska | 16% | 24% | 33% | 39% | 50% |
| Nevada | 33% | 51% | 69% | 85% | 100% |
| New Hampshire | 18% | 30% | 47% | 60% | 82% |
| New Jersey | 17% | 26% | 40% | 54% | 73% |
| New Mexico | 17% | 25% | 34% | 44% | 58% |
| New York | 28% | 43% | 66% | 90% | 100% |
| North Carolina | 16% | 26% | 36% | 44% | 56% |
| North Dakota | 6% | 9% | 12% | 14% | 19% |
| Ohio | 34% | 54% | 78% | 100% | 100% |
| Oklahoma | 9% | 14% | 17% | 20% | 25% |
| Oregon | 34% | 57% | 88% | 100% | 100% |
| Pennsylvania | 31% | 49% | 74% | 92% | 100% |
| Rhode Island | 54% | 96% | 100% | 100% | 100% |
| South Carolina | 14% | 22% | 30% | 35% | 45% |
| South Dakota | 9% | 15% | 21% | 26% | 33% |
| Tennessee | 10% | 15% | 20% | 23% | 30% |
| Texas | 8% | 11% | 14% | 16% | 19% |
| Utah | 26% | 40% | 56% | 76% | 100% |
| Vermont | 64% | 100% | 100% | 100% | 100% |
| Virginia | 2% | 3% | 4% | 5% | 7% |
| Washington | 32% | 52% | 81% | 100% | 100% |
| West Virginia | 7% | 11% | 15% | 17% | 22% |
| Wisconsin | 27% | 41% | 59% | 77% | 100% |
| Wyoming | 7% | 9% | 11% | 14% | 18% |

# 6 INCENTIVE ANALYSIS

A final analysis looks at the impact of incentives on the economic and high achievable potential. This analysis serves to help understand the shape of the energy efficiency supply curve at both the economic and high achievable potential levels as well as understand the potential gains in energy efficiency economic potential that can be achieved by targeted incentives or through further cost reduction.

In order to assess the impact of an external incentive, an incentive ranging from $5 to $20/MWh in $5 increments was added to the total resource cost (TRC) test to reduce the measure cost (denominator) or increase the avoided cost (numerator) (see Appendix A). Unlike a utility incentive, this external incentive is not a transfer, which would have no net impact on economic potential. Instead this has the effect of shifting the supply curve. Each measure is tested for cost-effectiveness in each year 2016 through 2035 (19 years), and in each of the 13 Census divisions/states, resulting in a total of 247 passing measure tests for each measure considered. The national results of this analysis are presented below. The state-level allocation of the four levels of incentives and the high achievable potential are provided in separate spreadsheets

A $20/MWh incentive increased 2035 EE economic potential by 14% across all sectors, with a 25% increase in the residential sector and a 7% increase in both the industrial and commercial sectors.[15] For high achievable potential, the $20/MWh incentive results in 14%, with residential EE potential increasing 30% with the incentive. Table 6-1 illustrates the cumulative baseline forecast and five levels of economic (EP) potential energy savings for the residential sector.

[15] Due to the limited resolution, available in the industrial sector model, the relative impact observed in the commercial results was applied to the industrial sector.

**Table 6-1**
**Impact of Varying Incentive Levels on Cumulative Economic and High Achievable Potentials**

| | 2016-2035 Cumulative Energy | 2016-2035 Savings as a Share of Cumulative Baseline |
|---|---|---|
| AEO2012 baseline consumption | 79,866 TWh | - |
| Technical potential efficiency savings | 18,477 TWh | 23.1% |
| **Economic Potential Efficiency Savings** | | |
| No incentives | 9,628 TWh | 12.1% |
| $5/MWh incentive | 10,156 TWh | 12.7% |
| $10/MWh incentive | 10,491 TWh | 13.1% |
| $15/MWh incentive | 10,758 TWh | 13.5% |
| $20/MWh incentive | 11,076 TWh | 13.9% |
| **High Achievable Potential Efficiency Savings** | | |
| No incentives | 7,266 TWh | 9.1% |
| $5/MWh incentive | 7,650 TWh | 9.6% |
| $10/MWh incentive | 7,894 TWh | 9.9% |
| $15/MWh incentive | 8.102 TWh | 10.1% |
| $20/MWh incentive | 8,367 TWh | 10.5% |

The impact of incentives is most visible in the residential sector, with $20/MWh increasing the 2016 to 2035 cumulative high achievable potential by 33% compared to the base case without incentives. These impacts are shown overtime relative to the baseline in Figure 6-1.

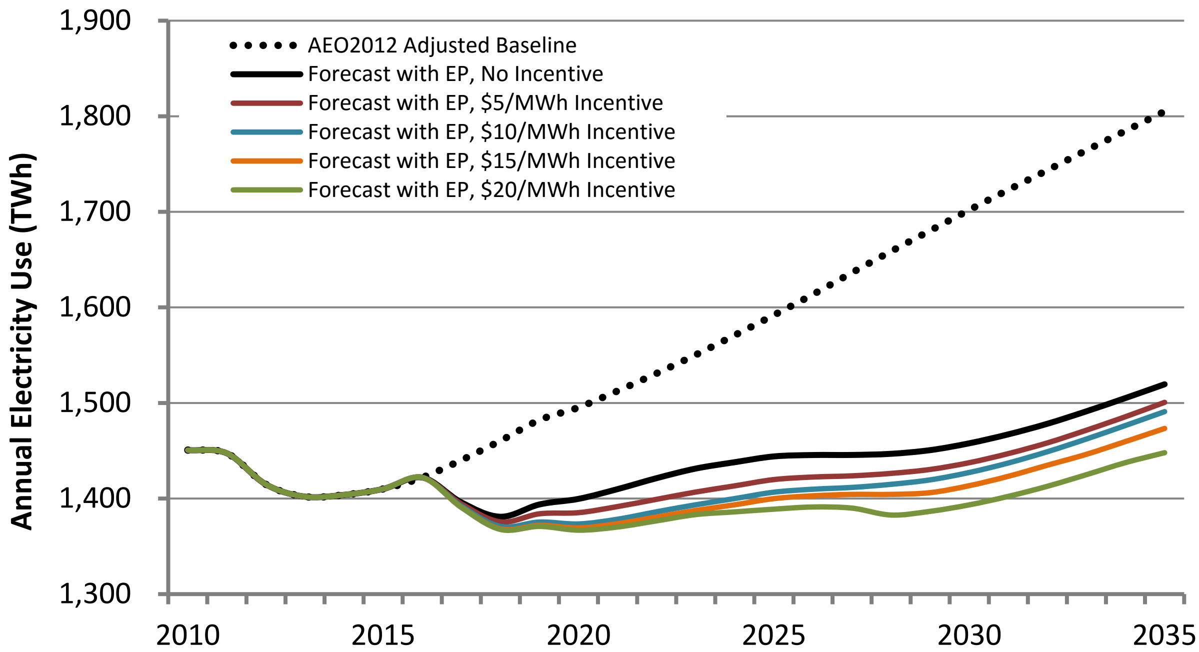



**Figure 6-1**
**Residential Economic Potential (EP) with Varying Levels of Incentives**

Figure 6-2 shows the varying levels of economic potential (EP) at different incentive levels by end use, compared to the baseline in 2035. The changes in potential at the end use level with increasing incentives are subtle.

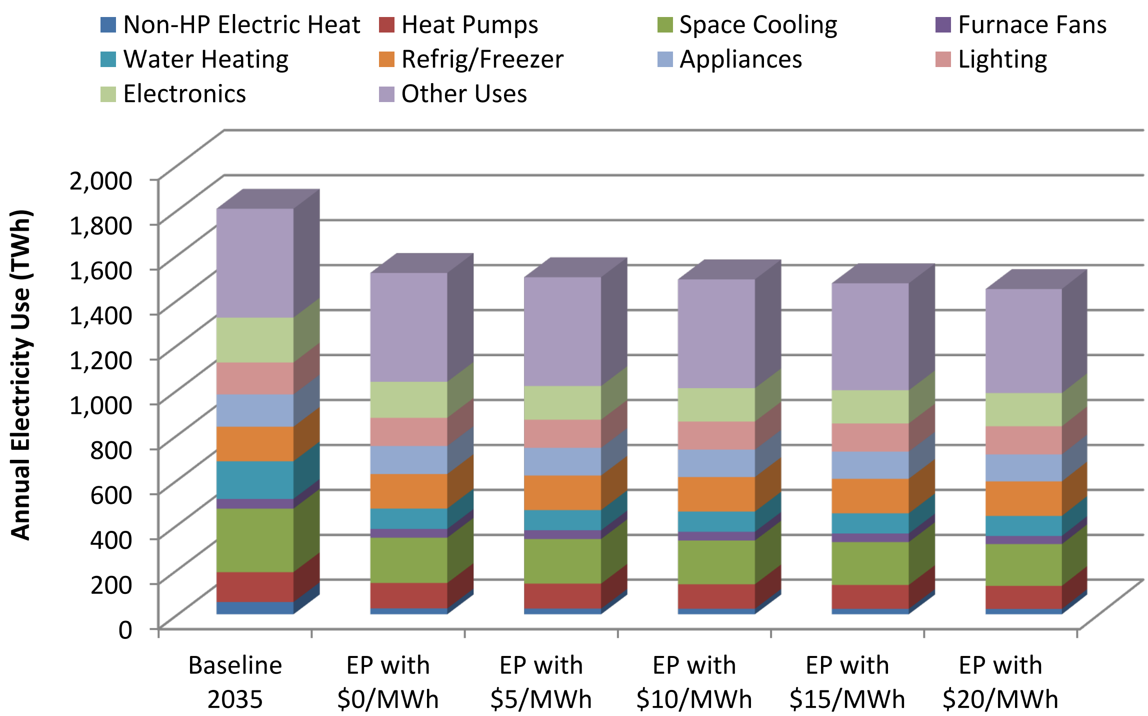



**Figure 6-2**
**U.S. Residential Adjusted Baseline in 2035 and Forecast in 2035 with Impacts on Economic Potential (EP) for the Case without Incentives ($0/MWh) and with Four Levels of Incentives, by End Use**

Taking a closer look at the impacts of incentives on residential economic potential, Table 6-2 highlights key differences in residential measures that pass the TRC without incentives and with the highest level of $20/MWh incentive, and differences between Census regions.

- This table focuses on the top six areas for growth in economic potential, accounting for 86% of the additional sectoral savings from the $20/MWh incentive.
- Note that the remaining 14% is growth in potential from ground-source heat pumps, furnace fans, water heating, lighting, room air conditioning (AC), and dishwashers.
- There is no potential savings for clothes washers, freezers, or refrigerators, without or with incentives based upon the technology cost and avoided cost projections used.

The impact of incentives is more pronounced in the South where electricity consumption is higher than in other locations, due in part to higher space cooling needs. Therefore, for the same incremental measure cost with higher avoided costs there are higher levels of energy efficient technologies that are cost effective in the South. The addition of incentives decreases the incremental costs in the TRC and results in a more favorable benefit-cost ratio, particularly in the South compared to the other regions. Where measures were much more favorable in the South to begin with, the addition of incentives may have the impact of increasing the number of measures that are cost effective (i.e. passing measures) in other regions. Customized incentives by state or region were not considered.

In the following table the share of passing occurrences provides a relative measure of the impact of the $20/MWh incentive. A "passing occurrence" indicates that the more efficient measure is cost effective – thus the increase in passing occurrences indicates the ability of an incentive to drive additional cost effective savings. For each of the examples in Table 6-2, the growth in economic potential with the $20/MWh incentive relative to the saving without incentives is provided The "growth in savings relative to base" reflects the increased savings for a given measure (i.e. televisions) relative to the $0/MWh case; the "cumulative savings growth" reflects the fraction of growth in a given measure (i.e. televisions) with the added incentive relative to the growth in total sector savings with the added incentive.

**Table 6-2**
**Primary Differences in Residential Economic Potential with $20/MWh Incentive**

| | |
|---|---|
| Televisions | • 251% growth in savings relative to base, and 18% of cumulative savings growth.<br>• ENERGY STAR® or better, 43% passing (avoided costs from efficient TV outweigh additional costs including program administration costs) in base case for South Census region, up to 99% passing with $20/MWh incentive. Did not pass at all in other regions in base case, but with $20/MWh incentive, 82% passing in the Midwest Census region—in both regions driven in part by relatively higher electricity use for electronics.<br>• Use of a smart plug strip to eliminate standby power draw has 88% and 66% passing in South and Midwest Census regions respectively in base case. Increases to 100% passing in both with $20/MWh incentive, and 66% and 61% passing in Northeast and West Census regions. |
| Personal computers | • 88% growth relative to base, and 24% of cumulative savings growth.<br>• ENERGY STAR or better with the following pass rate in each Census region in the base case: 61% Northeast, 65% South, 61% Midwest, and 12% West.<br>• This increases to 100% in all regions with $20/MWh incentive. |
| Cooking | • 462% growth in savings relative to base, and 4% of cumulative growth.<br>• Efficient technology passes 36% of the time in the South in base case. Increases to 83% of the years in the South, with 3% in the Northeast, 55% in the Midwest, and 21% West with $20/MWh incentive. |
| Central AC | • 15% growth in savings relative to base, and 13% of cumulative savings growth.<br>• About 4% passing without incentives (SEER 15 or SEER 16 units with 14-20% HVAC savings) and 16% passing with incentives (about a third of passes for higher efficiency units with 35-50% HVAC savings). In the base case all passing is in the South (Texas) and with $20/MWh incentive has passing measures in 33% of South cases, and 11% of West cases.<br>• A handful of measures with reasonable space cooling savings, with some increase in passing with $20/MWh incentive:<br>o Whole house fans: 39% to 50% passing in the West where 31% cooling savings, otherwise no pass.<br>o External shades: 3% to 32% passing in Midwest and 44% to 63% passing in the South. No change to 25% pass rate in West (Mountain South) and no passing in Northeast. |

| | |
|---|---|
| | o Reflective roof: 26% to 42% passing in Midwest and 74% to 80% passing in the South. No change to 25% pass rate in West (Mountain South) and no passing in Northeast.<br>o Windows: 50% to 74% passing in Midwest and 74% to 80% passing in the South. No change to 25% pass rate in West (Mountain South) and no passing in Northeast.<br>o AC maintenance: 68% to 76% passing in Midwest, 0% to 13% passing in Northeast. No change to 80% pass rate in South and 50% pass rate in West.<br>• Duct repair: 84% to 100% passing in Midwest and 29% to 41% passing in the West. No change to 80% pass rate in South and no passing in Northeast. |
| Clothes dryers | • 109% growth in savings relative to base, and 2% of cumulative savings growth.<br>o The following pass rates in the base case: 26% Northeast, 73% South, 71% Midwest, and 42% West. Passing in all regions in all years with $20/MWh incentive. |
| Air-source heat pumps | • 19% growth in savings relative to base, and 13% of cumulative savings growth.<br>• In 2020 and beyond, where "Future Technology" with about 40% more energy savings than the currently available max efficiency ductless heat pump is available, pass in 67% of cases with $20/MWh incentive compared to 38% of cases without incentives.<br>• In homes with non-heat pump electric heating and central AC space cooling, duct repair provides over 20% heating and cooling energy savings, passes 100% in South and Midwest in all cases; increases from about 25% pass rate in base to about 79% passing in the Northeast and 70% in the West with $20/MWh incentive.<br>• Increase in energy efficient windows with about 25-37% HVAC energy savings passing across the board, from about 85% passing to 96-100% passing with $20/MWh incentive. |
| Other uses | • There was no savings in this category without incentives, and 18% of cumulative savings growth.<br>• Enhanced bill presentation/format is assumed to provide savings in multiple end-use categories and the savings are accounted for in the other uses category. This measure is assumed to provide customers with information about their usage compared to other consumers', similar to several in-home display program designs.<br>• This measure does not pass without incentives, but with $20/MWh incentive passes 20% of the time, primarily in the South Census division. |

Figure 6-3 illustrates the baseline forecast and five levels of economic potential (EP) energy savings for the commercial sector. The effect of incentives is not quite as impactful as in the residential sector, with $20/MWh increasing the 2016 to 2035 cumulative commercial high achievable potential by 8% compared to the base case without incentives. This may be because the commercial sector has a much higher level of high achievable potential to begin with, at 17.4% savings in 2035 without incentives, compared to the residential section that has 11.3% high achievable potential savings in 2035 without incentives.

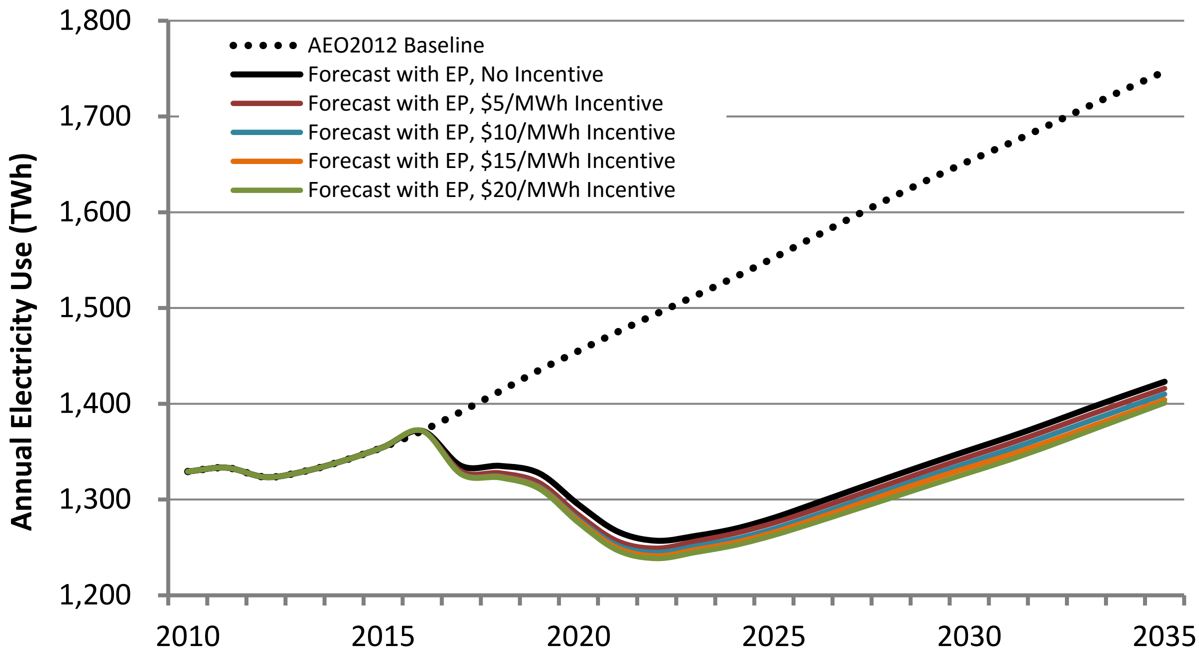



**Figure 6-3**
**Commercial Economic Potential (EP) with Varying Levels of Incentives**

Figure 6-4 shows the varying levels of economic potential in the commercial sector at different incentive levels by end use, compared to the baseline in 2035. The changes in potential at the end use level with increasing incentives are subtle.

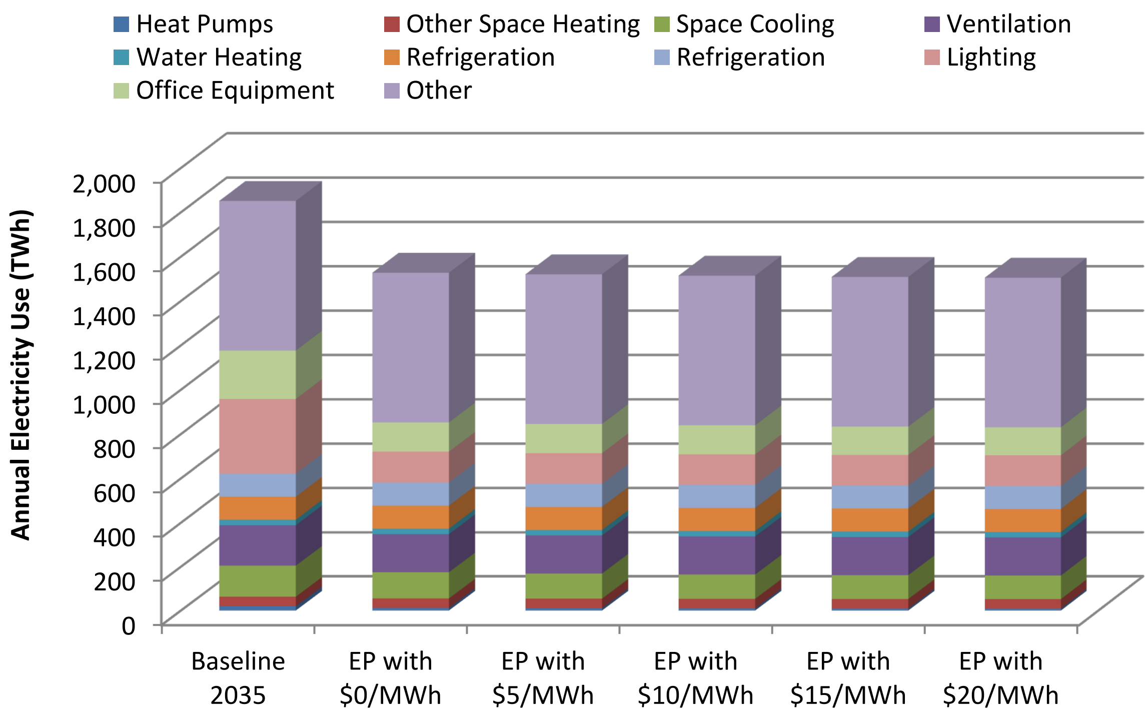



**Figure 6-4**
**U.S. Commercial Adjusted Baseline in 2035 and Forecast in 2035 with Impacts on Economic Potential (EP) for the Case without Incentives ($0/MWh) and with Four Levels of Incentives, by End Use**

Taking a closer look at the impacts of incentives on commercial economic potential, Table 6-3 highlights key differences in passing measures, and differences between Census regions. This table focuses on the top five areas for growth in economic potential, accounting for 97% of the additional savings from the $20/MWh incentive. Note that the remaining 3% is growth in copiers, printers, and other office electronics potential. There is no economic potential in refrigeration with or without incentives.

**Table 6-3**
**Primary Differences in Commercial Economic Potential with $20/MWh Incentive**

<table>
<tr><td>Central AC cooling</td><td><ul><li>215% growth in savings relative to base, and 48% of cumulative savings growth.</li><li>There are no passing higher-efficiency central AC units passing in the Northeast, Midwest, or West Census region.<ul><li>At some point in the forecast period there is some level of efficient AC passes in all Census divisions comprising the South Census region. In the base case an efficient unit passes 77% of the time and with $20/MWh, an efficient unit passes 99% of the time.</li><li>The passing technology also shifts from a mix of 12 EER, 14 EER, and a Future Technology in the base case to predominantly the Future Technology (more than double energy savings of 14 EER units) with the inclusion of the $20/MWh incentive.</li></ul></li><li>For the South Census region only, there are a handful of measures with reasonable space cooling savings, with some increase in passing with $20/MWh incentive:<ul><li>Programmable thermostat: 43%% to 95% passing.</li><li>Duct testing and sealing: 24% to 80% passing.</li><li>Windows: 0% to 38% passing.</li></ul></li></ul></td></tr>
<tr><td>Computers</td><td><ul><li>20% growth in savings relative to base, and 17% of cumulative savings growth.</li><li>In all cases, some level of higher-efficiency computer passes.</li><li>In the base case 34% of passing is for a base level of ENERGY STAR and 66% of passing is for a mid-level ENERGY STAR computer; with the $20/MWh incentive, 86% pass at the mid-level ENERGY STAR, and 14% pass at a high-level of ENERGY STAR.</li></ul></td></tr>
<tr><td>Indoor lighting</td><td><ul><li>2% growth in savings relative to base, and 17% of cumulative savings growth.</li><li>Screw-in lighting has efficient technologies that pass pre-EISA Tier 2 (2020), and in the base case after the required higher-efficiency baseline technology starts to filter in, above-and-beyond technologies are not cost effective starting in 2023.<ul><li>With $20/MWh incentives, the above-and-beyond efficient technologies become cost effective, even relative to the higher-efficiency baseline requirements, therefore there are additional savings from above-and-beyond screw-in lighting technologies about 80% of the time starting in 2023.</li></ul></li><li>There are also slight differences in the passing linear fluorescent technology in 2017-2020 without and with incentives, contributing to additional savings in early years in nearly all locations.</li></ul></td></tr>
<tr><td>Heat pumps for heating and cooling</td><td><ul><li>46% growth in savings relative to base, and 10% of cumulative savings growth.</li><li>Some level of efficient heat pump passes in all cases, the shift to higher-efficiency units passing accounts for increased savings:<ul><li>43% of passing is 3.4 or 4.0 COP units in the base case, and in the $20/MWh incentive case, 74% of passing is 5.1, 5.7, and Future Technology.</li></ul></li></ul></td></tr>
</table>

| | |
|---|---|
| | ○ In 2020 and beyond, where "Future Technology" with about 40% more energy savings than the maximum efficiency 5.7 COP heat pump, passes in 71% of cases with $20/MWh incentive compared to 56% of cases without incentives.<br>• A handful of measures with reasonable space cooling savings, with some increase in passing with $20/MWh incentive:<br>○ Programmable thermostat: 28% to 56% passing overall, with increased occurrences of passing in all regions<br>○ Windows: 43% to 50% passing in West and 0% to 24% passing in the South. No change in the Northeast and Midwest where the measure does not pass in any year. |
| Chiller cooling<br>24-28 | • 24% growth in savings relative to base, and 5% of cumulative savings growth.<br>• Some level of efficient chillers passes for a portion of the forecast in the South and the West, with a shift to higher efficiency passing units with incentives:<br>○ 50% passing of 1.3 kW/ton and 1.23 kW/ton units in the base case, shifts to 50% passing of 1.23 kW/ton and 1.11 kW/ton units with $20/MWh incentive in the West.<br>○ 94% total passing in the base and 98% total passing for efficient units in the South.<br>○ 86% passing of 1.3 kW/ton and 1.23 kW/ton units in the base case, shifts to 91% passing of 1.23 kW/ton and 1.11 kW/ton units with $20/MWh incentive in the South<br>• A handful of measures with reasonable space cooling savings, with some increase in passing in the South and West with $20/MWh incentive:<br>○ Variable speed drive on pump: 8% to 39% passing in the West.<br>○ Energy management system and variable air volume system: Some increase in passing occurrences in all Census regions.<br>○ HVAC retro-commissioning: 0% to 50% passing in the West, and 43%to 100% passing in the South. |

Figure 6-5 illustrates the baseline forecast and five levels of economic potential energy savings for the industrial sector. The bottom-up model of the industrial sector does not include economic inputs, rather an economic level of efficiency is applied in different manufacturing segments by end use and scaled to reflect customer barriers in the high achievable potential case. Therefore, to estimate the impact of incentives on the economic and high achievable potential in the industrial sector, commercial sector results are used. The amount of increased savings in each of the commercial incentives scenarios is used to scale up the high achievable potential in the industrial sector. Therefore, incentives have a similar impact in the industrial sector, with $20/MWh increasing the 2016 to 2035 cumulative high achievable potential by 7% compared to the base case without incentives.

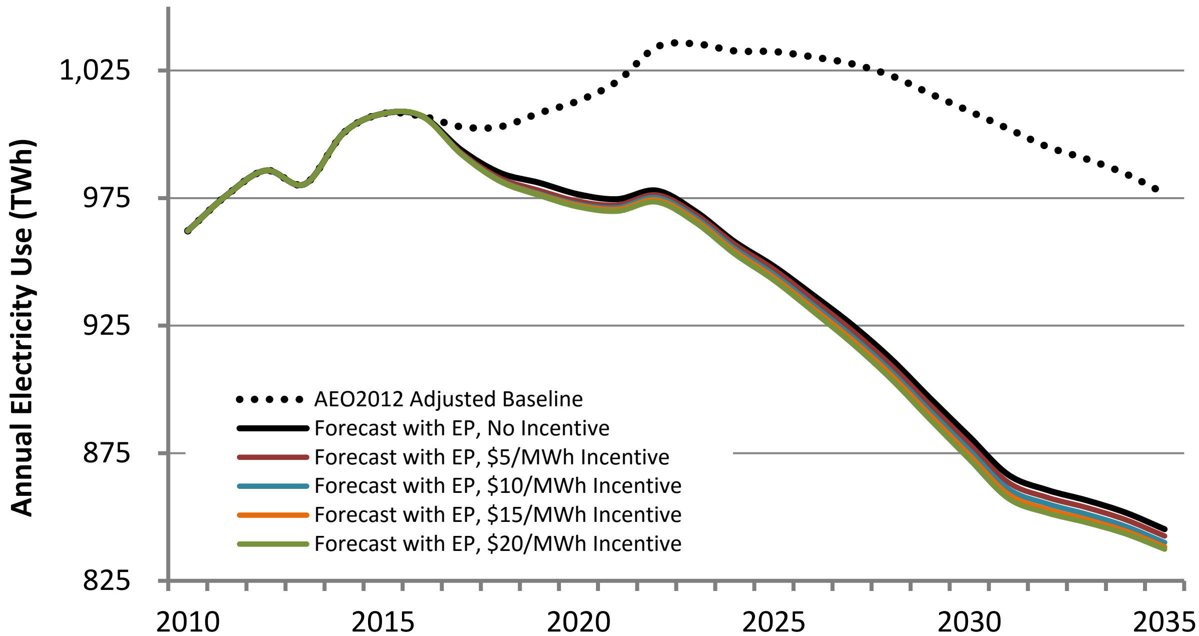



**Figure 6-5**
**Industrial Economic Potential (EP) with Varying Levels of Incentives**

Overall the impact of state level or regional incentive levels resulted in about a 14 percent increase in cost-effective economic potential when the incentive is raised from zero to $20/MWh ($0.02/kWh). This suggests that once the cost effective energy efficiency potential is captured, much of the easy-to-obtain, elastic energy efficiency has probably been achieved, and that without more new cost-effective measures, the incentive impact will diminish. However, the impact of incentives could have a larger impact in regions where energy efficiency has not yet been fully realized as a low cost energy resource.

# 7
# SUMMARY

This analysis shows that every state has a large amount of electric energy efficiency potential available as a resource, and that potential grows over time. Energy efficiency can be utilized as a cost-effective energy resource; however, the extent to which states are taking advantage of these resources varies. States with well-established energy efficiency programs are well positioned to take advantage of these resources. Other states have yet to take advantage of energy efficiency to the same degree.

In the out years of this projection, the states with historically high annual incremental savings, could far exceed the potential that is reported in this study, because these results are constrained by the model outputs. If policies mandate higher levels of savings than projected in this study, programs might find new efficiencies or utilize additional efficiency measures in order to reduce costs and achieve more savings, taking advantage of both technological innovation as well as behavioral savings.

The incentives analysis shows that incentives can increase the potential savings and points to specific measures that are near cost-competitive. Additional targeted incentives or further cost reductions can help deploy these technologies.

Updates to the underlying building stock data and technology library used to build equipment baselines and calculated efficiency impacts are needed to better align with the AEO2017 forecast. EPRI is planning to update its models for a revised national study release in late 2017 or early 2018, which will illustrate the impacts of ongoing increases in codes and standards, mature programmatic efficiency efforts, and other market-driven efficiencies.

# A

# APPENDIX A – EPRI'S EFFICIENCY POTENTIAL ESTIMATES

While a full description of the model and assumptions is available in the 2014 report, briefly, the EPRI study relies on a stock turnover model in which the number and efficiency of the end-use stock of residential and commercial equipment is used to determine various levels of energy efficiency potential and a top-down approach is used for the industrial sector.

EPRI used the U.S. DOE Energy Information Administration's (EIA) Annual Energy Outlook (AEO) 2012[16] for its forecast of end-use electricity consumption, including detailed stock forecasts for the residential and commercial sectors (not available for industrial). It also uses expert advice from its technology subject matter experts to assess the efficiency measures available today and in the future. EPRI uses end-use stock, energy consumption, and vintage information gathered from the EIA's 2009 Residential Energy Consumption Survey[17] (RECS) and the 2003 Commercial Building Energy Consumption Survey[18] (CBECS) to estimate bottom-up potential in the residential and commercial sectors. Residential consumption is based on unit energy consumption (UEC) in kWh per year when the appliances are present, calculated from the AEO2012 and RECS consumption and equipment stock. Commercial consumption is based on energy use intensity (EUI) in kWh per year per square foot, calculated from the AEO2012 and CBECS consumption and end-use saturation.

Because detailed customer and equipment accounting is not currently available within in the industrial sector, nor is there uniformity of equipment size and application, a top-down approach is used to determine the energy efficiency potential in the industrial sector. The industrial model relies on energy consumption data from the EIA's 2010 Manufacturing Energy Consumption Survey[19] (MECS) along with the EIA's model Plant Energy Profiler, or PEP[20] (formerly called QuickPEP) to estimate savings in the manufacturing portion of the industrial sector. With forecasts of energy consumption at the end-use level, efficiency options that pass technical and/or economic screens are then phased in replacing equipment as it turns over in the residential and commercial sectors, or the energy savings are phased into electricity consumption over time in the industrial sector. In the residential and commercial sectors with bottom-up end-use accounting, installed efficiency measures change over time as economics change. Further detail

---

[16] "Annual Energy Outlook 2012 with Projections to 2035," U.S. DOE EIA, Washington DC, DOE/EIA-0383(2012), June 2012. http://www.eia.gov/forecasts/aeo/pdf/0383%282012%29.pdf

[17] "2009 Residential Energy Consumption Survey," U.S. DOE EIA, Washington DC, Oct. 2012. http://www.eia.gov/consumption/residential/

[18] "2003 Commercial Buildings Energy Consumption Survey," U.S. DOE EIA, Washington DC, Sept. 2008. http://www.eia.gov/consumption/commercial/

[19] "2010 Manufacturing Energy Consumption Survey," U.S. DOE EIA, Washington DC, March 2013. http://www.eia.gov/emeu/mecs/

[20] Plant Energy Profiler, U.S. DOE, released Nov. 10, 2011. Available: https://ecenter.ee.doe.gov/EM/tools/Pages/ePEP.aspx

on the technologies considered, cost assumptions and other information can be found in the 2014 study.

The 2014 national study began with the development of baseline forecasts of electricity consumption absent any new utility programs or other programs administered by state agencies or third parties. The forecasts are consistent with the AEO2012 Reference case and the 2011 Demand Technology case for electricity consumption. The 2014 study estimated the potential for annual energy efficiency for the years 2013 through 2035 at the end-use level for the residential, commercial, and industrial sectors. The updated savings projections in this study reflect changes to avoided costs and uses 2016 as the base year (2017 is the first year with savings). The following section describes, at a high level, the approach used in the EPRI studies, with further detail provided in the 2014 national study report.

Both the 2014 national study and the updated projections for this study yield forecasts of changes in U.S. electricity use for each of the ten Census divisions and three states (California, Florida and Texas) as shown in Figure A-1.

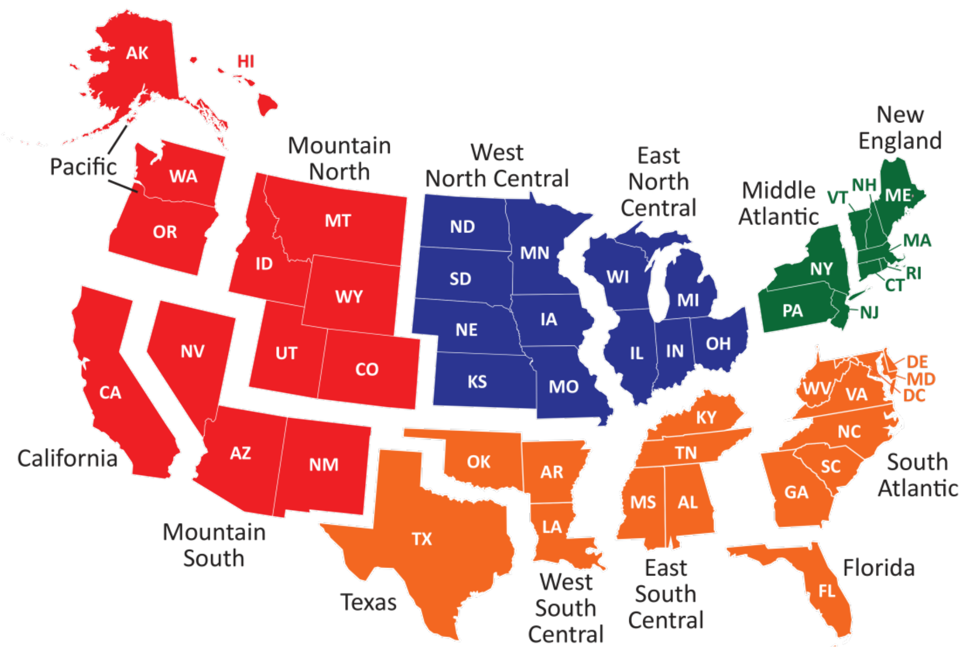



**Figure A-1**
**Geographic Divisions.** Ten census divisions plus three states.

A comparison of the 2016 to the 2012 AEO Reference case annual electricity use forecasts is provided in Figure A-2. Relative to AEO2012, the AEO2016 has reduced electricity consumption in these sectors due to changes to building energy codes and appliance and equipment efficiency standards, and changes in production and energy use in key manufacturing segments. This slightly lower forecast for electricity consumption would lead to lower estimated energy savings than is reported here using the AEO2012 baseline. The changes reflected in the AEO2016 are discussed further in Section 3.

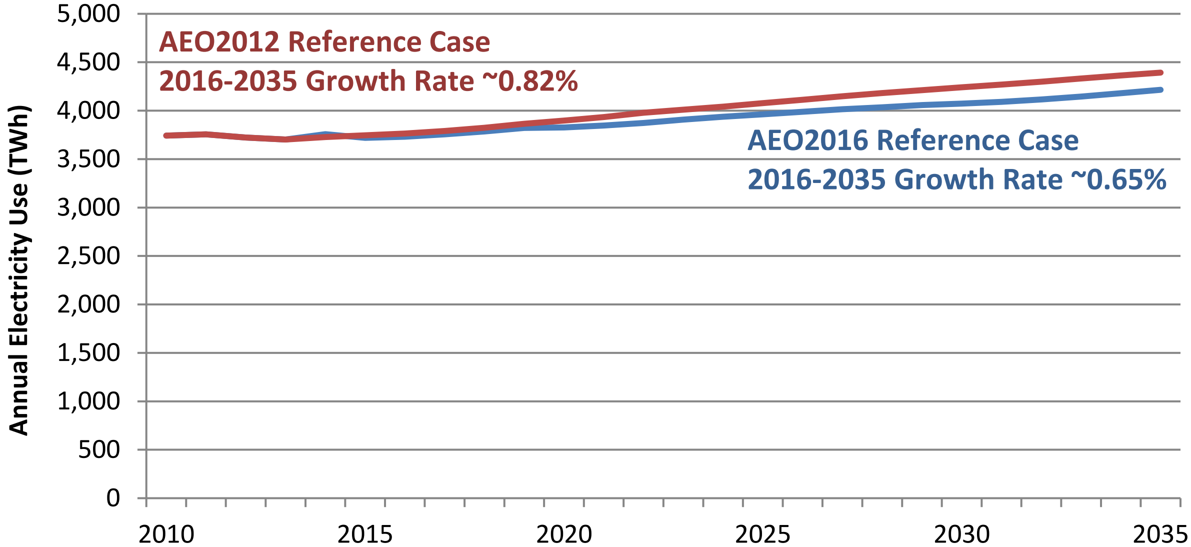



**Figure A-2**
**Comparison of AEO2012 and AEO2016 Reference Case Baseline Forecasts for Annual Electricity Use, in TWh**

For the residential and commercial sectors, a bottom-up approach is applied to estimate EE economic potential, which requires detailed microeconomic modeling at the end-use level. To this end, EPRI uses a stock accounting-based model that estimates energy savings and peak demand reduction for each end use within a given division and sector. The model baseline captures changes in efficiency due to efficiency standards coming into effect throughout the period of study.

Figure A-3 illustrates the mechanics of the calculation with input data in green, estimated inputs in yellow. These are then used in the model engine (in blue) to generate outputs.

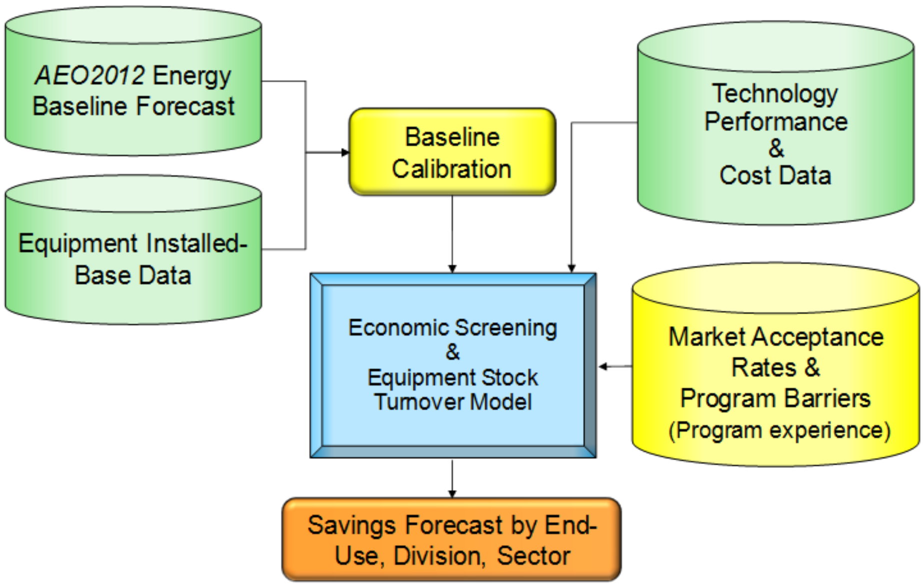



**Figure A-3**
**Model Approach.** Illustrates the mechanics of the calculation with input data in green, estimated inputs in yellow.

### Overall Analysis Approach

The residential and commercial sectors have been the primary focus of detailed electricity forecasts and energy efficiency market research and potential studies for many years. This level of data resolution allowed a bottom-up modeling approach for these two sectors. By contrast, the industrial sector provides much less data resolution, due largely to the diverse array of highly specialized processes that take place in industrial facilities. Because of its unique character, the industrial sector was modeled using a top-down analysis of the data available through AEO2012 and other sources. Energy savings in the industrial model are calculated at the process level in each NAICS segment using model output from the EIA's PEP[21] model. These energy savings are then applied within each NAICS segment at the process level.

### Developing Forecasts of Energy Efficiency Potential

Using the stock model described above that is based on the AEO2012, 2009 RECS, 2003 CBECS, and the 2010 MECS, EPRI calculates four levels of energy efficiency potential described below. EPRI's efficiency measure data is used as inputs for technical and economic potential screening. The measure data for the residential and commercial sectors includes incremental cost for the measure, and incremental energy and demand savings relative to the base level in each year. The base level of technology or measure is updated as needed over the forecast period to reflect changes in building energy codes and appliance and equipment standards. The measure data was developed based primarily on input from EPRI's technology subject matter experts. Commercial and residential building modeling was used to estimate energy and demand impacts for weather-dependent end uses to reflect the impacts of local

[21] Plant Energy Profiler, U.S. DOE, released Nov. 10, 2011. Available: https://ecenter.ee.doe.gov/EM/tools/Pages/ePEP.aspx

climate. EPRI's experts expanded the data to capture the latest technologies available to customers and vet existing technology savings and cost data. The measure databases are available in the Appendices of the 2014 National Study.

The AEO2012 Reference case baseline forecast used in the 2014 National Study and in this update to the study reflect macroeconomic drivers including U.S. population, employment, Gross Domestic Product (GDP), value of shipments, housing starts, and building construction. By 2035, electricity use is expected to increase to 4,393 TWh, an 18% increase over use in 2012. This Reference case forecast includes expected savings from several efficiency drivers including:

- Codes and Standards
    - Federal, state, and local building energy codes already enacted
    - Appliance and equipment standards already enacted; this includes the Energy Independence and Security Act of 2007, which, among its features, mandates higher lighting efficiency standards
- Market-Driven and Naturally Occurring Efficiency
    - Trends in customer purchases of energy-efficient equipment attributable to market-driven effects outside of utility programs
    - Other possible related effects, including structural changes in the economy that impact overall electric energy intensity
- Implicit Programs
    - An estimate of the utility-based energy efficiency programs adopted prior to 2012, and an estimate of the impact of these existing programs

The estimated impact of energy efficiency programs "embedded" in the AEO2012 Reference case was "added back" to construct an adjusted "baseline" forecast, in accordance with standard industry practice. This baseline represents a projection of electricity consumption absent of any assumed impact of naturally occurring efficiency and energy efficiency programs. The baseline forecast does not assume any expected savings from future federal or state appliance and equipment standards or building codes not enacted at the time of the AEO2012. Section 3 further describes the baselines used in EPRI's models.

Throughout the forecast period the energy consumption for newly installed equipment is reduced as new products conform to the requirements of previously legislated codes and standards. To estimate the impacts of these codes and standards in the residential and commercial sectors, a scenario was run in which the energy consumption of new products was frozen at 2012 levels throughout the forecast horizon. In the residential sector the end-use UECs in kilowatt-hours per year were held constant; and in the commercial sector the EUIs in kilowatt-hours per square foot were held constant. The difference between newly installed stock with 2012 energy consumption vs. evolving consumption over time reflects the impact of current codes and standards in the residential and commercial baselines. This case of the electricity forecast "but for the impact of existing codes and standards" is depicted as the top line in Figure A-4, shown with the AEO2012 Reference case, and the adjusted baseline from which potential is calculated in EPRI's model.

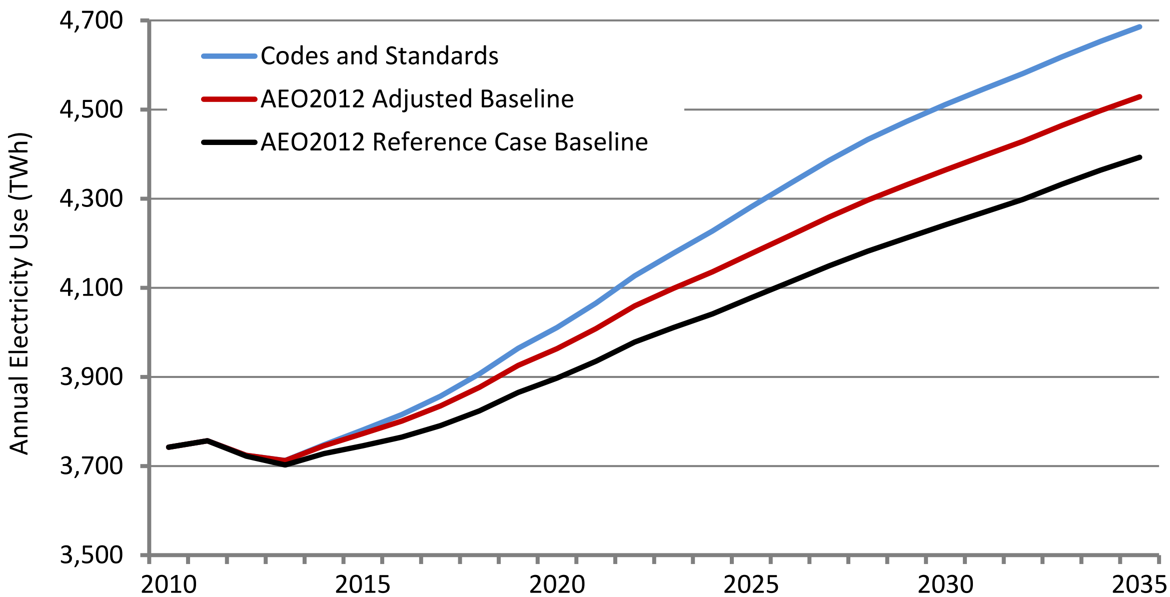



**Figure A-4**
**Estimated Impact of Energy Efficiency Drivers Inherent in AEO2012 Reference Case**

### *Technical Potential*

The technical potential represents the savings due to energy efficiency and programs that would result if all homes and businesses adopted the most efficient, commercially available technologies and measures, *regardless of cost*. Replacement of existing equipment in the residential and commercial sectors is assumed to occur at the end of their useful lives by the most efficient option available. Technical potential does not take into account the cost-effectiveness of the measures, or any market barriers.

### *Economic Potential*

The economic potential represents the savings due to programs that would result if all homes and businesses adopted the most energy efficient cost-effective commercially available measures. The economic test applied is a variation of the Total Resource Cost test (TRC), which compares projected avoided costs to the incremental cost of the measure plus program administration costs. Program administration costs are assumed to be 20 percent of the incremental cost to the participant.

With the efficiency measure inputs and avoided costs, the TRC benefit-cost ratio is calculated over the life of the measure. The ratio compares the present worth of the avoided power supply costs to the utility, to the incremental measure cost. The incremental measure cost includes both the incremental cost to the customer plus the energy efficiency program administration cost (20% of the incremental cost), as shown in the following equation.

$$\frac{\sum_{i=1}^{t}\left(\frac{AvoidedPowerSupplyCosts_i}{(1+r)^i}\right)}{1.2 * IncrementalMeasureCost}$$

Where:

$i$ = year in which costs or savings are incurred

$t$ = life of measure

$r$ = discount rate (real discount rate, varies by cost test and sector)

Economic potential does not take into account market barriers to adoption. Within a measure category, if several measures pass with a benefit-cost ratio greater than or equal to 1.0, the most efficient measure (greatest energy savings) is adopted.

In the scenarios with incentives included in the economic screen, the societal cost test is used, the incentives are assumed to be applied at a state or regional level. This is a modification of the TRC presented here, where the incentive in dollars per megawatt-hour is multiplied by a measure's energy savings, and is then subtracted from the measure costs in the denominator. This lowers the costs and increases the benefit-cost ratio for each measure. The impacts of including incentives in the economic screen are discussed further in Section 4.

### High Achievable Potential

The high achievable potential takes into account those barriers that limit customer participation. These barriers can include perceived or real quality differences, aesthetics, customer inertia, or customer preferences for product attributes other than energy efficiency. High achievable potential is estimated by applying market acceptance ratios (MARs) to scale the economic potential savings from each measure in each year.

The MARs, determined by a heuristic panel approach and described in the 2014 report, capture the effects of market barriers which at a high level include transactional, informational, behavioral, and financial barriers. The MARs can also be thought of as representing what exemplary energy efficiency programs have achieved, assuming that they have overcome market barriers to some extent. This level of potential is the focus of this study and allocated to states based on historical levels of achieved energy efficiency.

### Achievable Potential

Unlike the other potential estimates, the achievable potential represents a forecast of likely customer adoption. It takes into account existing market delivery, financial, political and regulatory barriers that are likely to limit the amount of savings that might be achieved through energy-efficiency programs. For example, utilities do not have unlimited budgets for program implementation. There can be regional differences in attitudes toward energy efficiency and its value as a resource. Achievable potential is calculated by applying a program implementation factor (PIF) to the high achievable potential for each measure to reflect recent utility experience with such programs and their reported savings. These factors also change over time to reflect that programs may be able to achieve increased savings as programs mature. The achievable potential can be thought of as the level of potential achieved by newer efficiency programs.

Further details on these calculations and assumptions can be found in the 2014 report.

# B
# APPENDIX B – UPDATES FROM AEO2012

Although the bulk of the models and assumptions used for EPRI's 2014 National Study[22] (described in Appendix A) remained unchanged for this work, this analysis makes several key updates, including an update to the avoided costs used in performing the total resource cost test (TRC), and changing the base year for the simulation from 2012 to 2016 (2017 is the first year with energy savings), and running scenarios with societal incentives. Technology assumptions (energy savings and associated equipment costs) and baseline forecasts remain unchanged. While changes have occurred relative to the AEO2012 baseline used in the 2014 study, updating the all inputs was beyond the scope of this project. The current assumptions are unbiased and consistent and a full update is planned for 2017 or 2018. A comparison of the most recent AEO, AEO2016, to the AEO2012 Reference case is provided for context.

As in the 2014 study, an adjusted AEO2012 baseline is used as a point of comparison in the current study for calculated energy savings potential. The adjusted baseline is based on the AEO2012 Reference case—electricity sales that reflect naturally occurring and existing levels of programmatic energy efficiency—with an estimate of existing levels of energy efficiency added back in for the purposes of EPRI's study. EPRI's estimates of savings potential are based primarily on available efficient technologies and cost-effective efficiency options applied to existing equipment stocks. EPRI's estimated potential savings then captures both naturally occurring and existing programmatic efficiency—assuming that there is always some level of early adoption of efficient technologies not due to efficiency programs, cost savings potential, or required by codes and standards (naturally occurring efficiency), as well as efficiency programs promoting adoption of cost-effective technologies. To account for this existing efficiency (naturally occurring and programmatic) which is included in EPRI's potential estimates, EPRI's savings potential is then compared to the adjusted AEO2012 baseline. The AEO2012 Reference case and adjusted baselines are illustrated with estimates of potential in Section 3.

A key driver for the economic potential when screening using the TRC are avoided utility costs for energy as well as capacity. To better reflect current resource availability, generation mix, and projected capacity needs on a regional basis, the avoided energy, and avoided generation and transmission capacity cost forecasts have been updated for this study to use current projections. The following are key updates to the avoided cost forecasts (at the source):

- Avoided energy forecasts for 2015 to 2050 are Census division-level prices, REGEN[23,24] Wholesale Reference Electricity Prices from a reference run from a recent REGEN model

---

[22] *U.S. Energy Efficiency Potential through 2035*. EPRI, Palo Alto, CA: 2014. 1025477. http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001025477

[23] *Program on Technology Innovation: US-REGEN Model Documentation 2014*. EPRI, Palo Alto, CA: 2014. 3002004693.

[24] Wholesale Reference Electricity Prices REGEN, provided Oct. 12, 2016 These come from a "reference" run from a recent model inter-comparison project that assumes all current policies (including the Clean Power Plan with mass-based trading) and fuel prices per the AEO2016 reference.

run that assumes all current policies (including the Clean Power Plan with mass-based trading) and fuel prices per the AEO2016 reference. Avoided costs are shown in Appendix 3.

- Used division-level building modeling to apply seasonal on- and off-peak variation to annual avoided energy values.
- Avoided generation capacity cost of $72.94/kW-yr for 2016 based on independent power producer (IPP) cost to install an LM100PA Simple Cycle Combustion turbine; split 80% summer, and 20% winter.
- No change to the avoided transmission capacity cost of $30/kW-yr; 50% summer, and 50% winter.
- An annual escalation rate of 1.2% has been applied to generation and transmission capacity costs.
- Loss factors and generation reserve rates have been applied to these cost forecasts at the sector level for avoided costs at the meter.

A case without incentives using the TRC reflects base case economic potential. Four additional cases have been run including a customer incentive of $5/MWh, $10/MWh, $15/MWh, and $20/MWh for energy savings, using the societal cost test. These incentives are assumed to come as an external incentive, as opposed to incentives from a utility or program administrator which would be a transfer payment from ratepayers to program participants.

## Comparing the AEO2012 to the AEO2016

Each year the U.S. DOE EIA releases an updated AEO, with major updates now made every other year starting in 2015, and minor updates in between. These annual updates to the Reference case reflect new legislation or regulations enacted since that time or to incorporate modeling changes and data updates. Input data or supply and demand models are also updated for relevant segments as updated survey data becomes available or to reflect changes in feedstock prices and availability. This includes updated Census data, and new releases of the EIA's residential, commercial buildings, and manufacturing energy consumption surveys (RECS, CBECS, and MECS respectively).

A comparison of the Reference case annual electricity use forecasts for the residential, commercial, and industrial sectors is illustrated in Figure A-2. The AEO2016 has reduced electricity consumption in these sectors due in part to changes to building efficiency standards, and changes in production and energy use in key manufacturing segments. The reduction in energy consumption estimates in the AEO2016 compared to the AEO2012 would likely result in lower potential for energy efficiency overall, particularly where the reduced forecast is related to building energy codes and appliance and equipment efficiency standards, which would result in lower energy savings potential for space conditioning measures.

This analysis makes several key updates with impacts on energy consumption between the AEO2012 and the AEO2016 References cases. Beginning in 2015 there was a change to the AEO release cycle, with a major update released only every other year. The 2015 is the first year where a shorter edition of the AEO was released with a limited number of model updates. Therefore, changes from the AEO2014 and AEO2015 are not summarized here.

Notes on changes between the AEO2016 and AEO2017 are included as well, although there is a significant difference in the demand forecasts compared to previous versions of the AEO, and in the underlying assumptions in EPRI's efficiency models.

Changes to the aggregate demand forecasts, AEO 2014, 2016 or 2017, make it difficult to speculate about the impact on efficiency potential. This is because it depends upon the source of the changes. The source of these changes could be the result of changing energy intensities, changes in the appliance stock and its age, changes in incremental equipment costs, changes in load shapes, codes and standards and the availability of new technologies. Any of these inputs could produce variations in the energy efficiency potential at the state level. To fully capture the combined impacts of a change in aggregate demand forecast really requires an update to the U.S. Potential Study.

Notable changes from the AEO2016 to AEO2017:

> "California state law SB-32, which was passed in 2016, requires statewide greenhouse gas emissions to be 40% below the 1990 level by 2030. This law has cross-cutting effects in California, particularly on electricity and transportation emissions, and also has national implications because of the size of California's energy market.
>
> Data from the 2012 Commercial Buildings Energy Consumption Survey (CBECS) were released in 2016, leading to revised estimates of commercial building mix and energy consumption.
>
> AEO2017 projections include higher time-of-day and seasonal resolution of both utility-scale and distributed solar output as compared to AEO2016, as well as higher geographic resolution (at the ZIP code level) of distributed solar. The net result of these model changes is to reduce projected utility-scale solar generation and increase distributed solar generation, although not to the same degree.
>
> AEO2017 is based on the latest Commercial Buildings Energy Consumption Survey (CBECS), which was released during 2015 and 2016 and is the first update to be included in the AEO since AEO2007. The sample of buildings surveyed was drawn from the set of commercial buildings as of 2012.
>
> Across most cases, natural gas production increases despite relatively low and stable natural gas prices, supporting higher levels of domestic consumption and natural gas exports. Projections are sensitive to resource and technology assumptions"

Notable changes from the AEO2015 to AEO2016:

> "New buildings equipment standards promulgated since the AEO2015 Reference case was completed, including standards affecting commercial cooling equipment, commercial furnaces, residential boilers, commercial oil-fired water heaters, fluorescent lamps, commercial pumps, and commercial ice makers and beverage vending machines.

Cost and energy impacts of energy efficiency activities in support of the Clean Power Plan (CPP) through rebates for energy-efficient buildings end-use equipment, based on EIA analysis and a report by Leidos.

Updated cost assumptions associated with switching of fuels and/or technologies for residential end-use services and updated estimates for efficiency of the installed stock of residential end-use equipment, based on reports by Navigant Consulting, Inc. and Leidos.

Updated motors model in NEMS to reflect increased efficiency standards for motors." [25]

Notable changes from the AEO2013 to AEO2014:

"Updated costs and improved representation of residential lighting applications, including wider representation of light emitting diode (LED) lighting and outdoor lighting, based on the 2009 RECS and two U.S. Department of Energy (DOE) reports.

Revised handling of the regional efficiency standard for residential furnaces, based on an ongoing legal appeal of the standard. The regional standard scheduled to take effect in 2013 is not included in AEO2014 because of a court challenge and proposed settlement that would vacate the standard in question and require DOE to develop new standards for residential furnaces.

Revised commercial capacity factors governing annual usage of major end-use equipment, based on an EIA-contracted analysis.

Revised outlook for industrial production to reflect the effects of increased shale gas production and lower natural gas prices, resulting in faster growth for industrial production and energy consumption. The industries primarily affected include energy-intensive bulk chemicals and primary metals, both of which provide products used by the mining and other downstream industries, such as fabricated metals and machinery. The bulk chemicals industry is also a major user of natural gas and, increasingly, hydrocarbon gas liquid (HGL) feedstocks." [26]

Notable changes from the AEO2012 to AEO2013:

"A revised outlook for industrial production to reflect the impacts of increased shale gas production and lower natural gas prices, which result in faster growth for industrial production and energy consumption. The industries affected include, in particular, bulk chemicals and primary metals.

Incorporation of a new aluminum process flow model in the industrial sector, which allows for diffusion of technologies through choices made among known

[25] U.S. DOE EIA, Changes from Annual Energy Outlook 2015. [Online]. Available: http://www.eia.gov/outlooks/aeo/chapter_changes.cfm.

[26] U.S. DOE EIA, Changes from Annual Energy Outlook 2013. [Online]. Available: http://www.eia.gov/outlooks/archive/aeo14/chapter_changes.cfm.

commercial and emerging technologies based on relative capital costs and fuel expenditures and provides for a more realistic representation of the evolution of energy consumption than in previous AEOs.

Updated handling of the EPA's National Emissions Standards for Hazardous Air Pollutants for industrial boilers and process heaters to address the maximum degree of emissions reduction using maximum achievable control technology.

Modeling of California's AB32, that allows for representation of a cap-and-trade program developed as part of California's GHG reduction goals for 2020. AEO2013 reflects all covered sectors, including emissions offsets and allowance allocations." [27]

---

[27] U.S. DOE EIA, Changes from Previous AEO. [Online]. Available: http://www.eia.gov/outlooks/archive/aeo13/chapter_changes.cfm.

# C
# APPENDIX C – AVOIDED COSTS

This section documents the avoided costs used in the evaluation of the measures in the calculation of the economic and high achievable potentials.

There are primarily three components to the avoided cost calculation – generation capacity costs measured in $/peak or coincident kW, energy costs ($/MWh) and transmission costs $/peak-kW. Each of these avoided costs are applied to the load shapes produced by efficiency measures (decremental load shapes) and summed over the course of a year. The result is a dollar savings produced by the installation of the measures that can be used to offset other implementation costs.

Generation capacity costs are the costs associated with providing sufficient capacity to meet peak demands. Generally the least cost value of capacity is used which is normally a simple combustion turbine. Energy costs reflect the fuel used to generate the electrical energy and transmission costs reflect the delivery cost through the transmission system to deliver the power to its ultimate customers.  Transmission costs often also require additional ancillary services to be purchased when moving power from power plant to retail loads. For this analysis EPRI used a value of $30/kW for transmission.

There are several additional adjustments to these costs. These reflect the losses on the system when transmitting energy (kWh) from busbar to meter. These vary by season. They also vary by voltage level or more often by customer class.

There are also peak demands (kW) losses that vary by season. These losses usually occur at a single point of time when the system peak occurs. These typically occur on hot summer weekday afternoons for summer peaking utilities or cold early mornings for winter peaking utilities. For dual peaking utilities these two system peaks occur – summer and winter, and capacity to meet those peaks is allocated between those two periods.

Utilities also reserve aa certain amount of capacity to cover unexpected outages at peak times. These are called reserve margins. So efficiency measures that produce reduced peak or coincident demand such as efficiency air conditioning produce even larger savings due to eh reserve margin benefit it produces.

Finally, regional differences in the cost of all of these components exist due to labor costs, land costs, regulatory costs etc. A regional estimate of these costs differences is used to approximate differences in regional avoided costs.

**Table C-1**
**Average Annual Wholesale Electricity Price ($/MWh)**

| **Annual Average Wholesale Electricity Price ($/MWh)** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2018 | 2021 | 2024 | 2027 | 2030 | 2035 | 2040 | 2045 | 2050 |
| **New England** | 35.43 | 33.26 | 37.65 | 43.80 | 46.80 | 53.967 | 49.41 | 49.69 | 49.36 | 50.83 |
| **New York** | 33.81 | 32.70 | 37.01 | 44.57 | 46.56 | 55.10 | 51.38 | 52.55 | 54.65 | 54.71 |
| **Mid Atlantic** | 30.93 | 31.10 | 34.88 | 41.54 | 45.59 | 55.44 | 50.65 | 51.15 | 51.54 | 51.76 |
| **South Atlantic** | 35.69 | 36.60 | 40.28 | 47.81 | 49.94 | 56.65 | 50.43 | 50.60 | 50.86 | 51.30 |
| **Florida** | 64.10 | 69.66 | 44.32 | 50.19 | 51.01 | 57.62 | 50.12 | 50.34 | 51.36 | 53.07 |
| **NE-Central-R** | 29.46 | 30.30 | 33.51 | 40.46 | 46.48 | 56.38 | 50.18 | 50.65 | 50.91 | 51.58 |
| **NE-Central-D** | 27.49 | 30.73 | 34.61 | 42.11 | 47.80 | 57.83 | 50.01 | 50.99 | 51.12 | 51.66 |
| **SE-Central** | 32.32 | 33.13 | 36.52 | 43.86 | 48.24 | 56.92 | 51.21 | 51.40 | 51.80 | 52.60 |
| **NW-Central** | 25.37 | 27.30 | 31.42 | 39.01 | 46.36 | 56.09 | 49.50 | 49.78 | 50.19 | 49.96 |
| **SW-Central** | 27.29 | 27.99 | 31.59 | 37.82 | 43.41 | 51.54 | 47.88 | 48.52 | 47.91 | 47.42 |
| **Texas** | 23.58 | 23.02 | 27.18 | 34.19 | 41.81 | 52.45 | 44.15 | 44.77 | 45.40 | 45.28 |
| **Mountain-N** | 26.75 | 28.36 | 29.55 | 36.20 | 42.42 | 52.30 | 45.24 | 46.59 | 46.73 | 46.34 |
| **Mountain-S** | 30.94 | 32.89 | 33.94 | 37.62 | 44.29 | 53.42 | 48.42 | 50.67 | 52.31 | 52.97 |
| **Pacific** | 30.23 | 32.20 | 34.19 | 40.04 | 46.27 | 54.45 | 49.27 | 49.71 | 51.62 | 52.32 |
| **California** | 36.34 | 41.09 | 39.16 | 42.81 | 50.09 | 60.97 | 50.92 | 50.97 | 53.72 | 55.05 |

Source: EPRI REGEN reference electricity prices, October 2016.

**Table C-2**
**Least Cost Capacity Costs**

| | **Average Simple Cycle CT Capacity Costs ($2016/kW-year to meet system peak demands)** | **Reliability Allocations** |
|---|---|---|
| **Annual** | $ 72.94 | 1 |
| **Summer** | $ 58.35 | 0.8 |
| **Winter** | $ 14.59 | 0.2 |

Source: Based on IPP cost to install GE LM100PA Simple Cycle Combustion turbine w/o land.

**Table C-3**
**Avoided Cost Adjustments**

| | Summer | Winter |
|---|---|---|
| Applicable Generation Capacity Reserve Margin: | 15% | 15% |

| | Res | Com | Ind |
|---|---|---|---|
| Demand Line (Peak) Loss Factors: | 15.0% | 12.0% | 7.5% |
| Energy Line Loss Factors: | 12.0% | 7.5% | 5.0% |

**The Electric Power Research Institute, Inc.** (EPRI, www.epri.com) conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public. An independent, nonprofit organization, EPRI brings together its scientists and engineers as well as experts from academia and industry to help address challenges in electricity, including reliability, efficiency, affordability, health, safety and the environment. EPRI members represent 90% of the electric utility revenue in the United States with international participation in 35 countries. EPRI's principal offices and laboratories are located in Palo Alto, Calif.; Charlotte, N.C.; Knoxville, Tenn.; and Lenox, Mass.

Together…Shaping the Future of Electricity



3002009988

**Electric Power Research Institute**
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com