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U.S. Energy Efficiency Potential Through 2035

Executive Summary

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Abstract

This report summarizes the results of EPRI's analysis of U.S. Energy Efficiency Potential through 2035. The achievable potential represents an estimated range of savings attainable through programs that encourage adoption of energy-efficient technologies, taking into consideration technical, economic, and market constraints. The study's objective is to provide an independent, technically grounded estimate of the potential for electricity energy savings and peak demand reduction from energy efficiency programs through 2035 that can help inform decisions of both policy makers and electric utilities.

The U.S. Energy Information Administration in its 2012 Annual Energy Outlook projects that electricity consumption in the U.S. residential, commercial, and industrial sectors will grow at an annual rate of 0.72% from 2012 through 2035. Energy efficiency programs have the potential to realistically reduce this growth rate to 0.36% per year from 2012 through 2035. Under an ideal set of conditions conducive to energy efficiency programs, this growth rate can be reduced to as low as 0.20% per year. The estimated cost of implementing programs to achieve realistic potential savings ranges from $8 billion in 2015, growing to $30 billion by 2025, and to $80 billion by 2035. This study is intended to inform utilities, policymakers, regulators, and other stakeholder groups.

Keywords
Energy efficiency potential
Demand-side management (DSM)
Market barriers
Codes and standards
Utility economic perspectives

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Section 1: Executive Summary

Electricity plays an integral role in supporting the standard of living to which Americans have grown accustom, enabling comfort, convenience, health and safety, security, and productivity in its traditional end-use applications, including air conditioning, lighting, refrigeration, and motive power. Moreover, the computational and communications infrastructure associated with our digital economy depends on electricity – from powering data centers to charging ever-proliferating mobile electronic devices.

Understanding growth in demand is key for electric service providers at all levels as they plan resources to meet customers' needs while maintaining reliable operation of the power system. The challenge to provide affordable, reliable and environmentally responsible electricity encourages providers 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 2009 the Electric Power Research Institute commissioned a study to assess the potential energy savings achievable through energy efficiency and demand response programs in the U.S. from 2010 through 2030. This study updates the 2009 assessment with several modifications to the modeling engine, treatment of end-uses, and an enhancement to reflect the U.S. Energy Information Administration's 2012 Annual Energy Outlook (*AEO2012*) baseline. A key objective of the study is to inform utilities, electric system operators and planners, policymakers, and other electricity sector industry stakeholders in their efforts to develop actionable savings estimates for end-use energy efficiency programs. The majority of the effort focused on the identification of cost-effective energy efficiency and assessment of the impacts of application of cost-effective efficiency measures beginning in 2013 through 2035. In addition to savings from energy efficiency programs, this report presents high-level impacts from the substitution of highly efficient electric technologies for fossil fueled end-uses to provide for a holistic view of the combined impact of energy-efficient electrification.

Key Findings

Electricity Consumption

According to the *AEO2012* Reference case baseline forecast, U.S. electricity consumption in 2012 of 3,722 TWh is projected to increase to 4,393 TWh in 2035, for an average annual growth of 0.72% per year. This outlook is significantly lower load growth than was evidenced over the past 30 years of 1.9% annual load growth. The *AEO2012* Reference case is predicated on a relatively flat electricity price forecast in real dollars between 2012 and 2035, suggesting slow growth in demand in the electric sector. Despite this lower load growth outlook, this study shows that energy efficiency remains a significant resource.

The *AEO2012* Reference case includes the impacts of market-driven efficiency improvements such as ENERGY STAR® labeling, the impacts of all currently legislated federal appliance standards and building codes (including the Energy Independence and Security Act of 2007) and rulemaking procedures such as California's Title 20.

The *AEO2012* also assumes continued contributions of existing utility- and government- sponsored energy efficiency programs established prior to 2012. The savings impact of energy efficiency programs "embedded" in the *AEO2012* Reference case is estimated in Section 2 of the report. Removing this estimate of embedded savings from the *AEO2012* Reference case results in an adjusted baseline forecast that is higher; this adjusted baseline is used throughout this report.

EPRI estimates that energy efficiency programs have the potential to reduce electricity consumption in 2035 by 488 to 630 billion kWh. This represents a range of achievable potential reduction in electricity consumption in 2035 – from a "moderate case" or *achievable potential* of 11% to a "high case" or *high achievable potential* of 14%.[1,2] Relative to the *AEO2012* Reference case, which implicitly assumes some level of energy efficiency program impact, this study identifies between 352 and 494 billion kWh of *additional cost-effective savings potential* from energy efficiency programs.

Therefore, energy efficiency programs have the potential to reduce the 0.72% annual *growth rate* in electricity consumption forecasted in the *AEO2012* Reference case between 2012 and 2035 by 51% to 72%, to an annual growth rate of 0.36% to 0.20%.

These estimated levels of electricity savings are achievable through voluntary energy efficiency programs implemented by utilities or similar entities. Our analysis does not assume the enactment of new energy codes and efficiency standards beyond what is already in law. More progressive codes and standards would yield even greater levels of electricity savings.

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[1] The values for achievable and high achievable potentials in 2035 measured with respect to the baseline forecast described in footnote 3 (and detailed in Section 2) are 488 and 630 billion kWh, respectively, or 11 to 14%. These values represent the total savings impact of cost-effective energy efficiency programs in 2035 inclusive of savings embedded in the *AEO2012* Reference case.

[2] Achievable potential (AP) can be thought of as a "moderate case" for the savings impact of energy efficiency programs; high achievable potential (HAP) can be thought of as a "high case" for the savings impact of energy efficiency programs. Though the terms may be used interchangeably, the nomenclature of AP and HAP are used throughout this report.

Peak Demand

Summer coincident peak demand in the U.S., is projected to be 595 GW in 2012, and is expected to increase to 714 GW by 2035, reflecting 0.8% compound annual growth.

Energy efficiency programs have the potential to reduce coincident summer peak demand by 79 to 117 GW. This represents a range of achievable potential reduction in 2035 summer peak demand of 11% to 16%. This can also be expressed as a 65% to 98% reduction in the forecasted *annual growth rate* of summer peak demand through 2035.

Winter coincident peak demand in the U.S., is projected to be 495 GW in 2012, and is expected to increase to 628 GW by 2035, reflecting 1.03% compound annual growth. Winter peak demand is expected to grow at a faster annual rate than electricity use due partly to the expected growth in the share of electric water heating.

Energy efficiency programs have the potential to reduce coincident winter peak demand by 64 to 89 GW. This represents a range of achievable potential reduction in winter peak demand in 2035 of 10% to 14%. This can also be expressed as a 45% to 65% reduction in the forecasted *annual growth rate* of winter peak demand through 2035.

These estimated levels of peak demand reduction are achievable through voluntary energy efficiency programs implemented by utilities or similar entities. Our analysis does not assume the enactment of new energy codes and efficiency standards beyond what is already in law. More progressive codes and standards would yield even greater levels of peak demand reduction.

Analysis Approach

This study implemented an analysis approach consistent with the methods described in EPRI's Energy Efficiency Planning Guidebook,[3] (as depicted in steps 1 through 5 of Figure 1-1), and the National Action Plan for Energy Efficiency (NAPEE) Guide for Conducting Energy Efficiency Potential Studies[4].

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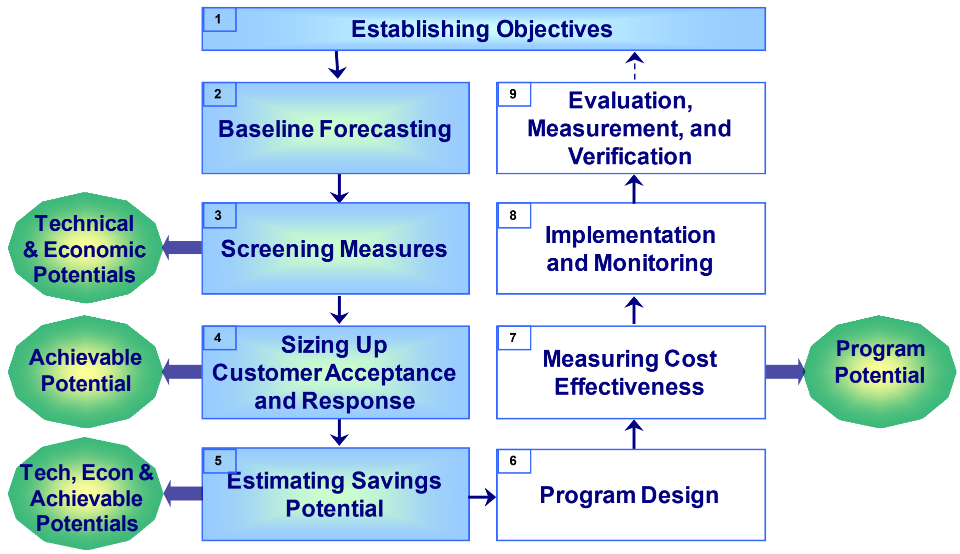
[3] *Energy Efficiency Planning Guidebook.* EPRI, Palo Alto, CA: 2008. 1016273.

[4] P. Mosenthal and J. Loiter, "Guide for Conducting Energy Efficiency Potential Studies," U.S. EPA, Arlington, VA, 2007.



Source: Energy Efficiency Planning Guidebook, EPRI 1016273, June 2008

Figure 1-1
General Energy Efficiency Analysis Framework

Defining Potential

The primary focus of this study was to develop a range of energy efficiency potentials. The approach for deriving *achievable potential* is predicated on first establishing the theoretical constructs of *technical potential* and *economic potential* and then discounting them to reflect market and institutional constraints. This study applies the condition that new equipment does not replace existing equipment instantaneously or prematurely, but rather is "phased-in" over time as existing equipment reaches the end of its useful life.

All categories of potentials in this study conform to this condition, and may be termed "phase-in" potentials.[5] The categories of potential employed in this study are described in the following.

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 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.

[5] For the purposes of this study, no "mid-life" replacements of existing equipment for more efficient equipment are assumed, even though in some instances such replacements may be economically justifiable. Consumers or firms that initiate such replacements could be considered predisposed to efficiency or conservation, and their actions may be grouped in the category or market-driven or "naturally-occurring" savings if they would occur independent of an energy efficiency program.

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. With the efficiency measure inputs and avoided costs, the Total Resource Cost test (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 incremental measure cost plus the energy efficiency program administration cost.

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.

The initial modeling outputs are a set of electricity and peak demand reduction values under the technical and economic potential cases. As described above, these potentials are the result of assumptions about the adoption of efficiency measures, whether through a stock accounting framework, a device saturation approach, or the application of savings values to the pertinent segments of the baseline. The next step is to obtain the achievable potentials through the introduction of market acceptance ratios and program implementation factors, which reflect known barriers to demand-side activities.

High Achievable Potential

The high achievable potential (HAP) 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. HAP is estimated by applying market acceptance ratios (MARs) to the economic potential savings from each measure in each year.

MARs capture the effects of market barriers which at a high level include transactional, informational, behavioral, and financial barriers. They are essentially scaling factors applied to the measure savings over time, and are defined in ten-year intervals and change over time (maximum of 100%) to reflect that market barriers are likely to decrease over time. 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.

Achievable Potential

Unlike the other potential estimates, the achievable potential (AP) represents a forecast of likely consumer 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. AP is calculated by applying a program implementation factor (PIF) to the HAP for each measure. The program implementation factors were developed by taking into account 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 Starting Point: Base-Year Electricity Use by Sector and End Use

Based on the *AEO2012* baseline, annual electricity use for the U.S. is estimated at 3,724 TWh. This represents 11.8 MWh per capita and 0.28 kWh per dollar of Gross Domestic Product in 2012. The allocation of U.S. electricity use across sectors is fairly even, where the residential sector accounts for 38%, the commercial sector accounts for 36%, and the industrial sector uses 26%.

Overall, other uses accounts for 22% of consumption across all three sectors. Lighting and heating, air conditioning and ventilation (HVAC) are major categories in both residential and commercial. This is the top end-use category in industrial, grouped under "industrial facilities" which includes HVAC, lighting and other non-process consumption. The complete breakout of 2012 consumption in each sector by end use is shown in Figure 1-2.

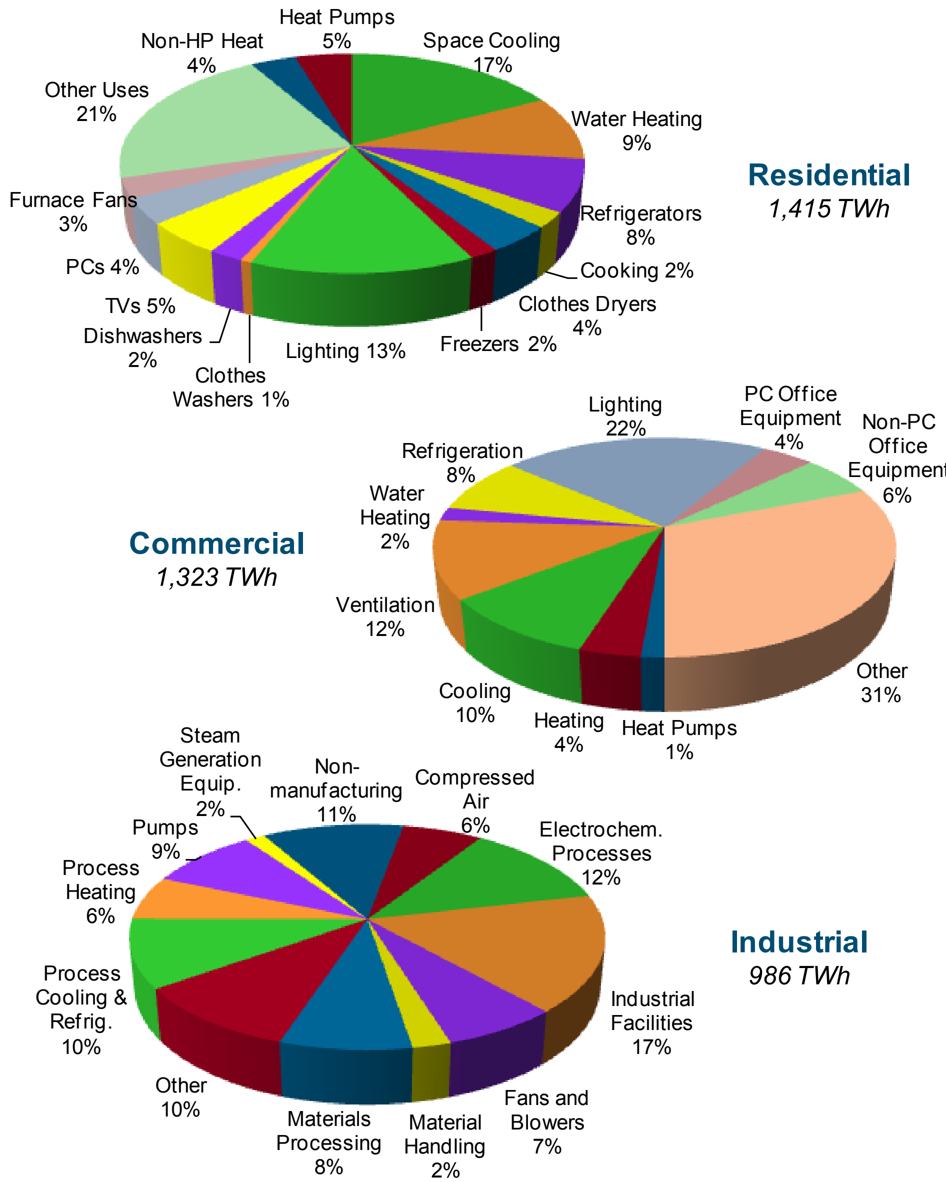


Figure 1-2

2012 U.S. Electricity Consumption by Sector and End Use[6]

The Baseline Forecast

Our nation's usage of electricity to power homes, buildings, industrial facilities and public areas is expected to increase by 18% between 2012 and 2035, according to the *AEO2012* Reference case baseline.[7] The projected annual growth rate for the residential, commercial and industrial sectors is forecast to be

[6] These values represent the total electricity consumption in 2012 inclusive of savings embedded in the *AEO2012* Reference case.

[7] "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

0.72% between 2012 and 2035, as illustrated in Figure 1-3. Although steady growth is predicted, the AEO forecast of growth in electricity consumption has been declining year over year accounting for shifts in the economy, energy prices, and technology innovation among other things.

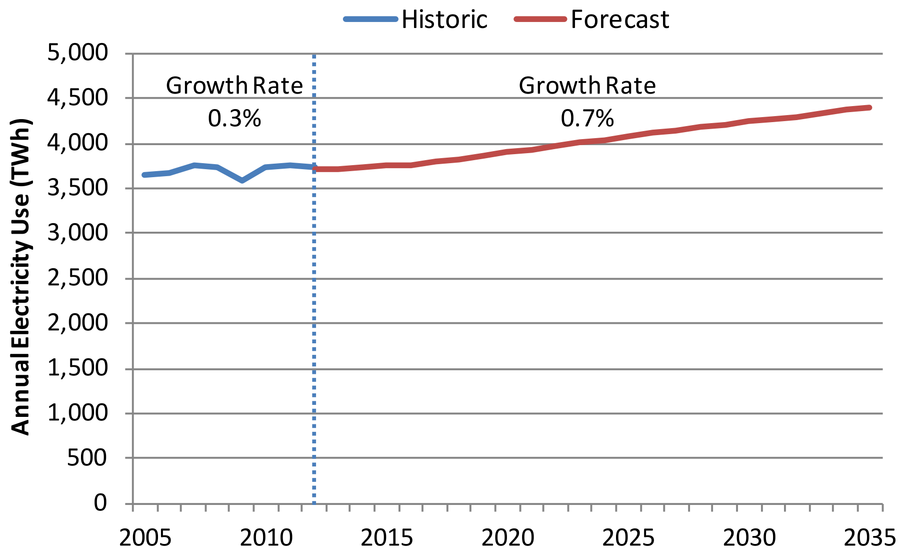


Figure 1-3
AEO2012 Reference Case Electricity Consumption Forecast

The macroeconomic drivers of the AEO forecast include U.S. population, employment, Gross Domestic Product (GDP), value of shipments, housing starts, and building construction. Average growth in GDP between 2012 and 2035 is 2.6%, more than three times the rate of projected electricity growth. This implies a decline in the electricity intensity per GDP.

By 2035, electricity use is expected to increase to 4,393 TWh, a 18% increase over use in 2012. This Reference case forecast already includes expected savings from several efficiency drivers including:

- Codes and Standards
  - Federal, state, and local building efficiency 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
  - Other possible related effects, including structural changes in the economy that impact overall electric energy intensity
- Market-Driven Efficiency
  - Trends in customer purchases of energy-efficient equipment attributable to market-driven effects outside of utility programs
- 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

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, the project team ran a scenario in which the energy consumption of new products was frozen at 2012 levels throughout the forecast horizon. In the residential sector the end-use unit energy consumption (UEC) in kWh per year was held constant; and in the commercial sector the energy use intensity (EUI) in kWh per square foot was 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 1-4.

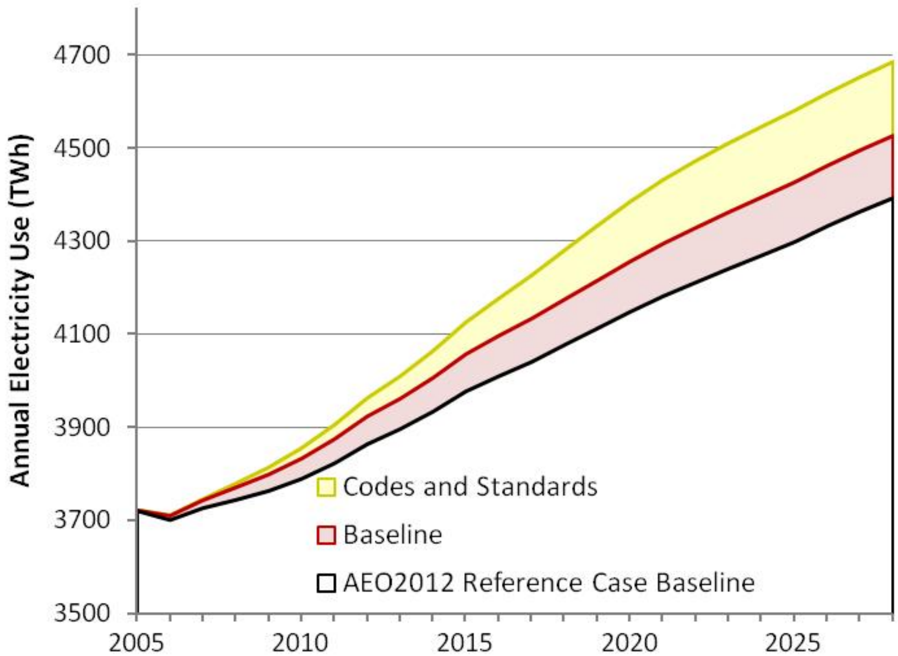


Figure 1-4
Estimated Impact of Energy Efficiency Drivers Inherent in AEO2012 Reference Case

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 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 currently enacted. Finally, the baseline embodies the *AEO2012* price forecast, which is relatively flat in real terms over the forecast horizon.

The Potential for Electricity Savings from Utility Programs

The analysis of potential savings from utility programs began with a list of energy efficiency measures. This list includes high-efficiency appliances and equipment for most end uses, many of which have numerous efficiency levels, devices, controls, maintenance actions, and enabling technologies such as programmable thermostats. Table 1-1 and Table 1-2 summarize the residential and commercial energy-efficiency measure categories included in the analysis.

No measures are applied per se in the industrial sector. Instead, the savings are applied top-down to process-level consumption within each manufacturing segment.

Table 1-1
Summary of Residential Efficiency Measure Categories

Residential Sector Measure Categories
Efficient air conditioning (central, room)
Efficient space heating and cooling (heat pumps)
Efficient water heating (e.g. heat pump water heaters & solar water heating)
Efficient appliances (refrigerators, freezers, washers, dryers)
Efficient lighting (CFL, LED, linear fluorescent)
Efficient power supplies for Information Technology and consumer electronic appliances
Air conditioning and heat pump maintenance
Duct repair and insulation
Infiltration control
Whole-house and ceiling fans
Reflective roof, storm doors, external shades
Roof, wall and foundation insulation
High-efficiency windows
Faucet aerators and low-flow showerheads
Pipe insulation
Programmable thermostats
In-home energy displays

Table 1-2
Summary of Commercial Efficiency Measure Categories

Commercial Sector Measure Categories
Efficient cooling equipment (chillers, central AC)
Efficient space heating and cooling equipment (heat pumps)
Efficient water heating equipment
Efficient refrigeration equipment & controls
Efficient lighting (interior and exterior)
Efficient power supplies for Information Technology and electronic office equipment
Water temperature reset
Efficient air handling and pumps
Economizers and energy management systems (EMS)
Programmable thermostats
Duct insulation

As described above, the full set of measures is included in the estimation of technical potential, while only the subset that passes the economic screen is included in economic and achievable potentials.

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

- Achievable Potential is 488 TWh, or an 11% reduction in projected consumption
- High Achievable Potential is 630 TWh, or an 14% reduction in projected consumption

Relative to the *AEO2012* Reference case, in 2035:

- Achievable Potential represents 352 TWh of *additional* energy efficiency savings, or a 8% reduction in projected consumption.
- High Achievable Potential represents 494 TWh of *additional* energy efficiency savings, or an 11% reduction in projected consumption.

These estimates suggest that energy efficiency programs can realistically reduce the annual growth rate of U.S. electricity consumption from 2012 to 2035 projected by the *AEO2012* Reference case by 51%, from 0.72% to 0.36%.

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

	***AEO2012* Reference Case**	**Baseline Forecast**	**Achievable Potential**	**High Achievable Potential**
Forecasts (TWh)				
2025	4,078	4,177	3,893	3,725
2035	4,393	4,529	4,041	3,898
Savings Relative to *AEO2012* Reference Case (TWh)				
2025	-	-	185	352
2035	-	-	352	494
Savings Relative to Baseline Forecast (TWh)				
2025	-	-	284	451
2035	-	-	488	630

Figure 1-5 illustrates this achievable savings potential.

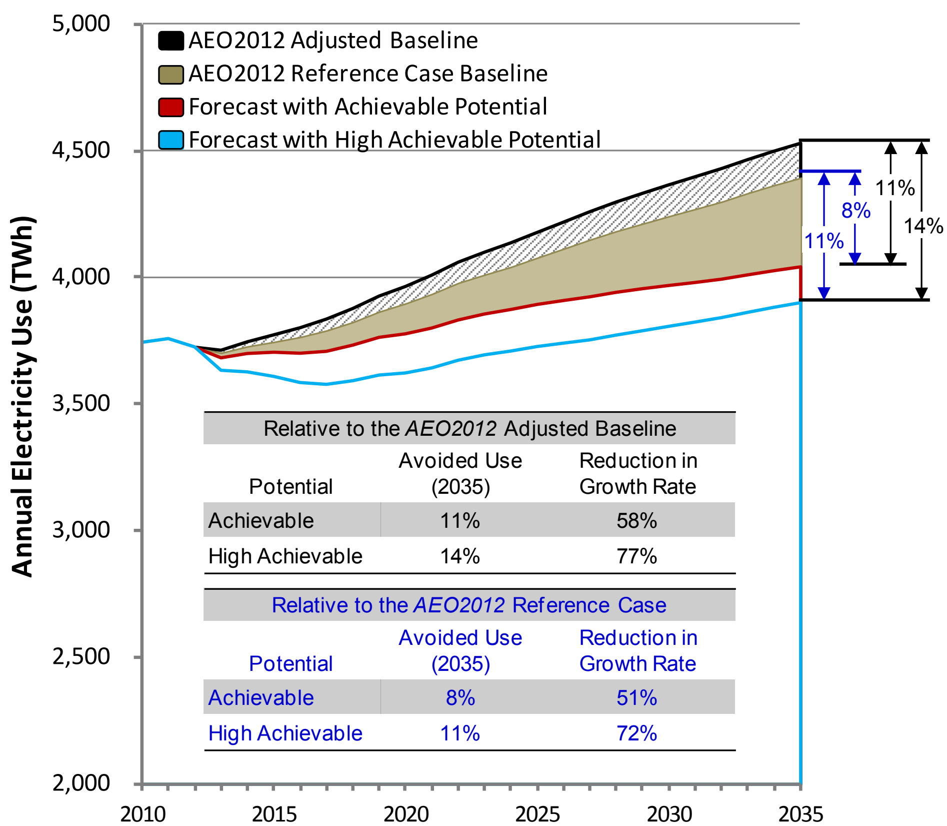


Figure 1-5
U.S. Energy Efficiency Achievable Potential

Although there are savings in a wide range of end uses in the residential, commercial and industrial sectors, Figure 1-6 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 1-6, and 38% of the total achievable 2035 energy savings. Lighting opportunities are also captured under the heading of industrial facilities which includes HVAC, water heating and lighting for the industrial sector.

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

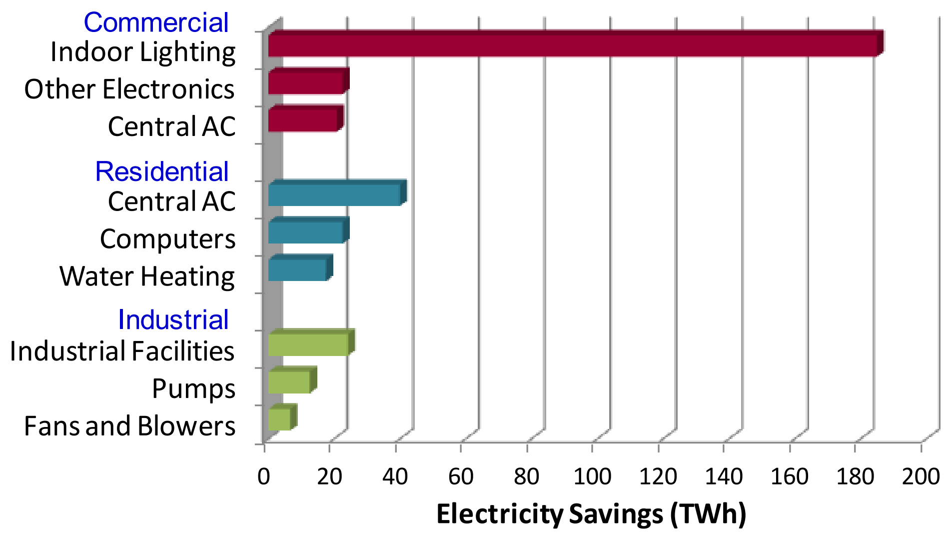


Figure 1-6
Top Three End Uses for Achievable Energy Savings, 2035

Water heating also presents the opportunity for significant savings in the residential sector for smaller units, with capacity less than 55 gallons.

The remaining heavy hitters have several common threads that will provide new opportunities for energy savings beyond what we expect to see today:

- Advanced motor technologies,
- New materials in batteries and electronics, and
- Advanced power management.

Figure 1-7 displays the individual measures with the highest potential for savings across all the sectors.

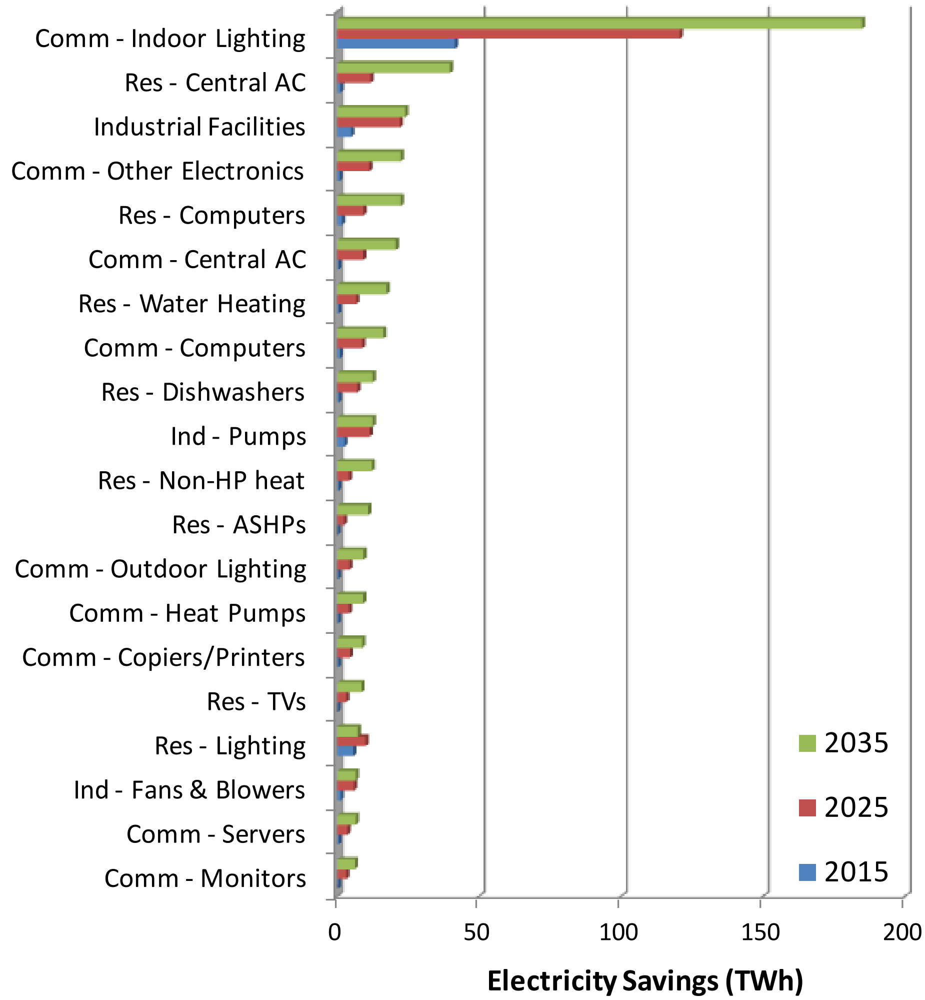


Figure 1-7
Top Twenty End Uses for Achievable Energy Savings, 2035

Energy Efficiency Savings Potential by U.S. Census Region

This study disaggregates electricity baseline consumption and potential energy efficiency savings by the ten U.S. Census divisions plus three large states (Florida, Texas and California) shown in Figure 1-8.

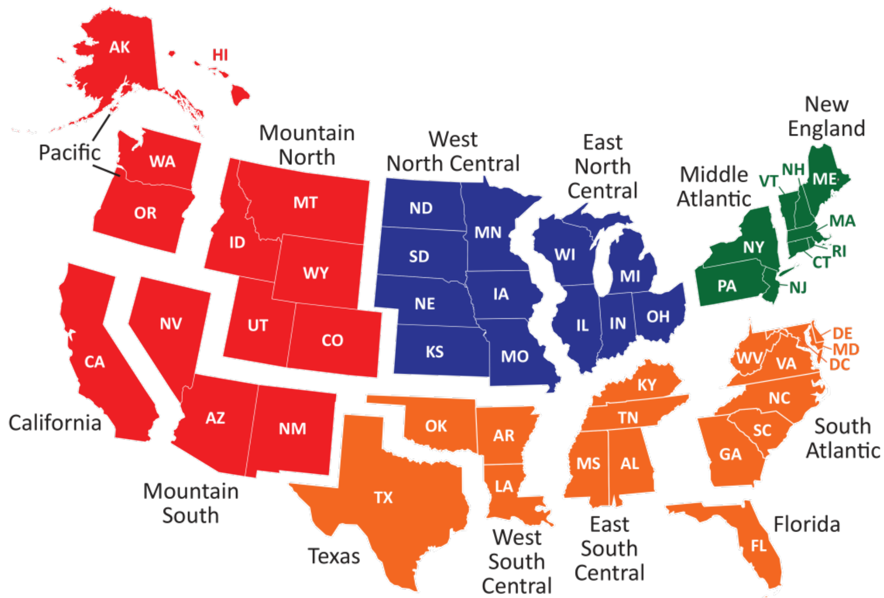


Figure 1-8
Geographic Divisions – Ten Census Divisions plus Three States

Figure 1-9 illustrates how the total U.S. 2035 achievable potential is broken out among the divisions.

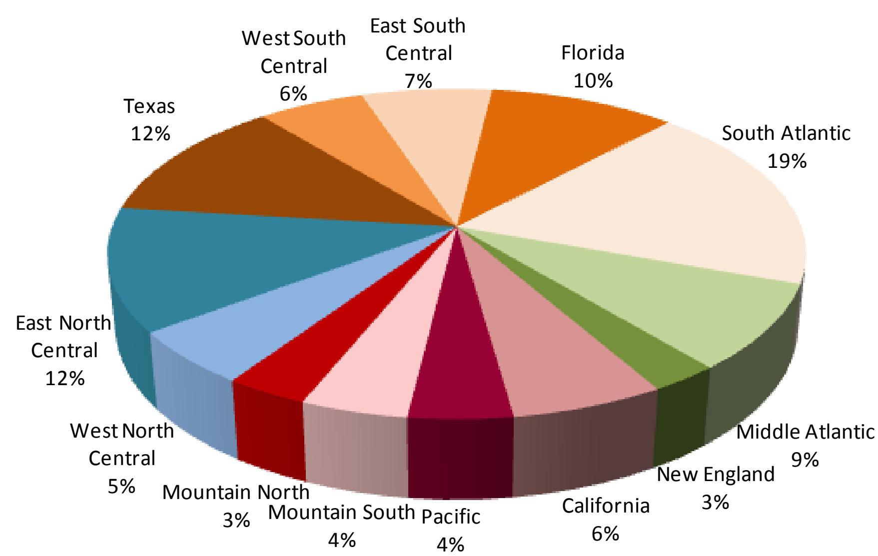


Figure 1-9
Division Shares of 2035 Achievable Potential

Key takeaways for achievable potential in the regions include:

- Electricity consumption is highest in the South, and is expected to grow at an annual rate of 1.1% through 2035. The South is also the region with the greatest potential for energy efficiency in absolute terms.
- Electricity consumption is lowest in the Northeast, with the smallest expected to growth rate of 0.2% through 2035. The Northeast's energy efficiency potential is the smallest of the four regions, although by share of total load it ranks third.
- The Midwest is the second largest region in terms of both current and forecasted growth, with an annual growth rate of 0.4%.
- Finally, the West is the region of most rapid forecasted growth at 1.2% per year, and has the third largest potential for energy efficiency in percentage terms.

Table 1-4 shows the absolute values for 2035 achievable potential by division and broken out by sector. In all cases the potential for savings is greatest in the commercial sector with indoor lighting providing top savings across the board.

Table 1-4
2035 Achievable Potential by Division and Sector

	Residential	Commercial	Industrial	Total
Northeast Census Region				
New England	2,795	9,359	1,321	13,475
Middle Atlantic	7,383	30,620	3,090	41,093
South Census Region				
South Atlantic	29,666	54,312	5,912	89,889
Florida	19,432	27,089	2,946	49,468
East South Central	11,749	15,282	7,639	34,670
West South Central	9,326	15,424	3,442	28,192
Texas	22,840	29,857	6,663	59,360
Midwest Census Region				
East North Central	8,625	40,488	9,602	58,715
West North Central	7,204	14,611	4,232	26,047
West Census Region				
Mountain North	3,664	10,258	2,235	16,158
Mountain South	6,016	12,180	2,654	20,850
Pacific	3,772	14,024	2,399	20,195
California	6,035	20,315	3,475	29,826

Figure 1-10 illustrates how the savings in each sector compares to the division's baseline consumption. Although the absolute savings vary among divisions, the savings as a percentage of the division's baseline range from 8% to 14%. In all but one Southern division the savings are the highest across all divisions, while in the Midwest divisions (East North Central and West North Central) the savings are below 10% of the baseline.

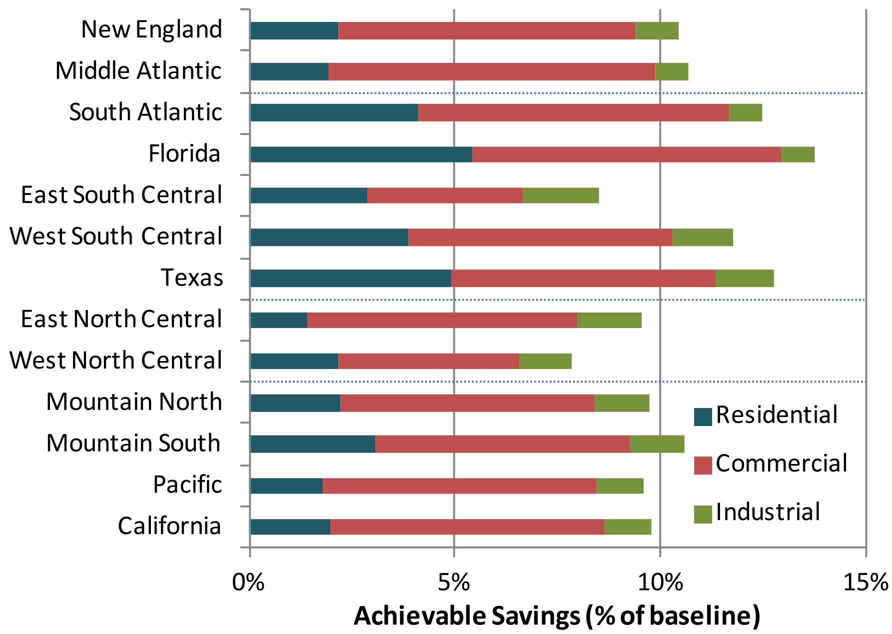


Figure 1-10
2035 Division-Level Achievable Potential as a Percentage of Division Baseline

Table 1-5 through Table 1-8 lend some insight into the differences between savings among the divisions. Commercial indoor lighting is top in all divisions, the other top saving end uses lend some insight into variations in end-use consumption amongst the divisions.

Table 1-5 shows the top three end uses for 2035 achievable potential for the Northeast divisions. Electronics, both miscellaneous electronics for commercial or residential computers present relatively high opportunities for savings compared to other end uses. It would be useful to better understand trends in electronics in the Northeast in the future to best understand how the potential for savings will change over time.

Table 1-5
Top Three End Uses for 2035 Achievable Potential, Northeast Census Region

Division	End Use	Savings (GWh)	% of Baseline
New England	Comm - Indoor Lighting	6,680	5.2%
	Res - Computers	882	0.7%
	Comm - Other Electronics	742	0.6%
Middle Atlantic	Comm - Indoor Lighting	20,842	5.4%
	Comm - Other Electronics	2,729	0.7%
	Res - Computers	2,436	0.6%

Notes: New England includes NH, VT, ME, MA, RI, and CT. Middle Atlantic includes NY, NJ, and PA.

The top three end uses in the South are shown in Table 1-6. Central air conditioning both in the residential and commercial sectors make it into the top three in almost all cases. This points to the increased consumption for space cooling in the South. Industrial facilities also makes the top three in the East South Central and presents the largest opportunity for savings in the industrial sector.

Table 1-6
Top Three End Uses for 2035 Achievable Potential, South Census Region

Division	End Use	Savings (GWh)	% of Baseline
South Atlantic	Comm - Indoor Lighting	31,595	4.4%
	Res - Central AC	9,198	1.3%
	Comm - Central AC	7,154	1.0%
Florida	Comm - Indoor Lighting	15,746	4.4%
	Res - Central AC	6,735	1.9%
	Comm - Central AC	3,567	1.0%
East South Central	Comm - Indoor Lighting	10,367	2.5%
	Industrial Facilities	3,233	0.8%
	Res - Central AC	3,211	0.8%
West South Central	Comm - Indoor Lighting	8,228	3.4%
	Res - Central AC	3,310	1.4%
	Comm - Central AC	3,036	1.3%
Texas	Comm - Indoor Lighting	15,929	3.4%
	Res - Central AC	11,253	2.4%
	Comm - Central AC	5,873	1.3%

Notes: South Atlantic includes WV, VA, DE, MD, DC, NC, SC, and GA. East South Central includes KY, TN, MS, and AL. West South Central includes OK, AR, and LA.

Table 1-7 presents the top three for the Midwest. Industrial facilities is in the top three for both divisions, which includes industrial HVAC and lighting. Otherwise no heating or cooling makes it into the top three in the Midwest where there is less electric space heating and cooling than in other divisions.

Table 1-7
Top Three End Uses for 2035 Achievable Potential, Midwest Census Region

Division	End Use	Savings (GWh)	% of Baseline
East North Central	Comm - Indoor Lighting	28,222	4.6%
	Industrial Facilities	4,043	0.7%
	Comm - Other Electronics	3,681	0.6%
West North Central	Comm - Indoor Lighting	10,367	3.1%
	Industrial Facilities	1,782	0.5%
	Residential Computers	1,544	0.5%

Notes: East North Central includes WI, MI, IL, IN, and OH. West North Central includes ND, SD, MN, NE, IA, KS, and MO.

Table 1-8 shows mixed results for the West with electronics – residential computer or commercial electronics – showing up in a few of the West divisions. Mountain South has residential cooling in the top three pointing to the relatively high share of central AC consumption in the baseline.

Table 1-8
Top Three End Uses for 2035 Achievable Potential, West Census Region

Division	End Use	Savings (GWh)	% of Baseline
Mountain North	Comm - Indoor Lighting	6,668	4.0%
	Industrial Facilities	1,011	0.6%
	Res - Computers	902	0.5%
Mountain South	Comm - Indoor Lighting	7,917	4.0%
	Res - Central AC	1,810	0.9%
	Industrial Facilities	1,201	0.6%
Pacific	Comm - Indoor Lighting	9,089	4.3%
	Comm - Other Electronics	1,744	0.8%
	Res - Computers	1,340	0.6%
California	Comm - Indoor Lighting	13,167	4.3%
	Comm - Other Electronics	2,526	0.8%
	Res - Computers	1,941	0.6%

Notes: ASHP = air-source heat pumps. Mountain North includes MT, ID, WY, UT, and CO. Mountain South includes AZ, NM, and NV. Pacific includes WA, OR, AK, and HI.

The Potential for Peak Demand Savings from Utility Programs

In addition to the impacts on annual electricity use, the study assessed both summer and winter coincident peak demand savings from energy efficiency.

Energy efficiency programs have the potential to reduce coincident summer peak demand by 79 GW to 635 GW. This represents a range of achievable potential reduction in summer peak demand in 2035 of 11% to 16%. This can also be expressed as a reduction in the forecasted growth rate in peak demand of 65% to 98% through 2035.

Energy efficiency programs have the potential to reduce coincident winter peak demand by 64 GW to 564 GW. This represents a range of achievable potential reduction in summer peak demand in 2035 of 10% to 14%. This can also be expressed as a reduction in the forecasted growth rate in peak demand of 45% to 65% through 2035.

Figure 1-11 shows the various levels of potential for summer coincident demand savings in the key forecast years, with 11.1% achievable potential in 2035 across all sectors. This illustrates how the potential builds over time as the efficient measures are installed.

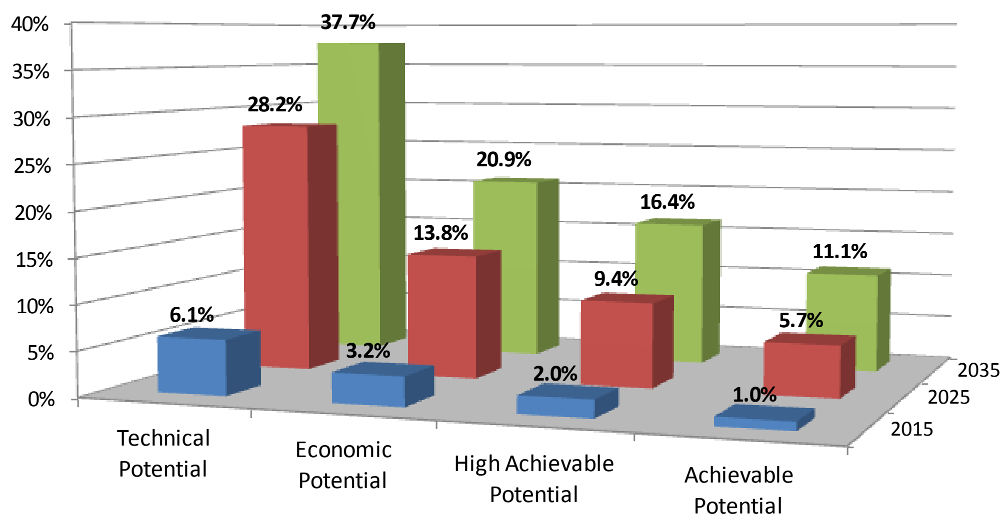


Figure 1-11
U.S. Summer Coincident Peak Demand Reduction

Figure 1-12 breaks out the achievable potential by sector as a percentage of each sector's baseline. Clearly there is great potential for savings in the commercial sector, which is in line with the energy savings results presented in Section 4.

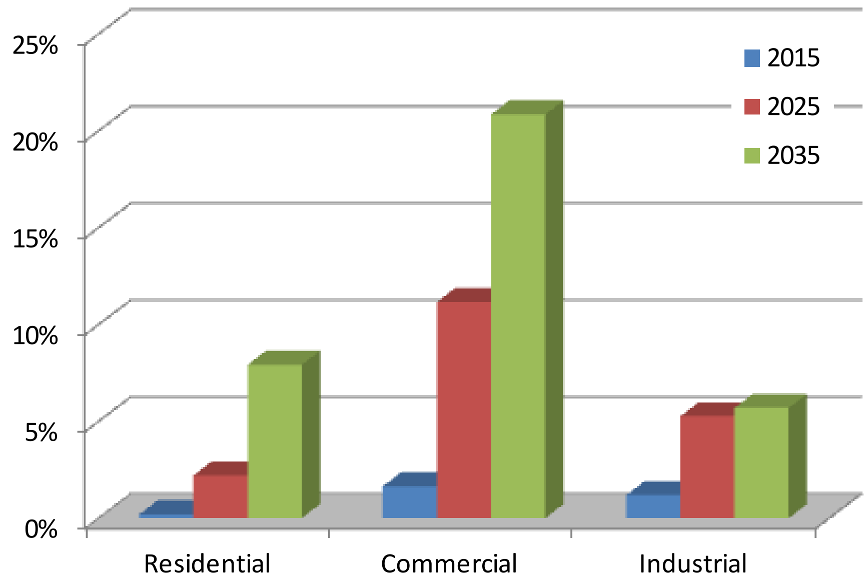


Figure 1-12
Summer Peak Demand Achievable Potential by Sector, as Percentage of Sector Energy Baseline

Table 1-9 presents summer coincident peak demand achievable savings potential by sector and end use, the achievable potential savings in 2035 across all sectors is 11.1%.

The majority of summer demand savings are in the areas of HVAC, water heating and lighting, together accounting for 69% of the 2035 savings.

Space cooling in the residential and commercial sectors accounts for about 30% of summer demand savings in 2035. Lighting accounts for another 30% of 2035 achievable potential. These do not include industrial facilities, which captures HVAC and lighting savings in the industrial sector.

Table 1-9
Achievable Summer Peak Demand Reductions by Sector and End Use (MW)

	2015	2025	2035
Residential			
Space Cooling	377	4,034	16,787
Electronics	145	1,532	5,689
Water Heating	73	959	2,996
Lighting	92	1,233	2,705
Appliances	48	490	1,373
Residential Total	**735**	**8,248**	**29,550**
Commercial			
Lighting	2,886	15,545	22,236
Office Equipment	304	4,391	12,867
Space Cooling	126	2,404	6,513
Ventilation	9	172	428
Water Heating	1	1	1
Refrigeration	0.0	0.0	1
Commercial Total	**3,326**	**22,512**	**42,046**
Industrial			
Industrial Facilities	718	3,172	3,429
Pumps	372	1,646	1,784
Fans and Blowers	194	861	933
Process Cooling & Refrig.	140	616	665
Process Heating	132	584	630
Compressed Air	90	398	432
Steam Generation Equipment	13	57	62
Industrial Total	**1,660**	**7,334**	**7,935**
U.S. Total	**5,721**	**38,094**	**79,531**

Note: Numbers in table may not sum to the total due to rounding.

Figure 1-13 shows the various levels of potential for winter coincident demand savings in the key forecast years, with 10.2% achievable potential in 2035 across all sectors. This illustrates how the potential builds over time as the efficient measures are installed.

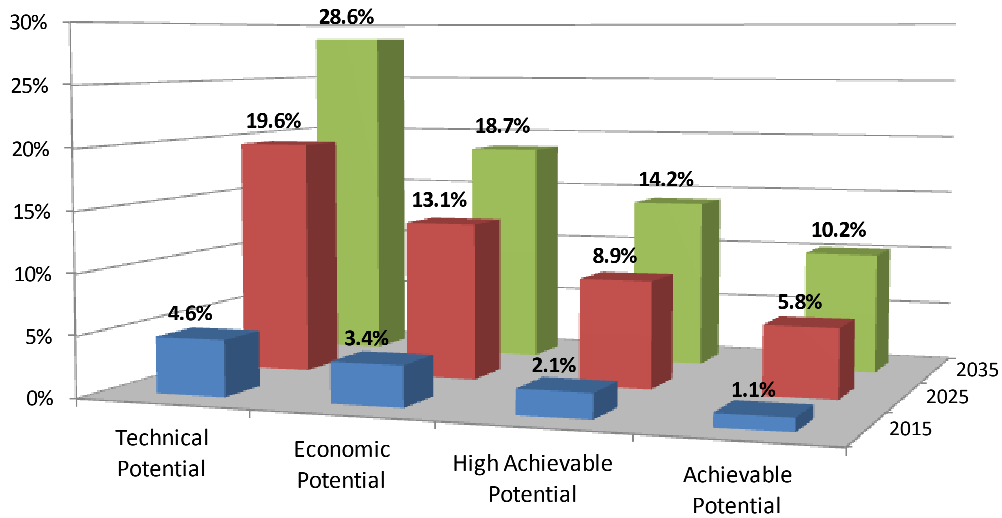


Figure 1-13
U.S. Summer Coincident Peak Demand Reduction

Figure 1-14 breaks out the achievable potential by sector as a percentage of each sector's baseline. The relatively high potential in the commercial sector, is again evident.

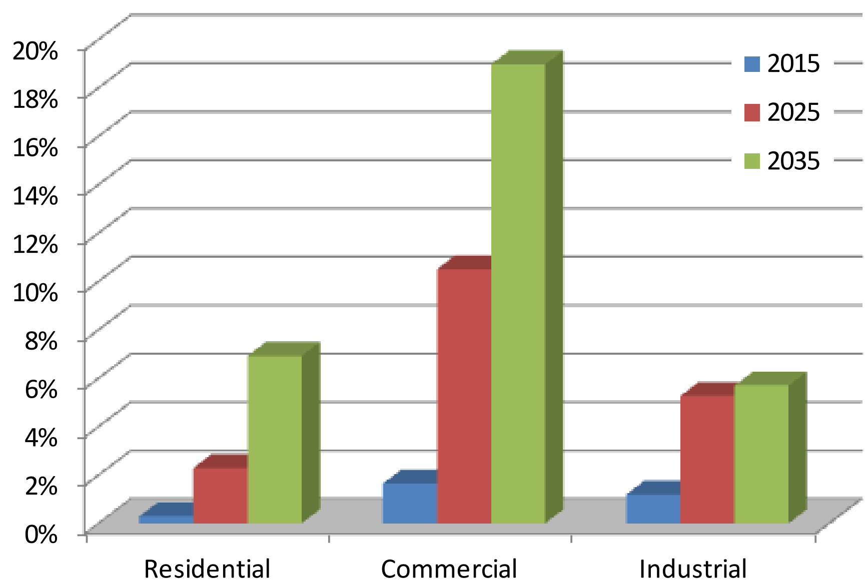


Figure 1-14
Winter Peak Demand Achievable Potential by Sector, as Percentage of Sector Energy Baseline

Table 1-10 presents winter coincident peak demand achievable savings potential by sector and end use, the achievable potential savings in 2035 across all sectors is 10.2%. The majority of winter demand savings are also in the areas of HVAC, water heating and lighting, together accounting for 62% of the 2035 savings.

Energy efficiency in heating end uses does not have quite as much impact on winter demand savings as space cooling on summer demand, accounting for about 14% of 2035 achievable potential. Lighting presents the bulk of savings potential for winter demand contributing about 40% of the total. Again, space heating and lighting savings from industrial facilities is not included in these totals due to lack of details on how it is broken out.

Table 1-10
Achievable Winter Peak Demand Reductions by Sector and End Use (MW)

	2015	**2025**	**2035**
Residential			
Space Heating	236	2,288	8,361
Electronics	123	1,306	4,848
Lighting	413	2,236	4,479
Water Heating	55	721	2,233
Appliances	44	453	1,252
Residential Total	**871**	**7,004**	**21,173**
Commercial			
Lighting	2,659	14,410	20,788
Office Equipment	305	4,403	12,903
Space Heating	11	157	465
Ventilation	10	176	439
Water Heating	2	3	2
Refrigeration	0.0	0.0	0.5
Commercial Total	**2,986**	**19,149**	**34,598**
Industrial			
Industrial Facilities	718	3,172	3,429
Pumps	372	1,646	1,784
Fans and Blowers	194	861	933
Process Cooling and Refrig.	140	616	665
Process Heating	132	584	630
Compressed Air	90	398	432
Steam Generation Equipment	13	57	62
Industrial Total	**1,660**	**7,334**	**7,935**
U.S. Total	**5,517**	**33,487**	**63,706**

Note: Numbers in table may not sum to the total due to rounding.

Net Impacts of Efficiency and Electrification

Forecasts for load growth vary by utility and are influenced by population growth, industrial development, economic growth and many other factors. Historically growth in electricity consumption was in the range of several percent. There are now places where this growth has fallen to less than a percent – as is the case with the national *AEO2012* forecasts – or may be expected to decline.

The energy savings evaluated herein represent cost-effective efficiency from the point of view of the utility, which also yield net benefits to customers and society at-large. Similarly, certain applications of *electrification*, defined as the substitution of electric for non-electric end-use technologies, can also yield net benefits to customers, the utility, and society at-large. Electrification can be inclusive of the residential, commercial, and industrial sectors, as well as the transportation sector through the adoption of electric vehicles.

EPRI's previous evaluations of electrification, have focused on quantifying expected market trends and resultant impacts on net CO_2 emissions, more so than cost-effectiveness. The latter is a subject of current EPRI industry initiative.

EPRI has conducted a high-level analysis of electrification potential, as well as assessments of electric transportation market trends for both light-duty vehicles and non-road transportation. Together, these analyses provide a basis for estimating the resultant increase in electricity consumption. The results of these studies are presented along with the achievable energy savings form energy efficiency in Figure 1-15.

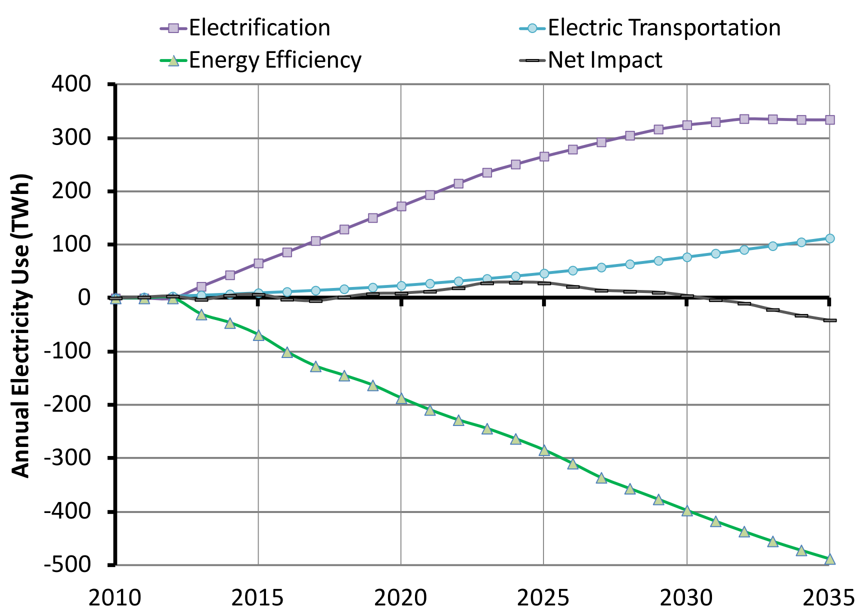


Figure 1-15
Net Impacts of Electric Load Growth and Energy Efficiency

Preliminary analysis of these three trends show that the savings achieved with energy efficiency could net the effects of increased electricity consumption through electrification. With respect to carbon emissions, reductions can be achieved through both electric efficiency and electrification. This presents expanded opportunities for utilities to increase value and productivity with one or more of these activities with a net result that could increase or decrease their forecast growth.

Follow-on Research

As current efforts to promote energy efficiency including advocacy groups, codes and standards and utility programs continue to produce energy savings it is important to understand emerging trends that impact efficiency.

Understanding end-use consumption and emerging technologies is key in this effort. As mentioned earlier there are key technologies that are expected to play a continuing role in energy efficiency while at the same time offering new opportunities for customer flexibility. Some key areas to consider include:

- Advanced motor technologies,
- Advanced thermal technologies such as heat pumps with expanded market potential in colder climates,
- More efficient electronics incorporating advanced materials, batteries and power management,
- Emerging electric end-use categories such as smart phones and tablets, and electric transportation.

Codes and standards continue to identify new areas for energy efficiency efforts and at the same time new end-uses continue to emerge creating new opportunities for energy savings. As the technology landscape unfolds the realm of cost-effective efficiency will also continue to change.

Program:

End-Use Energy Efficiency and Demand Response

3002001871

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