Achievable Potential for Energy Efficiency in the U.S. (2010-2030)

Ingrid Rohmund, Global Energy Partners, LLC, San Diego, CA
Omar Siddiqui, Electric Power Research Institute, Palo Alto, CA
Greg Wikler, Global Energy Partners, LLC, San Diego, CA
Kelly Smith, Global Energy Partners, LLC, San Diego, CA
Ahmad Faruqui, The Brattle Group, San Francisco, CA

ABSTRACT

In 2008, EPRI conducted a study to estimate the potential for energy efficiency and demand response in U.S. between 2008 and 2030 (National Potentials Study). The first study of its kind since the early 1990's, this work included estimates for the U.S. as a whole and for four Census regions, with resolution at the level of customer sector, end use, and technology. The study will be released in January 2009.

This paper presents the analysis approach and key findings from this study.

Introduction

The Electric Power Research Institute (EPRI) commissioned a study (National Potential Study)to assess the potential for the reducing electricity use and summer peak demand through utility programs for the United States and four Census regions for the time horizon of 2008 to 2030. A key objective of the study is to inform utilities, policymakers, and other industry stakeholders in their efforts to develop actionable savings targets for energy-efficiency and demand-response programs.

The study forecasts U.S. energy-efficiency and demand-response potential with respect to the DOE Energy Information Administration's "Reference Forecast" for electricity consumption as presented in its 2008 Annual Energy Outlook (AEO) and NERC's 2005 Peak Demand and Energy Projection Bandwidths extrapolated to 2030. The first step was to develop baseline forecasts of electricity consumption and peak demand at the region, end-use, and technology levels which are consistent with the AEO 2008 and NERC forecasts. Then we developed annual energy-efficiency and demand-response potentials for the years 2009 through 2030 at the same level of detail. These two efforts combined result in forecasts of electricity use and non-coincident summer peak demand, as well as annual energy use and peak-demand savings estimates, for the U.S. and four Census regions for 2008 through 2030.

Types of Potential

The focus of the National Potential Study was to estimate achievable potential, which represents savings attainable through programs that encourage the adoption of energy-efficient technologies, taking into consideration technical, economic and market constraints. In addition to achievable potential, the study also estimated technical and economic potential. All estimates represent "phased-in" potential since it is assumed that appliance and equipment replacement takes place at the end of its useful life, rather than instantaneously. The study employs the following definitions of potential.

- **Technical potential** represents the savings due to energy-efficiency (EE) and demand-response (DR) measures that would result if all of the most efficient measures and actions were adopted by customers, regardless of cost. It does not take into account the cost-effectiveness of the measures.

- **Economic potential** represents the savings due to EE measures that would result if only cost-effective measures are adopted by the utility's customers. It is a subset of the technical potential and is quantified only over those measures that pass an economic screen. For our analysis, we use a variation of the participant test.
- **Maximum achievable potential (MAP)** refines the economic potential by taking into account expected program participation, customer preferences, and budget constraints. Maximum achievable potential establishes a maximum target for the savings that a utility can hope to achieve through its programs. MAP usually involves incentives that represent 100% of the incremental cost of energy efficient measures above baseline measures, combined with high administrative and marketing costs.
- **Realistic achievable potential (RAP)**, unlike the other potential estimates, represents a forecast of likely customer behavior and penetration rates of efficient technologies. It takes into account existing market, financial, political, and regulatory barriers that are likely to limit the amount of savings that might be achieved through energy efficiency or demand response programs. The RAP also takes into account recent utility experience and reported savings.

Analysis Approach

The study began with a full characterization of electricity use by region, sector, end use and technology as shown in Figure 1.

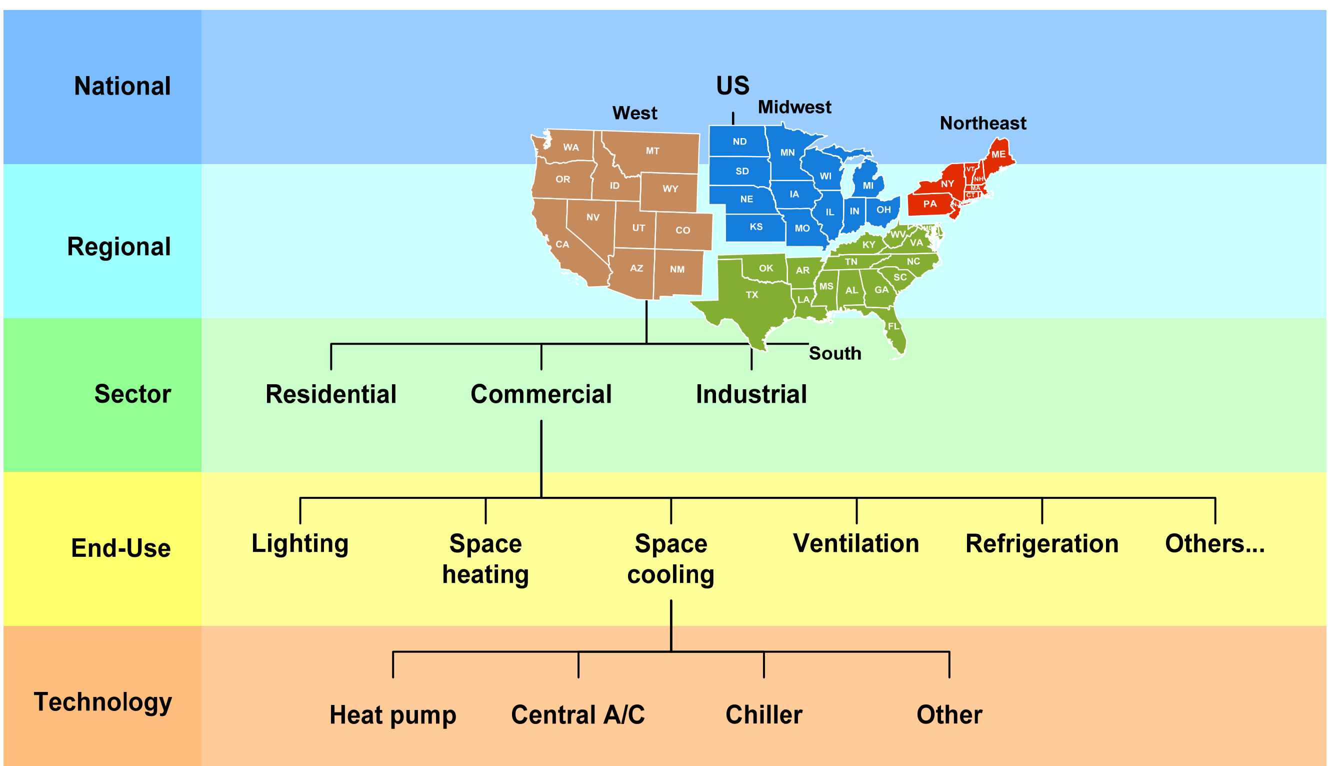

Figure 1. Segmentation used in the EPRI National Potentials Study

The Starting Point: Base-Year Electricity Use by Sector and End Use

Before any analysis of energy savings can begin, it is critical to understand, to the best of our ability, how customers use energy today. For this study, we began with the 2008 AEO estimate of 3,717 TWh for electricity use in the U.S. across the residential, commercial, and industrial sectors. Figure 2 shows the AEO breakdown by sector and end use. The largest sector is the residential, with commercial only slightly smaller. In both residential and commercial sectors, lighting and cooling are major end uses. Both sectors also have a substantial "other" category which includes various plug loads not classified among the other end uses. Office equipment is another large use in the commercial sector. Machine drives (motors) are the largest electric end use in the industrial sector.

In addition to quantifying end-use energy use and peak demand in the base-year, it is necessary to understand the fuel mix, specific equipment types, and the efficiency levels of the equipment in place. Information about fuel shares and specific equipment types is relatively easy for utilities to gather, but efficiency levels pose a challenge. For this national study, we utilized the market studies (RECS, CBECS, and MECS) conducted periodically by the Energy Information Administration and other publicly available sources.

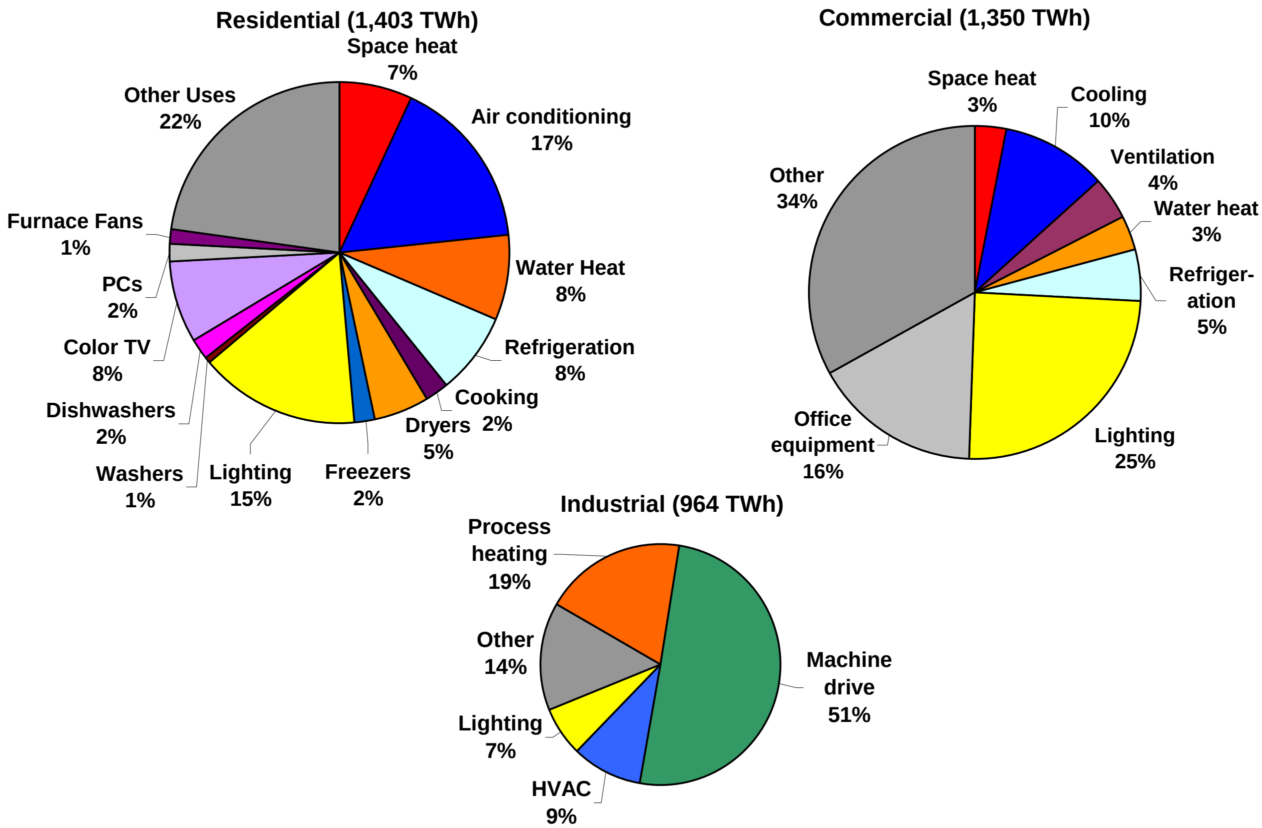

Figure 2. 2008 U.S. Electricity Use by Sector and End Use
Source: Annual Energy Outlook 2008

The Baseline Forecast

By 2030, electricity use is expected to increase to 4,858 TWh, a 31% increase over 2008 and an average growth rate of 1.2% per year through 2030. As illustrate in Figure 2, this baseline forecast already includes expected savings from several drivers of efficiency:

- Appliance and equipment standards on the books as of January 1, 2008
- Trends in customer purchases of energy efficient equipment outside of utility programs
- Existing state and local building, appliance and equipment standards
- The Energy Information and Security Act of 2007 (particularly the lighting standards)
- The impact of energy efficiency programs adopted prior to 2008

The estimated impact of codes and standards is significant at 1,187 TWh in 2030, which is about a fourth of forecasted baseline use in the same year. Stated differently, without codes and standards that are already on the books, electricity use is expected to be 25% higher in 2030.

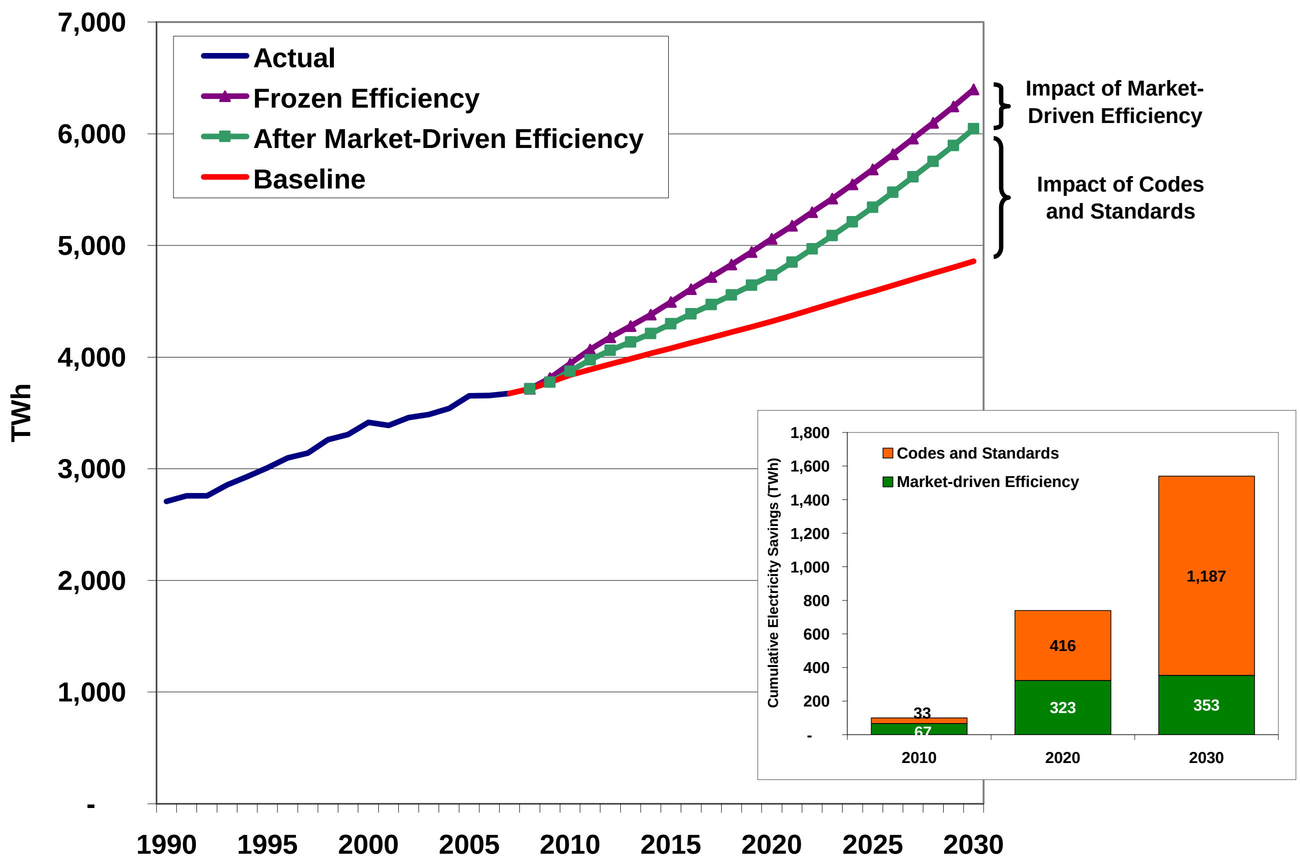

Figure 3. The Baseline Forecast

It is important to note that this forecast includes the impacts of codes and standards on the books as of 2007. It does not include the expected savings from future Federal and State appliance and equipment standards and building codes. Finally, the forecast assumes the AEO 2008 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 begins with a list of energy efficiency measures that 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). A summary of these measures is presented below:.

Residential Sector Measures	Commercial Sector Measures
Efficient air conditioning (central, room, heat pump)	Efficient cooling equipment (chillers, central AC)
Efficient space heating (heat pumps)	Efficient space heating equipment (heat pumps)
Efficient water heating (e.g. heat pump water heaters & solar water heating)	Efficient water heating equipment
Efficient appliances (refrigerators, freezers, washers, dryers)	Efficient refrigeration equipment & controls
Efficient lighting (CFL, LED, linear fluorescent)	Efficient lighting (interior and exterior)
Efficient power supplies for IT equipment and electronics	Lighting controls (occupancy sensors, daylighting, etc.)
Air conditioning maintenance	Efficient power supplies for IT and electronic office equipment
Duct repair and insulation	Water temperature reset
Infiltration control	Efficient air handling and pumps
Whole-house and ceiling fans	Economizers and energy management systems (EMS)
Reflective roof, storm doors, external shades	Programmable thermostats
Roof, wall and foundation insulation	Duct insulation
High-efficiency windows	**Industrial Sector Measures**
Faucet aerators and low-flow showerheads	Process improvements
Pipe insulation	High-efficiency motors
Programmable thermostats	High-efficiency HVAC
In-home energy displays	Efficient lighting

The savings potential of an individual energy-efficiency measure is a function of its unit energy savings relative to a baseline technology. This potential is then discounted by a variety of factors that take into account technical applicability, economic feasibility, the turnover rate of installed equipment, and market penetration. This is consistent with the National Action Plan for Energy Efficiency (NAPEE) "Guide to Conducting Energy Efficiency Potential Studies," published in November 2007.

The study utilized Global Energy Partner's Load Management Analysis and Planning (LoadMAP^{TM}) tool for forecasting energy use, peak demand, and estimating savings. LoadMAP is a highly detailed micro-economic model of energy and peak-demand savings at the level of major end uses (i.e., residential lighting, commercial air conditioning, industrial motors, etc.). LoadMAP leverages a comprehensive technology database, as well as a sophisticated building simulation tool based on the DOE-2 engine. Savings potentials are developed using a "bottom-up" approach, aggregating the impact of discrete technology options within end uses across sectors and regions. This approach follows industry best practices and has been applied successfully in numerous utility potential studies.

Expected Savings from Utility Programs

The range of achievable energy-efficiency potential for the U.S. in 2030 from the EPRI National Study is 398-544 TWh, or a decrease of 8-11% in projected consumption in 2030. Figures 4 shows achievable potential together with economic and technical potential as a share of total energy consumption in each year. Figure 5 shows potential savings relative to the baseline forecast.

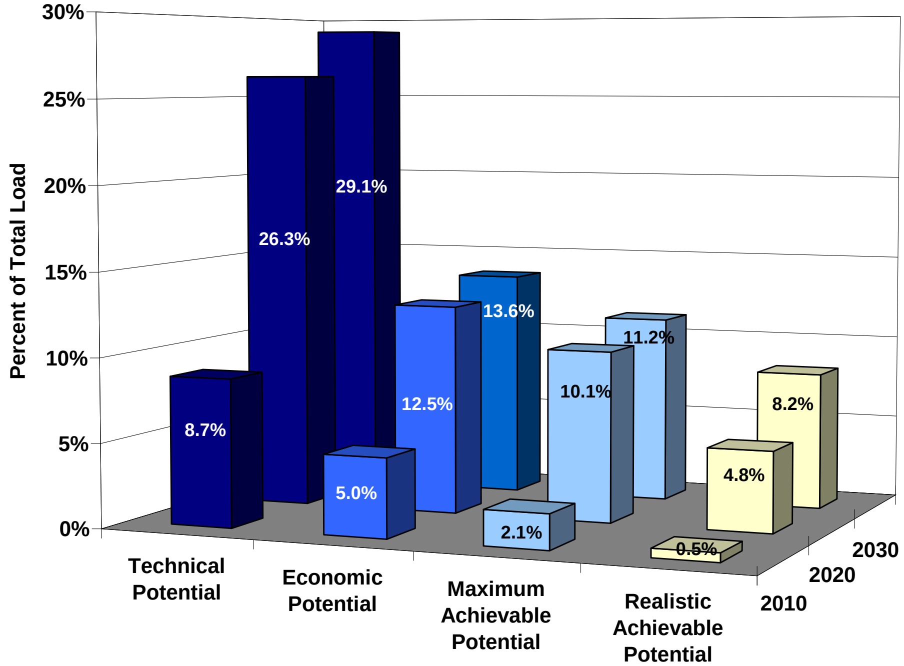

Figure 4. Reference-Case Estimates of Energy-Efficiency Potential

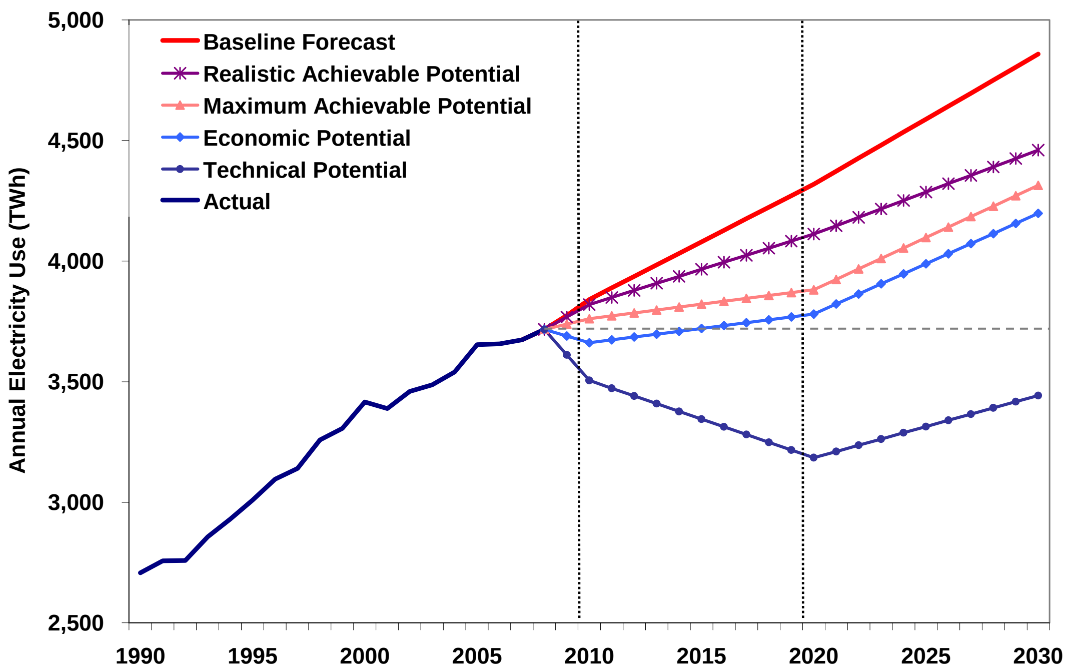

Figure 5. Potential Estimates in the Context of the Baseline Forecast

The transition from technical potential to realistic achievable potential is described below using residential air conditioning as an example.

- **Technical Potential**: Central air conditioning (CAC) systems in existing homes are replaced, upon reaching the end of their useful lives, with the highest SEER level equipment available regardless of cost; in new homes, the highest SEER level available in each year is installed. In 2010, this is the SEER 20 air conditioner or the ductless (mini-split) heat pump with variable speed operation.
- **Economic Potential**: CAC systems in existing homes are replaced, upon reaching the end of their useful lives, with the highest SEER level CAC that passes the economic screen; in new homes, the highest SEER level CAC passing the economic screen is installed. The results of the economic screening vary by region. In the Southern region in 2010, for example, the highest-efficiency CAC that passes the economic screen is SEER 15.
- **Maximum Achievable Potential (MAP)**: MAP applies a market-acceptance rate to the economic potential results, based on the best experiences of energy efficiency programs per technology or end-use category, as well as the considered judgment of industry experts. The market acceptance rate for the high-efficiency CAC unit is estimated to be 25% by 2010, and is projected to increase to 75% in 2020 and remain at that level through 2030.
- **Realistic Achievable Potential (RAP)**: RAP applies a program implementation factor to MAP. The program implementation factor for the high-efficiency CAC unit is assumed to be 15% in 2010, and is projected to increase to 42% in 2020 and 70% in 2030. The combined effect of the market acceptance rate and program implementation factor for residential central air conditioning gives a realistic achievable potential that is 4% of economic potential in 2010, 32% in 2020 and 53% in 2030. Program implementation factors vary by technology category.

Figure 5 identifies realistically achievable savings by sector and end use. Two broad categories of opportunity include the following:

- First, there continues to be a large opportunity for savings in end uses that already have a long history in energy efficiency, suggesting that there is potentially more “low-hanging fruit” to harvest. Commercial lighting, industrial motors, and residential cooling fall into this category.
- Second, the recent growth in consumer electronics and computing equipment has not only added to the baseline forecast, it creates a sizeable opportunity for efficiency improvements that will result in electricity savings. We are only beginning to understand what is possible for these end uses and to exploit the potential for savings.

In the next two years, the majority of the opportunity lies in commercial and residential lighting. After 2010, the opportunity in residential lighting diminishes due to the lighting standards that are part of EISA. However, commercial lighting continues to show significant opportunities.

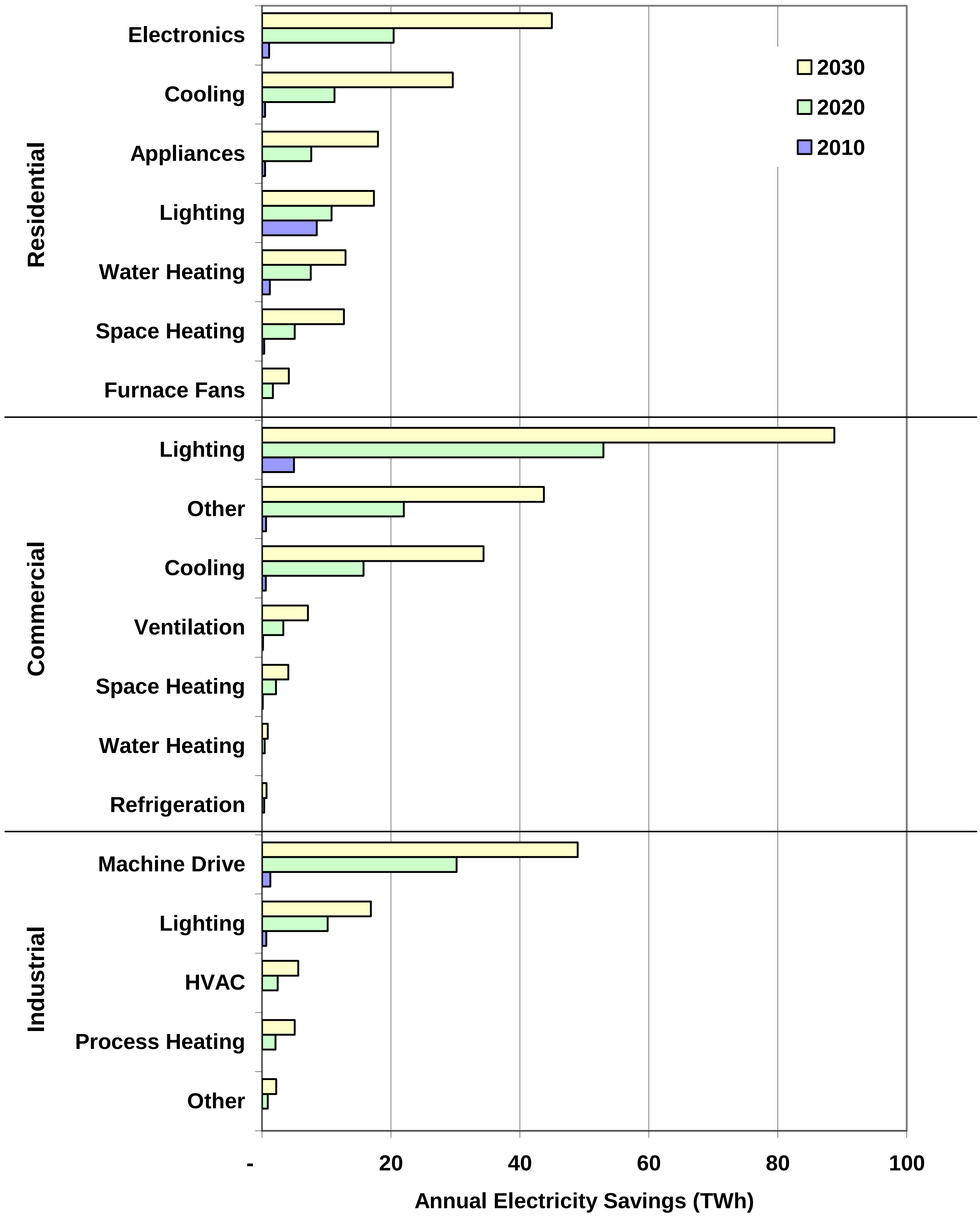

Figure 5. Realistic Achievable Potential by End Use

Energy Efficiency Savings Potential by U.S. Census Region

This study disaggregates electricity baseline consumption and potential energy efficiency savings by the four U.S. Census regions shown in Figure 6 : Northeast, South, Midwest, and West.

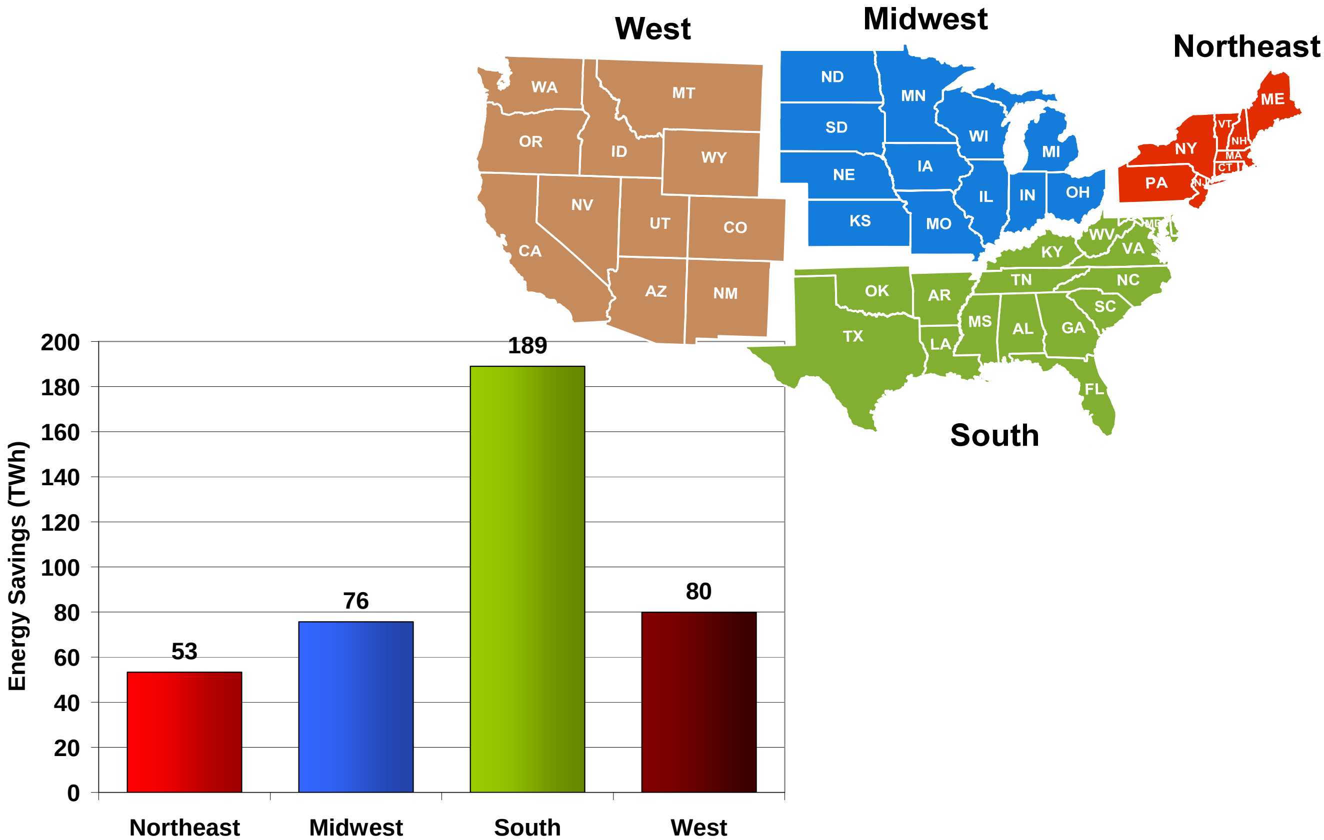

Figure 6. Realistic Achievable Potential by U.S. Census Region

Generally speaking, the Northeast and West regions have had a longer legacy of energy efficiency programs than the South and Midwest. Sub-regions of long-standing energy efficiency activity include California and the Pacific Northwest in the West, and the greater New England area in the Northeast.

- Electricity consumption is currently highest in the South, and is expected to grow at an annual rate of 1.4% through 2030. The South is also the region with the greatest potential for energy efficiency in absolute terms.
- Electricity consumption is currently lowest in the Northeast, and is expected to grow at an annual rate of 0.9% through 2030. The Northeast's energy efficiency potential is the smallest of the four regions, although by share of total load it ranks second.
- The Midwest is the second largest region in terms of both current and forecasted consumption, although its annual growth rate of 0.7% is the smallest of the four regions.
- Finally, the West is the region of most rapid forecasted growth at 1.6% per year, and has the largest potential for energy efficiency in percentage terms.

The top areas of potential within each region by sector (residential, commercial, industrial) and end use are shown in Figure 7. Key highlights are:

- Commercial lighting – inclusive of upgrading lighting systems, daylighting controls, occupancy sensors, and task lighting – represents the largest energy savings opportunity. This result contradicts a widespread belief that the opportunities for reducing commercial-sector lighting use have been exhausted. While some utilities have already undertaken substantial energy efficiency efforts in commercial lighting, most of these activities have addressed easier-to-implement lighting measures, leaving room for significant additional savings potential.
- Air conditioning in the commercial and residential sectors contributes significantly to savings potential, above and beyond savings from equipment standards.
- Efficiency savings from computers, other office equipment, and electronics are substantial. Utilities can achieve these savings through a variety of initiatives including educating customers and providing incentives for the purchase of high efficiency equipment.
- Numerous residential appliances, from water heaters to freezers, also contribute materially to savings potential, even beyond existing and soon to be implemented Federal appliance standards.
- In the industrial sector, electricity savings potential is pre-dominantly in motor-driven applications, above and beyond savings associated with long-standing motor efficiency standards.

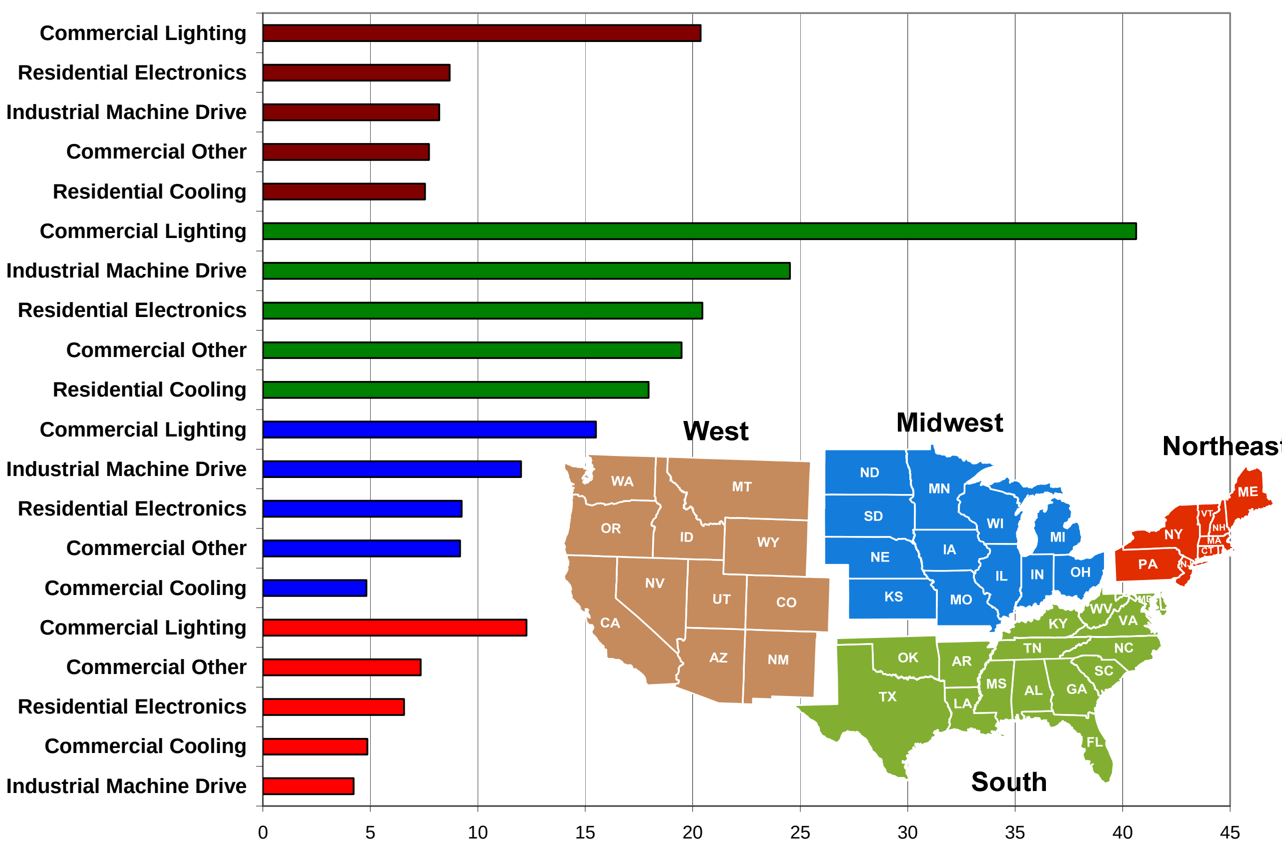

Figure 7. Realistic Achievable Potential (billion kWh) by Region and End Use in 2030

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Conclusions and Implications

The potential for electricity and summer peak demand savings from energy-efficiency and demand-response programs is significant. Across the U.S., these programs have the potential to reduce the annual growth rate of electricity consumption from a historical 1.7% growth rate per year from 1996 to 2006 to a realistically achievable 0.83% growth rate per year from 2009 to 2030.

Over the period 2008 to 2030, the achievable potential of energy efficiency programs identified in this study equates to an annual incremental reduction in electricity consumption of 0.37% to 0.51%.per year. This is above and beyond what will be achieved through market-driven efficiency and codes and standards already on the books. The analysis of energy efficiency potential is based on the turnover of currently installed energy-consuming devices (as well new construction) to efficient technologies commercially available today, and since most devices have a useful life of less than fifteen years, it is instructive to examine the results for the year 2020, by which time the existing stock of most energy-consuming devices has turned over. Over the twelve year period of 2008 through 2020, the achievable potential of energy efficiency programs identified in this study equates to an annual incremental reduction in electricity consumption of 0.40% to 0.85%.per year.

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