Demand-side Management Market Potential Study

Volume 3: Energy Efficiency Analysis

Final Report

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INTRODUCTION

Ameren Missouri commissioned this Demand Side Management (DSM) Market Potential Study to assess the various categories of electrical energy efficiency (EE), demand response (DR), and distributed generation/combined heat and power (DG/CHP) potentials in the residential, commercial, and industrial sectors for the Ameren Missouri service area from 2016 to 2033. This study uses updated baseline estimates based on the latest information pertaining to federal, state, and local codes and standards for improving energy efficiency. It also quantifies and includes estimates of naturally occurring energy efficiency in the baseline projection.

Ameren Missouri will use the results of this study in its integrated resource planning process to analyze various levels of energy efficiency related savings and peak demand reductions attributable to both EE and DR initiatives at various levels of cost. This study also provides estimated levels of combined heat and power (CHP) and distributed generation (DG) installations over the specified time horizon. Furthermore, Ameren Missouri has adhered to both the Missouri Public Service Commission ("Commission") rules, 4 CSR 240-3.164 regarding potential study requirements for purposes of complying with the Missouri Energy Efficiency Investment Act (MEEIA) and 4 CSR 240-22 regarding potential study requirements for Ameren Missouri's next Integrated Resource Plan (IRP) to be filed in April 2014. Both rules contain new provisions that were not part of Ameren Missouri's previous DSM Potential Study published in 2010.

Ameren contracted with EnerNOC Utility Solutions Consulting (EnerNOC) to conduct this study and EnerNOC has performed the following tasks to meet Ameren's key objectives:

- Conducted primary market research to collect data for the Ameren Missouri service territory, including: electric end-use data, saturation data, and customer demographics and psychographics.
- Characterized how customers in the Ameren Missouri service territory make decisions related to their electric use and energy efficiency investment decisions. Translated that understanding in a clear and transparent manner to establish annual market acceptance rates for EE measures.
- Employed updated baselines that reflect both current and anticipated federal, state, and local energy efficiency legislation. Identify all known pending legislation that may also impact DSM potential.
- Developed Ameren Missouri-specific market acceptance rates for EE for the planning cycle of 2016 through 2034 that, when applied to economic potential, will yield estimates of maximum achievable and realistic achievable potential.
- Analyzed the potential for energy efficiency, demand response, and customer distributed generation/combined heat and power application over the 2016-2033 planning horizon[1].
- Worked with Ameren Missouri to develop sensitivity analyses for assessing uncertainty around DSM potential.
- Analyzed the impact of demand-side rates on DSM potential.
- Provided a series of webinars for Missouri stakeholders to review study assumptions and provide comments for consideration.

[1] Although estimates were developed through 2034, we show results for 2033, which is 20 years out from the start of the forecast in 2014.

- Clearly communicated the DSM potential and uncertainty in an objective way that is useful for the Commission, Ameren senior management, Missouri stakeholders, Ameren DSM staff, Ameren EE Implementation team, and Ameren IRP staff – both operational and planning. This includes the following:
    - Documented compliance with IRP/MEEIA rule references, including specific references to rule requirements.
    - Provided measure-level information, in a way that is readily compatible with Ameren Missouri's modeling methodology in DSMore.
    - Generated energy efficiency potential supply curves, which clearly show the incremental cost (in dollars per kWh) of increasing DSM energy efficiency efforts (in kWh) over the 2016-2033 planning horizon.
    - Generated demand response potential supply curves, which clearly show the incremental cost (in dollars per kW) of increasing DSM demand response efforts (in kW) over the 2016-2033 planning horizon.
    - Generated distributed generation/combined heat and power potential supply curves, which clearly show the incremental cost (in dollars per kW) of increasing DG/CHP efforts (in kW) over the 2016-2033 planning horizon.

Report Organization

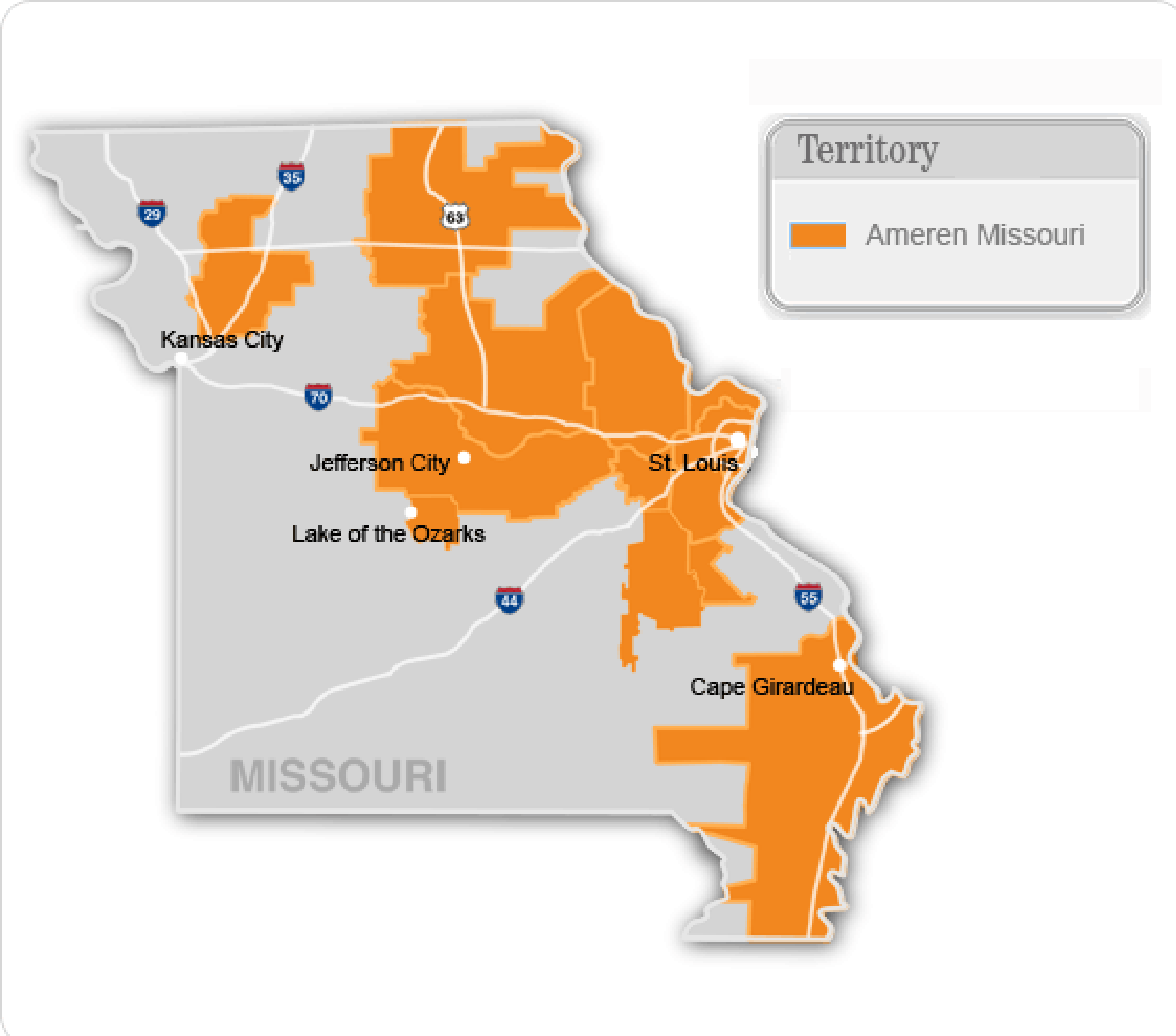
This report is presented in 5 volumes as outlined below. This document is **Volume 3: Energy Efficiency Analysis**.

- Volume 1, Executive Summary
- Volume 2, Market Research
- Volume 3, Energy Efficiency Analysis
- Volume 4, Demand Response Analysis
- Volume 5, Distributed Generation Analysis
- Volume 6, Demand-side Rates Analysis

Background

Ameren Corporation is a large investor-owned utility serving large parts of Missouri and Illinois. Figure 1-1 below presents Ameren Missouri's service territory.

Figure 1-1 Ameren Missouri Service Territory



Ameren Missouri DSM Overview

The Missouri Rules of the Department of Economic Development (4 CSR 240-22) require that electric utilities in Missouri prepare an integrated resource plan (IRP) that "[c]onsider[s] and analyze[s] demand-side efficiency and energy management measures on an equivalent basis with supply-side alternatives in the resource planning process." per Section 4 CSR 240-22.010(2)(A). Section 4 CSR 240-22.050 prescribes the elements of the demand-side analysis, including reporting requirements. A copy of the Missouri rules governing electric utility resource planning is available on the Missouri Secretary of State's website. Details of the Missouri Energy Efficiency Investment Act (MEEIA) are available on the Missouri Public Service Commission website.

Over the past several years, Ameren Missouri has been implementing EE programs and analyzing EE as a long-term resource option. From 2009 through September, 2011, Ameren Missouri implemented full-scale EE programs including five residential and four business programs.

Ameren Missouri spent approximately $70 million on energy efficiency programs between 2009 and 2011 and achieved approximately 550,000 MWH of verified energy savings. This level of expenditure resulted in deployment of approximately:

- 4 million CFLs
- 21,000 Energy Star® appliances

- 12,000 Multi-Family Income Qualified (“MFIQ”) tenant units
- 9,000 decommissioned refrigerators and freezers
- 3,000 new residential central air conditioning systems
- 3,000 business projects

In 2012, Ameren Missouri scaled back its energy efficiency expenditures to $10 million due to uncertainty regarding regulatory framework issues for its next cycle of energy efficiency programs. Concurrently, in January 2012, Ameren Missouri filed its first 3-year EE implementation plan under the new Missouri rules implementing MEEIA.

Definitions of Potential

In this study, we estimate the potential for energy efficiency savings. The savings estimates represent net savings[2] developed into three types of potential: technical potential, economic potential, and achievable potential. Technical and economic potential are both theoretical limits to efficiency savings. Achievable potential embodies a set of assumptions about the decisions consumers make regarding the efficiency of the equipment they purchase, the maintenance activities they undertake, the controls they use for energy-consuming equipment, and the elements of building construction. Because estimating achievable potential involves the inherent uncertainty of predicting human behaviors and responses to market conditions, we developed realistic and maximum achievable potential as boundaries for a likely range. The various levels are described below.

- **Technical Potential** is defined as the theoretical upper limit of energy efficiency potential. It assumes that customers adopt all feasible measures regardless of their cost. At the time of existing equipment failure, customers replace their equipment with the most efficient option available. In new construction, customers and developers also choose the most efficient equipment option. Examples of measures that make up technical potential for electricity in the residential sector include ductless mini-split air conditioners with variable refrigerant flow and ground source (or geothermal) heat pumps.

  Technical potential also assumes the adoption of every other available measure, where applicable. For example, it includes installation of high-efficiency windows in all new construction opportunities and air conditioner maintenance in all existing buildings with central and room air conditioning. These retrofit measures are phased in over a number of years, which is longer for higher-cost and complex measures.

- **Economic Potential** represents the adoption of all ***cost-effective*** energy efficiency measures. In this analysis, the cost-effectiveness is measured by the total resource cost (TRC) test, which compares lifetime energy and capacity benefits to the incremental cost of the measure. If the benefits outweigh the costs (that is, if the TRC ratio is greater than 1.0), a given measure is considered in the economic potential. Customers are then assumed to purchase the most cost-effective option applicable to them at any decision juncture.

- **Maximum Achievable Potential (MAP)** estimates customer adoption of economic measures when delivered through efficiency programs under ideal market, implementation, and customer preference conditions and an appropriate regulatory framework. Information channels are assumed to be established and efficient for marketing, educating consumers, and coordinating with trade allies and delivery partners. Maximum Achievable Potential establishes a maximum target for the EE savings that an administrator can hope to achieve through its EE programs and involves incentives that represent a substantial portion of the incremental cost combined with high administrative and marketing costs.

[2] Savings in “net” terms instead of “gross” terms mean that the baseline projection does include naturally occurring efficiency. In other words, the baseline assumes that energy efficiency levels reflect that some customers are already purchasing the more efficient option. In the baseline projection chapter we explore other types of baselines, including a codes and standards case and a business-as-usual case.

- **Realistic Achievable Potential (RAP)** reflects expected program participation given barriers to customer acceptance, non-ideal implementation conditions, and limited program budgets. This represents a lower bound on achievable potential.

Abbreviations and Acronyms

Throughout the report we use several abbreviations and acronyms. Table 1-1 shows the abbreviation or acronym, along with an explanation.

Table 1-1 Explanation of Abbreviations and Acronyms

Acronym	Explanation
ACS	American Community Survey
AEO	Annual Energy Outlook forecast developed by EIA
AHAM	Association of Home Appliance Manufacturers
B/C Ratio	Benefit to cost ratio
BEST	EnerNOC's Building Energy Simulation Tool
CAC	Central air conditioning
C&I	Commercial and industrial
CFL	Compact fluorescent lamp
DEEM	EnerNOC's Database of Energy Efficiency Measures
DEER	State of California Database for Energy-Efficient Resources
DSM	Demand side management
DR	Demand response
EE	Energy efficiency
EIA	Energy Information Administration
EISA	Energy Efficiency and Security Act of 2007
EPACT	Energy Policy Act of 2005
EPRI	Electric Power Research Institute
EUI	Energy-use index
HH	Household
HID	High intensity discharge lamps
LED	Light emitting diode lamp
LoadMAP	EnerNOC's Load Management Analysis and Planning™ tool
MAP	Maximum achievable potential
NWPCC	Northwest Power and Conservation Council
RAP	Realistic achievable potential
RTU	Roof top unit
Sq. ft.	Square feet
TRC	Total resource cost
TRM	Technical Reference Manual
UEC	Unit energy consumption

ANALYSIS APPROACH AND DATA DEVELOPMENT

This section describes the analysis approach taken for the study and the data sources used to develop the potential estimates.

Analysis Approach

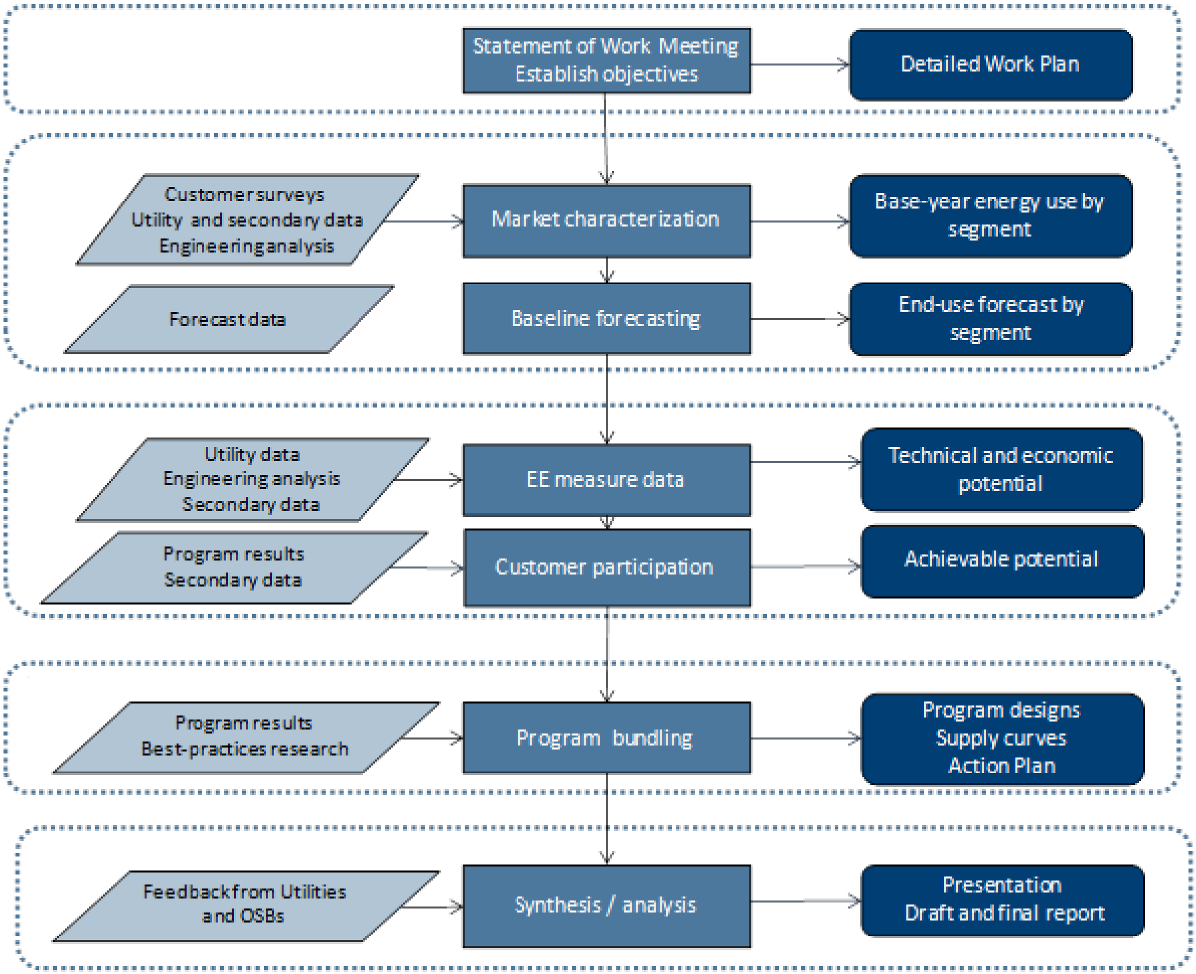
To perform the energy efficiency analysis, EnerNOC used a bottom-up analysis approach as shown in Figure 2-1. This involved the following steps.

1. Held a meeting with Ameren staff and stakeholders to refine the objectives of the project in detail. This resulted in a work plan for the study.
2. Conducted primary market research to identify equipment saturations, building characteristics, measure applicability and saturations, occupant behavior, and customer interest in programs.[3]
3. Performed a market characterization to describe sector-level electricity use for the residential, commercial, and industrial sectors for the base year, 2011. This included using the results from the customer surveys and other secondary data sources such as the Energy Information Administration (EIA).
4. Developed a baseline projection by sector, segment, and end use for 2012 through 2033. Results presented in this volume focus on the three-year implementation cycle of 2016-2018 as well as the longer term horizon through 2033.
5. Identified several hundred measures and estimated their effects in four levels of energy-efficiency potential: *Technical, Economic, Maximum Achievable,* and *Realistic Achievable*. Measure costs and savings were taken from the Missouri TRM where available.
6. Reviewed the current programs offered by Ameren in light of the study findings to make strategic program recommendations for achieving savings.
7. Created detailed program plans representing the program potential for Ameren, basing them on the potential analysis and strategic recommendations developed in the previous steps.
8. Used program design analysis to develop supply curves.

These steps are described in further detail throughout the remainder of this chapter.

[3] Details on the market research methodology and results are available in Volume 2, Market Research.

Figure 2-1 Overview of Analysis Approach



LoadMAP Model

We used EnerNOC's Load Management Analysis and Planning tool (LoadMAP^{TM}) version 3.0 to develop both the baseline projection and the estimates of energy efficiency potential. EnerNOC developed LoadMAP in 2007 and has enhanced it over time, using it for the EPRI National Potential Study and numerous utility-specific forecasting and potential studies. Built in Excel, the LoadMAP framework (see Figure 2-2) is both accessible and transparent and has the following key features.

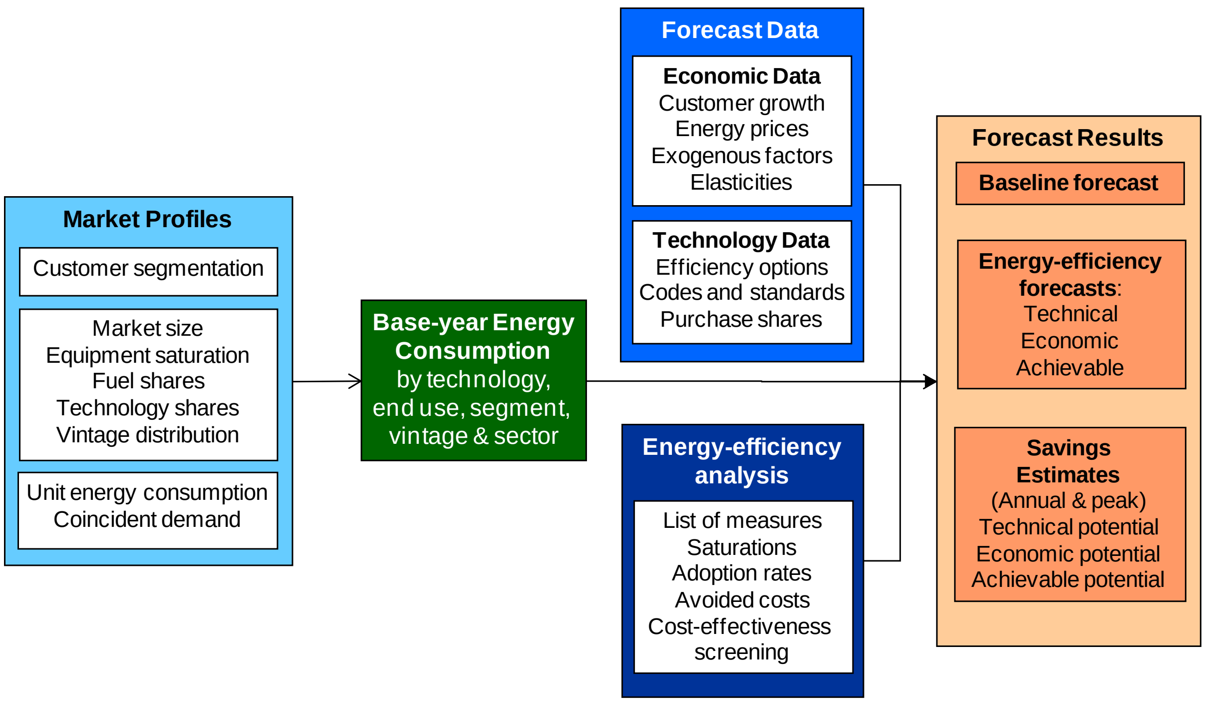
- Embodies the basic principles of rigorous end-use models (such as EPRI's REEPS and COMMEND) but in a more simplified, accessible form.
- Includes stock-accounting algorithms that treat older, less efficient appliance/equipment stock separately from newer, more efficient equipment. Equipment is replaced according to the measure life and appliance vintage distributions defined by the user.
- Balances the competing needs of simplicity and robustness by incorporating important modeling details related to equipment saturations, efficiencies, vintage, and the like, where market data are available, and treats end uses separately to account for varying importance and availability of data resources.
- Isolates new construction from existing equipment and buildings and treats purchase decisions for new construction and existing buildings separately.
- Uses a simple logic for appliance and equipment decisions. Other models available for this purpose embody complex decision choice algorithms or diffusion assumptions, and the model

parameters tend to be difficult to estimate or observe and sometimes produce anomalous results that require calibration or even overriding. The LoadMAP approach allows the user to drive the appliance and equipment choices year by year directly in the model. This flexible approach allows users to import the results from diffusion models or to input individual assumptions. The framework also facilitates sensitivity analysis.

- Includes appliance and equipment models customized by end use. For example, the logic for lighting is distinct from refrigerators and freezers.
- Can accommodate various levels of segmentation. Analysis can be performed at the sector level (e.g., total residential) or for customized segments within sectors (e.g., housing type or income level).

Consistent with the segmentation scheme and the market profiles we describe below, the LoadMAP model provides forecasts of baseline energy use by sector, segment, end use, and technology for existing and new buildings. It also provides forecasts of total energy use and energy-efficiency savings associated with the four types of potential.[4]

Figure 2-2 LoadMAP Analysis Framework



Market Characterization

In order to estimate the savings potential from energy-efficient measures, it is necessary to understand how much energy is used today and what equipment is currently being used. This characterization begins with a segmentation of Ameren's electricity footprint to quantify energy use by sector, segment, end-use application, and the current set of technologies used. We incorporate information from the customer surveys performed for this study, the 2010 Ameren DSM Potential Study (2010 Study) and secondary research sources to advise the market characterization.

[4] The model computes energy and peak-demand forecasts for each type of potential for each end use as an intermediate calculation. Annual-energy and peak-demand savings are calculated as the difference between the value in the baseline projection and the value in the potential forecast (e.g., the technical potential forecast).

Segmentation for Modeling Purposes

The market assessment first defined the market segments (building types, end uses and other dimensions) that are relevant in the Ameren service territory. The segmentation scheme for this project is presented in Table 2-1.

Table 2-1 Overview of Segmentation Scheme for EE Potentials Modeling

Market Dimension	Segmentation Variable	Dimension Examples
1	Sector	Residential, commercial, industrial
2	Building type	Residential (single family, multi family) Commercial (office, restaurant, retail, etc.) Industrial
3	Vintage	Existing and new construction
4	End uses	Cooling, lighting, water heat, motors, etc. (as appropriate by sector)
5	Appliances/end uses and technologies	Technologies such as lamp type, air conditioning equipment, motors by application, etc.
6	Equipment efficiency levels for new purchases	Baseline and higher-efficiency options as appropriate for each technology

Following this scheme, the residential sector was segmented into two housing types: single family and multi-family. In addition to segmentation by housing type, we identified the set of end uses and technologies that are appropriate for Ameren. These are shown in Table 2-2.

Table 2-2 Residential Electric End Uses and Technologies

End Use	Technology
Cooling	Central AC
Cooling	Room AC
Cooling	Air-Source Heat Pump
Cooling	Geothermal Heat Pump
Heating	Electric Resistance
Heating	Furnace
Heating	Air-Source Heat Pump
Heating	Geothermal Heat Pump
Water Heating	Water Heater <= 55 gal
Water Heating	Water Heater > 55 gal
Interior Lighting	Screw-in
Interior Lighting	Linear Fluorescent
Interior Lighting	Specialty
Exterior Lighting	Screw-in
Appliances	Refrigerator
Appliances	Second Refrigerator
Appliances	Freezer
Appliances	Clothes Washer
Appliances	Clothes Dryer
Appliances	Dishwasher
Appliances	Stove
Appliances	Microwave
Electronics	Personal Computers
Electronics	Monitor
Electronics	Laptops
Electronics	TVs
Electronics	Printer/Fax/Copier
Electronics	Set-top Boxes/DVR
Electronics	Devices and Gadgets
Miscellaneous	Air Purifier/Cleaner
Miscellaneous	Dehumidifier
Miscellaneous	Pool Pump
Miscellaneous	Pool Heater
Miscellaneous	Hot Tub / Spa
Miscellaneous	Furnace Fan
Miscellaneous	Miscellaneous

For the commercial sector, it is useful to analyze the segments based on the unique characteristics of the building type. For this study, we used the following segments.

- Offices—all types including medical/dental offices and government offices
- Restaurant—fast-food, sit-down and cafeteria-style restaurants
- Retail—retail establishments such as small boutiques, and large box retailers
- Grocery—convenience stores, small markets, and supermarkets
- Education—primary and secondary schools, colleges, universities and technical colleges
- Health—hospitals and nursing homes

- Lodging—motels, hotels, resorts and small inns
- Warehouse—storage facilities, refrigerated and unrefrigerated
- Miscellaneous—all remaining building types, such as police stations, parking garages, public assembly, amusement parks, etc.

In addition to segmentation by building type, we identified the set of end uses and technologies that are appropriate for Ameren. Table 2-3 lists the end uses and technologies used in this study.

Table 2-3 Commercial Electric End Uses and Technologies

End Use	Technology
Cooling	Air-Cooled Chiller
Cooling	Water-Cooled Chiller
Cooling	Roof top AC
Cooling	Air Source Heat Pump
Cooling	Geothermal Heat Pump
Cooling	PTAC
Cooling	PTHP
Heating	Electric Furnace
Heating	Air Source Heat Pump
Heating	Geothermal Heat Pump
Heating	Electric Room Heat
Heating	PTHP
Ventilation	Ventilation
Water Heating	Water Heating
Interior Lighting	Screw-in
Interior Lighting	High-Bay Fixtures
Interior Lighting	Linear Fluorescent
Exterior Lighting	Screw-in
Exterior Lighting	HID
Exterior Lighting	Linear Fluorescent
Refrigeration	Walk-in Refrigerator
Refrigeration	Reach-in Refrigerator
Refrigeration	Glass Door Display
Refrigeration	Open Display Case
Refrigeration	Icemaker
Refrigeration	Vending Machine
Food Preparation	Oven
Food Preparation	Fryer
Food Preparation	Dishwasher
Food Preparation	Hot Food Container
Office Equipment	Desktop Computer
Office Equipment	Laptop
Office Equipment	Server
Office Equipment	Monitor
Office Equipment	Printer/Copier/Fax
Office Equipment	POS Terminal
Miscellaneous	Non-HVAC Motors
Miscellaneous	Pool Pump
Miscellaneous	Pool Heater
Miscellaneous	Clothes Washer
Miscellaneous	Clothes Dryer
Miscellaneous	Miscellaneous

The industrial sector was modeled as a whole. The set of end uses and technologies that are appropriate for Ameren's industrial sector are shown in Table 2-4.

Table 2-4 Industrial Electric End Uses and Technologies

End Use	Technology
Cooling	Air-Cooled Chiller
Cooling	Water-Cooled Chiller
Cooling	Roof top AC
Cooling	Air-Source Heat Pump
Cooling	Geothermal Heat Pump
Cooling	PTAC
Cooling	PTHP
Heating	Electric Furnace
Heating	Air-Source Heat Pump
Heating	Geothermal Heat Pump
Heating	Electric Room Heat
Heating	PTHP
Ventilation	Ventilation
Interior Lighting	Screw-in
Interior Lighting	High-Bay Fixtures
Interior Lighting	Linear Fluorescent
Exterior Lighting	Screw-in
Exterior Lighting	HID
Exterior Lighting	Linear Fluorescent
Motors	Pumps
Motors	Fans & Blowers
Motors	Compressed Air
Motors	Material Handling
Motors	Material Processing
Motors	Other Motors
Process	Process Heating
Process	Process Cooling and Refrigeration
Process	Electro-Chemical Processes
Process	Other Process
Miscellaneous	Miscellaneous

With the segmentation scheme defined, we then performed a high-level market characterization of electricity sales in the base year to allocate sales to each customer segment. We used various data sources to identify the annual sales in each customer segment, as well as the market size for each segment. This information provided control totals at a sector level for calibrating the LoadMAP model to known data for the base-year.

Market Profiles

The next step was to develop market profiles for each sector, customer segment, end use, and technology. A market profile includes the following elements:

- **Market size** is a representation of the number of customers in the segment. For the residential sector, it is number of households. In the commercial sector, it is floor space measured in square feet. For the industrial sector, it is number of employees.
- **Saturations** define the fraction of homes and square feet with the various technologies. (e.g., homes with electric space heating).

- **UEC (unit energy consumption) or EUI (energy-use index)** describes the amount of energy consumed in 2011 by a specific technology in buildings that have the technology. For electricity, UECs are expressed in kWh/household for the residential sector, and EUIs are expressed in kWh/square foot or kWh/employee for the commercial and industrial sectors, respectively.
- **Intensity** for the residential sector represents the average energy use for the technology across all homes in 2011. It is computed as the product of the saturation and the UEC and is defined as kWh/household for electricity. For the commercial and industrial sectors, intensity, computed as the product of the saturation and the EUI, represents the average use for the technology across all floor space or all employees in 2011.
- **Usage** is the annual energy use by an end use technology in the segment. It is the product of the market size and intensity and is quantified in GWh. The market assessment results and the market profiles are presented in Chapter 3.

Baseline Projection

The next step was to develop the baseline projection of annual electricity use for 2012 through 2033 by customer segment and end use without new utility programs. The end-use projection includes the relatively certain impacts of codes and standards that will unfold over the study timeframe. All such mandates that were defined as of January 2013 are included in the baseline. The baseline projection is the foundation for the analysis of savings from future EE efforts as well as the metric against which potential savings are measured.

Inputs to the baseline projection include:

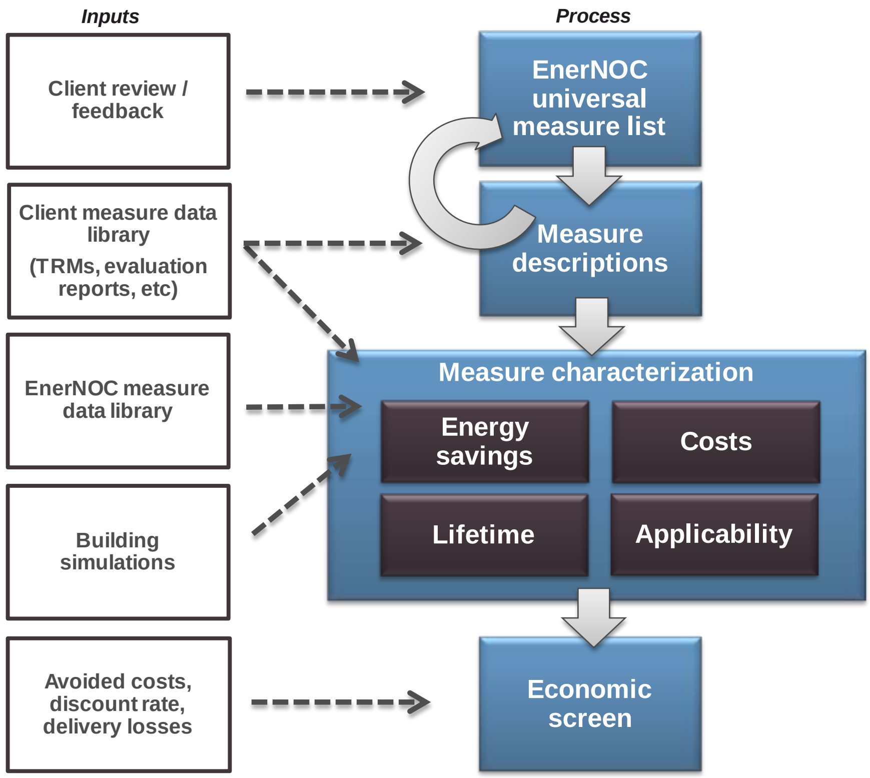
- Current economic growth forecasts (i.e., customer growth, income growth)
- Electricity price forecasts
- Trends in fuel shares and equipment saturations
- Existing and approved changes to building codes and equipment standards
- Naturally occurring efficiency improvements, which include purchases of high-efficiency equipment options by early adopters.

In addition to the baseline projection that includes naturally occurring efficiency improvements, the study also developed a projection that does not include these naturally occurring improvements. It is based on purchase shares that are held fixed at the minimum efficiency level available in the marketplace. The difference between these two projections is the amount of naturally occurring efficiency. We present the baseline-projection results, along with estimates of naturally occurring efficiency savings, in Chapter 4.

Energy Efficiency Measure Analysis

This section describes the framework used to assess the savings, costs, and other attributes of energy-efficiency measures. These characteristics form the basis for measure-level cost-effectiveness analyses as well as for determining measure-level savings. For all measures, EnerNOC assembled information to reflect equipment performance, incremental costs, and equipment lifetimes. We used this information, along with Ameren's avoided costs data, in the economic screen to determine economically feasible measures. Figure 2-3 outlines the framework for measure analysis.

Figure 2-3 Approach for Measure Assessment



The framework for assessing savings, costs, and other attributes of energy efficiency measures involves identifying the list of energy efficiency measures to include in the analysis, determining their applicability to each market sector and segment, fully characterizing each measure, and performing cost-effectiveness screening.

We compiled a robust list of energy efficiency measures for each customer sector, drawing upon Ameren program experience and protocols, the Missouri TRM, EnerNOC's own measure databases and building simulation models, and secondary sources. This universal list of EE measures covers all major types of end-use equipment, as well as devices and actions to reduce energy consumption. If considered today, some of these measures would not pass the economic screens initially, but may pass in future years as a result of lower projected equipment costs or higher avoided costs.

The selected measures are categorized into two types according to the LoadMAP taxonomy: equipment measures and non-equipment measures.

- **Equipment measures** are efficient energy-consuming pieces of equipment that save energy by providing the same service with a lower energy requirement than a standard unit. An example is an ENERGY STAR refrigerator that replaces a standard efficiency refrigerator. For equipment measures, many efficiency levels may be available for a given technology, ranging from the baseline unit (often determined by code or standard) up to the most efficient product commercially available. For instance, in the case of central air conditioners, this list begins with the current federal standard SEER 13 unit and spans a broad spectrum up to a maximum efficiency of a SEER 21 unit.
- **Non-equipment measures** save energy by reducing the need for delivered energy, but do not involve replacement or purchase of major end-use equipment (such as a refrigerator or air conditioner). An example would be a programmable thermostat that is pre-set to run heating and cooling systems only when people are home. Non-equipment measures can

apply to more than one end use. For instance, addition of wall insulation will affect the energy use of both space heating and cooling. Non-equipment measures typically fall into one of the following categories:

- Building shell (windows, insulation, roofing material)
- Equipment controls (thermostat, energy management system)
- Equipment maintenance (cleaning filters, changing setpoints)
- Whole-building design (building orientation, passive solar lighting)
- Lighting retrofits (included as a non-equipment measure because retrofits are performed prior to the equipment's normal end of life)
- Displacement measures (ceiling fan to reduce use of central air conditioners)
- Commissioning and retrocommissioning

We developed a preliminary list of EE measures, which was distributed to Ameren staff and stakeholders for review. The list was finalized after incorporating comments and is presented in the appendix to this volume.

Once we assembled the list of EE measures, the project team assessed their energy-saving characteristics. For each measure we also characterized incremental cost, service life, and other performance factors. Following the measure characterization, we performed an economic screening of each measure, which serves as the basis for developing the economic and achievable potential.

Representative Measure Data Inputs

To provide an example of the measure data, Table 2-5 and Table 2-6 present examples of the detailed data inputs behind both equipment and non-equipment measures, respectively, for the case of residential CAC in single-family homes. Table 2-5 displays the various efficiency levels available as equipment measures, as well as the corresponding useful life, energy usage, and cost estimates. The columns labeled On Market and Off Market reflect equipment availability due to codes and standards or the entry of new products to the market.

Table 2-5 Example Equipment Measures for Central Air Conditioning – Single Family Home

Efficiency Level	Useful Life	Equipment Cost	Energy Usage(kWh/yr)	On Market	Off Market
SEER 13	18	$3,311	2,287	2011	n/a
SEER 14 (ENERGY STAR)	18	$3,716	2,097	2011	n/a
SEER 15 (CEE Tier 2)	18	$4,120	2,013	2011	n/a
SEER 16 (CEE Tier 3)	18	$4,524	1,942	2011	n/a
SEER 17 (Ductless Mini-split)	18	$5,943	1,882	2011	n/a
SEER 21	18	$6,395	1,524	2011	n/a

Table 2-6 lists some of the non-equipment measures applicable to CAC in an existing single-family home. All measures are evaluated for cost-effectiveness based on the lifetime benefits relative to the cost of the measure. The total savings and costs are calculated for each year of the study and depend on the base year saturation of the measure, the applicability[5] of the measure, and the savings as a percentage of the relevant energy end uses.

[5] The applicability factors take into account whether the measure is applicable to a particular building type and whether it is feasible to install the measure. For instance, attic fans are not applicable to homes where there is insufficient space in the attic or there is no attic at all.

Table 2-6 Example Non-Equipment Measures – Single Family Home, Existing

End Use	Measure	Saturation in 2011[6]	Applica-bility	Lifetime (yrs)	Measure Installed Cost	Energy Savings (%)
Cooling	Central AC - Maintenance	37%	100%	2	$175	5%
Cooling	Repair and Sealing – Ducting	16%	50%	18	$498	16%
Cooling	Insulation - Ceiling	33%	38%	20	$363	1%
Cooling	Windows – Install Reflective Film	5%	45%	10	$1,029	11%
Cooling	Windows - ENERGY STAR	47%	90%	20	$7,134	32%

Screening Measures for Cost-Effectiveness

Only measures that are cost-effective are included in economic and achievable potential. Therefore, for each individual measure, LoadMAP performs an economic screen. This study uses the TRC test that compares the lifetime energy benefits (and peak demand for electricity) of each applicable measure with its incremental installed cost, including material and labor. There is no program administration cost considered in this analysis, and therefore, no specific program delivery methods or mechanisms are assumed. The lifetime benefits are calculated by multiplying the annual energy and demand savings for each measure by all appropriate avoided costs for each year, and discounting the dollar savings to the present value equivalent. The analysis uses each measure's values for savings, costs, and lifetimes that were developed as part of the measure characterization process described above.

The LoadMAP model performs this screening dynamically, taking into account changing savings and cost data over time. Thus, some measures pass the economic screen for some — but not all — of the years in the forecast.

It is important to note the following about the economic screen:

- The economic evaluation of every measure in the screen is conducted relative to a baseline condition. For instance, in order to determine the kilowatt-hour (kWh) savings potential of a measure, kWh consumption with the measure applied must be compared to the kWh consumption of a baseline condition.
- The economic screening was conducted only for measures that are applicable to each building type and vintage; thus if a measure is deemed to be irrelevant to a particular building type and vintage, it is excluded from the respective economic screen.

Table 2-7 shows the results of the economic screen, highlighting the economic unit for a central air-source heat pump and select other measures. In 2014, the federal minimum standard efficiency for heat pumps changes from SEER 13 to SEER 14. Before this change, the cost is prohibitive to improve from a SEER 13 baseline. After 2014, however, the incremental cost to go from a SEER 14 to a SEER 15 is proportionally less, thereby making this measure cost-effective. For pool heaters, a heat pump unit is cost effective in all years. For refrigerators, the AHAM federal efficiency standards cause existing Energy Star units to become obsolete in 2014. Units compliant with AHAM 2014 thus become the new minimum efficiency baseline. Since there is not a more efficient, cost-effective unit available, they become both the baseline unit and the economic unit by default. If the measure passes the screen (has a B/C ratio greater than or equal to 1), the measure is included in economic potential. Otherwise, it is screened out for that year. If multiple equipment measures have B/C ratios greater than or equal to 1.0, the most efficient technology is selected by the economic screen.

[6] Note that saturation levels reflected for the base year change over time as more measures are adopted.

Table 2-7 Economic Screen Results for Selected Residential Equipment Measures

Technology	2016	2017	2018
Air Source Heat Pump	SEER 16	SEER 16	SEER 16
Pool Heater	Electric Resistance	Electric Resistance	Heat Pump (COP = 5.0)
Refrigerator	AHAM (2014)	AHAM (2014)	AHAM (2014)

Table 2-8 summarizes the number of equipment and non-equipment measures evaluated for each segment within each sector.

Table 2-8 Number of Measures Evaluated

	Residential	Commercial	Industrial	Total Number of Measures
Equipment Measures Evaluated	115	151	102	**368**
Non-Equipment Measures Evaluated	47	85	67	**199**
Total Measures Evaluated	**162**	**236**	**169**	**567**

The appendix to this volume presents results for the economic screening process by segment, vintage, end use and measure for all sectors.

Energy-Efficiency Potential

The approach we used for this study adheres to the approaches and conventions outlined in the National Action Plan for Energy-Efficiency (NAPEE) Guide for Conducting Potential Studies (November 2007).[7] The NAPEE Guide represents the most credible and comprehensive industry practice for specifying energy-efficiency potential. As described in Chapter 1, four types of potentials were developed as part of this effort: Technical potential, Economic potential, Realistic Achievable Potential and Maximum Achievable potential.

The calculation of Technical and Economic potential is a straightforward algorithm. To develop estimates for **Achievable potential**, we develop market adoption rates for each measure that specify the percentage of customers that will select the highest–efficiency economic option. The market adoption rates are developed based on the results of the program interest surveys that were conducted as part of the primary market research. This more accurately reflects the attitudes of Ameren Missouri's customers.

- For **Realistic Achievable**, we used the average take rates for a 3-year payback period for the measure. Several measures were tested in the survey. These were then mapped to the other remaining measures based on familiarity and ease of installing.
- For **Maximum Achievable**, we used the 1-year payback take rates for those respondents that were more aware and/or more experienced with the measure. This represents a scenario where customers are aware of the measure and the program and receive a higher incentive that reduces the payback to one year. Volume 2 provides detailed information about the estimation of take rates.

Based on EnerNOC's experience running programs and evaluating programs at other utilities, we estimate that the take rates will increase slightly each year as the program and awareness ramps up. Therefore we increase the base year take rates by 0.5% per year. The measure-level potential results are presented in Chapter 5.

[7] National Action Plan for Energy Efficiency (2007). *National Action Plan for Energy Efficiency Vision for 2025: Developing a Framework for Change*. www.epa.gov/eeactionplan.

Program Potential

We then developed preliminary energy efficiency programs for the purpose of developing supply curves. In this step, cost-effective measures are mapped into a specific set of programs. We describe the programs in terms of costs, savings, strategy, and delivery mechanism. Incentive strategies are set and quantified in terms of the appropriate portion of incremental measure costs. In turn, the various program costs (implementation, marketing & education, evaluation, and administration) are added to the incentive budget using best practice research, industry benchmarks, and market trends.

We created two levels of program potential that correspond with measure-level MAP and RAP potential. In their development, we considered industry benchmarks, past Ameren programs, and feedback from Ameren staff. Program-level results and supply curves are presented in Chapter 6.

Data Development

This section details the data sources used in this study, followed by a discussion of how these sources were applied. In general, data were adapted to local conditions, for example, by using local sources for measure data and local weather for building simulations.

Data Sources

The data sources are organized into the following categories:

- Ameren data
- EnerNOC's databases and analysis tools
- Other secondary data and reports

Ameren Data

Our highest priority data sources for this study were those that were specific to Ameren.

- **Ameren customer data:** Ameren provided billing data for non-residential customer establishments. These data were used to develop the sample designs and for the customer surveys.
- **Load forecasts:** Ameren provided an economic growth forecast by sector; electric load forecast; peak-demand forecasts at the sector level; and retail electricity price history and forecasts.
- **Economic information:** Ameren provided avoided cost forecasts, a discount rate, and line loss factor.
- **Missouri TRM:** Ameren provided the Missouri TRM and EnerNOC used it to characterize the energy efficiency measures evaluated in this study.
- **Ameren program data**: Ameren provided information about past and current programs, including program descriptions, goals and achievements to date.

EnerNOC maintains several databases and modeling tools that we use for forecasting and potential studies.

- **EnerNOC Energy Market Profiles**: For more than 10 years, EnerNOC staff have maintained profiles of end-use consumption for the residential, commercial, and industrial sectors. These profiles include market size, fuel shares, unit consumption estimates, and annual energy use by fuel (electricity and natural gas), customer segment and end use for 10 regions in the U.S. The Energy Information Administration surveys (RECS, CBECS and MECS) as well as state-level statistics and local customer research provide the foundation for these regional profiles.

- **Building Energy Simulation Tool (BEST)**. EnerNOC's BEST is a derivative of the DOE 2.2 building simulation model, used to estimate base-year UECs and EUIs, as well as measure savings for the HVAC-related measures.
- **EnerNOC's EnergyShape™:** This database of load shapes includes the following: Residential – electric load shapes for 10 regions, 3 housing types, 13 end uses; Commercial – electric load shapes for 9 regions, 54 building types, 10 end uses; Industrial – electric load shapes, whole facility only, 19 2-digit SIC codes, as well as various 3-digit and 4-digit SIC codes
- **EnerNOC's Database of Energy Efficiency Measures (DEEM):** EnerNOC maintains an extensive database of measure data for our studies. Our database draws upon reliable sources including the California Database for Energy Efficient Resources (DEER), the EIA Technology Forecast Updates – Residential and Commercial Building Technologies – Reference Case, RS Means cost data, and Grainger Catalog Cost data**.**
- **Recent studies**. EnerNOC has conducted numerous studies of EE potential in the last five years. We checked our input assumptions and analysis results against the results from these other studies, which include the 2010 Ameren Missouri Study, Indianapolis Power & Light, Tennessee Valley Authority, Ameren Illinois, Los Angeles Department of Water and Power, Consolidated Edison of New York, Avista Utilities, the State of New Mexico, and Seattle City Light. In addition, we used the information about impacts of building codes and appliance standards from recent reports for the Edison Electric Institute[8].

Other Secondary Data and Reports

Finally, a variety of secondary data sources and reports were used for this study. The main sources are identified below.

- **Annual Energy Outlook**. The Annual Energy Outlook (AEO), conducted each year by the U.S. Energy Information Administration (EIA), presents yearly projections and analysis of energy topics. For this study, we used data from the 2013 AEO.
- **American Community Survey:** The US Census American Community Survey is an ongoing survey that provides data every year on household characteristics. Data for Ameren were available for this study. http://www.census.gov/acs/www/
- **Missouri Weather Data:** Weather from NOAA's National Climatic Data Center for St. Louis was used as the basis for building simulations.
- **EPRI End-Use Models (REEPS and COMMEND)**. These models provide the elasticities we apply to electricity prices, household income, home size and heating and cooling.
- **Database for Energy Efficient Resources (DEER).** The California Energy Commission and California Public Utilities Commission (CPUC) sponsor this database, which is designed to provide well-documented estimates of energy and peak demand savings values, measure costs, and effective useful life (EUL) for the state of California. We used the DEER database to cross check the measure savings we developed using BEST and DEEM.
- **Northwest Power and Conservation Council Sixth Plan workbooks.** To develop its Power Plan, the Council maintains workbooks with detailed information about measures.
- **Other relevant regional sources:** These include reports from the Consortium for Energy Efficiency, the EPA, and the American Council for an Energy-Efficient Economy.

[8] EnerNOC staff have prepared three white papers on the topic of factors that affect U.S. electricity consumption, including appliance standards and building codes. Links to all three white papers are provided:
http://www.edisonfoundation.net/IEE/Documents/IEE_RohmundApplianceStandardsEfficiencyCodes1209.pdf
http://www.edisonfoundation.net/iee/Documents/IEE_CodesandStandardsAssessment_2010-2025_UPDATE.pdf.
http://www.edisonfoundation.net/iee/Documents/IEE_FactorsAffectingUSElecConsumption_Final.pdf

Application of Data to the Analysis

We now discuss how the data sources described above were used for each step of the study.

Data Application for Market Characterization

To construct the high-level market characterization of electricity use and households/floor space for the residential, commercial, and industrial sectors, we applied the following data sources:

- Ameren customer surveys to allocate residential customers by housing type. This was compared to American Community Survey (ACS) and the 2010 Ameren study.
- Ameren billing data and customer surveys to estimate sales and square footage by building type for the commercial sector. The estimates were also compared with the 2010 Ameren study, estimates used by Load Forecasting, and our Energy Market Profiles Database.
- Ameren billing data and customer surveys to estimate energy use and employment for the industrial sector. These estimates were then compared to the 2010 Ameren study.

Data Application for Market Profiles

The specific data elements for the market profiles, together with the key data sources, are shown in Table 2-9. To develop the market profiles for each segment, we used the following approach:

1. Developed control totals for each segment. These include market size, segment-level annual electricity use, and annual intensity.
2. Used Ameren saturation surveys from this study, survey results from the 2010 Ameren Study, RECS 2009, and the American Housing Survey to incorporate information on existing appliance saturations, appliance and equipment characteristics, and building characteristics.
3. Incorporated secondary data sources to supplement and corroborate the data from items 1 and 2 above.
4. Compared and cross-checked with regional data in the Energy Market Profiles Database and other recent EnerNOC studies.
5. Ensured calibration to control totals for annual electricity sales in each sector and segment.
6. Worked with Ameren staff to vet the data against their knowledge and experience.

Data Application for Baseline projection

Table 2-10 summarizes the LoadMAP model inputs required for the baseline projection. These inputs are required for each segment within each sector, as well as for new construction and existing dwellings/buildings.

In addition, we implemented assumptions for known future equipment standards as of June 2013, as shown in Table 2-11 and Table 2-12.

Table 2-9 Data Applied for the Market Profiles

Model Inputs	Description	Key Sources
Market size	Base-year residential dwellings, commercial floor space, and industrial employment	Ameren billing data Ameren current saturation survey 2010 Ameren Study Ameren Load Forecasting
Annual intensity	Residential: Annual energy use (kWh/household) Commercial: Annual energy use (kWh/sq ft) Industrial: Annual energy use (kWh/employee)	Ameren current saturation surveys 2010 Ameren Study Energy Market Profiles AEO 2012 Other recent studies
Appliance/equipment saturations	Fraction of dwellings with an appliance/technology Percentage of C&I floor space/employment with equipment/technology	Ameren current saturation survey 2010 Ameren Study Energy Market Profiles Ameren Load Forecasting
UEC/EUI for each end-use technology	UEC: Annual electricity use for a technology in dwellings that have the technology EUI: Annual electricity use per square foot/employee for a technology in floor space that has the technology	HVAC uses: BEST simulations using prototypes developed for Missouri Missouri TRM Engineering analysis DEEM Recent EnerNOC studies
Appliance/equipment vintage distribution	Age distribution for each technology	Ameren saturation surveys Recent EnerNOC studies
Efficiency options for each technology	List of available efficiency options and annual energy use for each technology	Missouri TRM DEEM DEER NWPCC workbooks AEO 2013 Previous studies
Peak factors	Share of technology energy use that occurs during the peak hour	EnergyShape database

Table 2-10 Data Needs for the Baseline projection and Potentials Estimation in LoadMAP

Model Inputs	Description	Key Sources
Customer growth forecasts	Forecasts of new construction in residential and C&I sectors	Ameren Missouri load forecast AEO 2013 economic growth forecast
Equipment purchase shares for baseline projection	For each equipment/technology, purchase shares for each efficiency level; specified separately for existing equipment replacement and new construction	Shipments data from AEO AEO 2013 regional forecast assumptions[9] Appliance/efficiency standards analysis Ameren Missouri program results and evaluation reports
Electricity prices	Forecast of average energy and capacity avoided costs and retail prices	Ameren Missouri forecast AEO 2013
Utilization model parameters	Price elasticities, elasticities for other variables (income, weather)	EPRI's REEPS and COMMEND models AEO 2013

[9] We developed baseline purchase decisions using the Energy Information Agency's *Annual Energy Outlook* report (2013), which utilizes the National Energy Modeling System (NEMS) to produce a self-consistent supply and demand economic model. We calibrated equipment purchase options to match manufacturer shipment data for recent years and then held values constant for the study period. This removes any effects of naturally occurring conservation or effects of future DSM programs that may be embedded in the AEO forecasts.

Table 2-11 Residential Electric Equipment Standards

Today's Efficiency or Standard Assumption | 1st Standard (relative to today's standard) | 2nd Standard (relative to today's standard)

<table>
<tr><th>End Use</th><th>Technology</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th></tr>
<tr><td rowspan="4">Cooling</td><td>Central AC</td><td colspan="14">SEER 13</td></tr>
<tr><td>Room AC</td><td colspan="2">EER 9.8</td><td colspan="12">EER 11.0</td></tr>
<tr><td>Evaporative Central AC</td><td colspan="14">Conventional</td></tr>
<tr><td>Evaporative Room AC</td><td colspan="14">Conventional</td></tr>
<tr><td>Cooling/Heating</td><td>Heat Pump</td><td colspan="3">SEER 13.0/HSPF 7.7</td><td colspan="11">SEER 14.0/HSPF 8.0</td></tr>
<tr><td>Space Heating</td><td>Electric Resistance</td><td colspan="14">Electric Resistance</td></tr>
<tr><td rowspan="2">Water Heating</td><td>Water Heater (<=55 gallons)</td><td colspan="3">EF 0.90</td><td colspan="11">EF 0.95</td></tr>
<tr><td>Water Heater (>55 gallons)</td><td colspan="3">EF 0.90</td><td colspan="11">Heat Pump Water Heater</td></tr>
<tr><td rowspan="2">Lighting</td><td>Screw-in/Pin Lamps</td><td colspan="2">Incandescent</td><td colspan="6">Advanced Incandescent - tier 1 (20 lumens/watt)</td><td colspan="6">Advanced Incandescent - tier 2 (45 lumens/watt)</td></tr>
<tr><td>Linear Fluorescent</td><td>T12</td><td colspan="13">T8</td></tr>
<tr><td rowspan="5">Appliances</td><td>Refrigerator/2nd Refrigerator</td><td colspan="2">NAECA Standard</td><td colspan="12">25% more efficient</td></tr>
<tr><td>Freezer</td><td colspan="2">NAECA Standard</td><td colspan="12">25% more efficient</td></tr>
<tr><td>Dishwasher</td><td>Conventional (355kWh/yr)</td><td colspan="13">14% more efficient (307 kWh/yr)</td></tr>
<tr><td>Clothes Washer</td><td colspan="3">Conventional (MEF 1.26 for top loader)</td><td colspan="3">MEF 1.72 for top loader</td><td colspan="8">MEF 2.0 for top loader</td></tr>
<tr><td>Clothes Dryer</td><td colspan="3">Conventional (EF 3.01)</td><td colspan="11">5% more efficient (EF 3.17)</td></tr>
</table>

Table 2-12 Commercial Electric Equipment Standards

Today's Efficiency or Standard Assumption

1st Standard (relative to today's standard)

2nd Standard (relative to today's standard)

<table>
<tr><th>End Use</th><th>Technology</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th></tr>
<tr><td rowspan="3">Cooling</td><td>Chillers</td><td colspan="14">2007 ASHRAE 90.1</td></tr>
<tr><td>Roof Top Units</td><td colspan="14">EER 11.0/11.2</td></tr>
<tr><td>Packaged Terminal AC/HP</td><td colspan="14">EER 11.0/11.2</td></tr>
<tr><td>Cooling/Heating</td><td>Heat Pump</td><td colspan="14">EER 11.0/COP 3.3</td></tr>
<tr><td>Ventilation</td><td>Ventilation</td><td colspan="14">Constant Air Volume/Variable Air Volume</td></tr>
<tr><td rowspan="3">Lighting</td><td>Screw-in/Pin Lamps</td><td colspan="2">Incandescent</td><td colspan="6">Advanced Incandescent - tier 1 (20 lumens/watt)</td><td colspan="6">Advanced Incandescent - tier 2 (45 lumens/watt)</td></tr>
<tr><td>Linear Fluorescent</td><td>T12</td><td colspan="13">T8</td></tr>
<tr><td>High Intensity Discharge</td><td colspan="14">88 lumens/watt</td></tr>
<tr><td>Water Heating</td><td>Water Heater</td><td colspan="14">EF 0.97</td></tr>
<tr><td rowspan="6">Refrigeration</td><td>Walk-in Refrigerator/Freezer</td><td colspan="14">EISA 2007 Standard</td></tr>
<tr><td>Reach-in Refrigerator</td><td colspan="14">EPACT 2005 Standard</td></tr>
<tr><td>Glass Door Display</td><td colspan="14">42% more efficient</td></tr>
<tr><td>Open Display Case</td><td colspan="14">18% more efficient</td></tr>
<tr><td>Vending Machines</td><td colspan="14">33% more efficient</td></tr>
<tr><td>Icemaker</td><td colspan="14">2010 Standard</td></tr>
<tr><td rowspan="2">Miscellaneous</td><td>Non-HVAC Motors</td><td colspan="3">62.3% Efficiency</td><td colspan="11">70% Efficiency</td></tr>
<tr><td>Commercial Laundry</td><td>MEF 1.26</td><td colspan="13">MEF 1.6</td></tr>
</table>

Energy Efficiency Measure Data Application

Table 2-13 details the energy-efficiency data inputs to the LoadMAP model. It describes each input and identifies the key sources used in the Ameren analysis.

Table 2-13 Data Needs for the Measure Characteristics in LoadMAP

Model Inputs	Description	Key Sources
Energy Impacts	The annual reduction in consumption attributable to each specific measure. Savings were developed as a percentage of the energy end use that the measure affects.	Missouri TRM BEST DEEM DEER NWPCC workbooks Other secondary sources
Peak Demand Impacts	Savings during the peak demand periods are specified for each electric measure. These impacts relate to the energy savings and depend on the extent to which each measure is coincident with the system peak.	Missouri TRM BEST EnergyShape
Costs	Equipment Measures: Includes the full cost of purchasing and installing the equipment on a per-household, per-square-foot, or per employee basis for the residential, commercial, and industrial sectors, respectively. Non-equipment measures: Existing buildings – full installed cost. New Construction - the costs may be either the full cost of the measure, or as appropriate, it may be the incremental cost of upgrading from a standard level to a higher efficiency level.	Missouri TRM DEEM DEER NWPCC workbooks RS Means Other secondary sources
Measure Lifetimes	Estimates derived from the technical data and secondary data sources that support the measure demand and energy savings analysis.	Missouri TRM DEEM DEER NWPCC workbooks Other secondary sources
Applicability	Estimate of the percentage of either dwellings in the residential sector or square feet/employment in the C&I sectors where the measure is applicable and where it is technically feasible to implement.	Missouri TRM DEEM DEER Other secondary sources
On Market and Off Market Availability	Expressed as years for equipment measures to reflect when the equipment technology is available or no longer available in the market.	EnerNOC appliance standards and building codes analysis

Data Application for Cost-effectiveness Screening

To perform the cost-effectiveness screening, a number of economic assumptions were needed. All cost and benefit values were analyzed as real 2012 dollars. A discount rate of 7% in nominal terms was used. This is equivalent to a 3.93% discount rate in real terms when adjusting for 2.92% inflation.[10] Electric delivery losses of 6.7% were provided by Ameren.

[10] Inflation adjuster of 2.92% based on the average annual growth forecast in US Consumer Price Index from the 2012 Annual Energy Outlook for 2010-2035.

Achievable Potential Estimation

To estimate achievable potential, three sets of parameters are needed to represent customer decision making behavior with respect to energy-efficiency choices.

- **Adoption curves for non-equipment measures**. Equipment measures are installed when existing units fail. Non-equipment measures do not have this natural periodicity, so rather than installing all available non-equipment measures in the first year of the projection (instantaneous potential), they are phased in according to adoption schedules that vary based on cost and complexity. The adoption rates used in this analysis take several factors into account to determine how quickly the market can absorb these measures. Typically, measures that cause disruption to the building, such as wall insulation in existing buildings, receive longer adoption curves, while those with drop-in installations, such as programmable thermostats in new buildings, receive shorter ones. High capital cost measures will also receive longer adoption curves than ones with low capital cost. These adoption rates are used within LoadMAP to generate the Technical and Economic potentials. In general, the rates align with the diffusion of similar equipment measures.
- **Maximum Achievable adoption rates**. Maximum achievable adoption rates are applied to Economic potential to estimate Maximum Achievable potential. These rates represent customer adoption of economic measures when delivered through ideally-operated efficiency programs and under a supportive regulatory framework. Information channels are assumed to be established and efficient for marketing, educating consumers, and coordinating with trade allies and delivery partners. The only barrier to adoption reflected in this case is customer preferences.

  The Maximum Achievable adoption rates are based on the take rates for a 1-year payback from customers that are aware and have information about energy efficiency measures and programs. The take rates were developed based on the results of the program interest survey conducted as part of this study and described in Volume 2 of the report.
- **Realistic Achievable adoption rates**. To calculate Realistic Achievable potential, Realistic Achievable adoption rates are applied. The Realistic Achievable adoption rates are based on the average three-year payback take rate from the primary market research. These rates reflect expected program participation given significant barriers to customer acceptance, non-ideal implementation conditions, and limited program budgets. This represents a lower bound on achievable potential.

Realistic Achievable and Maximum Achievable adoption rates are presented in the appendix to this volume. The development of the take rates are detailed in Volume 2.

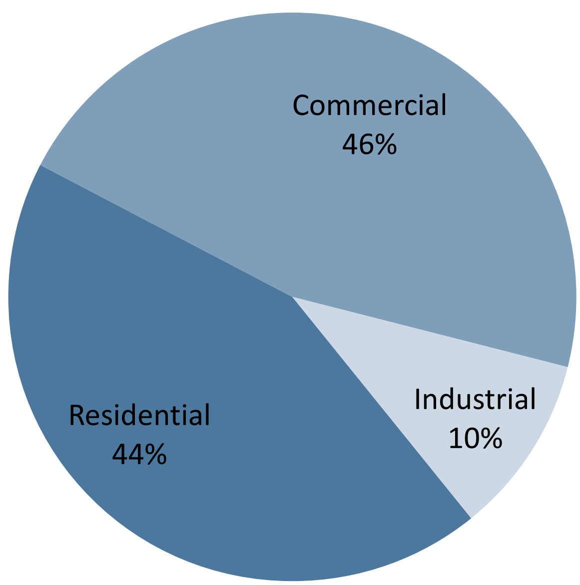
MARKET CHARACTERIZATION AND MARKET PROFILES

In this section, we describe how customers in the Ameren Missouri service territory use electricity in the base year of the study, 2011. It begins with a high-level summary of energy use by sector and then delves into each sector in detail.

Energy Use Summary

Total electricity use for the residential, commercial, and industrial sectors for Ameren in 2011 was 30,753 GWh. This total does not include opt-out customers. As a result, and as shown in Figure 3-1, the largest sector is commercial, accounting for 46% of load at 14,241 GWh. The residential sector accounts for 44% or 13,375 GWh. The industrial sector, less some very large opt-out customers, accounts for 10%, or 3,137 GWh.

Figure 3-1 Sector-Level Electricity Use, 2011



Residential Sector

The total number of households and electric sales for the service territory were obtained from Ameren's customer database. In 2011, there were just over 1 million households in the Ameren territory that used a total of 13,375 GWh. We allocated these totals into the two residential segments and the values are shown in Table 3-1. These are the *control totals* to which residential electricity use is calibrated in the base year of the study.

Table 3-1 Residential Sector Energy Usage and Intensity by Segment Type, 2011

Segment	No. of Households	2011 Electricity Use (GWh)	Intensity (kWh/Household)
Single Family	754,472	11,208	14,856
Multi Family	280,077	2,167	7,737
Total	**1,034,549**	**13,375**	**12,929**

Composite Electric Profile

As we describe in the previous chapter, the market profiles provide the foundation for development of the baseline projection and the potential estimates. The average market profile for the residential sector is presented in Table 3-2. Segment specific market profiles are presented in the appendix to this volume.

Figure 3-2 shows the distribution of electricity use by end use for all homes. Three main electricity end uses —appliances, space heating and cooling — account for 60% of total use. Appliances include refrigerators, freezers, stoves, clothes washers, clothes dryers, dishwashers, and microwaves. The remainder of the energy falls into the electronics, lighting, water heating and the miscellaneous category – which is comprised of furnace fans, pool pumps, and other "plug" loads (all other usage not covered by those listed in Table 3-2 such as hair dryers, power tools, coffee makers, etc).

Figure 3-2 Residential Electricity by End Use (2011), All Homes

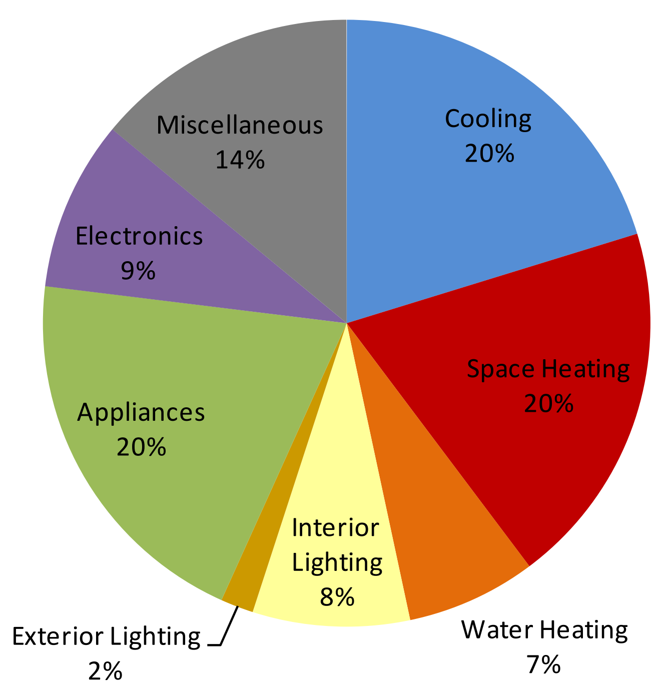


Table 3-2 Average Electric Market Profile for the Residential Sector, 2011

End Use	Technology	Saturation	UEC (kWh)	Intensity (kWh/HH)	Usage (GWh)
Cooling	Central AC	88.9%	2,736	2,434	2,518
Cooling	Room AC	4.8%	1,712	83	86
Cooling	Air-Source Heat Pump	2.9%	2,897	83	86
Cooling	Geothermal Heat Pump	0.9%	2,027	17	18
Space Heating	Electric Resistance	2.0%	6,441	129	133
Space Heating	Electric Furnace	32.6%	6,763	2,208	2,284
Space Heating	Air-Source Heat Pump	2.9%	5,628	166	171
Space Heating	Geothermal Heat Pump	0.9%	1,993	19	19
Water Heating	Water Heater <= 55 gal	26.3%	2,512	661	684
Water Heating	Water Heater > 55 gal	8.6%	2,678	231	239
Interior Lighting	Screw-in	100.0%	945	945	978
Interior Lighting	Linear Fluorescent	60.6%	104	63	65
Interior Lighting	Specialty	31.0%	236	73	76
Exterior Lighting	Screw-in	84.9%	268	227	235
Appliances	Refrigerator	100.0%	725	725	750
Appliances	Second Refrigerator	36.3%	844	306	317
Appliances	Freezer	36.9%	576	213	220
Appliances	Clothes Washer	90.0%	96	86	89
Appliances	Clothes Dryer	77.4%	704	544	563
Appliances	Dishwasher	80.6%	401	323	334
Appliances	Stove	68.0%	434	295	305
Appliances	Microwave	96.9%	121	117	121
Electronics	Personal Computers	64.0%	279	178	185
Electronics	Monitor	64.0%	55	35	37
Electronics	Laptops	71.5%	120	86	89
Electronics	TVs	284.7%	233	664	687
Electronics	Printer/Fax/Copier	82.5%	42	35	36
Electronics	Set-top Boxes/DVR	82.8%	141	117	121
Electronics	Devices and Gadgets	53.4%	105	56	58
Miscellaneous	Air Purifier/Cleaner	12.4%	1,282	159	164
Miscellaneous	Dehumidifier	20.0%	1,533	307	318
Miscellaneous	Pool Pump	5.5%	1,575	87	90
Miscellaneous	Pool Heater	2.2%	5,230	114	118
Miscellaneous	Hot Tub / Spa	6.6%	998	65	68
Miscellaneous	Furnace Fan	89.3%	373	332	344
Miscellaneous	Miscellaneous	100.0%	744	744	770
	Total			**12,929**	**13,375**

Figure 3-3 and Table 3-3 present the electricity intensities by end use and housing type.

Figure 3-3 Residential Electricity Intensity by End Use and Segment (kWh/household, 2011)

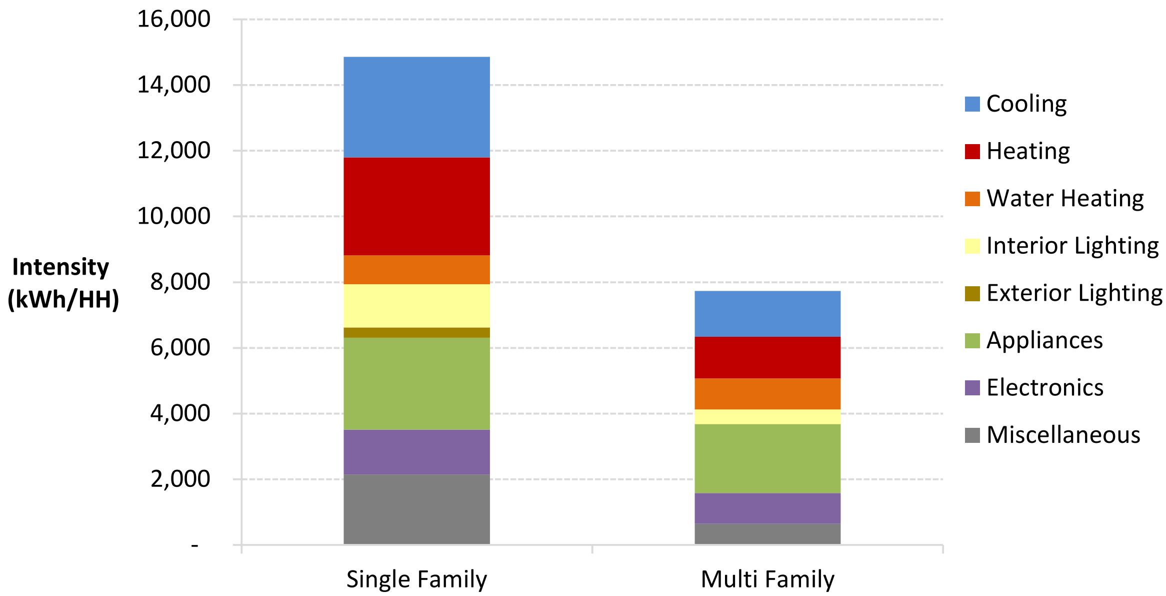


Table 3-3 Residential Electricity Use by End Use and Segment (kWh/HH/year, 2011)

End Use	Single Family	Multi Family	Total
Cooling	3,060	1,402	2,611
Space Heating	2,985	1,259	2,518
Water Heating	871	950	892
Interior Lighting	1,317	448	1,081
Exterior Lighting	311	0	227
Appliances	2,801	2,094	2,609
Electronics	1,359	940	1,246
Misc.	2,152	644	1,744
Total	**14,856**	**7,737**	**12,929**

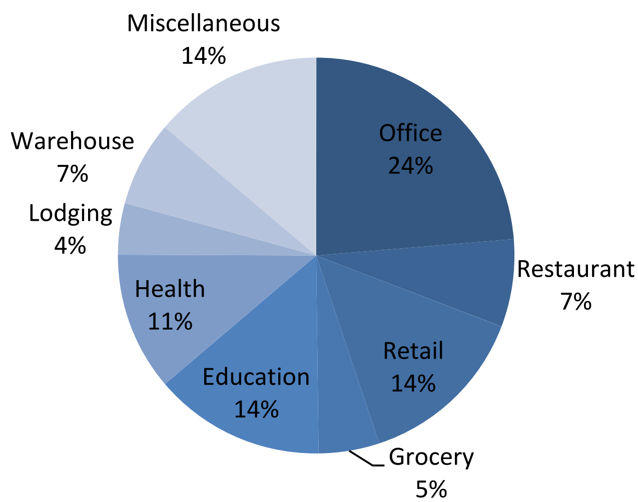
Commercial Sector

The total electric energy consumed by commercial customers in Ameren's service area in 2011 was 14,231 GWh. The results of the saturation survey and information from Ameren's forecast were used to allocate this energy usage to building types and to develop estimates of energy intensity (annual kWh/square foot). Using the electricity use and intensity estimates, we infer floor space which is the unit of analysis in LoadMAP for the commercial sector. The values are shown in Table 3-4 . These are the commercial-sector *control totals* to which all energy usage is calibrated in the base year of the study. Figure 3-4 shows the size of each of the building-types as a percentage of total commercial electricity use.

Table 3-4 Commercial Electricity Use by End Use and Segment (2011)

Segment	Electricity Use (GWh)	Intensity (kWh/SqFt)	Floor Space (million SqFt)
Office	3,370	21.6	156.1
Restaurant	1,019	37.2	27.4
Retail	1,992	11.2	178.4
Grocery	707	61.1	11.6
Education	1,985	8.0	248.1
Health	1,608	15.2	105.9
Lodging	598	11.5	51.9
Warehouse	987	6.3	156.5
Miscellaneous	1,963	9.7	201.9
All	14,231	12.5	1,137.8

Figure 3-4 Commercial Market Segmentation by Building Type – Percentage of Electricity Use



Composite Electric Profile

Table 3-5 shows the average market profile for electricity of the commercial sector as a whole, representing a composite of all the building types. Market profiles for each building type are presented in the appendix to this volume.

Table 3-5 Average Electric Market Profile for the Commercial Sector, 2011

End Use	Technology	Saturation	EUI (kWh)	Intensity (kWh/Sq ft)	Usage (GWh)
Cooling	Air-Cooled Chiller	5.8%	2.63	0.15	174
Cooling	Water-Cooled Chiller	7.1%	4.20	0.30	341
Cooling	Roof top AC	27.1%	3.12	0.85	964
Cooling	Air-Source Heat Pump	1.3%	3.21	0.04	49
Cooling	Geothermal Heat Pump	0.4%	2.05	0.01	9
Cooling	PTAC	0.5%	3.17	0.02	19
Cooling	PTHP	4.8%	3.17	0.15	173
Heating	Electric Furnace	4.6%	6.18	0.29	327
Heating	Air-Source Heat Pump	1.3%	6.20	0.08	95
Heating	Geothermal Heat Pump	0.4%	3.32	0.01	14
Heating	Electric Room Heat	3.4%	6.99	0.24	270
Heating	PTHP	4.8%	2.99	0.14	163
Ventilation	Ventilation	100.0%	1.70	1.70	1,935
Water Heating	Water Heating	28.0%	0.92	0.26	293
Interior Lighting	Screw-in	100.0%	0.76	0.76	861
Interior Lighting	High-Bay Fixtures	100.0%	0.30	0.30	339
Interior Lighting	Linear Fluorescent	100.0%	2.33	2.33	2,647
Exterior Lighting	Screw-in	100.0%	0.13	0.13	145
Exterior Lighting	HID	100.0%	0.37	0.37	421
Exterior Lighting	Linear Fluorescent	100.0%	0.13	0.13	146
Refrigeration	Walk-in Refrigerator	14.7%	1.96	0.29	327
Refrigeration	Reach-in Refrigerator	19.1%	0.12	0.02	27
Refrigeration	Glass Door Display	21.0%	1.21	0.25	290
Refrigeration	Open Display Case	11.9%	1.41	0.17	192
Refrigeration	Icemaker	32.8%	0.41	0.14	154
Refrigeration	Vending Machine	18.6%	0.40	0.07	84
Food Preparation	Oven	16.0%	0.34	0.05	62
Food Preparation	Fryer	4.3%	0.51	0.02	25
Food Preparation	Dishwasher	19.8%	0.72	0.14	162
Food Preparation	Hot Food Container	8.8%	0.11	0.01	11
Office Equipment	Desktop Computer	100.0%	0.33	0.33	371
Office Equipment	Laptop	98.2%	0.06	0.06	70
Office Equipment	Server	88.4%	0.28	0.25	285
Office Equipment	Monitor	100.0%	0.09	0.09	103
Office Equipment	Printer/Copier/Fax	100.0%	0.11	0.11	125
Office Equipment	POS Terminal	63.6%	0.05	0.03	38
Misc	Non-HVAC Motors	3.0%	0.51	0.01	17
Misc	Pool Pump	4.6%	0.01	0.00	1
Misc	Pool Heater	1.4%	0.03	0.00	0
Misc	Clothes Washer	15.1%	0.01	0.00	1
Misc	Clothes Dryer	11.1%	0.01	0.00	1
Misc	Misc	100.0%	2.20	2.20	2,498
Total				**12.51**	**14,231**

Commercial Electricity Consumption

Figure 3-5 shows the distribution of electricity consumption by end use for all commercial building types. Electric usage is dominated by lighting, with interior and exterior uses accounting for one third of consumption. After lighting, the largest end uses are ventilation and cooling, which account for a quarter of total use. Miscellaneous uses, which include uses not elsewhere covered in the table above, include medical equipment, water coolers, power tools, and other plug loads.

Figure 3-5 Commercial Electricity Consumption by End Use (2011), All Building Types

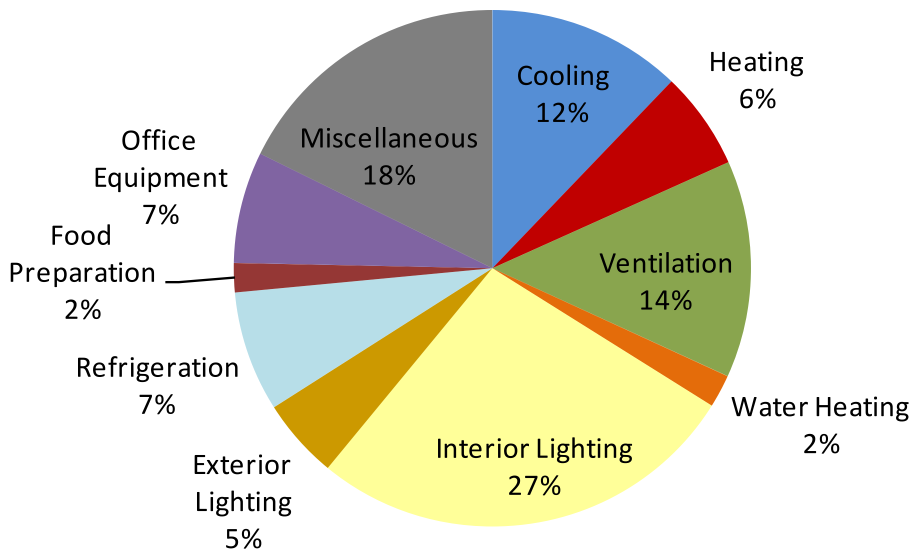


Figure 3-6 shows the electricity intensity by end use and building type in terms of kWh per square foot of building floor space. The grocery sector is the most energy intensive as a result of high refrigeration loads. Restaurants are second as a result of high refrigeration and electric food preparation loads. Offices are third with an intensity just over 20 kWh/sq.ft. per year in 2011.

Figure 3-6 Commercial Electricity Intensity by End Use and Segment (kWh/SqFt, 2011)

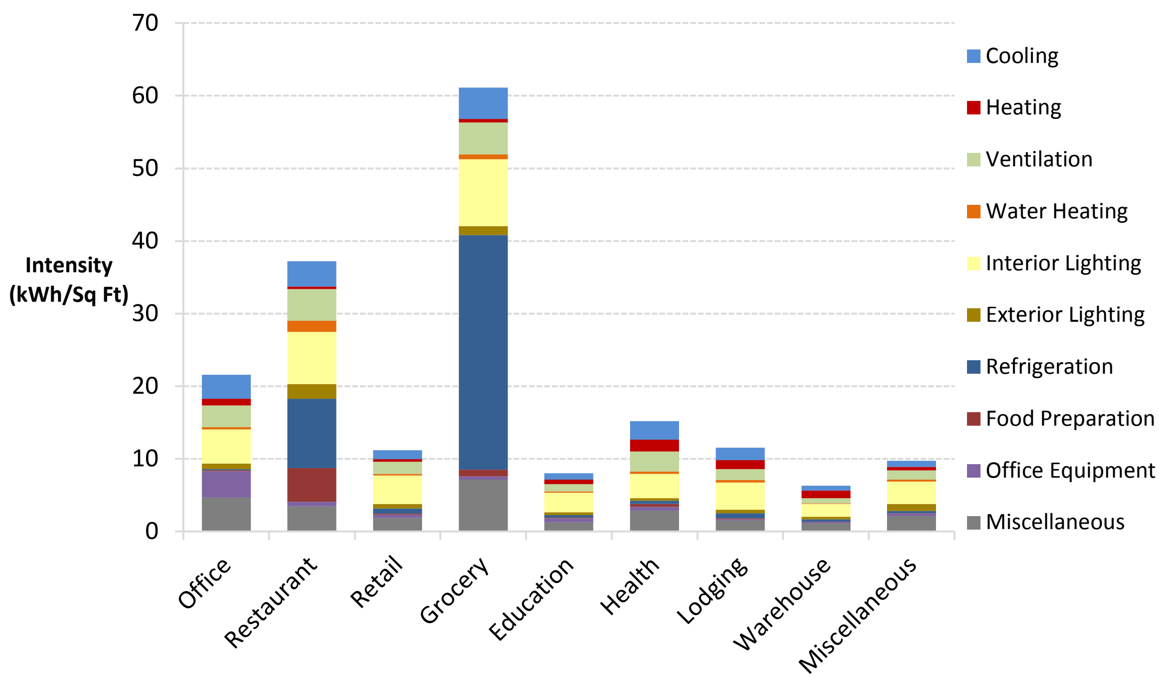


Figure 3-7 and Table 3-6 present the electricity usage in GWh by end use and building type. While offices are third highest in terms of electric intensity, they account for the highest share of electricity use in Ameren's commercial sector. As far as end uses, lighting is a major use across all buildings. Office equipment is concentrated in offices.

Figure 3-7 Commercial Electricity Usage by End Use Segment (GWh, 2011)

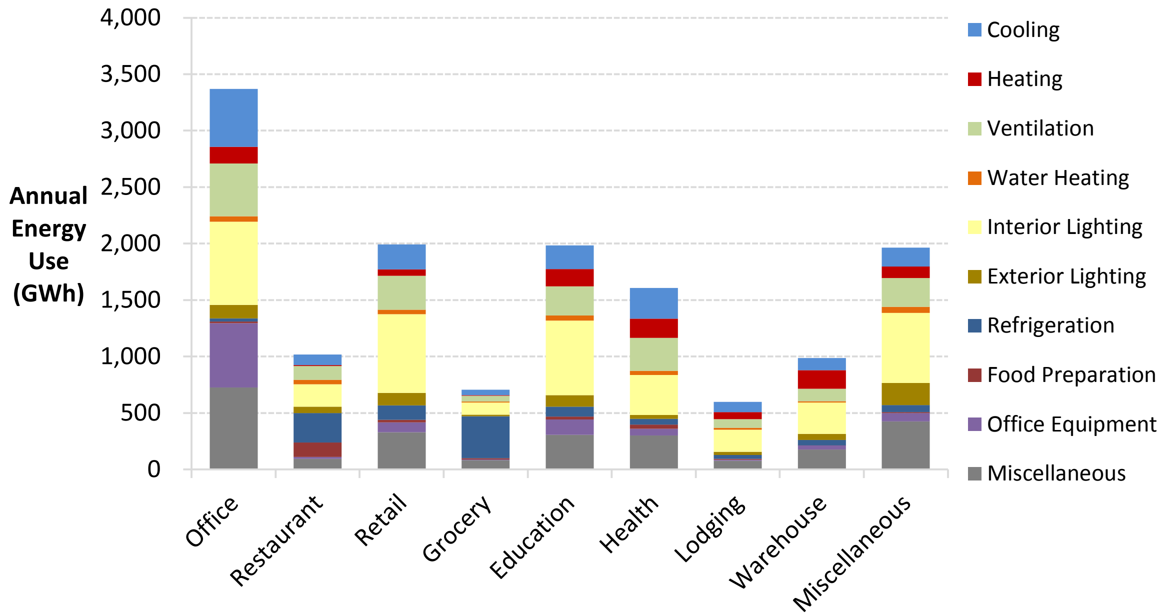


Table 3-6 Commercial Electricity Consumption by End Use (GWh, 2011)

End use	Office	Rest-aurant	Retail	Grocery	Educa-tion	Health	Lodging	Ware-house	Miscell-aneous	Total
Cooling	514	95	221	50	212	272	90	109	166	1,730
Heating	145	9	56	6	152	172	64	163	103	870
Ventilation	470	120	301	51	258	291	77	112	255	1,935
Water Heating	46	42	39	8	44	35	18	10	52	293
Interior Lighting	737	196	696	107	662	355	195	278	620	3,847
Exterior Lighting	121	56	110	14	101	34	26	52	197	712
Refrigeration	26	261	128	374	87	51	35	49	61	1,073
Food Preparation	16	127	23	11	28	39	8	1	9	261
Office Equipment	568	18	87	5	133	59	9	36	75	991
Misc	727	93	329	82	308	300	77	176	426	2,519
Total	**3,370**	**1,019**	**1,992**	**707**	**1,985**	**1,608**	**598**	**987**	**1,963**	**14,231**

Industrial Sector

The total electricity used in 2011 by Ameren's industrial customers who have not opted out was 3,137 GWh. Because this sector is relatively small and is heterogeneous with respect to industry type, the sector was treated as a whole in the analysis. We used the customer surveys and information from forecasting to disaggregate total electricity use into the major end uses. Table 3-7 shows the composite market profile for the industrial sector.

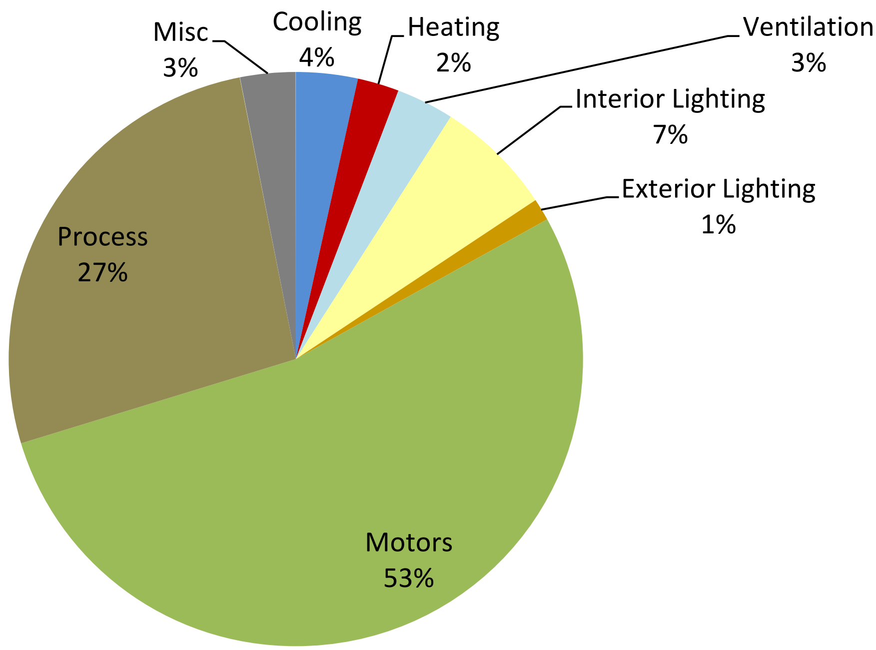
Table 3-7 Average Electric Market Profile for the Industrial Sector, 2011

Average Market Profiles

End Use	Technology	Saturation	EUI (kWh)	Intensity (kWh/Empl)	Usage (GWh)
Cooling	Air-Cooled Chiller	8.0%	1,310	105	16
Cooling	Water-Cooled Chiller	3.0%	2,047	61	9
Cooling	Roof top AC	21.0%	2,105	442	68
Cooling	Air Source Heat Pump	2.0%	2,105	42	6
Cooling	Geothermal Heat Pump	0.0%	1,404	-	-
Cooling	PTAC	0.3%	2,016	6	1
Cooling	PTHP	2.7%	2,016	54	8
Heating	Electric Furnace	2.0%	7,976	160	24
Heating	Air-Source Heat Pump	2.0%	8,008	160	25
Heating	Geothermal Heat Pump	0.0%	5,341	-	-
Heating	Electric Room Heat	1.0%	7,596	76	12
Heating	PTHP	2.7%	3,038	82	13
Ventilation	Ventilation	100.0%	667	667	102
Interior Lighting	Screw-in	100.0%	128	128	20
Interior Lighting	High-Bay Fixtures	100.0%	207	207	32
Interior Lighting	Linear Fluorescent	100.0%	1,020	1,020	156
Exterior Lighting	Screw-in	100.0%	91	91	14
Exterior Lighting	HID	100.0%	28	28	4
Exterior Lighting	Linear Fluorescent	100.0%	136	136	21
Motors	Pumps	100.0%	1,928	1,928	295
Motors	Fans & Blowers	100.0%	1,509	1,509	231
Motors	Compressed Air	100.0%	1,205	1,205	185
Motors	Matl Handling	100.0%	1,659	1,659	254
Motors	Matl Processing	100.0%	3,781	3,781	579
Motors	Other Motors	100.0%	843	843	129
Process	Process Heating	100.0%	2,970	2,970	455
Process	Process Cooling and Refrig	100.0%	1,454	1,454	223
Process	Electro-Chemical Processes	100.0%	761	761	117
Process	Other Process	100.0%	269	269	41
Misc	Misc	100.0%	639	639	98
	Total			**20,482**	**3,137**

Figure 3-8 shows the distribution of electricity energy consumption by end use for all industrial customers. Motors are clearly the largest overall end use for the industrial sector, accounting for 53% of energy use. Note that this end use includes a wide range of industrial equipment, such as air compressors and refrigeration compressors, pumps, conveyor motors, and fans. The process end use accounts for 27% of energy use, which includes heating, cooling, refrigeration, and electro-chemical processes. Lighting is the next highest, followed by cooling, ventilation, miscellaneous, and space heating.

Figure 3-8 Industrial Electricity Use by End Use (2011), All Industries



BASELINE PROJECTION

Prior to developing estimates of energy-efficiency potential, a baseline end-use projection was developed to quantify what the consumption is likely to be in the future in absence of new efficiency programs. The baseline projection incorporates assumptions about:

- Economic growth
- Appliance/equipment standards and building codes already mandated (see Chapter 2)
- Future electricity prices and other drivers of consumption
- Trends in fuel shares and appliance saturations and assumptions about miscellaneous electricity growth
- Naturally occurring energy efficiency, which reflects the manufacture of more efficient options in response to new appliance standards and purchases of high-efficiency appliances and equipment by early adopters outside of utility programs.

The baseline projection is not Ameren's official load forecast. Rather it was developed to serve as the metric against which energy efficiency potentials are measured. This chapter presents the baseline projection for each sector and end use. It also presents estimates of naturally occurring energy efficiency.

Residential Sector

Table 4-1 and Figure 4-1 present the baseline projection for electricity at the end-use level for the residential sector as a whole. Overall, residential use increases slightly from 13,375 GWh in 2011 to 14,343 GWh in 2030, an increase of 7.2%. This reflects the impact of the EISA lighting standard, additional appliance standards adopted in 2011, and modest customer growth. This table also shows the estimate of naturally occurring energy efficiency, which has the greatest impact in the early years of the projection due to early adoption of LED lamps. Naturally-occurring efficiency is computed as the difference between a "codes & standards projection" (also shown in Table 4-1 and Figure 4-1) and the baseline projection.

Table 4-1 Residential Baseline Projection by End Use (GWh)

End Use	2011	2016	2017	2018	2025	2030	% Change ('11-'30)
Cooling	2,701	2,643	2,656	2,677	2,804	2,898	7%
Heating	2,605	2,628	2,643	2,664	2,774	2,857	10%
Water Heating	923	921	919	919	900	879	-5%
Int. Lighting	1,119	709	717	675	479	474	-58%
Ext. Lighting	235	152	155	146	92	92	-61%
Appliances	2,699	2,388	2,352	2,326	2,250	2,320	-14%
Electronics	1,289	1,363	1,407	1,457	1,714	1,857	44%
Miscellaneous	1,804	2,086	2,160	2,243	2,726	2,967	64%
Total	**13,375**	**12,891**	**13,008**	**13,107**	**13,740**	**14,343**	**7.2%**
Naturally occurring EE	-	191	199	205	28	39	n/a
Codes & Stds Projection	**13,375**	**13,082**	**13,207**	**13,312**	**13,768**	**14,382**	**7.5%**

Figure 4-1 Residential Baseline Projection by End Use

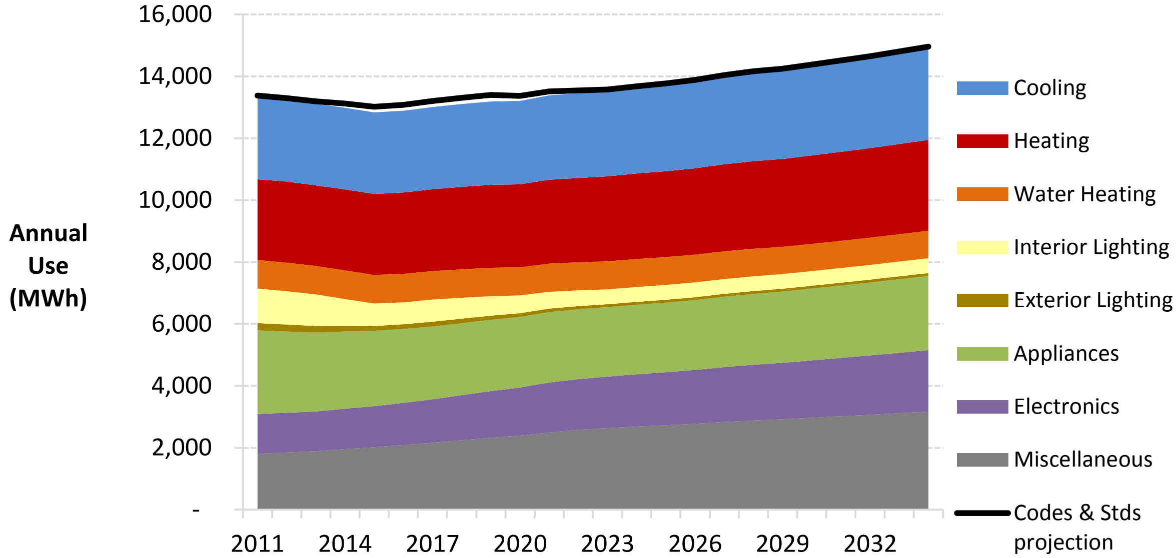


Figure 4-2 presents the baseline projection of annual electricity use per household. Most noticeable is that lighting use decreases significantly throughout the time period as the lighting efficiency standards from EISA come into effect.

Figure 4-2 Residential Use per Household by End Use

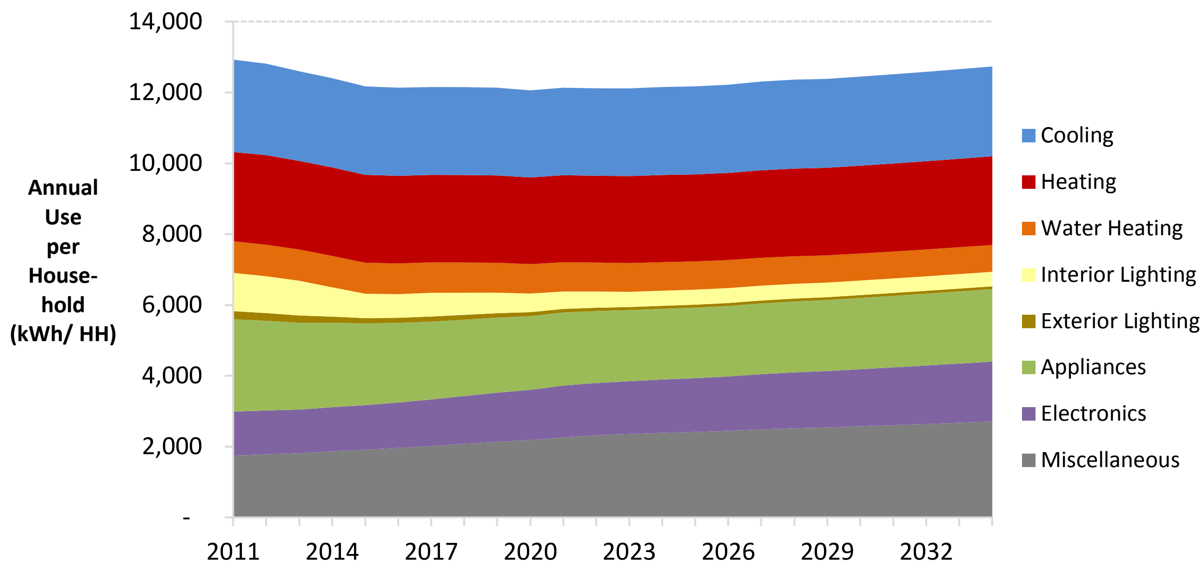


Table 4-2 shows the end-use forecast at the technology level for select years. Specific observations include:

1. The primary reason for the reduction in the baseline projection beginning in 2012 is the federal lighting standards. The standard phases general service incandescent lamps out of the market over a three-year period.
2. The baseline projection also incorporates the effects of naturally occurring efficiency, which reflects consumer purchases of more efficient options outside of utility programs, both early adopters and market transformation.
3. Appliance energy use decreases markedly, reflecting efficiency gains from standards.

4. Growth in use in electronics is substantial and reflects an increase in the saturation of electronics and the trend toward higher-powered computers.

5. Growth in miscellaneous use is also substantial. This end use has grown consistently in the past and we incorporate future growth assumptions that are consistent with the Annual Energy Outlook.

Table 4-2 Residential Baseline Projection by End Use and Technology (GWh)

End Use	Technology	2011	2016	2017	2018	2025	2030	% Change ('11-'30)
Cooling	Central AC	2,518	2,455	2,466	2,486	2,600	2,680	6.5%
	Room AC	86	80	79	79	75	74	-13.5%
	Air-Source Heat Pump	80	89	91	93	109	122	53.3%
	Geothermal Heat Pump	18	19	19	19	21	22	19.6%
Heating	Furnace	2,284	2,301	2,312	2,330	2,415	2,472	8.2%
	Electric Room Heat	133	128	127	126	120	117	-11.9%
	Air-Source Heat Pump	168	180	183	187	217	244	45.3%
	Geothermal Heat Pump	19	20	21	21	22	23	19.4%
Water Heating	Water Heater <= 55 gal	684	692	697	704	729	741	8.4%
	Water Heater > 55 gal	239	228	222	216	171	138	-42.4%
Interior Lighting	Screw-in	978	585	596	559	356	353	-63.9%
	Linear Fluorescent	65	67	67	68	72	74	13.6%
	Specialty	76	57	54	49	52	48	-36.8%
Ext. Light	Screw-in	235	152	155	146	92	92	-61.0%
Appliances	Clothes Washer	89	81	78	75	56	48	-46.7%
	Clothes Dryer	563	521	517	514	513	525	-6.8%
	Dishwasher	334	277	273	271	283	297	-11.0%
	Refrigerator	750	611	586	566	467	470	-37.3%
	Freezer	220	193	191	190	193	207	-5.9%
	Second Refrigerator	317	251	245	241	224	235	-25.7%
	Stove	305	328	334	339	374	395	29.3%
	Microwave	121	127	128	130	138	142	17.7%
Electronics	Personal Computers	185	235	247	260	319	342	85.6%
	Monitor	37	46	48	50	62	66	81.0%
	Laptops	89	109	114	120	167	208	134.2%
	Printer/Fax/Copier	36	34	34	34	36	36	1.2%
	TVs	687	674	684	696	753	793	15.4%
	Set-top Boxes/DVR	173	156	163	171	210	226	30.8%
	Devices and Gadgets	83	110	117	125	167	184	122.4%
Miscella-neous	Pool Pump	90	99	102	104	121	132	47.3%
	Pool Heater	118	125	127	129	145	157	32.7%
	Hot Tub / Spa	68	75	77	79	90	98	44.2%
	Furnace Fan	344	373	380	388	428	451	31.0%
	Air Purifier/Cleaner	164	174	177	180	201	218	32.5%
	Dehumidifier	318	294	291	289	283	290	-8.8%
	Miscellaneous	703	946	1,007	1,074	1,458	1,623	130.9%
Total		**13,375**	**12,891**	**13,008**	**13,107**	**13,740**	**14,343**	**7.2%**

Commercial Sector

Electricity use in the commercial sector grows modestly during the overall forecast horizon, starting at 14,231 GWh in 2011, and increasing to 15,867 in 2030. Table 4-3 and Figure 4-3 present the baseline projection at the end-use level for the commercial sector as a whole. Usage is declining in the early years of the forecast, due largely to the phasing in of codes and standards such as the EISA 2007 lighting standards and EPACT 2005 refrigeration standards, as well as naturally occurring energy efficiency. Also shown is the estimate of savings from naturally occurring energy efficiency, developed using a codes and standards projection. These savings are 422 GWh in 2030, or 2.6% of the codes and standards projection that was used to develop the estimates. Most of these savings come from early adoption of lighting upgrades.

Table 4-3 Commercial Baseline Projection by End Use (GWh)

End Use	2011	2016	2017	2018	2025	2030	% Change ('11-'30)
Cooling	1,730	1,745	1,735	1,734	1,666	1,653	-4.4%
Heating	870	971	979	990	1,017	1,029	18.2%
Ventilation	1,935	1,566	1,537	1,523	1,542	1,566	-19.1%
Water Heating	293	328	331	335	345	351	19.6%
Interior Lighting	3,847	3,266	3,220	3,195	3,016	2,988	-22.3%
Ext. Lighting	712	605	594	587	555	574	-19.5%
Refrigeration	1,073	921	908	900	901	960	-10.5%
Food Prep	261	286	289	293	325	354	35.9%
Office Equip	991	1,166	1,192	1,222	1,387	1,468	48.1%
Miscellaneous	2,519	3,295	3,414	3,540	4,351	4,924	95.5%
Total	**14,231**	**14,149**	**14,199**	**14,320**	**15,105**	**15,867**	**11.5%**
Naturally occurring EE	-	119	139	146	350	422	n/a
Codes & Stds Projection	**14,231**	**14,268**	**14,338**	**14,466**	**15,455**	**16,289**	**14.5%**

Figure 4-3 Commercial Baseline Projection by End Use

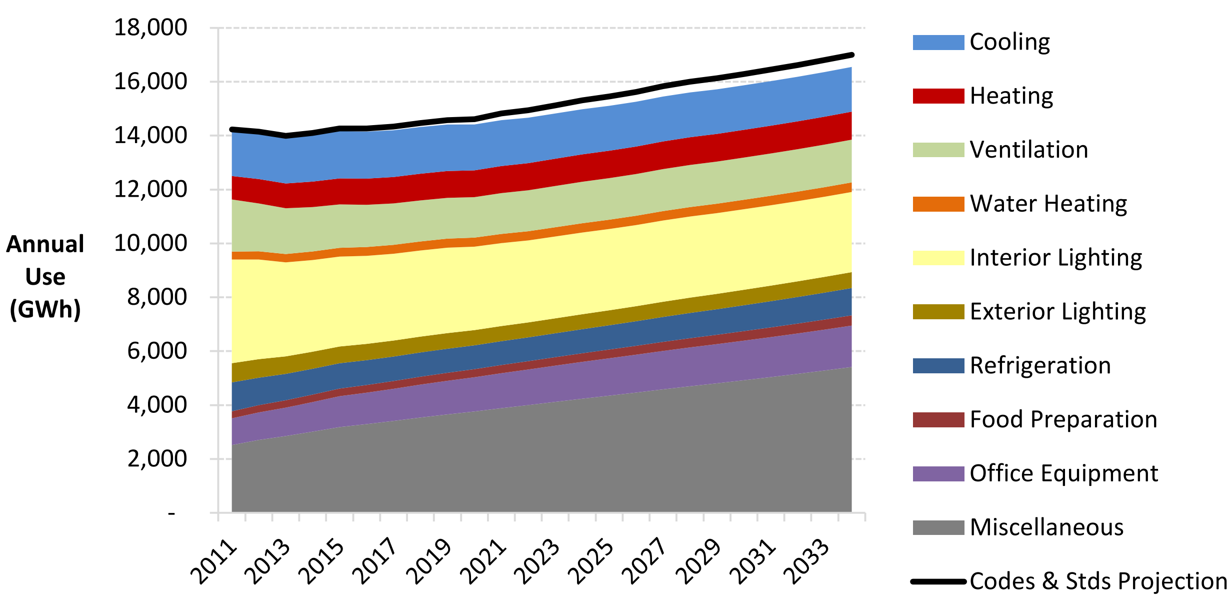


Table 4-4 presents the commercial sector electricity forecast by technology for select years. Interior screw-in lighting and refrigeration decrease significantly over the forecast period as a result of efficiency standards.

Table 4-4 Commercial Baseline Forecast by End Use and Technology (GWh)

End Use	Technology	2011	2016	2017	2018	2025	2030	% Change ('11-'30)
Cooling	Air-Cooled Chiller	174	195	197	199	204	204	17.3%
	Water-Cooled Chiller	341	324	321	319	289	275	-19.6%
	Roof top AC	964	972	965	962	923	924	-4.1%
	Geothermal Heat Pump	9	8	8	8	7	7	-17.6%
	Air Source Heat Pump	49	46	45	45	41	41	-17.1%
	PTAC	19	22	22	22	23	23	21.7%
	PTHP	173	178	178	178	177	179	3.3%
Heating	Geothermal Heat Pump	14	15	15	15	14	14	-0.4%
	Electric Room Heat	270	309	312	317	328	334	23.5%
	Electric Furnace	327	368	371	375	385	388	18.5%
	Air Source Heat Pump	95	97	96	96	96	96	1.3%
	PTHP	163	183	185	187	194	197	20.4%
Ventilation	Ventilation	1,935	1,566	1,537	1,523	1,542	1,566	-19.1%
Water Heating	Water Heating	293	328	331	335	345	351	19.6%
Interior Lighting	Screw-in	861	547	544	544	387	330	-61.7%
	High-Bay Fixtures	339	271	267	263	258	268	-20.8%
	Linear Fluorescent	2,647	2,449	2,409	2,388	2,371	2,390	-9.7%
Exterior Lighting	Screw-in	145	80	80	80	57	49	-66.4%
	HID	421	363	357	354	348	368	-12.6%
	Linear Fluorescent	146	161	157	154	150	157	7.5%
Refrigeration	Walk-in Refrigerator	327	241	232	226	218	231	-29.4%
	Reach-in Refrigerator	27	21	21	20	22	26	-3.9%
	Glass Door Display	290	231	228	226	216	229	-21.0%
	Open Display Case	192	189	189	190	194	204	6.6%
	Icemaker	154	173	176	179	199	216	40.7%
	Vending Machine	84	65	61	58	51	54	-35.7%
Food Preparation	Oven	62	72	74	75	86	95	51.3%
	Fryer	25	32	33	34	42	49	97.4%
	Dishwasher	162	170	171	172	184	197	21.4%
	Hot Food Container	11	12	12	12	13	14	24.5%
Office Equipment	Desktop Computer	371	431	439	449	502	526	41.6%
	Laptop	70	85	87	90	108	117	66.7%
	Server	285	333	343	353	413	445	56.2%
	Monitor	103	125	128	131	146	153	49.1%
	Printer/Copier/Fax	125	152	155	158	175	181	45.4%
	POS Terminal	38	39	40	40	44	46	22.7%
Miscellaneous	Non-HVAC Motors	17	20	21	21	23	24	40.2%
	Pool Pump	1	1	1	1	1	1	41.7%
	Pool Heater	0	1	1	1	1	1	40.7%
	Miscellaneous	2,498	3,271	3,389	3,515	4,323	4,895	96.0%
	Clothes Washer	1	1	1	2	2	2	34.8%
	Clothes Dryer	1	2	2	2	2	2	35.3%
Total		**14,231**	**14,149**	**14,199**	**14,320**	**15,105**	**15,867**	**11.5%**

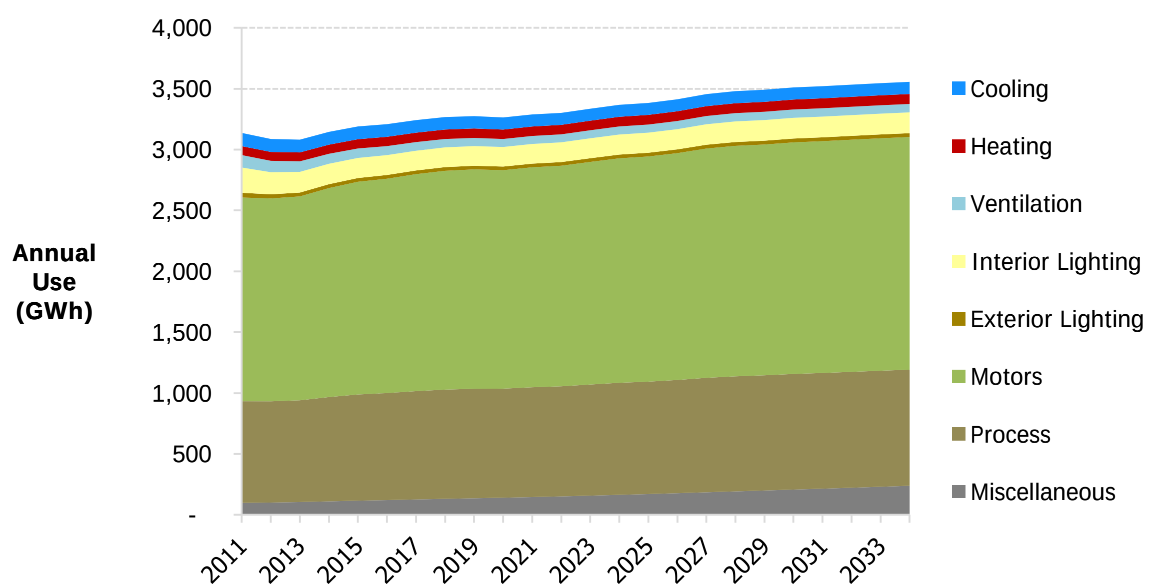
Industrial Sector

Table 4-5 and Figure 4-5 present the electricity baseline projection at the end-use level for the industrial sector. Overall, industrial annual electricity use increases from 3,137 GWh in 2011 to 3,511 GWh in 2030. This comprises an overall increase of 11.9%, or 0.4% per year, which is colored by a slow but recovering economy. These exhibits also show estimates of naturally occurring efficiency, which as quite small, developed using a codes and standards projection.

Table 4-5 Industrial Consumption by End Use (GWh)

End Use	2011	2016	2017	2018	2025	2030	% Change ('11-'30)
Cooling	109	104	103	103	98	100	-8.4%
Heating	73	76	77	77	79	81	11.2%
Ventilation	102	74	71	69	67	69	-32.9%
Int. Lighting	207	163	162	162	165	170	-17.9%
Ext. Lighting	39	31	30	30	31	31	-19.4%
Motors	1,673	1,761	1,782	1,797	1,849	1,902	13.7%
Process	835	879	890	897	923	950	13.7%
Miscellaneous	98	121	126	131	171	208	111.9%
Total	**3,137**	**3,209**	**3,242**	**3,267**	**3,383**	**3,511**	**11.9%**
Naturally occurring EE	-	2	2	3	2	2	n/a
Codes & Stds Projection	**3,137**	**3,211**	**3,245**	**3,270**	**3,385**	**3,512**	**12.0%**

Figure 4-4 Industrial Baseline Projection by End Use



Baseline Projection Summary

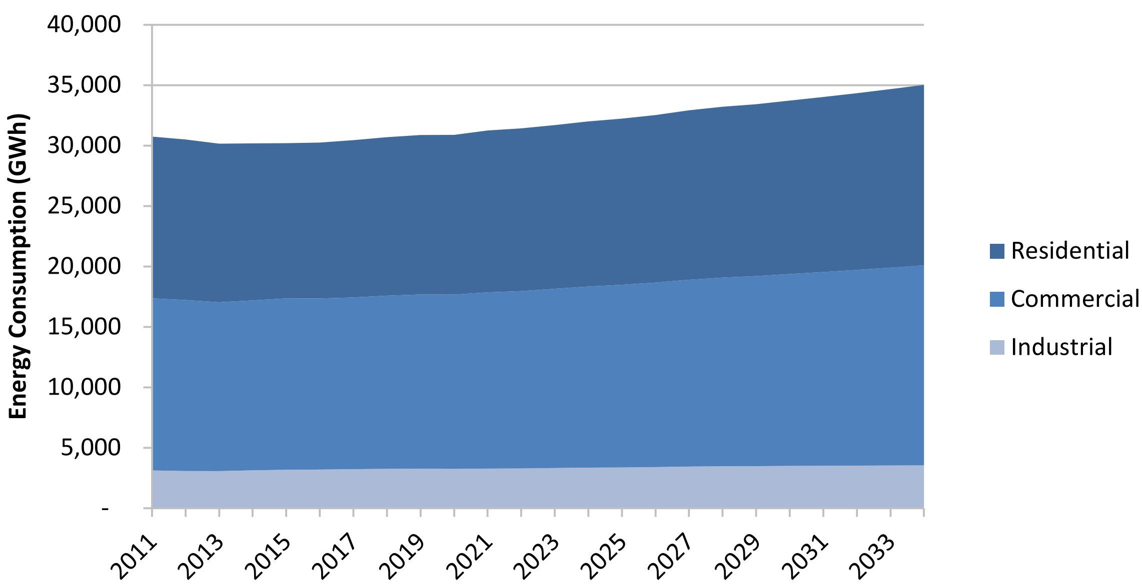
Table 4-6 and Figure 4-5 provide a summary of the baseline projection for electricity by sector for the entire Ameren service territory. Overall, the forecast shows only a slight incline in electricity use, driven primarily by oncoming codes and standards and a challenging macroeconomic environment.

Table 4-6 also shows the amount of naturally occurring energy efficiency savings. Across all sectors in 2030, savings are 460 GWh, or 1.4% of the codes and standards projection, what was used to develop the savings estimates.

Table 4-6 Baseline Projection Summary (GWh)

Sector	2011	2016	2017	2018	2025	2030	% Change
Residential	13,375	12,891	13,008	13,107	13,740	14,343	7.2%
Commercial	14,231	14,149	14,199	14,320	15,105	15,867	11.5%
Industrial	3,137	3,209	3,242	3,267	3,383	3,511	11.9%
Total	30,743	30,249	30,449	30,694	32,228	33,721	**9.7%**
Naturally occurring EE	-	313	340	354	380	462	n/a
Codes & Stds Projection	30,743	30,562	30,789	31,048	32,608	34,183	**11.2%**

Figure 4-5 Baseline Projection Summary (GWh)



MEASURE-LEVEL ENERGY EFFICIENCY POTENTIAL

This chapter presents the measure-level energy-efficiency potential for Ameren Missouri. Results for the next program cycle, 2016-2018, are shown, together with longer term potential for 2025 and 2030. Year-by-year savings for annual energy and peak demand are available in the LoadMAP model, which was provided to Ameren at the conclusion of the study.

Summary

Table 5-1 and Figure 5-1 summarize the energy-efficiency savings for all measures at the different levels of potential relative to the baseline projection. Naturally occurring efficiency is included in the baseline projection, so all estimates shown below represent net savings. Figure 5-2 displays the electric energy-efficiency forecasts.

- **Technical potential**, which reflects the adoption of all energy efficiency measures regardless of cost-effectiveness, is a theoretical upper bound on savings. First-year net savings are 1,242 GWh, or 4.1% of the baseline projection. Cumulative net savings in 2018 are 2,728 GWh, or 8.9% of the baseline. By 2030, cumulative savings reach 9,858 GWh, or 29.2% of the baseline projection.
- **Economic potential** reflects the savings when the most efficient cost-effective measures are taken by all customers. The first-year savings in 2016 are 858 GWh, or 2.8% of the baseline projection. By 2018, cumulative net savings reach 1,923 GWh, or 6.3% of the baseline. By 2030, cumulative savings reach 7,718 GWh, or 22.9% of the baseline projection.
- **Maximum achievable potential (MAP)** reflects an ideal regulatory and program implementation scenario. In 2016, savings for this case are 510 GWh, or 1.7% of the baseline and by 2018 cumulative net savings reach 1,179 GWh, or 3.8% of the baseline projection. By 2030, cumulative MAP savings reach 5,377 GWh, or 15.9% of the baseline projection. This results in average annual savings of 0.75% of the baseline each year.
- **Realistic Achievable Potential** reflects what is most realistically expected to happen. In 2016, net realistic achievable savings are 339 GWh, or 1.1% of the baseline projection. By 2018, RAP reaches 806 GWh, or 2.6% of the baseline. By 2030, RAP reaches 3,958 GWh, or 11.7% of the baseline projection. This results in average annual savings of 0.83%.

Table 5-1 Summary of Measure-Level Efficiency Potential

	2016	2017	2018		2025	2030
Baseline projection (GWh)	30,249	30,449	30,694		32,228	33,721
Cumulative Net Savings (GWh)						
Realistic Achievable Potential	339	561	806		2,697	3,958
Maximum Achievable Potential	510	833	1,179		3,753	5,377
Economic Potential	858	1,374	1,923		5,674	7,718
Technical Potential	1,242	1,955	2,728		7,563	9,858
Cumulative Net Savings as a % of Baseline						
Realistic Achievable Potential	1.1%	1.8%	2.6%		8.4%	11.7%
Maximum Achievable Potential	1.7%	2.7%	3.8%		11.6%	15.9%
Economic Potential	2.8%	4.5%	6.3%		17.6%	22.9%
Technical Potential	4.1%	6.4%	8.9%		23.5%	29.2%

Figure 5-1 Measure-Level Energy Efficiency Potential

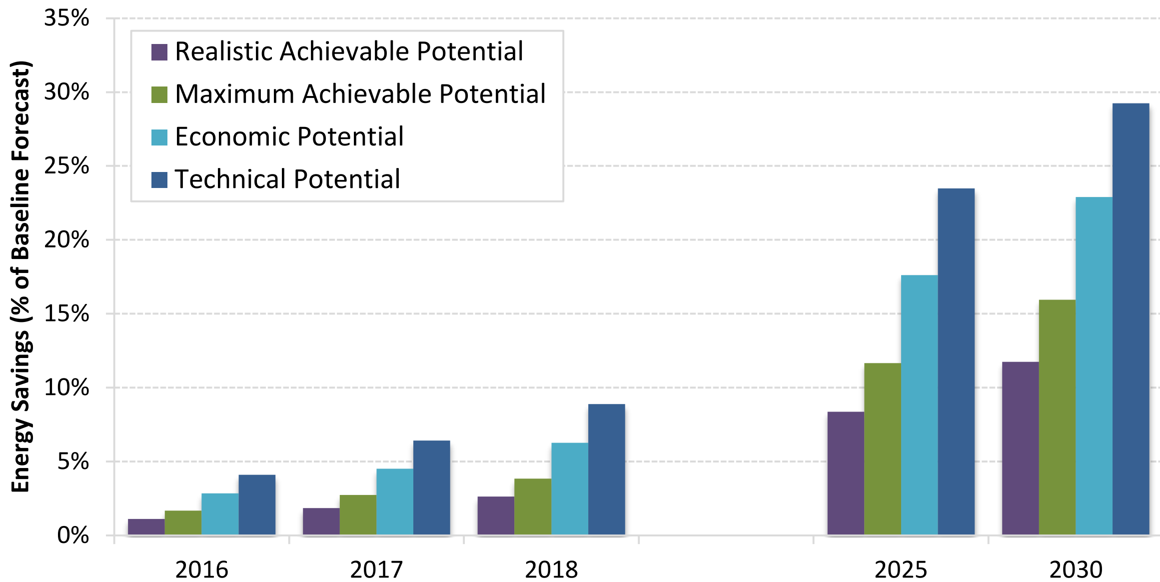
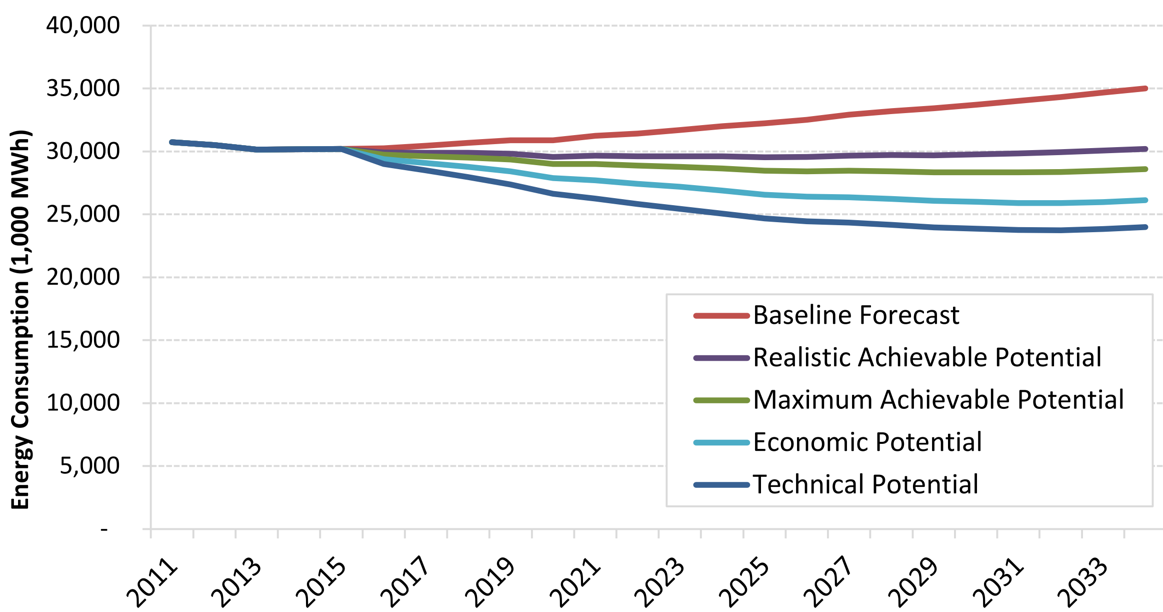


Figure 5-2 Summary of the Baseline Projection and Measure-level EE Forecasts (GWh)



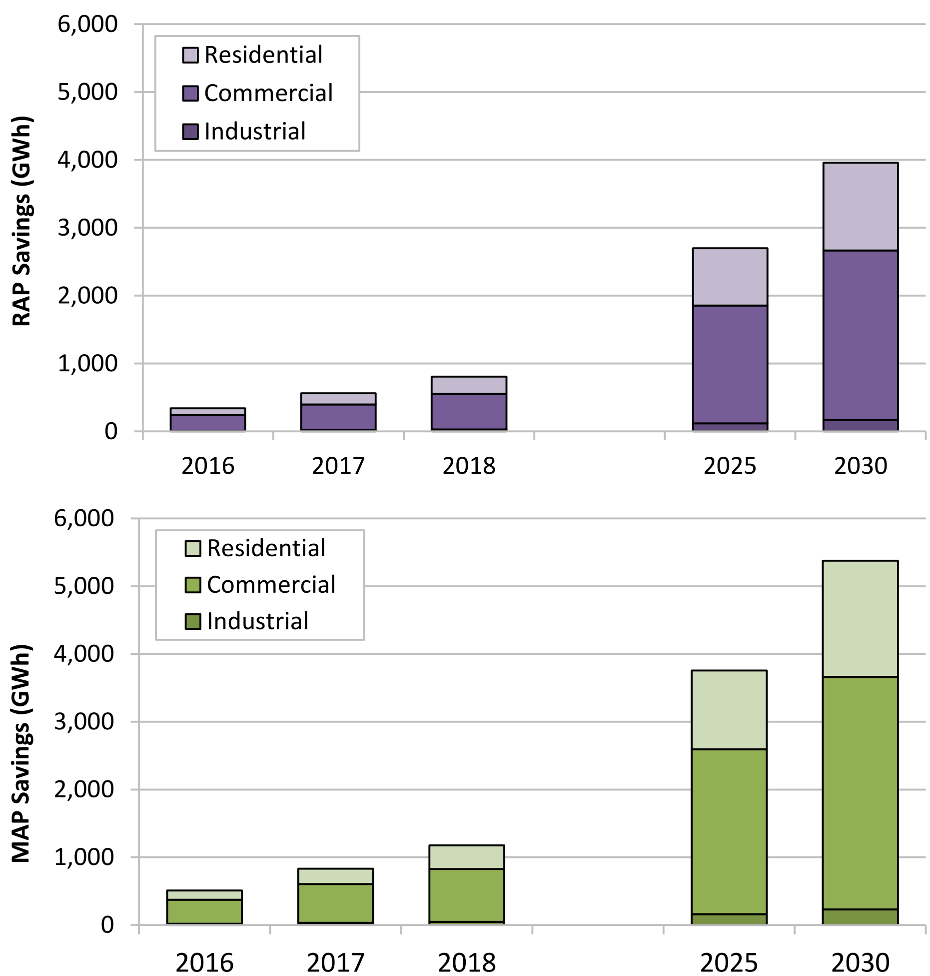
Overview of Measure-Level Energy Efficiency Potential by Sector

Table 5-2 and Figure 5-3 summarize the range of electric achievable potential by sector. The commercial sector accounts for the largest portion of the savings, followed by residential then industrial.

Table 5-2 Measure-level Achievable Potential by Sector (GWh)

	2016	2017	2018		2025	2030
RAP Cumulative Net Savings (GWh)						
Residential	95	162	251		843	1,290
Commercial	231	376	523		1,736	2,495
Industrial	13	23	32		118	173
Total	**339**	**561**	**806**		**2,697**	**3,958**
MAP Cumulative Net Savings (GWh)						
Residential	137	230	354		1,158	1,714
Commercial	354	570	779		2,435	3,430
Industrial	19	33	45		160	232
Total	**510**	**833**	**1,179**		**3,753**	**5,377**

Figure 5-3 Measure-level Achievable Potential by Sector (GWh)



Residential Measure-level Potential

Table 5-3 presents estimates for the four types of measure-level potential for the residential sector. Figure 5-4 depicts these potential energy savings estimates graphically. Net cumulative savings for achievable potential in 2018 are 251 GWh for RAP and 354 GWh for MAP, or 1.9% to 2.7% of the baseline projection, respectively. By 2030, the RAP and MAP savings are 1,290 GWh and 1,714 GWh, respectively.

Table 5-3 Measure-level EE Potential for the Residential Sector

	2016	2017	2018		2025	2030
Baseline projection (GWh)	**12,891**	**13,008**	**13,107**		**13,740**	**14,343**
Cumulative Net Savings (GWh)						
Realistic Achievable Potential	95	162	251		843	1,290
Maximum Achievable Potential	137	230	354		1,158	1,714
Economic Potential	282	459	701		2,111	2,902
Technical Potential	440	752	1,136		3,108	4,079
Cumulative Net Savings as a % of Baseline						
Realistic Achievable Potential	0.7%	1.2%	1.9%		6.1%	9.0%
Maximum Achievable Potential	1.1%	1.8%	2.7%		8.4%	12.0%
Economic Potential	2.2%	3.5%	5.3%		15.4%	20.2%
Technical Potential	3.4%	5.8%	8.7%		22.6%	28.4%

Figure 5-4 Residential Measure-level Energy Efficiency Savings

Residential Measure-level Potential by Market Segment

Single-family homes in Ameren account for the majority of this sector's total sales in the base year and throughout the forecast. Similarly, single-family homes account for the largest share of potential savings by segment, as displayed in Table 5-4 for 2018.

Table 5-4 Residential Measure-level Potential by Market Segment, 2018

	Single Family	Multi Family
Baseline projection (GWh)	**10,958**	**2,149**
Cumulative Net Savings (GWh)		
Realistic Achievable Potential	212	39
Maximum Achievable Potential	304	50
Economic Potential	586	115
Technical Potential	942	194
Cumulative Net Savings as a % of Baseline		
Realistic Achievable Potential	1.9%	1.8%
Maximum Achievable Potential	2.8%	2.3%
Economic Potential	5.3%	5.3%
Technical Potential	8.6%	9.0%

Residential Top 20 Measures

Table 5-5 identifies the top 20 residential measures in 2018 for RAP which account for 88% of cumulative RAP. The top measure is screw-in LED lamps, which account for 25% of the savings in 2018. These lamps are cost-effective when compared to the infrared halogen lamp that meets the EISA lighting standard starting in 2014. Savings from this measure in RAP are calculated relative to a market baseline that reflects purchases of the infrared halogen lamps, as well as substantial market share for CFLs and LEDs.

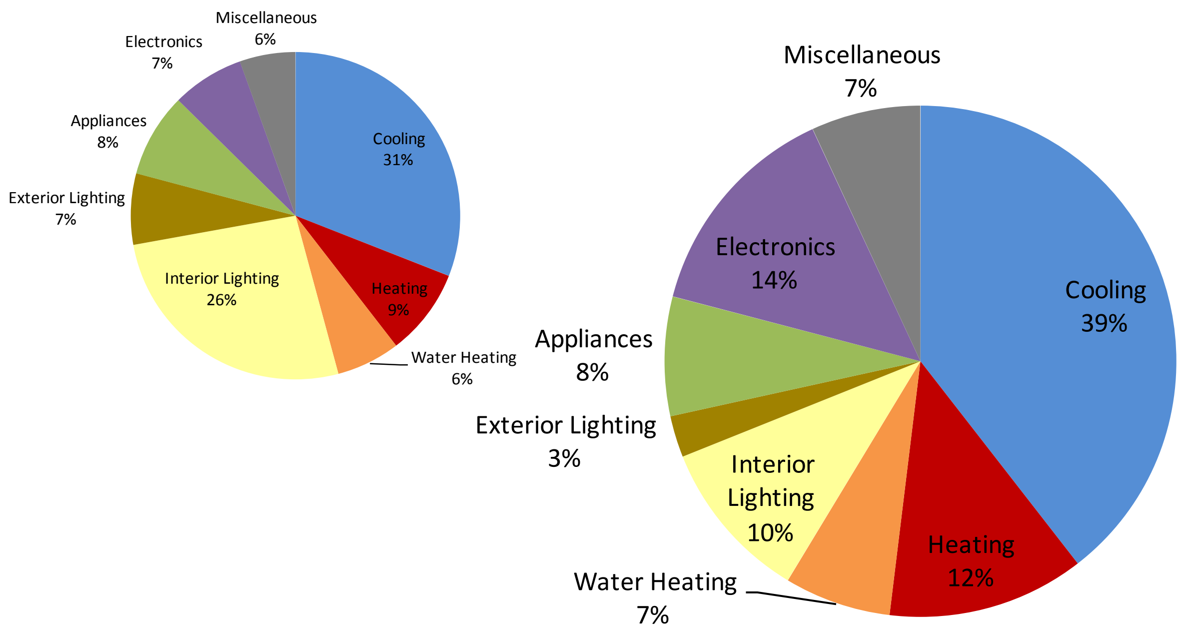
Table 5-5 Residential Top Measures in RAP in 2018

Rank	Measure	End use	2018 Savings	% of Total
1	Interior Lighting Screw-in – LED lamps	Int. Light	63.9	25%
2	Cooling Central AC – SEER 15	Cooling	18.7	7%
3	Exterior Lighting Screw-in – LED lamps	Ext. Light	17.6	7%
4	Central AC - Maintenance and Tune-Up	Cooling	13.5	5%
5	Refrigerator - Remove Second Unit	Appliances	13.2	5%
6	Windows - Install Reflective Film	Heat & Cool	12.2	5%
7	Ducting - Repair and Sealing	Heat & Cool	10.9	4%
8	Water Heater - Low-Flow Showerheads	Water heat	9.0	4%
9	Windows - High Efficiency/ENERGY STAR	Heat & Cool	8.9	4%
10	Freezer - Removal	Appliances	6.9	3%
11	Electronics Personal Computers	Electronics	6.9	3%
12	Pool/Spa cover	Misc.	5.6	2%
13	Electronics Set-top Boxes/DVR	Electronics	5.5	2%
14	Thermostat - Clock/Programmable	Heat & Cool	5.1	2%
15	Insulation - Infiltration Control	Heat & Cool	4.6	2%
16	Miscellaneous Air Purifier/Cleaner	Misc.	4.1	2%
17	Water Heater - Thermostat Setback	Water heat	4.0	2%
18	Room AC - Removal	Cooling	3.9	2%
19	Central AC - Early Replacement	Cooling	3.5	1%
20	Insulation – Ducting	Heat & Cool	3.4	1%
Total			**221.4**	**88%**

Figure 5-5 focuses on the RAP by end use in 2018 and 2025.

- Cooling measures, including CAC replacement, CAC maintenance, duct repair and sealing, and various thermal shell measures, account for the largest share of savings in the program cycle and in the long term.
- Lighting equipment replacement measures account for the second-highest portion of the savings in the near term as a result of the efficiency gap between LED lamps and advanced incandescent lamps that meet the EISA 2007 standard. In the longer term (2025), electronics and space heating measures contribute significantly to the savings.
- Electronics measures, including high-efficiency PCs and set-top boxes, contribute significant savings to RAP in the long term.
- Space heating measures, consisting mostly of thermal-shell measures, contribute 12% to net cumulative savings in 2025.

Figure 5-5 Residential Measure-level RAP by End Use in 2018 and 2025



Residential Measure-level Potential by End Use

Table 5-6 provides estimates of savings for each end use and type of potential.

Table 5-6 Residential Measure-level Savings by End Use and Potential Type (GWh)

End Use	Case	2016	2017	2018		2025	2030
Cooling	RAP	34	53	78		333	548
	MAP	49	75	109		451	721
	Economic Potential	103	155	222		821	1,217
	Technical Potential	154	246	354		1,119	1,502
Heating	RAP	10	15	21		105	165
	MAP	15	22	32		151	233
	Economic Potential	31	46	66		287	417
	Technical Potential	47	71	104		387	561
Water Heating	RAP	5	9	16		57	103
	MAP	8	14	24		81	139
	Economic Potential	17	30	51		158	244
	Technical Potential	42	83	130		392	561
Interior Lighting	RAP	23	42	66		87	122
	MAP	32	59	93		113	148
	Economic Potential	62	109	171		182	199
	Technical Potential	66	117	181		213	227
Exterior Lighting	RAP	6	11	18		22	29
	MAP	9	16	25		29	34
	Economic Potential	15	27	42		42	42
	Technical Potential	17	30	46		48	50
Appliances	RAP	6	12	21		63	81
	MAP	8	15	26		80	100
	Economic Potential	15	28	50		141	169
	Technical Potential	40	75	118		343	453
Electronics	RAP	6	11	18		118	156
	MAP	9	17	26		173	224
	Economic Potential	18	35	54		310	383
	Technical Potential	39	74	123		347	384
Miscellaneous	RAP	6	9	14		58	87
	MAP	8	12	19		79	115
	Economic Potential	20	29	45		171	231
	Technical Potential	35	57	79		260	341
Total	**RAP**	**95**	**162**	**251**		**843**	**1,290**
	MAP	**137**	**230**	**354**		**1,158**	**1,714**
	Economic Potential	**282**	**459**	**701**		**2,111**	**2,902**
	Technical Potential	**440**	**752**	**1,136**		**3,108**	**4,079**

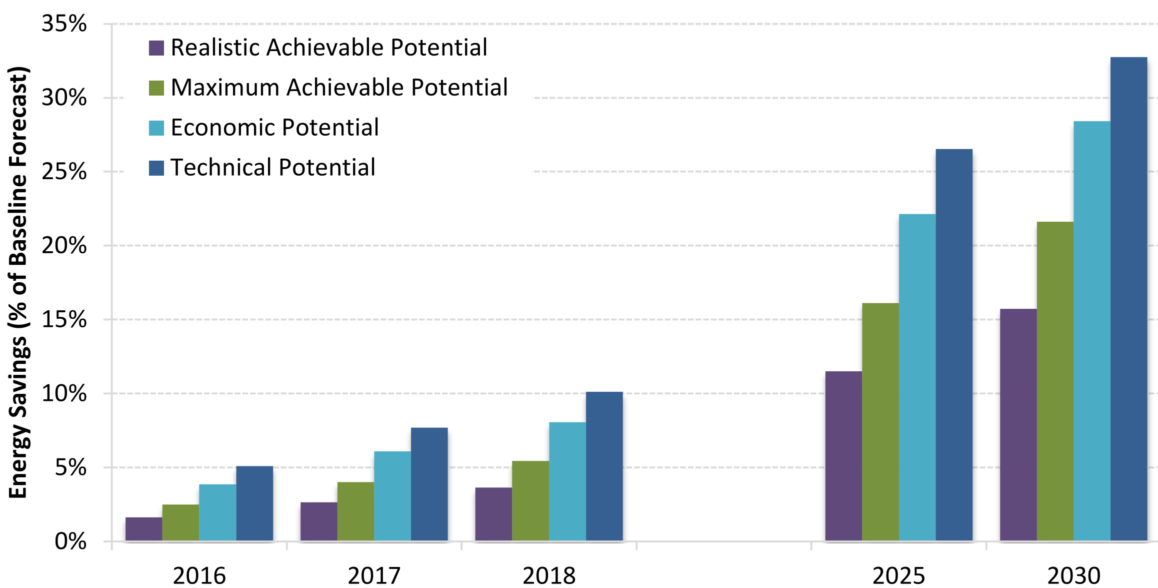
Commercial Measure-level Potential

Net cumulative savings for measure-level achievable potential in the commercial sector in 2018 are 523 GWh for RAP and 779 for MAP, or 3.7% to 5.4% of the baseline projection, respectively. These savings are twice as high as for the residential sector. Table 5-7 presents estimates for the four types of potential for the residential electricity sector. Figure 5-6 depicts these potential energy savings estimates graphically.

Table 5-7 Measure-level EE Potential for the Commercial Sector

	2016	2017	2018		2025	2030
Baseline projection (GWh)	14,149	14,199	14,320		15,105	15,867
Cumulative Net Savings (GWh)						
Realistic Achievable Potential	231	376	523		1,736	2,495
Maximum Achievable Potential	354	570	779		2,435	3,430
Economic Potential	547	864	1,155		3,342	4,507
Technical Potential	722	1,093	1,448		4,005	5,196
Cumulative Net Savings as a % of Baseline						
Realistic Achievable Potential	1.6%	2.6%	3.7%		11.5%	15.7%
Maximum Achievable Potential	2.5%	4.0%	5.4%		16.1%	21.6%
Economic Potential	3.9%	6.1%	8.1%		22.1%	28.4%
Technical Potential	5.1%	7.7%	10.1%		26.5%	32.7%

Figure 5-6 Commercial Measure-level Energy Efficiency Savings



Commercial Measure-level Potential by Market Segment

Table 5-8 shows measure-level achievable potential estimates by building type in 2018. Offices and retail have the largest share of MAP and RAP savings throughout the study horizon.

Table 5-8 Commercial Measure-level Potential by Market Segment, 2018

	2016	2017	2018		2025	2030
MAP (GWh)						
Office	75	123	176		595	813
Restaurant	25	39	51		153	220
Retail	52	83	112		350	502
Grocery	28	37	47		134	187
Education	45	72	99		303	438
Health	42	65	88		271	376
Lodging	16	30	41		83	108
Warehouse	22	35	48		178	258
Miscellaneous	50	86	117		367	528
Total	**354**	**570**	**779**		**2,435**	**3,430**
% of Total Savings – MAP						
Office	21%	22%	23%		24%	24%
Restaurant	7%	7%	7%		6%	6%
Retail	15%	14%	14%		14%	15%
Grocery	8%	7%	6%		6%	5%
Education	13%	13%	13%		12%	13%
Health	12%	11%	11%		11%	11%
Lodging	5%	5%	5%		3%	3%
Warehouse	6%	6%	6%		7%	8%
Miscellaneous	14%	15%	15%		15%	15%
Total	**100%**	**100%**	**100%**		**100%**	**100%**
RAP (GWh)						
Office	49	81	117		421	588
Restaurant	16	25	34		109	160
Retail	34	55	75		250	366
Grocery	18	24	30		93	133
Education	30	48	67		214	318
Health	27	43	59		193	272
Lodging	11	20	29		65	83
Warehouse	14	23	32		126	187
Miscellaneous	33	57	79		267	389
Total	**231**	**376**	**523**		**1,736**	**2,495**
% of Total Savings - RAP						
Office	21%	22%	22%		24%	24%
Restaurant	7%	7%	7%		6%	6%
Retail	15%	15%	14%		14%	15%
Grocery	8%	6%	6%		5%	5%
Education	13%	13%	13%		12%	13%
Health	12%	11%	11%		11%	11%
Lodging	5%	5%	5%		4%	3%
Warehouse	6%	6%	6%		7%	7%
Miscellaneous	14%	15%	15%		15%	16%
Total	**100%**	**100%**	**100%**		**100%**	**100%**

Commercial Top 20 Measures

Table 5-9 identifies the top 20 commercial-sector measures in 2018 for RAP. These measures account for 404 GWh in 2018 and 77.3% of total RAP. The top measure is screw-in LED lamps, which account for 26% of the savings in 2018. These lamps are cost-effective when compared to the infrared halogen lamp that meets the EISA lighting standard starting in 2014. Savings from this measure in RAP are calculated relative to a market baseline that reflects purchases of the infrared halogen lamps, as well as substantial market share for CFLs and LEDs.

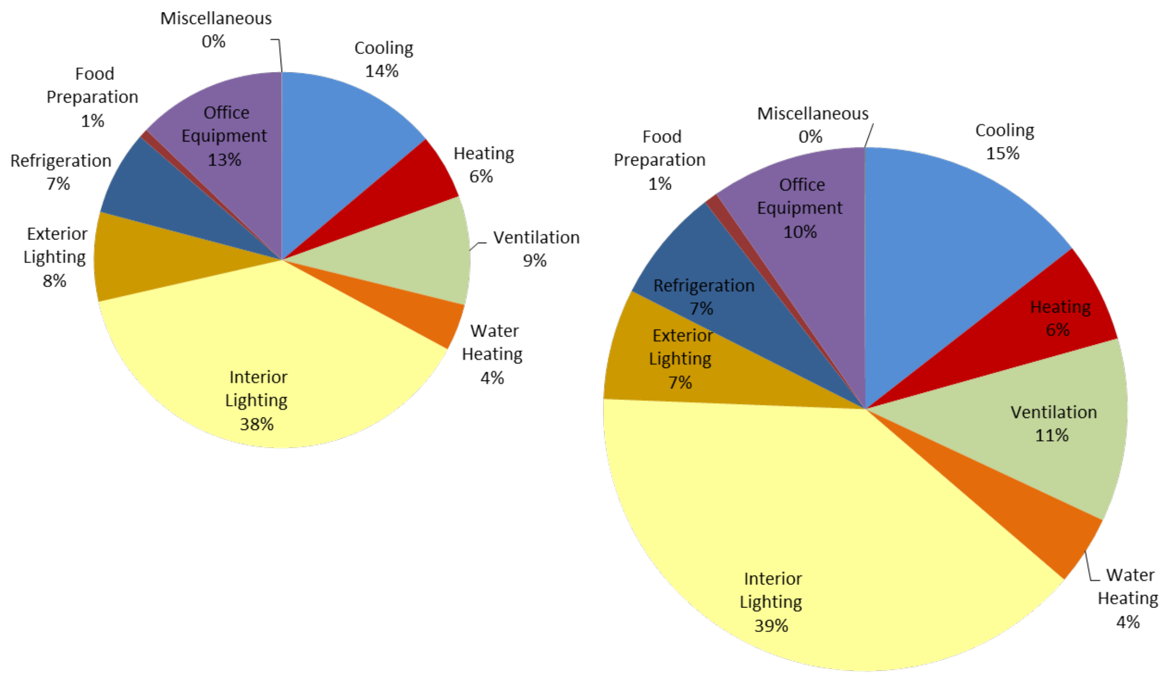
Table 5-9 Commercial Top 20 Measures in RAP in 2018

Rank	Measure	End Use	2018 Savings	% of Total
1	Interior Lighting - Screw-in – LED	Int. Light	94	18.0%
2	Interior Lighting - Linear Fluorescent	Int. Light	43	8.3%
3	Advanced New Construction Designs	Int. Light, HVAC	36	6.8%
4	Office Equipment – Server	Off. Eq.	27	5.1%
5	Interior Lighting - Daylighting Controls	Int. Light	22	4.2%
6	Water Heating – High-efficiency system	Water heat	19	3.6%
7	Energy Management System	HVAC	19	3.5%
8	Exterior Lighting – HID	Ext. Light	17	3.3%
9	Office Equipment - Desktop Computer	Off. Eq.	16	3.1%
10	Interior Lighting - High-Bay Fixtures	Int. Light	14	2.7%
11	Retrocommissioning – HVAC	HVAC	14	2.7%
12	Exterior Lighting - Screw-in	Ext. Light	14	2.6%
13	Ventilation - Variable Speed Control	Ventilation	12	2.3%
14	Interior Lighting - Occupancy Sensors	Int. Light	12	2.2%
15	Retrocommissioning – Lighting	Int. Light	11	2.2%
16	Office Equipment - Printer/Copier/Fax	Off. Eq.	7	1.4%
17	Commissioning – Lighting	Int. Light	7	1.4%
18	Refrigerator – eCube	Refrig.	7	1.3%
19	Ventilation - CO2 Controlled	Ventilation	7	1.3%
20	Ventilation - Ventilation	Ventilation	6	1.2%
	Total		**404**	**77.3%**

Figure 5-7 focuses on RAP by end use in 2018 and 2025.

- Interior lighting delivers the largest share of RAP savings throughout the study period. This results from lamp and system replacement, as well as lighting controls.
- Office equipment has the second largest share, resulting from high-efficiency servers, PCs, and printers, as well as monitor power maintenance.

Figure 5-7 Commercial Measure-level RAP Savings by End Use in 2018 and 2025



Commercial Measure-level Potential by End Use

Table 5-10 presents the commercial sector savings by end use and potential type.

Table 5-10 Commercial Measure-level Potential by End Use and Potential Type (GWh)

End Use	Case	2016	2017	2018		2025	2030
Cooling	RAP	37	52	70		243	324
	MAP	58	80	108		352	457
	Economic Potential	88	121	160		483	604
	Technical Potential	118	162	215		611	749
Heating	RAP	14	20	28		98	141
	MAP	23	31	43		145	203
	Economic Potential	35	49	65		207	278
	Technical Potential	47	65	88		255	329
Ventilation	RAP	21	30	44		175	229
	MAP	32	47	68		257	330
	Economic Potential	53	76	108		378	465
	Technical Potential	74	102	138		452	544
Water Heating	RAP	8	15	23		76	130
	MAP	11	21	32		104	173
	Economic Potential	17	31	47		144	230
	Technical Potential	19	34	50		151	236
Interior Lighting	RAP	93	161	218		744	1,094
	MAP	141	242	317		1,010	1,466
	Economic Potential	213	354	445		1,314	1,825
	Technical Potential	245	396	501		1,484	1,970
Exterior Lighting	RAP	17	32	44		136	208
	MAP	25	48	65		182	278
	Economic Potential	36	68	89		228	342
	Technical Potential	42	75	99		251	360
Refrigeration	RAP	21	27	34		108	159
	MAP	33	42	53		161	229
	Economic Potential	54	68	84		236	320
	Technical Potential	80	103	127		329	426
Food Preparation	RAP	1	2	4		12	17
	MAP	2	4	6		18	26
	Economic Potential	3	6	9		28	39
	Technical Potential	3	6	9		28	39
Office Equipment	RAP	19	36	59		142	191
	MAP	28	54	89		204	267
	Economic Potential	48	90	148		320	401
	Technical Potential	94	149	220		441	537
Miscellaneous	RAP	0	0	0		1	2
	MAP	0	0	0		1	2
	Economic Potential	0	0	0		2	3
	Technical Potential	0	0	1		3	4
Total	**RAP**	**231**	**376**	**523**		**1,736**	**2,495**
	MAP	**354**	**570**	**779**		**2,435**	**3,430**
	Economic Potential	**547**	**864**	**1,155**		**3,342**	**4,507**
	Technical Potential	**722**	**1,093**	**1,448**		**4,005**	**5,196**

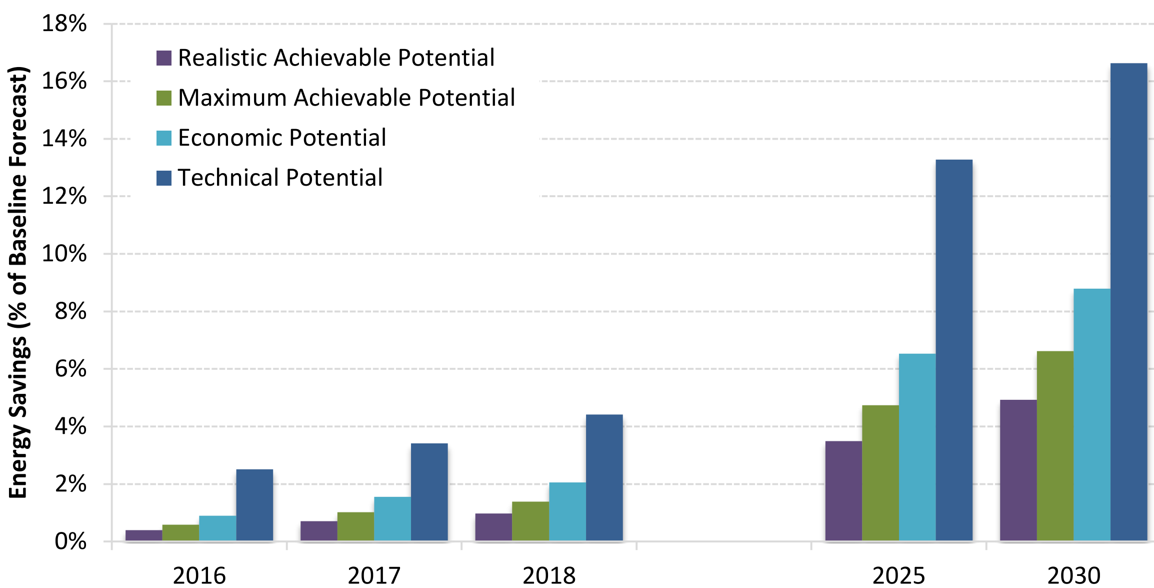
Industrial Measure-level Potential

In this study, Ameren's opt-out customers have been excluded from the study. Therefore, the industrial sector is the small sector in the analysis in terms of the baseline projection and savings potential. Net cumulative savings for measure-level achievable potential in the industrial sector are 32 GWh for RAP and 45 GWh for MAP in 2018. Table 5-11 and Figure 5-8 present the savings for the various types of potential considered in this study.

Table 5-11 Measure-level EE Potential for the Industrial Sector

	2016	2017	2018		2025	2030
Baseline projection (GWh)	3,209	3,242	3,267		3,383	3,511
Cumulative Net Savings (GWh)						
Realistic Achievable Potential	13	23	32		118	173
Maximum Achievable Potential	19	33	45		160	232
Economic Potential	29	50	67		221	309
Technical Potential	80	110	144		449	584
Cumulative Net Savings as a % of Baseline						
Realistic Achievable Potential	0.4%	0.7%	1.0%		3.5%	4.9%
Maximum Achievable Potential	0.6%	1.0%	1.4%		4.7%	6.6%
Economic Potential	0.9%	1.5%	2.1%		6.5%	8.8%
Technical Potential	2.5%	3.4%	4.4%		13.3%	16.6%

Figure 5-8 Industrial Measure-level Potential Savings



Industrial Top 10 Measures

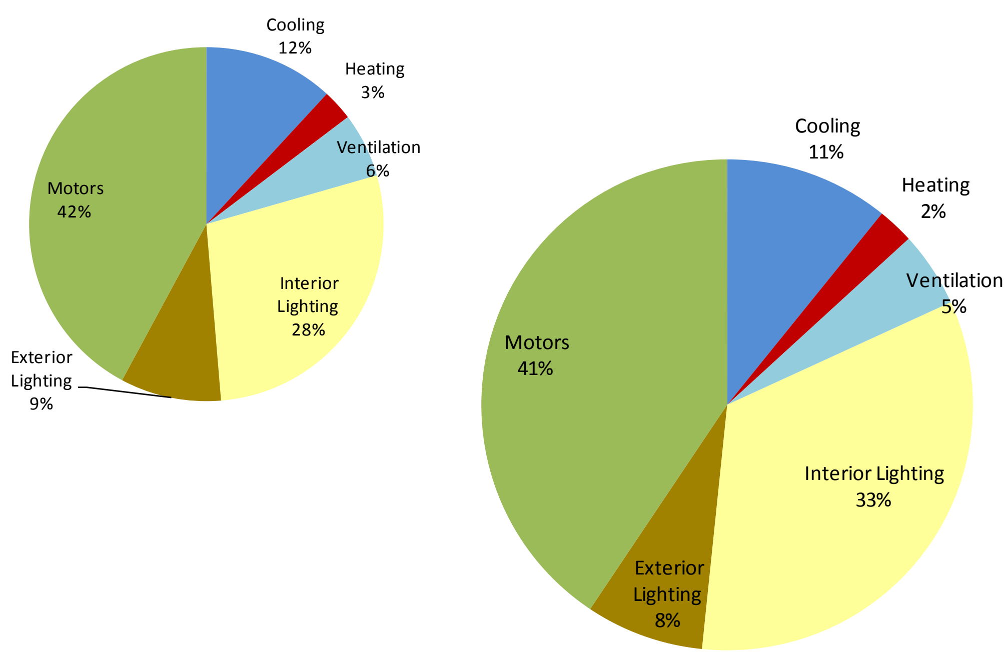
Table 5-12 identifies the top ten measures in the industrial sector for RAP in 2018. These ten measures account for 77% of total RAP savings. The measures with the most savings are variable speed controls for motors, high-efficiency linear fluorescent lighting and fan system optimization.

Table 5-12 Industrial Top 10 Measures in RAP in 2018

Rank	Measure	2018 Savings	% of Total
1	Motors - Variable Speed Controls	4.5	14.2%
2	Interior Lighting - Linear Fluorescent	3.7	11.8%
3	Fan System - Optimization	3.1	9.9%
4	Compressed Air - System Optimization and Improvements	2.7	8.4%
5	Interior Lighting - Screw-in	2.6	8.2%
6	Exterior Lighting - Screw-in	2.6	8.0%
7	Fan Equipment Upgrade	1.8	5.6%
8	Ventilation – Conversion to VAV	1.7	5.3%
9	Interior Lighting - Daylighting Controls	1.0	3.0%
10	Cooling - Roof top AC	1.0	3.0%
	Total	**24.5**	**77.4%**

Figure 5-9 illustrates RAP savings by end use in 2018 and 2025 for the industrial sector. The largest shares of savings opportunities are in the motors and machine drives. Potential savings for straight motor equipment change-outs are being eliminated due to the National Electrical Manufacturer's Association (NEMA) standards, which now make premium efficiency motors the baseline efficiency level. As a result, the savings opportunities in this end use come from controls, timers, and variable speed drives, which improve system efficiencies where motors are utilized. These system-level measures and upgrades are also applicable to a large swath of applications for heating, cooling, and electrochemical processes. Beyond motors and processes, there are large opportunities for savings in lighting and cooling.

Figure 5-9 Industrial Measure-level RAP Savings by End Use in 2018 and 2025



Industrial Potential by End Use

Table 5-13 provides estimates of savings for each end use and type of potential.

Table 5-13 Industrial Measure-level Potential by End Use and Potential Type (GWh)

End Use	Case	2016	2017	2018		2025	2030
Cooling	RAP	2	3	4		13	17
	MAP	2	4	6		18	23
	Economic Potential	4	6	8		24	31
	Technical Potential	6	9	12		32	40
Heating	RAP	1	1	1		3	4
	MAP	1	1	1		4	6
	Economic Potential	1	2	2		6	8
	Technical Potential	3	4	5		12	16
Ventilation	RAP	1	1	2		6	7
	MAP	1	2	3		9	10
	Economic Potential	2	3	4		13	14
	Technical Potential	2	4	5		15	17
Interior Lighting	RAP	4	6	9		39	65
	MAP	6	10	13		54	89
	Economic Potential	9	14	19		71	113
	Technical Potential	11	17	22		80	120
Exterior Lighting	RAP	1	2	3		9	12
	MAP	2	3	4		10	14
	Economic Potential	3	4	5		12	16
	Technical Potential	3	5	6		16	20
Miscellaneous	RAP	0	0	0		0	0
	MAP	0	0	0		0	0
	Economic Potential	0	0	0		0	0
	Technical Potential	7	10	14		54	64
Motors	RAP	5	10	13		48	68
	MAP	7	14	18		65	90
	Economic Potential	11	22	29		95	127
	Technical Potential	48	63	79		238	307
Process	RAP	0	0	0		0	0
	MAP	0	0	0		0	0
	Economic Potential	0	0	0		0	0
	Technical Potential	0	0	0		0	0
Total	**RAP**	**13**	**23**	**32**		**118**	**0**
	MAP	**19**	**33**	**45**		**160**	**0**
	Economic Potential	**29**	**50**	**67**		**221**	**0**
	Technical Potential	**80**	**110**	**144**		**449**	**0**

PROGRAM POTENTIAL

Within the program potential analysis, the energy efficiency measures covered in previous chapters are bundled into delivery mechanisms to form specific energy efficiency programs. Table 6-1 lists the preliminary programs to deliver an effective and balanced portfolio of energy savings opportunities across all customer segments.

Table 6-1 Portfolio of Energy Efficiency Programs Included in Program Potential

Residential Programs	Business Programs
Lighting	Prescriptive Rebates
Energy Efficient Products	Custom Incentives
Low Income	Retrocommissioning
New Construction & Code Support	New Construction & Code Support
Home Performance	Small Business Direct Install
HVAC	Multi Family Common Area
Appliance Recycling	Strategic Energy Management (SEM)
Consumer Electronics	
Multi Family Direct Install	

Programmatic Framework and Program Descriptions

For each program, the analysis considers and develops a programmatic framework for administrators and implementers and includes the items listed below.

- Target market
- Implementation strategy, including delivery channels, marketing, education and outreach
- Program issues, risks and risk management strategies
- Eligible measures and incentives
- Evaluation, measurement and verification requirements and guidance
- Administrative requirements
- Estimated participation
- Program budget
- Program energy savings and demand reduction
- Cost-effectiveness

To develop program potential from measure-level achievable potential, the measure mix may change due to a number of the program delivery factors described above. Therefore, the program potential is an optimized subset of the measure-level potential designed for implementation in a specific market and service territory. Also, the installations resulting from the measure-level analysis were smoothed to achieve continuity with historic programs and on a year-to-year basis. The measure-level results reflect the timing of equipment turnover based on appliance age and this sometimes creates modeling artifacts undesirable to an implementer. For instance, if the measure-level model produces a spike of installations in the year a new technology first becomes available, this should be leveled out in the program design to a pattern that is more realistic but such that the total number of installations over the study timeframe is equal to the measure-level model. This smoothing of installations typically has only minor effects from year to year.

For the business sector, we removed twenty-five percent of the measure-level potential from offices and schools to represent the potential that is associated with the public sector. The Ameren programs do not target public sector buildings, but they are included in the measure-level potential. Public sector buildings are the target of programs from other entitites.

The most significant difference between measure-level potential and program potential is the assignment of program costs. The approach used identifies costs as base-program costs (or above-the-line costs) and portfolio administration costs (or below-the-line costs). Base program costs include incentive costs and implementation costs. Incentive costs are defined as a percent of incremental measure costs, both for equipment and installation, based on generic rules that are used for best practice program planning around the country. Implementation costs are then specified and benchmarked to general best practices. A similar best practice allocation and benchmarking process is then followed for the below-the-line portfolio administration costs: EM&V, portfolio marketing, and portfolio administration.

With the additional program costs levied on the program-level potential, the cost-effectiveness criterion is violated for both RAP and MAP (TRC <1.0). Therefore, program design judgment was applied to refine the portfolio by scaling back installations of less economic measures. As an example, the number of installations of HVAC retrocommissioning in industrial facilities was reduced where it was is less effective than, say, in office buildings. Another example of where the number of installations was reduced is in expensive, emerging technology measures in the study's out-years: the number of SEER 21 installations for central air conditioning and linear fluorescent-style LED lamps, both of which show very marginal economics, were significantly reduced. Unless edited, these examples become cost effective in the 2020s, become very prevalent in programs, and levy disproportionate costs to the bottom line. (It should be noted that we did not alter the installation of more cost-effective, lower SEER levels or other LED lights.)

Another program design intervention that was applied to measure-level results was to manually include some CFL measures in the mix of screw-in lighting installations. The measure-level model selected LEDs for these installations exclusively, but the market reality is that some CFLs will continue to produce savings in programs. Aligning with program planning assumptions from Ameren, the program potential begins in 2016 by splitting the available screw-in measures 70% to CFLs and 30% to LEDs. This mix shifts rapidly toward LEDs, however, and is 90% LED by the end of the study timeframe.

Below are summary highlights of the programs we recommend for delivery, along with key elements of each one's programmatic framework.

Residential Programs

Lighting

This program emphasizes standardized rebates and upstream buydowns, with a market transformation focus. The concentration will be on both CFL and LED lighting, with LEDs becoming more prominent in the measure mix quickly as time progresses. LED technology costs are declining very quickly, and they are cost-effective for the residential sector in our models immediately when the study timeframe begins in 2016. Note that savings from general purpose lamps decrease over time due to the EISA standards, which increase the efficiency of the baseline technology, as well as ongoing market transformation. Meanwhile, the number of specialty lamps delivered by the program increases over the same period, as these lamps are not covered by EISA.

Energy Efficient Products

This program emphasizes standardized rebates, and upstream buydowns, with a market transformation focus. Specific measures covered under this program include high-efficiency central air conditioning and heat pumps, water heaters, pool pumps and heaters, attic and ceiling fans, air purifiers, thermostats, low-flow water fixtures, and water heater pipe insulation. The primary delivery mechanism for this program is via retailers, particularly big box stores.

Low Income

This program provides education and a suite of electric efficiency measures to help income-qualified customers reduce their energy bills. Whereas existing Ameren low income programs target multifamily housing, this recommended program expands offerings to all income-qualified residential customers. These customers are defined as those with an average household income at or below 200% of the federal poverty level. Full installation of direct-install measures is subsidized and provided to the residents.

Measures in this program are high-efficiency central air conditioning and heat pumps, water heaters, CFLs, LEDs, low-flow water fixtures, water heater pipe insulation, building shell infiltration control, insulation, windows, and ceiling fans.

This particular program is not highly cost-effective, but consensus agreement around the nation is that this is acceptable for income-limited populations, as long as the overall portfolio is still cost-effective.

New Construction & Code Support

This program is designed to accelerate the incorporation of energy efficient design, construction, and operation in new residential buildings. It provides education and incentive payments to upstream designer-builders and owner-builders for installing high efficiency end-use equipment — mainly HVAC and lighting — and building envelope measures.

Home Performance

This program incorporates a whole-home focus to provide education and a suite of electric efficiency measures that help residential customers improve the energy performance of their home and systems and reduce energy bills. The program is targeted at the existing home market and is a prime candidate for cross-selling into other programs and measures, chiefly the HVAC program.

Current direct install measures in this program are CFLs and low-flow water fixtures. More involved measures include efficient air conditioning and heat pump equipment, lighting, insulation, windows, duct repair & sealing, programmable thermostats, and ceiling and attic fans.

HVAC

This program is explicitly aimed at improving HVAC systems, with the primary delivery mechanism being trade allies such as contractors who install and maintain HVAC systems. Measures include high-efficiency central air conditioning and heat pumps, ducting insulation, ducting repair and sealing, and programmable thermostats. It also supports maintenance of AC and heat pump systems, and early replacement of aging central AC.

Appliance Recycling

This program pursues energy savings by offering a bounty payment to customers to remove their old, inefficient appliances from the grid and recycle them. It has the potential to deliver large savings available from three cost-effective measures: room air-conditioners, secondary refrigerators, and secondary freezers.

One concern with this program is the possibility that after program pick-up of their secondary refrigerator, residents might simply buy a new unit and move their former primary unit into the garage or basement to replace it. This is why the program is penalized with a challenging net-to-gross ratio.

Consumer Electronics

This program provides incentives to promote purchase of ENERGY STAR and high-efficiency televisions, personal computers, monitors, laptops, and set-top equipment such as DVRs or game systems. It also provides support for smart power strips that can reduce use when systems are in standby mode. The program emphasizes standardized rebates and upstream buydowns, with a market transformation focus.

Multi Family Direct Install

This program provides targeted, highly cost-effective measures to multifamily households in a quickly deployable program delivery mechanism. These are often rental units with split incentive barriers, i.e., the landlord is the owner of the equipment but the tenant pays the energy bills. It is therefore typically an underserved market with respect to energy efficiency programs and an important program to include in the portfolio.

Measures in this program are primarily CFLs, LEDs, infiltration control, thermostats, and low-flow water fixtures. Program delivery will rely heavily on trade allies. Full installation of these direct-install measures is provided at no cost to program participants.

Business Programs

Prescriptive Rebates

This program is designed to help business customers save energy through a broad range of EE options that address all major end uses and processes. It offers incentives to customers and engages equipment suppliers and contractors to promote the incentive-eligible equipment, focusing on standardized rebates, upstream buydowns, and market transformation.

Together with Custom Incentives, this program is where a bulk of business program savings and dollars are focused. Business energy efficiency efforts are very project-centric, with many large projects participating in a hybrid of standard, prescriptive rebates and custom project incentives. Thus, delivery is integrated in many ways between the two programs.

It is worth noting that, as in the residential portfolio, LED lighting is an important, cost-effective measure in non-residential applications at the outset of the study timeframe in 2016. LED technology costs are declining very quickly, and will become a larger and larger part of the business programs in the coming years.

Custom Incentives

This program is designed to help business customers save energy through customizable projects that are too complex to fit in a standard prescriptive rebate offering.

Together with Prescriptive Rebates, this program is where a bulk of business program savings and dollars are focused. Business energy efficiency efforts are very project-centric, with many large projects participating in a hybrid of standard, prescriptive rebates and custom project incentives. Thus, delivery is integrated in many ways between the two programs.

Retrocommissioning

This program involves the initial, periodic, or continual monitoring and commissioning of building energy systems such as heating, cooling, ventilation, and lighting in order to optimize energy consumption relative to actual building usage. The focus is on low-cost or no-cost measures such as control strategies, sensor adjustment or replacement, set-point adjustments, and the like.

New Construction & Code Support

This program, starting in 2016, is designed to accelerate the incorporation of energy efficient design, construction, and operation in new business facilities and buildings. It provides education and incentive payments to upstream designer-builders and owner-builders for installing high efficiency end-use equipment and building envelope measures.

Small Business Direct Install

This program provides targeted, highly cost-effective measures to small business customers in a quickly deployable program delivery mechanism to help them reduce their energy bills and foster awareness and cross-selling of other efficiency portfolio efforts.

Measures include lighting replacements, HVAC equipment maintenance, low-flow faucet aerators and pre-rinse sprayers, occupancy controls for lighting, programmable thermostats, and smart power strips. The program goal is to deploy a network of qualified trade allies and contractors that can install these measures quickly and free of charge to participants. The program aims to perform a site assessment and implementation of measures on the same day.

Multi Family Common Area

This program is a natural complement to the Multi Family program that addresses energy used within the residential units. Many of the same trade ally channels can be used to promote both programs. Measures covered for Multi Family Common Areas include LEDs, CFLs, high-bay fixtures, lighting and daylighting controls, HVAC equipment, non-HVAC motors, insulation, and water-saving low-flow fixtures.

Strategic Energy Management

Strategic Energy Management (or SEM) involves energy education, advising, and coaching for non-residential customers to drive behavioral change and transformation of company culture toward improved energy efficiency and utilization. This means the appointment of energy liaisons and teams within participating organizations who will regularly correspond with program representatives. Institutionalizing internal policies and practices this way creates long-lasting behavioral-based savings, operational savings, and installation of tangible energy-saving equipment and measures.

Program Potential Results

In this section, a high-level summary of program potential is presented, followed by year-by-year program savings and costs.

Summary of Program Potential

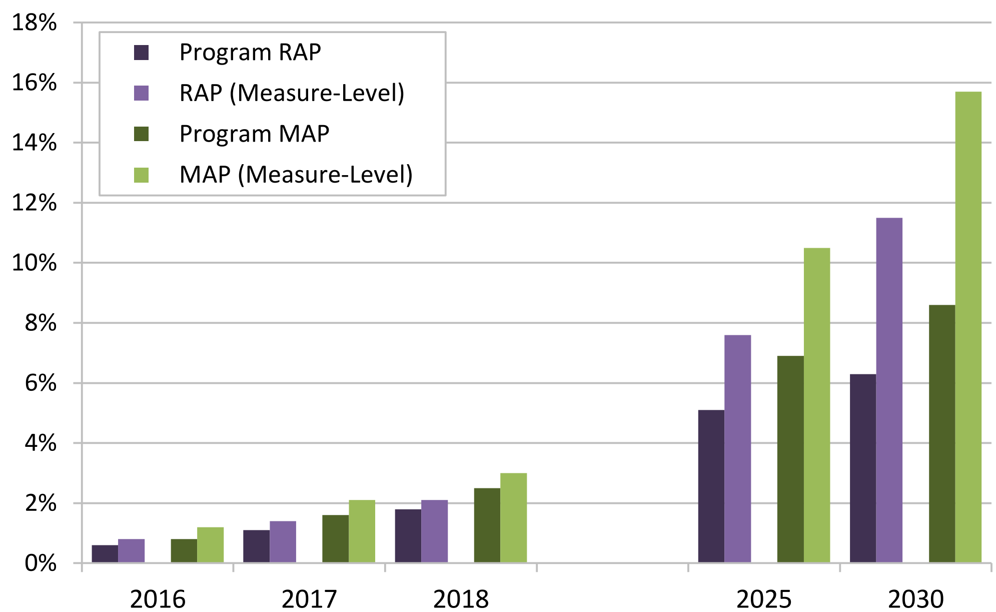
Table 6-2 and Figure 6-1 present a high-level summary of program potential as well as measure-level potential.

- At the end of the 2016-18 program cycle, program potential is in the range of 539 GWh to 768 GWh. As a percent of the baseline projection, the cumulative savings in 2018 are in the range of 1.8% to 2.5%.
- By 2030, program RAP and MAP increase to 2,133 GWh and 2,890 GWh, respectively.

Table 6-2 Summary of Program Potential

	2016	2017	2018		2025	2030
Baseline Projection (GWh)	30,249	30,449	30,694		32,228	33,721
Cumulative Savings (GWh)						
Program RAP	174	346	539		1,629	2,133
Program MAP	251	495	768		2,235	2,890
RAP (Measure-Level)	**339**	**561**	**806**		**2,697**	**3,958**
MAP (Measure-Level)	**510**	**833**	**1,178**		**3,753**	**5,376**
Cumulative Savings (% of Baseline)						
Program RAP	0.6%	1.1%	1.8%		5.1%	6.3%
Program MAP	0.8%	1.6%	2.5%		6.9%	8.6%
RAP (Measure-Level)	**1.1%**	**1.8%**	**2.6%**		**8.4%**	**11.7%**
MAP (Measure-Level)	**1.7%**	**2.7%**	**3.8%**		**11.6%**	**15.9%**

Figure 6-1 Summary of Program and Measure-level RAP and MAP (% of baseline)



Year-by-year Program Potential

The year-by-year program potential results for the RAP and MAP program portfolios are shown below. Figure 6-2 and Figure 6-3 show the net incremental energy savings in each year of the study by program for the RAP and MAP cases respectively. Figure 6-4 and Figure 6-5 show the annual budgets for RAP and MAP cases respectively for the portfolio. Note that the savings presented here are net savings not gross savings.

Figure 6-2 RAP Program Potential - Net Incremental Energy Savings (MWh)

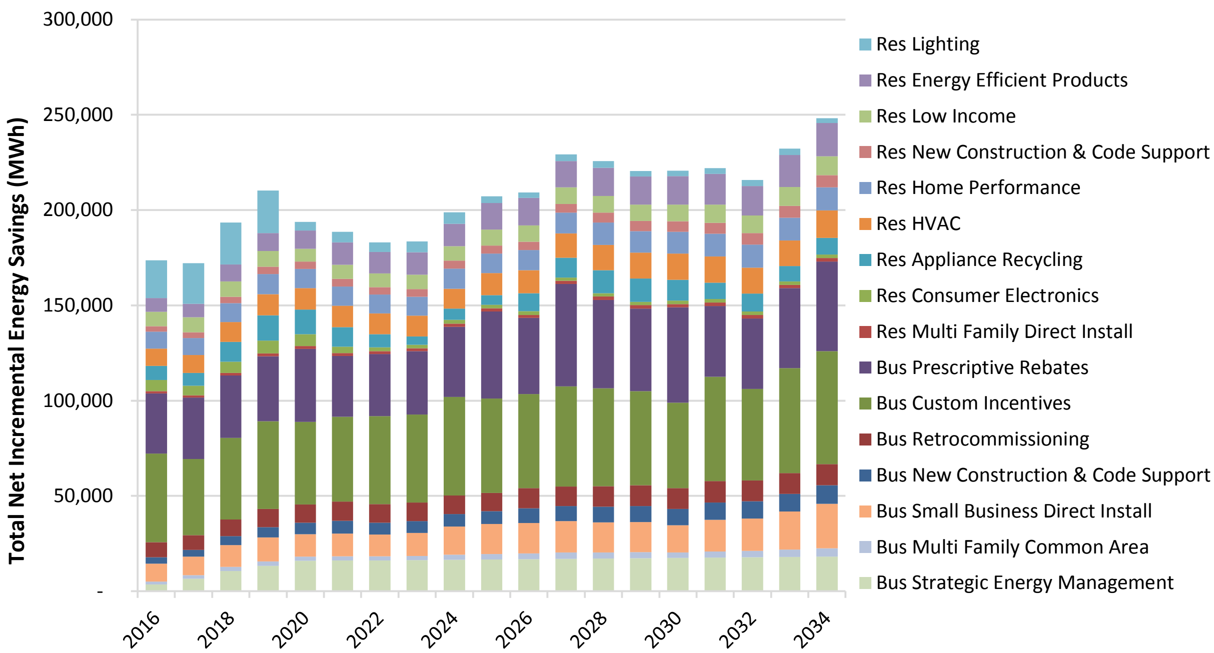


Figure 6-3 MAP Program Potential- Net Incremental Energy Savings (MWh)

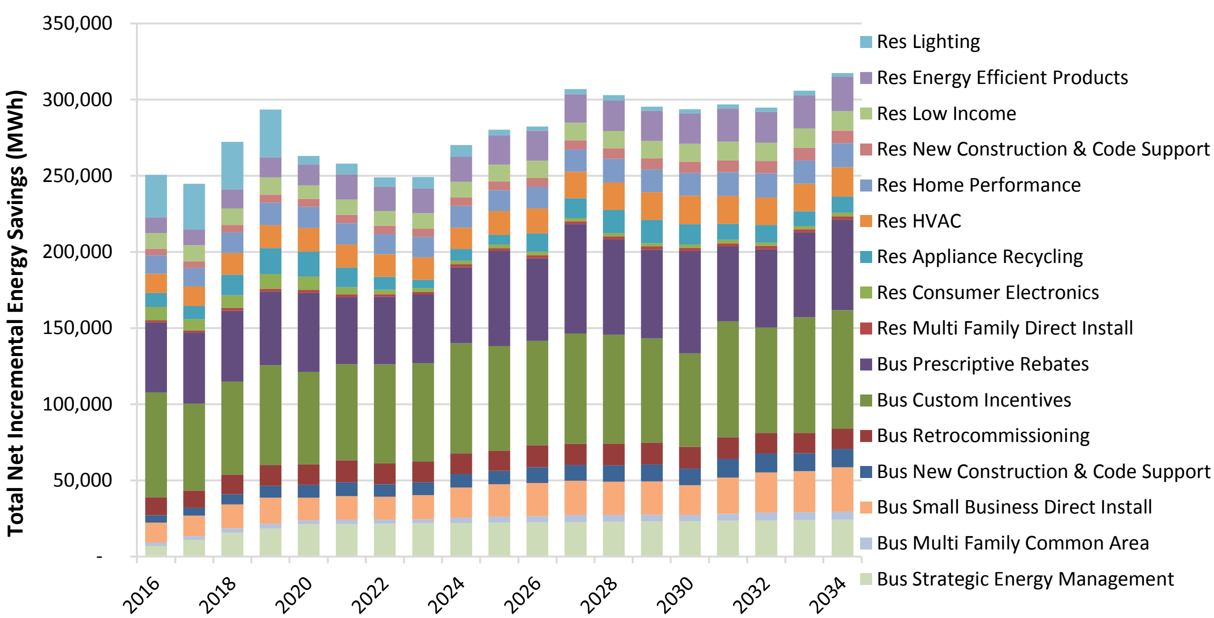


Figure 6-4 RAP Program Potential - Annual Utility Budgets

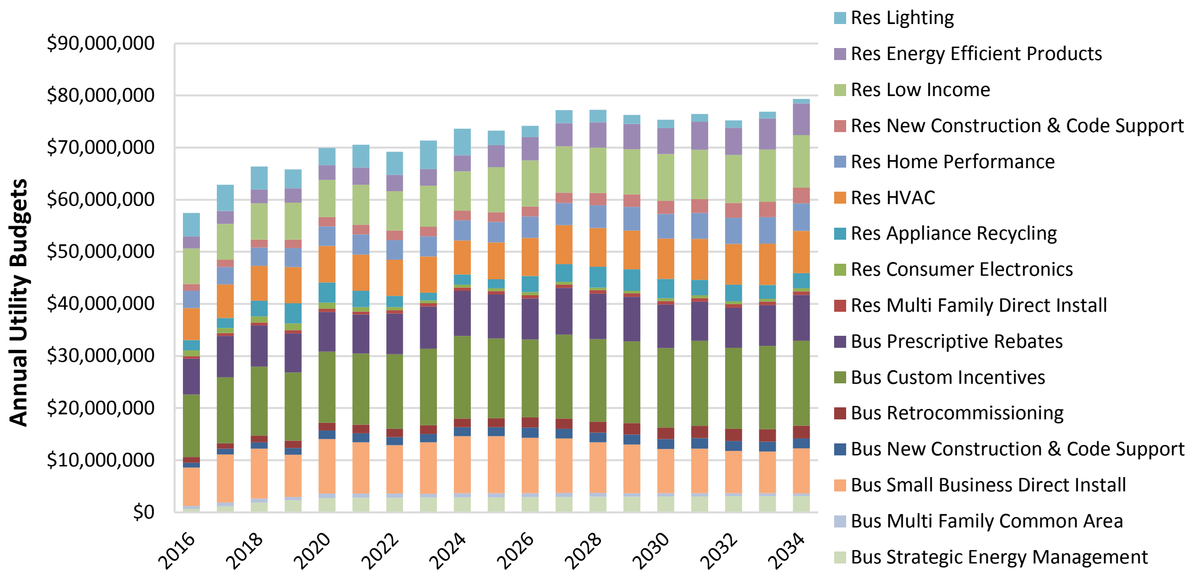


Figure 6-5 MAP Program Potential - Annual Utility Budgets

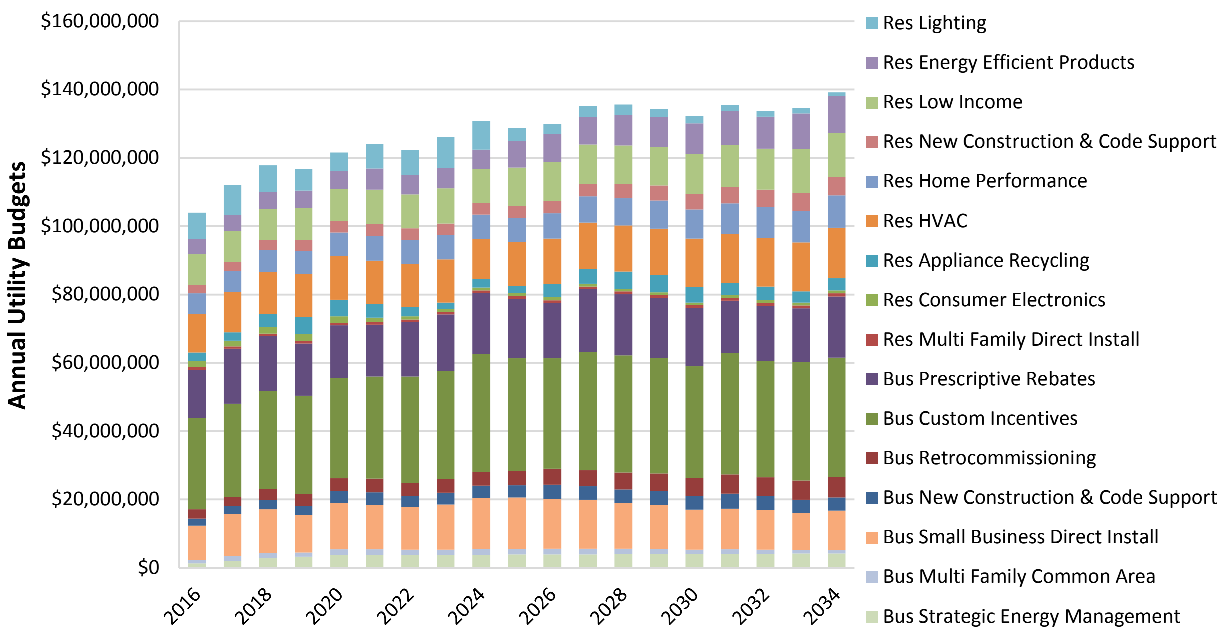


Table 6-3 and Table 6-4 shows the detailed annual savings and budgets for the recommended portfolios.

Table 6-3 RAP Program Potential Portfolio Summary

Program	Total Program Administrator Cost (000$)					Total Net Incremental Energy Savings (MWh)					Total Net Incremental Demand Savings (kW)				
	2016	2017	2018	2025	2030	2016	2017	2018	2025	2030	2016	2017	2018	2025	2030
Res Lighting	4,438	5,032	4,446	2,744	1,593	19,876	21,234	22,043	3,528	2,893	1,196	1,278	1,326	213	174
Res Energy Efficient Products	2,363	2,457	2,624	4,277	4,991	7,094	7,150	8,871	13,864	14,940	1,365	1,381	1,543	1,817	1,882
Res Low Income	6,817	6,881	6,942	8,648	8,980	7,613	7,797	8,031	8,403	8,830	971	970	995	889	877
Res New Construction & Code Support	1,268	1,423	1,546	1,846	2,498	2,912	3,057	3,452	4,206	5,508	391	464	631	752	842
Res Home Performance	3,344	3,357	3,515	3,945	4,717	8,819	8,839	9,815	10,243	11,400	1,721	1,707	1,979	1,895	2,049
Res HVAC	6,126	6,446	6,709	7,077	7,761	9,190	9,464	10,410	11,586	13,816	5,356	5,538	5,761	6,221	6,965
Res Appliance Recycling	1,966	1,886	2,998	1,671	3,718	7,261	6,717	10,499	5,058	10,908	887	820	1,280	525	1,408
Res Consumer Electronics	1,117	1,018	1,161	579	535	5,933	4,981	5,863	1,879	1,741	481	403	474	150	138
Res Multi Family Direct Install	534	543	576	615	672	1,166	1,192	1,370	1,594	1,719	230	237	267	351	405
Bus Prescriptive Rebates	6,856	7,943	7,958	8,510	8,340	31,556	32,325	32,614	45,694	50,035	8,351	7,149	7,557	8,028	6,441
Bus Custom Incentives	11,985	12,608	13,180	15,265	15,248	46,490	39,906	42,910	49,511	44,891	11,461	8,992	9,775	11,466	9,988
Bus Retrocommissioning	1,103	1,091	1,275	1,721	2,209	7,942	7,729	8,706	9,580	10,958	1,852	1,665	1,764	1,939	1,825
Bus New Construction & Code Support	908	1,063	1,251	1,717	1,905	3,406	3,501	4,762	6,754	8,455	350	383	440	670	747
Bus Small Business Direct Install	7,423	9,221	9,609	10,955	8,520	9,337	9,769	11,430	15,710	14,330	2,268	1,740	2,153	2,867	2,051
Bus Multi Family Common Area	534	736	752	778	616	1,617	1,879	2,160	2,923	2,883	262	299	345	427	400
Bus Strategic Energy Management	645	1,168	1,853	2,892	3,028	3,472	6,540	10,552	16,639	17,440	682	1,285	2,073	3,271	3,430
Residential Total:	27,972	29,043	30,517	31,403	35,466	69,862	70,432	80,353	60,362	71,756	12,599	12,797	14,257	12,812	14,740
Business Total:	29,455	33,831	35,878	41,839	39,866	103,819	101,650	113,134	146,812	148,991	25,226	21,513	24,106	28,668	24,884
Portfolio Total:	57,427	62,874	66,395	73,242	75,332	173,682	172,081	193,487	207,173	220,747	37,824	34,310	38,362	41,480	39,624

Table 6-4 MAP Program Potential Portfolio Summary

Program	Total Program Administrator Cost (000$)					Total Net Incremental Energy Savings (MWh)					Total Net Incremental Demand Savings (kW)				
	2016	2017	2018	2025	2030	2016	2017	2018	2025	2030	2016	2017	2018	2025	2030
Res Lighting	7,808	8,857	7,822	3,822	2,115	28,102	30,007	30,997	3,812	2,833	1,690	1,804	1,864	230	171
Res Energy Efficient Products	4,424	4,600	4,905	7,831	9,045	10,154	10,244	12,544	18,976	19,973	1,864	1,886	2,100	2,428	2,474
Res Low Income	8,970	9,068	9,139	11,193	11,619	10,387	10,655	10,954	11,114	11,566	1,313	1,315	1,346	1,174	1,150
Res New Construction & Code Support	2,401	2,690	2,944	3,443	4,600	4,066	4,262	4,826	5,762	7,379	560	660	910	1,024	1,112
Res Home Performance	6,158	6,173	6,481	7,130	8,495	12,206	12,202	13,563	13,723	14,985	2,383	2,349	2,742	2,505	2,664
Res HVAC	11,193	11,770	12,256	12,845	14,104	12,577	12,919	14,249	15,690	18,634	7,082	7,310	7,609	8,137	9,096
Res Appliance Recycling	2,564	2,448	3,857	2,095	4,626	9,366	8,614	13,419	6,254	13,461	1,142	1,049	1,633	644	1,741
Res Consumer Electronics	1,798	1,640	1,861	871	785	8,609	7,246	8,491	2,426	2,166	697	586	687	193	171
Res Multi Family Direct Install	688	700	735	773	839	1,468	1,503	1,698	1,910	2,057	273	281	313	401	462
Bus Prescriptive Rebates	14,080	16,084	16,115	17,450	16,995	46,042	46,630	46,616	62,400	67,305	11,983	10,119	10,639	10,772	8,423
Bus Custom Incentives	26,809	27,341	28,675	33,050	32,676	68,791	57,286	61,106	68,831	61,349	17,037	12,839	13,944	15,742	13,307
Bus Retrocommissioning	2,707	2,664	3,122	4,101	5,282	11,749	11,312	12,697	12,976	14,220	2,710	2,418	2,550	2,692	2,417
Bus New Construction & Code Support	1,985	2,280	2,716	3,600	4,013	4,995	5,025	6,824	8,874	11,016	493	530	612	909	1,007
Bus Small Business Direct Install	10,020	12,284	12,818	15,009	11,669	13,022	13,395	15,477	21,333	19,581	3,215	2,403	2,950	3,860	2,723
Bus Multi Family Common Area	1,093	1,520	1,555	1,666	1,305	2,234	2,568	2,908	3,975	3,956	357	405	463	575	536
Bus Strategic Energy Management	1,290	1,965	2,806	3,890	4,073	6,943	10,901	15,828	22,186	23,254	1,364	2,141	3,109	4,361	4,574
Residential Total:	46,004	47,946	49,999	50,004	56,227	96,934	97,653	110,742	79,667	93,054	17,003	17,241	19,204	16,735	19,041
Business Total:	57,984	64,137	67,808	78,768	76,014	153,776	147,118	161,456	200,574	200,681	37,161	30,855	34,267	38,911	32,986
Portfolio Total:	103,988	112,083	117,807	128,772	132,240	250,710	244,770	272,198	280,241	293,735	54,164	48,095	53,471	55,647	52,027

Cost-effectiveness

With the program savings and budgets, we perform the industry standard cost-effectiveness tests to gauge the economic merits of the portfolio. Each test compares the benefits of the EE programs to their costs — using its own unique perspectives and definitions — all defined in terms of net present value of future cash flows. The definitions for the four standard tests most commonly used in EE program design are described below.

- **Total Resource Cost test (TRC).** The benefits in this test are the lifetime avoided energy costs and avoided capacity costs. The costs in this test are the incremental measure costs plus all administrative costs spent by the program administrator.
- **Utility Cost Test (UCT).** The benefits in this test are the lifetime avoided energy costs and avoided capacity costs, the same as the TRC benefits. The costs in this test are the program administrator's incentive costs and administrative costs.
- **Participant Cost Test (PCT).** The benefits in this test are the lifetime value of retail rate savings (which is another way of saying "lost utility revenues"). The costs in this test are those seen by the participant; in other words: the incremental measure costs minus the value of incentives paid out.
- **Rate Impact Measure test (RIM).** The benefits of the RIM test are the same as the TRC benefits. The RIM costs are the same as the UCT, except for the addition of lost revenue. This test attempts to show the effects that EE programs will have on rates, which is almost always to raise them on a per unit basis. Thus, costs typically outweigh benefits from the point of view of this test, but the assumption is that absolute energy use decreases to a greater extent than per-unit rates are increased — resulting in lower average utility bills.

The cost-effectiveness results for the Program Plan RAP case are shown in Table 6-5, indicating lifetime TRC benefits of $2,008 million and costs of $1,547 million for a TRC ratio of 1.30. For the MAP case, shown in Table 6-6, TRC benefits and costs respectively are $2,718 million and $2,190, resulting in a TRC ratio of 1.24.

Table 6-5 RAP Portfolio Cost-Effectiveness Summary

	TRC Ratio	TRC Benefits	TRC Costs	UCT Ratio	PCT Ratio	RIM Ratio
Res Lighting	1.35	$87,778,355	$64,869,977	1.99	7.52	0.44
Res Energy Efficient Products	1.19	$105,744,748	$88,655,071	2.13	3.71	0.54
Res Low Income	0.69	$73,213,136	$106,343,099	0.69	-	0.35
Res New Construction & Code Support	1.12	$51,525,317	$45,979,925	1.99	3.00	0.60
Res Home Performance	1.01	$97,882,515	$96,848,516	1.83	2.99	0.53
Res HVAC	1.17	$198,678,743	$169,770,774	2.13	2.25	0.75
Res Appliance Recycling	1.55	$58,410,006	$37,597,855	1.55	-	0.46
Res Consumer Electronics	1.13	$11,596,914	$10,260,877	1.13	-	0.39
Res Multi Family Direct Install	1.37	$11,109,698	$8,092,535	1.37	-	0.51
Bus Prescriptive Rebates	1.71	$391,985,341	$228,951,865	3.72	3.55	0.72
Bus Custom Incentives	1.34	$560,574,779	$417,091,262	2.93	2.94	0.65
Bus Retrocommissioning	1.22	$61,320,491	$50,342,234	2.69	2.75	0.62
Bus New Construction & Code Support	1.24	$56,776,309	$45,703,176	2.67	3.44	0.54
Bus Small Business Direct Install	1.38	$170,452,265	$123,601,265	1.38	-	0.49
Bus Multi Family Common Area	1.61	$30,998,372	$19,253,581	3.38	4.28	0.59
Bus Strategic Energy Mgmt.	1.20	$40,126,710	$33,339,685	1.20	-	0.48
Residential Total:	1.11	$695,939,432	$628,418,628	1.62	4.47	0.53
Business Total:	1.43	$1,312,234,267	$918,283,068	2.59	3.84	0.63
Portfolio Total:	1.30	$2,008,173,699	$1,546,701,696	2.15	4.04	0.59

Table 6-6 MAP Portfolio Cost-Effectiveness Summary

	TRC Ratio	TRC Benefits	TRC Costs	UCT Ratio	PCT Ratio	RIM Ratio
Res Lighting	1.28	$111,840,012	$87,218,945	1.59	12.03	0.41
Res Energy Efficient Products	1.17	$142,520,051	$121,579,637	1.56	6.43	0.50
Res Low Income	0.70	$96,830,378	$138,418,512	0.70	-	0.35
Res New Construction & Code Support	1.08	$69,786,162	$64,463,104	1.44	5.09	0.54
Res Home Performance	1.00	$130,791,887	$131,299,149	1.34	5.12	0.48
Res HVAC	1.16	$266,376,831	$229,946,924	1.56	3.95	0.66
Res Appliance Recycling	1.54	$73,063,272	$47,471,692	1.54	-	0.46
Res Consumer Electronics	1.00	$15,937,374	$15,891,266	1.00	-	0.37
Res Multi Family Direct Install	1.32	$13,513,617	$10,218,208	1.32	-	0.49
Bus Prescriptive Rebates	1.62	$530,256,664	$327,533,467	2.47	5.28	0.65
Bus Custom Incentives	1.24	$778,261,341	$625,618,404	1.87	4.42	0.58
Bus Retrocommissioning	1.04	$84,900,708	$81,419,456	1.55	3.92	0.53
Bus New Construction & Code Support	1.14	$76,680,928	$67,548,965	1.70	5.03	0.48
Bus Small Business Direct Install	1.38	$230,857,250	$167,205,819	1.38	-	0.49
Bus Multi Family Common Area	1.48	$41,809,189	$28,216,191	2.18	6.46	0.54
Bus Strategic Energy Mgmt.	1.18	$54,534,459	$46,035,085	1.18	-	0.47
Residential Total:	1.09	$920,659,585	$846,507,437	1.33	7.54	0.49
Business Total:	1.34	$1,797,300,539	$1,343,577,388	1.87	5.69	0.57
Portfolio Total:	1.24	$2,717,960,124	$2,190,084,824	1.65	6.23	0.54

Supply Curves

The purpose of supply curves is to better understand the relationship between energy efficiency savings and the costs required to reach those savings levels. Energy efficiency measures and/or programs and their associated impacts are rank-ordered according to their cost per unit of savings. The two data points (unit cost and savings impacts) are plotted on a line chart. As programs become more expensive, there is a point on the supply curve where it appears that significantly greater cost will be required to reach very little additional EE savings.

Supply curves can yield insights about a portfolio of conservation programs. Such insights are not visible when one is looking at the impacts and costs associated with any one individual program.

In the supply curves, the y-axis shows the unit cost of the saved energy, and the x-axis shows the energy savings impacts. To develop the supply curves, the following data must be considered and assembled.

Y-axis: Unit Cost

For the y-axis, one must represent each measure or program's cost per unit of energy saved. This can be done on a first-year basis or a levelized/lifetime basis, wherein the cost is amortized or spread across the lifetime of the savings. Once this data is assembled, it is rank-ordered from least cost to highest cost.

X-axis: Energy Savings Impacts

For the x-axis, one must represent the energy savings obtained by each measure or program. This can be done in terms of absolute energy savings or as a percentage of the baseline projection. The supply curve and associated data can also be prepared for a single year at a time, or for a summation of cumulative savings over multiple years. Different formulations are useful for different purposes, and it is important to specify the assumptions when presenting the data. An example data set is shown in Table 6-7 below.

Table 6-7 Example of Measure Data Preparation for Supply Curve

Measures Entering Supply Curve	Incre-mental Measure Cost	Number of Units	Annual kWh Savings/ Unit	Effective Useful Life (years)	X-Axis	Y-Axis (option 1)	Y-Axis (option 2)
					Total First-Year kWh Savings	First-Year $/kWh	Lifetime or Levelized $/kWh*
	A	B	C	D	B * C	A / C	(A amortized over D)* / C
CFL lamp	$2	100,000	30	5	3,000,000	$0.07	$0.01
Ceiling Insulation	$500	1,200	1500	25	1,800,000	$0.33	$0.02
SEER 16 AC	$150	800	350	14	280,000	$0.43	$0.04
Heat Pump Maint.	$50	150	90	3	13,500	$0.56	$0.19

** Assuming a discount rate of 3.00%*

Program Supply Curves

Once the data is assembled, it can be plotted on a supply curve that has a new data point for every measure, stacked from lowest unit cost to highest unit cost. Figure 6-6 provides levelized cost supply curves for installations under the two Program Potential cases described above, for the period 2016–2018. Figure 6-7 provides this information for the period 2016-2033.

Figure 6-6 Levelized Cost Supply Curves, 2016–2018, RAP and MAP Portfolios

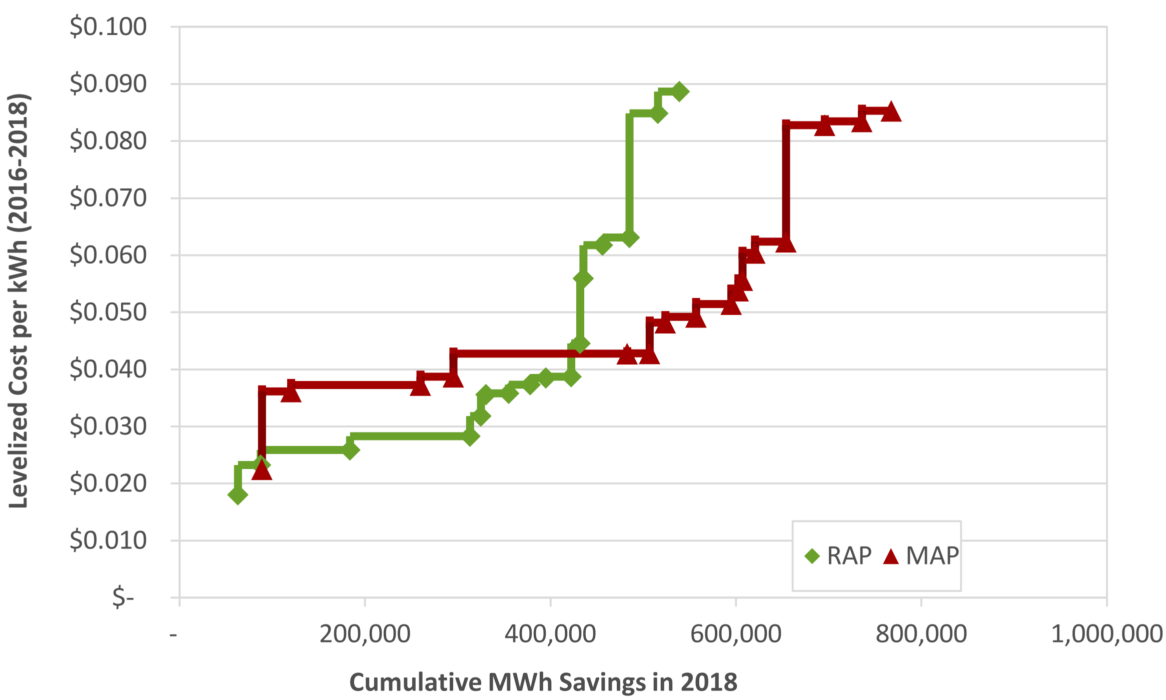
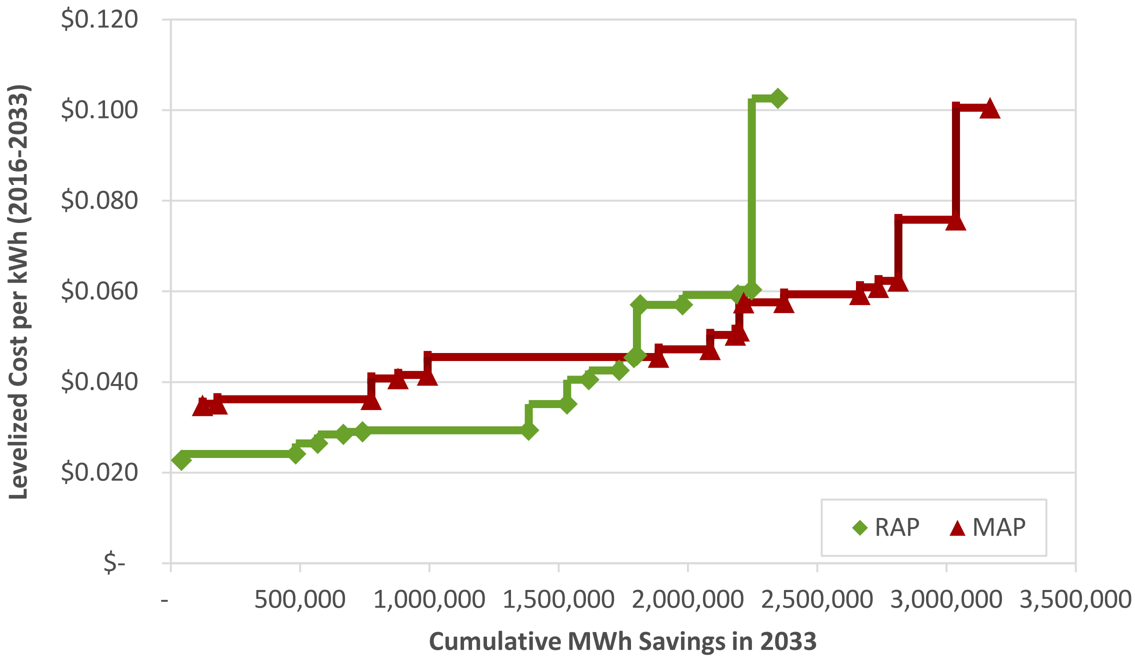


Figure 6-7 Levelized Cost Supply Curves, 2016–2033 RAP and MAP Portfolios



The data corresponding to Figure 6-6 and Figure 6-7 is provided in Table 6-8. Table 6-9 shows first-year costs by program.

Table 6-8 Levelized Cost by Program - RAP and MAP

	RAP Levelized $/kWh 2016-2018	MAP Levelized $/kWh 2016-2018	RAP Levelized $/kWh 2016-2033	MAP Levelized $/kWh 2016-2033
Res Lighting	$0.018	$0.023	$0.028	$0.035
Res Energy Efficient Products	$0.037	$0.049	$0.035	$0.047
Res Low Income	$0.089	$0.085	$0.103	$0.101
Res New Construction & Code	$0.045	$0.060	$0.045	$0.062
Res Home Performance	$0.039	$0.051	$0.043	$0.058
Res HVAC	$0.063	$0.083	$0.057	$0.076
Res Appliance Recycling	$0.036	$0.036	$0.041	$0.041
Res Consumer Electronics	$0.039	$0.043	$0.046	$0.051
Res Multi Family Direct Install	$0.056	$0.056	$0.057	$0.058
Bus Prescriptive Rebates	$0.026	$0.037	$0.024	$0.036
Bus Custom Incentives	$0.028	$0.043	$0.029	$0.046
Bus Retrocommissioning	$0.023	$0.039	$0.029	$0.050
Bus New Construction & Code	$0.032	$0.048	$0.026	$0.042
Bus Small Business Direct Install	$0.085	$0.083	$0.059	$0.059
Bus Multi Family Common Area	$0.036	$0.054	$0.023	$0.035
Bus Strategic Energy Management	$0.062	$0.062	$0.060	$0.061
Residential Total:	**$0.041**	**$0.049**	**$0.049**	**$0.059**
Non-Residential Total:	**$0.035**	**$0.046**	**$0.033**	**$0.045**
Portfolio Total:	**$0.037**	**$0.047**	**$0.039**	**$0.050**

Table 6-9 First-year Cost per kWh by Program — RAP and MAP

Program	RAP			MAP		
	2016	2017	2018	2016	2017	2018
Res Lighting	$0.22	$0.24	$0.20	$0.28	$0.30	$0.25
Res Energy Efficient Products	$0.33	$0.34	$0.30	$0.44	$0.45	$0.39
Res Low Income	$0.90	$0.88	$0.86	$0.86	$0.85	$0.83
Res New Construction & Code Support	$0.44	$0.47	$0.45	$0.59	$0.63	$0.61
Res Home Performance	$0.38	$0.38	$0.36	$0.50	$0.51	$0.48
Res HVAC	$0.67	$0.68	$0.64	$0.89	$0.91	$0.86
Res Appliance Recycling	$0.27	$0.28	$0.29	$0.27	$0.28	$0.29
Res Consumer Electronics	$0.19	$0.20	$0.20	$0.21	$0.23	$0.22
Res Multi Family Direct Install	$0.46	$0.46	$0.42	$0.47	$0.47	$0.43
Bus Prescriptive Rebates	$0.22	$0.25	$0.24	$0.31	$0.34	$0.35
Bus Custom Incentives	$0.26	$0.32	$0.31	$0.39	$0.48	$0.47
Bus Retrocommissioning	$0.14	$0.14	$0.15	$0.23	$0.24	$0.25
Bus New Construction & Code Support	$0.27	$0.30	$0.26	$0.40	$0.45	$0.40
Bus Small Business Direct Install	$0.80	$0.94	$0.84	$0.77	$0.92	$0.83
Bus Multi Family Common Area	$0.33	$0.39	$0.35	$0.49	$0.59	$0.53
Bus Strategic Energy Management	$0.19	$0.18	$0.18	$0.19	$0.18	$0.18
Residential Total	**$0.40**	**$0.41**	**$0.38**	**$0.47**	**$0.49**	**$0.45**
Non-Residential Total	**$0.28**	**$0.33**	**$0.32**	**$0.38**	**$0.44**	**$0.42**
Portfolio Total	**$0.33**	**$0.37**	**$0.34**	**$0.41**	**$0.46**	**$0.43**

SENSITIVITY ANALYSIS

In addition to development of a reference case of energy-efficiency potential, sensitivity analyses were performed for three key assumptions in the study:

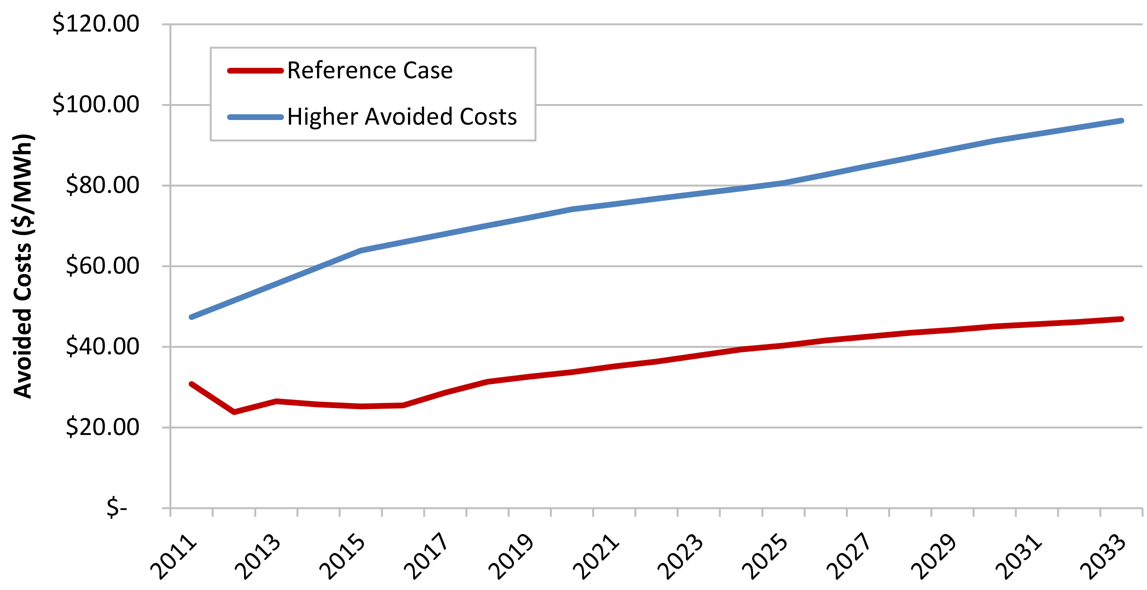
- Avoided costs
- Economic growth
- Program net-to-gross ratios

The remainder of this chapter describes the results of this analysis.

Avoided Cost

Avoided costs affect the cost-effectiveness of energy-efficiency measures. Higher avoided costs cause more measures to pass the screen and result in higher potential savings, while lower costs cause fewer measures to pass. Of these two options, higher avoided costs are more interesting to assess. Chapter 5 presents the measure-level results associated with the reference case avoided costs shown in Figure 7-1. For this sensitivity analysis, the avoided costs used in the 2010 Study were applied. All other assumptions were held constant. As shown in Figure 7-1, the avoided costs used in the previous study were significantly higher than those used in this study.

Figure 7-1 Comparison of Avoided Costs



As a result of higher avoided costs, more measures passed the economic screen (meaning it has a TRC benefit-to-cost ratio greater than or equal to 1.0). For each sector, only four additional measures passed the TRC. This indicates that very few measures are close to the marginal value of 1.0 in the reference case. The number of measures passing in each case is shown in Table 7-1.

Table 7-1 Number of Measures Passing the Economic Screen - Comparison

	Reference Case	Higher Avoided Costs	Additional Measures
Residential	43	47	4
Commercial	100	104	4
Industrial	39	43	4
Passing Measures	**182**	**194**	**12**

In the next program cycle (2016-2018), RAP savings using the higher avoided costs are 16% higher than in the reference case. By 2030, the cumulative RAP savings are 7% higher than in the reference case.

Table 7-2 EE Potential - Comparison of Avoided Cost Sensitivity Cases (GWh)

	2016	2017	2018		2025	2030
RAP Potential Energy Savings (GWh)						
Reference case	339	561	806		2,697	3,958
Higher avoided costs	395	650	932		2,968	4,229
Increase in potential savings	*56*	*89*	*126*		*270*	*271*
RAP Potential Energy Savings (% of Baseline)						
Reference case	1.1%	1.8%	2.6%		8.4%	11.7%
Higher avoided costs	1.3%	2.1%	3.0%		9.2%	12.5%
Increase in potential savings	*0.2%*	*0.3%*	*0.4%*		*0.8%*	*0.8%*
MAP Potential Energy Savings (GWh)						
Reference case	510	833	1,179		3,753	5,377
Higher avoided costs	592	963	1,360		4,116	5,727
Increase in potential savings	*82*	*130*	*181*		*363*	*350*
MAP Potential Energy Savings (% of Baseline)						
Reference case	1.7%	2.7%	3.8%		11.6%	15.9%
Higher avoided costs	2.0%	3.2%	4.4%		12.8%	17.0%
Increase in potential savings	*0.3%*	*0.5%*	*0.6%*		*1.1%*	*1.0%*

Economic Growth

Another major driver for the analysis is the economic growth assumption in the baseline projection. The reference case aligns with the assumptions used for Ameren's load forecast. For this sensitivity analysis, a low-high band was developed.

- For the low load growth case, customer growth was assumed to be flat in each sector.
- For the high load growth case, customer growth was 20% over the reference case in each year.

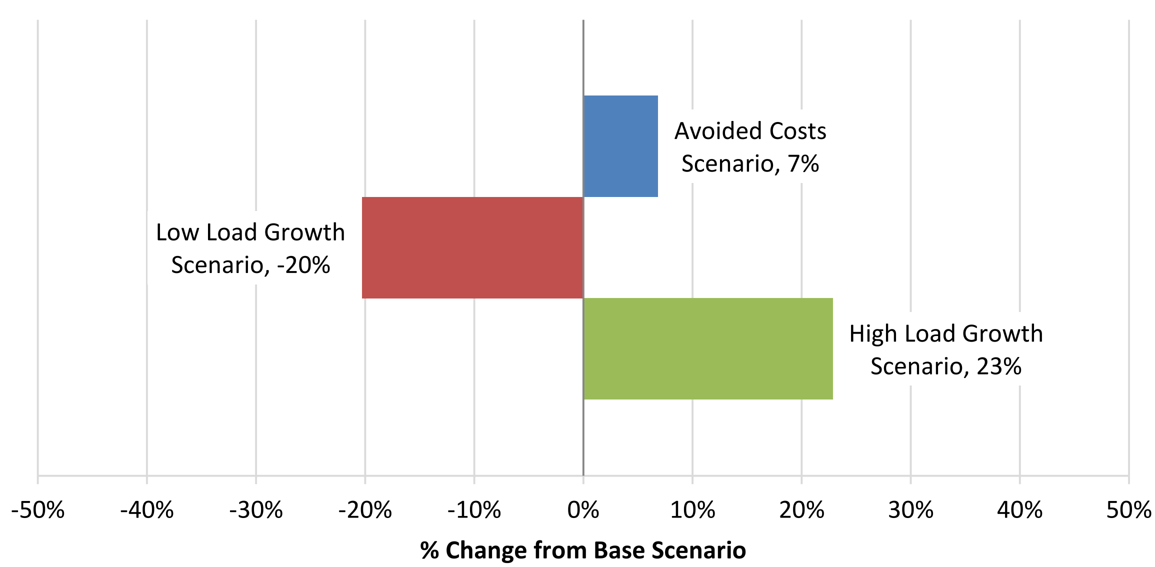
As expected and shown in Table 7-3, the potential savings are lower in the low economic case and higher in the high economic case.

Table 7-3 Comparison of Baseline Projection, MAP and RAP for Economic-Growth Sensitivity

	2016	2017	2018		2025	2030
RAP Potential Energy Savings (GWh)						
Reference case	339	561	806		2,697	3,958
Low load growth	301	492	698		2,180	3,155
High load growth	421	690	1,000		3,383	4,861
MAP Potential Energy Savings (GWh)						
Reference case	510	833	1,179		3,753	5,377
Low load growth	452	729	1,018		3,026	4,278
High load growth	635	1,029	1,466		4,719	6,616

Figure 7-2 shows the percentage change in the RAP potential for the various scenarios. The High Load Growth scenario shows the largest impact, increasing the potential savings by 23% from the reference case.

Figure 7-2 Comparison of Sensitivity Cases (% change in RAP Potential savings, 2030)



Net-to-gross Assumptions

A key assumption in the program design is the net-to-gross ratio assumed for each program. The net-to-gross ratio identifies the fraction of program participants who would not have purchased the EE measures in the absence of a program. The net-to-gross ratio used in the reference forecast was provided by Ameren and is based on EM&V results for each program. The sensitivity analysis assumed values 30% higher and 30% lower than the reference case.

Table 7-4 and Table 7-5 show the Program Administrator Costs for RAP and MAP respectively across the sensitivity analysis cases. With a lower net-to-gross ratio, more participants are needed to achieve the savings and therefore the program administrator cost increases. In the case where the net-to-gross ratio is higher, more savings are achieved without incurring the cost of fulfilling as many incentives. For the high case, if the 30% increase resulted in a ratio greater than 100%, the amount over 100% is considered spillover. Figure 7-3 and Figure 7-4 compares the Program Administrator Costs for the entire portfolio in each of the sensitivity cases.

Table 7-6 shows the cost-effectiveness ratios in each sensitivity case for the RAP Portfolio. Table 7-7 shows the cost-effectiveness ratios for the MAP Portfolio. With the higher program administration costs, the B/C ratio decreases significantly with a 30% reduction in the net-to-gross ratio, while it increase significantly with a 30% increase.

Table 7-4 RAP Program Administrator Cost

Program	Total Program Administrator Costs (000$)								
	Base Scenario			30% lower Net-to-Gross Ratio			30% higher Net-to-Gross Ratio		
	2016	2017	2018	2016	2017	2018	2016	2017	2018
Residential Total:	27,972	29,043	30,517	39,668	41,197	43,304	21,675	22,498	23,632
Non-Residential Total:	29,455	33,831	35,878	41,622	47,649	50,280	22,903	26,390	28,123
Portfolio Total:	**57,427**	**62,874**	**66,395**	**81,290**	**88,846**	**93,583**	**44,578**	**48,888**	**51,755**

Table 7-5 MAP Program Administrator Cost

Program	Total Program Administrator Costs (000$)								
	Base Scenario			30% lower Net-to-Gross Ratio			30% higher Net-to-Gross Ratio		
	2016	2017	2018	2016	2017	2018	2016	2017	2018
Residential Total:	46,004	47,946	49,999	65,225	68,000	70,932	35,654	37,148	38,727
Non-Residential Total:	57,984	64,137	67,808	82,101	90,602	95,486	44,997	49,887	52,904
Portfolio Total:	**103,988**	**112,083**	**117,807**	**147,327**	**158,602**	**166,418**	**80,652**	**87,035**	**91,632**

Table 7-6 RAP Cost-Effectiveness Across Sensitivity Cases

Program	Base Scenario				30% lower Net-to-Gross Ratio				30% higher Net-to-Gross Ratio			
	TRC Ratio	PA/UCT Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA/UCT Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA/UCT Ratio	PCT Ratio	RIM Ratio
Residential Total:	1.11	1.62	4.47	0.53	0.78	1.14	3.13	0.46	1.43	2.10	5.80	0.57
Non-Residential Total:	1.43	2.59	3.84	0.63	1.01	1.86	2.69	0.57	1.83	3.29	4.99	0.66
Portfolio Total:	**1.30**	**2.15**	**4.04**	**0.59**	**0.92**	**1.53**	**2.83**	**0.53**	**1.67**	**2.75**	**5.25**	**0.63**

Table 7-7 MAP Cost-Effectiveness Across Sensitivity Cases

Program	Base Scenario				30% lower Net-to-Gross Ratio				30% higher Net-to-Gross Ratio			
	TRC Ratio	PA/UCT Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA/UCT Ratio	PCT Ratio	RIM Ratio	TRC Ratio	PA/UCT Ratio	PCT Ratio	RIM Ratio
Residential Total:	1.09	1.33	7.54	0.49	0.77	0.94	5.28	0.43	1.41	1.72	9.80	0.54
Non-Residential Total:	1.34	1.87	5.69	0.57	0.95	1.33	3.98	0.51	1.72	2.39	7.40	0.62
Portfolio Total:	**1.24**	**1.65**	**6.23**	**0.54**	**0.88**	**1.17**	**4.36**	**0.48**	**1.60**	**2.11**	**8.10**	**0.59**

Figure 7-3 RAP Program Administrator Costs – Comparison of Sensitivity Cases

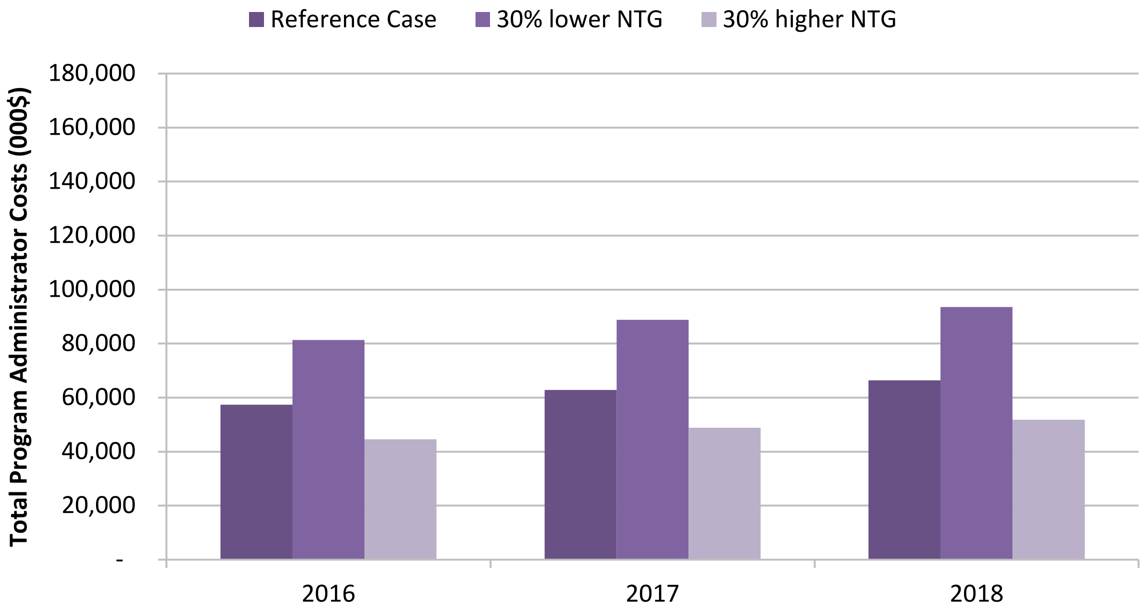
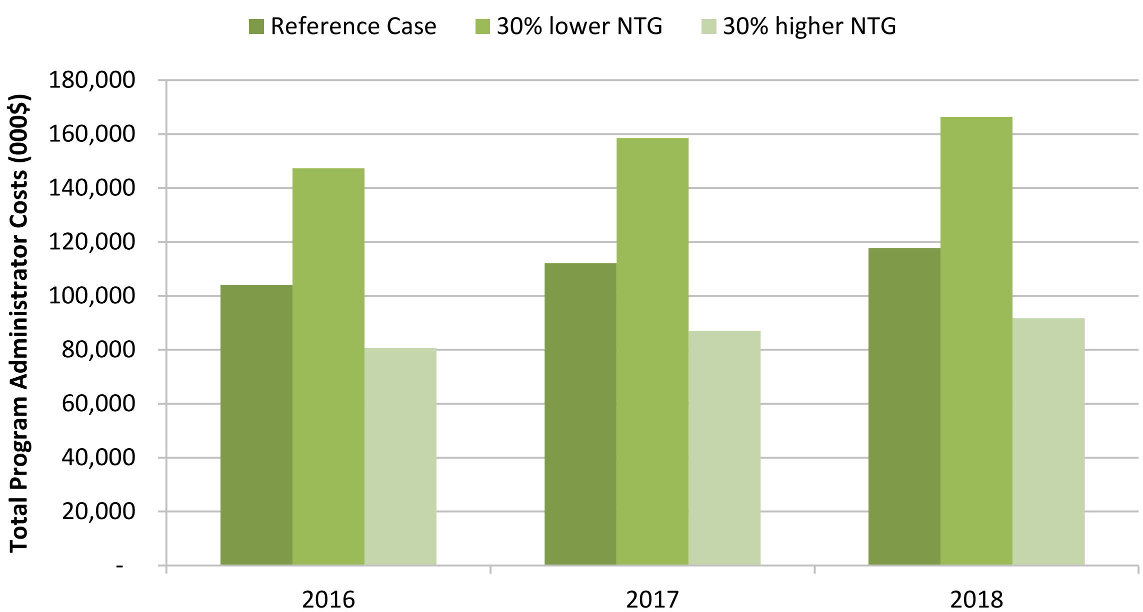


Figure 7-4 MAP Program Administrator Costs – Comparison of Sensitivity Cases



MARKET PROFILES

Market profiles describe electricity use by sector, segment, end use and technology in the base year of the study (2011). The market profiles are given for average buildings and new vintages.

As explained in Chapter 3 of Volume 3, a market profile includes the following elements:

- **Market size** is a representation of the number of customers in the segment. For the residential sector, it is number of households. In the commercial sector, it is floor space measured in square feet. For the industrial sector, it is number of employees.
- **Saturations** define the fraction of buildings with the specific technologies. (e.g., homes with electric space heating)
- **UEC (unit energy consumption) or EUI (energy-use index)** describes the amount of energy consumed in the base year by a specific technology in buildings that have the technology. We use UECs expressed in kWh/household for the residential sector, and EUIs expressed in kWh/square foot or kWh/employee for the commercial and industrial sectors respectively.
- **Intensity** for the residential sector represents the average energy use for the technology across all households in the base year. It is computed as the product of the saturation and the UEC and is defined as kWh/household for electricity. For the commercial and industrial sectors, intensity, computed as the product of the saturation and the EUI, represents the average use for the technology across all floor space or all employees in the base year.
- **Usage** is the annual energy use by a technology/end use in the segment. It is the product of the market size and intensity and is quantified in GWh for electricity.

The file “1434_Appendix_A_Tables-Market_Profiles.xlsx” presents the following market profiles:

- Residential market profiles by segment
- Commercial market profiles by building type
- Industrial market profile

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RESIDENTIAL ENERGY EFFICIENCY EQUIPMENT AND MEASURE DATA

This appendix presents detailed information for all energy-efficiency measures (*equipment* and *non-equipment* measures per the LoadMAP taxonomy) that were evaluated as part of this study. Several sets of tables are provided.

Measure Descriptions

Table B-1 and Table B-2 provide brief descriptions for all equipment and non-equipment measures that were assessed for potential.

Equipment Measure Data

The tables in the file "1434_Appendix_B_Tables-Residential_Equipment.xlsx" list the detailed unit-level data for the equipment measures for each of the housing type segments — Single Family, Multi Family, and for existing and new construction, respectively. Savings are in annual kWh per household, and incremental costs are in $/household ($/HH), unless noted otherwise. The BC ratio shown in the tables are for the first year of the potential analysis (2011), although the B/C ratio is calculated within LoadMAP for each year of the forecast. The B/C ratio in the tables is 1.00 if the measure represents the baseline technology, and zero if the technology is not available in 2013. The final data item in these tables is the levelized cost of conserved energy, which is defined as the cost of the measure divided by the cumulative amount of energy savings accrued over the measure's lifetime ($/kWh).

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Non-Equipment Measure Data

The tables in the file "1434_Appendix_B_Tables-Residential_Non-Equipment.xlsx" list the detailed unit-level data for the non-equipment energy efficiency measures for each of the housing type segments and for existing and new construction, respectively. Because these measures can produce energy-use savings for multiple end-use loads (e.g., insulation affects heating and cooling energy use) savings are expressed as a net percentage of all the relevant, combined end-use loads. Base saturation indicates the percentage of homes in which the measure is already installed. Applicability is a factor that accounts for whether the measure can be applied to the building. Cost is expressed in $/household. The detailed measure-level tables present the results of the benefit/cost (B/C) analysis for the first year of the analysis (2011) although the B/C ratio is calculated within LoadMAP for each year of the forecast. These tables also contain the levelized cost of conserved energy, which is defined as the cost of the measure divided by the cumulative amount of energy savings accrued over the measure's lifetime. This metric is given in terms of $/kWh.

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Table B-1 Residential Energy Efficiency Equipment Measure Descriptions

End Use	Technology	Measure Description
Cooling	Central AC	Central air conditioners consist of a refrigeration system using a direct expansion cycle. Equipment includes a compressor, an air-cooled condenser (located outdoors), an expansion valve, and an evaporator coil. A supply fan near the evaporator coil distributes supply air through air ducts to the building. Cooling efficiencies vary based on materials used, equipment size, condenser type, and system configuration. CACs may be unitary (all components housed in a factory-built assembly) or split system (an outdoor condenser section and an indoor evaporator section connected by refrigerant lines and with the compressor either indoors or outdoors). Energy efficiency is rated according to the size of the unit using the Seasonal Energy Efficiency Rating (SEER). Ductless systems with Variable Refrigerant Flow further improve the operating efficiency.
Cooling	Room AC	Room air conditioners are designed to cool a single room or space. They incorporate a complete air-cooled refrigeration and air-handling system in an individual package. Room air conditioners come in several forms, including window, split-type, and packaged terminal units. Energy efficiency is rated according to the size of the unit using the Energy Efficiency Rating (EER).
Cooling / Heating	Air-Source Heat Pump	A central heat pump consists of components similar to a CAC system, but is usually designed to function both as a heat pump and an air conditioner. It consists of a refrigeration system using a direct expansion (DX) cycle. Equipment includes a compressor, an air-cooled condenser (located outdoors), an expansion valve, and an evaporator coil (located in the supply air duct near the supply fan) and a reversing valve to change the DX cycle from cooling to heating when required. The cooling and heating efficiencies vary based on the materials used, equipment size, condenser type, and system configuration. Heat pumps may be unitary (all components housed in a factory-built assembly) or a split system (an outdoor condenser section and an indoor evaporator section connected by refrigerant lines, with either outdoors or indoors. A high-efficiency option for a ductless mini-split system is also analyzed.
Cooling / Heating	Geothermal Heat Pump	Geothermal heat pumps are similar to air-source heat pumps, but use the ground or groundwater instead of outside air to provide a heat source/sink. A geothermal heat pump system generally consists of three major subsystems or parts: a geothermal heat pump to move heat between the building and the fluid in the earth connection, an earth connection for transferring heat between the fluid and the earth, and a distribution subsystem for delivering heating or cooling to the building. The system may also have a desuperheater to supplement the building's water heater, or a full-demand water heater to meet all of the building's hot water needs.
Heating	Electric Room Heat	Resistive heating elements are used to convert electricity directly to heat. Conductive fins surrounding the element or another mechanism is used to deliver the heat directly to the surrounding room or area. These are typically either baseboard or wall-mounted units.
Heating	Furnace	Furnaces heat air and distribute the heated air through the building using ducts. Efficiency improvements can include: exhaust fan controls, electronic ignition (no pilot light), compact size and lighter weight to reduce cycling losses, smaller-diameter flue pipe, and sealed combustion. Very high efficiency units, or condensing units, condense the water vapor

End Use	Technology	Measure Description
		produced in the combustion process and also use the heat from this condensation.
Water Heating	Water Heater	For electric hot water heating, the most common type is a storage heater, which incorporates an electric heating element, storage tank, outer jacket, insulation, and controls in a single unit. Efficient units are characterized by a high recovery or thermal efficiency and low standby losses (the ratio of heat lost per hour to the content of the stored water). A further efficiency gain is available through a heat pump water heater (HPWH), which uses a vapor-compression thermodynamic cycle similar to that found in an air-conditioner or refrigerator to extract heat from an available source (e.g., air) and reject that heat to a higher temperature sink, in this case, the water in the water heater. Electric instantaneous water heaters are available, but are excluded from this study due to potentially high instantaneous demand concerns. For natural gas hot water heating, the most common type is a storage heater, which incorporates a burner, storage tank, outer jacket, insulation, and controls in a single unit. Efficient units are characterized by a high recovery or thermal efficiency and low standby losses (the ratio of heat lost per hour to the content of the stored water). A further efficiency gain is available in condensing units, which condense the water vapor produced in the combustion process and also use the heat from this condensation.
Interior Lighting	Screw-in	Infrared halogen lamps are designed to be a replacement for standards incandescent lamps. Also referred to as advanced incandescent lamps, these products meet the Energy Independence and Security Act (EISA) lighting standards and are phased in as the baseline technology screw-in lamp technology to reflect the timeline over which the EISA lighting standards take effect. Compact fluorescent lamps are designed to be a replacement for standard incandescent lamps and use about 25% of the energy used by standard incandescent lamps to produce the same lumen output. They can use either electronic or magnetic ballasts. Integral compact fluorescent lamps have the ballast integrated into the base of the lamp and have a standard screw-in base that permits installation into existing incandescent fixtures. Light-emitting diode (LED) lighting has seen recent penetration in specific applications such as traffic lights and exit signs. With the potential for extremely high efficiency, LEDs show promise to provide general-use lighting for interior spaces. Current models commercially available have efficacies comparable to CFLs. However, theoretical efficiencies are significantly higher. LED models under development are expected to provide improved efficacies.
Interior Lighting	Linear Fluorescent	T8 fluorescent lamps are smaller in diameter than standard T12 lamps, resulting in greater light output per watt. T8 lamps also operate at a lower current and wattage, which increases the efficiency of the ballast but requires the lamps to be compatible with the ballast. Fluorescent lamp fixtures can include a reflector that increases the light output from the fixture, and thus make it possible to use a fewer number of lamps in each fixture. T5 lamps further increase efficiency by reducing the lamp diameter to 5/8”. Light-emitting diode (LED) lighting has seen recent penetration in specific applications such as traffic lights and exit signs. With the potential for extremely high efficiency, LEDs show promise to provide general-use lighting for interior spaces. Current models commercially available have efficacies comparable to CFLs. However, theoretical efficiencies are significantly higher. LED models under development are expected to

End Use	Technology	Measure Description
		provide improved efficacies.
Interior Lighting	Specialty Lighting	Bulbs that the DOE does not consider conventional and are not covered by federal efficiency standards. These include: appliance bulbs, heavy-duty bulbs, dimmable bulbs, three-way bulbs, G shape (globe) lamps, candelabra base, and others.
Exterior Lighting	Screw-in	Infrared halogen lamps are designed to be a replacement for standards incandescent lamps. Also referred to as advanced incandescent lamps, these products meet the Energy Independence and Security Act (EISA) lighting standards and are phased in as the baseline technology screw-in lamp technology to reflect the timeline over which the EISA lighting standards take effect. Compact fluorescent lamps are designed to be a replacement for standard incandescent lamps and use about 25% of the energy used by standard incandescent lamps to produce the same lumen output. They can use either electronic or magnetic ballasts. Integral compact fluorescent lamps have the ballast integrated into the base of the lamp and have a standard screw-in base that permits installation into existing incandescent fixtures. Light-emitting diode (LED) lighting has seen recent penetration in specific applications such as traffic lights and exit signs. With the potential for extremely high efficiency, LEDs show promise to provide general-use lighting for interior spaces. Current models commercially available have efficacies comparable to CFLs. However, theoretical efficiencies are significantly higher. LED models under development are expected to provide improved efficacies.
Appliances	Refrigerator	Energy-efficient refrigerators/freezers incorporate features such as improved cabinet insulation, more efficient compressors and evaporator fans, defrost controls, mullion heaters, oversized condenser coils, and improved door seals. Further efficiency increases can be obtained by reducing the volume of refrigerated space, or adding multiple compartments to reduce losses from opening doors.
Appliances	Second Refrigerator	Energy-efficient refrigerators/freezers incorporate features such as improved cabinet insulation, more efficient compressors and evaporator fans, defrost controls, mullion heaters, oversized condenser coils, and improved door seals. Further efficiency increases can be obtained by reducing the volume of refrigerated space, or adding multiple compartments to reduce losses from opening doors.
Appliances	Freezer	Energy-efficient refrigerators/freezers incorporate features such as improved cabinet insulation, more efficient compressors and evaporator fans, defrost controls, mullion heaters, oversized condenser coils, and improved door seals. Further efficiency increases can be obtained by reducing the volume of refrigerated space, or adding multiple compartments to reduce losses from opening doors.
Appliances	Clothes Washer	High efficiency clothes washers use superior designs that require less water. Sensors match the hot water needs to the size and soil level of the load, preventing energy waste. Further energy and water savings can be achieved through advanced technologies such as inverter-drive or combination washer-dryer units. MEF is the official energy efficiency metric used to compare relative efficiencies of different clothes washers. MEF considers the energy used to run the washer, heat the water, and run the dryer. The higher the MEF, the more efficient the clothes washer.
Appliances	Clothes Dryer	An energy-efficient clothes dryer has a moisture-sensing device to

End Use	Technology	Measure Description
		terminate the drying cycle rather than using a timer and an energy-efficient motor is used for spinning the dryer tub. Application of a heat pump cycle for extracting the moisture from clothes leads to additional energy savings.
Appliances	Dishwasher	High efficiency dishwashers save by using both improved technology for the primary wash cycle, and by using less hot water. Construction includes more effective washing action, energy-efficient motors, and other advanced technology such as sensors that determine the length of the wash cycle and the temperature of the water necessary to clean the dishes.
Appliances	Stove	These products have additional insulation in the oven compartment and tighter-fitting oven door gaskets and hinges to save energy. Conventional ovens must first heat up about 35 pounds of steel and a large amount of air before they heat up the food. Higher efficiency options include convection ovens, halogen burners, and induction burners.
Appliances	Microwave	Appliance that heats food with microwave radiation. No high efficiency option is modeled.
Electronics	Personal Computers	Improved power management can significantly reduce the annual energy consumption of PCs and monitors in both standby and normal operation. ENERGY STAR and Climate Savers labeled products provide increasing level of energy efficiency.
Electronics	Monitor	High efficiency electronics use efficient components and employ sleep/power save modes.
Electronics	Laptops	High efficiency electronics use efficient components and employ sleep/power save modes.
Electronics	Printer/Fax/Copier	High efficiency electronics use efficient components and employ sleep/power save modes.
Electronics	TVs	In the average home, electronic products consumed significant energy, even when they are turn off, to maintain features like clocks, remote control, and channel/station memory. ENERGY STAR labeled consumer electronics can drastically reduce consumption during standby mode, in addition to saving energy through advanced power management during normal use.
Electronics	Devices and Gadgets	High efficiency electronics can use efficient components and employ sleep/power save modes.
Electronics	Set-top Boxes/DVR	High efficiency electronics can use efficient components and employ sleep/power save modes.
Miscellaneous	Pool Heater	Efficient pool heaters can make use of heat pump technology to achieve significantly higher coefficients of performance in the COP=5.0 range. Gas pool heaters have a burner to heat water in a loop. Efficiency improvements can include: exhaust fan controls, electronic ignition (no pilot light), compact size and lighter weight to reduce cycling losses, and sealed combustion. Very high efficiency units, or condensing units, condense the water vapor produced in the combustion process and also use the heat from this condensation.
Miscellaneous	Pool Pump	High-efficiency motors and two-speed pumps provide improved energy efficiency for this load.

End Use	Technology	Measure Description
Miscellaneous	Furnace Fan	In homes heated by a furnace, there is still substantial energy use by the fan responsible for moving the hot air throughout the ductwork. Application of an Electronically Commutating Motor (ECM) ensures that motor speed matches the heating requirements of the system and saves energy when compared to a continuously operating standard motor.
Miscellaneous	Well Pump	Existing well pumps can achieve efficiency improvements by using optimized system components and more efficient motors. Efficiencies: Baseline 40% EF, High Efficiency 60% EF
Miscellaneous	Hot Tub/Spa	High-efficiency motors and two-speed pumps provide improved energy efficiency for this load.
Miscellaneous	Air Purifier/Cleaner	An air purifier (cleaner) meeting the efficiency specifications of ENERGY STAR is purchased and installed in place of a model meeting the current federal standard.
Miscellaneous	Dehumidifier	A dehumidifier meeting the minimum qualifying efficiency standard established by the current ENERGY STAR(Version 2.1 or 3.0) is purchased and installed in a residential setting in place of a unit that meets the minimum federal standard efficiency.
Miscellaneous	Miscellaneous	Improvement of miscellaneous electricity uses.

Table B-2 Residential Energy Efficiency Non-Equipment Measure Descriptions

End Use	Measure	Description
HVAC (All)	Insulation - Ceiling	Thermal insulation is material or combinations of materials that are used to inhibit the flow of heat energy by conductive, convective, and radiative transfer modes. Thus, thermal insulation above ceilings can conserve energy by reducing the heat loss or gain into attics and/or through roofs. The type of building construction defines insulating possibilities. Typical insulating materials include: loose-fill (blown) cellulose, loose-fill (blown) fiberglass, and rigid polystyrene.
Cooling	Insulation - Ducting	Air distribution ducts can be insulated to reduce heating or cooling losses. Best results can be achieved by covering the entire surface area with insulation. Several types of ducts and duct insulation are available, including flexible duct, pre-insulated duct, duct board, duct wrap, tacked, or glued rigid insulation, and waterproof hard shell materials for exterior ducts. This analysis assumes that installing duct insulation can reduce the temperature drop/gain in ducts by 50%.
HVAC (All)	Insulation - Foundation	Thermal insulation is material or combinations of materials that are used to inhibit the flow of heat energy by conductive, convective, and radiative transfer modes. Thus, thermal insulation can conserve energy by reducing heat loss or gain from a building. The type of building construction defines insulating possibilities. Typical insulating materials include: loose-fill (blown) cellulose, loose-fill (blown) fiberglass, and rigid polystyrene. Foundation insulation is modeled for new construction / major retrofits only.
HVAC (All)	Insulation - Infiltration Control	Lowering the air infiltration rate by caulking small leaks and weather-stripping around window frames, doorframes, power outlets, plumbing, and wall corners can provide significant energy savings. Weather-stripping doors and windows will create a tight seal and further reduce air infiltration.
HVAC (All)	Insulation - Radiant Barrier	Radiant barriers are materials installed to reduce the heat gain in buildings. Radiant barriers are made from materials that are highly reflective and have low emissivity like aluminum. The closer the emissivity is to 0 the better they will perform. Radiant barriers can be placed above the insulation or on the roof rafters.
HVAC (All)	Insulation - Wall Cavity	Thermal insulation is material or combinations of materials that are used to inhibit the flow of heat energy by conductive, convective, and radiative transfer modes. Thus, thermal insulation can conserve energy by reducing heat loss or gain from a building. The type of building construction defines insulating possibilities. Typical insulating materials include: loose-fill (blown) cellulose, loose-fill (blown) fiberglass, and rigid polystyrene. Wall insulation is modeled for new construction / major retrofits only.
HVAC (All)	Insulation - Wall Sheathing	Thermal insulation is material or combinations of materials that are used to inhibit the flow of heat energy by conductive, convective, and radiative transfer modes. Thus, thermal insulation can conserve energy by reducing heat loss or gain from a building. The type of building construction defines insulating possibilities. Typical insulating materials include: loose-fill (blown) cellulose, loose-fill (blown) fiberglass, and rigid polystyrene. Wall sheathing is modeled for new construction / major retrofits only.
Cooling	Ducting - Repair and Sealing	Leakage in unsealed ducts varies considerably because of the differences in fabricating machinery used, the methods for assembly, installation workmanship, and age of the ductwork. Air leaks from the system to the outdoors result in a direct loss proportional to the amount of leakage and the difference in enthalpy between the outdoor air and the conditioned air. To seal ducts, a wide variety of sealing methods and products exist. Each has a relatively short shelf life, and no documented research has identified the aging characteristics of sealant applications.
HVAC (All)	Windows - High Efficiency/ENERGY STAR	High-efficiency windows, such as those labeled under the ENERGY STAR Program, are designed to reduce energy use and increase occupant comfort. High-efficiency windows reduce the amount of heat transfer through the

End Use	Measure	Description
		glazing surface. For example, some windows have a low-E coating, a thin film of metallic oxide coating on the glass surface that allows passage of short-wave solar energy through glass and prevents long-wave energy from escaping. Another example is double-pane glass that reduces conductive and convective heat transfer. Some double-pane windows are gas-filled (usually argon) to further increase the insulating properties of the window.
HVAC (All)	Windows - Install Reflective Film	Reflective films applied to the window interior help reduce solar gain into the space and thus lower cooling energy use.
HVAC (All)	Doors - Storm and Thermal	Like other components of the shell, doors are subject to several types of heat loss: conduction, infiltration, and radiant losses. Similar to a storm window, a storm door creates an insulating air space between the storm and primary doors. A tight fitting storm door can also help reduce air leakage or infiltration. Thermal doors have exceptional thermal insulation properties and also are provided with weather-stripping on the doorframe to reduce air leakage.
HVAC (All)	Roofs - High Reflectivity	The color and material of a building structure surface will determine the amount of solar radiation absorbed by that surface and subsequently transferred into a building. This is called solar absorptance. By using a living roof or a roofing material with a light color (and a lower solar absorptance), the roof will absorb less solar radiation and consequently reduce the cooling load. Living roofs also reduce stormwater runoff.
HVAC (All)	Attic Fan - Installation	Attic fans can reduce the need for AC by reducing heat transfer from the attic through the ceiling of the house. A well-ventilated attic can be several degrees cooler than a comparable, unventilated attic. An option for an attic fan equipped with a small solar photovoltaic generator is also modeled.
HVAC (All)	Attic Fan - Photovoltaic - Installation	Attic fans can reduce the need for AC by reducing heat transfer from the attic through the ceiling of the house. A well-ventilated attic can be several degrees cooler than a comparable, unventilated attic. An option for an attic fan equipped with a small solar photovoltaic generator is also modeled.
HVAC (All)	Whole-House Fan - Installation	Whole-house fans can reduce the need for AC on moderate-weather days or on cool evenings. The fan facilitates a quick air change throughout the entire house. Several windows must be open to achieve the best results. The fan is mounted on the top floor of the house, usually in a hallway ceiling.
HVAC (All)	Ceiling Fan - Installation	Ceiling fans can reduce the need for air conditioning. However, the house occupants must also select a ceiling fan with a high-efficiency motor and either shutoff the AC system or setup the thermostat temperature of the air conditioning system to realize the potential energy savings. Some ceiling fans also come with lamps. In this analysis, it is assumed that there are no lamps, and installing a ceiling fan will allow occupants to increase the thermostat cooling setpoint up by 2°F.
HVAC (All)	Thermostat - Clock/Programmable	A programmable thermostat can be added to most heating/cooling systems. They are typically used during winter to lower temperatures at night and in summer to increase temperatures during the afternoon. The energy savings from this type of thermostat are identical to those of a "setback" strategy with standard thermostats, but the convenience of a programmable thermostat makes it a much more attractive option. In this analysis, the baseline is assumed to have no thermostat setback.
HVAC (All)	Home Energy Management System	A centralized home energy management system can be used to control and schedule cooling, space heating, lighting, and possibly appliances as well. Some designs also allow the homeowner to remotely control loads via the Internet.
Cooling	Central AC - Early Replacement	CAC systems currently on the market are significantly more efficient that older units, due to technology improvement and stricter appliance standards. This measure incents homeowners to replace an aging but still working unit with a new, higher-efficiency one.
Cooling	Central AC - Maintenance and Tune-Up	An air conditioner's filters, coils, and fins require regular cleaning and maintenance for the unit to function effectively and efficiently throughout its life. Neglecting necessary maintenance leads to a steady decline in

End Use	Measure	Description
		performance, requiring the AC unit to use more energy for the same cooling load.
Cooling / Heating	Central Heat Pump - Maintenance	A heat pump's filters, coils, and fins require regular cleaning and maintenance for the unit to function effectively and efficiently throughout its life. Neglecting necessary maintenance ensures a steady decline in performance while energy use steadily increases.
Cooling	Room AC - Removal of Second Unit	Homeowners may have a second room AC unit that is extremely inefficient. This measure incents homeowners to recycle the second unit and thus also eliminates associated electricity use.
Water Heating	Water Heater - Drainwater Heat Recovery	Drainwater Heat Recovery is a system in which drain water is used to preheat cold water entering the water heater. While these systems themselves are relatively inexpensive, upgrading an existing system could be unreasonable because of demolition costs. Thus they are modeled for new vintage only.
Water Heating	Water Heater - Faucet Aerators	Water faucet aerators are threaded screens that attach to existing faucets. They reduce the volume of water coming out of faucets while introducing air into the water stream. This measure provides energy saving by reducing hot water use, as well as water conservation for both hot and cold water.
Water Heating	Water Heater - Low-Flow Showerheads	Similar to faucet aerators, low-flow showerheads reduce the consumption of hot water, which in turn decreases water heating energy use.
Water Heating	Water Heater - Pipe Insulation	Insulating hot water pipes decreases energy losses from piping that distributes hot water throughout the building. It also results in quicker delivery of hot water and may allow the lowering of the hot water set point, which saves energy. The most common insulation materials for this purpose are polyethylene and neoprene.
Water Heating	Water Heater - Timer	These measures use either a programmable thermostat or a timer to adjust the water heater setpoint at times of low usage, typically when a home is unoccupied.
Water Heating	Water Heater - Desuperheater	A desuperheater can be added to an existing geothermal heat pump system (typically installed with the primary function of space heating and cooling) in order to draw off a portion of the geothermal heat for water heating purposes. The system can either supplement the building's water heater, or be a full-demand water heater that meets all of the building's hot water needs.
Water Heating	Water Heater - Solar System	Solar water heating systems can be used in residential buildings that have an appropriate near-south-facing roof or nearby unshaded grounds for installing a collector. Although system types vary, in general these systems use a solar absorber surface within a solar collector or an actual storage tank. Either a heat-transfer fluid or the actual potable water flows through tubes attached to the absorber and transfers heat from it. (Systems with a separate heat-transfer-fluid loop include a heat exchanger that then heats the potable water.) The heated water is stored in a separate preheat tank or a conventional water heater tank. If additional heat is needed, it is provided by a conventional water-heating system.
Interior Lighting	Interior Lighting - Occupancy Sensors	Occupancy sensors turn lights off when a space is unoccupied. They are appropriate for areas with intermittent use, such as bathrooms or storage areas.
Exterior Lighting	Exterior Lighting - Photosensor Control	Photosensor controls turn exterior lighting on or off based on ambient lighting levels. Compared with manual operation, this can reduce the operation of exterior lighting during daylight hours.
Exterior Lighting	Exterior Lighting - Photovoltaic Installation	Solar photovoltaic generation may be used to power exterior lighting and thus eliminate all or part of the electrical energy use.
Exterior Lighting	Exterior Lighting - Timeclock Installation	Lighting timers turn exterior lighting on or off based on a preset schedule. Compared with manual operation, this can reduce the operation of exterior lighting during daylight hours.
Appliances	Refrigerator - Early	Refrigerators/freezers currently on the market are significantly more efficient

End Use	Measure	Description
	Replacement	that older units, due to technology improvement and stricter appliance standards. This measure incents homeowners to replace an aging but still working unit with a new, higher-efficiency one.
Appliances	Refrigerator - Maintenance	This measure includes repairing and recharging refrigerant lines, cleaning condenser coils, and replacing the oil. This reduces energy consumption by improving the rate at which the system can compress and cool refrigerant as it moves through the system.
Appliances	Refrigerator - Remove Second Unit	Homeowners may have a second refrigerator or freezer that is not used to full capacity and that, because of its age, is extremely inefficient. This measure incents homeowners to recycle the second unit and thus also eliminates associated electricity use.
Appliances	Freezer - Remove Second Unit	Homeowners may have a second refrigerator or freezer that is not used to full capacity and that, because of its age, is extremely inefficient. This measure incents homeowners to recycle the second unit and thus also eliminates associated electricity use.
Appliances	Freezer - Early Replacement	Refrigerators/freezers currently on the market are significantly more efficient that older units, due to technology improvement and stricter appliance standards. This measure incents homeowners to replace an aging but still working unit with a new, higher-efficiency one.
Appliances	Freezer - Maintenance	This measure includes repairing and recharging refrigerant lines, cleaning condenser coils, and replacing the oil. This reduces energy consumption by improving the rate at which the system can compress and cool refrigerant as it moves through the system.
Electronics	Electronics - Smart Power Strips	Representing a growing portion of home electricity consumption, plug-in electronics such as set-top boxes, DVD players, gaming systems, digital video recorders, and even battery chargers for mobile phones and laptop computers are often designed to supply a set voltage. When the units are not in use, this voltage could be dropped significantly (~1 W) and thereby generate a significant energy savings, assumed for this analysis to be between 4-5% on average. These savings are in excess of the measures already discussed for computers and televisions.
Miscellaneous	Pool Pump - Timer	A pool pump timer allows the pump to turn off automatically, eliminating the wasted energy associated with unnecessary pumping.
Miscellaneous	Pool Heater - Solar System	This measure replaces a conventional pool heater with a solar system.
HVAC (All)	ENERGY STAR Home Design	ENERGY STAR home design uses an integrated approach to the design of new buildings to account for the interaction of building systems. Designs may specify the building orientation, building shell, proper sizing of equipment and systems, and controls strategies with the goal of optimizing building energy efficiency and comfort. Options that may be evaluated and incorporated include passive solar strategies, increased thermal mass, natural ventilation, energy recovery ventilation, daylighting strategies, and shading strategies; but with specific requirements that adhere to the ENERGY STAR standard and measurement system. This measure is modeled for new vintage only.
Miscellaneous	Information Based Energy Efficiency Programs	This measure will include the impacts from behavioral information-based programs such as Opower, where the evaluations have isolated valid behavioral effects from the technology effects of all the other measures listed here.
Miscellaneous	Pool/Spa Cover	A pool or spa cover (also referred to as a solar cover or solar blanket) keeps the water in the pool warmer by absorbing heat from the sun and transferring the heat to the pool water, reducing the energy used by the pool heater.

APPENDIX | C

COMMERCIAL ENERGY EFFICIENCY EQUIPMENT AND MEASURE DATA

This appendix presents detailed information for all commercial energy-efficiency measures (*equipment* and *non-equipment* measures per the LoadMAP taxonomy) that were evaluated in this study.

Measure Descriptions

Table C-1 and Table C-2 provide brief descriptions for all equipment and non-equipment measures that were assessed for potential.

Equipment Measure Data

The tables in the file “1434_Appendix_C_Tables-Commercial_Equipment.xlsx” list the detailed unit-level data (including economic screen results) for commercial equipment measures in existing and new buildings. Savings are in annual kWh per square foot, and incremental costs are in $/square foot ($/sq.ft.), unless noted otherwise. The BC ratio shown in the tables are for the first year of the potential analysis (2011), although the B/C ratio is calculated within LoadMAP for each year of the forecast. The B/C ratio in the tables is 1.00 if the measure represents the baseline technology, and zero if the technology is not available in 2013. The final data item in these tables is the levelized cost of conserved energy, which is defined as the cost of the measure divided by the cumulative amount of energy savings accrued over the measure’s lifetime ($/kWh).

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Non-Equipment Measure Data

The tables in the file “1434_Appendix_C_Tables-Commercial_Non-Equipment.xlsx” list the detailed unit-level data (including economic screen results) for commercial non-equipment measures in existing and new construction. Because these measures can produce energy-use savings for multiple end-use loads (e.g., insulation affects heating and cooling energy use) savings are expressed as a net percentage of all the relevant, combined end-use loads. Base saturation indicates the percentage of square footage in which the measure is already installed. Applicability is a factor that accounts for whether the measure can be applied to the building. Cost is expressed in $/building or $/square foot, as indicated in the “unit” column. The detailed measure-level tables present the results of the benefit/cost (B/C) analysis for the first year of the analysis (2011) although the B/C ratio is calculated within LoadMAP for each year of the forecast. These tables also contain the levelized cost of conserved energy, which is defined as the cost of the measure divided by the cumulative amount of energy savings accrued over the measure’s lifetime. This metric is given in terms of $/kWh.

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Table C-1 Commercial Energy Efficiency Equipment Measure Descriptions

End Use	Technology	Measure Description
Cooling	Air-Cooled Chiller	A central chiller plant creates chilled water for distribution throughout the facility. Because of the wide variety of system types and sizes, savings and cost values for efficiency improvements represent an average over screw, reciprocating, and centrifugal technologies. Under this simplified approach, each central system is characterized by an aggregate efficiency value (inclusive of chiller, pumps, and motors), in kW/ton with a further efficiency upgrade through the application of variable refrigerant flow technology.
Cooling	Water-Cooled Chiller	A central chiller plant creates chilled water for distribution throughout the facility. Water source chillers include heat rejection via a condenser loop and cooling tower. Because of the wide variety of system types and sizes, savings and cost values for efficiency improvements represent an average over screw, reciprocating, and centrifugal technologies. Under this simplified approach, each central system is characterized by an aggregate efficiency value (inclusive of chiller, pumps, motors, and condenser loop equipment), in kW/ton with a further efficiency upgrade through the application of variable refrigerant flow technology.
Cooling	Roof Top AC	Packaged cooling systems, such as rooftop units (RTUs), are simple to install and maintain, and are commonly used in small and medium-sized commercial buildings. Applications range from a single supply system with air intake filters, supply fan, and cooling coil, or can become more complex with the addition of a return air duct, return air fan, and various controls to optimize performance. For packaged RTUs, varying Energy Efficiency Ratios (EER) are modeled, as well as a ductless mini-split system.
Cooling/ Heating	PTAC/PTHP	This measure includes efficiency upgrades to other small cooling systems in commercial buildings including room AC units, packaged terminal air conditioning (PTAC) units, and packaged terminal heat pumps (PTHP).
Cooling / Heating	Air-Source Heat Pump	For heat pumps, units with increasing EER and COP levels are evaluated, as well as a ductless mini-split system.
Cooling / Heating	Geothermal Heat Pump	For heat pumps, units with increasing EER and COP levels are evaluated.
Heating	Electric Furnace	Resistive heating elements are used to convert electricity directly to heat. The heat is then delivered by a supply fan and duct system to the regions that require heating.
Heating	Electric Room Heat	Resistive heating elements are used to convert electricity directly to heat. Conductive fins surrounding the element or another mechanism is used to deliver the heat directly to the surrounding room or area. These are typically either baseboard or wall-mounted units.
Ventilation	Ventilation	A variable air volume ventilation system modulates the air flow rate as needed based on the interior conditions of the building to reduce fan load, improve dehumidification, and reduce energy usage.
Water Heating	Water Heater	Efficient electric water heaters are characterized by a high recovery or thermal efficiency (percentage of delivered electric energy which is transferred to the water) and low standby losses (the ratio of heat lost per hour to the content of the stored water). Included in the savings associated with high-efficiency electric water heaters are timers that allow temperature setpoints to change with hot water demand patterns. For example, the heating element could be shut off throughout the night, increasing the overall energy factor of the unit. In addition, tank and pipe insulation reduces standby losses and therefore reduces the demands on the water heater. This analysis considers conventional electric water heaters and heat pump water heaters. For natural gas hot water heating, the most common type is a storage heater, which incorporates a burner, storage tank, outer jacket, insulation, and controls in a single unit. Efficient units are characterized by a high recovery or thermal efficiency and low standby losses (the ratio of heat lost per hour to the content of the stored water). A further efficiency gain is available in condensing

End Use	Technology	Measure Description
		units, which condense the water vapor produced in the combustion process and also use the heat from this condensation.
Interior Lighting	Screw-in	This measure evaluates higher-efficiency alternatives for screw-in interior lamps including halogen, CFL, and LED.
Interior Lighting	High-Bay Fixtures	With the exception of screw-in lighting, commercial lighting efficiency changes typically require more than the simple purchase and installation of an alternative lamp Restrictions regarding ballasts, fixtures, and circuitry limit the potential for direct substitution of one lamp type for another. Also, during the buildout for a leased office space, management could decide to replace all lamps, ballasts, and fixtures with different configurations. This type of decision-making is modeled on a stock turnover basis because of the time between opportunities for upgrades. For High-Bay fixtures, alternatives include mercury vapor, metal halides, T5 fluorescent high output, and high-pressure sodium.
Interior Lighting	Linear Fluorescent	With the exception of screw-in lighting, commercial lighting efficiency changes typically require more than the simple purchase and installation of an alternative lamp restriction regarding ballasts, fixtures, and circuitry limit the potential for direct substitution of one lamp type for another. Also, during the buildout for a leased office space, management could decide to replace all lamps, ballasts, and fixtures with different configurations. This type of decision-making is modeled on a stock turnover basis because of the time between opportunities for upgrades. For linear fluorescent fixtures, alternatives include T12, T8, Super T8, T5, and LED.
Exterior Lighting	Screw-in	This measure evaluates higher-efficiency alternatives for screw-in interior lamps including halogen, CFL, and LED.
Exterior Lighting	HID	Alternatives modeled include metal halides, T8 and T5 high output, high pressure sodium, and LEDs
Exterior Lighting	Linear Fluorescent	For linear fluorescent fixtures, alternatives include T12, T8, Super T8, T5, and LED.
Refrigeration	Walk-in Refrigerator	These refrigerators can be designed to perform at higher efficiency through a combination of compressor equipment upgrades, default temperature settings, and defrost patterns. Standard refrigeration compressors typically operate at approximately 65% efficiency. High-efficiency models are available that can improve compressor efficiency by 15%. Analysis assumes unit with: 140 square feet, Cooling capacity of 26,230 BTU/hr.
Refrigeration	Reach-in Refrigerator	A significant amount of energy in the commercial sector can be attributed to "reach-in" units. These stand-alone appliances can range from a residential-style refrigerator/freezer unit in an office kitchen or the breakroom of a retail store, to the larger reach-in units in foodservice applications. As in the case of residential units, these refrigerators can be designed to perform at higher efficiency through a combination of compressor equipment upgrades, default temperature settings, and defrost patterns. Analysis assumes unit with: 48 cubic feet, Cooling capacity of 3000 BTU/hr.
Refrigeration	Glass Door Display, Open Display Case	These refrigerators can be designed to perform at higher efficiency through a combination of compressor equipment upgrades, default temperature settings, and defrost patterns. Standard refrigeration compressors typically operate at approximately 65% efficiency. High-efficiency models are available that can improve compressor efficiency by 15%. Analysis assumes unit with: Cooling capacity of 20,000 BTU/hr
Refrigeration	Icemaker	By optimizing the timing of ice production and the type of output to the specific application, icemakers are assumed to deliver electricity savings.
Refrigeration	Vending Machine	High-efficiency vending machines incorporate more efficient compressors and lighting.
Food Preparation	Ovens, Fryers, Hot Food Containers, Dishwashers	This set of measures includes high-efficiency fryers, ovens, dishwashers, and hot food containers. Less common equipment, such as broilers and steamers, and assumed to be modeled with the other more common equipment types.

End Use	Technology	Measure Description
Office Equipment	Desktop Computer, Laptop, Monitors	ENERGY STAR labeled computers automatically power down to 15 watts or less when not in use and may actually last longer than conventional products because they spend a large portion of time in a low-power sleep mode. ENERGY STAR labeled computers also generate less heat than conventional models.
Office Equipment	Server	In addition to the "sleep" mode a reductions, servers have additional energy-saving opportunities through "virtualization" and other architecture solutions that involve optimal matching of computation tasks to hardware requirements
Office Equipment	Printer/Copier/Fax	ENERGY STAR labeled office equipment saves energy by powering down and "going to sleep" when not in use. ENERGY STAR labeled copiers are equipped with a feature that allows them to automatically turn off after a period of inactivity.
Office Equipment	POS Terminal	Point-of-sale terminals in retail and supermarket facilities are always on. Efficient models incorporate a high-efficiency power supply to reduce energy use.
Miscellaneous	Non-HVAC Motors	Includes motors for a variety of non-HVAC uses including vertical transportation. Premium efficiency motors can provide savings of 0.5% to 3% over standard motors. The savings results from the fact that energy efficient motors run cooler than their standard counterparts, resulting in an increase in the life of the motor insulation and bearing. In general, an efficient motor is a more reliable motor because there are fewer winding failures, longer periods between needed maintenance, and fewer forced outages. For example, using copper instead of aluminum in the windings, and increasing conductor cross-sectional area, lowers a motor’s I2R losses.
Miscellaneous	Pool Pump	High-efficiency motors and two-speed pumps provide improved energy efficiency for this load.
Miscellaneous	Pool Heater	Efficient pool heaters can make use of heat pump technology to achieve significantly higher coefficients of performance in the COP=5.0 range. Gas pool heaters have a burner to heat water in a loop. Efficiency improvements can include: exhaust fan controls, electronic ignition (no pilot light), compact size and lighter weight to reduce cycling losses, and sealed combustion. Very high efficiency units, or condensing units, condense the water vapor produced in the combustion process and also use the heat from this condensation.
Miscellaneous	Miscellaneous	Improvement of miscellaneous electricity uses

Table C-2 Commercial Energy Efficiency Non-Equipment Measure Descriptions

End Use	Measure	Description
HVAC (All)	Insulation - Ceiling	Thermal insulation is material or combinations of materials that are used to inhibit the flow of heat energy by conductive, convective, and radiative transfer modes. Thus, thermal insulation can conserve energy by reducing the heat loss or gain of a building. The type of building construction defines insulating possibilities. Typical insulating materials include: loose-fill (blown) cellulose; loose-fill (blown) fiberglass; and rigid polystyrene.
HVAC (All)	Insulation - Ducting	Air distribution ducts can be insulated to reduce heating or cooling losses. Best results can be achieved by covering the entire surface area with insulation. Insulation material inhibits the transfer of heat through the air-supply duct. Several types of ducts and duct insulation are available, including flexible duct, pre-insulated duct, duct board, duct wrap, tacked, or glued rigid insulation, and waterproof hard shell materials for exterior ducts.
HVAC (All)	Insulation - Radiant Barrier	Radiant barriers are materials installed to reduce the heat gain in buildings. Radiant barriers are made from materials that are highly reflective and have low emissivity like aluminum. The closer the emissivity is to 0 the better they will perform. Radiant barriers can be placed above the insulation or on the roof rafters.
HVAC (All)	Insulation-Foundation	Below Grade Insulation to R6
HVAC (All)	Insulation - Wall Cavity	Thermal insulation is material or combinations of materials that are used to inhibit the flow of heat energy by conductive, convective, and radiative transfer modes. Thus, thermal insulation can conserve energy by reducing the heat loss or gain of a building. The type of building construction defines insulating possibilities. Typical insulating materials include: loose-fill (blown) cellulose; loose-fill (blown) fiberglass; and rigid polystyrene.
HVAC (All)	HVAC - Duct Repair and Sealing	Leakage in unsealed ducts varies considerably because of the differences in fabricating machinery used, the methods for assembly, installation workmanship, and age of the ductwork. Air leaks from the system to the outdoors result in a direct loss proportional to the amount of leakage and the difference in enthalpy between the outdoor air and the conditioned air. To seal ducts, a wide variety of sealing methods and products exist. Each has a relatively short shelf life, and no documented research has identified the aging characteristics of sealant applications.
HVAC (All)	Doors - High Efficiency	Like other components of the shell, doors are subject to several types of heat loss: conduction, infiltration, and radiant losses. High efficiency doors have exceptional thermal insulation properties and tight-fitting, weather-stripping on the doorframe to reduce air leakage.
HVAC (All)	Windows - High Efficiency	High-efficiency windows, such as those labeled under the ENERGY STAR Program, are designed to reduce a building's energy bill while increasing comfort for the occupants at the same time. High-efficiency windows have reducing properties that reduce the amount of heat transfer through the glazing surface. For example, some windows have a low-E coating, which is a thin film of metallic oxide coating on the glass surface that allows passage of short-wave solar energy through glass and prevents long-wave energy from escaping. Another example is double-pane glass that reduces conductive and convective heat transfer. There are also double-pane glasses that are gas-filled (usually argon) to further increase the insulating properties of the window.
HVAC (All)	Roof - High Reflectivity	The color and material of a building structure surface will determine the amount of solar radiation absorbed by that surface and subsequently transferred into a building. This is called solar absorptance. By using a living roof or a roofing material with a light color (and a lower solar absorptance), the roof will absorb less solar radiation and consequently reduce the cooling load. Living roofs also reduce stormwater runoff.
Cooling	Air-Cooled Chiller -	Resetting the condenser water temperature to the lowest possible setting

End Use	Measure	Description
	Condenser Water Temperature Reset	allows the cooling tower to generate cooler water whenever possible and decreases the temperature lift between the condenser and the evaporator. This will generally increase chiller part-load efficiency, though it may require increased tower fan energy use.
Cooling	Air-Cooled Chiller - Economizer	Economizers allow outside air (when it is cool and dry enough) to be brought into the building space to meet cooling loads instead of using mechanically cooled interior air. A dual enthalpy economizer consists of indoor and outdoor temperature and humidity sensors, dampers, motors, and motor controls. Economizers are most applicable to temperate climates and savings will be smaller in extremely hot or humid areas.
Cooling	Air-Cooled Chiller - VSD on Fans	Variable speed drives, which reduce chiller energy use under part load, are modeled for both air-cooled and water-cooled chillers.
Cooling	Air-Cooled Chiller - Chilled Water Reset	Chilled water reset controls save energy by improving chiller performance through increasing the supply chilled water temperature, which allows increased suction pressure during low load periods. Raising the chilled water temperature also reduces chilled water piping losses. However, the primary savings from the chilled water reset measure results from chiller efficiency improvement. This is due partly to the smaller temperature difference between chilled water and ambient air, and partly due to the sensitivity of chiller performance to suction temperature.
Cooling	Air-Cooled Chiller - Chilled Water Variable-Flow System	The part-load efficiency of chilled water loops can be improved substantially by varying the flow speed of the delivered water with the building demand for cooling.
Cooling	Air-Cooled Chiller - High Efficiency Cooling Tower Fans	High-efficiency cooling fans utilize efficient components and variable frequency drives that improve fan performance by adjusting fan speed and rotation as conditions change.
Cooling	Air-Cooled Chiller - Maintenance	Filters, coils, and fins require regular cleaning and maintenance for the heat pump or roof top unit to function effectively and efficiently throughout its years of service. Neglecting necessary maintenance leads to a steady decline in performance while energy use increases.
Water- Cooled Chiller	Water Cooled Chiller Condenser Water Temperature Reset	Resetting the condenser water temperature to the lowest possible setting allows the cooling tower to generate cooler water whenever possible and decreases the temperature lift between the condenser and the evaporator. This will generally increase chiller part-load efficiency, though it may require increased tower fan energy use.
Water- Cooled Chiller	Water Cooled Chiller Economizer	Economizers allow outside air (when it is cool and dry enough) to be brought into the building space to meet cooling loads instead of using mechanically cooled interior air. A dual enthalpy economizer consists of indoor and outdoor temperature and humidity sensors, dampers, motors, and motor controls. Economizers are most applicable to temperate climates and savings will be smaller in extremely hot or humid areas.
Water- Cooled Chiller	Water-Cooled Chiller VSD on Fans	Variable speed drives, which reduce chiller energy use under part load, are modeled for both air-cooled and water-cooled chillers.
Water- Cooled Chiller	Water-Cooled Chiller-Chiller Water reset	Chilled water reset controls save energy by improving chiller performance through increasing the supply chilled water temperature, which allows increased suction pressure during low load periods. Raising the chilled water temperature also reduces chilled water piping losses. However, the primary savings from the chilled water reset measure results from chiller efficiency improvement. This is due partly to the smaller temperature difference between chilled water and ambient air, and partly due to the sensitivity of chiller performance to suction temperature.
Water- Cooled Chiller	Water- Cooled Chiller Variable Flow System	The part-load efficiency of chilled water loops can be improved substantially by varying the flow speed of the delivered water with the building demand for cooling.
Water- Cooled	Water-Cooled Chiller	High-efficiency cooling fans utilize efficient components and variable

End Use	Measure	Description
Chiller Water Cooled Chiller	High Efficiency Cooling Tower Fans	frequency drives that improve fan performance by adjusting fan speed and rotation as conditions change.
Water- Cooled Chiller	Water-Cooled Chiller Maintenance	Filters, coils, and fins require regular cleaning and maintenance for the heat pump or roof top unit to function effectively and efficiently throughout its years of service. Neglecting necessary maintenance leads to a steady decline in performance while energy use increases.
Cooling	RTU - Evaporative Precooler	Evaporative precooling can improve the performance of air conditioning systems, most commonly RTUs. These systems typically use indirect evaporative cooling as a first stage to pre-cool outside air. If the evaporative system cannot meet the full cooling load, the air steam is further cooled with conventional refrigerative air conditioning technology.
Cooling	RTU - Maintenance	Regular cleaning and maintenance enables a roof top unit to function effectively and efficiently throughout its years of service. Neglecting necessary maintenance leads to a steady decline in performance while energy use increases. Maintenance can increase the efficiency of poorly performing equipment by as much as 10%.
Heating	Space Heating - Heat Recovery Ventilator	Heat recovery ventilation uses a counter-flow, air-to-air heat exchanger between inbound and outbound air flow to selectively transfer heat and reduce space heating loads.
Cooling / Heating	Heat Pump - Maintenance	Regular cleaning and maintenance enables a heat pump to function effectively and efficiently throughout its years of service. Neglecting necessary maintenance leads to a steady decline in performance while energy use increases. Maintenance can increase the efficiency of poorly performing equipment by as much as 10%.
Ventilation	Ventilation - ECM on VAV Boxes	ECM motors are well suited to the variable flow rates of VAV boxes. ECMs are a higher efficiency option for the air blowers and maintain efficiency better over a wide range of loads.
Ventilation	Ventilation - Variable Speed Control	Variable speed controls adjust ventilation fans for part-load conditions to reduce energy use.
Ventilation	Ventilation- CO2 Controlled	Carbon dioxide (CO2) levels indicate the level of occupancy in a space. This measure uses sensors to monitor CO2 levels and controls on the air handling system to adjust the amount of outside air accordingly. Ventilation rates are thereby controlled based on occupancy, rather than a fixed rate, thus saving HVAC energy use.
Water Heating	Water Heater - Drainwater Heat Recovery	Drainwater Heat Recovery is a system in which drain water is used to preheat cold water entering the water heater. While these systems themselves are relatively inexpensive, upgrading an existing system could be unreasonable because of demolition costs. Thus they are modeled for new vintage only.
Water Heating	Water Heater - Faucet Aerators/Low Flow Nozzles	A faucet aerator or low flow nozzle spreads the stream from a faucet helping to reduce water usage. The amount of water passing through the aerator is measured in gallons per minute (GPM) and the lower the GPM the more water the aerator conserves.
Water Heating	Water Heater - High Efficiency Circulation Pump	A high efficiency circulation pump uses an electronically commutated motor (ECM) to improve motor efficiency over a larger range of partial loads. In addition, an ECM allows for improved low RPM performance with greater torque and smaller pump dimensions.
Water Heating	Water Heater - Desuperheater	A desuperheater can be added to an existing geothermal heat pump system (typically installed with the primary function of space heating and cooling) in order to draw off a portion of the geothermal heat for water heating purposes. The system can either supplement the building's water heater, or be a full-demand water heater that meets all of the building's hot water needs.
Water Heating	Water Heater - Solar System	Solar water heating systems can be used in residential buildings that have an appropriate near-south-facing roof or nearby unshaded grounds for installing a collector. Although system types vary, in general these systems use a solar

End Use	Measure	Description
		absorber surface within a solar collector or an actual storage tank. Either a heat-transfer fluid or the actual potable water flows through tubes attached to the absorber and transfers heat from it. (Systems with a separate heat-transfer-fluid loop include a heat exchanger that then heats the potable water.) The heated water is stored in a separate preheat tank or a conventional water heater tank. If additional heat is needed, it is provided by a conventional water-heating system.
Water Heating	Water Heater - Install Timer	These measures use either a programmable thermostat or a timer to adjust the water heater setpoint at times of low usage, typically when a home is unoccupied.
Water Heating	Water Heater - Pipe Insulation	Insulating hot water pipes decreases the amount of energy lost during distribution of hot water throughout the building. Insulating pipes will result in quicker delivery of hot water and allows lowering the water heating set point. There are several different types of insulation, the most common being polyethylene and neoprene.
Water Heating	Water Heater - Tank Blanket/Insulation	Insulation levels on hot water heaters can be increased by installing a fiberglass blanket on the outside of the tank. This increase in insulation reduces standby losses and thus saves energy. Water heater insulation is available either by the blanket or by square foot of fiberglass insulation with R-values ranging from 5 to 14.
Water Heating	Water Heater- Pre-Rinse Spray Valve	Pre-rinse valves use a spray of water to remove food waste from dishes prior to cleaning in a dishwasher. More efficient spray valves use less water thereby reducing water consumption, water heating cost, and waste water (sewer) charges. Pre-rinse spray valves include a nozzle, squeeze lever, and dish guard bumper. The primary impacts of this measure are water savings. Reduced hot water consumption saves either natural gas or electricity, depending on the type of energy the hot water heater uses. This measure applies to time of sale, retrofit and direct install and appropriate lookup tables are included to support these delivery methods.
Water Heating	Water Heater- Booster Water Heater	Gas booster heaters are used to supply sanitizing water to a dishwashing machine.
Interior Lighting	Interior Lighting - Daylighting Controls	Daylighting controls use a photosensor to detect ambient light and adjust or turn off electric lights accordingly.
Interior Lighting	Interior Lighting - LED Exit Lighting	The lamps inside exit signs represent a significant energy end-use, since they usually operate 24 hours per day. Many old exit signs use incandescent lamps, which consume approximately 40 watts per sign. The incandescent lamps can be replaced with LED lamps that are specially designed for this specific purpose. In comparison, the LED lamps consume approximately 2-5 watts.
Interior Lighting	Interior Lighting - Occupancy Sensors	The installation of occupancy sensors allows lights to be turned off during periods when a space is unoccupied, virtually eliminating the wasted energy due to lights being left on. There are several types of occupancy sensors in the market.
Interior Lighting	Interior Lighting - Timeclocks and Timers	In many cases lighting remains on at night and during weekends. A simple timer can set a schedule for turning lights off to reduce operating hours.
Interior Lighting	Interior Lighting - Task Lighting	Individual work areas can use task lighting instead of brightly lighting the entire area. Significant energy savings can be realized by focusing light directly where it is needed and lowering the general lighting level. An example of task lighting is the common desk lamp. A 25W desk lamp can be installed in place of a typical lamp in a fixture.
Interior Lighting	Interior Fluorescent - Bi-Level Fixture	Bi-level fixtures have the ability to reduce light output to a lower level, given a control strategy that is based on a timer, occupancy sensor, motion sensor, or manual switch.
Interior Lighting	Interior Fluorescent -	While sometimes included in lighting retrofit projects, delamping is often

End Use	Measure	Description
	Delamp and Install Reflectors	performed as a separate energy efficiency measure in which a lighting engineer analyzes the lighting provided by current systems compared to the requirements of building occupants. This often leads to the removal of unnecessary lamps corresponding to an overall reduction in energy usage. In addition, installing a reflector in each fixture can improve light distribution from the remaining lamps.
Exterior Lighting	Exterior Lighting - Bi-Level Fixture	Bi-level fixtures have the ability to reduce light output to a lower level, given a control strategy that is based on a timer, occupancy sensor, motion sensor, or manual switch.
Exterior Lighting	Exterior Lighting - Daylighting Controls	Daylighting controls use a photosensor to detect ambient light and adjust or turn off electric lights accordingly.
Exterior Lighting	Exterior Lighting - Photovoltaic Installation	Solar photovoltaic generation may be used to power exterior lighting and thus eliminate all or part of the electrical energy use.
Refrigeration	Refrigerator - Anti-Sweat Heater	Anti-sweat heaters are used in virtually all low-temperature display cases and many medium-temperature cases to control humidity and prevent the condensation of water vapor on the sides and doors and on the products contained in the cases. Typically, these heaters stay on all the time, even though they only need to be on about half the time. Anti-sweat heater controls can come in the form of humidity sensors or time clocks.
Refrigeration	Refrigerator- Auto Door Closer	Anti-sweat heaters are used in virtually all low-temperature display cases and many medium-temperature cases to control humidity and prevent the condensation of water vapor on the sides and doors and on the products contained in the cases. Typically, these heaters stay on all the time, even though they only need to be on about half the time. Anti-sweat heater controls can come in the form of humidity sensors or time clocks.
Refrigeration	Refrigerator - Decommissioning	Early retirement, removal, and recycling or older, little used refrigerators and freezers removes the energy use of these inefficient, aging units.
Refrigeration	Refrigerator - Demand Defrost	Units can be designed to perform at higher efficiency with a sensing and control system that runs defrost cycles based on demand/only when necessary.
Refrigeration	Refrigerator - Door Gasket Replacement	This measure involves replacing aging door gaskets that no longer adequately seal reach-in refrigerators or glass door display cases.
Refrigeration	Refrigerator- Economizer	Economizers save energy in walk-in coolers by bringing in outside air when it is sufficiently cool, rather than operating the compressor. In addition there is a control installed to cycle evaporator fans on and off as opposed to constantly running while economizer is running. In order for this characterization to apply, the efficient equipment is assumed to be a walk-in cooler with a refrigeration economizer
Refrigeration	Refrigerator - Evaporator Fan Controls	Evaporator fan motor controls allow for part load use or demand scheduling based on variable refrigeration load requirements, reducing energy consumption.
Refrigeration	Refrigeration- High Efficiency Evaporator Fan Motors	Electronically commutated motors (ECM) operate at variable speeds.
Refrigeration	Refrigerator - Floating Head Pressure	Floating head pressure control allows the pressure in the condenser to "float" with ambient temperatures. This method reduces refrigeration compression ratios, improves system efficiency and extends the compressor life. The greatest savings with a floating head pressure approach occurs when the ambient temperatures are low, such as in the winter season. Floating head pressure control is most practical for new installations. However, retrofits installation can be completed with some existing refrigeration systems. Installing floating head pressure control increases the capacity of the compressor when temperatures are low, which may lead to short cycling.
Refrigeration	Refrigerator - Strip	Strip curtains at the entrances to large walk-in coolers or freezers, such as

End Use	Measure	Description
	Curtain	those used in supermarkets; reduce air transfer between the refrigerated space and the surrounding space.
Refrigeration	Refrigerator - High Efficiency Compressor	Standard compressors typically operate at approximately 65% efficiency. High-efficiency models are available that can improve compressor efficiency by 15%.
Refrigeration	Refrigerator - Variable Speed Compressor	The part-load efficiency of drive systems can be improved by varying the speed of the motor drive. An additional benefit of variable-speed controls is the ability to start and stop the motor and process gradually, thus extending the life of the motor and associated machinery.
Refrigeration	Vending Machine- Controller	Cold beverage vending machines usually operate 24 hours a day regardless of whether the surrounding area is occupied or not. The result is that the vending machine consumes energy unnecessarily, because it will operate all night to keep the beverage cold even when there would be no customers until the next morning. A vending machine controller can reduce energy consumption without compromising the temperature of the vended product. The controller uses an infrared sensor to monitor the surrounding area's occupancy and will power down the vending machine when the area is unoccupied. It will also monitor the room's temperature and will re-power the machine at one to three hour intervals independent of occupancy to ensure that the product stays cold.
Refrigeration	Refrigerator - eCube	The eCube consists of a solid, waxy food simulant that is fitted around a thermostat sensor that would otherwise measure air temperature. The refrigeration controls therefore attempt to regulate the temperature of food, which changes more slowly and gradually than air, thereby reducing the frequency of refrigeration cycles.
Refrigeration	Grocery- Display Case- LED Lighting	High-efficiency LED display case lighting not only reduces direct lighting energy use, but also reduce internal heat gains to the case from lights that must be removed by the refrigeration system.
Refrigeration	Grocery- Display Case Motion Sensors	Motion sensors reduce lighting load when area around display case is unoccupied to save energy on lighting.
Refrigeration	Grocery- ECM's for Display Cases	Replacement of shaded-pole evaporator fan motors with ECM motors in display cases allows for variable refrigeration loads to be handled. Reductions come from increased motor efficiency and the reduction of heating load.
Refrigeration	Grocery- Open Display Case- Night Covers	Night covers can be used on open refrigeration cases when a facility is closed or few customers are in the store.
Food Preparation	Cooking Exhaust Hoods with Sensor Control	Improved exhaust hoods involve installing variable-speed controls on commercial kitchen hoods. These controls provide ventilation based on actual cooking loads. When grills, broilers, stoves, fryers or other kitchen appliances are not being used, the controls automatically sense the reduced load and decrease the fan speed accordingly. This results in lower energy consumption because the system is only running as needed rather than at 100% capacity at all times.
Office Equipment	Office Equipment - Plug Load Occupancy Sensors	Occupancy sensors can control power strips and thus turn off energy used by plug loads, such as task lights, when an office is unoccupied.
HVAC (All)	Energy Management System	An energy management system (EMS) allows managers/owners to monitor and control the major energy-consuming systems within a commercial building. At the minimum, the EMS can be used to monitor and record energy consumption of the different end-uses in a building, and can control operation schedules of the HVAC and lighting systems. The monitoring function helps building managers/owners to identify systems that are operating inefficiently so that actions can be taken to correct the problem. The EMS can also provide preventive maintenance scheduling that will reduce the cost of operations and maintenance in the long run. The control functionality of the EMS allows the building manager/owner to operate

End Use	Measure	Description
		building systems from one central location. The operation schedules set via the EMS help to prevent building systems from operating during unwanted or unoccupied periods. This analysis assumes that this measure is limited to buildings with a central HVAC system.
HVAC (All)	Thermostat - Clock/Programmable	A programmable thermostat can be added to most heating/cooling systems. They are typically used during winter to lower temperatures at night and in summer to increase temperatures during the afternoon. There are two-setting models, and well as models that allow separate programming for each day of the week. The energy savings from this type of thermostat are identical to those of a "setback" strategy with standard thermostats, but the convenience of a programmable thermostat makes it a much more attractive option. In this analysis, the baseline is assumed to have no thermostat setback.
Miscellaneous	Lodging- Guest Room Controls	Hotel guestrooms can be fitted with occupancy controls that turn off energy-using equipment when the guest is not using the room. The occupancy controls comes in several forms, but this analysis assumes the simplest kind, which is a simple switch near the room's entry where the guest can deposit their room key or card. If the key or card is present, then lights, TV, and air conditioning can receive power and operate. When the guest leaves and takes the key, all equipment shuts off.
HVAC, Lighting	HVAC - Occupancy Sensors	Occupancy sensors turn off or adjust HVAC settings when a space is unoccupied.
HVAC, Lighting	Commissioning - HVAC, Lighting	For new construction and major renovations, commissioning ensures that building systems are properly designed, specified, and installed to meet the design intent and provide high-efficiency performance. Commissioning begins during the design process.
HVAC, Lighting	Retrocommissioning - HVAC, Lighting	In existing buildings, the retrocommissioning process identifies low-cost or no cost measures, including controls adjustments, to improve building performance and reduce operating costs. Retrocommissioning addresses HVAC, lighting, DHW, and other major building systems.
HVAC (All)	Advanced New Construction Designs	Advanced new construction designs use an integrated approach to the design of new buildings to account for the interaction of building systems. Designs may specify the building orientation, building shell, proper sizing of equipment and systems, and controls strategies with the goal of optimizing building energy efficiency and comfort. Options that may be evaluated and incorporated include passive solar strategies, increased thermal mass, natural ventilation, energy recovery ventilation, daylighting strategies, and shading strategies. This measure is modeled for new vintage only.
HVAC, Lighting	Custom Measures	Custom measures may be included in the analysis to serve as a "catch all" for measures for which costs and savings are not easily quantified and that could be part of a custom program. Typical costs and energy savings are assumed such that the measures pass the economic screen.
Electronics	Electronics- Smart Power Strip	This measure relates to Controlled Power Strips (or Smart Strips) which are multi-plug power strips with the ability to automatically disconnect specific connected loads depending upon the power draw of a control load, also plugged into the strip. Power is disconnected from the switched (controlled) outlets when the control load power draw is reduced below a certain adjustable threshold, thus turning off the appliances plugged into the switched outlets. By disconnecting, the standby load of the controlled devices, the overall load of a centralized group of equipment (i.e. entertainment centers and home office) can be reduced. Uncontrolled outlets are also provided that are not affected by the control device and so are always providing power to any device plugged into it.
Electronics	Electronics- Monitor Power Management	EZ Save Monitor Power Management Software

End Use	Measure	Description
Miscellaneous	Pool Heater - Solar	This measure replaces a conventional pool heater with a solar system.
Miscellaneous	Pool Pump - Timer	A pool pump timer allows the pump to turn off automatically, eliminating the wasted energy associated with unnecessary pumping.
Miscellaneous	Non-HVAC Motors - Variable Speed Control	The part-load efficiency of motors can be improved by varying the speed of the motor drive. There are two major types of variable speed controls: mechanical and electronic. An additional benefit of variable-speed controls is the ability to start and stop the motor gradually, thus extending the life of the motor and associated machinery. This analysis assumes that electronic variable speed controls are installed.

INDUSTRIAL ENERGY EFFICIENCY EQUIPMENT AND MEASURE DATA

This appendix presents detailed information for industrial energy-efficiency measures (*equipment* and *other* measures per the LoadMAP taxonomy) that were evaluated in this study.

Measure Descriptions

Table D-1 and Table D-2 provide brief descriptions for all equipment and non-equipment measures that were assessed for potential.[11]

Equipment Measure Data

The tables in the file "1434_Appendix_D_Tables-Industrial_Equipment.xlsx" list the detailed unit-level data (including economic screen results) for industrial energy-efficiency equipment measures in existing and new buildings. Savings are in annual kWh per employee, and incremental costs are in $/employee ($/empl.), unless noted otherwise. The BC ratio shown in the tables are for the first year of the potential analysis (2011), although the B/C ratio is calculated within LoadMAP for each year of the forecast. The B/C ratio in the tables is 1.00 if the measure represents the baseline technology, and zero if the technology is not available in 2013. The final data item in these tables is the levelized cost of conserved energy, which is defined as the cost of the measure divided by the cumulative amount of energy savings accrued over the measure's lifetime ($/kWh).

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ables-Industrial_Equi

Non-Equipment Measure Data

The tables in the file "1434_Appendix_D_Tables-Industrial_Non-Equipment.xlsx" list the detailed unit-level data (including economic screen results) for industrial energy-efficiency non-equipment measures in existing and new buildings. Because these measures can produce energy-use savings for multiple end-use loads (e.g., insulation affects heating and cooling energy use) savings are expressed as a net percentage of all the relevant, combined end-use loads. Base saturation indicates the percentage of square footage in which the measure is already installed. Applicability is a factor that accounts for whether the measure can be applied to the building. Cost is expressed in $/building or $/square foot, as indicated in the "unit" column. The detailed measure-level tables present the results of the benefit/cost (B/C) analysis for the first year of the analysis (2011) although the B/C ratio is calculated within LoadMAP for each year of the forecast. These tables also contain the levelized cost of conserved energy, which is defined as the cost of the measure divided by the cumulative amount of energy savings accrued over the measure's lifetime. This metric is given in terms of $/kWh.

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ables-Industrial_Non-

[11] Measure Description Source: EnerNOC internal databases

Table D-1 Industrial Energy Efficiency Equipment Measure Descriptions

End Use	Technology	Measure Description
Cooling	Air-Cooled Chiller	A central chiller plant creates chilled water for distribution throughout the facility. Because of the wide variety of system types and sizes, savings and cost values for efficiency improvements represent an average over screw, reciprocating, and centrifugal technologies. Under this simplified approach, each central system is characterized by an aggregate efficiency value (inclusive of chiller, pumps, and motors), in kW/ton with a further efficiency upgrade through the application of variable refrigerant flow technology.
Cooling	Water-Cooled Chiller	A central chiller plant creates chilled water for distribution throughout the facility. Water source chillers include heat rejection via a condenser loop and cooling tower. Because of the wide variety of system types and sizes, savings and cost values for efficiency improvements represent an average over screw, reciprocating, and centrifugal technologies. Under this simplified approach, each central system is characterized by an aggregate efficiency value (inclusive of chiller, pumps, motors, and condenser loop equipment), in kW/ton with a further efficiency upgrade through the application of variable refrigerant flow technology.
Cooling	Roof Top AC	Packaged cooling systems, such as rooftop units (RTUs), are simple to install and maintain, and are commonly used in small and medium-sized commercial buildings. Applications range from a single supply system with air intake filters, supply fan, and cooling coil, or can become more complex with the addition of a return air duct, return air fan, and various controls to optimize performance. For packaged RTUs, varying Energy Efficiency Ratios (EER) are modeled, as well as a ductless mini-split system.
Cooling/ Heating	PTAC/PTHP	This measure includes efficiency upgrades to other small cooling systems in commercial buildings including room AC units, packaged terminal air conditioning (PTAC) units, and packaged terminal heat pumps (PTHP).
Cooling / Heating	Air-Source Heat Pump	For heat pumps, units with increasing EER and COP levels are evaluated, as well as a ductless mini-split system.
Cooling / Heating	Geothermal Heat Pump	For heat pumps, units with increasing EER and COP levels are evaluated.
Heating	Electric Furnace	Resistive heating elements are used to convert electricity directly to heat. The heat is then delivered by a supply fan and duct system to the regions that require heating.
Heating	Electric Room Heat	Resistive heating elements are used to convert electricity directly to heat. Conductive fins surrounding the element or another mechanism is used to deliver the heat directly to the surrounding room or area. These are typically either baseboard or wall-mounted units.
Ventilation	Ventilation	A variable air volume ventilation system modulates the air flow rate as needed based on the interior conditions of the building to reduce fan load, improve dehumidification, and reduce energy usage.
Interior Lighting	Screw-in	This measure evaluates higher-efficiency alternatives for screw-in interior lamps including halogen, CFL, and LED.
Interior Lighting	High-Bay Fixtures	With the exception of screw-in lighting, industrial lighting efficiency changes typically require more than the simple purchase and installation of alternative lamp restrictions regarding ballasts, fixtures, and circuitry limit the potential for direct substitution of one lamp type for another. Also, during the buildout for a leased office space, management could decide to replace all lamps, ballasts, and fixtures with different configurations. This type of decision-making is modeled on a stock turnover basis because of the time between opportunities for upgrades. For High-Bay fixtures, alternatives include mercury vapor, metal halides, T5 fluorescent high output, and high-pressure sodium.
Interior Lighting	Linear Fluorescent	With the exception of screw-in lighting, industrial lighting efficiency changes typically require more than the simple purchase and installation of alternative lamp restrictions regarding ballasts, fixtures, and circuitry limit the potential for

End Use	Technology	Measure Description
		direct substitution of one lamp type for another. Also, during the buildout for a leased office space, management could decide to replace all lamps, ballasts, and fixtures with different configurations. This type of decision-making is modeled on a stock turnover basis because of the time between opportunities for upgrades. For linear fluorescent fixtures, alternatives include T12, T8, Super T8, T5, and LED.
Exterior Lighting	Screw-in	This measure evaluates higher-efficiency alternatives for screw-in interior lamps including halogen, CFL, and LED.
Exterior Lighting	HID	Alternatives modeled include metal halides, T8 and T5 high output, high pressure sodium, and LEDs
Exterior Lighting	Linear Fluorescent	For linear fluorescent fixtures, alternatives include T12, T8, Super T8, T5, and LED.
Process	Process Electrochemical	Electrochemical processes deal with chemical reactions in solution driven by electricity applied at a cathode and anode.
Process	Other Process	This category is a "catch all" for the many unique process applications in the broader industrial sector.
Process	Process Cooling	Industrial process where cooling is applied
Process	Process Refrigeration	Industrial refrigeration process
Process	Process Heating	Industrial process where heating is applied
Motors	Pumps, Fans & Blowers, Compressed Air, Conveyors, Material Handling, Material Processing	Premium efficiency motors reduce the amount of lost energy going into heat rather than power. Since less heat is generated, less energy is needed to cool the motor with a fan. The initial cost of energy efficient motors is generally higher than for standard motors; however their life-cycle costs can make them far more economical because of savings they generate in operating expense. The fact that energy efficient motors run cooler than their standard counterparts also results in an increase in the life of the motor insulation and bearing. High efficiency units use copper instead of aluminum in the windings and increased conductor cross-sectional area to lower a motor's I2R losses.
Miscellaneous	Miscellaneous	Improvement of miscellaneous electric uses.

Table D-2 Industrial Energy Efficiency Non-Equipment Measure Descriptions

End Use	Measure	Description
HVAC (All)	Insulation - Ceiling	Thermal insulation is material or combinations of materials that are used to inhibit the flow of heat energy by conductive, convective, and radiative transfer modes. Thus, thermal insulation can conserve energy by reducing the heat loss or gain of a building. The type of building construction defines insulating possibilities. Typical insulating materials include: loose-fill (blown) cellulose; loose-fill (blown) fiberglass; and rigid polystyrene.
HVAC (All)	Insulation - Ducting	Air distribution ducts can be insulated to reduce heating or cooling losses. Best results can be achieved by covering the entire surface area with insulation. Insulation material inhibits the transfer of heat through the air-supply duct. Several types of ducts and duct insulation are available, including flexible duct, pre-insulated duct, duct board, duct wrap, tacked, or glued rigid insulation, and waterproof hard shell materials for exterior ducts.
HVAC (All)	Insulation - Wall Cavity	Thermal insulation is material or combinations of materials that are used to inhibit the flow of heat energy by conductive, convective, and radiative transfer modes. Thus, thermal insulation can conserve energy by reducing the heat loss or gain of a building. The type of building construction defines insulating possibilities. Typical insulating materials include: loose-fill (blown) cellulose; loose-fill (blown) fiberglass; and rigid polystyrene.
HVAC (All)	HVAC - Duct Repair and Sealing	Leakage in unsealed ducts varies considerably because of the differences in fabricating machinery used, the methods for assembly, installation workmanship, and age of the ductwork. Air leaks from the system to the outdoors result in a direct loss proportional to the amount of leakage and the difference in enthalpy between the outdoor air and the conditioned air. To seal ducts, a wide variety of sealing methods and products exist. Each has a relatively short shelf life, and no documented research has identified the aging characteristics of sealant applications.
Air-Cooled Chiller	Air-Cooled Chiller - Economizer	Economizers allow outside air (when it is cool and dry enough) to be brought into the building space to meet cooling loads instead of using mechanically cooled interior air. A dual enthalpy economizer consists of indoor and outdoor temperature and humidity sensors, dampers, motors, and motor controls. Economizers are most applicable to temperate climates and savings will be smaller in extremely hot or humid areas.
Air-Cooled Chiller	Air-Cooled Chiller - Efficient Mechanical Layout	Improvements to layout and placement of chiller equipment, for example to enable unobstructed access to cooling tower airflow or minimize the length of refrigerant run between cooling tower and chiller head unit.
Air-Cooled Chiller	Air-Cooled Chiller - Maintenance	Filters, coils, and fins require regular cleaning and maintenance for the heat pump or roof top unit to function effectively and efficiently throughout its years of service. Neglecting necessary maintenance leads to a steady decline in performance while energy use increases.
Air-Cooled Chiller	Air-Cooled Chiller - Chilled Water Reset	Chilled water reset controls save energy by improving chiller performance through increasing the supply chilled water temperature, which allows increased suction pressure during low load periods. Raising the chilled water temperature also reduces chilled water piping losses. However, the primary savings from the chilled water reset measure results from chiller efficiency improvement. This is due partly to the smaller temperature difference between chilled water and ambient air, and partly due to the sensitivity of chiller performance to suction temperature.
Air-Cooled Chiller	Air-Cooled Chiller - Chilled Water Variable-Flow System	The part-load efficiency of chilled water loops can be improved substantially by varying the flow speed of the delivered water with the building demand for cooling.
Air-Cooled Chiller	Air-Cooled Chiller - Condenser Water Temperature Reset	Resetting the condenser water temperature to the lowest possible setting allows the cooling tower to generate cooler water whenever possible and decreases the temperature lift between the condenser and the evaporator. This will generally increase chiller part-load efficiency, though it may require

End Use	Measure	Description
		increased tower fan energy use.
Air-Cooled Chiller	Air-Cooled Chiller - High Efficiency Cooling Tower Fans	High-efficiency cooling fans utilize efficient components and variable frequency drives that improve fan performance by adjusting fan speed and rotation as conditions change.
Air-Cooled Chiller	Air-Cooled Chiller - VSD on Fans	Variable speed drives, which reduce chiller energy use under part load, are modeled for both air-cooled and water-cooled chillers.
Water-Cooled Chiller	Water-Cooled Chiller Economizer	Economizers allow outside air (when it is cool and dry enough) to be brought into the building space to meet cooling loads instead of using mechanically cooled interior air. A dual enthalpy economizer consists of indoor and outdoor temperature and humidity sensors, dampers, motors, and motor controls. Economizers are most applicable to temperate climates and savings will be smaller in extremely hot or humid areas.
Water-Cooled Chiller	Water Cooled Chiller-Efficient Mechanical Layout	Improvements to layout and placement of chiller equipment, for example to enable unobstructed access to cooling tower airflow or minimize the length of refrigerant run between cooling tower and chiller head unit.
Water-Cooled Chiller	Water Cooled Chiller Maintenance	Filters, coils, and fins require regular cleaning and maintenance for the heat pump or roof top unit to function effectively and efficiently throughout its years of service. Neglecting necessary maintenance leads to a steady decline in performance while energy use increases.
Water-Cooled Chiller	Water Cooled Chiller-Chilled Water Reset	Chilled water reset controls save energy by improving chiller performance through increasing the supply chilled water temperature, which allows increased suction pressure during low load periods. Raising the chilled water temperature also reduces chilled water piping losses. However, the primary savings from the chilled water reset measure results from chiller efficiency improvement. This is due partly to the smaller temperature difference between chilled water and ambient air, and partly due to the sensitivity of chiller performance to suction temperature.
Water-Cooled Chiller	Water Cooled Chiller-Variable Flow System	The part-load efficiency of chilled water loops can be improved substantially by varying the flow speed of the delivered water with the building demand for cooling.
Water-Cooled Chiller	Water Cooled Chiller Condenser Water Temperature Reset	Resetting the condenser water temperature to the lowest possible setting allows the cooling tower to generate cooler water whenever possible and decreases the temperature lift between the condenser and the evaporator. This will generally increase chiller part-load efficiency, though it may require increased tower fan energy use.
Water-Cooled Chiller	Water Cooled Chiller High Efficiency Cooling Tower Fans	High-efficiency cooling fans utilize efficient components and variable frequency drives that improve fan performance by adjusting fan speed and rotation as conditions change.
Water-Cooled Chiller	Water Cooled Chiller VSD on Fans	Variable speed drives, which reduce chiller energy use under part load, are modeled for both air-cooled and water-cooled chillers.
Roof Top AC	RTU - Maintenance	Regular cleaning and maintenance enables a roof top unit to function effectively and efficiently throughout its years of service. Neglecting necessary maintenance leads to a steady decline in performance while energy use increases. Maintenance can increase the efficiency of poorly performing equipment by as much as 10%.
Cooling / Heating	Heat Pump - Maintenance	Regular cleaning and maintenance enables a heat pump to function effectively and efficiently throughout its years of service. Neglecting necessary maintenance leads to a steady decline in performance while energy use increases. Maintenance can increase the efficiency of poorly performing equipment by as much as 10%.
HVAC (All)	Roofs - High Reflectivity	The color and material of a building structure surface will determine the amount of solar radiation absorbed by that surface and subsequently transferred into a building. This is called solar absorptance. By using a living roof or a roofing material with a light color (and a lower solar absorptance), the roof will absorb less solar radiation and consequently reduce the cooling load.

End Use	Measure	Description
		Living roofs also reduce stormwater runoff.
HVAC (All)	Energy Management System	An energy management system (EMS) allows managers/owners to monitor and control the major energy-consuming systems within a commercial building. At the minimum, the EMS can be used to monitor and record energy consumption of the different end-uses in a building, and can control operation schedules of the HVAC and lighting systems. The monitoring function helps building managers/owners to identify systems that are operating inefficiently so that actions can be taken to correct the problem. The EMS can also provide preventive maintenance scheduling that will reduce the cost of operations and maintenance in the long run. The control functionality of the EMS allows the building manager/owner to operate building systems from one central location. The operation schedules set via the EMS help to prevent building systems from operating during unwanted or unoccupied periods. This analysis assumes that this measure is limited to buildings with a central HVAC system.
HVAC (All)	Thermostat - Clock/Programmable	A programmable thermostat can be added to most heating/cooling systems. They are typically used during winter to lower temperatures at night and in summer to increase temperatures during the afternoon. There are two-setting models, and well as models that allow separate programming for each day of the week. The energy savings from this type of thermostat are identical to those of a "setback" strategy with standard thermostats, but the convenience of a programmable thermostat makes it a much more attractive option. In this analysis, the baseline is assumed to have no thermostat setback.
Interior Lighting	Interior Lighting - Occupancy Sensors	The installation of occupancy sensors allows lights to be turned off during periods when a space is unoccupied, virtually eliminating the wasted energy due to lights being left on. There are several types of occupancy sensors in the market.
Interior Lighting	Interior Lighting - Skylights	Addition of transparent windows/fixtures in the roof to allow daylight to enter and reduce the need for powered lighting.
Interior Lighting	Interior Lighting - Time Clocks and Timers	In many cases lighting remains on at night and during weekends. A simple timer can set a schedule for turning lights off to reduce operating hours.
Interior Lighting	Interior Lighting - LED Exit Lighting	The lamps inside exit signs represent a significant energy end-use, since they usually operate 24 hours per day. Many old exit signs use incandescent lamps, which consume approximately 40 watts per sign. The incandescent lamps can be replaced with LED lamps that are specially designed for this specific purpose. In comparison, the LED lamps consume approximately 2-5 watts.
Interior Lighting	Interior Lighting - Daylighting Controls	Daylighting controls use a photosensor to detect ambient light and adjust or turn off electric lights accordingly.
Interior Lighting	Interior Screw-in - Task Lighting	Individual work areas can use task lighting instead of brightly lighting the entire area. Significant energy savings can be realized by focusing light directly where it is needed and lowering the general lighting level. An example of task lighting is the common desk lamp. A 25W desk lamp can be installed in place of a typical lamp in a fixture.
Interior Lighting	Interior Fluorescent - Bi-Level Fixture	Bi-level fixtures have the ability to reduce light output to a lower level, given a control strategy that is based on a timer, occupancy sensor, motion sensor, or manual switch.
Interior Lighting	Interior Fluorescent - Delamp and Install Reflectors	While sometimes included in lighting retrofit projects, delamping is often performed as a separate energy efficiency measure in which a lighting engineer analyzes the lighting provided by current systems compared to the requirements of building occupants. This often leads to the removal of unnecessary lamps corresponding to an overall reduction in energy usage. In addition, installing a reflector in each fixture can improve light distribution from the remaining lamps.
Exterior Lighting	Exterior Lighting - Bi-Level Fixture	Bi-level fixtures have the ability to reduce light output to a lower level, given a control strategy that is based on a timer, occupancy sensor, motion sensor, or manual switch.

End Use	Measure	Description
Exterior Lighting	Exterior Lighting - Daylighting Controls	Daylighting controls use a photosensor to detect ambient light and adjust or turn off electric lights accordingly.
Exterior Lighting	Exterior Lighting - Photovoltaic Installation	Solar photovoltaic generation may be used to power exterior lighting and thus eliminate all or part of the electrical energy use.
Process	Process - Conductivity Controls	Automated control of conductivity levels in a process solution, for example by variably injecting CO2 into a stream of rinse water, can maintain an optimal solution that increases process effectiveness, decreases impurities, reduces scaling or corrosion, and minimizes required rinse time.
Process	Process - Controls on Fume Hoods	Improved fume hoods involve installing sensors and variable-speed controls to provide ventilation based on actual demand. When the relevant equipment or process is not active, the controls automatically decrease the fan speed accordingly.
Process	Process - Timers and Controls	Significant energy savings can frequently be attained from processes by adding a timer or altering their control algorithms.
Refrigeration	Refrigeration - Floating Head Pressure	Floating head pressure control allows the pressure in the condenser to "float" with ambient temperatures. This method reduces refrigeration compression ratios, improves system efficiency and extends the compressor life. The greatest savings with a floating head pressure approach occurs when the ambient temperatures are low, such as in the winter season. Floating head pressure control is most practical for new installations. However, retrofits installation can be completed with some existing refrigeration systems. Installing floating head pressure control increases the capacity of the compressor when temperatures are low, which may lead to short cycling.
Refrigeration	Refrigeration - System Controls	Refrigeration System Controls would include measures such as temperature sensors, flow/float controls, and pressure controls. These work to improve the refrigeration system by limiting demand and improving overall system efficiency.
Refrigeration	Refrigeration - System Maintenance	This measure includes repairing and recharging refrigerant lines, cleaning condenser coils, and replacing the oil. This reduces energy consumption by improving the rate at which the system can compress and cool refrigerant as it moves through the system.
Refrigeration	Refrigeration - System Optimization	Refrigeration system optimization is a thorough overhaul of the refrigeration system which involves the resizing, sequencing, and controlling of compressors in order to optimize load.
Compressed Air	Compressed Air - Air Usage Reduction	This measure involves a process audit of the facility to determine if the actual application of compressed air can be reduced, reconfigured, consolidated, or otherwise optimized.
Compressed Air	Compressed Air - Compressor Replacement	This measure is the replacement of existing air compressor equipment with more efficient compressors and motors in order to improve energy efficiency.
Compressed Air	Compressed Air - System Controls	Compressed Air System Controls would include measures such as VSDs, centralized controls, and system performance monitoring. These measures work in tandem to reduce energy usage by lowering system demand.
Compressed Air	Compressed Air - System Maintenance	This measure includes repairing holes in air lines, replacing failed nozzles, and lubricating the compressors. This reduces energy consumption by improving compressor efficiency and reducing line loss as gas moves through the system.
Compressed Air	Compressed Air - System Optimization and Improvements	System optimization is a thorough overhaul of the compressed air system which involves the resizing, sequencing, and improving control over all compressors in a system in order to reduce energy consumption to a minimum. This measure may include those from Controls and Maintenance.
Pumps	Pumping System - Controls	Significant energy savings can frequently be attained from processes by adding a timer or altering their control algorithms.
Pumps	Pumping System - Maintenance	This measure includes clearing traps, repairing impellers, and repairing broken seals or valves. This reduces energy consumption by reducing losses incurred

End Use	Measure	Description
		by moving fluids through the system.
Pumps	Pumping System - Optimization	Optimization integrates best practices of system analysis, equipment improvements, and operational improvements into a sustaining energy program. A facility that implements such a practice treats its energy program in a similar manner to safety or quality control programs: an individual or team is tasked with developing and enforcing standards, goals are set, regular reports are generated and reported to management, and all plant employees are engaged and held accountable.
Pumps	Pumps - Variable Speed Control	The part-load efficiency of drive systems can be improved by varying the speed of the motor drive. An additional benefit of variable-speed controls is the ability to start and stop the motor and process gradually, thus extending the life of the motor and associated machinery.
Pumps	Pump Equipment Upgrade	Improved design of flow, housing, control valves, impeller trimming, proper sizing, etc to increase productive output per energy input. Moreover, these improved systems could be assessed and managed in accordance with recognized standards such as ASME EA-2-2008.
Fans & Blowers	Fan Equipment Upgrade	Improved design of airflow, blades, housing, sizing, etc to increase productive output per energy input. Fans are widely used in industry for conveyance, drying and ventilation. For example, relatively inefficient centrifugal-radial fans, with efficiency as low as 22%, are commonly used in industry. These fans could be replaced with more efficient centrifugal backwardly inclined fans that increase overall fan efficiency by 20% to 30%. The savings potential for premium-efficiency fans is high, and the costs are relatively low. However, premium-efficiency fans are sometimes not chosen for industrial applications because of concerns about reliable operation in dirty environments.
Fans & Blowers	Fan System - Controls	Significant energy savings can frequently be attained from processes by adding a timer or altering their control algorithms.
Fans & Blowers	Fan System - Maintenance	This measure includes repairing holes in ducts, replacing clogged filters, and lubricating the motors. This reduces energy consumption by improving fan efficiency and reducing system loss as gas moves through the ductwork.
Fans & Blowers	Fan System - Optimization	Optimization integrates best practices of system analysis, equipment improvements, and operational improvements into a sustaining energy program. A facility that implements such a practice treats its energy program in a similar manner to safety or quality control programs: an individual or team is tasked with developing and enforcing standards, goals are set, regular reports are generated and reported to management, and all plant employees are engaged and held accountable.
Fans & Blowers	Fans - Variable Speed Control	The part-load efficiency of drive systems can be improved by varying the speed of the motor drive. An additional benefit of variable-speed controls is the ability to start and stop the motor and process gradually, thus extending the life of the motor and associated machinery.
Motors	Motors - Magnetic Adjustable Speed Drives	To allow for adjustable speed operation, this technology uses magnetic induction to couple a drive to its load. Varying the magnetic slip within the coupling controls the speed of the output shaft. Magnetic drives perform best at the upper end of the speed range due to the energy consumed by the slip. Unlike traditional ASDs, magnetically coupled ASDs create no power distortion on the electrical system. However, magnetically coupled ASD efficiency is best when power needs are greatest. VFDs may show greater efficiency when the average load speed is below 90% of the motor speed, however this occurs when power demands are reduced.
Motors	Motors - Efficient Rewind	When a motor burns out or is in need of repair, the owner may elect to either replace the motor or have it rewound. A typical motor rewind costs less than a replacement motor, but at the cost of efficiency. An efficient rewind, however, attempts to improve the efficiency of the motor by reducing stator losses. If the manufacturer has left stator slots open, or not entirely filled, additional copper wire can be included to reduce resistance and increase efficiency.

End Use	Measure	Description
Motors	Motors - Variable Frequency Drive	The part-load efficiency of drive systems can be improved by varying the speed of the motor drive. An additional benefit of variable-speed controls is the ability to start and stop the motor and process gradually, thus extending the life of the motor and associated machinery.
HVAC, Lighting	Commissioning - HVAC, Lighting	For new construction and major renovations, commissioning ensures that building systems are properly designed, specified, and installed to meet the design intent and provide high-efficiency performance. Commissioning begins during the design process.
HVAC, Lighting	Retrocommissioning - HVAC, Lighting	In existing buildings, the retrocommissioning process identifies low-cost or no cost measures, including controls adjustments, to improve building performance and reduce operating costs. Retrocommissioning addresses HVAC, lighting, DHW, and other major building systems.
Ventilation	Ventilation - CO2 Controlled	Also known as Demand Controlled Ventilation, this measure uses carbon dioxide (CO2) levels to indicate the level of occupancy in a space. Sensors monitor CO2 levels so that air handling controls can adjust the amount of outside air the system needs to intake. Ventilation rates are thereby controlled based on occupancy, rather than a fixed rate, thus saving HVAC energy use.
All	Custom Measures	Custom measures may be included in the analysis to serve as a "catch all" for measures for which costs and savings are not easily quantified and that could be part of a custom program. Typical costs and energy savings are assumed such that the measures pass the economic screen.

MARKET ADOPTION FACTORS

To calculate achievable potential, we apply a set of market adoption factors to economic potential. These parameters are described below, followed by a discussion of how they are applied to calculate achievable potential. Finally, we present the three sets of factors at the end of this section.

Maximum Achievable Potential Adoption Rates

These factors are applied to Economic potential to estimate the upper bound of achievable potential: Maximum Achievable Potential. These estimate customer adoption of economic measures when delivered through efficiency programs under ideal market, implementation, and customer preference conditions. Information channels are assumed to be established and efficient for marketing, educating consumers, and coordinating with trade allies and delivery partners. The Maximum Achievable Potential adoption rates are based on the take rates from the program interest surveys. For Maximum Achievable Potential we used the 1-year payback take rate for the customer segment that is most inclined to adopt energy efficiency measures. This reflects what the best practice could achieve in the Ameren Missouri service territory.

The Maximum Achievable Potential adoption rates are applied directly to economic potential to calculate the Maximum Achievable Potential estimates.

Realistic Achievable Potential Adoption Rates

These factors are applied to Maximum Achievable Potential to calculate Realistic Achievable Potential. They reflect expected program participation given current barriers to customer acceptance, non-ideal implementation conditions, and limited program budgets. This represents a lower bound on achievable potential and are also developed using the results of the program interest survey of Ameren Missouri customers. The Realistic Achievable Potential adoption rates are based on the average take rate across all segments at the 3-year payback level.

Like the Maximum Achievable Potential rates, these rates increase over time.

To review the take rates from the program interest surveys, please see Volume 2: Market Research.

Estimates of Achievable Potential

The tables in the file "1434_Appendix_E_Tables-Potential Factors.xlsx" present the Potential Factors. Maximum Achievable Potential Factors as well as the product of Maximum Achievable Potential factors and Realistic Achievable Potential factors (High x Low) are used to demonstrate how Economic potential is changed to reach Realistic Achievable Potential for residential equipment and non-equipment measures.

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ables-Potential Facto

About EnerNOC

EnerNOC's Utility Solutions Consulting team is part of EnerNOC's Utility Solutions, which provides a comprehensive suite of demand-side management (DSM) services to utilities and grid operators worldwide. Hundreds of utilities have leveraged our technology, our people, and our proven processes to make their energy efficiency (EE) and demand response (DR) initiatives a success. Utilities trust EnerNOC to work with them at every stage of the DSM program lifecycle – assessing market potential, designing effective programs, implementing those programs, and measuring program results.

EnerNOC's Utility Solutions deliver value to our utility clients through two separate practice areas – Implementation and Consulting.

- Our Implementation team leverages EnerNOC's deep "behind-the-meter expertise" and world-class technology platform to help utilities create and manage DR and EE programs that deliver reliable and cost-effective energy savings. We focus exclusively on the commercial and industrial (C&I) customer segments, with a track record of successful partnerships that spans more than a decade. Through a focus on high quality, measurable savings, EnerNOC has successfully delivered hundreds of thousands of MWh of energy efficiency for our utility clients, and we have thousands of MW of demand response capacity under management.
- The Consulting team provides expertise and analysis to support a broad range of utility DSM activities, including: potential assessments; end-use forecasts; integrated resource planning; EE, DR, and smart grid pilot and program design and administration; load research; technology assessments and demonstrations; evaluation, measurement and verification; and regulatory support.

The team has decades of combined experience in the utility DSM industry. The staff is comprised of professional electrical, mechanical, chemical, civil, industrial, and environmental engineers as well as economists, business planners, project managers, market researchers, load research professionals, and statisticians. Utilities view EnerNOC's experts as trusted advisors, and we work together collaboratively to make any DSM initiative a success.

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