TENNESSEE VALLEY AUTHORITY POTENTIAL STUDY

VOLUME 1: EXECUTIVE SUMMARY

Final Report

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CHAPTER | 1

INTRODUCTION

Background

The Tennessee Valley Authority (TVA) has contracted with Global Energy Partners (Global) to conduct a potential study to assess 20-year potentials for energy efficiency (EE) and demand response (DR). TVA has an aspirational goal to lead the southeast in energy efficiency, and believes this leadership can be accomplished through the development and implementation of action plans for EE, DR, and end-use generation. This potential study will provide information to assist TVA in meeting that goal.

Toward this end, Global conducted a detailed, bottom-up assessment of the TVA market to deliver forecasts of energy use and peak demand, as well as forecasts of energy and peak-demand savings achievable through energy efficiency and demand response programs. The 20-year potentials study addresses the residential, small commercial, large commercial, and industrial sectors. Results of this task are discussed in two volumes, one for energy efficiency and one for demand response, as described below in the report organization.

Global also compared the results of the potential savings to those from existing regional potential studies that are specific to the Southeast and other select studies. This analysis, which appears in both the energy efficiency and demand response reports, also compares these potential studies with regard to methodology, assumptions, approaches, estimated baselines, technical performance, adoption, and program/regulatory context.

This document is **Volume 1: Executive Summary,** an overview of the entire energy efficiency and demand response analysis. The other volumes are:

- Volume 2, Energy Efficiency Potential
- Volume 3, Demand Response Potential

Objectives

Key objectives for the study include:

- Conduct a 20-year bottom-up energy efficiency potential study to determine the potential for specific energy efficiency measures to reduce the consumption and peak demand of electricity in the TVA service territory.
- Conduct a demand response potential study to determine the potential for reduction in peak demand through demand response programs.
- Compare the potential study results with other national and regional studies, including details regarding assumptions used to develop each of the studies.

Definitions of Potential

In this study, we estimate the potential for energy efficiency savings. The savings estimates represent gross savings[1] 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

[1] Savings in "gross" terms instead of "net" terms means that the baseline forecast does not include naturally occurring efficiency. In other words, the baseline assumes that energy efficiency levels remain fixed as they are today. This rule holds true except in cases where enactment of future codes and standards were on the books before January 2011, e.g., the effects of the EISA 2007 lighting efficiency standard.

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. For this reason, we developed a range of achievable potential. These 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 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 in the residential sector include:

- Ductless mini-split air conditioners with variable refrigerant flow
- Ground source (or geothermal) heat pumps
- LED lighting

Technical potential also assumes the adoption of every available other 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. The retrofit measures are phased in over a number of years, which is longer for higher-cost measures.

Economic potential represents the adoption of all ***cost-effective*** energy efficiency measures. In this analysis, the total resource cost (TRC) test, which compares lifetime energy and capacity benefits to the incremental cost of the measure, is applied. Economic potential assumes that customers purchase the most cost-effective option at the time of equipment failure and also adopt every other cost-effective and applicable measure.

Achievable - High potential takes into account expected program participation resulting from ideal implementation conditions and customer preferences for energy-efficient technologies and demand response programs. Achievable - High establishes a maximum target for the EE savings that a utility 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.

Achievable - Low potential represents a lower bound on Achievable potential. It reflects limited DSM budgets and significant barriers to customer acceptance.

CHAPTER | 2

ENERGY EFFICIENCY POTENTIAL

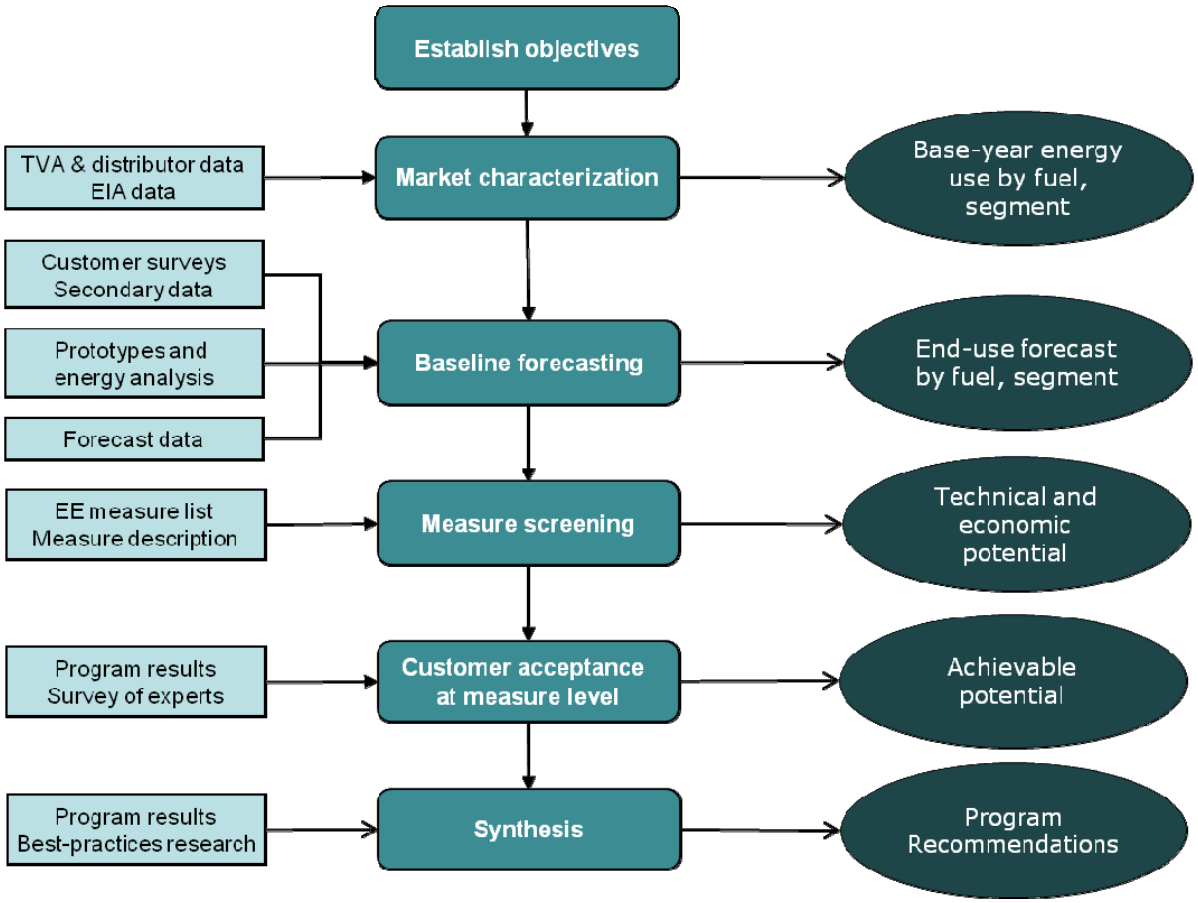
Analysis Approach

To perform the energy efficiency analysis, Global used a bottom-up analysis approach as shown in Figure 2-1. We took the following steps:

1. Held a meeting with the project team to refine the objectives that were identified in the TVA RFP. This resulted in a work plan for the study.
2. Performed a market characterization to describe sector-level electricity use for the residential, commercial, and industrial sectors for the base year, TVA 2009. (Note that all years referred to in this report are TVA fiscal years). This included using utility data and secondary data from sources such as the American Community Survey (ACS) and the Energy Information Administration (EIA).
3. Utilized TVA primary market research (such as TVA's 2010 residential market saturation survey) and secondary sources to understand how customers in the Tennessee Valley currently use electricity. Combining this information with the market characterization, we developed energy market profiles that describe energy use by sector, segment, and end use for 2009.
4. Developed a baseline electricity forecast by sector, segment, and end use for 2012 through 2032. Results presented in this volume are through 2030.
5. Identified and analyzed energy-efficiency measures appropriate for the Valley.
6. Estimated four levels of energy-efficiency potential, *Technical, Economic, Achievable - High,* and *Achievable - Low*.
7. Reviewed the current programs offered by TVA in light of the study findings to make strategic program recommendations for achieving savings.

The results from these steps are presented in the remainder of this chapter. Details are provided in Volume 2.

Figure 2-1 Overview of Analysis Approach



Market Characterization

The Tennessee Valley Authority (TVA) is the largest electric utility in the U.S. on the basis of energy sales, with annual sales of 174 billion kWh in 2010.[2] TVA serves as the wholesale provider for 155 power distributors and directly serves 59 industrial and federal facilities. Its service territory, with an approximate area of 80,000 square miles, encompasses more than 9 million people in seven southeastern states. It includes nearly the entire state of Tennessee as well as portions of Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia. Major cities are Memphis, Nashville, Knoxville, Huntsville, and Chattanooga. The top industries in the service territory are chemical products, primary metals, paper products, and food products.

Total electricity use for the residential, commercial and industrial sectors for TVA in 2009 was 146,118 GWh.[3] As shown in Figure 2-2, the largest sector is residential, accounting for 42%, or 62,246 GWh. The remaining use is split between the commercial and industrial sectors, at 39,561 GWh and 44,311 GWh respectively.

[2] http://www.tva.com/abouttva/index.htm

[3] Energy given "at-the-meter," i.e., does not include line losses. Also, totals do not include outdoor lighting, federal customers, or a small number of DSI customers as specified by TVA project management.

Figure 2-2 Sector-Level Electricity Use, 2009

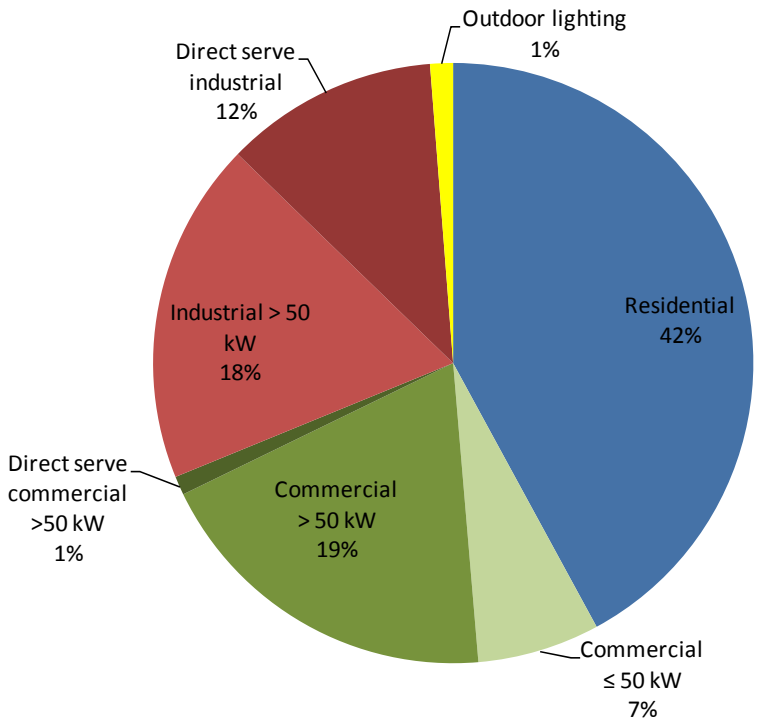


Figure 2-3 presents the end-use shares of residential electricity use for each housing type. Here, the single family segment is shown as a segment average as well as broken out into single family all-electric homes and single family other homes. The TVA territory has a large number of all-electric homes, roughly half of the single family homes in the Valley, with comparatively larger consumption in heating, water heating, and cooking.

Figure 2-3 End-Use Shares of Total Electricity Use by Housing Type, 2009

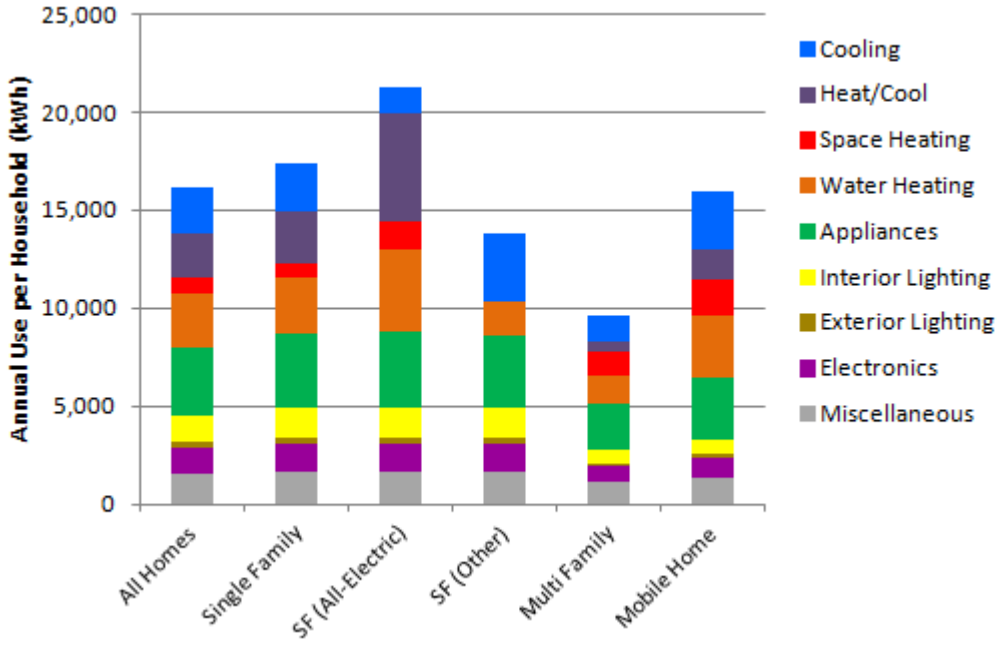


Figure 2-4 shows the breakdown of annual commercial electricity usage by end use. Cooling and lighting are the largest end uses in the commercial sector, accounting for over half of total usage.

Refrigeration and ventilation are the next largest end uses. Each of the remaining end uses accounts for 5% or less of total usage.

Figure 2-4 Commercial Electricity Consumption by End Use, 2009

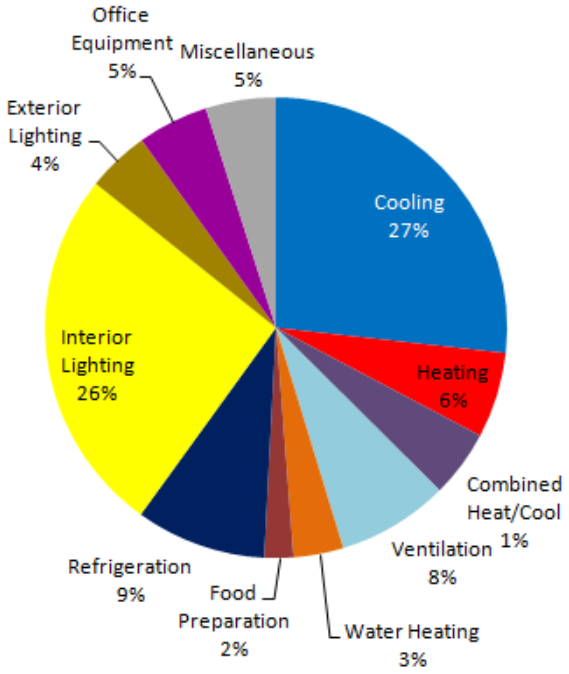
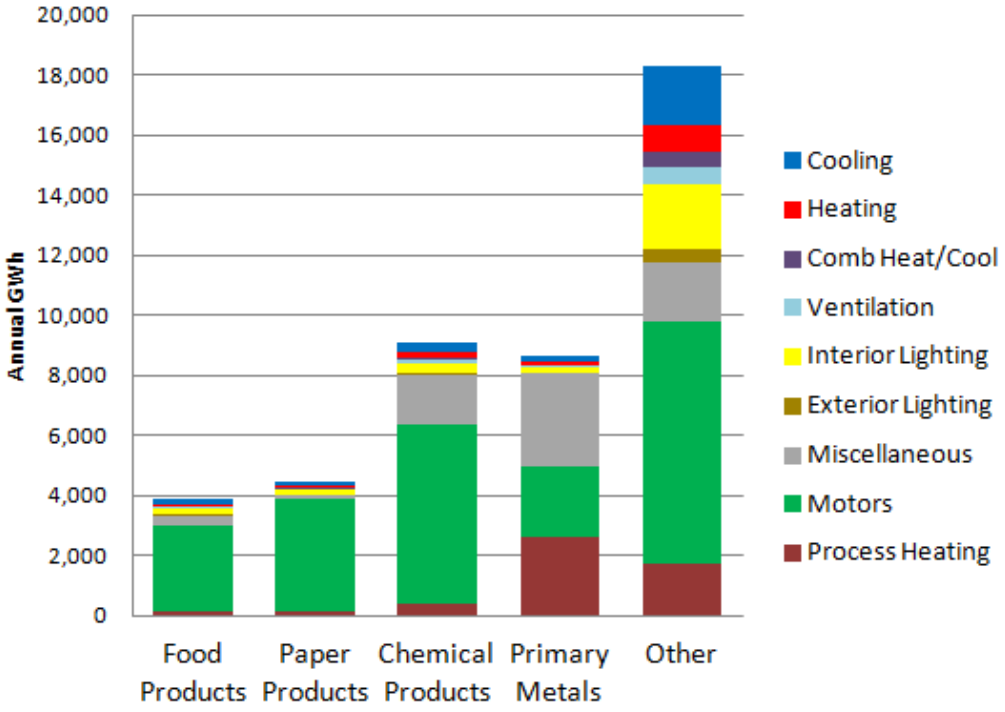


Figure 2-5 shows how the major industrial segments in the Valley used electricity in 2009. Machine drives dominate all segments, though process heating is more prevalent in the primary metals segment.

Figure 2-5 Industrial Electricity Use by End Use and Segment, 2009



Baseline Forecast

Prior to developing estimates of energy-efficiency potential, a baseline end-use forecast was developed to quantify how electricity is used by end use in the base year and what the consumption is likely to be in the future in absence of new utility programs and naturally occurring efficiency. The baseline forecast serves as the metric against which energy efficiency potentials; technical, economic, and achievable, are measured. The baseline forecast we developed for TVA was consistent with its official forecast from October 2011.

Figure 2-6 through Figure 2-8 present the baseline end-use forecasts for the residential, commercial and industrial sectors. Referring to Table 2-1 and Figure 2-9, electricity use across all three sectors is expected to increase by 24% between the base year, 2009, and 2030, for an average annual growth rate of 1.0%.

- The residential sector has the highest growth, with a 33% increase (1.4% annual growth rate) over the forecast horizon.
- The commercial sector has a dip in the short term and then recovers after 2015. Overall, it has the slowest growth at 0.6% per year on average.
- The industrial sector shows a steady increase in use throughout the forecast period with an average growth rate of 0.9% per year.

Figure 2-6 Residential Baseline Forecast by End Use

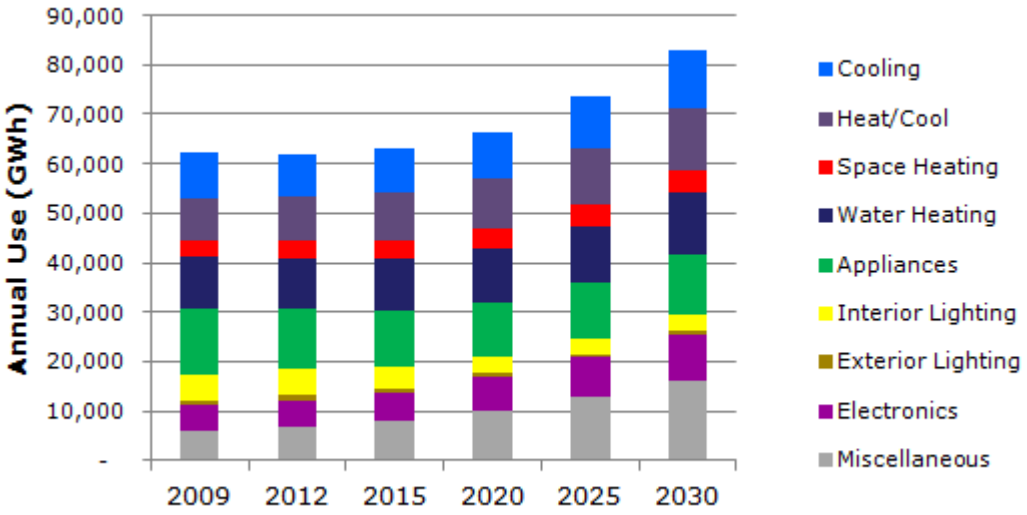


Figure 2-7 Commercial Baseline Electricity Forecast by End Use

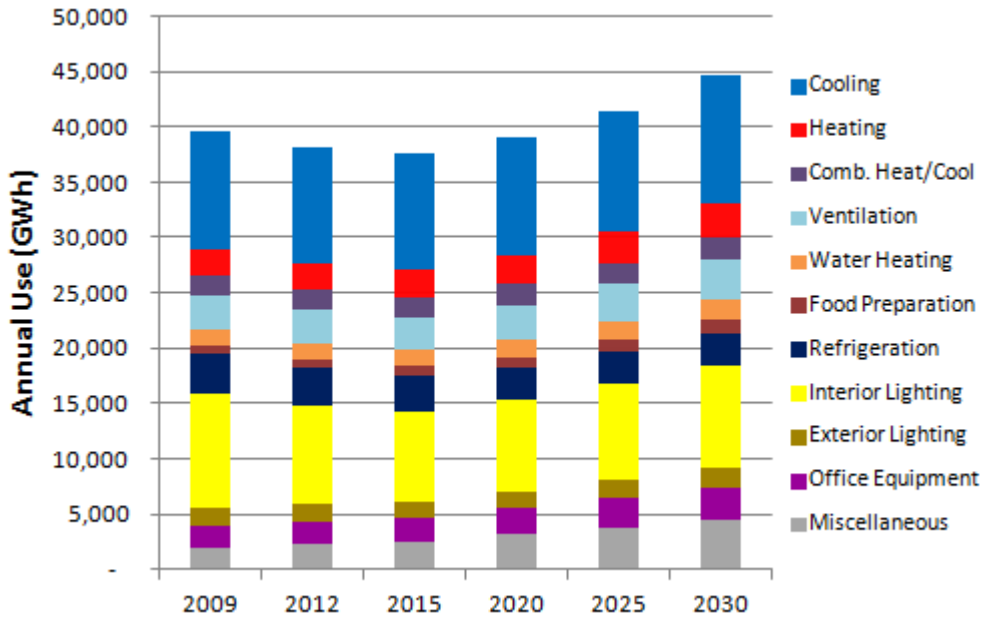


Figure 2-8 Industrial Baseline Electricity Forecast by End Use

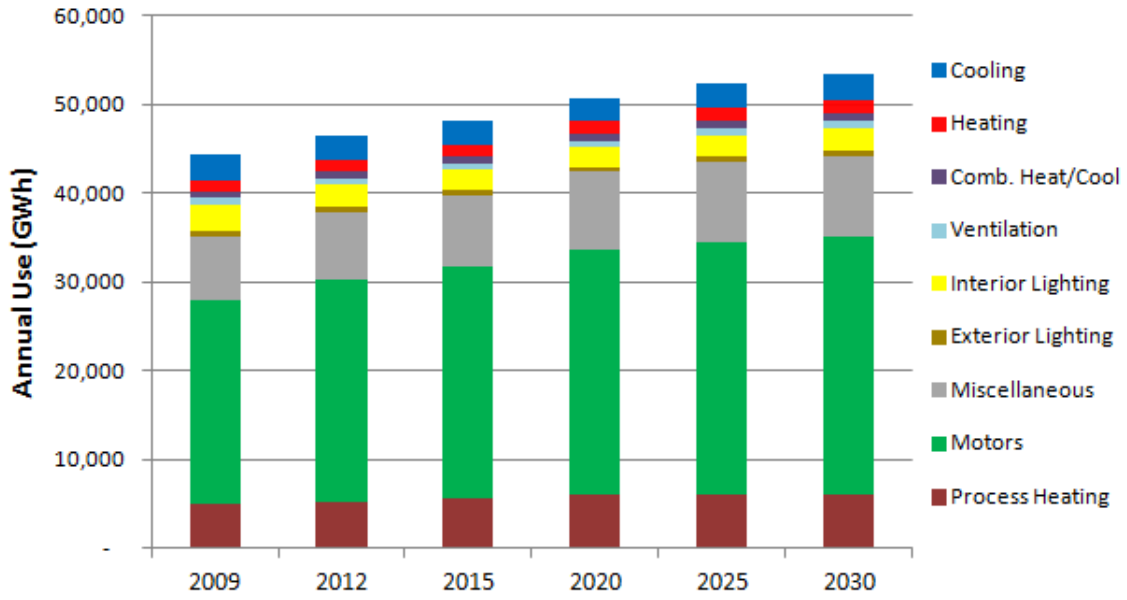
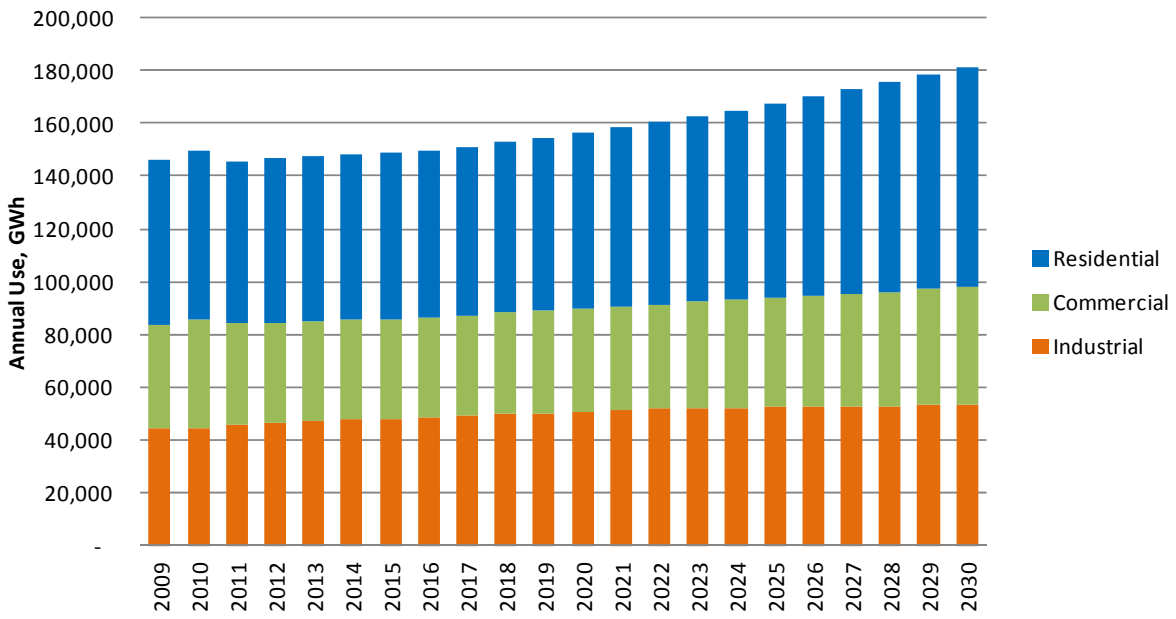


Table 2-1 Baseline Forecast Summary

Sector	2009	2012	2015	2020	2025	2030	% Change	Avg. growth rate
Residential	62,246	61,936	62,932	66,440	73,613	82,830	33%	1.4%
Commercial	39,561	38,176	37,587	39,026	41,485	44,718	13%	0.6%
Industrial	44,311	46,394	48,173	50,777	52,364	53,412	21%	0.9%
Total	**146,118**	**146,505**	**148,692**	**156,243**	**167,462**	**180,959**	**24%**	**1.0%**

Figure 2-9 Baseline Forecast Summary



Energy Efficiency Measures

The first step of the energy efficiency measure analysis was to identify the list of all relevant energy efficiency measures that should be considered for the TVA potential assessment. Sources for the measure assumptions were drawn from TVA's Measurement Manual and latest program evaluation results, Global's building modeling tool BEST, and Global's other measure databases from previous studies and program work.

The measures are categorized into two types according to the LoadMAP[4] taxonomy: equipment measures and non-equipment measures:

- ***Equipment measures,*** or efficient energy-consuming pieces of equipment, save energy by providing the same service with a lower energy requirement. An example is the replacement of a standard efficiency refrigerator with an ENERGY STAR model. For equipment measures, many efficiency levels are available for a specific technology that range 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 federal standard SEER 13 unit and spans a broad spectrum of efficiency, with the highest efficiency level represented by 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 the air conditioner only when people are home. Non-equipment measures fall into one of the following categories:
    - Building shell (windows, insulation, roofing material)
    - Equipment controls (thermostat, occupancy sensors)
    - Equipment maintenance (cleaning filters, changing setpoints)
    - Whole-building design (natural ventilation, passive solar lighting)
    - Lighting retrofits (included as a non-equipment measure because retrofits are performed prior to the equipment's normal end of life)

[4] Global's Load Management Analysis and Planning™ tool

- Displacement measures (ceiling fan to reduce use of central air conditioners)
- Commissioning and retrocommissioning

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

Table 2-2 Number of Measures Evaluated

	Residential	Commercial	Industrial	Total Number of Measures
Equipment Measures Evaluated	102	126	85	**313**
Non-Equipment Measures Evaluated	42	52	74	**168**
Total Measures Evaluated	**144**	**178**	**159**	**481**

Energy Efficiency Potential Results

Table 2-3 and Figure 2-10 summarize the energy-efficiency savings for the different levels of potential relative to the baseline forecast. Figure 2-11 displays the energy-efficiency forecasts.

- ***Achievable - Low potential*** forms a lower point on the range of achievable potential. Across all sectors, this metric is 3,256 GWh in 2015 and increases to 19,093 by 2030. This represents 2.2% of the baseline forecast in 2015 and 10.6% in 2030. By 2030, Achievable – Low offsets 55% of the growth in the baseline forecast.
- ***Achievable - High potential*** forms the upper bound on the range of achievable potential. It is 7,494 GWh in 2015, which represents 5.0% of the baseline forecast. By 2030, the cumulative savings are 35,781 GWh, 19.8% of the baseline forecast, for an annual average of just over 1% per year. By 2030, Achievable – High completely offsets growth in the baseline forecast.
- ***Economic potential***, which reflects the savings when all cost-effective measures are taken, is 12,418 GWh in 2015. This represents 8.4% of the baseline energy forecast. By 2030, economic potential reaches 44,821 GWh, 24.8% of the baseline energy forecast.
- ***Technical potential***, which reflects the adoption of all energy efficiency measures regardless of cost-effectiveness, is a theoretical upper bound on savings. In 2015, energy savings are 15,347 GWh, or 10.3% of the baseline energy forecast. By 2030, technical potential reaches 57,244 GWh, 31.6% of the baseline energy forecast.

Table 2-3 Summary of Energy Efficiency Potential

	2012	2015	2020	2025	2030
Baseline Forecast (GWh)	146,505	148,692	156,243	167,462	180,959
Energy Savings (Cumulative GWh)					
Achievable - Low	811	3,256	7,963	13,420	19,093
Achievable - High	2,417	7,494	15,337	25,215	35,781
Economic	4,481	12,418	21,658	33,091	44,821
Technical	5,349	15,347	27,545	42,822	57,244
Energy Savings (% of Baseline)					
Achievable - Low	0.6%	2.2%	5.1%	8.0%	10.6%
Achievable - High	1.7%	5.0%	9.8%	15.1%	19.8%
Economic	3.1%	8.4%	13.9%	19.8%	24.8%
Technical	3.7%	10.3%	17.6%	25.6%	31.6%

Figure 2-10 Summary of Achievable Potential Energy Savings

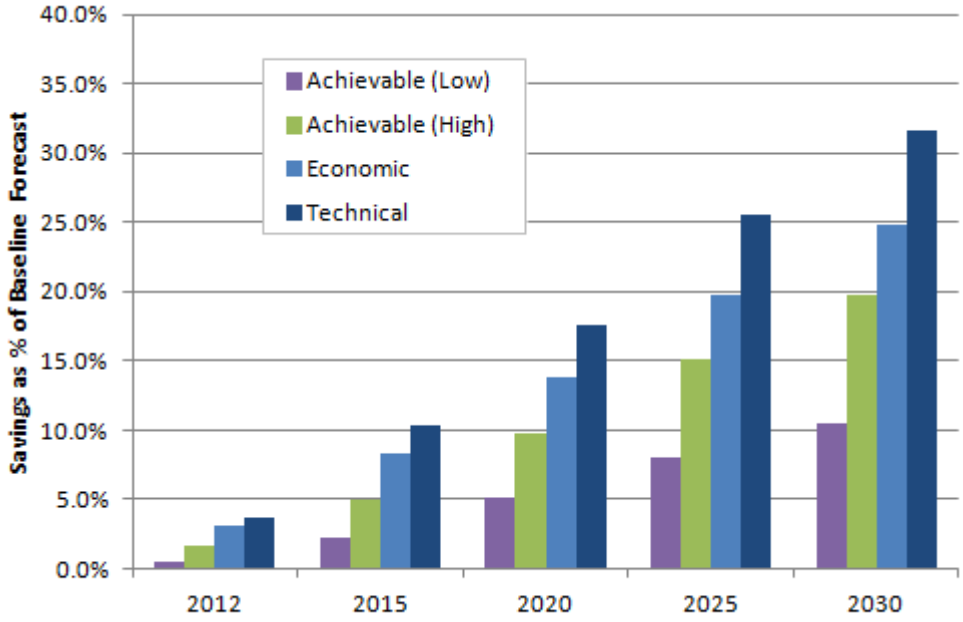


Figure 2-11 Energy Efficiency Potential Energy Forecasts (GWh)

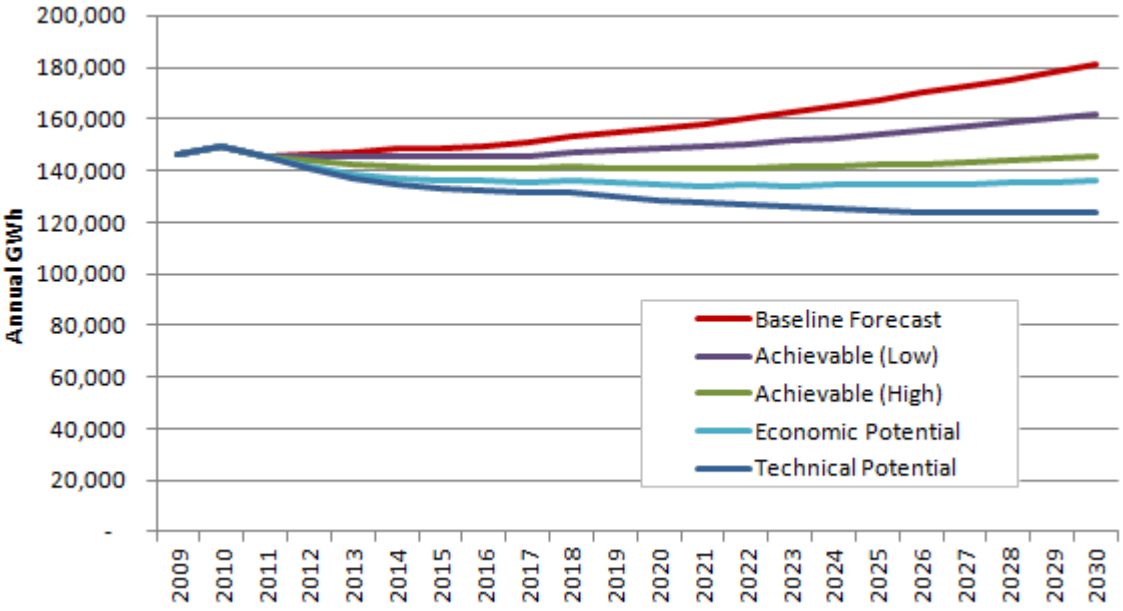


Table 2-4 summarizes the range of achievable potential by sector. The residential sector accounts for the largest portion of the savings, about half of the Achievable - Low potential, followed by the commercial and then the industrial sectors.

Table 2-4 Achievable Energy Efficiency Potential by Sector (GWh)

	2012	2015	2020	2025	2030
Achievable - Low Savings (GWh)					
Residential	384	1,444	3,216	5,652	8,307
Commercial	228	985	2,613	4,163	5,557
Industrial	199	826	2,134	3,604	5,229
Total	**811**	**3,256**	**7,963**	**13,420**	**19,093**
Achievable - High Savings (GWh)					
Residential	1,107	3,356	6,445	10,961	15,759
Commercial	660	2,181	4,693	7,419	10,130
Industrial	651	1,957	4,199	6,835	9,892
Total	**2,417**	**7,494**	**15,337**	**25,215**	**35,781**

Figure 2-12 focuses on the range of residential achievable potential in 2015 and 2030.

- Lighting equipment replacement accounts for the highest portion of the savings in the near term as a result of the efficiency gap between advanced incandescent lamps and CFL lamps.
- Water heating accounts for large savings in the long term because heat pump water heaters are found to be cost-effective.
- Electronics, appliances, and space conditioning measures also contribute significantly to the savings.

Figure 2-12 Residential Achievable Potential by End Use in 2015 and 2030

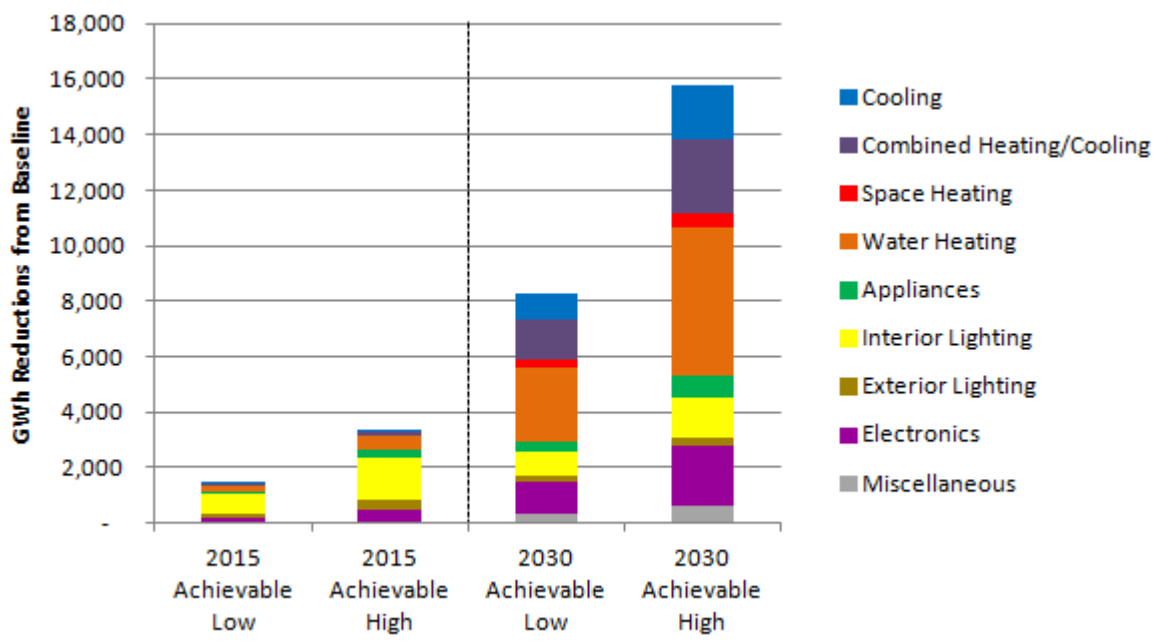


Figure 2-13 compares the range of potential in 2015 and 2030 for the commercial sector. Not surprisingly, interior lighting delivers the highest achievable savings throughout the study period. In 2015, exterior lighting is second, office equipment is third, and ventilation and cooling are next highest in terms of Achievable - Low potential. In 2030, though interior lighting still provides the greatest Achievable - Low potential, cooling is the second greatest source of savings, followed by refrigeration and exterior lighting.

Figure 2-13 Commercial Achievable Potential Savings by End Use in 2015 and 2030

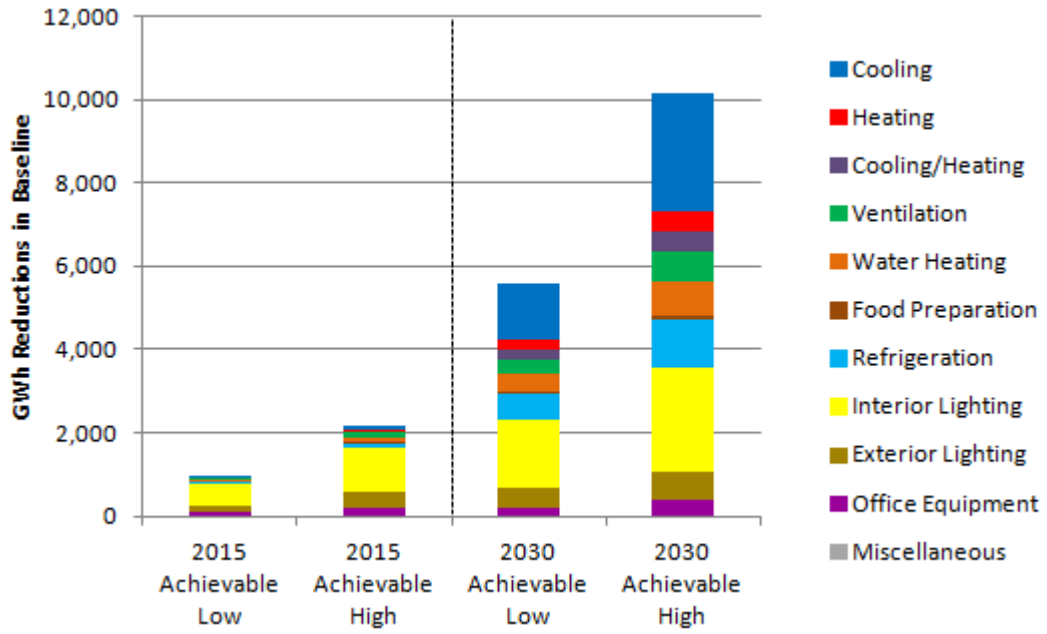
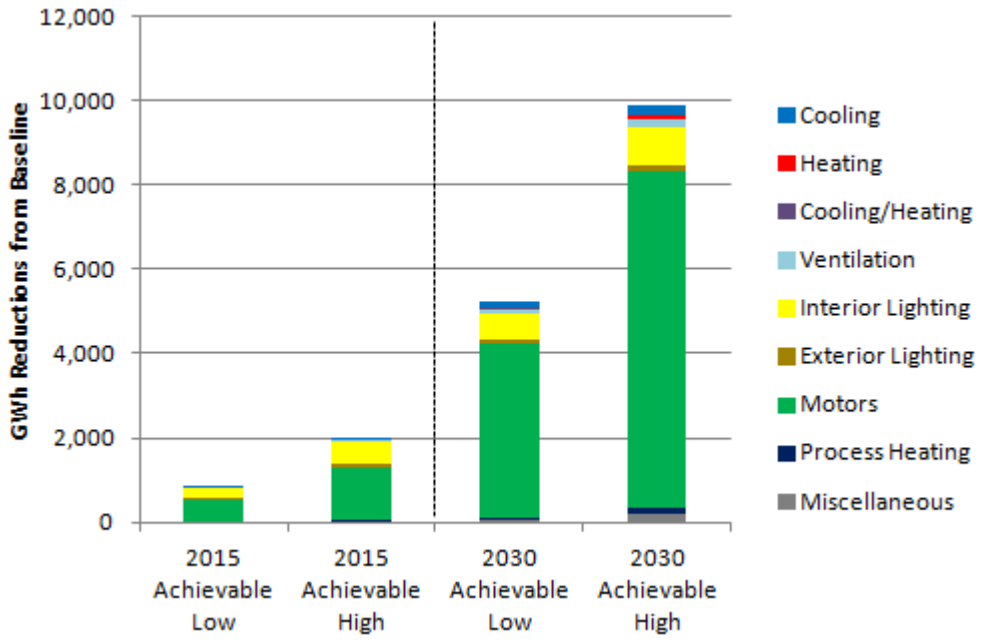


Figure 2-14 illustrates the range of achievable potential savings by end use in 2015 and 2030 for the industrial sector, reinforcing the dominance of the machine drive (motors) category. The specific measures that account for the largest savings in the industrial segment are:

- Integrated plant energy management: 45 MWh and 392 MWh of Achievable – Low potential in 2015 and 2030 respectively
- Fan and pump system measures, which include system optimization, energy management, and equipment upgrades: 135 GWh and 1,425 GWh of Achievable – Low potential in 2015 and 2030 respectively

Figure 2-14 Industrial Achievable Potential Savings by End Use in 2015 and 2030



EE Program Recommendations

The results of the EE assessment reveal that TVA has significant potential for energy efficiency resources over the next two decades. Our analysis has shown that TVA can realize an achievable range of reductions between 10.4% and 19.4% of the baseline forecast in 2030 with the measures represented in this report.

TVA's energy-efficiency programs are off to a strong start, with a comprehensive suite of programs currently moving from the planning phase to the implementation phase. Based on this study, Global provides the following recommendations to preserve and augment that momentum.

General Recommendations

- ***Coordinate distributor layer between TVA and end-user:*** As a wholesale provider for 155 power distributors, TVA's business landscape poses unique challenges for the administration of energy efficiency programs. Because of this arm's-length relationship with end users, TVA does not have the same level of information about customers as other utilities. TVA will need to coordinate closely with its power distributors. To facilitate better coordination, TVA should consider the hiring and training of dedicated personnel to serve as liaisons with the distributors.
- ***Maintain transparent stakeholder process:*** To date, TVA has been transparent and aboveboard with internal and external stakeholders. Continuing to involve stakeholders and cultivating a mutual understanding of continuous improvement is of paramount importance to the future success of programs. We recommend an open and transparent stakeholder process with regular touchpoints and workshops. Suggested workshop topics are: technical resource manual with deemed measure databases; evaluation, measurement, and verification protocols; emerging technologies; innovative program strategies; periodic reviews of program results; and sharing success stories from individual power distributors or customers.
- ***Create internal EE targets:*** TVA should continue to evolve and formulate its specific objectives regarding energy efficiency by creating targets and goals. Global recommends targets that fall within the range of achievable potentials identified in this study.
- ***Aggressively pursue lighting savings in the near-term:*** Lighting represents a bulk of the low-hanging fruit in the near term, with significant untapped potential in all sectors. Programs have not yet aggressively targeted lighting, beyond a limited CFL giveaway effort. Working upstream with trade allies and retailers will likely yield significant savings. In particular, as the EISA standards take effect, educational programs and coordination with retailers can help customers move beyond EISA-compliant lamps to more efficient CFL and LED technologies.
- ***Create targeted marketing messages:*** Energy prices in the Valley are cheaper than the national average. Correspondingly, the customer base does not have a long history of exposure to marketing and education regarding energy and sustainability issues like other jurisdictions around the nation. As a result, customers have not been strongly driven to consider energy efficiency measures, and awareness and adoption will be lower than national averages at first. Targeted marketing and education efforts should be developed with messages that speak to the customer base and cultivate shared attitudes.
- ***Expand knowledge of the customer base:*** TVA's pre-existing data regarding the customer base is minimal. Opportunities should be explored to expand this knowledge base. Not only will this information be valuable for program efforts, the results can be shared with distributors, many of whom are too small to conduct surveys on their own. Surveys should collect data in all sectors on end use equipment saturations, customer attitudes, and measure penetration.

Residential Recommendations

- ***Pursue CFLs:*** Significant, cost-effective potential is available with CFLs, in spite of the forthcoming EISA standards that will reduce their per-unit savings compared to the new baseline. Also, TVA should focus strong attention on specialty CFL programs, as these bulbs are not addressed in the EISA standard.
- ***Focus on all-electric homes:*** The prominence of all-electric homes, roughly 50%, has many implications for program design. Audit programs with direct install measures are one mechanism for reaching these customers. New construction incentives can help to boost the penetration of heat pumps, heat pump water heaters (HPWH), and advanced construction designs.
- ***Pursue heat pump water heaters:*** Heat pump water heaters offer significant potential, but educational efforts, for trade allies as well as homeowners, will be required to achieve this potential. Consider bundling HPWH with the existing and established space conditioning heat pump program to take advantage of the gains the heat pump programs have made in acquainting trade allies and targeted participants with heat pump technology.

Commercial and Industrial Recommendations

- ***Pursue lighting savings:*** Strongly pursue lighting savings to accelerate the phase out of T12 fluorescent lighting. In particular, program efforts can help intercept building operators before they make purchase and stocking decisions that could lead to the hoarding of T12 lamps.
- ***Create customized, multi-year plans for large, complex customers***: For large enough customers, large success can be obtained with strategic energy management (SEM)[5] initiatives over longer time horizons. This means a larger tracking and time commitment, but many jurisdictions are finding this to be a more effective method than a "one and done" installation and rebate approach. These relationships involve personalized plans, identification of metrics, goal-setting, technical assistance, and attention from account executives.
- ***Focus program efforts on motor controls and system optimizations:*** Low-cost retrofits can have significant, low-cost energy impacts with minimal disruption (and often times improvement) of business processes.

[5] Sometimes called Continuous Energy Improvement (CEI).

CHAPTER | 3

DEMAND RESPONSE POTENTIAL

Analysis Approach

The analysis approach for estimating demand response potential is, by necessity, different from the approach used for energy efficiency. Energy efficiency can occur outside of utility programs to the extent that it is naturally occurring or technology driven; but can be enhanced and enabled by utility programs. Demand response, however, does not exist without a utility program. A program-by-program analysis is therefore at the core of a demand-response potential study. The basic steps used to perform this assessment are as follows:

1. ***Characterize the market.*** The first step is to segment the market into the relevant customer segments. The first level of segmentation is by sector: residential and C&I customers. Within residential customers, we further segment the population by describing housing types and presence of end uses (such as single family homes with central air conditioning (CAC) and electric water heating). For C&I customers, the next level of segmentation is based on the maximum demand values, typically following utility rate schedules.
2. ***Identify baseline forecast.*** The second step is to identify what the peak demand forecast will be, absent any DR programs, for both summer and winter in the TVA service territory.
3. ***Define relevant DR options.*** The next step is to identify applicable DR options for each customer segment. DR options include direct load control (DLC), curtailable, demand reduction, capacity reduction, load shifting, pricing, and voltage reduction programs. Each of these options is mapped to the applicable customer segments. For some options, such as DLC, specific end uses can be controlled and they are identified. Also, enabling technologies, such as programmable communicating thermostats (PCT) are identified by customer segment.
4. ***Outline DR program participation hierarchy.*** For each customer segment that has more than one DR option, the next step is to define the participation hierarchy. This accounts for program overlaps and ensures that cross-participation in DR events and double counting does not take place.
5. ***Develop program parameters.*** Program parameters include participation rates, number of participants equipped with enabling technology, unit load reduction impacts, attrition rates, and DR event participation rates. Cost data are also developed for the analysis, including program development costs, customer marketing and recruitment costs, technology costs, customer incentives, operation and maintenance (O&M) costs, and program administrative costs.
6. ***Estimate preliminary potential and assess cost-effectiveness.*** The final step is to estimate the load reduction potential associated with each of the DR options by customer segment, and also at the aggregate level across programs and segment. Utility-provided avoided capacity costs are used to assess benefits from DR programs
7. ***Develop estimates of achievable potential.*** The final step is to estimate the load reduction potential associated with each of the DR options by customer segment, and also at the aggregate level across programs and segment. Achievable potential takes into account expected participation rates as well as cost-effectiveness of the program. For this study, we estimate a range of achievable potential:

- Achievable – High assumes higher participation rates that result from application of industry best practices in program design, higher budget limits for implementation, and does not incorporate the results of the cost effectiveness screen. Therefore, Achievable – High represents the upper bound of savings, regardless of cost.
- Achievable – Low assumes lower levels of participation as a result of limited budgets for program implementation and includes only those programs that pass the cost-effectiveness screen. Therefore the Achievable – Low represents a more realistic picture of DR potential given barriers to participation and cost constraints.

Unlike the energy-efficiency analysis, we do not consider technical or economic potential for demand response.

Matrix of Demand Response Options

For this study, a broad set of demand response options that combines traditional and emerging approaches was identified. They fall into eight groups: direct load control programs, curtailable programs, demand and capacity reduction programs, dynamic pricing programs, aggregator managed programs, load shifting programs, voltage regulation programs, and fast-DR. Table 3-1 translates the eight groups into eleven specific options by customer segment and identifies the enabling technology options and targeted end uses for each.

Table 3-1 Relevant DR Options Matrix

Demand Response Option	Brief Description	Eligible Customer Segments	Targeted End Uses
Residential Direct Load Control	Traditional DLC program utilizing either load control switches or programmable thermostats	Single Family residential customers with CAC, Water Heating, or Space Heating	CAC, Water Heating, Space Heating
C&I Direct Load Control	Traditional DLC program utilizing either load control switches or programmable thermostats	Small C&I customers with CAC, Water Heating, or Space Heating	CAC, Water Heating, Space Heating
Capacity Reduction	Voluntary load nomination program with capacity credits and energy credits	Small C&I, Medium C&I, Large C&I, Extra Large C&I (except 5&60 MR, > 500kW), Direct Serve	Customer Specific
Demand Reduction	Voluntary load nomination program with energy credits	Extra Large C&I, Direct Serve	Customer Specific
Curtailable	Contractual commitment to reduce load to a pre-specified level; capacity credits and non-performance provisions apply	Extra Large C&I, Direct Serve	Customer Specific
Dynamic Pricing	Voluntary time-variant pricing tariff (i.e., CPP)	Residential, Small C&I, Medium C&I, Large C&I, Extra Large C&I, Direct Serve	All
Fast DR	Load reduction with response time less than 10 minutes, suitable for providing ancillary services	All	Customer Specific
Third Party Aggregated	Represents primarily the existing TVA program	Medium C&I, Large C&I, Extra Large C&I	Customer Specific
Distributor Aggregated	Represents TVA's Distributor Aggregated Demand Response (DADR) Program	Residential, Small C&I, Medium C&I, Large C&I, Extra Large C&I	Customer Specific
Load Shifting	Represents TVA's 'Residential and Commercial Shift and Store Program	Residential, Small C&I, Medium C&I	Customer Specific
Voltage Regulation	Represents TVA's Conservation Voltage Regulation (CVR) and Dispatchable Voltage Regulation (DVR) Programs	Residential, Small C&I, Medium C&I	Not applicable

Load Impacts

Table 3-2 presents the load reductions per program participant (or unit impacts). Where current TVA DR programs exist, unit impacts are benchmarked to the values observed in those programs. Where there are no existing programs, unit impacts are based on the FERC study's Expanded Business as Usual (EBAU) scenario for Tennessee and values from Global's other recent potential studies.[6]

Table 3-2 Load Reduction Impact Assumptions [7]

DR Option	Unit of Impact	Residential	Small C&I	Medium C&I	Large C&I	Xlarge C&I	Direct Serve
AC DLC	kW load reduction per customer (summer)	1.0 kW	1.0 kW				
Space Heating DLC	kW load reduction per customer (winter)	1.0 kW	1.0 kW				
Water Heating DLC	kW load reduction per customer	0.5 kW	0.5 kW				
Capacity Reduction	Per Customer %Impact w/ tech		12%				
Capacity Reduction	Per Customer %Impact w/o tech		5%	12%	39%	100%*	100%*
Third Party Aggregated	Per Customer %Impact			40%	40%	40%	
Distributor Aggregated	Per Customer % Impact	30%	30%	40%	40%	40%	
Demand Reduction	Per Customer %Impact					100%*	100%*
Dynamic Pricing	Per Customer %Impact w/ tech	34%	15%	14%	14%	100%*	100%*
Dynamic Pricing	Per Customer %Impact w/o tech	17%	5%	9%	9%	100%*	100%*
Fast DR	Per Customer Summer %Impact w/ tech	30%	30%	39%	39%	100%*	100%*
Fast DR	Per Customer Winter %Impact w/ tech	30%	30%	39%			
Load Shifting	Per Customer %Impact	20%	25%	25%			
Curtailable	Per Customer %Impact					100%*	100%*

[6] Global has conducted numerous studies of DR potential in the last five years. We checked our input assumptions and analysis results against the results from these other studies which include AmerenUE, Los Angeles Department of Water and Power, and the State of New Mexico, and Avista Utilities.

[7] Gray shaded boxes indicate that a DR option is not applicable for that sector.
Xlarge and Direct serve % impacts are applied to eligible MW rather than eligible customers.
Impacts with asterisk (*) indicate programs for which 100% represents the expected interruptible load.

Demand Response Potential Results

Demand response has the potential to reduce peak demand by 1,504 MW to 1,520 MW in 2012. The achievable potential increases to a range of 3,870 MW to 4,579 MW in 2030.[8]

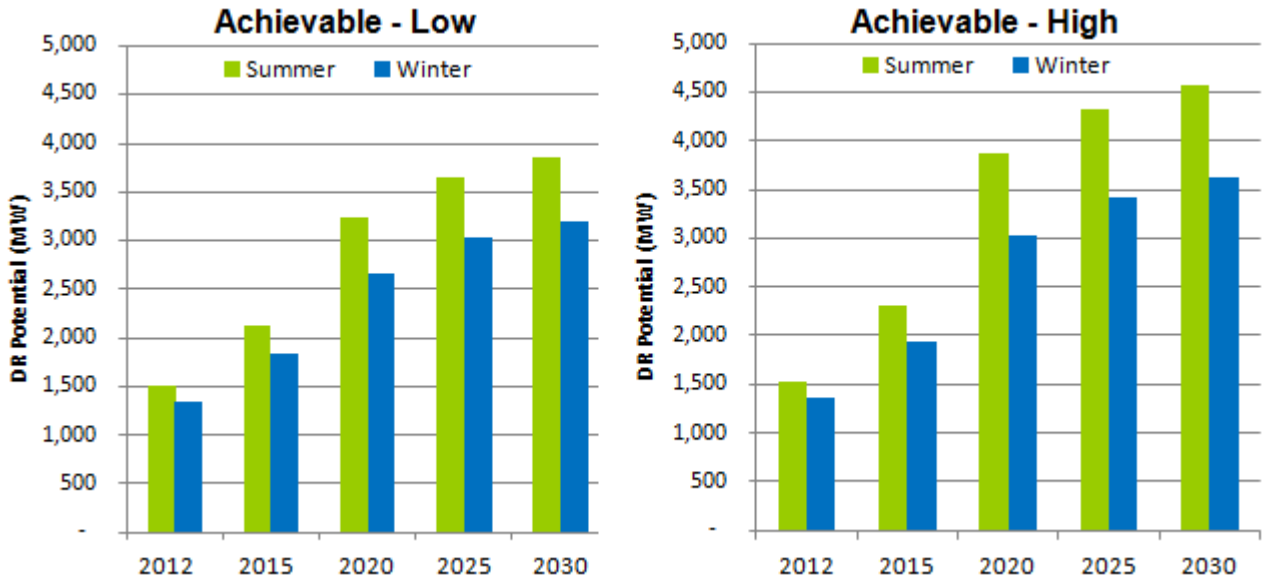
Table 3-3 presents the overall summary of demand response potential for the two cases. Figure 3-1 presents this information graphically. The primary observations are:

- In summer of 2012, achievable potential reduces peak demand by approximately 5%. This starting point takes into account the achievements in 2011 from TVA's current DR program portfolio.
- By summer of 2030, the achievable potential reduces peak demand by 10% to 12%. This level of savings represents an offset in growth of between 53% and 63%.
- In winter of 2012, achievable potential reduces peak demand by approximately 4%.
- By winter of 2030, the achievable potential reduces peak demand by 8% in the low case and 9% in the high case which represents an offset in growth of between 71% and 80%.

Table 3-3 Summary of Demand Response Savings for TVA

		2012	2015	2020	2025	2030
Summer	Peak Forecast (MW)	31,036	32,074	34,031	36,234	38,353
	Achievable - Low (MW)	1,504	2,137	3,245	3,662	3,870
	Achievable - High (MW)	1,520	2,301	3,872	4,331	4,579
	Achievable - Low (% of baseline)	***5%***	***7%***	***10%***	***10%***	***10%***
	Achievable - High (% of baseline)	***5%***	***7%***	***11%***	***12%***	***12%***
Winter	Peak Forecast (MW)	32,886	31,252	33,145	35,284	37,390
	Achievable - Low (MW)	1,353	1,782	2,618	3,030	3,199
	Achievable - High (MW)	1,363	1,881	2,985	3,422	3,616
	Achievable - Low (% of baseline)	***4%***	***6%***	***8%***	***8%***	***8%***
	Achievable - High (% of baseline)	***4%***	***6%***	***9%***	***9%***	***9%***

Figure 3-1 Summary of Demand Response Potential for TVA



[8] Fast DR is not included in the total potential estimates presented here. As discussed in more detail in Volume 3, Fast-DR events are considered distinct from traditional DR events. Customers can dual enroll in Fast DR and any other customer based dispatchable DR program, therefore the impacts associated with DR cannot be added to the total potential.

Potential Estimates by DR Program Type

Table 3-4and Table 3-5 show the range of achievable potential for each program type in both summer and winter. The primary observations from the analysis are:

- Capacity reduction has, by far, the largest contribution to the overall potential from all DR programs, with a 33% share in the total achievable potential in the high case in 2030. The achievable potential for this program represents a migration from the curtailable program to the capacity reduction program by 2016.[9]
- The Curtailable program is phased out completely by the year 2016 as all participants migrate into the Capacity Reduction option. In our experience, this trend is common in the industry as many utilities move away from emergency response programs and toward programs that can be integrated into wholesale markets based on economic dispatch models.
- While the total potential attributable to DLC varies widely from 645 MW and 17% in the low case to 1,174 MW and 26% in the high case DLC remains the second largest contributor to overall potential. The key difference between estimates of potential in the high and low case is the participation rates. The high case assumes an effective participation of 23.1% while the low case assumes an effective participation of 11.3%. DLC potential also varies from summer to winter; this is a result of the saturation of central air conditioning in the Tennessee Valley being higher than the saturation of electric heat.
- The Voltage Reduction programs also contribute substantially to the overall potential with CVR contributing 14% and DVR contributing 4% to overall potential.
- Savings from the Third Party Aggregated program come in fourth with an 11% share of the total potential in 2030. When combined with the Distributor Aggregated Program, which is very similar to the Third Party Program, the two programs represent 16% of the total potential in 2030.
- Savings from the Dynamic Pricing program are moderate with a total contribution of about 4% in 2030. Under a voluntary scenario, we assume a very conservative participation rate, which limits the potential of this program type.
- Load shifting has the smallest contribution to overall potential with about a 2% contribution in 2030.

[9] This migration is representative of the migration of customers from TVA's current 5MR and 60MR programs to the new Reserve Preservation program which falls within the capacity reduction program option for this study.

Table 3-4 Summary of Summer MW Savings by Program for TVA

DR Program	Type	2012	2015	2020	2025	2030
Direct Load Control	Achievable - Low	11	136	575	610	645
	Achievable - High	19	249	1,048	1,111	1,174
Curtailable	Achievable - Low	530	37	0	0	0
	Achievable - High	530	37	0	0	0
Capacity Reduction	Achievable - Low	441	1,086	1,283	1,369	1,452
	Achievable - High	447	1,117	1,360	1,453	1,543
Third Party Aggregator	Achievable - Low	395	518	520	522	523
	Achievable - High	395	518	520	522	523
Distributor Aggregator	Achievable - Low	61	86	129	134	139
	Achievable - High	62	96	173	181	188
Demand Reduction	Achievable - Low	1	16	68	73	77
	Achievable - High	1	16	68	73	77
Dynamic Pricing	Achievable - Low	2	29	132	161	191
	Achievable - High	2	33	141	171	203
Conservation Voltage Regulation	Achievable - Low	46	121	320	543	576
	Achievable - High	46	121	320	543	576
Dispatchable Voltage Regulation	Achievable - Low	16	42	112	190	202
	Achievable - High	16	42	112	190	202
Load Shifting	Achievable - Low	1	13	50	53	56
	Achievable - High	2	20	75	80	84
All Programs	**Achievable - Low**	**1,504**	**2,084**	**3,190**	**3,656**	**3,861**
	Achievable - High	**1,520**	**2,249**	**3,817**	**4,324**	**4,570**

Table 3-5 Summary of Winter MW Savings by Program for TVA

DR Program	Type	2012	2015	2020	2025	2030
Direct Load Control	Achievable - Low	5	62	259	275	290
	Achievable - High	9	115	481	510	539
Curtailable	Achievable - Low	507	34	0	0	0
	Achievable - High	507	34	0	0	0
Capacity Reduction	Achievable - Low	410	999	1,170	1,248	1,325
	Achievable - High	415	1,021	1,226	1,309	1,391
Third Party Aggregator	Achievable - Low	313	399	400	402	403
	Achievable - High	313	399	400	402	403
Distributor Aggregator	Achievable - Low	50	75	132	138	144
	Achievable - High	51	89	193	203	213
Demand Reduction	Achievable - Low	1	16	68	73	77
	Achievable - High	1	16	68	73	77
Dynamic Pricing	Achievable - Low	2	31	141	172	205
	Achievable - High	2	35	149	181	216
Conservation Voltage Regulation	Achievable - Low	47	115	300	502	524
	Achievable - High	47	115	300	502	524
Dispatchable Voltage Regulation	Achievable - Low	17	40	105	176	183
	Achievable - High	17	40	105	176	183
Load Shifting	Achievable - Low	1	11	42	45	47
	Achievable - High	1	16	62	66	70
All Programs	**Achievable - Low**	**1,353**	**1,782**	**2,618**	**3,030**	**3,199**
	Achievable - High	**1,363**	**1,881**	**2,985**	**3,422**	**3,616**

Figure 3-2 and Figure 3-3 show the range of achievable potential by customer class. The residential class has the largest contribution to overall potential at 41% in 2030 for the high achievable case. This is primarily due to participation in the DLC program option. Large C&I and Direct Serve come in second and third in overall contribution to potential, with 14% and 21% respectively, with their contribution being concentrated heavily in the capacity reduction program. Large, Medium C&I contribute 12% and 9% to overall potential respectively. Small C&I has the smallest contribution with 4%.

Figure 3-2 Achievable – Low Potential by Customer Class

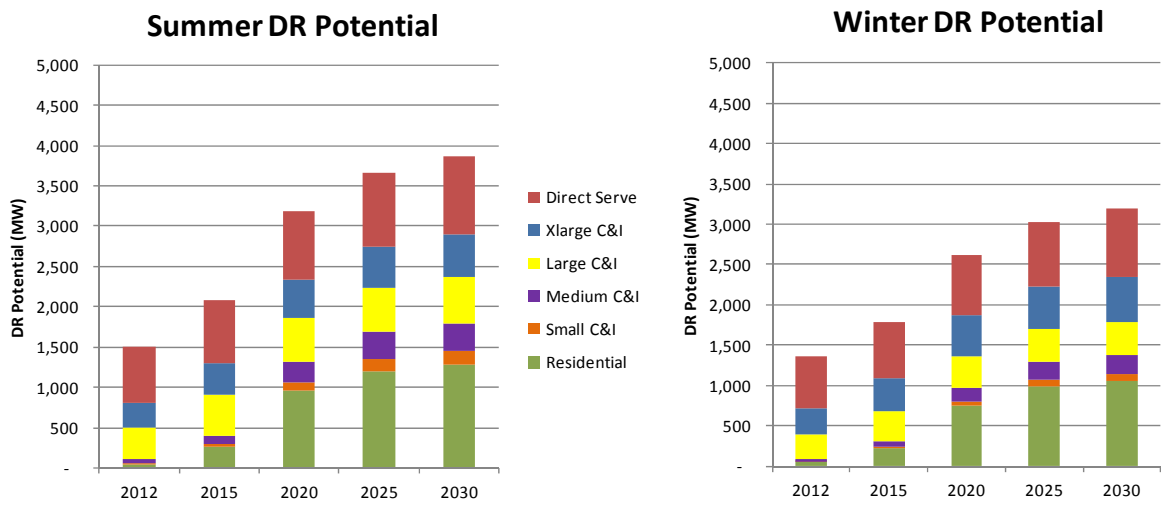
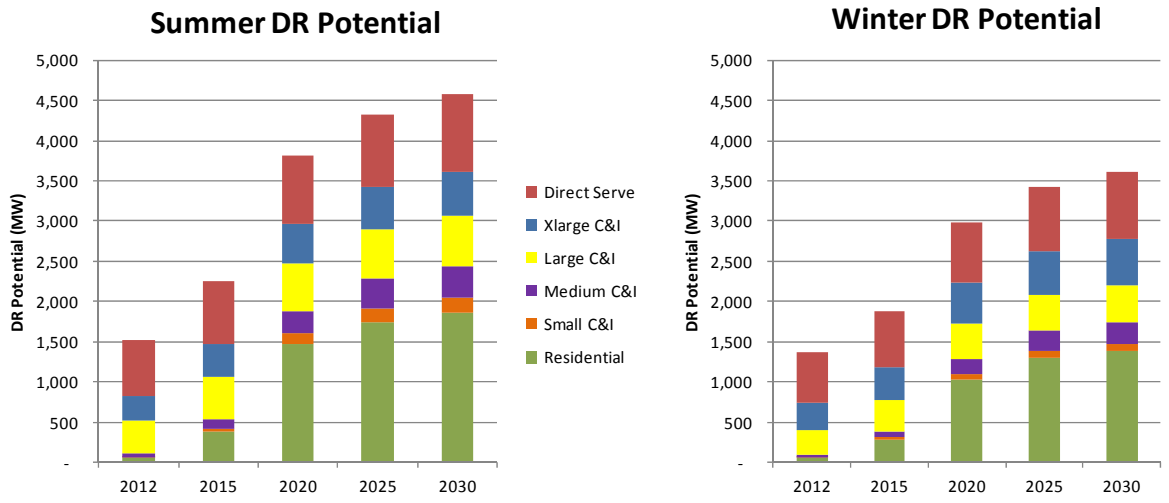


Figure 3-3 Achievable – High Potential by Customer Class



Summary of Cost-Effectiveness Analysis Results

Table 3-6 presents a summary of the cost-effectiveness results based on the TRC test for all programs.[10] The cost effectiveness tests were performed using a bottom up approach that employs cost assumptions based on secondary information and industry best practices.[11] The analysis was performed in this manner in order to provide TVA with realistic annual costs that can be passed on to distributors including: equipment costs, incentive costs, administrative, and marketing costs[12]. The results of the TRC test analysis show that the overall portfolio of DR programs is cost-effective.[13] The cost-effectiveness assessment is done for the Achievable - High level.

The most cost effective programs are Curtailable, Capacity Reduction, Demand Reduction, Dynamic Pricing and Fast DR. Curtailable has the highest B/C ratio due to a shortened program life of three years. Demand Reduction, Capacity Reduction, and Dynamic Pricing are also highly cost effective. These programs have lower administrative costs, and fewer equipment costs than the other non-aggregated programs. The voltage regulation programs are also considered cost effective, however it is important to note that costs for these programs are based solely on the incentive payment that TVA pays to the distributors. All equipment and implementation costs are assumed to be covered by that incentive and additional external (rate-based) costs and benefits to the distributor are not captured. The remaining programs; DLC, Third Party and Distributor Aggregated, and Load Shifting, are all cost effective with B/C ratios ranging from 1.05 to 1.31.

Table 3-6 Results of Cost-Effectiveness Screening (B/C ratios)

DR Option	Summer	Winter
DLC	2.07	2.02
Curtailable	18.15	17.22
Capacity Reduction	5.89	5.29
Third Party Aggregated	1.24	1.24
Distributor Aggregated	1.05	1.05
Demand Reduction	3.94	3.93
Dynamic Pricing	3.23	3.40
Fast DR	4.19	3.80
Conservation Voltage Regulation	1.60	1.60
Dispatchable Voltage Regulation	1.60	1.60
Load Shifting	1.31	1.09

DR Program Recommendations

The results of the DR assessment reveal that TVA has significant potential for demand response resources over the next two decades. Our analysis has shown that it is economically feasible for TVA to realize up to 11% reductions in summer peak and 9% reductions in winter peak by 2030 if it moves forward with the DR options represented in this report.

TVA's demand response programming efforts have a strong basis with large C&I customers in the field today. Moreover, a comprehensive suite of new programs is currently emerging from the planning phase and entering the implementation phase. In light of this study, Global provides the following recommendations to preserve and augment that momentum.

[10] Cost effectiveness results by program and customer segment are included in Appendix B.
[11] Cost effectiveness inputs and assumptions are included in Appendix A.
[12] While utility incentives are not included in the TRC test as costs, we provide estimates of incentives that could reasonably be assumed for each program in the appendix.
[13] The $/kW payment for the Distributor aggregated program was adjusted from the $63/kW year in the TVA provided program data sheet to $55/kW year in order for the program to pass the economic screen. The Distributor Aggregated program was not cost effective given our assumptions in the analysis at the higher incentive rate. Payments from the utility to aggregators for both the 3rd Party Aggregated and Distributor Aggregated programs are included as implementation costs in the TRC analysis.

- ***Expand programs to include smaller customers:*** TVA's current DR programs total approximately 1,300 MW of DR, which indicates that the potential for future success with new DR programs is very high. The majority of the currently installed DR capacity is concentrated in the Large, X-Large, and Direct Serve customers. Targeting the largest customers first is an excellent strategy for utilities as they begin their DR efforts, however, as portfolios mature it becomes necessary to target other customer segments such as residential and small and medium C&I.
- ***Focus efforts on programs with the largest potential:*** DLC and Capacity Reduction are the DR programs with the largest opportunity for savings among end-users. DLC is a program that can be targeted to residential and small commercial customers and has been shown to be very successful given the right combination of technology and incentives.[14] Capacity reduction is gaining ground on the west coast as a highly favorable program with commercial and industrial customers. Customers particularly like the monthly capacity payments they receive all year long and the flexibility to determine their own reduction bid. Marketing efforts to expand DR program participation to the smaller customers should focus on DLC and capacity reduction.
- ***Voltage regulation programs need carefully designed incentives:*** Voltage reduction has significant potential to reduce demand on the distribution side. This is a unique program in that it involves infrastructure improvements to optimize and reduce voltage levels without affecting the power quality ultimately distributed to end users. Sufficient incentives will be needed to encourage distributors to participate in this program and therefore more information on the cost of specific voltage regulation technologies will need to be gathered.
- ***Coordinate distributor layer between TVA and end user:*** Because TVA is a wholesale provider, maintaining a cohesive DR message to end users may be challenging, especially as DR programs focus on residential and small C&I customers. We recommend dedicated resources to ensure that TVA programs are marketed and implemented consistently across distributors.
- ***Create internal DR targets:*** TVA should continue to evolve and formulate its specific objectives regarding demand response by creating targets and goals. Global recommends targets that fall within the range of achievable potentials identified in this study.
- ***Consider limiting the number of programs:*** TVA has a longer list of DR programs than many utilities do. TVA may consider limiting the number and type of DR programs to facilitate distributor and end-user understanding. Customers are often overwhelmed by too many options when it comes to utility programs, and many utilities with a large number of programs are now focused on reducing or bundling programs to make participation simpler for customers. We recommend focusing on those programs with the highest potential: capacity reduction in the C&I sectors, DLC in the residential sector, and voltage reduction for the distributors.
- ***Provide market-friendly customer incentives***: Most customers are willing to offer their loads for participation in demand response programs if the utility is willing to compensate them for any inconvenience that they may realize due to the temporary service interruption. While incentive strategies must be structured in a way that ensures economic viability for the program, we have found that there is significant room to expand customer incentives while still maintaining cost-effectiveness.
- ***Provide enabling technology incentives:*** Enabling technology has been shown to improve the reliability of DR resources and to maximize load reduction in DR programs. It is therefore crucial to provide incentives to customers for adopting enabling technology in order to automate response to DR events.

[14] Southern California Edison, NV Energy, Florida Power & Light, and others all have very successful DLC programs with participation rates of 20% or more.

CHAPTER | 4

COMPARISON OF PREVIOUS POTENTIAL STUDIES

Analysis Approach

Previous studies of energy efficiency potential for the Valley and for the southeast region have produced a range of results. The objectives of this task are as follows:

- Develop a detailed report comparing the results of Task 1 to regional potential studies that are specific to the southeast.
- Consider the methodology, assumptions, approaches, estimated baselines, technical performance, adoption, and program/regulatory context of the studies.
- Create a matrix to enable side by side comparison of the studies.

List of Studies Considered

The reports Global reviewed are listed below.

- **EPRI National** — *Assessment of Achievable Potential from Energy Efficiency and Demand Response Programs in the U.S. (2010–2030)*
- **EPRI TVA** — *Assessment of Achievable Potential from Energy Efficiency and Demand Response Programs for the Tennessee Valley Authority (2010-2030)*
- **Georgia Tech** — *Meta-Review of Efficiency Potential Studies and Their Implications for the South*
- **Georgia Tech** — *Energy Efficiency in the South, a meta-study*
- **McKinsey** — *Unlocking Energy Efficiency in the U.S. Economy*
- **SEEA** — *Energy Efficiency in Appalachia "How Much More is Available, at What Cost, and by When?"*
- **REPP** — *Powering the South: A Clean & Affordable Energy Plan for the Southern United States*
- **PA Consulting** — *Tennessee Valley Authority: Energy Efficiency and Demand Response Plan 2008*
- **ACEEE** — *North Carolina's Energy Future: Electricity, Water, and Transportation Efficiency*
- **FERC** — *A National Assessment of Demand Response*
- **MISO** — *The Midwest ISO Study* (includes estimates of DR for regions within the Eastern Interconnection)

The review of these studies considered each study's analysis approach, the key input assumptions and sources for these assumptions, the relevant baseline, and the regulatory context. This report compares and contrast the studies listed above and the Global study for TVA with regard to these considerations.

This executive summary provides an at-a-glance overview of the comparison, with high-level conclusions and commentary. At the end of Volume 2, we examine each of the energy-efficiency studies in detail and compare them side by side with this Global study. In turn, at the end of Volume 3, we do the same for the demand-response studies.

Comparison Summary

Table 4-1 and Table 4-2 present a matrix of key elements from each of the studies considered in this task to provide a high-level overview.

Table 4-1 Energy Efficiency Studies at a Glance

Source	Area	Year Released	Type of Potential	10-yr Savings[15] Estimate	20-yr Savings Estimate
This Study: Global TVA	**TVA**	**2011**	**Economic**	**13.9%** ***21.7 TWh***	**24.8%** ***44.8 TWh***
			Achievable (High)	**9.8%** ***15.3 TWh***	**19.8%** ***35.8 TWh***
			Achievable (Low)	**5.1%** ***8.0 TWh***	**10.6%** ***19.1 TWh***
EPRI National, South Region	Southern region	2009	Economic	12.2%	13.4%
			MAP	10.0%	11.1%
			RAP	4.4%	8.1%
EPRI-TVA	TVA	2010	Economic	10%	10%
			RAP	4.6%	6.9%
Meta-Review of South EE Studies-Georgia Tech	Southern region	2009	MAP	1.18% per year	
			RAP	0.88% per year	
EE in the South-Georgia Tech	Southern region	2010	Program potential	12%	16%
McKinsey Study	U.S.	2009	NPV-positive	23%	
EE in Appalachia-SEEA	Appalachian region	2009	Program potential	11%	24%
Powering the South-REPP	SERC and FRCC regions	2002	Clean Power Plan potential	13.5%	22.9%
TVA- PA Consulting	TVA	2008	Program potential	*11.7 TWh*	*19.5 TWh*
North Carolina study- ACEEE	North Carolina	2010	Medium program	14.9%	
			High program	20.4%	

The most directly comparable studies to the Global TVA study are the EPRI National Study and EPRI's 2010 study of the TVA service territory. These both use a similar bottom-up modeling approach.

The most dissimilar studies are the REPP "Powering the South" study, because of its age, and the McKinsey study because of its different definitions and methodologies, as discussed in Volume 2.

As far as baseline forecasts, the assumptions used in the various studies are all relatively similar. Except for the REPP study mentioned above, all the baseline forecasts are relatively recent and

[15] 10-year and 20-year savings are approximations. Because several studies start one or two years earlier or later, they do not fit in these categories exactly, but this simplification is made for comparison purposes.

include the effects of the EISA lighting standards. However, Global's baseline forecast includes the appliance and equipment standards that were adopted in 2010, which was a major year for new standards. This has the most significant impact in the residential sector.

Overall, Global's savings estimates are higher than either of the EPRI studies. They are in line with the other studies to the extent they are comparable. Direct comparison from study to study should be made mindfully, taking into account the caveats and considerations spelled out in the EE and DR Volumes.

Table 4-2 Demand Response Studies at a Glance

Source	Area	Year Released	Type of Potential	10-yr Savings Estimate	20-yr Savings Estimate
This Study: Global TVA	**TVA**	**2011**	**Achievable (High)**	**11%** ***3.8 GW***	**12%** ***4.6 GW***
			Achievable (Low)	**10%** ***3.2 GW***	**10%** ***3.9 GW***
FERC National Assessment of DR	U.S.	2009	Economic	20%	
			Achievable	14%	
			Expanded BAU	9%	
MISO Assessment	MISO	2010	Program potential	7.6%	7.6%
	Eastern Interconnection			11.1%	10.8%

The more limited landscape of DR potential studies shows a fair amount of convergence on the range of achievable potentials. There is less complexity and variation in the way that DR potentials are analyzed. With the exception of some differences in definition of potentials in the FERC National study, these three studies are relatively comparable.

ABOUT GLOBAL

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