The Opportunity for Energy Efficiency that is Cheaper than Supply in Rhode Island

Phase II Report – August 30, 2010

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Prepared for: Rhode Island Energy Efficiency and Resource Management Council (EERMC)

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1. Executive Summary

The Rhode Island Comprehensive Energy Conservation, Efficiency and Affordability Act of 2006 placed a requirement on the distribution utility to procure all electric energy efficiency that is less costly than supply. To help determine the quantity of such efficiency resources and the cost savings to be enjoyed by Rhode Island ratepayers, the General Assembly charged the Energy Efficiency and Resource Management Council (EERMC) with producing an Opportunity Report to identify the Energy Efficiency (EE), resource. This study was commissioned by the EERMC to more fully identify and estimate the size of the potential for energy and peak-demand savings from electric efficiency measures in Rhode Island over a 10 year period that are cheaper than supply. The results demonstrate that significant additional and long-lasting cost-effective electric efficiency resources exist within the state, which can be procured by the distribution utility, National Grid, through their efficiency programs to save Rhode Island ratepayers money. This study does not include an estimate of the CHP or RE potential in Rhode Island.

Phase I of the Opportunity Report was submitted to the General Assembly, Public Utilities Commission, the Office and Energy Resources, and National Grid on July 15, 2008 and was a first step to characterize and quantify the electric efficiency resources that are lower cost than electric supply. That report also included estimates of CHP and RE potential. The Phase I results and report are available at the Council's website at www.rieermc.ri.gov/documents/OER-EERMC-OpportunityRept(7-15-08).pdf. Phase I of the EE Opportunity Report was primarily based on a review of recent potential studies in other jurisdictions and the past results of the Rhode Island efficiency programs, and some limited information from key market players.

Thus, this Phase II of the Opportunity Report was commissioned by the EERMC to more fully and specifically identify and estimate the size of the cost saving electric efficiency potential by conducting more than 450 specific surveys and site-visits with Rhode Island residential, commercial, and industrial electric customers. In light of the collection and analysis of primary data from Rhode Island end-use consumer, Phase II represents the most detailed, comprehensive, and state-specific estimate of the electric efficiency potential conducted in Rhode Island to date.

1.1 Study Scope – Energy Efficiency

The study addresses the potential for electric energy efficiency in Rhode Island. This includes all efficiency opportunities including, but not limited to, behavioral measures, price response programs and new technologies. It does not include an assessment of the potential for savings from fuel switching. In the study, three levels of electric energy efficiency potential are estimated, which are defined below.

- **Technical potential** is defined in this study as the complete penetration of all measures analyzed in applications where they were deemed technically feasible from an engineering perspective.

- **Economic potential** refers to the subset of technically potential energy efficiency measures that are cost effective when compared to supply-side alternatives. This is estimated at the measure level.

- **Achievable program potential** refers to the amount of cost-effective savings that are estimated to occur in response to a specific funded set of program activities. Achievable potential reflects *net* savings — in other words incremental savings over and above those projected to occur naturally from future changes in codes and standards or from other market activities outside of National Grid's efficiency program interventions and efforts. Achievable potential is estimated at the program level – namely groups of measures are bundled into program offerings.

It is important to note that the Rhode Island legislation requires the procurement of all energy efficiency resources that are cheaper than supply and this mandate correlates most closely with economic potential.

The focus of the study was on the ten-year period, 2011-2020. Given the near to mid-term focus, the study was conservatively restricted to energy efficiency measures and practices that are presently widely commercially available and likely to be cost-effective in Rhode Island. As such, the potential estimates should be considered a lower bound of total potential opportunities by 2020. Note that summarized below and more fully described in Section 6, estimates and discussion of likely additional potential beyond this lower bound are provided and listed broadly as "new technologies." However, by necessity these are rough approximations and again meant to reflect conservative assumptions about possible future efficiency potential and opportunities.

Cost effectiveness is based on the **Total Resource Cost Test** (TRC test). The Total Resource Cost Test compares the benefits and costs of the efficiency measure and/or program, including benefits and costs that accrue to ratepayers, the utility, and society. While the majority of benefits result from avoided electric costs, they also include other quantifiable benefits such as fossil fuel, water and maintenance savings. If the TRC benefit-cost ratio is greater than 1.0, then the benefits (savings) of the efficiency resource are greater than the costs and the resource is cost effective and should be procured pursuant to the Comprehensive Act of 2006 and the Rhode Island PUC recent Least Cost Procurement and System Reliability Standards. The modeling approach was implemented using KEMA's DSM ASSYST™ model. This model allows for efficient integration of large quantities of measure, building, and economic data in the determination of energy efficiency potential.

The data presented here is based on Rhode Island specific data. Surveys were conducted of residential customers and on-site data was collected from Commercial / Industrial customers to support this study. The data collected from customers included consideration of how they use electricity, saturations of key measures, and awareness of conservation in general.

1.2 Key Findings

This study estimates the potential for cost-effective energy (MWh or GWh) and peak-demand savings (MW) from cost-effective energy-efficiency measures from 2010 to 2020.

The following table summarizes the results of the study by showing the electric energy efficiency potential over a 10 year period, the savings as a percent of the base energy use, and average annual savings as a percent of the base energy use. As the table indicates, the technical, economic, and achievable potential would reduce projected energy consumption by 3.4%, 2.9% and 2.7% respectfully (simple average annual savings).

Table 1-1:
Energy Savings Compared to 2009 Actual Sales

	Efficiency Potential (GWh)	% of Base Energy Use	Simple Average Annual Savings
Technical	2552	34%	3.4%
Economic	2140	29%	2.9%
Achievable	2046	27%	2.7%

Figure 1-1 presents the load forecast along with the projected achievable savings in GWhs. As shown in this figure the achievable savings become a significant portion of projected energy sales by 2020. Capture of the full achievable potential results in an average annual *reduction* in load as compared to the base forecast growth rate of 1.47 percent/yr. for energy.

Figure 1-1:
Forecast and Achievable Energy Savings 2011- 2020

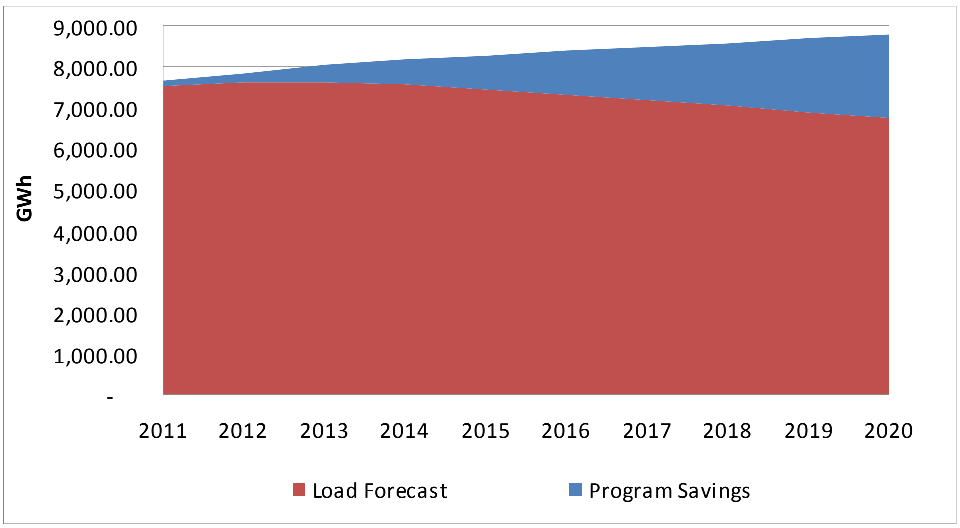
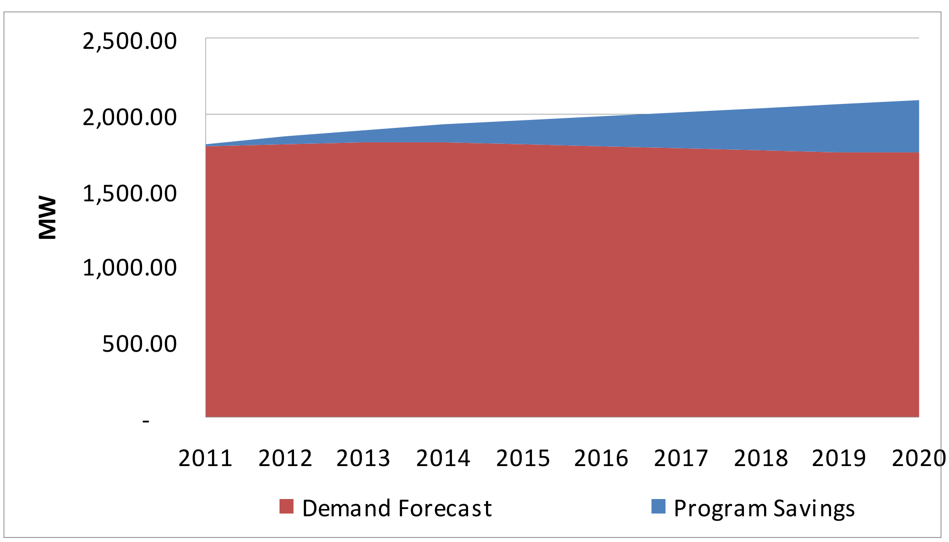


Figure 1-2 below presents the similar data for demand (in MWs) which is projected to grow at over one and half percent per year:

Figure 1-2:
Forecast and Achievable Energy Savings 2011- 2020



1.2.1 Electricity Peak-Demand Savings

Technical potential is estimated at 555 MW. 77 percent of this potential, 429 MW, is estimated to be economically viable (i.e., cost-effective when compared to supply-side alternatives). Total achievable potential is estimated to be 392 MW.

The residential sector contributes the most to both technical and economic savings potential, followed by the commercial sector (see Figure below).

Capturing all economic potential requires that all measures that are lower cost than supply be installed. This entire low-cost efficiency resource cannot be procured by the distribution utility instantaneously. Taking this into consideration, the estimate of achievable potential reflects one set of assumptions regarding potential program offerings and measure adoption, with the goal of aggressively supplementing and revising programs to capture all efficiency cheaper than supply as quickly as possible.

Technical Potential Findings:

We estimated technical and economic potential for energy efficiency using KEMA's Demand Side Assyst model. In our approach, we first estimate **technical potential** for energy savings by integrating key measure and market segment parameters using the following equation:

$$\begin{array}{c}\text{Technical}\\\text{Potential of}\\\text{Efficient}\\\text{Measure}\end{array} = \begin{array}{c}\text{Total}\\\text{sq. ft. or}\\\text{\# of}\\\text{Dwellings}\end{array} \times \begin{array}{c}\text{Base Case}\\\text{Equipment}\\\text{EUI or UEC}\end{array} \times \begin{array}{c}\text{Applicability}\\\text{Factor}\end{array} \times \begin{array}{c}\text{Not}\\\text{Complete}\\\text{Factor}\end{array} \times \begin{array}{c}\text{Feasibility}\\\text{Factor}\end{array} \times \begin{array}{c}\text{Savings}\\\text{Factor}\end{array}$$

We then assess **economic potential** by first developing a supply-curve analysis. This analysis eliminates double counting of measure savings. On a market segment and end-use/technology basis, measures are stacked in order of cost effectiveness, and the energy consumption of the system being affected by the efficiency measures goes down as each measure is applied. As a result, the savings attributable to each subsequent measure decrease if the measures are interactive. After eliminating double counting of savings, the benefits and costs associated with a given measure and market segment are compared using the **Total Resource Cost (TRC)**.

The Total Resource Cost Test is the ratio between the benefits of an efficiency measure and the cost of the efficiency measure including benefits and costs that accrue to all of Rhode Island society irrespective of distributional equity. If the TRC is greater than 1.0, then the benefits (savings) of the efficiency resource are greater than the costs and the resource is cost effective and is included in the economic potential results as it should be procured pursuant to the Comprehensive Act of 2006 and the Rhode Island PUC's Least Cost Procurement Standards. The avoided costs used were developed by Synapse Energy Economics based on those found in the 2009 AESC report. The following figures illustrate the magnitude of the cumulative amount of efficiency resources that are cost effective in Rhode Island with a TRC Test result that is greater than 1.0. This is depicted in the following figures as the economic potential.

Figure 1-3 presents a summary of the technical potential and economic potential (efficiency resources that are cost effective/cheaper than supply) for programs to save energy in GWh for Rhode Island.

Figure 1-3:
Technical, Economic and Achievable Energy Savings

	GWH			
Sector	**2010 Base Energy Use**	**Ten Year Technical Savings**	**Ten Year Economic Savings**	**Ten Year Achievable Savings**
Residential Existing	2,980	1,147	920	729
Residential New	7	2	2	
Subtotal	2,987	1,148	922	729
Savings % of Base		**38%**	**31%**	**24%**
Commercial Existing	3,503	1,206	1,043	787
Commercial New	26	9	9	
Subtotal	3,529	1,215	1,052	787
Savings % of Base		**34%**	**30%**	**22%**
Industrial	975	189	166	90
Savings % of Base		**19%**	**17%**	**9%**
New Technologies				440
Total	7,491	2,552	2,140	2,046
Savings % of Base		**34%**	**29%**	**27%**

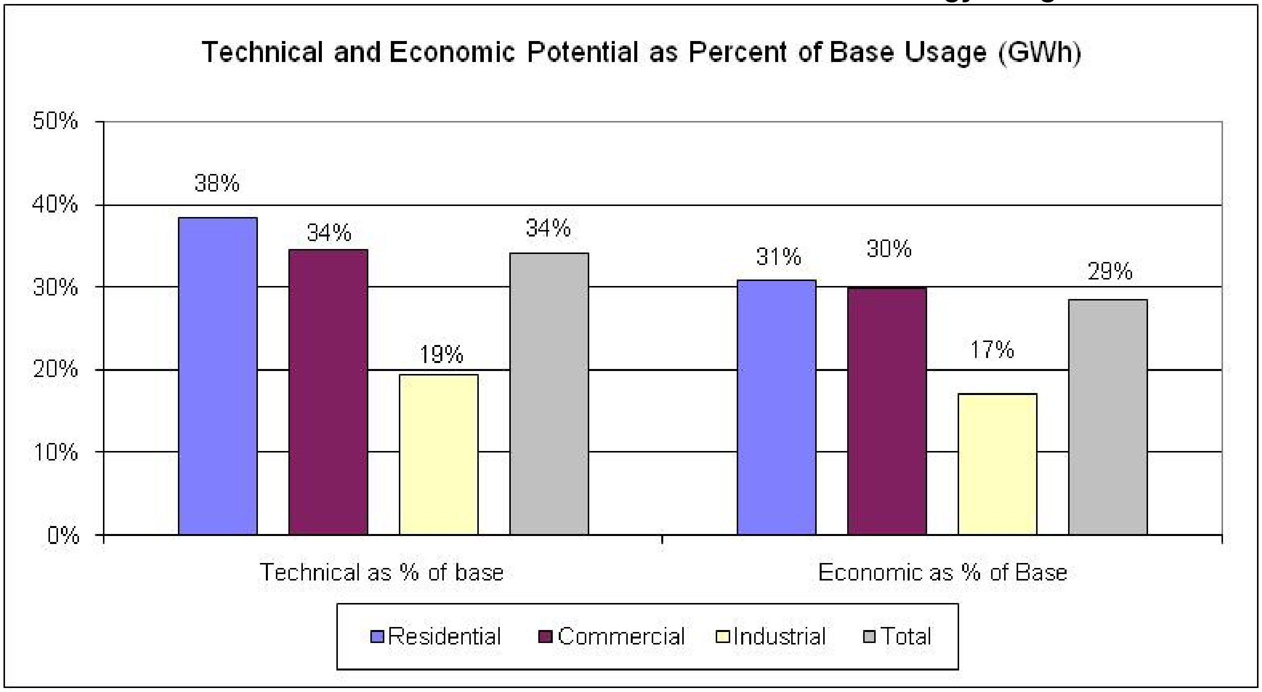
Figure 1-4 presents a summary of the technical potential and economic potential (efficiency resources that are cost effective/cheaper than supply) for programs to reduce demand in MW for Rhode Island.

Figure 1-4:
Technical, Economic and Achievable Demand Savings

	MW			
Sector	**2010 Base Demand**	**Ten Year Technical Savings**	**Ten Year Economic Savings**	**Ten Year Achievable Savings**
Residential Existing	745	262	200	181
Residential New	2	0.36	0.36	
Subtotal	747	263	201	
Savings % of Base		**35%**	**27%**	**24%**
Commercial Existing	899	260	201	151
Commercial New	7	2	2	
Subtotal	906	262	203	151
Savings % of Base		**29%**	**22%**	**17%**
Industrial	172	30	26	15
Savings % of Base		**17%**	**15%**	**9%**
New Technologies				45
Total	1,825	555	429	392
Savings % of Base		**30%**	**24%**	**21%**

Figure 1-5 presents the GWh technical and economic potential efficiency savings as a percent of total energy use for that sector and overall. This includes lost opportunities such as new construction and replace on burnout. Namely these are cases where the customer needs to replace or add the measure anyway. Measures are modeled as either retrofit, replace on burnout or new construction in the technical and economic potential. The achievable results also include behavioral measures and new technologies.

Figure 1-5:
Technical and Economic Potential as a Percent of Energy Usage



Achievable potential can be calculated in several ways - some researchers calculate it as a fixed percentage of technical or economic potential; while others take a more nuanced modeling approach, which is what was done here. Achievable potential is sometimes presented in MWh and MW per year over time. It is important to note that the goal is to innovate on program design to stretch the achievable as close as possible towards economic potential.

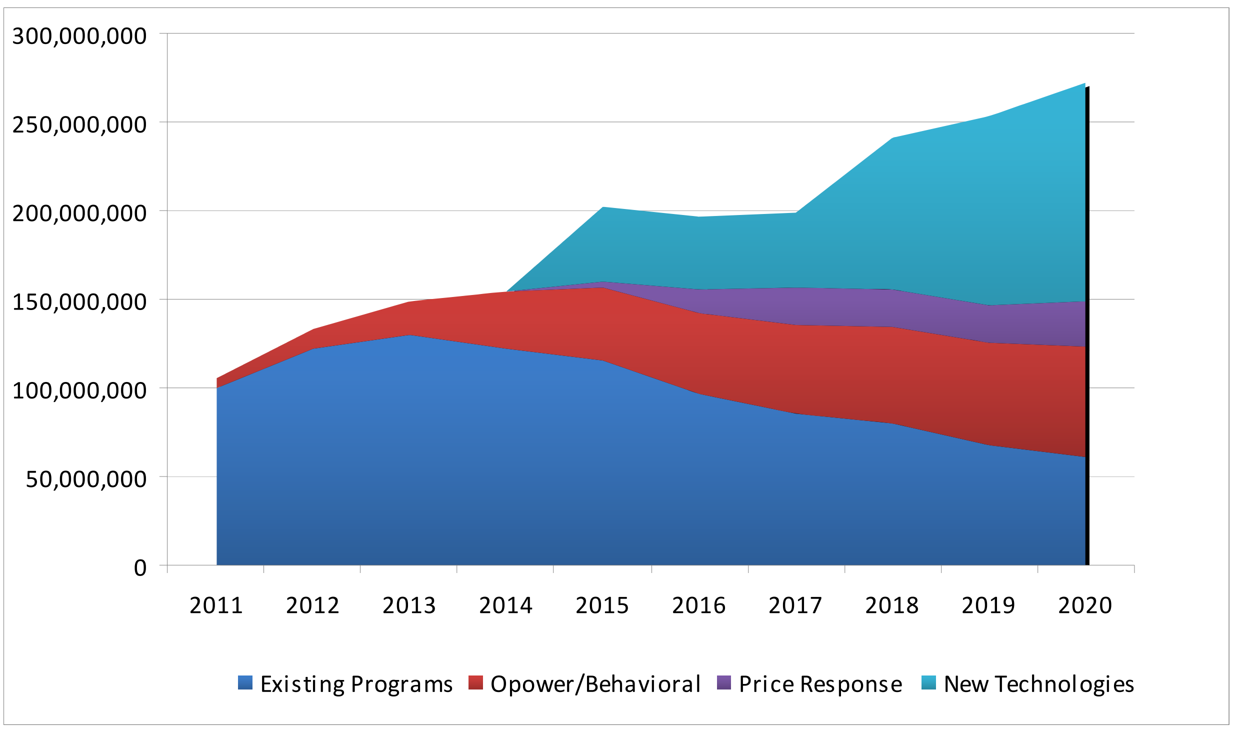
The overall net annual energy savings for the Achievable results are presented below in Figure 1-6.

[1] Achievable Potential is defined as the amount of potential that can be estimated to occur from a specific set of efficiency procurement and programmatic activity.

The results are segmented into the following categories of achievable savings:

- Savings from existing programs as currently designed,
- Savings from all existing non-behavioral measures achievable over and above those anticipated if there are no program changes,
- Savings from behavioral programs,
- Savings from price response programs , and
- Savings from new/emerging technologies.

Figure 1-6:
Overall New Net Energy Savings:



Achievable Energy Potential is compared to Economic and Technical Potential in Figure 1-7 below:

Figure 1-7:
Technical, Economic and Achievable Energy Savings

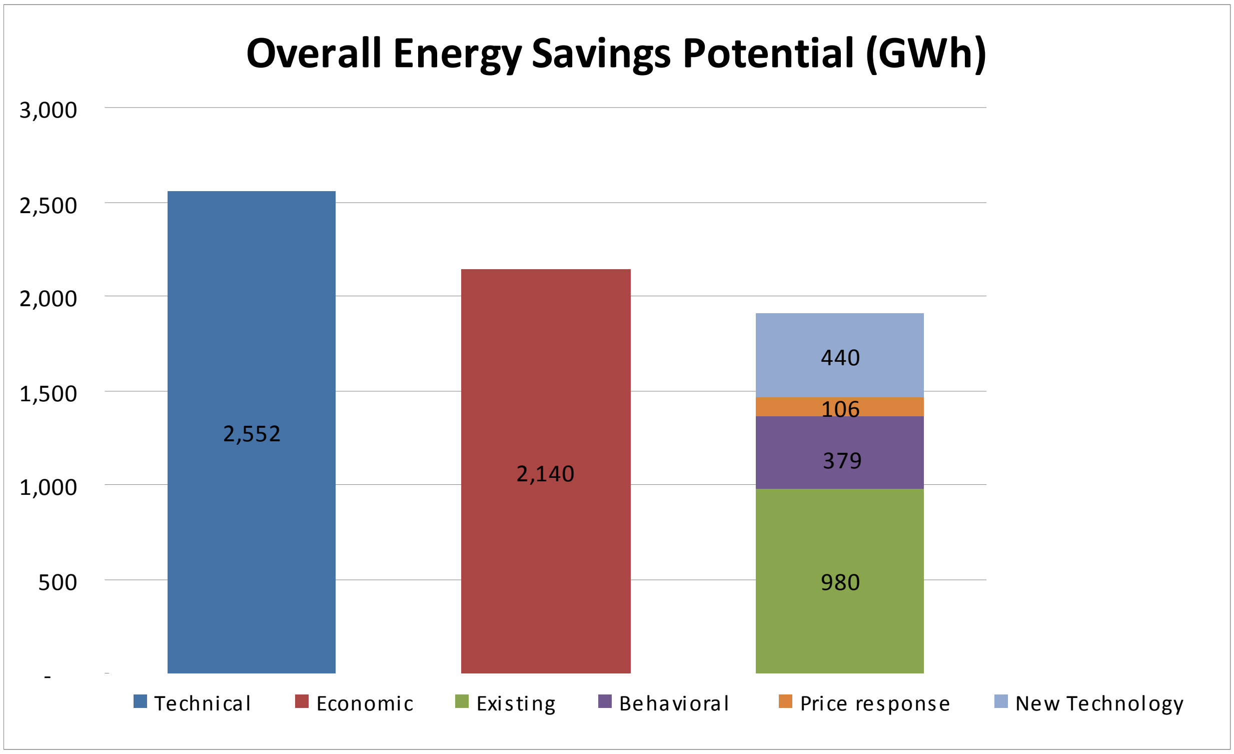
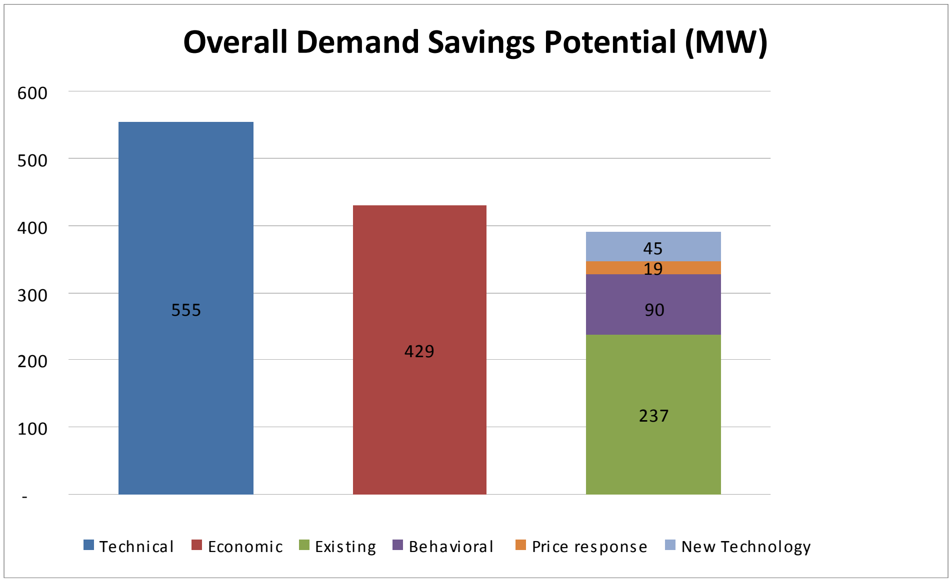


Figure 1-8:
Technical, Economic and Achievable Demand Savings



As we have modeled the Existing Programs, most of the efficient retrofit measures available today are assumed to have already been installed through the program or by non–participants by the end of the period. However, because of continuous technology advancement we expect that large additional opportunities will be available by 2020 facilitating continued aggressive programs. For example, National Grid currently retrofits many facilities' lighting that use standard T8 technology to high performance T8 despite the fact that some of these facilities actually received National Grid incentives in the past to install these standard T8s which were the best efficiency option at the time.

1.3 New Program Areas

As discussed above we modeled three new areas of program activities and savings. They are described briefly here and in additional detail in Chapter 5. They are:

- Savings from Behavioral Conservation,
- Savings from Price Response programs and
- Savings from New Technologies

Behavioral Conservation- Estimates of savings from behavioral type programs can be as much as 3.8 to 8.4 percent. Examples of these types of programs include: on-line audits with feedback, O Power, and programs providing feedback after the fact. [2] We have conservatively assumed savings of only on average 2 to 3 percent for this type of program.

Savings from Price response–New software and other technologies will allow for real time feedback to customers and/or can control energy at a home or business directly. Estimates of savings from these types of activities can be as much as 9.2 percent to 12 percent.[3] We have conservatively assumed savings of only a maximum of 2 to 3 percent for this program and only for the Commercial sector. This assumed savings is in addition to any already counted under "behavioral conservation".

New Technologies- New technologies are continuously being placed into the market place. We conservatively estimated how much potential is likely to be available in the time frame in question.

The estimated potential in this report reflects currently known and cost-effective opportunities from widely available, commercial technologies that are on average cost-effective among a wide range of facilities. As such, this potential should be viewed as a low to moderate estimate of efficiency opportunities available over the next decade. This study also does not include other opportunities to save energy such as combined heat and power and fuel switching. Through decades of planning and analyses related to energy efficiency opportunities, it is clear that, despite capture of significant efficiency savings, cost-effective potential has generally not decreased over time, and in fact has often increased. For example, in 1989 technical potential in New York State was estimated at 38% of forecast load.[4] A similar study of New York State

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[2] ACEEE, Advanced Metering Initiatives and Residential Feedback Programs, A Meta Review for Household Electricity Saving Opportunities.

[3] ACEEE, Advanced Metering Initiatives and Residential Feedback Programs, A Meta Review for Household Electricity Saving Opportunities.

[4] American Council for an Energy Efficient Economy, *The Potential for Electricity Conservation in New York State,* prepared for the New York State Energy Research and Development Authority (NYSERDA), September 1989, p. S-4

potential in 2003 estimated almost exactly the same amount of potential (35%), despite the fact that New York was a leader in efficiency efforts in the 1990s and captured a significant portion of the original potential.[5] *It is important that readers understand that this "snapshot in time" includes many conservatisms, and that aggressive pursuit of efficiency by National Grid will unlikely ever result in running out of opportunities for more cost-effective efficiency – efficiency opportunities are replenished constantly through breakthrough new innovations in lighting, appliances, motors, customer interfaces, and other equipment.*

1.4 Comparison to Supply Side Resources and Net Benefits

The figures presented in this section provide additional data related to using energy efficiency as part of the Least Cost Procurement strategy. Figure 1-9 compares the cost of energy efficiency to the cost of supply. As this figure illustrates, energy efficiency costs on average over 20 years about 4 cents per kWh; while supply in the first year costs approximately 12 cents per kWh.[6] This figure also shows that while the energy efficiency cost increases over time it still remains significantly cheaper than supply. In addition, it is important to note that efficiency provides significant additional benefits beyond just the value of electric energy savings. These include, for example, benefits from reduced need to build new power plants and T&D upgrades (avoided electric capacity costs), as well as fossil fuel benefits and maintenance savings. Therefore, while the above figures indicate EE is roughly 1/3 the cost of new electric supply, in fact the overall cost-effectiveness of EE is significantly higher when including these other benefits.

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[5] Optimal Energy Inc., *Energy Efficiency and Renewable Energy Resource Development Potential in New York State,* prepared for NYSERDA, August 2003, Volume 1, pp. 3-3 and 3-22.

[6] These estimates based on KEMA's analysis for this potential study and may differ from National Grid estimates.

**Figure 1-9:
Comparison to Supply Side Resources**

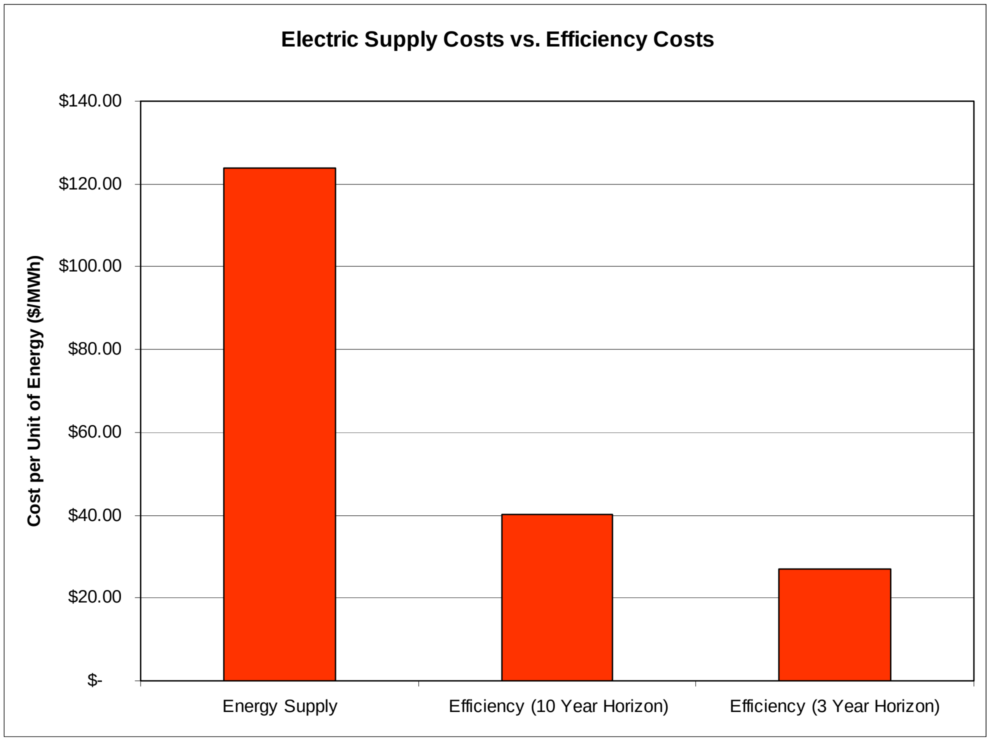
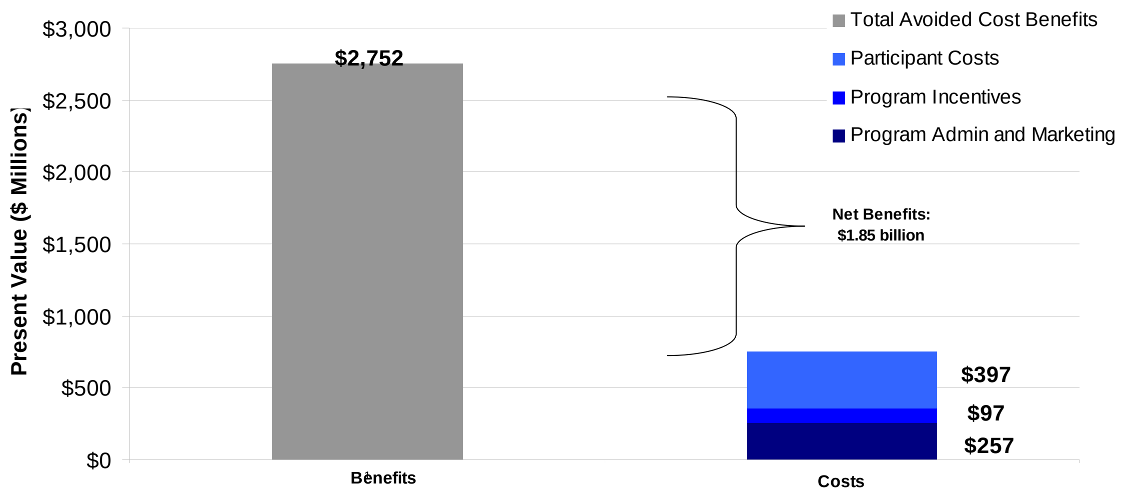


Figure 1-10 presents the overall costs of the achievable results relative to Rhode Island's avoided electric energy cost. The avoided costs are a proxy of the avoided supply costs.

Figure 1-10:
Overall Cost Effectiveness (TRC Test)



As shown in this figure, the programs we modeled are highly cost effective. For every dollar invested by ratepayers in these modeled versions of National Grid's programs Rhode Island would get back roughly $3.76.

Figures 1-11 and 1-12 respectively present the net cumulative savings over time for both energy and demand.

Figure 1-11:
Total Cumulative Energy Savings

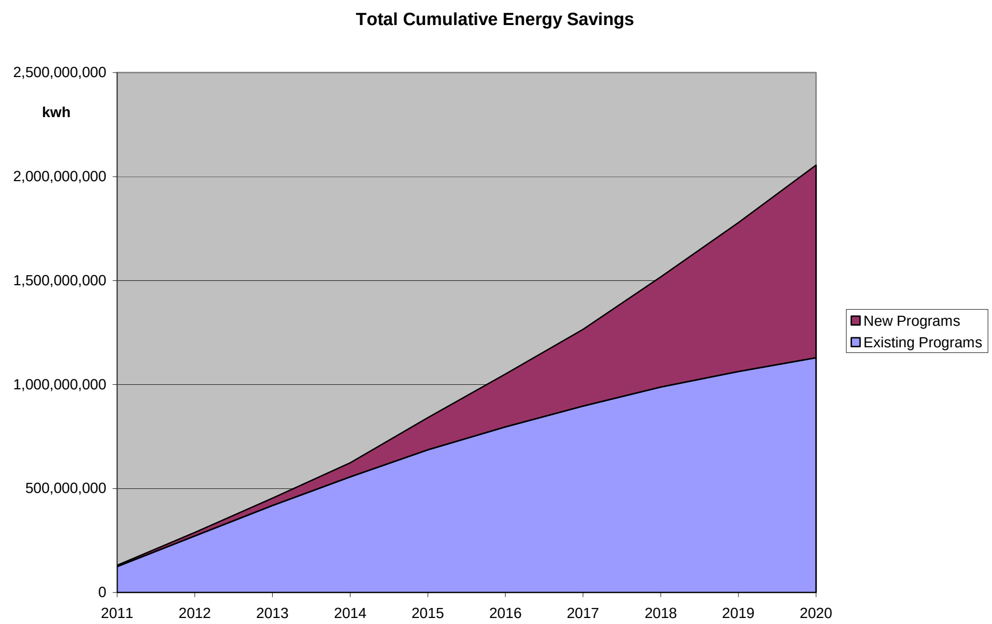
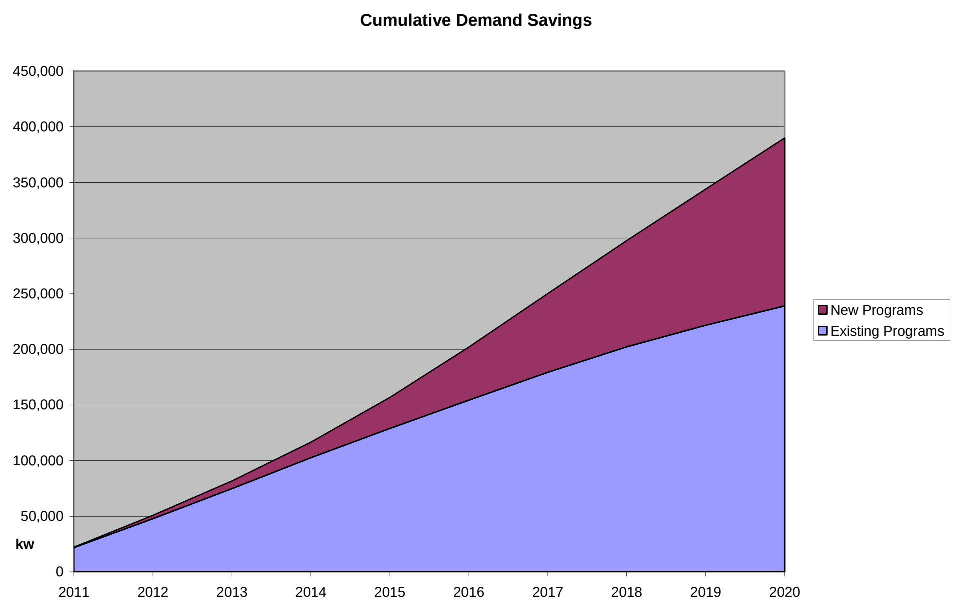


Figure 1-12:
Total Cumulative Demand Savings



Emissions savings are presented in Figure 1-13 below:

Figure 1-13:
Emissions Savings in Pounds

Emission Reductions - LB	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Residential Emissions Savings										
NOx	24,972	30,536	32,330	36,723	40,939	32,197	35,840	36,391	33,098	33,324
SO2	72,514	88,673	93,880	106,639	118,880	93,496	104,073	105,674	96,111	96,768
CO2	42,740,269	52,264,216	55,333,525	62,853,536	70,068,275	55,106,733	61,340,773	62,284,685	56,648,068	57,035,554
Commercial Emissions Reduction										
NOx	23,792	32,247	38,597	39,643	38,638	40,961	43,455	41,858	40,215	41,973
SO2	69,087	93,641	112,080	115,118	112,198	118,945	126,187	121,550	116,779	121,883
CO2	40,720,402	55,192,150	66,060,256	67,850,777	66,129,960	70,106,692	74,375,407	71,642,146	68,829,801	71,838,041
Industrial Emissions Reduction										
NOx	4,848	5,112	4,893	4,754	4,492	4,238	3,995	3,794	3,692	2,748
SO2	14,078	14,846	14,209	13,804	13,045	12,307	11,602	11,018	10,720	7,981
CO2	8,297,523	8,750,017	8,374,594	8,135,945	7,689,043	7,253,995	6,838,412	6,494,043	6,318,433	4,703,742
Total Emissions Reduction										
NOx	53,612	67,896	75,820	81,120	105,592	99,182	105,086	126,686	132,368	141,920
SO2	155,680	197,159	220,169	235,560	306,622	288,010	305,154	367,876	384,378	412,114
CO2	91,758,194	116,206,383	129,768,375	138,840,258	180,724,378	169,753,971	179,858,942	216,827,373	226,553,712	242,901,376

In 2020 this is the equivalent of taking over 21,000 cars off the road.

Figure 1-14 presents a comparison of spending on supply and energy efficiency in 2010.

Figure 1-14
Spending on Supply Versus Energy Efficiency

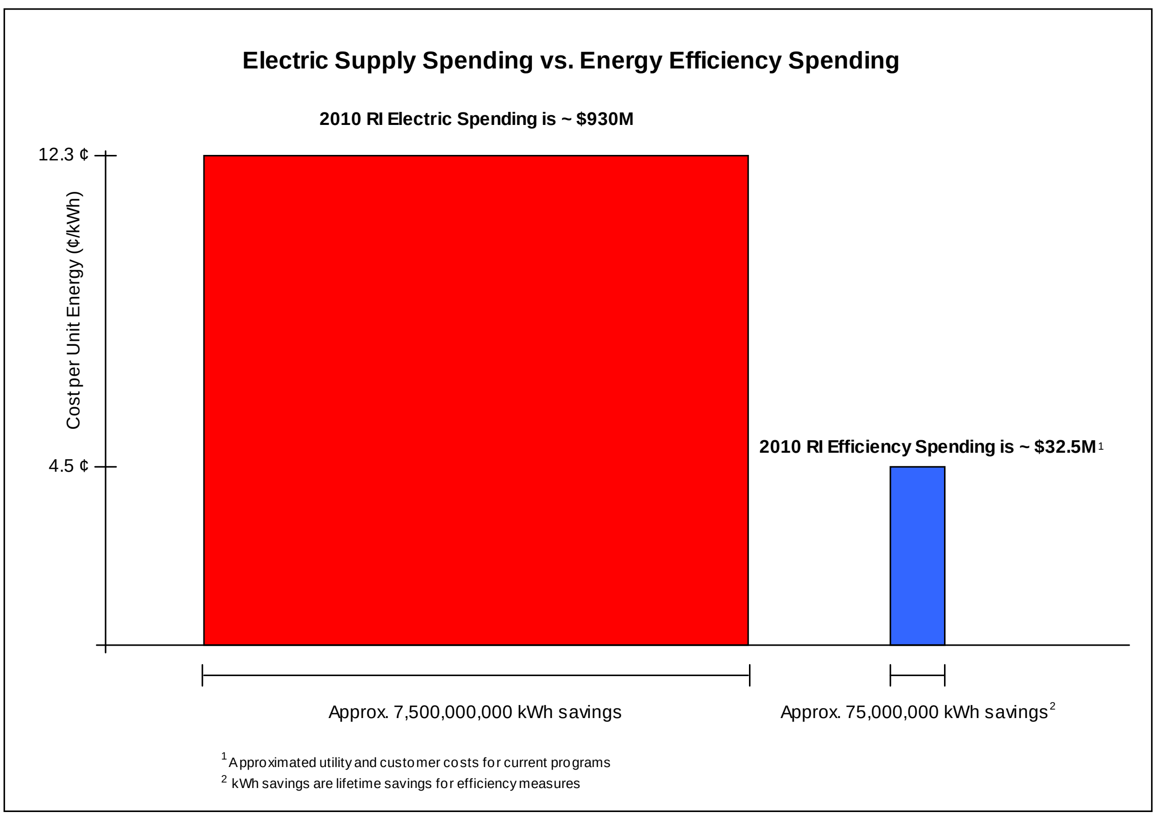
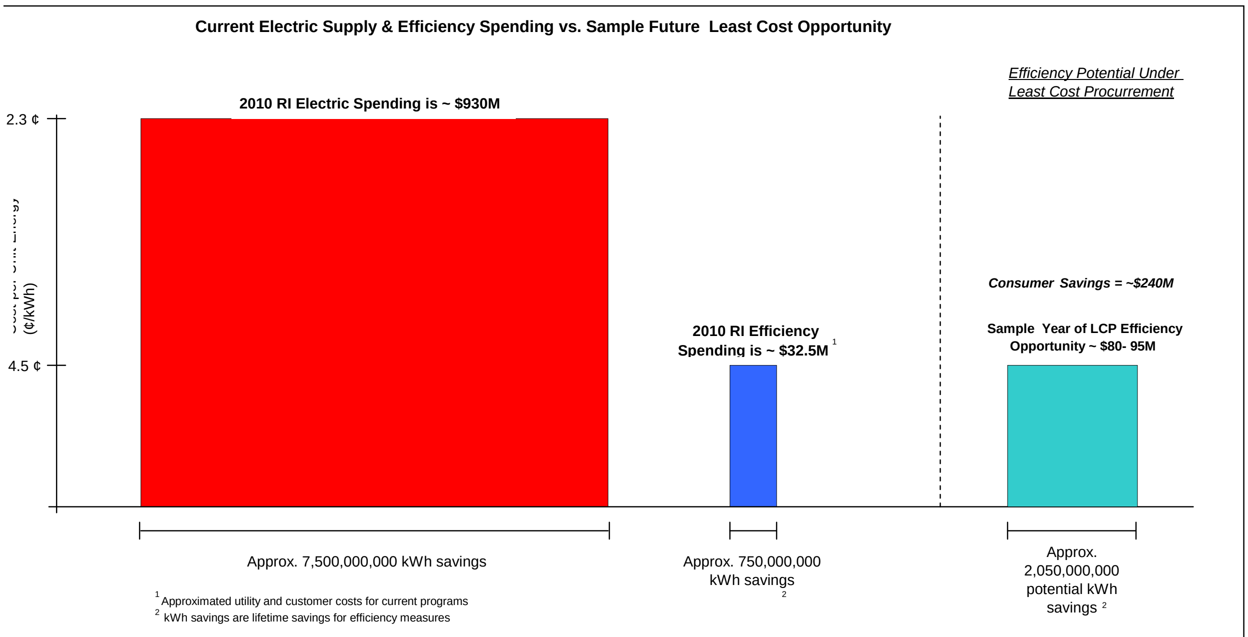


Figure 1-15 presents 2010 savings presented in Figure 1-14 compared to potential savings from Least Cost Procurement.

Figure 1-15
Supply Spending Compared to Least Cost Procurement



1.5 Key Findings

The key findings of this study are presented below**:**

- There is a large potential energy efficiency resource in Rhode Island in all customer sectors.
- The technical achievable resource is modeled at 34 percent of the base year, the economic potential at 29 percent, and the achievable resource at approximately 27 percent of the base year. The technical, economic, and achievable simple average annual percentages as a percent of sales are 3.4%, 2.9%, and 2.7% respectfully.
- The majority of savings are based on the modeling of National Grid's existing programs.
- To achieve more of these savings over time, it may be necessary to include new technologies and gain savings from behavioral programs and price response programs.

Recommendations

- Explore ramping up existing programs and/or add new strategies to bring National Grid's overall program effort in line with maximum achievable potential identified.
- Start behavioral pilots in the next two years.
- Identify programs and activities that would give customers access to time differentiated pricing.
- The EERMC and National Grid should monitor development in LEDs in all markets for emerging efficiency opportunities.
- The EERMC and National Grid should monitor developments in more efficient incandescent technology and market response to lighting standards in EISA 2007 (Energy Independence and Security Act of 2007) and modify program offerings as appropriate over the next 4 years.
- Conduct a detailed emerging technologies study.
- Continue to evaluate programs to improve them.

2. Methodology

This section provides a brief overview of the concepts, methods, and scenarios used to conduct this study. Additional methodological details are provided in Appendix A.

2.1 Characterizing the Energy Efficiency Resource

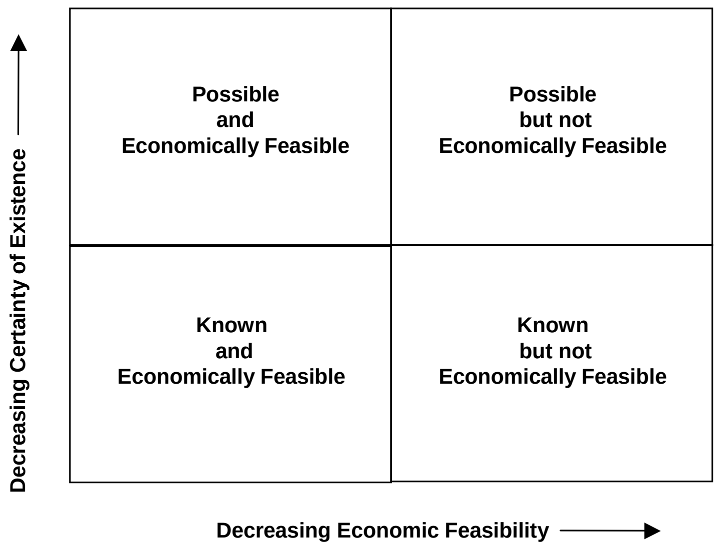
Energy efficiency has been characterized for some time now as an alternative to energy supply options, such as conventional power plants that produce electricity from fossil or nuclear fuels. In the early 1980s, researchers developed and popularized the use of an energy efficiency supply curve paradigm to characterize the potential costs and benefits of efficiency programs. Under this framework, technologies or practices that reduced energy use through efficiency are thought of as a resource and plotted on an energy supply curve. The energy efficiency resource paradigm argues simply that the more energy efficiency or “nega-watts” produced, the fewer new expensive plants and transmission and distribution lines would be needed to meet end users’ power demands.

2.1.1 Defining Energy Efficiency Potential

Energy efficiency potential studies have been used frequently throughout the utility industry in the late 1980s through the mid-1990s. This period coincided with the advent of what was called integrated resource planning (IRP). Energy efficiency potential studies became one of the primary means of characterizing the resource availability and value of energy efficiency within the overall resource planning process. Today, with the rise of energy efficiency procurement requirements for distribution utilities to invest in all energy efficiency resources that are cheaper than supply, efficiency potential or opportunities reports are a crucially relied upon tool.

Like any resource, there are a number of ways in which the energy efficiency resource can be estimated and characterized. Definitions of energy efficiency potential are similar to definitions of potential developed for finite fossil fuel resources, like coal, oil, and natural gas. For example, fossil fuel resources are typically characterized along two primary dimensions: the degree of geological certainty with which resources may be found and the likelihood that extraction of the resource will be economic. This relationship is shown conceptually in Figure 2-1 below.

Figure 2-1:
Conceptual Framework for Estimates of Fossil Fuel Resources



In an analogous fashion, this energy efficiency potential study defines three types of energy efficiency potential, namely, technical, economic, achievable program potential. All potential scenarios are calculated at the measure level. Examples of efficiency measures include premium T-8 lamps, weatherization and efficient pumps. For technical and economic potential measures are not grouped into programs as they are for achievable, thus determining the economic viability of a measure does not include non-measure program costs. Achievable potential cost-effectiveness results include anticipated non-measure program costs (such as administrative overhead, marketing, planning, evaluation, etc.)

- **Technical potential** is defined in this study as the complete penetration of all measures analyzed in applications where they were deemed technically feasible from an engineering perspective.

  Technical potential assumes complete penetration of all efficiency measures that are technically possible without regard to cost-effectiveness, market barriers, or the ability of efficiency programs to capture the resource.

- **Economic potential** refers to the subset of technically potential energy conservation measures that are cost effective based on the TRC test. Use of the TRC Test to identify efficiency resources for Least Cost Procurement is required by the “Standards for Energy

Efficiency Procurement" approved by the PUC at Open Meeting on June 12, 2008. The TRC Test is a benefit-cost test that compares the quantifiable benefits with the costs of efficiency measures and (for achievable only) program activities. Quantifiable benefits include the value of avoided energy production, transmission, distribution and power plant construction as well as non-electric system benefits such as fossil fuel and water savings, maintenance cost reductions, or other significant and quantifiable benefits. When the TRC test is greater than 1.0 that means the benefits of efficiency measures' savings are greater than the costs and the efficiency resources are to be procured.

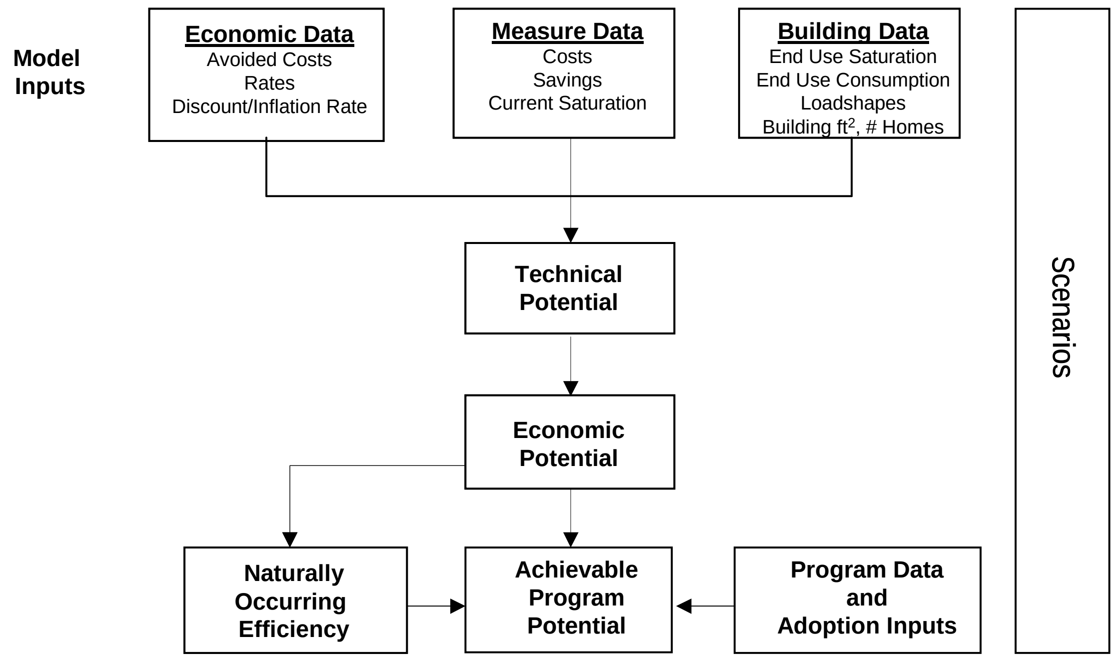
- **Achievable program potential** refers to the amount of savings that could be captured in response to aggressive, well designed, fully funded programs. Savings associated with achievable potential are savings that are projected beyond those that would occur naturally in the absence of any market intervention. Achievable potential is done at a program level – namely groups of measures are bundled in to program offerings.
- **Naturally occurring** refers to the amount of savings estimated to occur as a result of normal market forces, as well as interventions outside of those resulting from National Grid's programs. These include natural market adoption as well as known or expected changes to codes and standards, federal tax credits, or other interventions outside Rhode Island.[7]
- **Free riders** are a subset of naturally occurring savings. Free riders refer to the portion of savings that would have been installed absent the program or intervention but nonetheless receive program support, e.g. an incentive and effect program budgets and cost-effectiveness.

[7] KEMA was provided a forecast of future loads that was econometrically developed. There was very limited information about what naturally occurring and projected energy efficiency from programs was in the forecast.

2.2 Summary of Analytical Approach

The basic analytical steps for this study are shown in relation to one another in Figure 2-2.

Figure 2-2:
Conceptual Overview of Study Process



The bulk of the analytical processes for this study were carried out in a model developed by KEMA for conducting energy efficiency potential studies. Details on the steps employed and analyses conducted are described in Appendix A. The model, DSM ASSYST™, is a Microsoft Excel®-based analytic tool that integrates technology-specific engineering and customer behavior data with utility market saturation data, load shapes, rate projections, and marginal costs into an easily updated data management system.

2.3 Key Steps

The key steps involved with estimating the efficiency potential in Rhode Island are briefly described below:

Step 1: Develop Initial Input Data

- **Develop a list of energy efficiency measures** to include in analysis. In this step, an initial draft measure list was developed and circulated. Examples of efficiency measures include premium T-8 lamps, weatherization and efficient pumps. The final efficiency measure list was developed after incorporating comments from the EERMC and its VEIC/Optimal Consultant Team and National Grid and is provided in the Appendices B and E.

- **Gather and develop technical data (costs and savings)** on efficiency measures opportunities. This data includes savings data for both energy and demand and cost data. Data on measures was gathered from a variety of sources. Measure descriptions are provided in Appendix B, and detail on measure inputs is provided in Appendix E. Results from the surveys and on-sites with Rhode Island customers are included in Appendices H.

- **Gather, analyze, and develop information on building characteristics and the forecast** , including:
    - projected energy and demand,
    - total square footage or total number of households,
    - energy consumption and intensity by end use,
    - end use consumption load patterns by time of day and year (i.e., load shapes),
    - market shares of key electric consuming equipment, and
    - market shares of energy efficiency technologies and practices.

Section 4 of this report describes the baseline data developed for this study.

- **Collect data on economic and other global parameters,** including
    - avoided costs,
    - line losses
    - electricity rates,
    - discount rates, and
    - the inflation rate.

These inputs are provided in Appendix C of this report.

Step 2: Estimate Technical Potential and Develop Efficiency Supply Curves

- Match and integrate data on efficiency measures to data on existing building end-use characteristics to produce estimates of technical potential and energy efficiency supply curves.

In our approach, we first estimate **technical potential** for energy savings by integrating key measure and market segment parameters using the following equation:

$$\textit{Technical Potential of Efficient Measure} = \textit{Total sq. ft. or \# of Dwellings} \times \textit{Base Case Equipment EUI or UEC} \times \textit{Applicability Factor} \times \textit{Not Complete Factor} \times \textit{Feasibility Factor} \times \textit{Savings Factor}$$

We then assess economic potential by first developing a supply-curve analysis. This analysis eliminates double counting of measure savings.

Step 3: Estimate Economic Potential

- Estimate total economic potential – all technically feasible efficiency measures that are cost-effective based on the total resource cost (TRC) test. These are gross savings.

Step 4: Estimate Achievable Program Potential

- Take the measures that passed the economic test and group them into program areas. For this study, measures were screened with a total resource cost test that included both customer and utility costs and only the benefits associated with electric avoided-costs and gas savings in measures that save both electricity and gas as noted above.

- Gather and develop potential of some future efficiency program designs, new technologies and behavior-change programs.

- Estimate the program costs of these program concepts including customer incentives, marketing costs and administrative costs.

- Develop estimates of customer adoption of energy efficiency measures, which depends on the customer's view economic attractiveness of the measures, barriers to their adoption, and the effects of program intervention.

- Develop estimates for program estimates outside of the economic potential. This is where estimates for behavioral programs, price response programs and new technologies were developed. These were done outside the model.

- Estimate achievable program potential. This is presented by program in appendix H.

2.4 Sources of Data

As illustrated in the previous section the model requires economic, building, measure, penetration, and other data. Table 2-1 below presents the sources of the key data elements. As noted in Section 2.3 this data is provided in the appendices.

Table 2-1:
Major Sources of Data

Type of Data	Key Sources
Avoided Costs	Synapse Study
Retail Rates	National Grid
Existing Market Saturations and Penetrations	The residential, commercial and industrial surveys and on-site visits of Rhode Island electric customers conducted by KEMA for this Phase II Opportunity Report; supplemented by the EIA consumptions surveys: e.g. RECS, CEBCS and MECS as needed.[8] Surveys are in Appendix G
Energy and Demand Data by Sector	National Grid
Square Footage	The residential, commercial and industrial surveys and on-site visits conducted by KEMA for this Phase II Opportunity Report; supplemented by the EIA consumption surveys RECS, CBECS and MECS as needed. Surveys are in Appendix G.
Measure Load Shapes	Derived from various sources including National Grid evaluations
Baselines for measures	The residential, commercial and industrial surveys and on-site visits conducted by KEMA along with additional data from National Grid's DREEM data base.
Measure savings	KEMA internal data bases; National Grid data the California, Vermont and Pacific NW reference manuals (TRM); ENERGY STAR Calculator, California and Connectict Technical Potential studies. See
Measure Costs	KEMA internal data bases; National Grid the California, Vermont and Pacific NW TRMs; ENERGY STAR Calculator, California and Connecticut potential studies; Database for Energy Efficiency Resources (DEER)
Free Rider Percent of Naturally occurring conservation	KEMA estimate based on program experience and National Grid

[8] Acronyms are for Energy Information Agency, Residential Energy Consumption Survey, Commercial Building Energy Consumption Survey, and Manufacturing Energy Consumption Survey respectively.

2.5 Overview of the Appendices

The sources used in Section 2.4 are presented in the appendices which are outlined here.

- Appendix A: Detailed Methodology and Model Description—Further detail on what is discussed in Section 2.
- Appendix B: Measure Descriptions—Describes the measures included in the study.
- Appendix C: Economic Inputs—Provides avoided cost, electric rate, discount rate, and inflation rate assumptions used for the study.
- Appendix D: Building and Time of Use (TOU) Factor Inputs—Shows the base household counts, square footage estimates for commercial building types, and base energy use by industrial segment. This appendix also includes time-of-use factors by sector and end use.
- Appendix E: Measure Inputs—Lists the measures included in the model with the costs, estimated savings, applicability, and estimated current saturation factors.
- Appendix F: Supply Curve Data—Shows the data behind the energy supply curves provided in Section 5.3 of the report.
- Appendix G - Customer Surveys- Reports on the results from the residential, commercial, and industrial customer surveys
- Appendix H - Achievable Potential.

2.6 Overview of Survey and On-Sites

2.6.1 Residential Survey

The *Rhode Island EERMC Residential Survey* was designed to assist in understanding the quantity and types of appliances owned by customers located in National Grid's Rhode Island service territory. The survey was designed to provide National Grid with current data to support resource planning, program planning and improved characterization of the residential market including:

- Saturation of energy end-uses by type
- Penetration of energy efficient equipment by end use
- Trends in energy efficiency purchase behavior
- Awareness and interest in National Grid program offerings

This data was used to develop up-to-date energy use information by fuel, sector and end-use necessary to determine the baseline conditions and develop an estimate of the potential savings from energy efficiency in National Grid's service territory.

This report is based on a computer assisted telephone interview (CATI) administered to 300 residential households in National Grid's Rhode Island service territory during June of 2009. The survey sought to determine the following characteristics of residential housing:

- Dwelling type along a variety of indices including ownership, age and size
- Insulation
- Windows
- Space heating & cooling
- Water heating
- Dehumidifiers
- Lighting
- Appliances including refrigerators, freezers, dishwashers, cooking, laundry
- Pool
- Electric plug loads (e.g., computers, office machines, televisions, fans, hybrid vehicles)

The survey also sought to determine respondents' awareness of and attitudes towards:

- National Grid energy efficiency programs
- Energy Star branding and equipment

Additionally, the survey included basic questions on household demographics to allow for segmentation of results along these lines.

2.6.2 Residential Survey Methodology

This section presents an overview of the residential survey. These aspects included sample design, survey design (i.e., item generation, coding, computer programming), data analysis and report preparation.

National Grid provided KEMA with a list of 56,520 residential electricity customers obtained from a 2008 billing database. KEMA used simple random sampling to randomly select 3,000 addresses from this revised list. In simple random sampling each house in the population is given an equal chance to be selected into the sample. Results are calculated for the sample, which serve as an unbiased estimator of the population. Results for the sample are then projected back to the population to estimate the savings potential for the population. Simple random sampling is well suited for residential sample designs because the projects do not vary substantially in size.

This information was then sent to a CATI vendor in order to obtain completed surveys from 300 electric customers to provide a statistically valid representation of the NIPSCO residential service territory. As a point of reference, The *Rhode Island EERMC Residential Survey* experienced a 10% response rate on the CATI survey. (This percentage is representative of most CATI surveys conducted with residential households, with response rates typically fewer than 25%). The average time to complete the survey was 24 minutes.

Table 2-2 provides an overview of the principal data collection and analysis efforts for the study.

Table 2-2:
Summary of Research and Analysis Efforts

Population / Summary of Topics Covered	Sample Frame	Sample Size and Other Details
Residential DSM Potential Survey Estimate saturation of key electric end-uses Assess awareness and interest of National Grid energy efficiency programs Assess awareness and purchasing of ENERGY STAR brand appliances	**2008 National Grid billing database**	**300:** Represents a margin for error of +/- 4% at the midpoint of a 90% confidence level. KEMA believes that estimates with this precision are usable for resource and program planning purposes.

Survey results are presented in Appendix H. A summary of key results is presented in the next section.

2.7 Selected Key Findings from the Residential Survey

Program Awareness

- Customers are aware of National Grid's programs (88%).
- However, the majority of customers (68%) had not yet participated in these programs
- Most who had participated would participate again (86%).

Energy Star Awareness:

- Most respondents surveyed had heard of and/or seen the Energy Star label (78%).
- Ownership of Energy Star appliances varies by appliance. Refrigerators (68%), dishwashers (50%), televisions (48%) water heaters (53%) and room air-conditioners (33%) had the highest mentions.

CFLs

- A significant majority of respondents (89%) were aware of CFLs.
- 84% of participants have purchased CFLs.
- Of those who had purchased a CFL – 59% did so without a rebate.
- CFL usage is somewhat bi-modal- although 45 % of residences have replaced less than 25% of their incandescent lamps; there is a segment of the population (25%) who claim to have replaced 75% of more of incandescent lamps with CFLs. [9]
- CFL usage has increased greatly but the majority of sockets are still incandescent – this makes CFLs a significant source of economic potential that goes away after 2013.

Air Conditioning

- Most homes in Rhode Island have some form of AC – yet only 27 percent have central air conditioning.
- 63% of those who have central air conditioning have a programmable thermostat.

[9] National Grid is currently conduction an on-site residential socket study in RI to further research this.

- Of those who have central air conditioning (71%) use their central air conditioning less than 60 days a year.

2.7.1 Commercial / Industrial On-Sites

KEMA conducted on-site surveys of a sample of commercial and industrial customers to support the energy efficiency potential study. The on-sites were designed to collect the data required for DSM Assyst to develop the estimates of potential. On-survey results are presented in Appendix H. This data includes:

- Saturation of energy end-uses by type
- Penetration of energy efficient equipment by end use
- Trends in energy efficiency purchase behavior
- Awareness and interest in National Grid program offerings

2.7.2 Commercial / Industrial Methodology

Building types were assigned to the population based on SIC codes provided in the tracking data by National Grid. In the first data set provided by National Grid, SIC codes were missing for over 60% of the accounts in the population. After discussion on how to handle this difficulty with various sample design techniques, National Grid was able to provide SIC codes for accounts in the population that they purchased from a secondary source. A final combined dataset was created that merged the two sources of SIC code information to the population.

Table 2-3 shows a list of the total number of accounts dropped as well as the contribution of those accounts to the total energy in the program. For the final sample design, accounts with less than 5,000 annual kWh were removed from the population because there is very little potential for savings from accounts that small. Accounts less than 5,000 annual kWh accounted for less than 0.5% of the total program annual kWh. Accounts that were dropped due to small usage came from all building categories but the two largest categories were office and retail. It was decided not to include the agricultural building type in this analysis because a large percentage of this category contained inaccurate SIC codes and because agricultural accounts represented only 0.3% of the annual kWh for the program.

Table 2-3:
Dropped Accounts Summary

	n obs	% of sites in Population	annual kwh	% of total annual kWh
No SIC code	17,417	31.3%	368,639,838	8.3%
kWh < 5000	12,255	22.0%	31,522,303	0.7%
AG	479	0.9%	14,601,568	0.3%
Total Dropped	30,151	54.2%	414,763,709	9.3%

The remaining population file after screening contained 25,448 accounts that were grouped into thirteen building categories. Table 2-4 shows the summary statistics of the final nonresidential population file. The commercial category with the largest contribution to annual consumption was office buildings with over 1,000 GWh and the largest industrial category was assembly industrial which accounted for nearly 1,000 GWh.

Table 2-4:
Nonresidential Population Summary (in kWh)

business	Accounts	annual_kwh_sum	Mean	Minimum	Maximum	StdDev	CV
office	8,662	1,021,319,854	117,908	5,002	106,649,000	1,251,790	10.62
Restaurant	2,080	201,850,636	97,044	5,014	5,169,277	166,998	1.72
Grocery	882	209,141,729	237,122	5,062	3,995,250	576,268	2.43
Retail	4,679	373,377,103	79,798	5,000	23,344,000	525,429	6.58
Warehouse	584	135,243,004	231,580	20,036	10,020,000	718,814	3.10
Health	1,423	258,620,105	181,743	5,027	44,448,218	1,420,482	7.82
School	475	117,434,993	247,232	5,243	2,551,400	364,112	1.47
College	184	235,195,224	1,278,235	21,129	70,490,482	6,654,681	5.21
Lodging	176	81,756,917	464,528	25,225	6,860,000	910,490	1.96
Commercial Misc.	1,558	157,470,311	101,072	5,001	30,304,768	863,033	8.54
Assembly Industrial	1,955	969,337,865	495,825	5,000	96,510,341	2,874,029	5.80
Process Industrial	1,008	73,004,915	72,426	5,007	2,834,000	241,121	3.33
Trans, Commun, Utility	1,782	209,968,001	117,827	5,022	23,420,810	854,416	7.25

A total of 150 accounts were initially selected for the nonresidential sample, 108 commercial accounts and 42 industrial accounts. Table 2-5 shows the sample size and number of strata for each of the 13 chosen building categories. Sample sizes were selected to optimally allocate accounts by building type based on their contribution to the total nonresidential load. This is why offices and assembly facilities have the most sample points for commercial and industrial sectors respectively. A minimum of 4 accounts was set for each business type to ensure adequate survey information to be provided for modeling.

Table 2-5:
Sample Size and Number of Strata by Building Type

Business Type	Sample Size	Strata
Office	24	4
Restaurant	9	2
Grocery	8	2
Retail	16	4
Warehouse	6	2
Health	7	3
School	7	2
College	6	2
Lodging	4	1
Commercial Misc.	13	3
Assembly Industrial	35	5
Process Industrial	7	2
Trans, Commun, Utility	8	2

The tracking data included accounts that contain inaccurate SIC code mapping designations. While conducting the onsite surveys, the true building type for each account included in the sample was confirmed or modified compared to the tracking database. For accounts that were mislabeled, KEMA kept track of the original building type designation as well as the true building type. When conducting the analysis, accounts that were mislabeled maintained their original weight based on the tracking data assigned building code from the sample design, but were extrapolated back to the population using the true building type. In this way the results represent the distribution of the true building type within the utility and not the distribution based on the SIC building type mapping that contain incorrect building assignments.

Weights were recalculated after the onsite surveys were completed to reflect the sites that were able to be recruited into the sample. A total of 149 accounts were recruited out of the initial target of 150. Based on the parameters outlined in Table 2-5, strata cut points were selected using model-based stratification. Table 2-6 shows the resulting strata cut points by business type and the associated weight for each business type and stratum combination.

Table 2-6:
Strata Cut Points by Business Type--in Annual kWh

Business Type	Stratum	Strata Cutpoint (annual kwh)	Accounts in Pop	Total kwh in Strata	Sites in Sample	Weight
Office	1	63,100	6,859	130,924,543	6	1,143
Office	2	361,800	1,373	191,229,221	6	229
Office	3	1,800,942	351	266,553,284	6	59
Office	4	106,649,000	79	432,612,806	6	13
Restuarant	1	144,210	1,690	83,053,057	5	338
Restuarant	2	5,169,277	390	118,797,579	4	98
Grocery	1	612,960	817	75,048,879	4	204
Grocery	2	3,995,250	65	134,092,850	4	16
Retail	1	41,561	3,383	52,869,191	4	846
Retail	2	154,081	932	71,648,332	4	233
Retail	3	774,000	302	95,522,582	4	76
Retail	4	23,344,000	62	153,336,998	4	16
Warehouse	1	454,320	534	47,678,770	3	178
Warehouse	2	10,020,000	50	87,564,234	3	17
Health	1	345,520	1,321	44,228,602	4	330
Health	2	2,144,700	87	78,748,590	1	87
Health	3	44,448,218	15	135,642,913	2	8
School	1	440,000	401	48,557,753	4	100
School	2	2,551,400	74	68,877,240	3	25
College	1	4,616,000	178	71,073,214	4	45
College	2	70,490,482	6	164,122,010	2	3
Lodging	1	6,860,000	176	81,756,917	4	44
Commercial Miscellaneous	1	86,341	1,293	29,952,840	4	323
Commercial Miscellaneous	2	543,600	225	44,747,662	6	38
Commercial Miscellaneous	3	30,304,768	40	82,769,809	3	13
Assembly Industrial	1	357,600	1,595	100,392,386	8	199
Assembly Industrial	2	1,232,900	215	147,283,884	7	31
Assembly Industrial	3	3,526,400	89	182,616,664	8	11
Assembly Industrial	4	7,552,800	43	221,525,496	9	5
Assembly Industrial	5	96,510,341	13	317,519,435	2	7
Process Industrial	1	198,480	941	25,294,331	4	235
Process Industrial	2	2,834,000	67	47,710,584	3	22
Transport, Communications, Utility	1	621,300	1,727	64,669,388	4	432
Transport, Communications, Utility	2	23,420,810	55	145,298,613	4	14

Results from the On-sites are presented in a summary manner in Appendix H. Key findings are shown in the next section.

2.7.3 Key Findings from the Commercial and Industrial On–sites

The following are some key findings from the Commercial/ Industrial on sites:

- There is limited potential from large (over 100 hp) premium motors in the industrial sector – 87% of the fan motor systems above 100 HP are NEMA premium; 100% of pump motor systems are NEMA premium and 42 percent of process motors over 100 HP are NEMA premium motors.
- There is still potential in smaller motor sizes (below 100 HP)
- Most process boiler systems us fossil fuel (88%)
- Electricity is used for process heating in 53% of facilities that have process heating – most of the rest is Natural gas.
- Most of industrial space cooling is provided by split systems or DX.
- High performance T-8 systems are becoming common in 4 foot systems in Commercial buildings.
- High performance T-8 systems are less prevalent in 8 foot systems.
- There are still some incandescent lamps in commercial that could be replaced by CFLs.

3. Development of the Energy and Demand Baseline

3.1 Overview

Estimating the potential for energy efficiency improvements requires a comparison of the energy impacts of standard efficiency technologies with those of alternative high efficiency equipment. This, in turn, dictates a relatively detailed understanding of the energy characteristics of the marketplace. Baseline data that were required for each studied market segment included:

- Total count of energy consuming units (floor space of commercial buildings, number of residential dwellings, and the base kWh-consumption of industrial facilities):
- Annual energy consumption for each end use studied (both in terms of total consumption in GWh and normalized for intensity on a per-unit basis;
- End use load shapes (that describe the amount of energy used or power demand over certain times of the day and days of the year):
- The saturation of electric end uses (for example, the fraction of total commercial floor space with electric air conditioning):
- The market share of each base equipment type (for example, the fraction of total commercial floor space served by 4-foot fluorescent lighting fixtures); and,
- Market share for each energy efficiency measure in scope (for example, the fraction of total commercial floor space already served by CFLs).

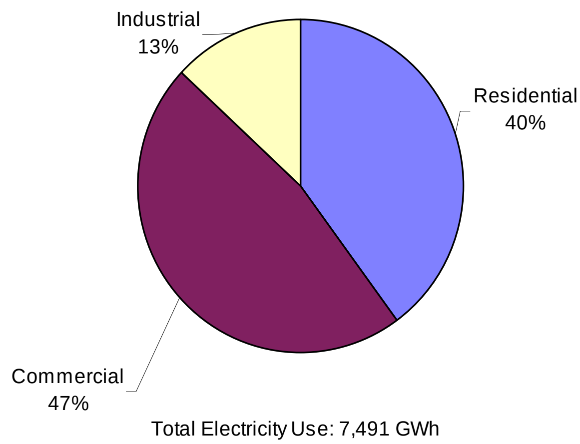
Data for the baseline analysis comes from a number of sources, including Rhode Island billing data extracts, National Grid internal data, telephone surveys conducted as part of this project with customers, U.S. Department of Energy surveys[10], on-site visits with commercial and

[10] Residential Energy Consumption Survey, Commercial Building Energy Consumption Survey, and Manufacturing Energy Consumption Survey respectively.

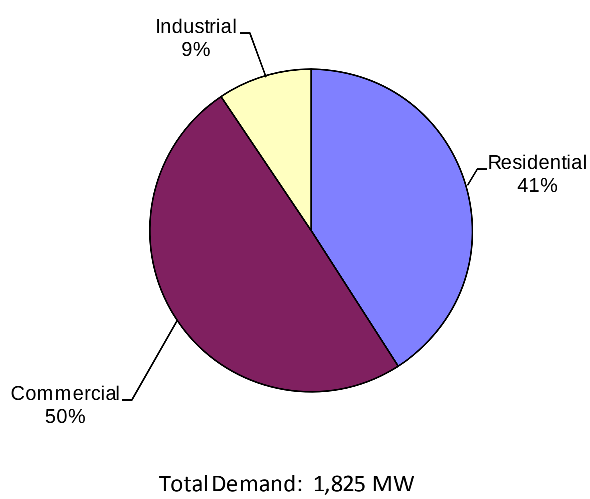
industrial customers, and additional secondary sources. Baseline data sources can vary by sector and are described in more detail in the sector discussions that follow.

Figure 3-1 below shows the overall breakdown of electricity use and peak demand by sector for the Rhode Island. The industrial sector accounts for 13% electric energy usage, with the balance used by the residential (40%) and commercial (47%) sectors.

Figure 3-1:
Electricity Energy Usage by Sector



Electricity Demand by Sector



3.2 Residential

The number of residential customers was provided by National Grid. Dwellings were split into single-family and multi-family components using data from the billing system and the 300 residential phone surveys that were conducted as part of this study. There were 222 single family homes in the sample and 78 multi-family homes.

A saturation analysis was used to derive the percent of homes that have a given end use was conducted using the residential customer survey results (e.g. the number of homes with central air-conditioning). Unit energy consumption (UEC) factors, a measure of electricity use per unit per year, were developed using data from the surveys as well as secondary source data such as the ENERGY STAR calculators and data available in public sources such as the EIA Residential Energy Consumption Survey (RECS).

Load shape data and KEMA end use databases were used to allocate annual energy usage to the time-of-use (TOU) periods used for this study and shown in Appendix D. Peak period usage, developed on a sector-specific and end use basis, was calibrated to the summer peak.

Figure 3-2:
Residential Electric Energy Consumption by Building Type

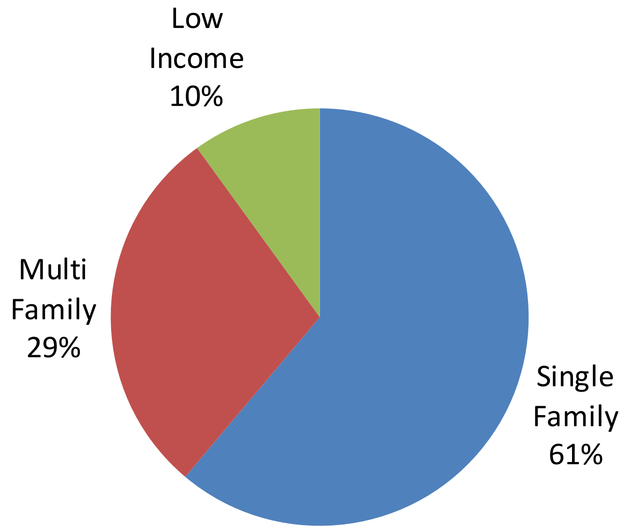


Figure 3-3:
Residential Electric Demand by Building Type

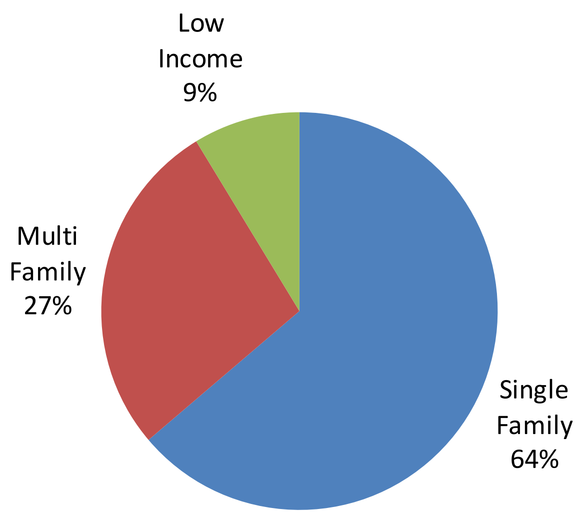
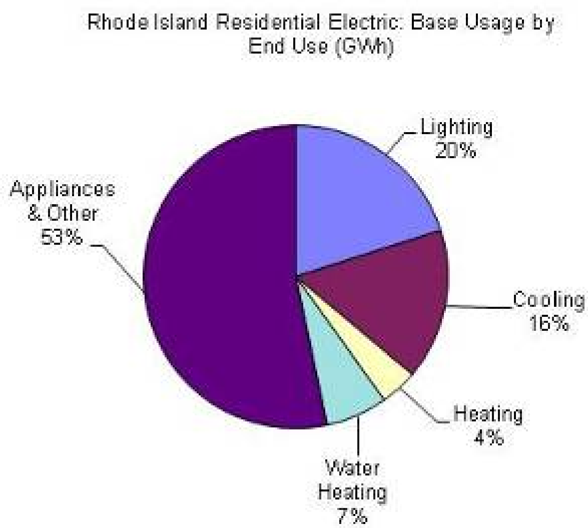


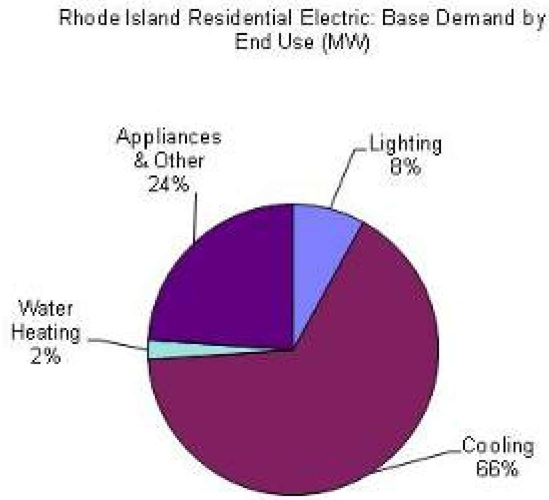
Figure 3-4
Residential Electric Energy Consumption by End Use



As shown above, lighting and appliances are the largest end uses in terms of electricity consumption, each with over 600 GWh, followed by cooling and water heating.

Figure 3-5 below shows the breakdown of residential peak demand by end use.

Figure 3-5
Residential Electric Peak Demand by End Use



Cooling dominates peak demand, contributing 66% of demand attributable to this sector.

3.3 Commercial

KEMA used the on-site data collected from 125 surveys of Rhode Island commercial facilities, and billed consumption data and the EIA's Commercial Building Energy Consumption Survey (CBECS) data for the Northeast to develop end use saturation and EUI (Energy Utilization Indices in kWh per square foot) data. For the commercial sector, no estimates of consuming units (square feet of commercial space by building type) were available for the territory. Square footage estimates were derived for each key building type by dividing Rhode Island energy consumption (kWh) by whole-building EUIs (kWh per square foot). EUI's were developed from billing data, survey data and data from CBECS Figure 3-6 summarizes the commercial baseline electricity consumption by building type developed for the study. The office and retail building types account for the largest shares of both energy and peak demand, followed by healthcare and grocery stores.

Figure 3-6:
Commercial Electric Energy Consumption by Building Type

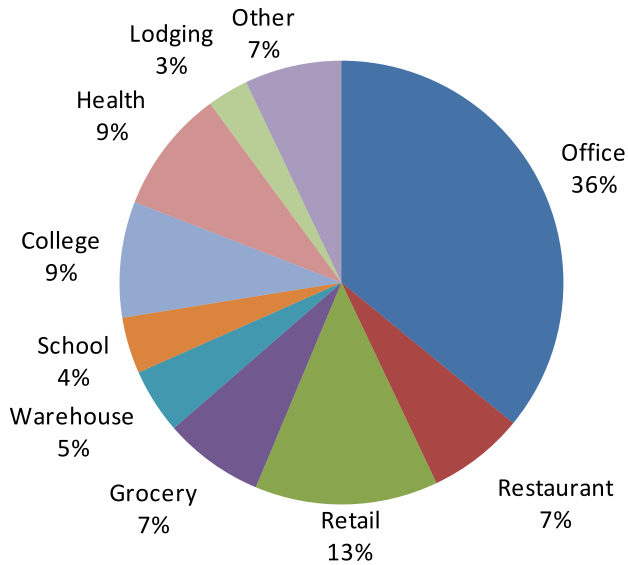


Figure 3-7:
Commercial Electric Demand by Building Type

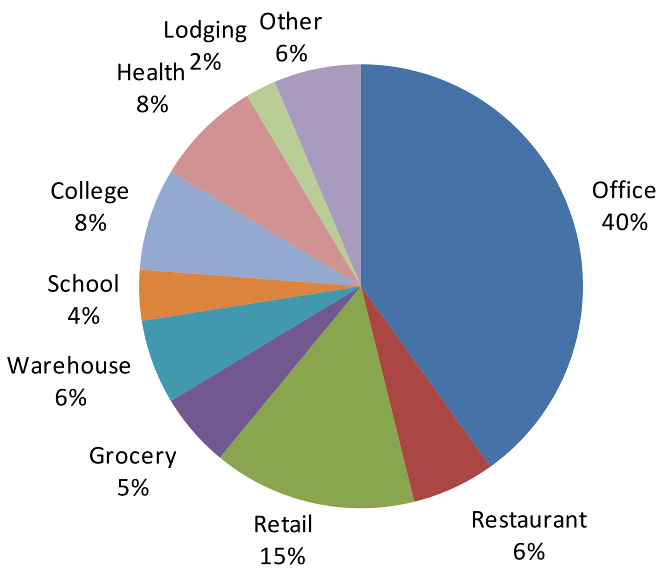


Figure 3-8 shows commercial electricity consumption by end use. Lighting contributes the most to commercial electricity consumption at almost 1,300 GWh per year, followed by cooling and ventilation at roughly 775 and 475 GWh per year, respectively.

Figure 3-8:
Commercial Electric Energy Consumption by End Use

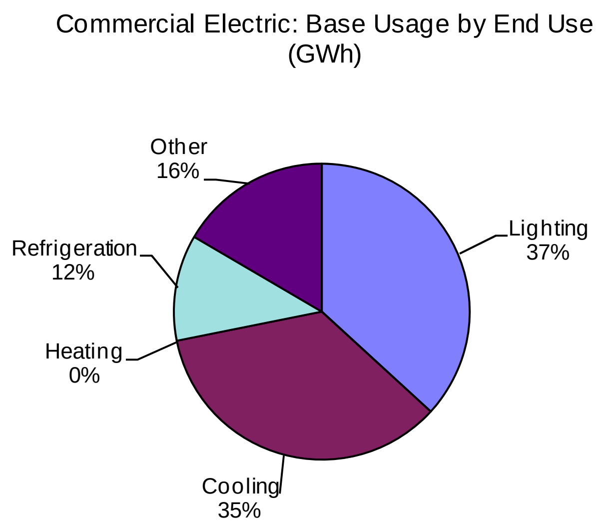
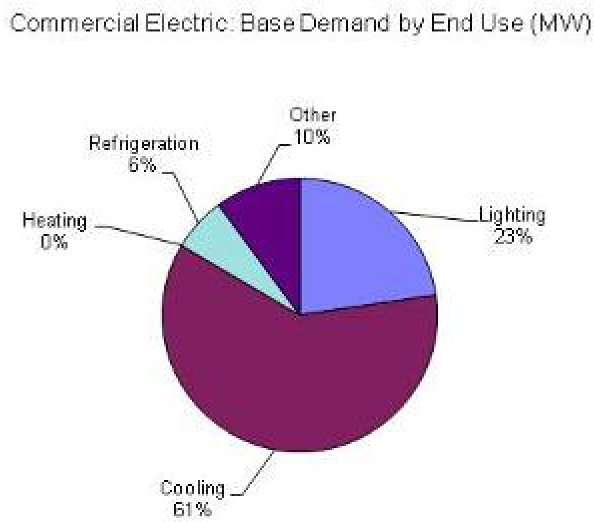


Figure 3-9 shows commercial electricity peak demand by end use. For peak demand, cooling contributes the largest share at almost 450 MW, followed by lighting at about 200 MW.

Figure 3-9:
Commercial Electric Peak Demand by End Use



3.4 Industrial

KEMA based the industrial sector analysis on billing data, the on-site surveys and end use consumption data at the national level developed as part of the EIA's Manufacturing Energy Consumption Survey (MECS). KEMA further disaggregated the motors end use into pumps, fans, compressed air and drives using national level data developed as part of a U.S. Motors Assessment Study conducted for the Department of Energy (DOE) in 1998. As with the residential and commercial sectors, industrial peak demand estimates were calibrated to ensure that they were consistent with system peak demand.

Figure 3-10 summarizes industrial electricity energy consumption by industry type. Figure 3-11 presents demand by industry type.

Figure 3-10:
Industrial Electric Energy Consumption by Industry Type

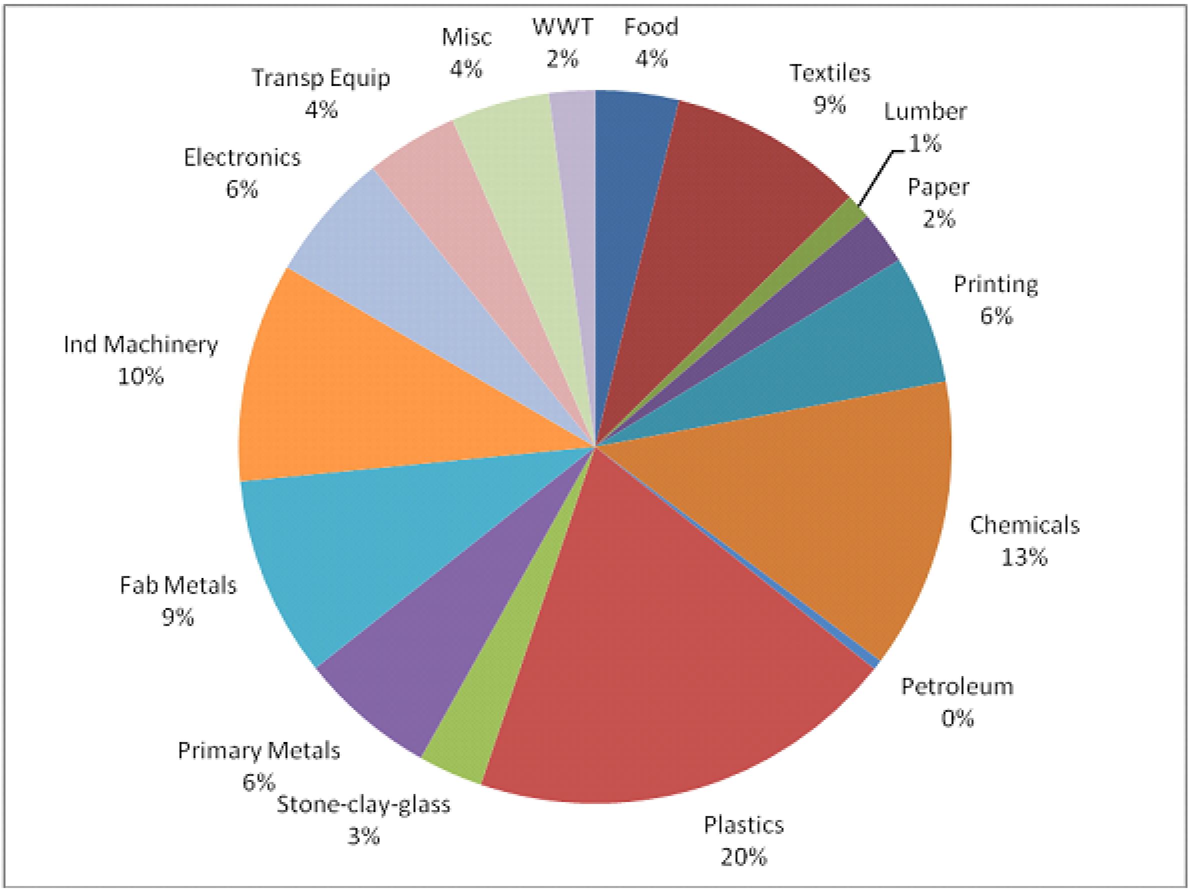


Figure 3-11:
Industrial Electric Demand by Industry Type

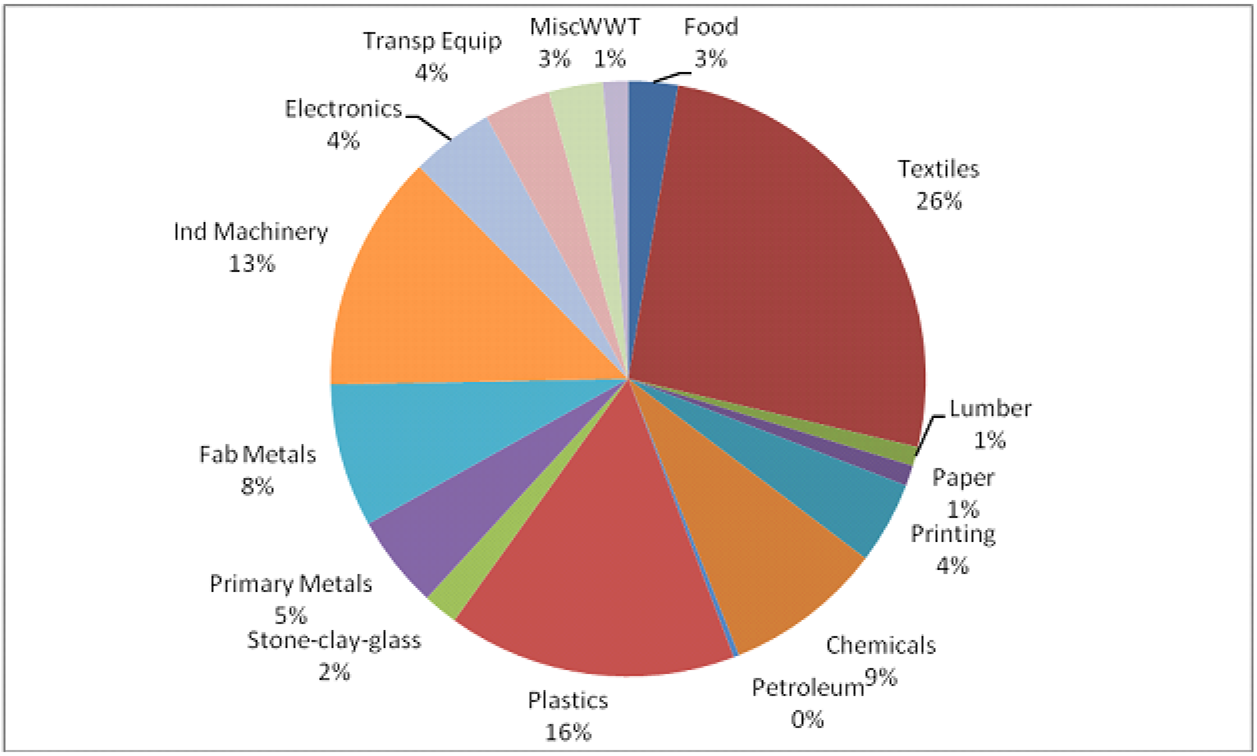


Figure 3-12 breaks down industrial electric energy consumption by end use. Figure 3-13 indicates industrial peak demand by end use. These figures show that each end use contributes the same, or very close to the same, portion of the sector total of both energy and demand requirements. For example, process drives, the largest single contributor to energy and demand, accounts for 23% and 24% of the respective totals.

Figure 3-12:
Industrial Electric Energy Consumption by End Use

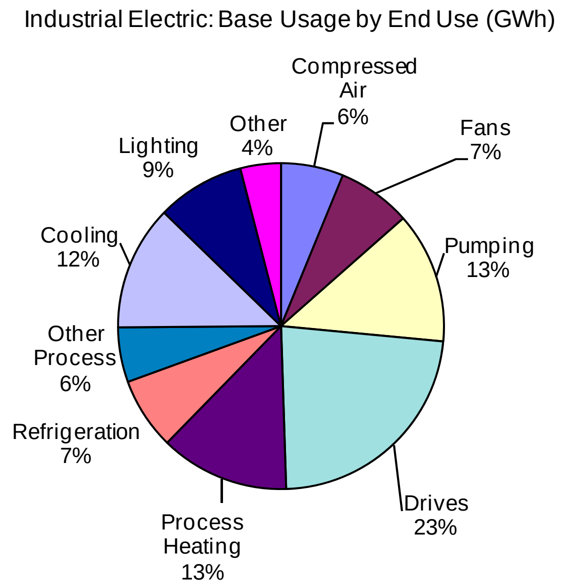
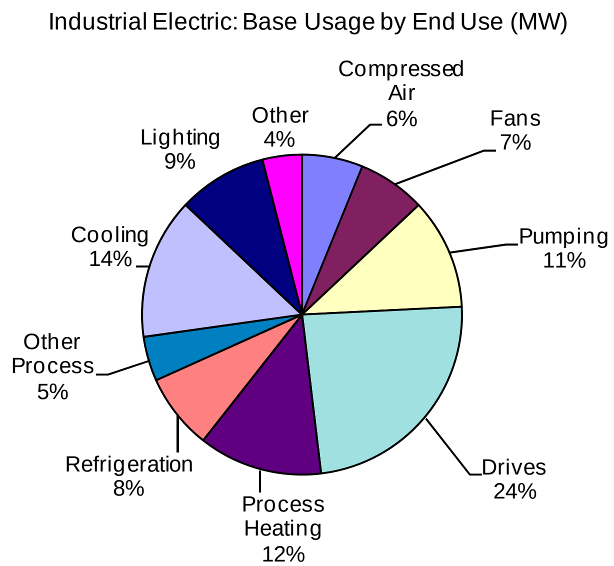


Figure 3-13:
Industrial Electric Peak Demand by End Use



4. Technical and Economic Potential

In this section, we present technical and economic potential results for all electric measures considered in the study. Estimates of overall *technical* and *economic* energy efficiency potential are discussed in Section 4.2, with a more detailed discussion presented in Section 4.3. Energy efficiency supply curves are shown in Section 4.3.2.

4.1 Explanation of Results and Assumptions

Technical and economic potential results for each sector were calculated off the baseline (or current electricity use) estimates described previously in Section 4. As stated in Section 4, estimates and assumptions regarding the market saturation of different energy efficiency measures and equipment were determined primarily from customer and market survey results.. When necessary, secondary sources, as described in Section 3.4, were used to supplement the survey results.

To review,

- *Technical potential* represents the sum of all savings from all of the measures deemed applicable and technically feasible, whereas
- *Economic potential* is the subset of technically feasible efficiency measures that are cost-effective based on the total resource cost (TRC) test. That is, economic potential refers to the efficiency potential in which the benefits are greater than costs (i.e. the TRC is greater than 1.0).

The TRC test is a benefit-cost test that compares the value of avoided energy production, transmission, distribution and power plant construction (i.e., the value of efficiency resources), as well as other quantifiable benefits, to the costs of the energy efficiency measures. When the TRC benefit-cost ratio is greater than 1.0 that means the benefits of efficiency measures' savings are greater than the costs and the efficiency resources are to be procured.

4.2 Overall Technical and Economic Potential

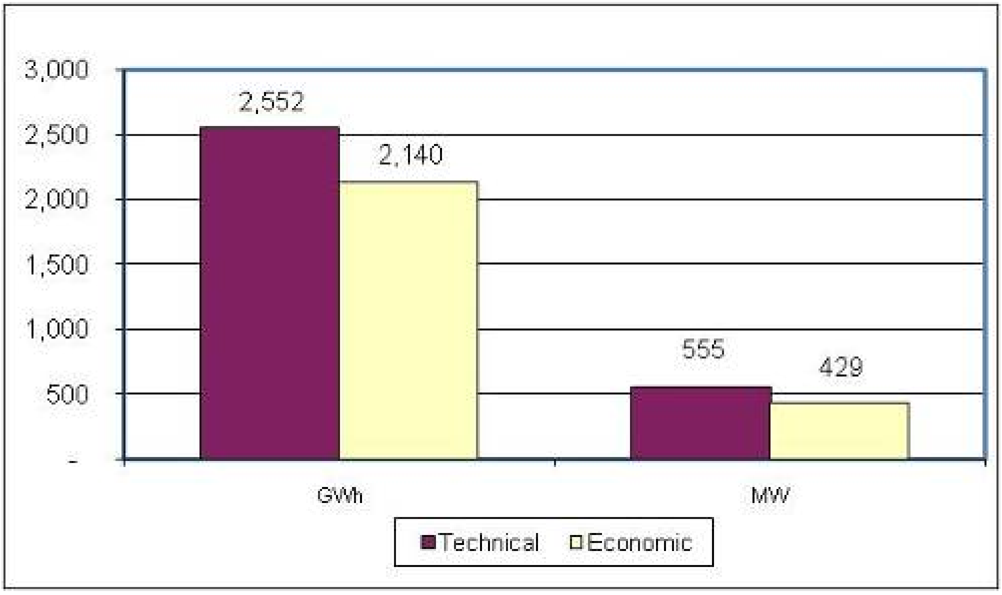
Energy Savings. Technical potential is estimated to be approximately 2,552 GWh. Economic potential is estimated to be approximately 2,140 GWh by 2020. Thus, technical and economic efficiency potential is estimated equal to approximately 30 and 29 percent of forecasted base usage, respectively. Technical Potential is a snapshot in time.

Peak-Demand Savings. Technical potential is estimated at about 555 MW and economic potential at 429 MW by 2020. This is about 29 and 22 percent of forecasted base 2010 demand, respectively. Note that the technical and economic potential include the effect of CFLs although federal lighting standards effective in 2014 may preclude much of the future (post 2014) CFL potential in National Grid's programs. This is discussed in more detail in Section 6.

Treatment of Naturally Occurring and Lost Opportunities. In the calculation of technical and economic potential no adjustment is made for naturally occurring energy efficiency. This is done at the achievable potential stage. New Construction for residential and commercial are modeled separately.

Figure 4-1 presents the estimates of total technical and cost-effective economic energy efficiency potential that can be obtained by for electrical energy and peak-demand savings for Rhode Island. The estimates of technical and economic are based on instantaneously early retirement of all measures. This is not done on a year by year calculation.

Figure 4-1:
Estimated Technical and Economic Energy and Demand Savings Potential by 2020



4.3 Technical and Economic Potential by Sector

This subsection presents the technical and economic potential by sector and by end use.

Table 4-1 and Table 4-2 show estimates of technical and economic energy and demand savings potential for each sector. We used 2010 as the base year for the metric to compare savings to.

Table 4-1:
Energy Savings Potential by Sector for 2011-2020 period

	GWH		
Sector	**2010 Base Energy Use**	**Ten Year Technical Savings**	**Ten Year Economic Savings**
Residential Existing	2,980	1,147	920
Residential New	7	2	2
Subtotal	2,987	1,148	922
Savings % of Base		**38%**	**31%**
Commercial Existing	3,503	1,206	1,043
Commercial New	26	9	9
Subtotal	3,529	1,215	1,052
Savings % of Base		**34%**	**30%**
Industrial	975	189	166
Savings % of Base		**19%**	**17%**
New Technologies			
Total	7,491	2,552	2,140
Savings % of Base		**34%**	**29%**

Table 4-2:
Energy Savings Potential by Sector for 2011-2020 period

	MW		
Sector	**2010 Base Demand**	**Ten Year Technical Savings**	**Ten Year Economic Savings**
Residential Existing	745	262	200
Residential New	2	0.36	0.36
Subtotal	747	263	201
Savings % of Base		**35%**	**27%**
Commercial Existing	899	260	201
Commercial New	7	2	2
Subtotal	906	262	203
Savings % of Base		**29%**	**22%**
Industrial	172	30	26
Savings % of Base		**17%**	**15%**
New Technologies			
Total	1,825	555	429
Savings % of Base		**30%**	**24%**

Figure 4-2 and Figure 4-3 show estimates of technical and economic energy and demand savings potential by sector. Figure 4-4 and Figure 4-5 show the same potentials as a percentage of 2010 base energy and base peak demand for each sector.

Figure 4-2:
Technical and Economic Potential by 2020 - Energy Savings by Sector – GWh

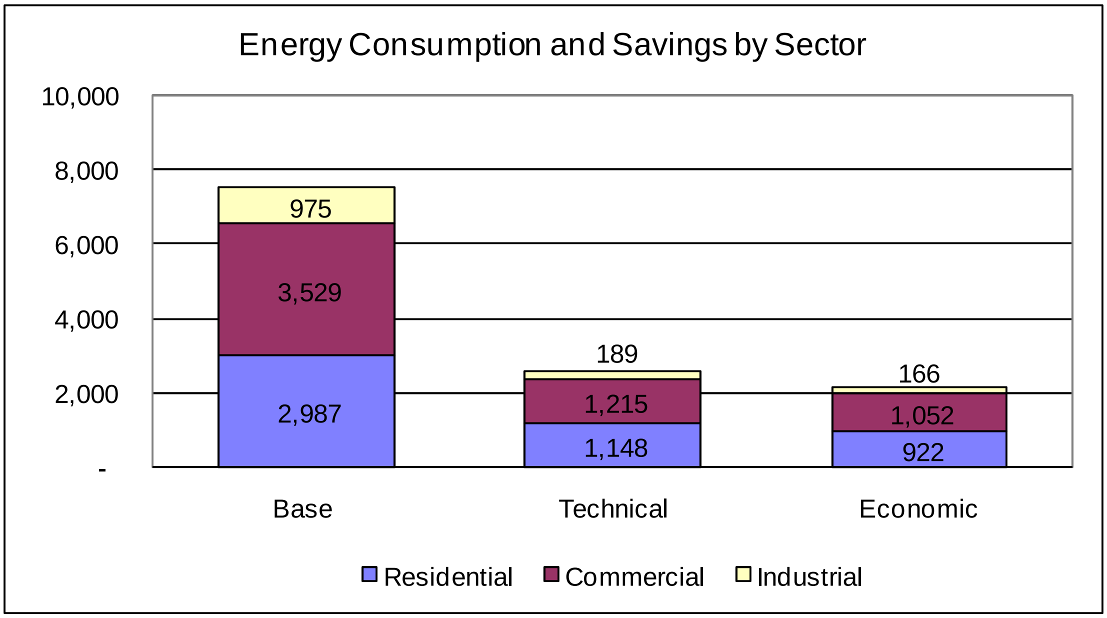
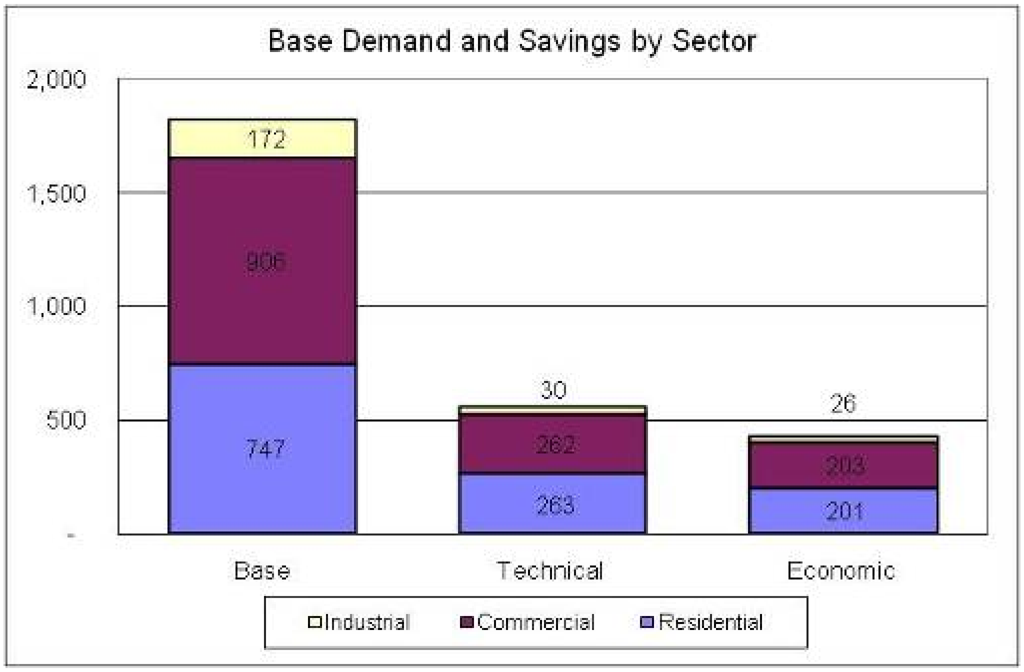


Figure 4-3:
Technical and Economic Potential by 2020 - Demand Savings by Sector – MW



As shown in Figure 4-4 and Figure 4-5 below the residential sector has a somewhat higher savings potential in relation to its base energy use than do the commercial and industrial sectors.

Figure 4-4:
Technical and Economic Potential by 2020 Percentage of Base Energy Use

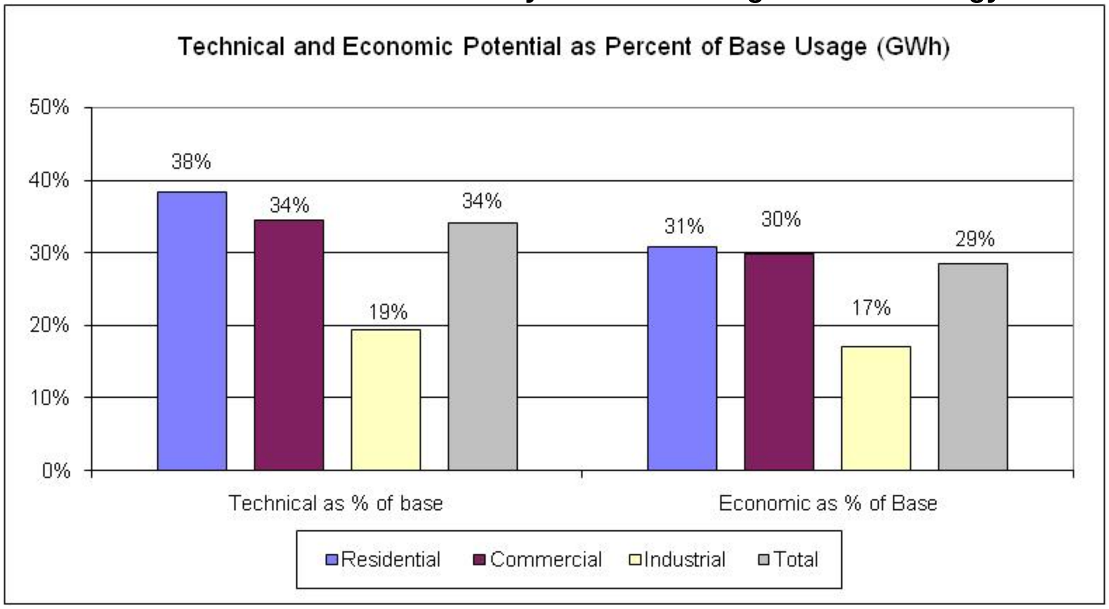
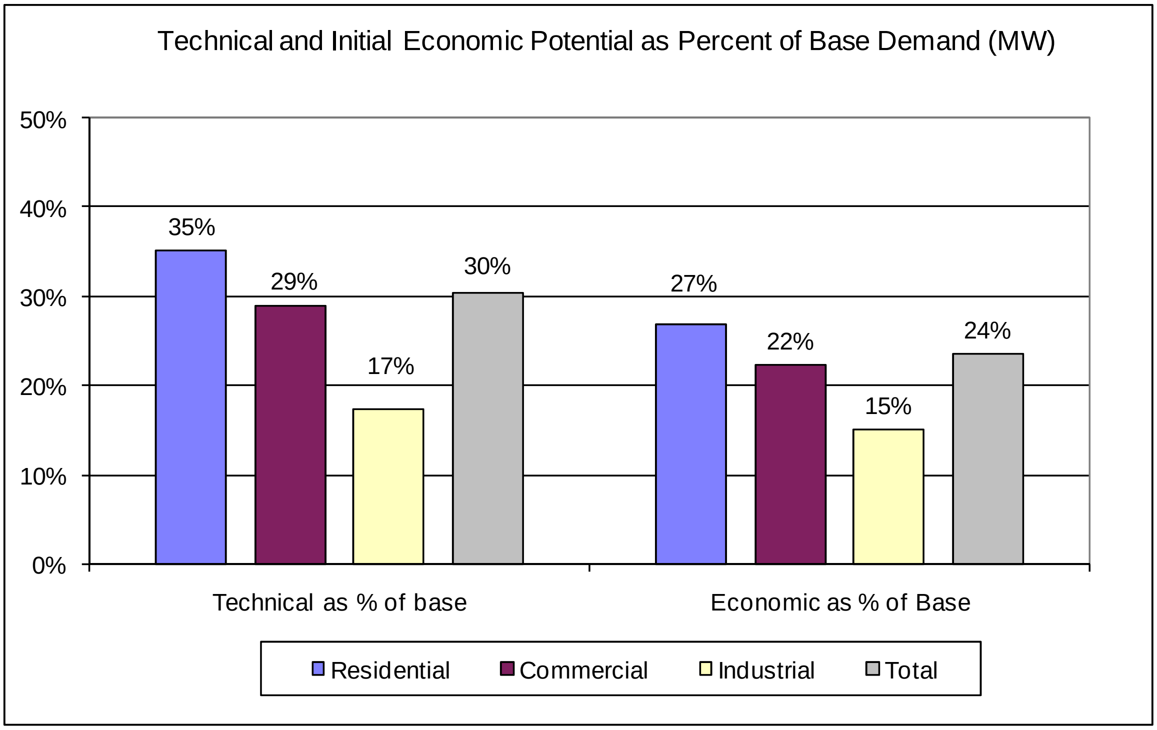


Figure 4-5:
Technical and Economic Potential by 2020 Percentage of Base Demand Use



4.3.1.1 Treatment of Emerging Technologies in Technical and Economic

The ultimate impacts and timing of emerging technologies are very uncertain due to both technological and market barriers. Despite these uncertainties associated with particular technologies, we know that energy-efficiency measures will continue to evolve, and emerging technologies will play a significant role in future program years. Examples of some emerging technologies that might become available over the next 10 years include: energy-efficient smart windows, automated fault detection of air conditioners, night ventilation cooling systems, evaporative pre-condensers for air conditioners, advanced cooling refrigerants, advanced controls and sensors for industry, microwave processing of materials, and indirect evaporative cooling in the commercial sector.

In order to address the possible effects of emerging energy-efficiency measures, we included in our potential analysis on several of the more promising emerging technologies:

- LED lighting, including LED street lighting, LED replacements for incandescent/CFL lighting in the residential sector, and LED replacements for fluorescent tube lighting in the commercial sector; and
- Fiber-optic refrigeration display lighting.

For the analysis, we assumed that these measures were all commercially available and could provide claimed savings. We also assumed equipment costs that made these measures commercially viable.

4.3.1.2 Technical and Economic Potential by End Use and Measure

We present the technical and economic potential for energy and demand savings with sets of matched figures. The first is a pie chart showing the contribution to the total potential by end use. The second is a table that provides detail on the measures that will acquire this potential.

These tables rank the measures by their technical or economic savings potential and also show the measure specific TRC associated with the measure as modeled for the technical and economic potential. As it is being used to screen measures, the TRC includes only the measure costs and savings.[11] For the commercial and industrial tables, we show an average TRC across building types. Thus, some measures may appear to have a TRC below 1, but still have economic savings. In this case, the measure is not cost effective in some building types, but is in others, and therefore has economic potential for a some sectors.

Residential Sector

Figure 4-6 and Figure 4-7 show the contribution to the economic potential in the residential sector by building type. Single family homes account for about 60 percent of the economic energy savings potential and 62 percent of the economic demand savings potential.

Figure 4-6: Residential Economic Energy Savings Potential by Building Type by 2020

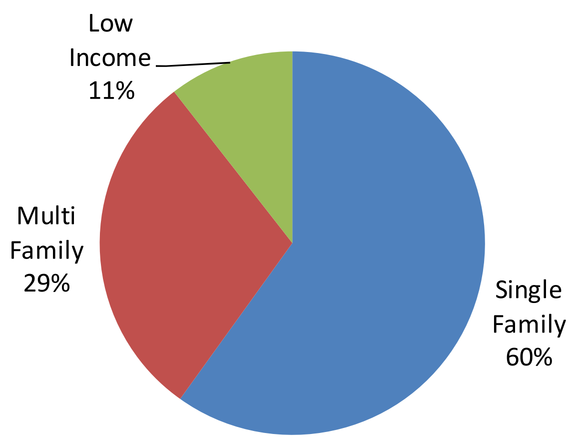
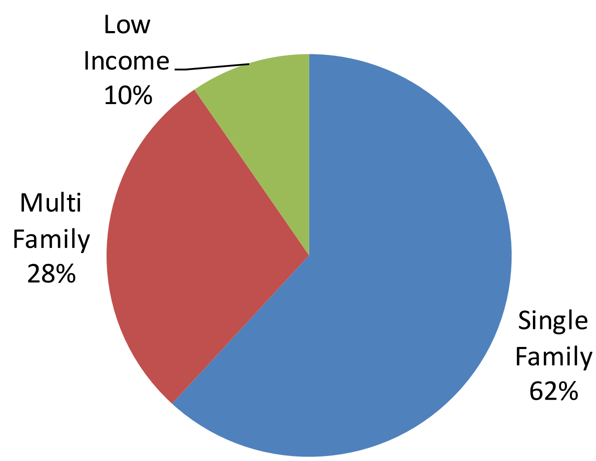


Figure 4-7: Residential Economic Demand Savings Potential by Building Type by 2020



[11] In measure screening just the costs and savings are assessed. Measure screening does not include any program costs – it is just used to determine which measures should be considered in programs.

4.3.1.2.1 Residential Summary

Overall, lighting and cooling end uses each contribute to over half of the energy savings potential. Cooling accounts for most of the peak demand savings potential, as very little lighting is used on warm summer afternoons when the system peak occurs.

In terms of measures, CFLs and second refrigerator recycling have the highest technical and economic energy savings potential. The potential from these two measures in both single and multi-family homes accounts for roughly 38% of total technical and 51% of total economic potential. Other high achieving measures for energy savings include new ENERGY STAR appliances and variable speed furnace fans. Treatment of CFLs over time is discussed in more detail in Section 6.

For demand savings, CFLs have the highest energy savings. Because of the large savings CFLs provide compared to incandescent lamps, they contribute a considerable amount to demand savings; 13.6% of technical demand savings potential and 18% of economic demand potential in this sector. However, it is important to note that much of the CFL savings in technical potential are naturally occurring and will likely be achieved over time without program interventions. Many of the other top demand saving measures are from the cooling end use, such as room and central air conditioners. Other cooling measures like whole house fans, proper refrigerant charging and air flow, and weatherization measures also have a large impact on both the technical and economic demand savings.

Figure 4-8:
Residential Technical Energy Savings Potential by End Use by 2020

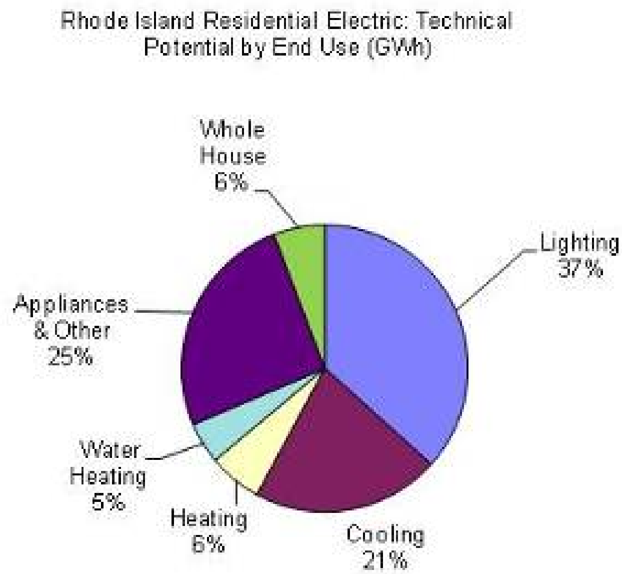


Table 4-3:
Residential Technical Energy Savings Top Twenty Saving Measures

Residential Existing Top Twenty by Technical Potential (GWh)

Base	Measure Number	Measure Name	Building Type	Technical GWh	TRC	Economic GWh
210	211	CFL (15-Watt integral ballast), 1.8 hr/day	Single Family	207.79	79.92	207.79
210	211	CFL (15-Watt integral ballast), 1.8 hr/day	Multi-family	112.91	79.92	112.91
700	711	Heat Pump Dryer	Single Family	62.83	0.35	0.00
340	341	Second Refrigerator Recycling	Single Family	44.77	68.18	44.77
970	971	Conservation Practices	Single Family	43.74	13.22	43.74
210	211	CFL (15-Watt integral ballast), 1.8 hr/day	Low Income	33.75	79.92	33.75
180	182	Variable speed furnace fans (ROB)	Single Family	32.05	42.16	32.05
970	971	Conservation Practices	Multi-family	20.63	8.90	20.63
180	181	Variable speed furnace fans (RET)	Single Family	19.17	1.89	19.17
210	212	LEDs w/ Incandescent Baseline	Single Family	18.79	0.68	0.00
220	221	LEDs w/ CFL Baseline	Single Family	17.07	1.80	17.07
180	182	Variable speed furnace fans (ROB)	Multi-family	13.90	42.16	13.90
340	341	Second Refrigerator Recycling	Multi-family	13.40	68.18	13.40
170	171	Energy Star Dehumidifier (ROB)	Single Family	12.26	59.32	12.26
190	191	Single Pane Windows to Double Pane with Gas	Single Family	11.65	7.91	11.65
700	710	High Efficiency CD (EF=3.01 w/moisture sensor)	Single Family	11.57	0.97	0.00
220	221	LEDs w/ CFL Baseline	Multi-family	11.13	2.16	11.13
100	113	Proper Refrigerant Charging and Air Flow	Single Family	10.81	4.32	10.81
700	711	Heat Pump Dryer	Multi-family	10.60	0.21	0.00
210	212	LEDs w/ Incandescent Baseline	Multi-family	10.21	0.68	0.00

Figure 4-9: Residential Technical Demand Savings Potential by End Use by 2020

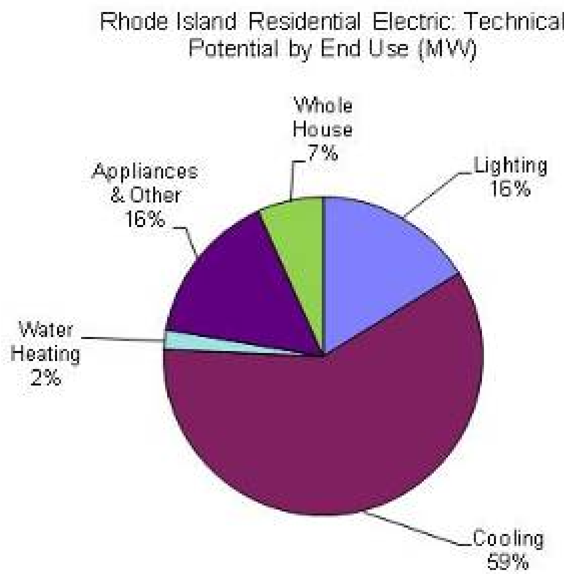


Table 4-4: Residential Technical Demand Savings Top Twenty Measures

Residential Existing Top Twenty by Technical Potential (MW)

Base	Measure Number	Measure Name	Building Type	Technical MW	TRC	Economic MW
210	211	CFL (15-Watt integral ballast), 1.8 hr/day	Single Family	21.04	79.92	21.04
170	171	Energy Star Dehumidifier (ROB)	Single Family	12.72	59.32	12.72
970	971	Conservation Practices	Single Family	11.66	13.22	11.66
210	211	CFL (15-Watt integral ballast), 1.8 hr/day	Multi-family	11.43	79.92	11.43
100	113	Proper Refrigerant Charging and Air Flow	Single Family	11.21	4.32	11.21
140	142	HE Room Air Conditioner - CEE Tier 1 EER 11.3	Single Family	10.22	2.15	10.22
140	142	HE Room Air Conditioner - CEE Tier 1 EER 11.3	Multi-family	9.26	2.05	9.26
100	114	Duct Repair	Single Family	8.51	1.73	8.51
700	711	Heat Pump Dryer	Single Family	8.39	0.35	0.00
100	103	17 SEER Split-System Air Conditioner	Single Family	6.98	0.32	0.00
100	102	15 SEER Split-System Air Conditioner	Single Family	6.17	1.54	6.17
340	341	Second Refrigerator Recycling	Single Family	6.17	68.18	6.17
100	111	Whole House Fans	Single Family	5.99	1.02	5.99
970	971	Conservation Practices	Multi-family	5.50	8.90	5.50
140	146	Whole House Fans	Single Family	4.56	0.64	0.00
130	131	15 SEER Split-System AC Early Replacement	Single Family	4.16	0.97	0.00
140	156	Wall 2x4 R-0 to Blow-In R-13 Insulation	Multi-family	4.16	13.91	4.16
170	171	Energy Star Dehumidifier (ROB)	Multi-family	3.43	58.53	3.43
140	156	Wall 2x4 R-0 to Blow-In R-13 Insulation	Single Family	3.42	5.12	3.42
210	211	CFL (15-Watt integral ballast), 1.8 hr/day	Low Income	3.42	79.92	3.42

Figure 4-10:
Residential Economic Energy Savings Potential by End Use (2020)

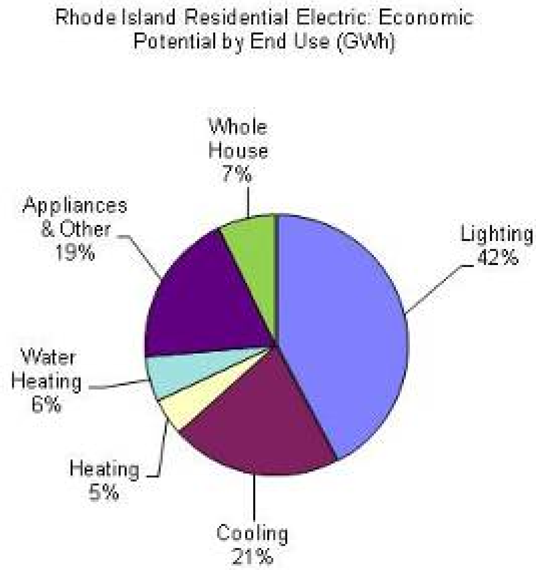


Table 4-5:
Residential Economic Energy Savings Top Twenty Measures

Residential Existing Top Twenty by Economic Potential (GWh)

Base	Measure Number	Measure Name	Building Type	Technical GWh	TRC	Economic GWh
210	211	CFL (15-Watt integral ballast), 1.8 hr/day	Single Family	207.79	79.92	207.79
210	211	CFL (15-Watt integral ballast), 1.8 hr/day	Multi-family	112.91	79.92	112.91
340	341	Second Refrigerator Recycling	Single Family	44.77	68.18	44.77
970	971	Conservation Practices	Single Family	43.74	13.22	43.74
210	211	CFL (15-Watt integral ballast), 1.8 hr/day	Low Income	33.75	79.92	33.75
180	182	Variable speed furnace fans (ROB)	Single Family	32.05	42.16	32.05
970	971	Conservation Practices	Multi-family	20.63	8.90	20.63
180	181	Variable speed furnace fans (RET)	Single Family	19.17	1.89	19.17
220	221	LEDs w/ CFL Baseline	Single Family	17.07	1.80	17.07
180	182	Variable speed furnace fans (ROB)	Multi-family	13.90	42.16	13.90
340	341	Second Refrigerator Recycling	Multi-family	13.40	68.18	13.40
170	171	Energy Star Dehumidifier (ROB)	Single Family	12.26	59.32	12.26
190	191	Single Pane Windows to Double Pane with Gas	Single Family	11.65	7.91	11.65
220	221	LEDs w/ CFL Baseline	Multi-family	11.13	2.16	11.13
100	113	Proper Refrigerant Charging and Air Flow	Single Family	10.81	4.32	10.81
140	142	HE Room Air Conditioner - CEE Tier 1 EER 11.3	Single Family	9.85	2.15	9.85
500	509	2011 Energy Star Clotheswasher (MEF 2.00)	Single Family	9.58	5.49	9.58
300	301	HE Refrigerator - Energy Star version of above (Top	Single Family	9.53	2.37	9.53
930	931	Energy Star LCD TV	Single Family	9.06	18.82	9.06
140	142	HE Room Air Conditioner - CEE Tier 1 EER 11.3	Multi-family	8.93	2.05	8.93

Figure 4-11:
Residential Economic Demand Savings Potential by End Use (2020)

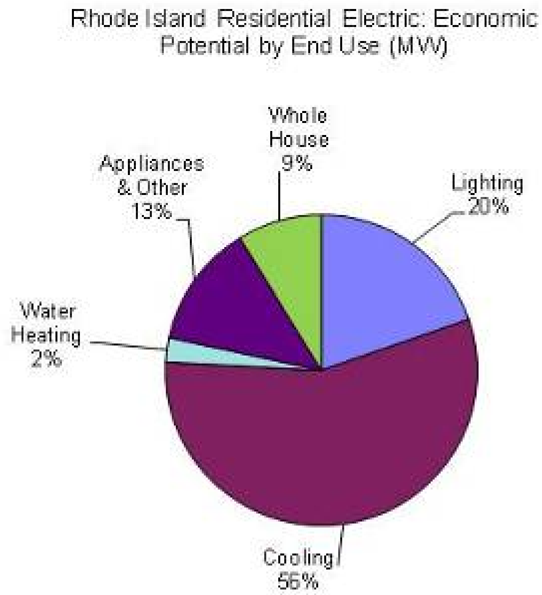


Table 4-6:
Residential Economic Demand Savings Top Twenty Measures

Residential Existing Top Twenty by Economic Potential (MW)

Base	Measure Number	Measure Name	Building Type	Technical MW	TRC	Economic MW
210	211	CFL (15-Watt integral ballast), 1.8 hr/day	Single Family	21.04	79.92	21.04
170	171	Energy Star Dehumidifier (ROB)	Single Family	12.72	59.32	12.72
970	971	Conservation Practices	Single Family	11.66	13.22	11.66
210	211	CFL (15-Watt integral ballast), 1.8 hr/day	Multi-family	11.43	79.92	11.43
100	113	Proper Refrigerant Charging and Air Flow	Single Family	11.21	4.32	11.21
140	142	HE Room Air Conditioner - CEE Tier 1 EER 11.3	Single Family	10.22	2.15	10.22
140	142	HE Room Air Conditioner - CEE Tier 1 EER 11.3	Multi-family	9.26	2.05	9.26
100	114	Duct Repair	Single Family	8.51	1.73	8.51
100	102	15 SEER Split-System Air Conditioner	Single Family	6.17	1.54	6.17
340	341	Second Refrigerator Recycling	Single Family	6.17	68.18	6.17
100	111	Whole House Fans	Single Family	5.99	1.02	5.99
970	971	Conservation Practices	Multi-family	5.50	8.90	5.50
140	156	Wall 2x4 R-0 to Blow-In R-13 Insulation	Multi-family	4.16	13.91	4.16
170	171	Energy Star Dehumidifier (ROB)	Multi-family	3.43	58.53	3.43
140	156	Wall 2x4 R-0 to Blow-In R-13 Insulation	Single Family	3.42	5.12	3.42
210	211	CFL (15-Watt integral ballast), 1.8 hr/day	Low Income	3.42	79.92	3.42
140	149	Single Pane Windows to Double Pane with Gas	Multi-family	2.93	1.53	2.93
100	117	Single Pane Windows to Double Pane with Gas	Single Family	2.89	1.58	2.89
160	161	EER 8.5 AC Early Replacement, CEE Tier 1 EER 11.3	Single Family	2.72	2.53	2.72
160	161	EER 8.5 AC Early Replacement, CEE Tier 1 EER 11.3	Multi-family	2.57	2.53	2.57

4.3.1.3 Commercial Sector

Figure 4-11 and Figure 4-12 show the contribution to the total commercial energy savings potential by building-type. Offices account for almost 38% of the economic energy and demand potential, followed by retail, grocery, and other commercial buildings.

Figure 4-11:
Commercial Economic Energy Savings Potential by Building Type by 2020

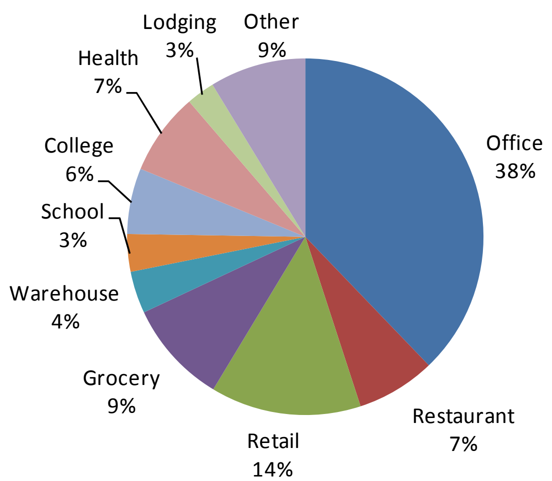
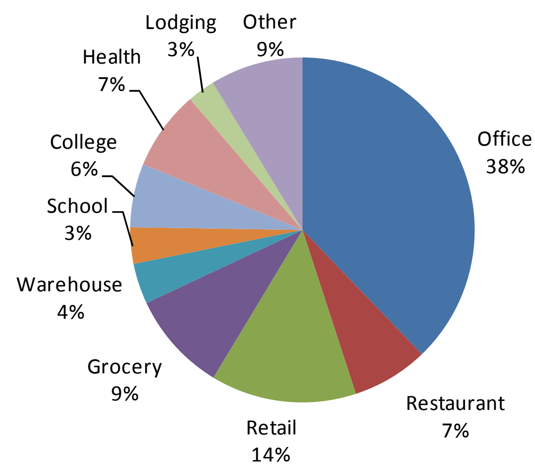


Figure 4-12:
Commercial Economic Demand Savings Potential by Building Type by 2020



4.3.1.3.1 Commercial Sector Summary

Due to the large amount of lighting used throughout the commercial sector and the numerous highly efficient and cost effective energy efficient lighting technologies that currently exist, the lighting end use is the largest contributor to both energy and peak demand economic savings potential. CFLs and premium T8 lamps with electronic ballasts are key lighting measures, as well as some LED outdoor and street lighting applications.[12] Potential savings in cooling account for the next largest share in both technical and economic potential.

In the top twenty energy saving measures, more than half of those on the technical and economic potential lists are lighting related. The measure mix changes between technical and economic top twenty as some fall out of the mix due to cost effectiveness. Overall lighting related measures in the top twenty technical potential list account for 354 GWh of technical savings and the savings from the lighting measures in the economic potential top twenty list accounts for 349 GWh of economic potential savings. Other measures within the top twenty list include PC power management enabling, variable speed drive controls, Aerosol duct sealing and demand controlled ventilation. The aerosol duct sealing measures is not cost effective across the entire commercial sector and thus not all of the technical potential is included in the economic energy savings potential.

For demand, cooling dominates the technical and economic potentials and the top twenty lists of measures. Similar cooling and lighting measures from the top twenty energy potential lists are also included in the top twenty for demand savings, but more HVAC measures, such as high efficiency chillers, duct and pipe insulation, aerosol duct sealing, and tune up and diagnostics account for a large amount of the potential demand savings.

[12] While it is highly likely that by 2020 the potential from LEDs for broad-based general illumination will far exceed current lighting potential, currently LEDs are primarily cost-effective only in specialty applications.

4.3.1.3.2 Commercial Potential Figures

Figure 4-13
Commercial Technical Energy Savings Potential by End Use by 2020

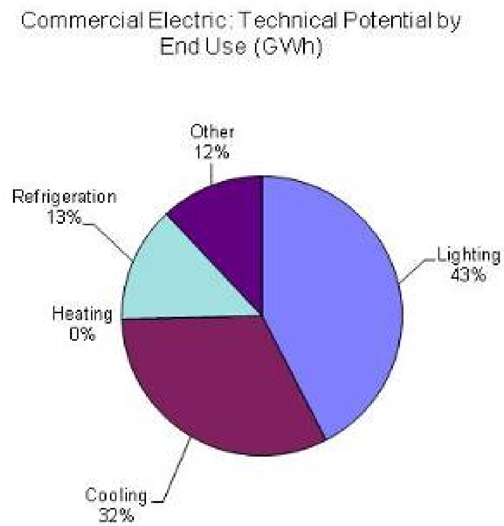


Table 4-6:
Commercial Technical Energy Savings Top Twenty Measures

Commercial Existing Top Twenty by Technical Potential (GWh)

Base	Measure Number	Measure Name	Technical GWh	TRC	Economic GWh
140	141	CFL Screw-in 18W	94.56	27.62	94.56
610	613	PC Network Power Management Enabling	54.77	23.23	54.77
350	353	DX Packaged System, EER=13.4, 10 tons	53.65	3.78	50.82
400	402	Variable Speed Drive Control, 5 HP	44.29	4.70	42.03
150	151	CFL Hardwired, Modular 18W	38.18	7.13	38.17
210	212	LED Outdoor Area Lighting	32.92	4.84	32.08
210	211	High Pressure Sodium 250W Lamp	30.71	3.38	29.93
220	222	LED Streetlighting	30.59	4.49	30.59
350	361	Aerosol Duct Sealing - DX	27.79	0.88	27.01
210	214	Outdoor Lighting Controls (Photocell/Timeclock)	24.95	17.25	24.25
520	538	Fiber Optic Display Lighting	24.82	95.59	24.82
400	403	Demand Controlled Ventilation	24.51	2.72	23.65
190	191	ROB 2L4' Premium T8, 1EB	22.76	12.78	22.55
520	521	High-efficiency fan motors	22.38	8.92	21.99
350	357	Prog. Thermostat - DX	21.30	3.30	18.84
520	530	Demand Defrost Electric	20.83	147.86	20.83
190	194	LED Indoor Lighting - Base 2L4'T8	20.39	0.56	1.12
160	161	High Bay T5 - Base Std MH	20.38	12.46	19.18
190	196	ormance Lighting Remod/Renov - 25% Savings - Ba	17.81	9.42	17.81
610	611	Energy Star or Better PC	16.81	106.33	16.81

Figure 4-14:
Commercial Technical Demand Savings Potential by End Use (2020)

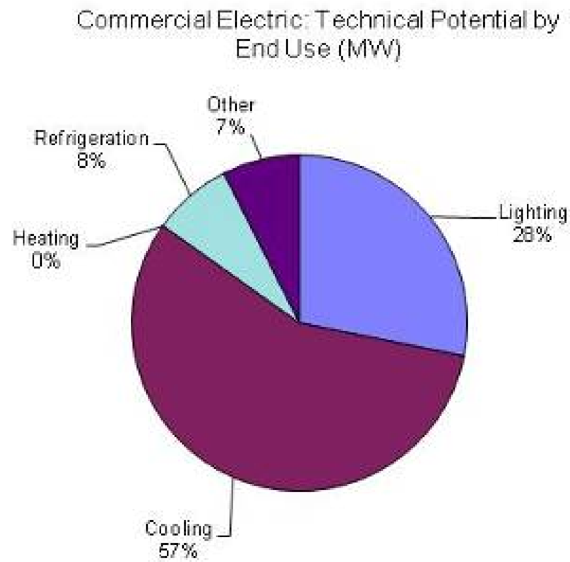


Table 4-7:
Commercial Technical Demand Savings Top Twenty Measures

Commercial Existing Top Twenty by Technical Potential (MW)

Base	Measure Number	Measure Name	Technical MW	TRC	Economic MW
350	353	DX Packaged System, EER=13.4, 10 tons	30.72	3.78	28.06
140	141	CFL Screw-in 18W	17.27	27.62	17.27
350	357	Prog. Thermostat - DX	12.27	3.30	10.24
300	301	Centrifugal Chiller, 0.51 kW/ton, 500 tons	7.98	11.31	7.98
350	362	Ceiling/roof Insulation - DX	7.97	16.06	7.97
150	151	CFL Hardwired, Modular 18W	6.97	7.13	6.97
350	363	Duct/Pipe Insulation - DX	6.47	11.44	6.47
350	359	Optimize Controls	6.47	1.62	5.58
610	613	PC Network Power Management Enabling	6.05	23.23	6.05
350	361	Aerosol Duct Sealing - DX	5.80	0.88	5.63
190	191	ROB 2L4' Premium T8, 1EB	4.10	12.78	4.06
190	194	LED Indoor Lighting - Base 2L4'T8	3.67	0.56	0.20
160	161	High Bay T5 - Base Std MH	3.59	12.46	3.37
520	538	Fiber Optic Display Lighting	3.39	95.59	3.39
190	196	ormance Lighting Remod/Renov - 25% Savings - Ba	3.21	9.42	3.21
350	351	DX Tune Up/ Advanced Diagnostics	3.12	1.69	3.03
520	521	High-efficiency fan motors	3.02	8.92	2.97
520	530	Demand Defrost Electric	2.93	147.86	2.93
180	184	LED Indoor Lighting - Base 4L4'T8	2.78	0.58	0.12
190	192	Occupancy Sensor, 8L4' Fluorescent Fixtures	2.69	5.33	2.69

Figure 4-15:
Commercial Economic Energy Savings Potential by End Use (2020)

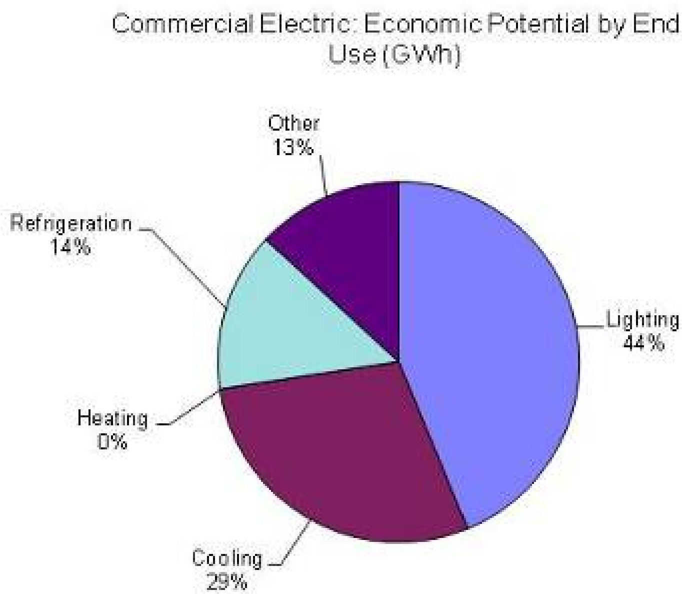


Table 4-8:
Commercial Economic Energy Savings Top Twenty Measures

Commercial Existing Top Twenty by Economic Potential (GWh)

Base	Measure Number	Measure Name	TRC	Economic GWh
140	141	CFL Screw-in 18W	27.62	94.56
610	613	PC Network Power Management Enabling	23.23	54.77
350	353	DX Packaged System, EER=13.4, 10 tons	3.78	50.82
400	402	Variable Speed Drive Control, 5 HP	4.70	42.03
150	151	CFL Hardwired, Modular 18W	7.13	38.17
210	212	LED Outdoor Area Lighting	4.84	32.08
220	222	LED Streetlighting	4.49	30.59
210	211	High Pressure Sodium 250W Lamp	3.38	29.93
350	361	Aerosol Duct Sealing - DX	0.88	27.01
520	538	Fiber Optic Display Lighting	95.59	24.82
210	214	Outdoor Lighting Controls (Photocell/Timeclock)	17.25	24.25
400	403	Demand Controlled Ventilation	2.72	23.65
190	191	ROB 2L4' Premium T8, 1EB	12.78	22.55
520	521	High-efficiency fan motors	8.92	21.99
520	530	Demand Defrost Electric	147.86	20.83
160	161	High Bay T5 - Base Std MH	12.46	19.18
350	357	Prog. Thermostat - DX	3.30	18.84
190	196	rmance Lighting Remod/Renov - 25% Savings - Ba	9.42	17.81
610	611	Energy Star or Better PC	106.33	16.81
190	192	Occupancy Sensor, 8L4' Fluorescent Fixtures	5.33	14.77

Figure 4-16:
Commercial Economic Demand Savings Potential by End Use (2020)

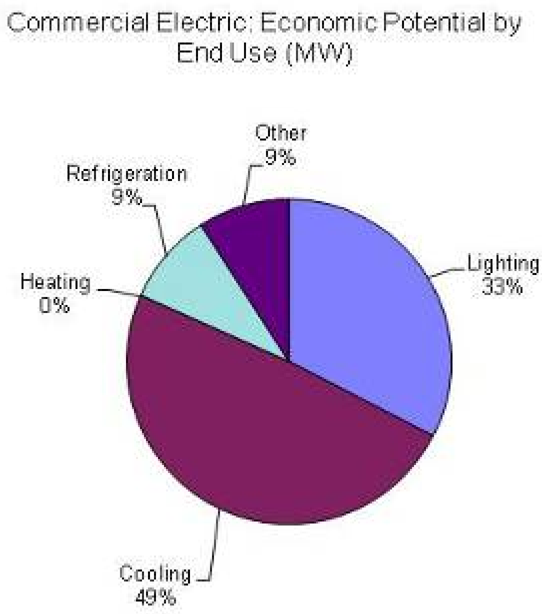


Table 4-9:
Commercial Economic Demand Savings Top Twenty Measures

Commercial Existing Top Twenty by Economic Potential (MW)

Base	Measure Number	Measure Name	TRC	Economic MW
350	353	DX Packaged System, EER=13.4, 10 tons	3.78	28.06
140	141	CFL Screw-in 18W	27.62	17.27
350	357	Prog. Thermostat - DX	3.30	10.24
300	301	Centrifugal Chiller, 0.51 kW/ton, 500 tons	11.31	7.98
350	362	Ceiling/roof Insulation - DX	16.06	7.97
150	151	CFL Hardwired, Modular 18W	7.13	6.97
350	363	Duct/Pipe Insulation - DX	11.44	6.47
610	613	PC Network Power Management Enabling	23.23	6.05
350	361	Aerosol Duct Sealing - DX	0.88	5.63
350	359	Optimize Controls	1.62	5.58
190	191	ROB 2L4' Premium T8, 1EB	12.78	4.06
520	538	Fiber Optic Display Lighting	95.59	3.39
160	161	High Bay T5 - Base Std MH	12.46	3.37
190	196	rmance Lighting Remod/Renov - 25% Savings - B	9.42	3.21
350	351	DX Tune Up/ Advanced Diagnostics	1.69	3.03
520	521	High-efficiency fan motors	8.92	2.97
520	530	Demand Defrost Electric	147.86	2.93
190	192	Occupancy Sensor, 8L4' Fluorescent Fixtures	5.33	2.69
180	181	ROB 4L4' Premium T8, 1EB	15.30	2.56
120	125	Continuous Dimming, 10L4' Fluorescent Fixtures	2.59	2.44

4.3.1.4 Industrial Sector

Figure 4-17 and Figure 4-18 show the contribution to industrial sector potential savings by business type. The rubber and plastics industries are the largest contributors to both energy and demand potential. Textiles and apparel also have very large peak demand potential.

Figure 4-17: Industrial Economic Energy Savings Potential by Business Type by 2020

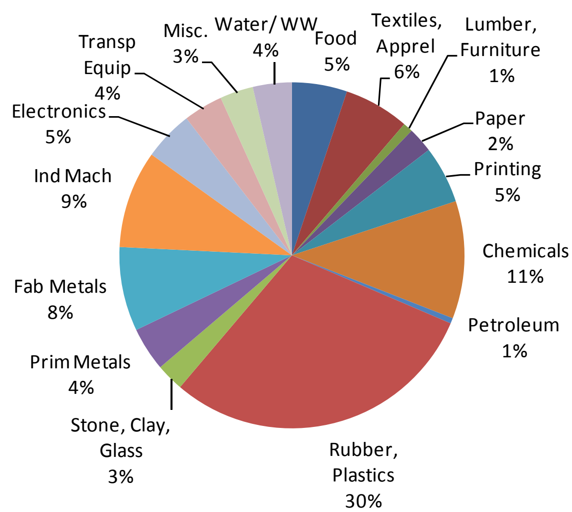
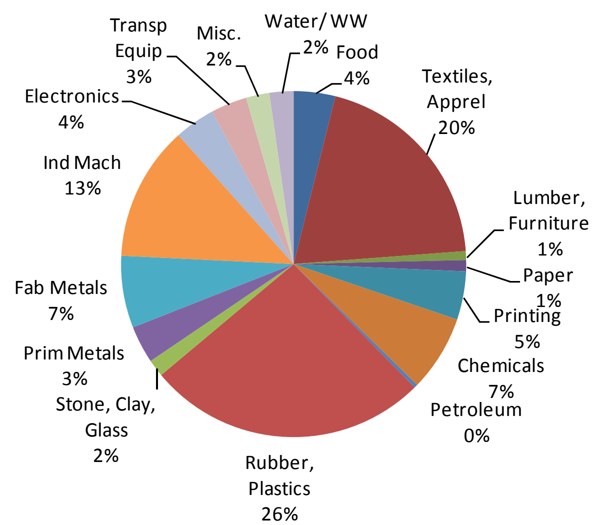


Figure 4-18: Industrial Economic Demand Savings Potential by Business Type by 2020



4.3.1.4.1 Industrial Sector Summary

Motor process measures provide the largest source of economic potential, at 25% of overall economic potential energy savings and 24% of economic demand savings, followed by fans and pumping systems. The end use splits between energy and demand savings do not differ by much since many of the end uses are not related to the time of day or year, and are generally processes running continuously.

Controls, system optimization, and improved operations and maintenance (O&M) for pumps, fans, and compressed air have a large amount of potential economic energy savings. Extruders/Injection moulding, premium T8 systems, and high efficiency are also a large part of the top twenty energy saving measures. All cost effective measures for motor processes, pumps, fans, drives and compressed air account for 72% of total economic potential.

The demand savings potential has a similar top twenty measure mix as the energy savings potential. Again, controls, system optimization, and improved O&M for pumps, fans, and compressed air account for a large amount of the economic demand savings potential, as well as extruders/injection moulding, high efficiency chillers, and direct drive extruders. Similar to energy savings, if all cost effective measures between motor processes, compressed air, pumps, and fans were installed, 66% of the demand savings economic potential could be achieved.

4.3.1.4.2 Industrial Sector Figures

Figure 4-19:
Industrial Technical Energy Savings Potential by End Use by 2020

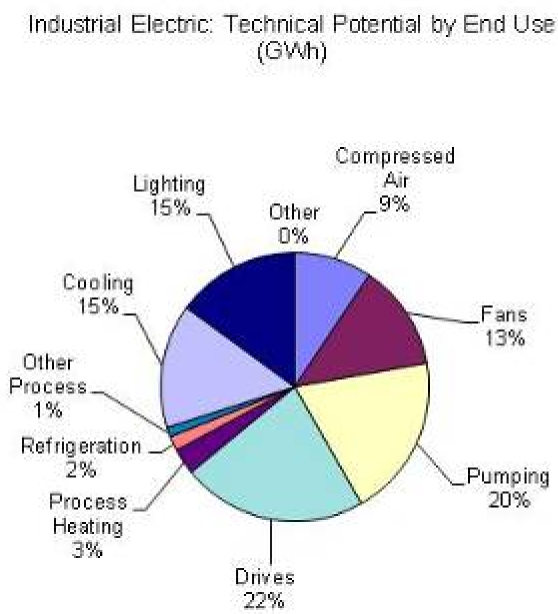


Table 4-10:
Industrial Technical Energy Savings Top Twenty Measures

Industrial Top Twenty by Technical Potential (GWh)

Base	Measure Number	Measure Name	Technical GWh	TRC	Economic GWh
800	803	Metal Halide, 50W	14.80	0.53	0.00
400	418	Extruders/injection Moulding-multipump	14.64	4.19	14.64
800	801	RET 2L4' Premium T8, 1EB	11.77	5.50	11.77
300	303	Pumps - System Optimization	11.37	6.19	11.37
200	202	Fans - Controls	10.81	4.28	10.81
300	302	Pumps - Controls	7.41	16.41	7.41
700	701	Centrifugal Chiller, 0.51 kW/ton, 500 tons	7.20	8.71	7.20
400	419	Direct drive Extruders	6.91	1.39	6.91
100	103	Compressed Air - System Optimization	6.18	14.55	6.18
200	203	Fans - System Optimization	6.08	2.92	6.08
300	304	Pumps - Sizing	5.60	12.42	5.60
300	301	Pumps - O&M	3.70	25.35	3.70
400	417	O&M - Extruders/Injection Moulding	3.67	29.04	3.67
400	420	Injection Moulding - Impulse Cooling	3.51	3.04	3.51
710	712	DX Packaged System, EER=10.9, 10 tons	3.38	2.06	3.38
400	421	Injection Moulding - Direct drive	3.37	1.87	3.37
700	703	EMS - Chiller	3.27	1.16	3.27
300	312	Pumps - ASD (100+ hp)	3.13	4.02	3.13
100	101	Compressed Air-O&M	3.04	21.54	3.04
500	552	Optimization Refrigeration	2.29	3.62	2.29

Figure 4-20:
Industrial Technical Demand Savings Potential by End Use by 2020

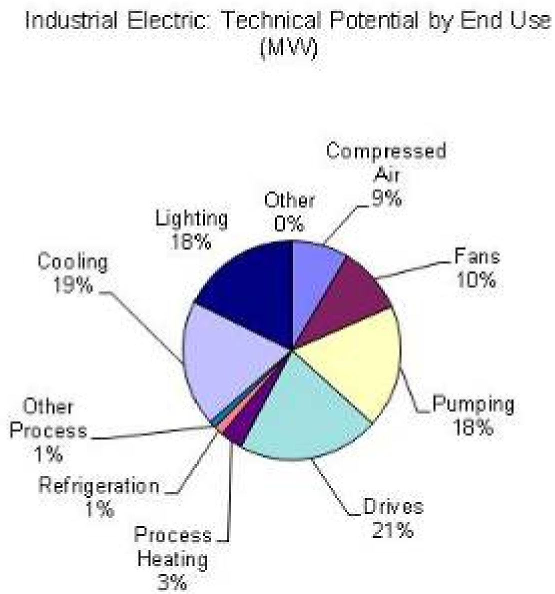


Table 4-11:
Industrial Technical Demand Savings Top Twenty Measures

Industrial Top Twenty by Technical Potential (MW)

Base	Measure Number	Measure Name	Technical MW	TRC	Economic MW
800	803	Metal Halide, 50W	2.74	0.53	0.00
800	801	RET 2L4' Premium T8, 1EB	2.19	5.50	2.19
300	303	Pumps - System Optimization	2.13	6.19	2.13
400	418	Extruders/injection Moulding-multipump	2.09	4.19	2.09
200	202	Fans - Controls	1.59	4.28	1.59
700	701	Centrifugal Chiller, 0.51 kW/ton, 500 tons	1.55	8.71	1.55
300	302	Pumps - Controls	1.20	16.41	1.20
100	103	Compressed Air - System Optimization	1.10	14.55	1.10
400	419	Direct drive Extruders	0.99	1.39	0.99
300	304	Pumps - Sizing	0.86	12.42	0.86
700	703	EMS - Chiller	0.70	1.16	0.70
300	301	Pumps - O&M	0.69	25.35	0.69
710	712	DX Packaged System, EER=10.9, 10 tons	0.67	2.06	0.67
400	402	O&M/drives spinning machines	0.60	9.17	0.60
400	417	O&M - Extruders/Injection Moulding	0.52	29.04	0.52
100	101	Compressed Air-O&M	0.52	21.54	0.52
400	420	Injection Moulding - Impulse Cooling	0.50	3.04	0.50
400	421	Injection Moulding - Direct drive	0.48	1.87	0.48
200	203	Fans - System Optimization	0.46	2.92	0.46
700	702	Window Film - Chiller	0.46	1.98	0.46

Figure 4-21:
Industrial Economic Energy Savings Potential by End Use by 2020

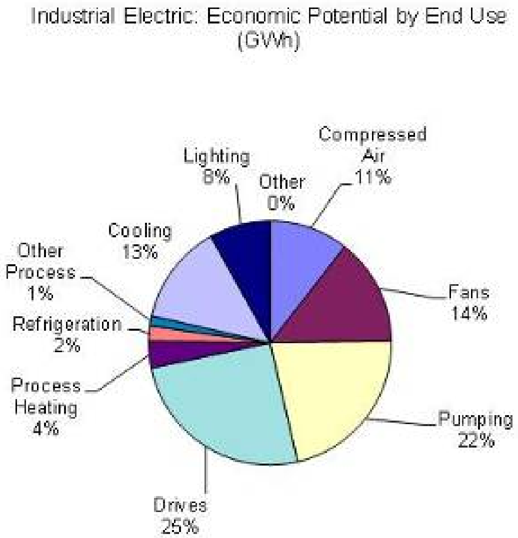


Table 4-12:
Industrial Economic Energy Savings Top Twenty Measures

Industrial Top Twenty by Economic Potential (GWh)

Base	Measure Number	Measure Name	TRC	Economic GWh
400	418	Extruders/injection Moulding-multipump	4.19	14.64
800	801	RET 2L4' Premium T8, 1EB	5.50	11.77
300	303	Pumps - System Optimization	6.19	11.37
200	202	Fans - Controls	4.28	10.81
300	302	Pumps - Controls	16.41	7.41
700	701	Centrifugal Chiller, 0.51 kW/ton, 500 tons	8.71	7.20
400	419	Direct drive Extruders	1.39	6.91
100	103	Compressed Air - System Optimization	14.55	6.18
200	203	Fans - System Optimization	2.92	6.08
300	304	Pumps - Sizing	12.42	5.60
300	301	Pumps - O&M	25.35	3.70
400	417	O&M - Extruders/Injection Moulding	29.04	3.67
400	420	Injection Moulding - Impulse Cooling	3.04	3.51
710	712	DX Packaged System, EER=10.9, 10 tons	2.06	3.38
400	421	Injection Moulding - Direct drive	1.87	3.37
700	703	EMS - Chiller	1.16	3.27
300	312	Pumps - ASD (100+ hp)	4.02	3.13
100	101	Compressed Air-O&M	21.54	3.04
500	552	Optimization Refrigeration	3.62	2.29
700	702	Window Film - Chiller	1.98	2.15

Figure 4-22:
Industrial Economic Demand Savings Potential by End Use by 2020

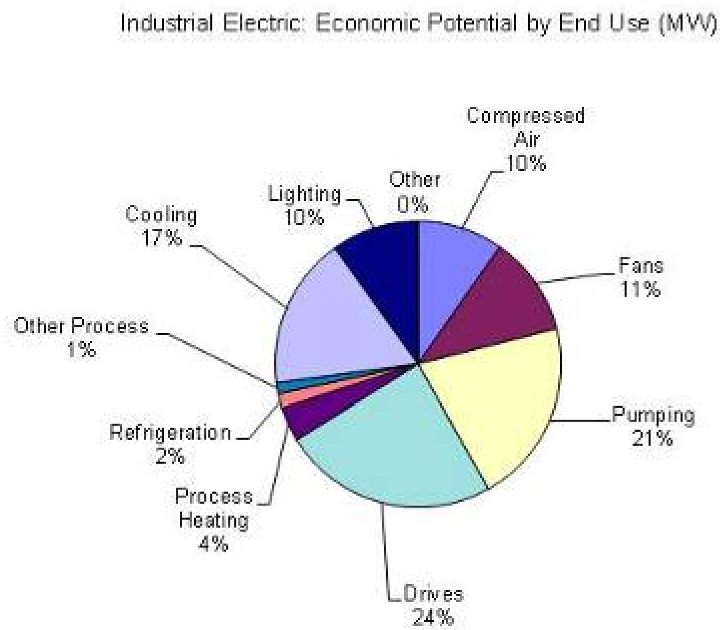


Table 4-13:
Industrial Economic Demand Savings Top Twenty

Industrial Top Twenty by Economic Potential (MW)

Base	Measure Number	Measure Name	TRC	Economic MW
800	801	RET 2L4' Premium T8, 1EB	5.50	2.19
300	303	Pumps - System Optimization	6.19	2.13
400	418	Extruders/injection Moulding-multipump	4.19	2.09
200	202	Fans - Controls	4.28	1.59
700	701	Centrifugal Chiller, 0.51 kW/ton, 500 tons	8.71	1.55
300	302	Pumps - Controls	16.41	1.20
100	103	Compressed Air - System Optimization	14.55	1.10
400	419	Direct drive Extruders	1.39	0.99
300	304	Pumps - Sizing	12.42	0.86
700	703	EMS - Chiller	1.16	0.70
300	301	Pumps - O&M	25.35	0.69
710	712	DX Packaged System, EER=10.9, 10 tons	2.06	0.67
400	402	O&M/drives spinning machines	9.17	0.60
400	417	O&M - Extruders/Injection Moulding	29.04	0.52
100	101	Compressed Air-O&M	21.54	0.52
400	420	Injection Moulding - Impulse Cooling	3.04	0.50
400	421	Injection Moulding - Direct drive	1.87	0.48
200	203	Fans - System Optimization	2.92	0.46
700	702	Window Film - Chiller	1.98	0.46
710	716	Cool Roof - DX	1.18	0.35

4.3.2 Energy Efficiency Supply Curves

A common way to illustrate the amount of energy savings per total resource cost dollar spent is to construct an energy efficiency supply curve based on the measures in the economic potential. A supply curve typically is depicted on two axes—the vertical axis represents the cost per unit of saved energy (i.e., levelized $/kWh saved) and the horizontal axis shows energy savings at each level of cost. Measures are ranked from least to most costly and total savings are calculated incrementally with respect to measures that precede them. The costs of the measures are levelized over the life of the savings achieved, and reflect total resource costs to Rhode Island ratepayers. The data presented here is from the economic potential calculated in DSM ASSYST. These are cost per levelized $/ KWh for the measure. The costs are the levelized measure costs.

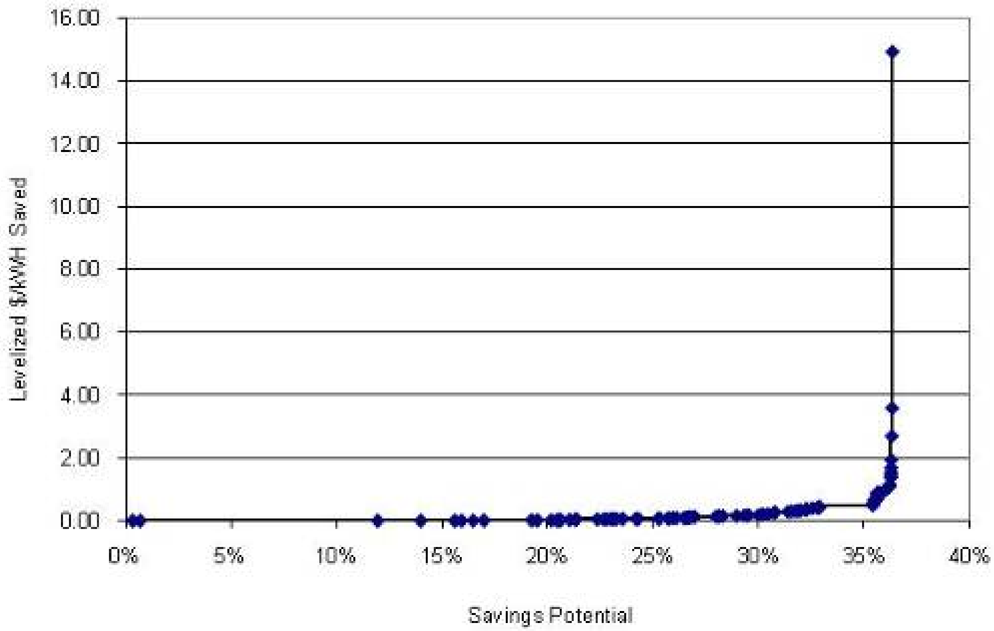
Figure 4-23 through Figure 4-28 present the supply curves constructed for this study for electric energy efficiency and peak demand efficiency. Each curve represents savings as a percentage of total energy or peak demand and is plotted against the levelized measure cost (levelized $/kWh saved) for the marginal measures at each point. This cost is exclusive of program costs like incentives and marketing; it only looks at the levelized cost of the measure as calculated for technical and economic savings. Savings potentials and levelized costs for the individual measures that comprise the supply curves are provided in Appendix F.

It is important to note that these graphs compare the total costs of each measure against only one single component of benefits. As a result, these graphs cannot be used directly to determine cost-effectiveness of measures, nor compared directly with electric avoided costs. For example, a measure may show as costing 20 cents/kWh (well above avoided electric kWh costs) yet still is highly cost-effective because of other significant benefits such as the avoided capacity costs of generation, transmission and distribution. Similarly, a measure that costs $20,000/kW saved (again well above electric kW avoided capacity costs) could be very cost-effective because of large energy (kWh) savings. In fact, by definition all measures shown in these graphs are cost-effective compared to supply because the graphs show results from economic potential.

ELECTRIC ENERGY SUPPLY CURVES:

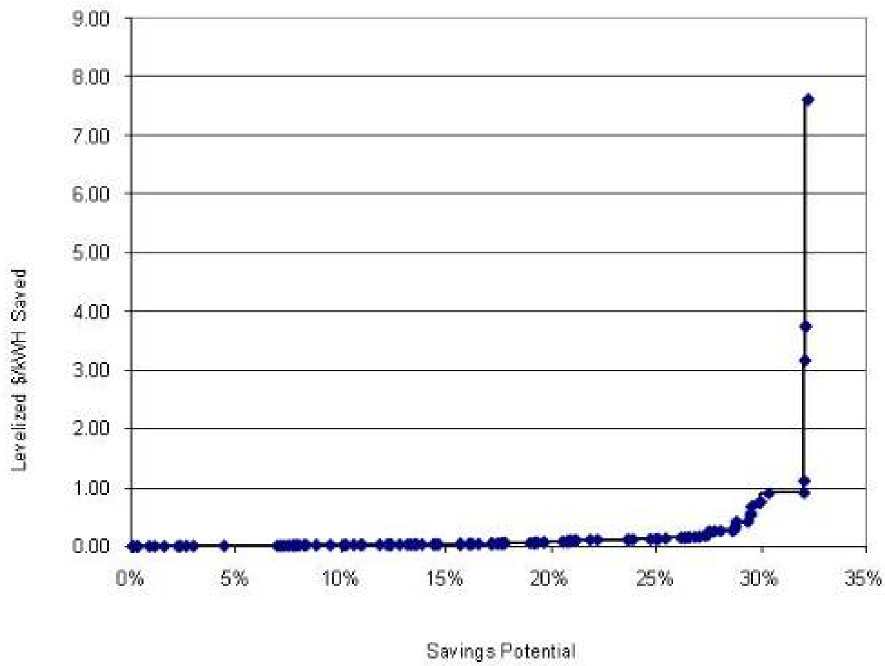
Energy Star televisions are the first two points on the residential energy supply curve, and will save roughly 1% of the residential load. Up to 20% of the base load can be saved by 10 different measures and a marginal measure cost of $0.02/kWh. These measures include plasma and LCD televisions, CFLs, appliance recycling, energy star dehumidifiers and computers, variable speed furnace fans, conservation practices. All measures cost effective or not are included in this curve, and in order to reach the maximum technical potential using all currently available technologies modeled for residential, the marginal measure cost would be $14.91/kWh.

Figure 4-23:
Residential Electric Energy Supply Curve



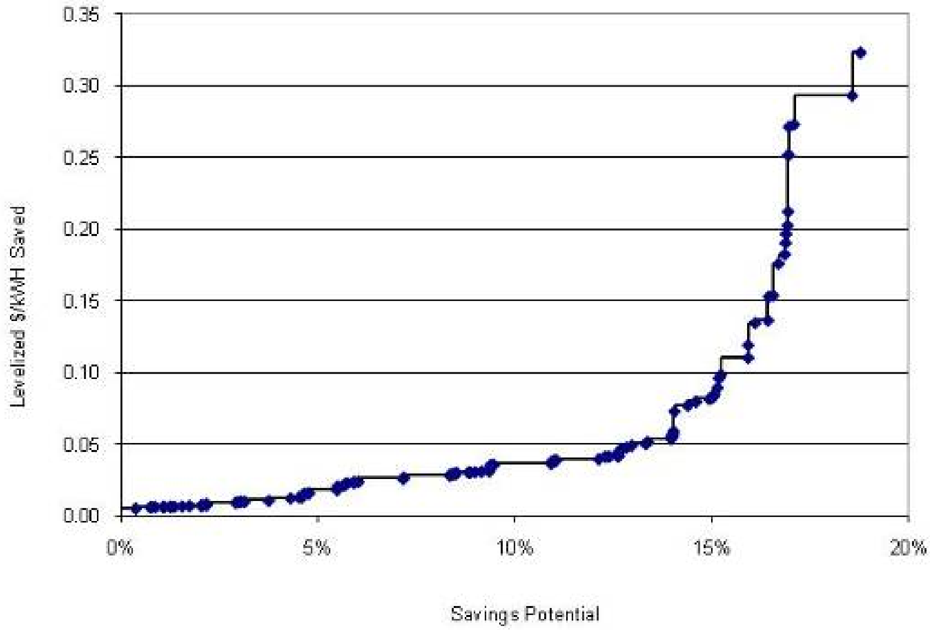
In the commercial sector, twenty percent savings can be achieved with a marginal measure cost of $0.08/kWh. The measures included in this mix span many end uses, but are mostly comprised of office equipment and behavior measures, as well as lighting and cooling measures. To achieve the maximum technical potential, there would be a marginal measure cost of $7.63/kWh.

Figure 4-24:
Commercial Electric Energy Supply Curve*



As seen in Figure 4-25 in the industrial sector, a large majority of the measures are cost effective and remain in the economic potential. As seen in the energy supply curve below, the marginal measure cost of the last measure to achieve all technical potential is much lower than in commercial at $0.32/kWh. The lowest part of the curve has many O&M measures for various motor end uses. These measures have very low costs and could achieve high savings, thus they have a small marginal cost.

Figure 4-25:
Industrial Electric Energy Supply Curve*

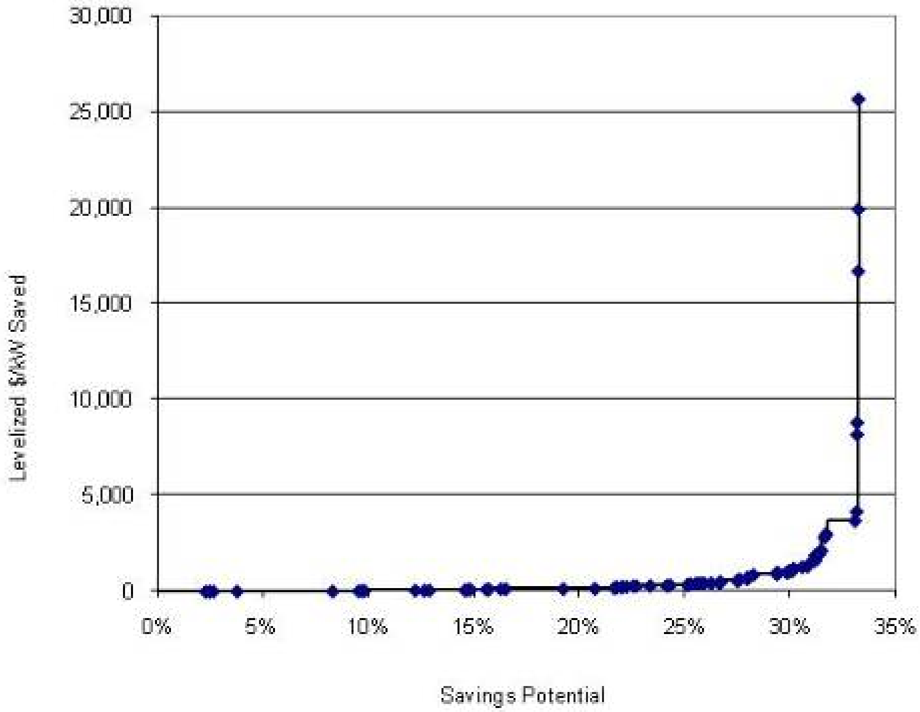


*Levelized cost per kWh saved is calculated using a 3.63 percent nominal discount rate.

ELECTRIC DEMAND SUPPLY CURVES:

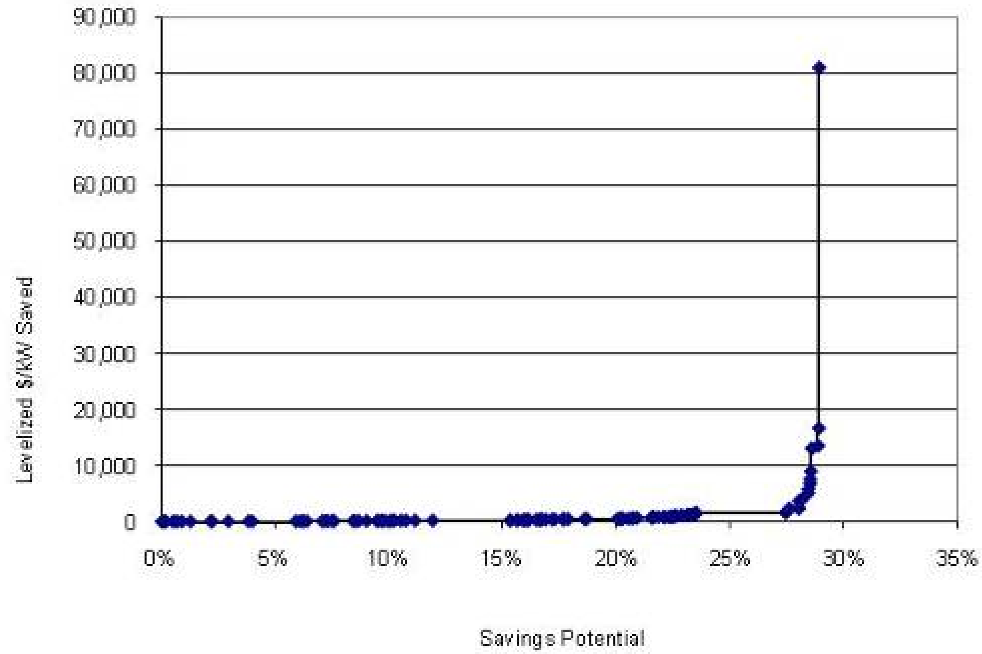
Twenty different measures are included in the first twenty percent of residential savings. In order to achieve the maximum technical demand savings potential, a marginal measure cost of around $25,000/kW is required as the last measure in the capacity curve has a very high marginal cost in order to obtain the last few MW of savings. Some of the measures on the lower portion of the curve include ENERGY STAR dehumidifiers and televisions, appliance recycling, and CFLs.

Figure 4-26:
Residential Peak Demand Supply Curve*



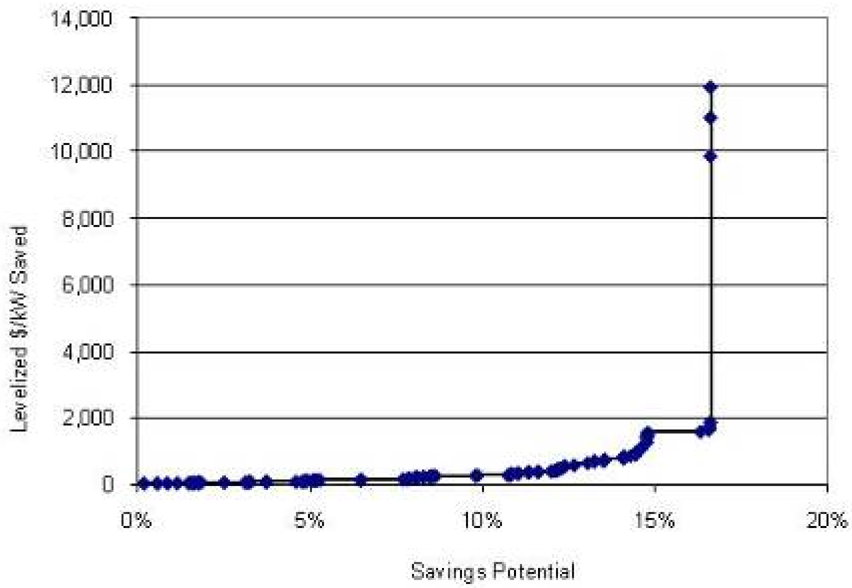
As shown in Figure 4-27 below, for the commercial sector the marginal measure cost of $464/kW acquires twenty percent of the technical demand savings. In order to get all technical demand savings, a marginal measure cost of over $80,000/kW is estimated. Some of the measures on the lower portion of the curve include office equipment and behavioral measures, and a variety of cooling and refrigeration measures.

Figure 4-27:
Commercial Peak Demand Supply Curve*



Similar to the energy supply curve in the industrial sector, most of the low cost measures on the demand curve are behavioral or operational measures that have a low cost associated with them. These measures include O&M and system and process optimizations across various motor end uses. In order to achieve the maximum technical demand savings potential, there would be a marginal measure cost of almost $12,000 per KW.

Figure 4-28:
Industrial Peak Demand Supply Curve*



*Levelized cost per kW saved is calculated using a 3.63 percent nominal discount rate.

5. Achievable (Program) Potential

In contrast to technical and economic potential estimates, achievable potential estimates take into account market and other factors that affect the adoption of efficiency measures. Our method of estimating measure adoption takes into account market barriers and reflects actual consumer- and business-implicit discount rates. This section presents results for achievable potential, first at the summary level and then by sector. More detail on achievable program potential is contained in Appendix H.

Achievable potential refers to the amount of savings that would occur in response to one or more specific program interventions. *Net* savings associated with program potential are savings that are projected beyond those that would occur naturally in the absence of any market intervention. For this analysis we created two sets of overall program portfolios. The first program portfolio consisted of the existing programs. These programs are modeled with assumptions about marketing, administrative and incentive budgets for each program grouping that reflect current National Grid programs. Customer participation is modeled using market penetration curves. The second set of programs include technologies and practices (such as new technologies, behavioral conservation, and savings associated with program activities based on exposing customers to time varying prices. New technologies were estimated at an overall level. A major difference in our results compared to proposed 2011 budgets for National Grid was the amount of CFLs – our modeling produced significantly more in the program modeled.

National Grid has been running programs in Rhode Island for over 20 years. Their programs are comprehensive and cover the retrofit, replace–on-burnout and new construction programs. The Commercial / Industrial programs have a "custom" component which allows any electric savings that are cost effective for any measure. Consistent with current program, we model the existing program potential using the following budget assumptions: we modeled these programs ramping up over time to tap as much as possible of the potential.

Table 5-1 below lists the portfolios for the Current programs and the categories of additional program activity.

Table 5-1:
Achievable Programs

Current Program Portfolio	**Existing – Residential** 1. Energy Wise 2. Low Income 3. ENERGY STAR Products 4. Appliance Recycling 5. New Construction	**Existing– Commercial/ Industrial** 1. Energy Initiative 2. Small Commercial Industrial 3. Design 2000
Additional Program Potential Categories	**Additional Programs– Residential** 1. Conservation- Behavior Conservation 2. New Technologies	**Additional Programs – Commercial/ Industrial** 1. Conservation- Behavior Conservation 2. New Technologies 3. Saving from Price Responsive Programs

Figure 5-1 presents overall new net energy savings by program type. More detail on costs and savings is presented in Appendix H.

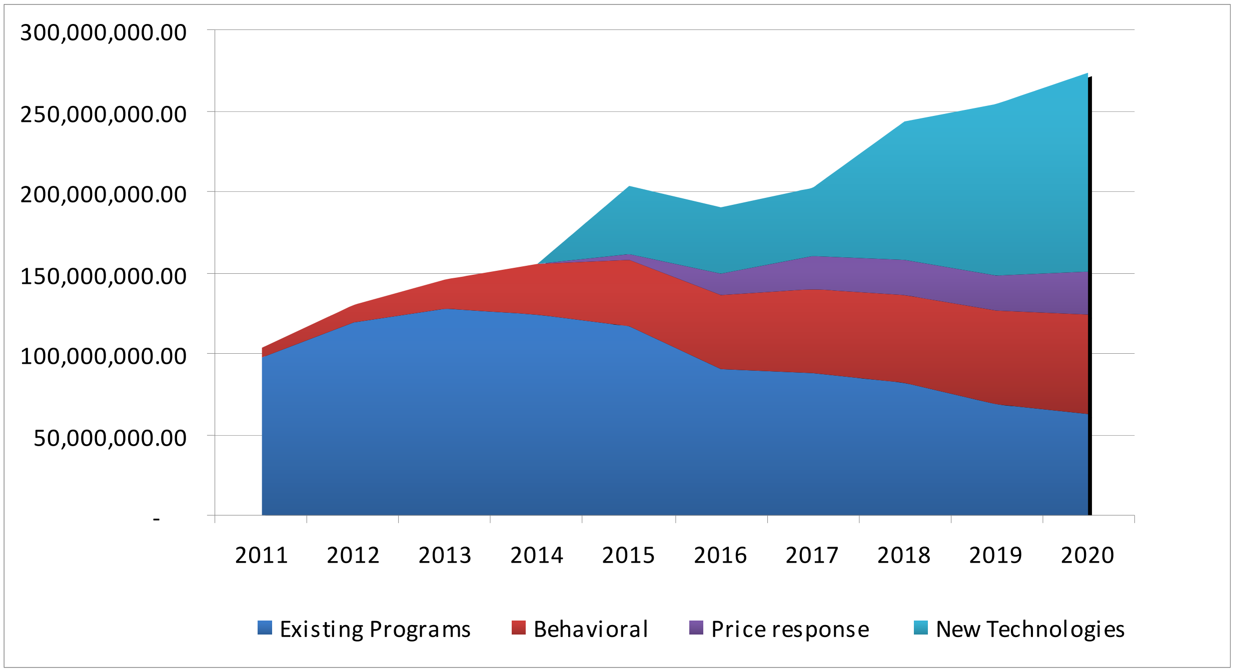
5.1 Treatment of Naturally Occurring savings and Free Riders

In the achievable analysis the model does project what would happen without program intervention given the cost effectiveness of a given measure from a customer payback perspective. As part of the achievable modeling process some an assumption is made about what percentage of naturally occurring is “counted” in a program achievable modeling on a measure by measure basis. This was informed by free rider information we were provided by National Grid.

5.2 Overall Results

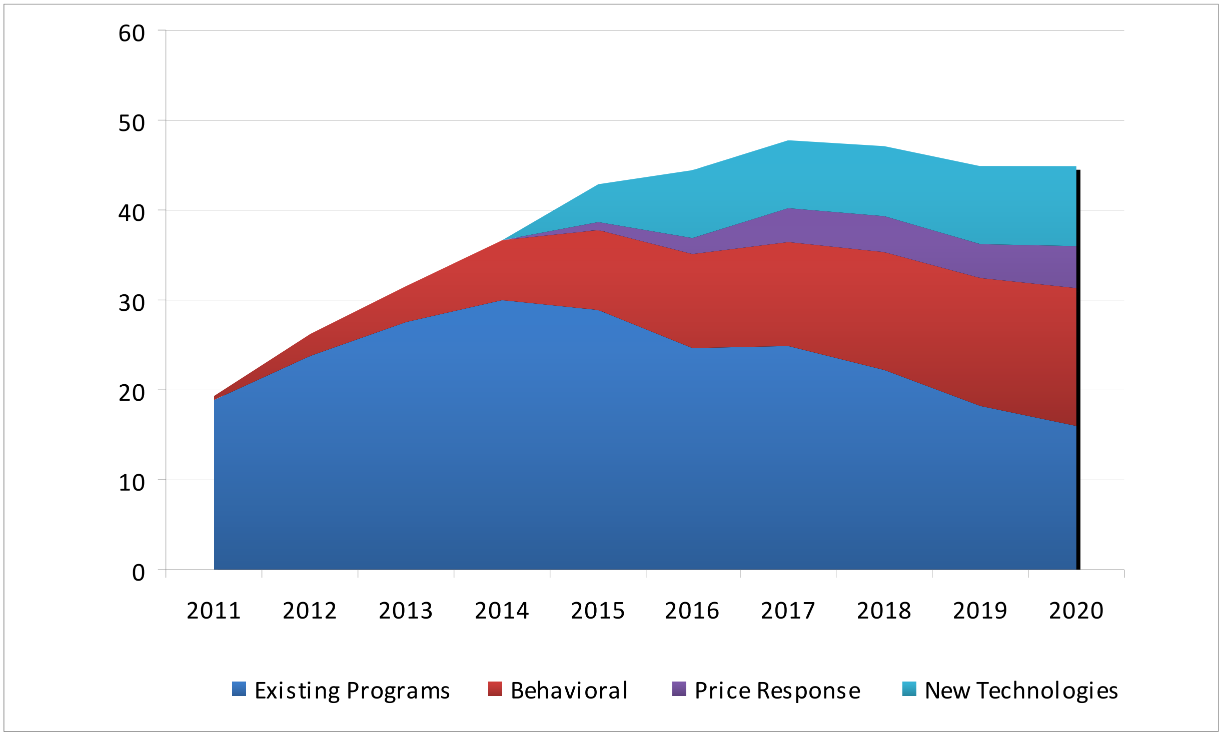
Overall new net savings for energy and demand are presented below in Figures 5-1 and 5-2 below. Cumulative results are presented by sector later in this chapter. As these results indicate, the mix of program over time changes to include more than the existing program base.

Figure 5-1
New Net Energy Savings from Programs Types in KWh



The associated demand savings are shown below:

Figure 5-2:
New Net Demand Savings from Program Types in MW



Saving are presented cumulatively in Figures 5-3 and 5-4. In these figures we combined behavioral, price response and new technologies into the "new programs" category.

Figure 5-3:
Cumulative Energy Savings

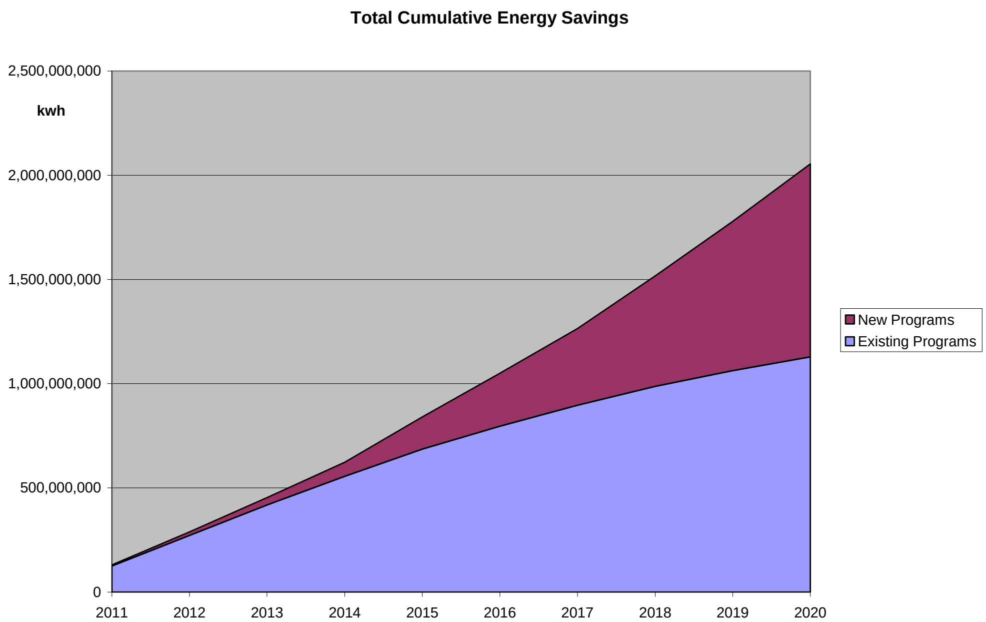
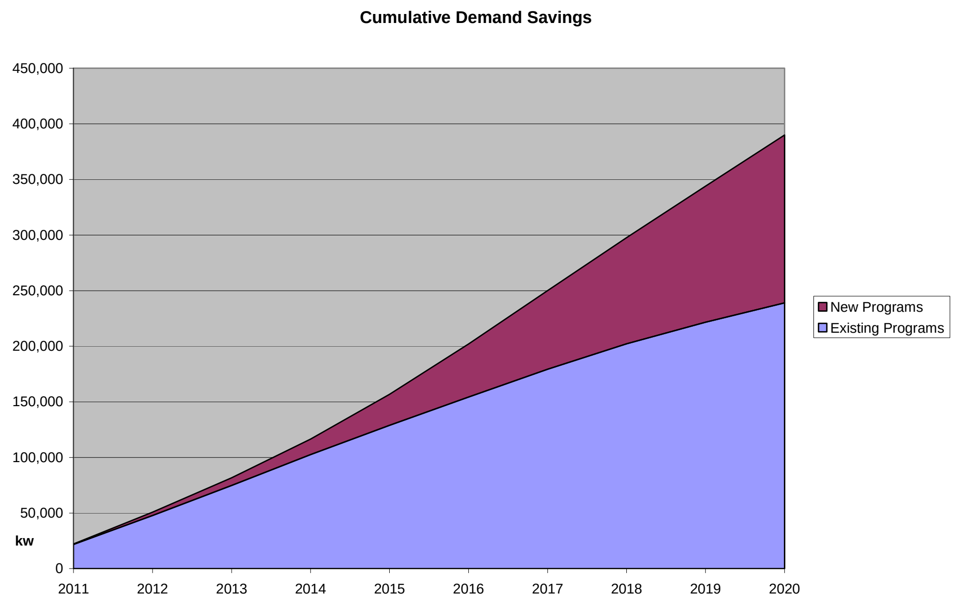


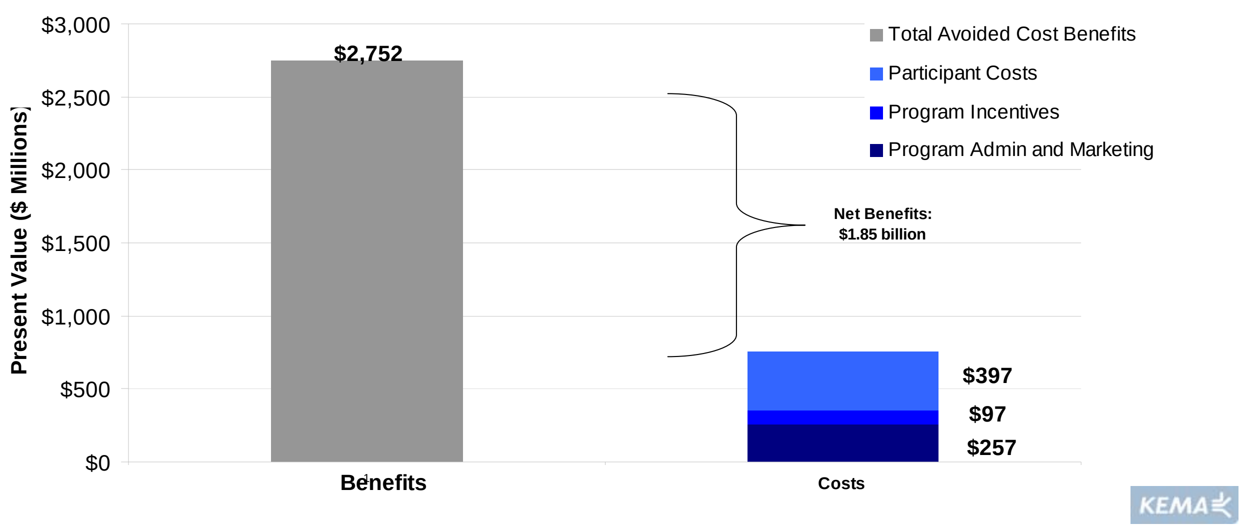
Figure 5-4:
Cumulative Demand Savings



5.2.1 Overall Cost Effectiveness

The overall benefits and costs are presented in the figure below:

Figure 5-5:
Overall Benefits and Costs



As this figure illustrates the achievable savings are very cost effective. For every dollar invested by Rhode Island ratepayers in efficiency programs they would recoup close to 3 dollars in benefits.

Table 5-2 below presents the total resource cost test for all programs.

Table 5-2:
Total Resource Cost Results

Program	Overall TRC
All Programs	3.75
Existing Industrial Programs	3.99
Existing Commercial Programs	5.24
Existing Residential Programs	3.20
Behavioral Industrial	2.66
Behavioral Commercial	2.42
Behavioral Residential	2.29
Price Responsive Commercial	3.87
New Technologies	1.13

As this table indicates the programs modeled are for the most part highly cost effective. New Technologies is less given it is a proxy for new measures that will be more cost effective in the longer run. The TRCs presented here represent the measure mix in the programs as modeled in our analysis. They contain a different measure mix than National Grid's programs. They also do not include evaluation, planning, RIEERMC costs and shareholder incentives that are included in National Grid's benefit cost analysis.

5.3 Residential Results

5.3.1 Overall Residential Results

This section presents summary results for all residential programs. Table 5-3 presents residential energy savings by existing programs and proposed program activities.

Table 5-3:
New Net Energy Saving by Program for Residential Programs

Residential Energy Savings - kWh	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Existing Programs										
Replace on Burnout	6,768,694	8,375,721	8,843,094	9,860,218	9,169,035	8,730,554	6,467,246	8,626,318	8,142,654	7,795,693
Replace on Burnout Low Income	732,575	867,408	992,414	1,114,286	1,210,724	1,308,738	1,289,470	1,273,489	1,222,967	1,172,664
Retrofit	8,671,114	10,413,486	10,338,053	12,755,806	10,318,945	8,135,400	12,974,922	8,843,592	6,114,115	4,268,574
Retrofit Low Income	1,836,593	2,178,290	2,275,030	2,143,441	1,848,956	1,461,884	1,083,394	732,474	414,876	190,536
CFLs/LEDs	24,064,849	30,886,225	26,548,785							
LEDs Post CFLs				18,376,661	21,803,021	3,756,169	4,244,022	4,551,515	4,696,045	4,699,751
New Construction	154,710	208,470	180,882	177,298	183,478	194,693	208,923	225,164	242,858	261,674
Refrigerator Recycling	5,794,240	5,794,240	5,794,240	5,794,240	5,794,240	5,794,240	5,794,240	5,794,240		
New Programs										
Behavioral			7,200,000	20,400,000	28,400,000	32,536,000	36,860,000	39,936,000	42,816,000	45,696,000
Price Response	-	-								
Energy Savings Totals										
Program Total	48,022,774	58,723,839	62,172,500	70,621,950	78,728,398	61,917,678	68,922,217	69,982,792	63,649,514	64,084,893

Table 5-4 presents the new net demand saving by program for the residential programs.

Table 5-4:
New Net Demand Savings by Program for Residential Programs

Residential Demand Savings-kW	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Existing Programs										
Replace on Burnout	1,406	1,813	1,907	2,179	2,077	2,007	1,716	2,933	2,851	2,785
Replace on Burnout Low Income	143	180	214	248	278	309	322	327	318	310
Retrofit	2,241	2,922	3,227	4,573	3,954	3,247	5,577	4,055	3,013	2,282
Retrofit Low Income	603	744	791	757	665	536	407	291	180	105
CFLs/LEDs	2,437	3,127	2,688							
LEDs Post CFLs				1,861	2,208	380	430	461	475	476
New Construction	33	44	39	38	39	41	45	48	52	56
Refrigerator Recycling	661	661	661	661	661	661	661	661		
New Programs										
Behavioral			1,530	4,335	6,375	7,747	9,152	10,526	11,750	12,974
Price Response	-	-								
Demand Savings Totals										
Program Total	7,524	9,492	11,057	14,651	16,258	14,929	18,310	19,302	18,639	18,988

5.3.2 CFL Potentials and Federal Lighting Standards

This study assumes there will be no net program savings from CFLs after 2014 as the new lighting standards determined in the Energy Independence and Security Act of 2007 take effect. This legislation requires that bulbs phased in between 2012 and 2014 must be at least thirty percent (30%) more efficient than incandescent lamps. Currently CFLs are highly cost effective and as such provide a large amount of savings during the early years of this study. CFLs also have a lot of naturally occurring savings associated with them due to their cost effectiveness and prominence in the market and advertisements. Their savings are not counted after 2014 due to the Energy Independence and Security Act.

The survey provided this study with information on CFL usage. Respondents who previously purchased a compact fluorescent light bulb indicate a wide distribution of responses in regards to the approximate percentage of standard incandescent light bulbs they replaced with CFLs. Even though 45% of residents have replaced less than a quarter of their standard incandescent lights with CFLs, 25% have replaced three quarters or more of their standard incandescent lights with CFLs. CFLs are a large component of the economic potential and their continued price reductions make them highly cost effective.

5.3.3 Modeling of Existing Residential National Grid Programs

As many of National Grid's Programs are multi measure and different programs contain the same measures; we mapped measures into the following categories rather than based on current programs:

- Retrofit
- Replace on Burnout
- Lighting
- New Construction
- Refrigerator Recycling

Modeling of New Programs/ Activities

As discussed previously the following new program activities were modeled:

- Behavioral Conservation
- Savings from New Technologies

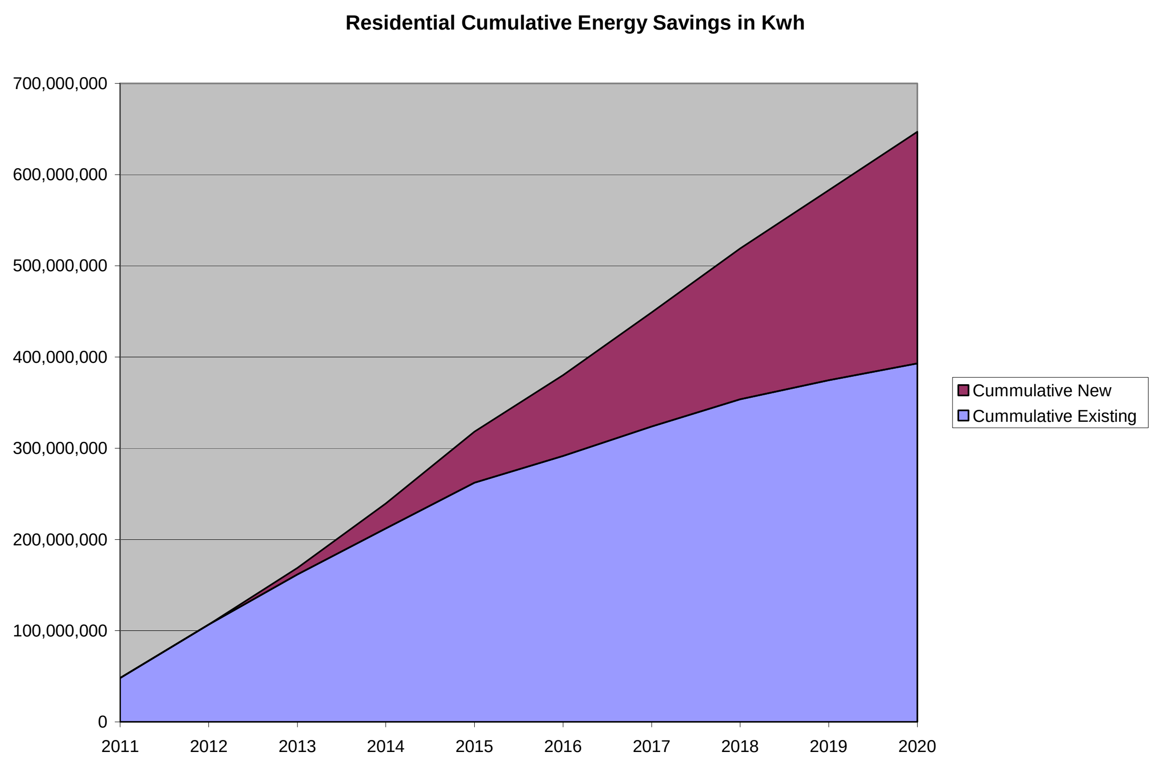
Behavioral conservation in the residential sector was modeled as with customer using a display to provide feedback on their usage continuously. Overall program assumptions are provided in detail in Appendix H. This was modeled outside the model.

The measures that were in the technical potential but not in the Economic and would be representative of new technologies. Those include:

- Other LEDs
- Heat Pump Driers
- Hi Efficiency Dryers
- Whole house fans
- 17 Seer Split system
- 15 Seer Split system -early replacement

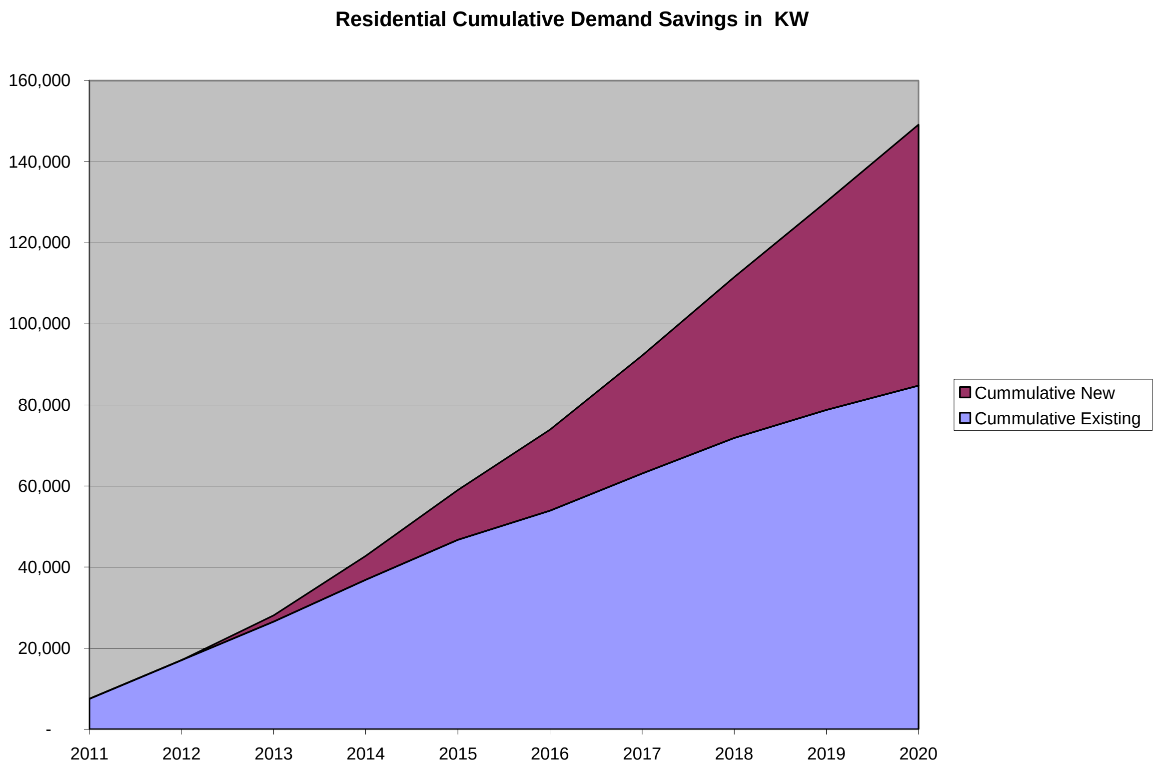
The relative importance over time of the existing programs versus new program activities is shown for energy in Figure 5-6 below:

Figure 5-6:
Cumulative Residential Energy Savings



Total Residential program demand savings overtime is shown in Figure 5-7.

**Figure 5-7:
Cumulative Residential Demand Savings**



5.4 Commercial Results

This section presents summary results by sector all Commercial programs. Table 5-5 presents Commercial energy savings at an overall level.

Table 5-5:
Overall Commercial Results by Program

Commercial Energy Savings - kWh	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Existing Programs										
LEDs	11,285	11,000	10,729	10,470	10,223	9,986	9,760	9,544	9,337	9,139
CFLs	1,779,542	1,751,650	1,588,777	1,348,177						
CFLs not in program	796,448	990,527	1,172,331	1,333,336						
Retrofit	27,492,537	33,711,995	35,408,065	33,629,111	29,739,765	24,981,590	20,235,404	15,988,026	12,423,657	9,545,448
Reftrofit not in program	1,179,548	1,417,821	1,577,321	1,664,255	1,688,087	1,660,073	1,594,768	1,500,273	1,386,260	1,261,092
Replace on Burnout	851,406	1,068,390	1,360,834	1,807,591	2,561,185	3,583,875	4,760,005	5,861,154	6,442,861	6,423,711
ROB not in program	1,161,616	1,318,999	1,466,329	1,604,125	1,529,554	1,603,877	1,642,477	1,692,832	1,541,561	1,545,693
New Construction	6,855,879	10,493,269	20,390,621	23,589,762	23,457,229	23,293,373	23,112,265	22,920,935	22,723,284	22,521,650
New Programs										
Behavioral	5,625,000	11,250,000	11,250,000	11,250,000	11,250,000	11,250,000	11,250,000	11,250,000	11,250,000	13,200,000
Price Response	-	-	-	-	4,067,283	12,388,790	20,963,193	21,274,029	21,559,895	26,210,167
Energy Savings Totals										
Program Total	45,753,261	62,013,652	74,225,007	76,236,828	74,303,326	78,771,564	83,567,873	80,496,793	77,336,855	80,716,900

Table 5-6 presents the overall demand results by Program for the Commercial Programs.

Table 5-6
Overall Demand Results by Program for Commercial Programs

Commercial Demand Savings - kW	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Existing Programs										
LEDs	1	1	1	1	1	1	1	1	1	1
CFLs	323	318	289	245						
CFLs not in program	149	186	220	250						
Retrofit	3,509	4,418	5,701	6,850	7,300	6,717	5,604	4,140	2,801	1,926
Reftrofit not in program	375	430	466	484	487	478	459	433	402	368
Replace on Burnout	3,976	4,943	5,323	5,233	4,834	4,279	3,682	3,115	2,610	2,177
ROB not in program	149	186	220	250	278	237	243	246	248	248
New Construction	1,464	2,224	4,312	4,987	4,960	4,928	4,891	4,853	4,813	4,773
New Programs										
Behavioral	500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Price Response			-	-	910	1,821	3,644	4,102	3,649	4,564
Demand Savings Totals										
Program Total	10,446	15,206	19,031	20,800	21,270	20,960	21,024	19,389	17,023	16,557

5.4.1 Modeling of Existing Residential National Grid Programs

As many of National Grid's Programs Commercial and Industrial are multi measure and different programs contain the same measures; we modeled the existing programs in the following manner:

- LEDs
- CFLs
- CFLs not in program
- Retrofit
- Retrofit not in program
- Replace on Burnout
- Replace on burnout not in program
- New Construction

The program runs for these are found in Appendix H.

5.4.2 Modeling of New Programs/ Activities

As discussed previously the following new program activities were modeled:

- *Behavioral Conservation*
- *Savings from New Technologies*
- *Savings from Price Response*

Behavioral conservation in the commercial sector was modeled as a feedback program. Customers are provided with displays and software to review their usage and possible be able to benchmark against similar customers. Details of how this program was modeled are provided in Appendix H.

Price response program savings were modeled in a similar manner with significant costs associated with marketing and education along with access of some kind to time differentiated prices.

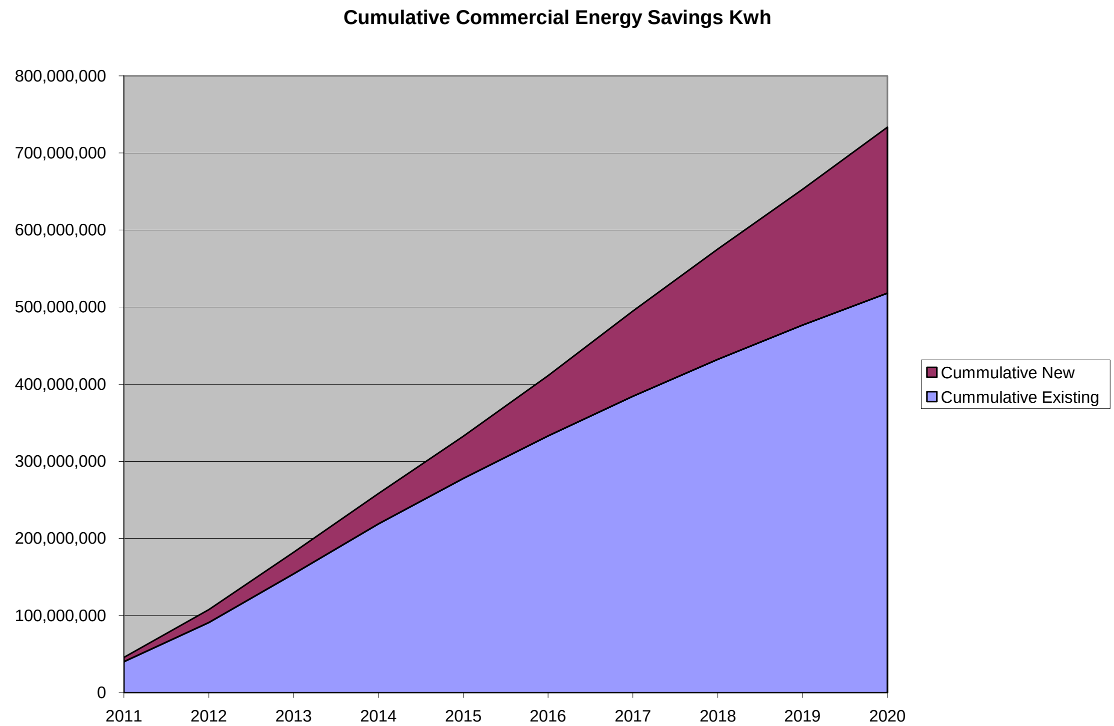
The measures that were in the technical potential but not in the economic potential are show below. These would be representative new technologies. Those include:

- Ceramic Metal Halide
- LED Indoor Lighting - Base 4L4'T8
- LED Indoor Lighting - Base 2L4'T8
- LED Outdoor Bi-level Fixtures
- Window Film (Standard)
- Cool Roof - Chiller
- Duct/Pipe Insulation - Chiller
- DX Packaged System, EER=13.4, 10 tons
- Cool Roof - DX
- Duct/Pipe Insulation - DX
- Air Handler Optimization, 15 HP
- Demand Controlled Ventilation

- Energy Recovery Ventilation
- HE Refrigerator - CEE Tier 2 (side by side freezer)
- Hot Water Pipe Insulation
- Heat Recovery Unit
- Demand controlled circulating systems
- Efficient Fryer
- Efficient Steamer
- Energy Star Hot Food Holding Cabinets
- Ceramic Metal Halide
- LED Outdoor Bi-level Fixtures
- DX Packaged System, EER=13.4, 10 tons
- Duct/Pipe Insulation - DX
- Energy Recovery Ventilation
- HE Refrigerator - CEE Tier 2 (side by side freezer)
- Evaporator fan controller for MT walk-ins
- Multiplex Compressor System
- LED Display Lighting
- Efficient Steamer
- Convection Oven
- Ceramic Metal Halide

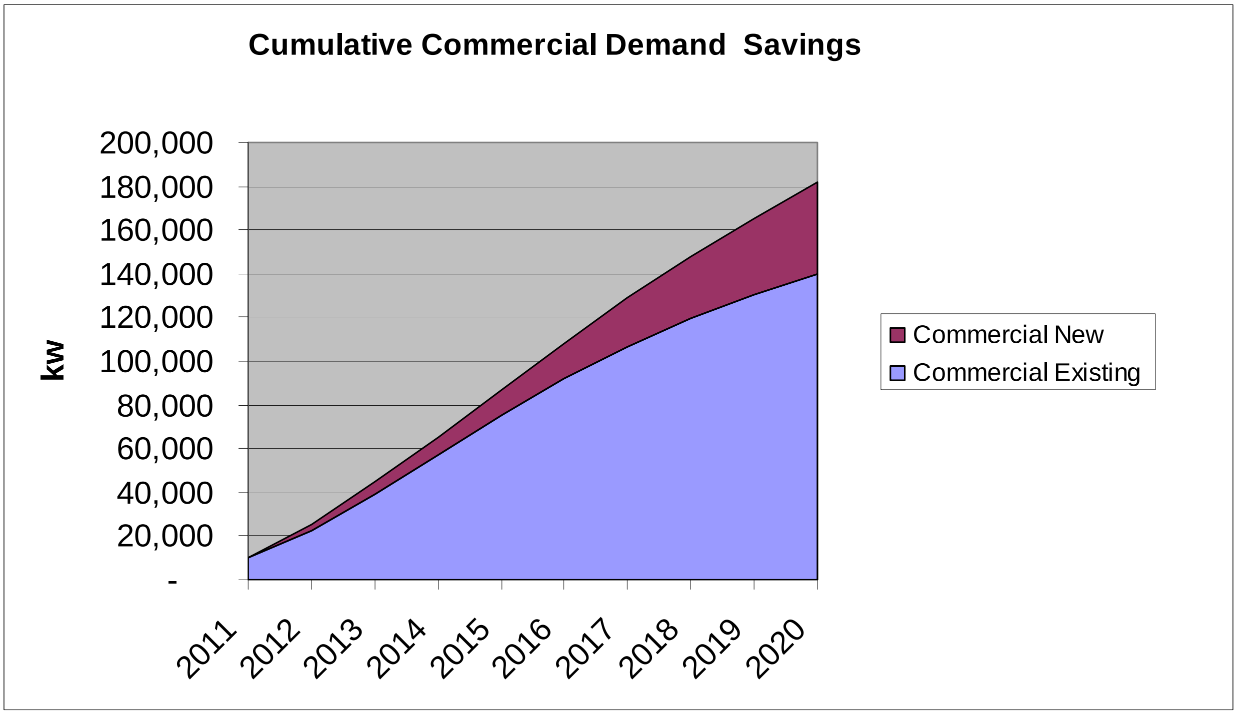
The relative importance over time of the existing programs versus new program activities is shown for energy in Figure 5-8 below:

**Figure 5-8:
Cumulative Commercial Energy Savings**



Program demand overtime is shown in Figure 5-10.

Figure 5-9:
Cumulative Commercial Demand Savings



5.5 Industrial Results

This section presents summary results by sector all for all industrial programs. Figure 5-10 presents total industrial savings for all activities.

Figure 5-10:
Overall New Net Energy Industrial Results

Industrial Energy Savings - kWh	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Existing Programs										
Replace on Burnout	2,141,958	2,275,921	2,385,757	2,472,573	2,536,918	2,586,028	2,617,967	2,636,927	2,632,642	2,626,477
Retrofit	7,181,102	7,555,558	7,023,899	5,948,939	4,662,457	3,404,529	2,305,641	1,419,750	746,721	258,626
New Programs										
	-	-	-							
Behavioral				720,000	1,440,000	2,160,000	2,760,000	3,240,000	3,720,000	2,400,000
Energy Savings Totals										
Program Total	9,323,060	9,831,480	9,409,656	9,141,511	8,639,375	8,150,556	7,683,609	7,296,677	7,099,363	5,285,103

Figure 5-11:
Overall New Net Demand Industrial Results

Industrial Demand Savings - kW	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Existing Programs										
Replace on Burnout	340	357	372	383	391	397	401	402	399	397
Retrofit	1,108	1,167	1,089	930	737	549	382	246	140	63
New Programs										
Savings from AMI										
Behavioral				400	400	400	400	400	400	360
Indsutrial Demand Savings Totals										
Program Total	1,447	1,524	1,461	1,713	1,528	1,346	1,183	1,048	940	820

5.5.1 Modeling of Existing industrial National Grid Programs

National Grid's Energy Initiative program provides energy efficiency services for Industrial customers. This was modeled as Replace on Burnout and Retrofit.

5.5.2 Modeling of New Programs/ Activities

As discussed previously the following new program activities were modeled:

- Behavioral Conservation
- Savings from New Technologies

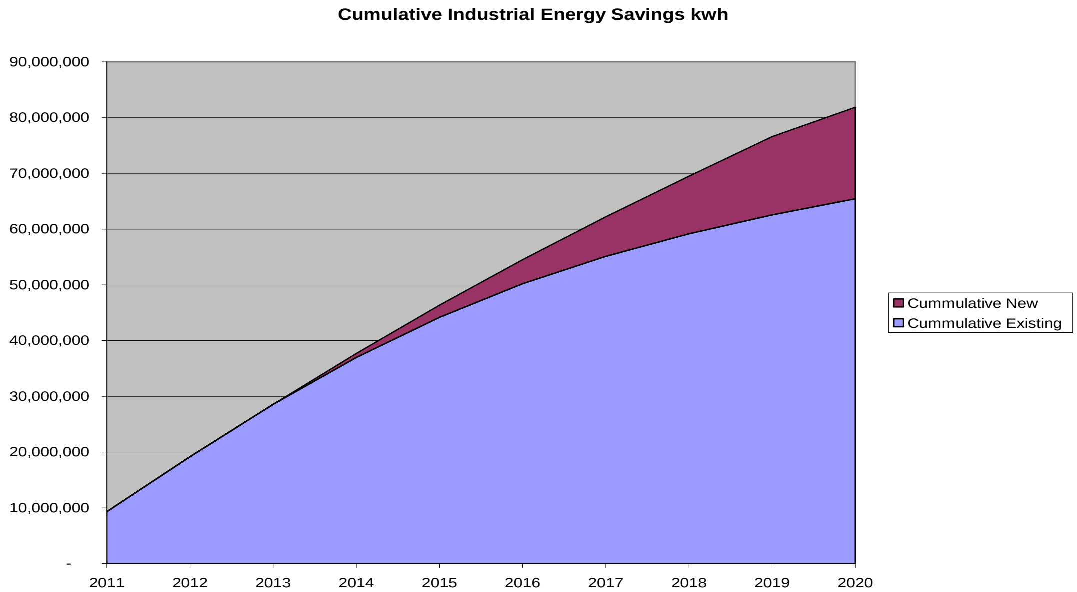
Behavioral conservation in the industrial sector was modeled as providing customer with a display along with software which would provide them with regular feedback on their usage as well as a comparison to a other similar customers in their industry. The comparison to other customers would most likely be some type of benchmarking tool.

Technologies that were in the technical potential but not in the economic in this sector include:

Measure	Building Type
Cooling Circ. Pumps - VSD	Water / WW
Pumps - Replace 6-100 HP motor	Electronics
Pumps - Replace 6-100 HP motor	Printing
Fans - Replace 6-100 HP motor	Lumber-Furniture
Cooling Circ. Pumps - VSD	Food
Cool Roof - Chiller	Textiles-Apparel
Evaporative Pre-Cooler	Petroleum
Evaporative Pre-Cooler	Chemicals
Cooling Circ. Pumps - VSD	Electronics
Cooling Circ. Pumps - VSD	Printing
Evaporative Pre-Cooler	Stone-Clay-Glass
Evaporative Pre-Cooler	Misc Ind
Evaporative Pre-Cooler	Water / WW
Pumps - Replace 6-100 HP motor	Transp Equip
Cooling Circ. Pumps - VSD	Rubber-Plastics
Drives - Process Controls (batch + site)	Stone-Clay-Glass
Pumps - Replace 6-100 HP motor	Lumber-Furniture
Evaporative Pre-Cooler	Food
Cooling Circ. Pumps - VSD	Fab Metals
Cooling Circ. Pumps - VSD	Transp Equip
Evaporative Pre-Cooler	Electronics
Evaporative Pre-Cooler	Printing
Cooling Circ. Pumps - VSD	Prim Metals
Cooling Circ. Pumps - VSD	Lumber-Furniture
Evaporative Pre-Cooler	Rubber-Plastics
Evaporative Pre-Cooler	Fab Metals
Comp Air - Replace 1-5 HP motor	Textiles-Apparel
Evaporative Pre-Cooler	Transp Equip
Evaporative Pre-Cooler	Prim Metals
Evaporative Pre-Cooler	Lumber-Furniture
Comp Air - Replace 6-100 HP motor	Paper

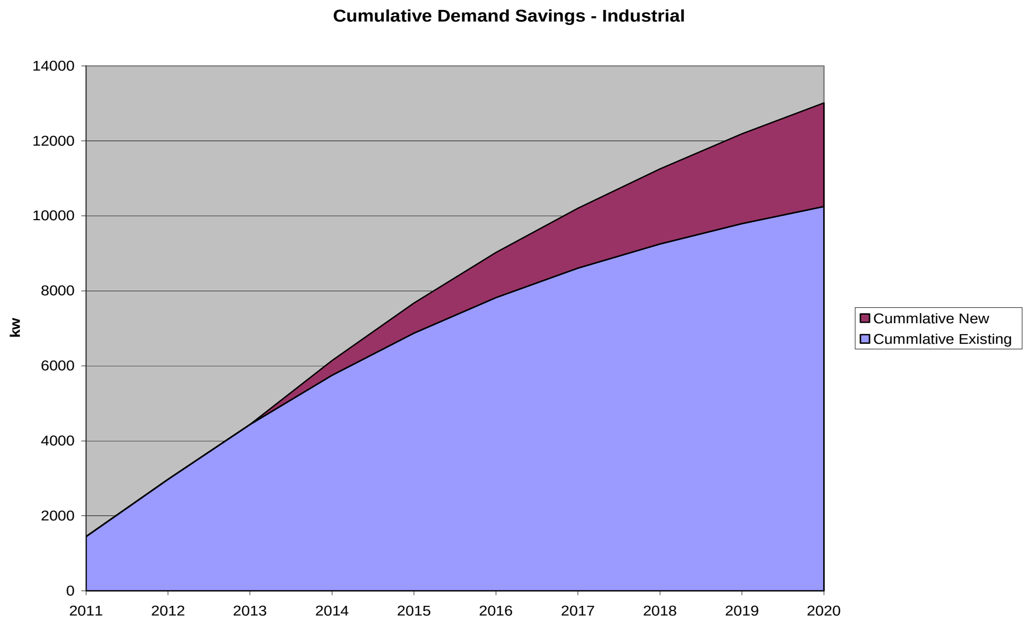
The relative importance over time of the existing programs versus new program activities is shown for cumulative energy in Figure 5-12 below:

Figure 5-12:
Industrial Energy Savings



Total demand over time is show in Figure 5-13 below:

Figure 5-13:
Industrial Demand



5.6 Approach to New Technologies and Savings Projections

KEMA reviewed the technologies that did not pass the cost effectiveness test in the Economic Potential analysis. The overall costs varied significantly by technology and sector. We ultimately decided to use a generic, simplistic and conservative approach and estimated new technologies to grow to approximately three percent of total energy and demand by 2020. We priced these at 10 cents/ first year per kWh to provide a placeholder cost for implementation of these technologies in a program. As noted in the next section there is much greater potential for savings from new technologies. The Table below presents the overall savings from our estimates along with an estimate of costs which is in the administrative cost line. Overall benefit cost is about 1.12. We anticipate these would in actuality be added to an existing program delivery mechanism. We feel these are a very conservative estimate of the potential impacts of new technologies as discussed in the next section. Figures 5-14 and 5-15 present the cumulative energy and demand from new technologies at an overall level.

Figure 5-14: Cumulative Energy from New Technologies

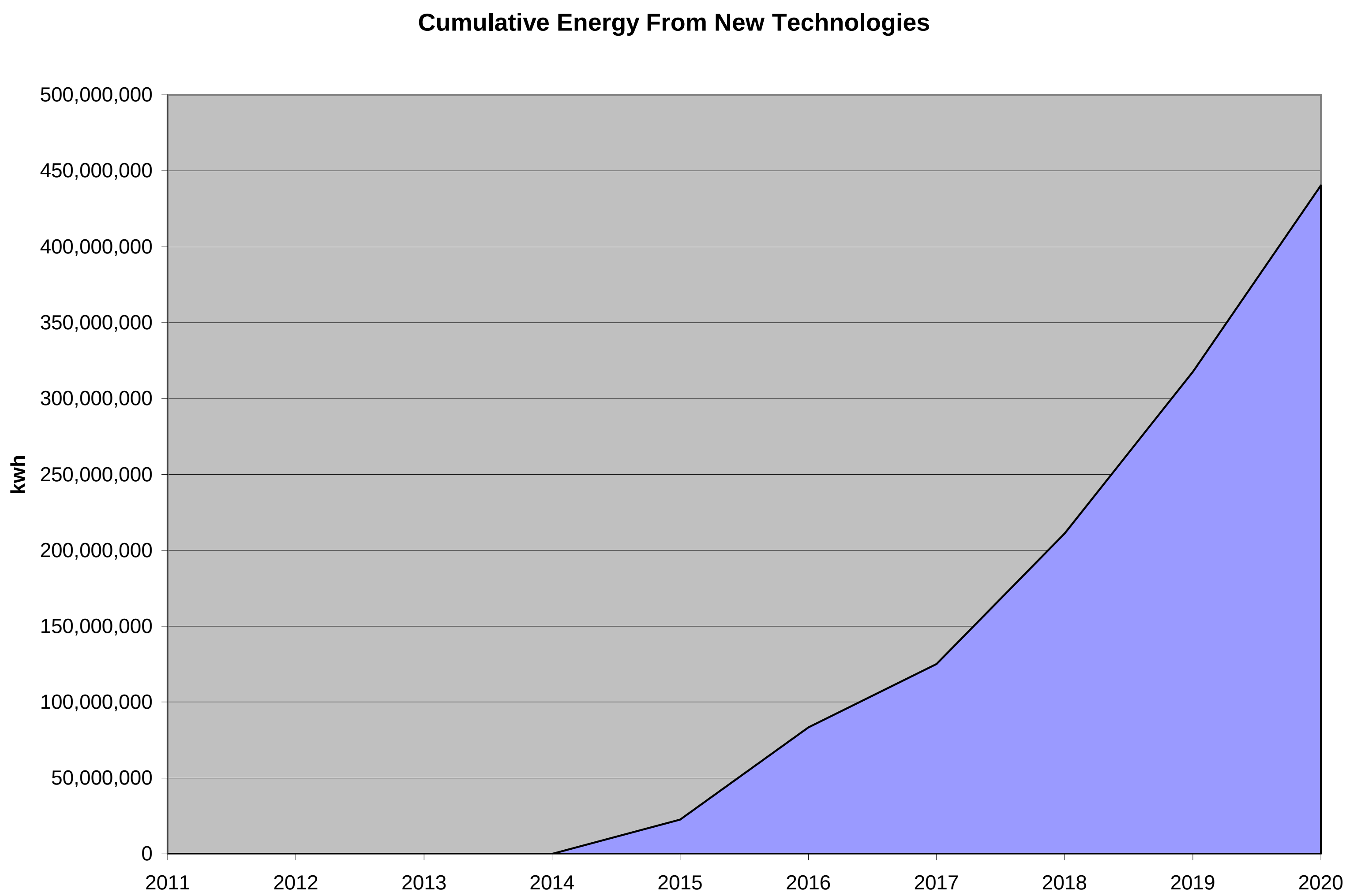
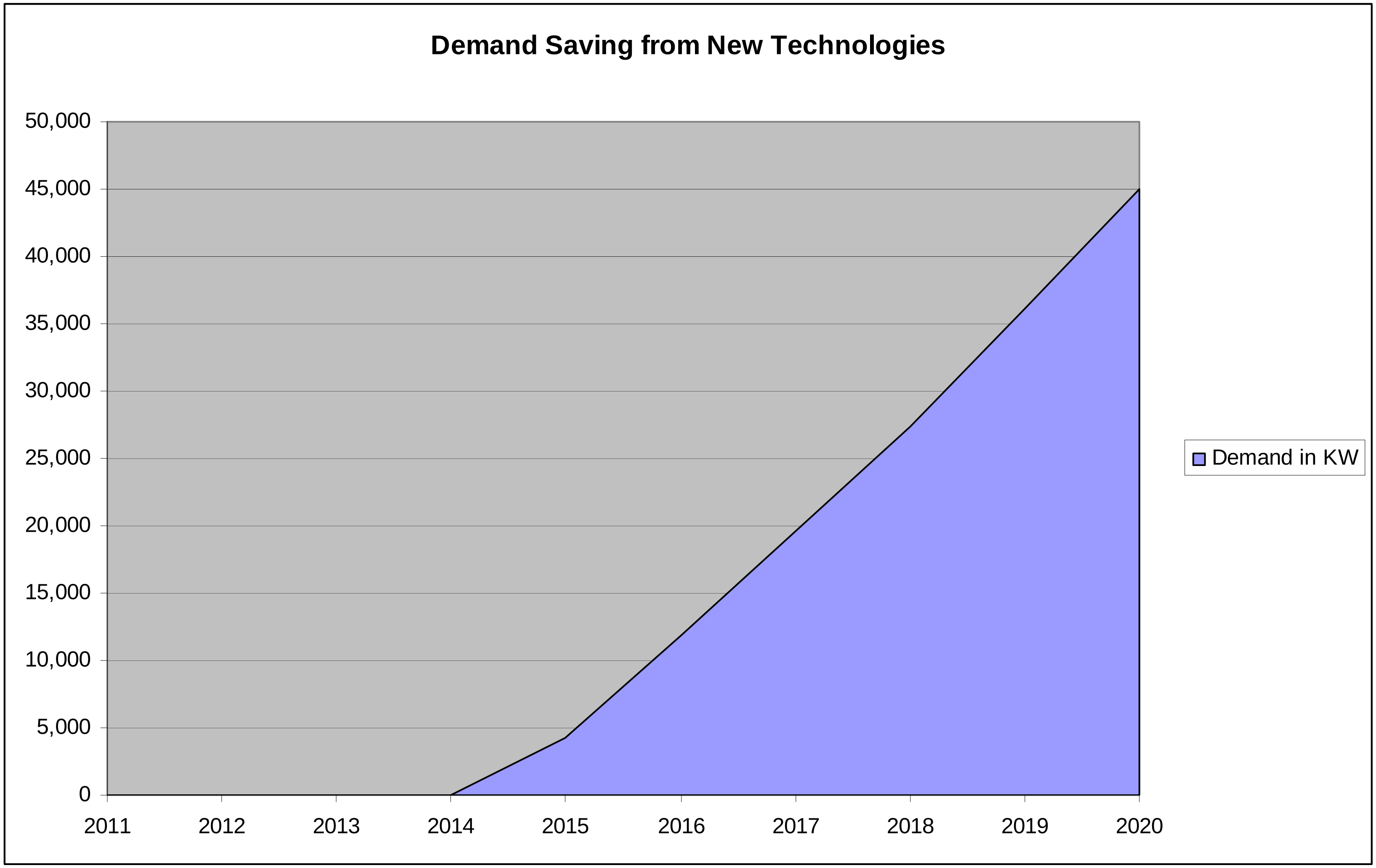


Figure 5-15: Demand Saving from New Technologies



5.7 Perspective on New Technologies

5.7.1 Interpreting the Results of This Study

The estimated potential by KEMA in this report reflects currently known and cost-effective opportunities from widely available, commercial technologies that are on average cost-effective among a wide range of facilities. As such, this potential should be viewed as a low to moderate bound of efficiency opportunities available over the next decade. These savings do not include other opportunities for efficiency such as Combined Heat and Power. Through decades of planning and analyses related to energy efficiency opportunities, it is clear that, despite capture of significant efficiency savings, cost-effective potential has generally not decreased over time, and in fact has often increased. For example, in 1989 technical potential in New York State was estimated at 38% of forecast load.[13] A similar study of New York State potential in 2003 estimated almost exactly the same amount of potential (35%), despite the fact that New York was a leader in efficiency efforts in the 1990s and captured a significant portion of the original potential.[14] *It is important that readers understand that this "snapshot in time" includes many conservatisms, and that aggressive pursuit of efficiency by National Grid will unlikely ever result in running out of opportunities for more cost-effective efficiency – efficiency opportunities are replenished constantly through breakthrough new innovations in lighting, appliances, motors, customer interfaces, and other equipment.*

This study, as with almost all potential studies, does not attempt to fully forecast all potential that likely will be available. There are a number of conservatisms typically built into all potential studies that will generally make them low to moderate estimates. These include, but are not limited to:

- Omission of some emerging technologies. This includes technologies that are already proven but not widely commercially available, as well as those far along in research and

[13] American Council for an Energy Efficient Economy, *The Potential for Electricity Conservation in New York State,* prepared for the New York State Energy Research and Development Authority (NYSERDA), September 1989, p. S-4

[14] Optimal Energy Inc., *Energy Efficiency and Renewable Energy Resource Development Potential in New York State,* prepared for NYSERDA, August 2003, Volume 1, pp. 3-3 and 3-22.

development which show a very high probability of being commercially available at cost-effective prices within the next decade.

- Static avoided costs. Avoided costs are likely to increase significantly over the decade, in part due to shifts to higher cost renewable supply, retirement of older coal plants, and significantly increased costs of traditional electricity generation.[15]

- Static prices and performance. KEMA's model cannot handle shifting costs and performance over time. As a result, its estimates are a "snapshot" simply of what is already known to be available today, rather than a projection of what will be available in the future.

- Omission of opportunities that are cost-effective for only a portion of facilities. In Demand Side Assyst measures either pass or fail the cost-effectiveness screening. As a result, many measures that may be highly cost-effective for a significant portion of facilities, but not on average for a whole market segment, are screened out and all potential is excluded from economic or achievable potential. However, National Grid obtains much of its savings from "custom" measures that are screened for cost-effectiveness on a project-specific basis and promoted only for those specific instances where it passes.

- Lack of fully capturing interactions between technologies and a "systems" approach. Our analysis is a bottom-up analysis that attempts to identify specific pieces of equipment and estimate the opportunities for each independently. They then *reduce* savings based on interactions between measures that would otherwise result in double-counting.[16] KEMA includes some measure of this nature but could not model all possibilities. Many of the significant and cost-effective *additional* opportunities resulting from more complex interactions are may not captured. For example, building a super-insulated house may appear in the model to not be cost-effective; however, if this house can then omit a heating system, ductwork, etc. then significant capital savings can be obtained that may

[15] For example, new Nuclear power plants are now estimated to be more costly than photovoltaic power generation, and significantly more costly than wind. See, for example, Powers, Diana, "*Nuclear Energy Loses Cost Advantage*", New York Times, July 26, 2010.

[16] For example, if a high efficiency chiller passes the cost-effectiveness screening, the cooling load of the building is then reduced when considering additional measures such as window film.

make it cost-effective when considered in a more integrated, systems approach. Similarly, industrial processes can often obtain huge and cost-effective savings through systems approaches that redesign the whole process. However, KEMA's model for the most part only captures specific, equipment based incremental improvements to existing systems.

All these and other reasons result in potential studies generally identifying the lower bound of cost-effective savings opportunities. This is clear when one considers that we know how to cost-effectively build new buildings that use less than 50% of a typical new building built to code, which would likely reflect about a 75% improvement over existing building stock. When considering net metering, we can technically build zero energy buildings.[17]

5.7.2 Comparison of Results to Possible Annual Savings Goals

Given the above, and also considering timing effects, simply dividing the ten year potential by ten to arrive at possible annual efficiency savings generates a conservative estimate of what is possible. This is both because potential is always growing due to new technologies and improvements in existing technologies (increased performance and/or reductions in incremental costs), as well as timing effects. The economic potential in this study reflects today's potential from 2010 existing building stock. As a result, the vast majority of this *is available today.* In other words, even if no new potential became available, National Grid could fast track capture much of today's existing potential, meeting short term goals that are significantly above one tenth of the total decade's achievable potential identified. Based on review of other achievements already proven *(e.g.,* Efficiency Vermont obtained 2.5% of load in annual incremental savings in 2008)[18] and our analysis of the timing effects and likely additional un-quantified potential, we believe ramping up to annual goals of around or above 2.5% would be feasible and sustainable for the indefinite future.

[17] In fact, CA has established a goal of all residential and commercial buildings being net zero energy by 2020 and 2030, respectively. California Public Utilities Commission, *California's Long Term Energy Efficiency Strategic Plan,* September 2008.

[18] Efficiency Vermont 2008 Annual Report, March 2009.

5.7.2.1 Estimating Un-quantified Potential

Given the above, we have reviewed some of the literature on emerging technologies and plans to attempt to bound the additional cost-effective savings likely to be available. By necessity this range is speculative, and should be viewed as an approximate range of opportunity. At the lower bound, we estimate that simply including many of the currently non-cost-effective measures would increase the potential by 4-6 %. Because of the static model that assumes no improvements in performance, reductions in incremental cost, or un-forecasted increases in avoided costs, many of these technologies will likely become cost-effective over time. We view this as a lower bound because it still ignores all new opportunities from emerging technologies, and does not capture many of the other conservatisms mentioned above.

Estimating the higher bound with certainty would require knowing exactly what products, and their associated performance and cost, would be available when. Obviously this is not possible. However, based on a review of emerging technology literature, we believe the available potential by 2020 will likely be significantly more than the current estimates. This is illustrated by a few examples below.

5.7.2.2 LED and OLED Technology

One of the most promising and near term technologies that is likely to have a major impact on efficiency potential is light emitting diodes (LED) and organic light emitting diodes (OLED). These technologies already exist, and in some niche applications are cost-effective.[19] The following curve shows U.S. DOE's current projects of performance improvements for LEDS and OLEDS, compared to current lighting technologies.[20] These are currently in both achievable program results in both the residential sector as well as commercial.

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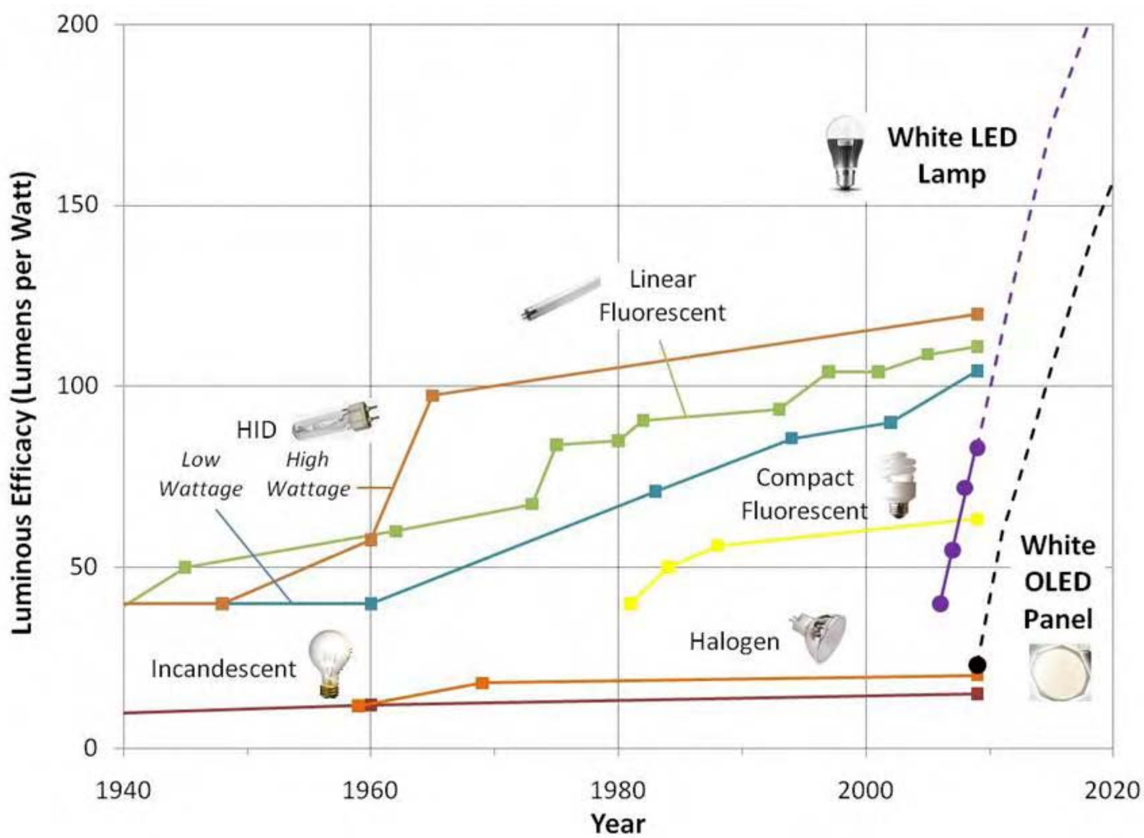
[19] LEDs are already cost-effective in some general illumination applications and are starting to see adoption, particularly in niche markets such as refrigeration display cases, signage, exit signs, exterior lighting, and applications that require directional lighting. OLEDs currently are primarily used for high value things like cell phone and computer displays, but are expected to be viable for general illumination in the future, lagging LEDs by only a few years in development. OLEDs offer the prospect of fundamentally transforming building illumination by virtue of their thinness and flexibility. This will allow lighting to be integrated into building materials and components in unique and as yet undefined ways.

[20] U.S. DOE, *Solid State Lighting Research and Development: Multi-year Program Plan*, March 2010, P. 23.

Figure 5-16: Lighting Technologies and Costs Over Time



As the above shows, projections by 2020 are over 200 lumens per watt (lpw) for LEDs and over 150 lpw for OLEDs. In addition, DOE projects costs to be highly competitive and cost-effective by this point. Compared to the current mix of lighting in Rhode Island facilities, this would result in a likely range of *additional lighting savings (over and above what is already built in to the KEMA estimate) of from 50-70% of lighting energy.*[21] As a result, this single technology area would translate into an additional 10% economic potential by 2020, over and above the current

[21] Assuming an average potential lpw of 175 by 2020, and with existing buildings otherwise at an average of: 70 lpw for commercial, 50 lpw for residential and 80 lpw for industrial.

economic potential directly estimated by KEMA.[22] In short, just with lighting alone, the likely long term potential is roughly 50% greater than the directly known current estimate.

Clearly, many other emerging technologies are on the horizon besides just solid state lighting. As a point of reference, the Northwest Power and Conservation Council's Sixth Power Plan calls for 85% of the region's power needs to come from energy efficiency by 2030.[23] This goal is supported by a carefully constructed estimate of what can be achieved in the northwest through an extensive study by experts of the emerging technology opportunities and the development of an "technology roadmap" that will drive R&D and planning and implementation activities over the next 20 years.[24] This technology roadmap considers literally hundreds of opportunities among the following categories:

- Building design/envelop for retrofit of existing buildings;
- Building design/envelop for new construction;
- Lighting;
- Electronics;
- Heating, ventilation and air conditioning;
- Sensors, meters and energy management systems; and
- Services.

The roadmap focuses on R&D needs, and does not directly quantify the opportunities likely to come from each emerging technology. However, taken as a whole, the NPCC's goals and substantial investigation into the feasibility of these goals makes clear that very large efficiency opportunities are highly likely to be available by 2020, and potentially captured by 2030 and hence in future programs.

Considering the above, we believe the efficiency potential unaccounted for by the direct bottom-up analysis of known and widely available cost-effective technologies is *at least equal to, and*

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[22] Calculated based on KEMA's end use disaggregation of energy usage in existing buildings for lighting of: Commercial =25%, Residential 7% and Industrial 9%.

[23] Bonneville Power Administration, *Northwest Energy Efficiency Technology Roadmap, March 2010,* p. iii.

[24] *Op. Cit.*

perhaps as much as double, that which has been directly quantified. In short, we see ample cost-effective efficiency potential that is equal to or in actuality much greater than 2.5% annually for National Grid's programs over the next decade.

5.8 Overall Conclusions

Overview

The energy efficiency market is continuously changing. This study was conducted at a time where a major sea change is occurring in the lighting markets. By 2014 most incandescent light bulbs that are now available will no longer be available. Yet they are in the majority of residential lighting sockets in Rhode Island and in many commercial sockets as well. Recently there has been increased research on behavioral activities. These hold the promise of being able to provide savings without having to replace equipment and would benefit from testing. There is also much new research on the reaction of customers to variable pricing of some kind. Much of this data comes from pilots not full scale program activity. However these areas along with new technology hold promise to save additional energy in the years to come.

Conclusions:

- This study illustrates that significant amounts of cost effective efficiency – both energy in terms of GWh and demand in terms of MW – are available at significantly less than the cost of supply.
- The programs modeled here are for the most part highly cost effective even in a time of relatively low avoided costs.
- Most of the program's cumulative savings over time come from the existing program structure.
- However as modeled most of the existing retrofit programs start to run out of resource after 2017.
- Most of the new program savings after 2017 come from the behavioral, price response and new technologies.
- The programs modeled here reduce greenhouse gases significantly.
- Many customers have not yet participated in National Grid's programs; those who have are very willing to participate again.

- Customers are very aware of the Energy Star Brand and its meaning.
- The commercial lighting market has changed significantly – premium t-8s are becoming very common especially with four foot tubes.
- Most large motors already are very efficient leaving little room for new market intervention without new technology.
- Behavioral program suggest large cost effective energy savings.
- Price response or other programs that provide customer with time variant pricing also show the potential for significant energy and demand savings.

5.8.1 Uncertainty of Results

We want to caution the reader that there is some inherent uncertainty in the results presented in this report as with all forecasts of what could happen in the future. Our estimates of technical and economic potential have the lowest degree of uncertainty. These are estimates that account for savings, costs, and current saturations of DSM measures but do not factor in human behavior.

The achievable program estimates do take into account behavior, as our modeling efforts try to predict program participation levels while factoring in measure awareness and economics, as well as barriers to measure uptake. Hence, the uncertainty in our achievable potential estimates is greater than in technical and economic potential. This uncertainty is lowest in modeling of the existing programs as they assumptions are based on industry history. This uncertainty is larger for the estimates of the behavioral programs and the new technologies. In the case of the behavioral programs there is limited “real world” program experience with these types of programs. In the case of new technologies we are providing a proxy for measures we in our professional judgment think will become cost effective in the future.