FORECAST 20

Electricity Savings in Vermont from 20 Years of Continued End-Use Efficiency Investment

FINAL REPORT

Prepared for
The Vermont Public Service Board
and
The Vermont Systems Planning Committee

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by

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ACRONYMS AND ABBREVIATIONS

ACEEE	American Council for an Energy-Efficient Economy
AEO	Annual Energy Outlook (document from the EIA)
AHRI	Air Conditioning, Heating, and Refrigeration Institute (manufacturers' trade association)
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BED	Burlington Electric Department, providing demand-side management services for the Energy Efficiency Utility in the city of Burlington
Board	Vermont Public Service Board
BR	Bulged reflector (a type of lamp shape)
C & I	Commercial and industrial market sector
CCX	Chicago Climate Exchange (North America's cap-and-trade system)
CDA	Copper Development Association
CEE	Consortium for Energy Efficiency
CFI	Carbon Financial Instrument (issued via the Chicago Climate Exchange – CCX)
CHP	Combined heat and power (customer-sited generation systems)
CO_2	Carbon dioxide, one of the six primary greenhouse gases
DCPM	DC permanent magnet (type of motor, also known as electrically commutated motor, or ECM)
Department	Vermont Department of Public Service
DHW	Domestic hot water
DOE	U.S. Department of Energy
DPS	Vermont Department of Public Service
DRR	Demand response resources
DSM	Demand-side management (energy efficiency services)
EEC	Energy efficiency charge (systems benefit charge, based on consumption, added to Vermont ratepayers' utility bills for efficiency services delivered statewide)
EEU(s)	Energy Efficiency Utility(ies): Efficiency Vermont and Burlington Electric Department (serving Burlington only)
EIA	U. S. Energy Information Administration (statistical agency for the U.S. Department of Energy)
EISA	Energy Independence and Security Act of 2007 (a federal law designed to "move the United States toward greater energy independence and security, to increase the

	production of clean renewable fuels, to protect consumers, to increase the efficiency of products, buildings, and vehicles, to promote research on and deploy greenhouse gas capture and storage options, and to improve the energy performance of the Federal Government, and for other purposes.")
EPA	U. S. Environmental Protection Agency, an agency within the U. S. Department of Energy
ECM	Electrically commutated motor (also known as DC permanent magnet motor, or DCPM)
EPRI	Electric Power Research Institute
EUA	European Union Allocations (administered through EU ETS)
EU ETS	European Union Greenhouse Gas Emission Trading System
GHG	Greenhouse gas(es)
GMP	Green Mountain Power Company
GSFL	General service fluorescent lamps
GSHP	Ground source heat pumps (also known as a geothermal heat pump)
GWh	Gigawatt-hours
Hp	Horsepower (unit of energy)
HVAC	Heating, ventilation, and air conditioning systems
HVAC / R	Heating, ventilation, air conditioning, and refrigeration systems
Hz	Hertz (unit of frequency)
IECC	International Energy Conservation Code (a model building code establishing minimum standards for energy efficiency – begun in 2006)
IR	Infrared (referring typically to lamp technology)
IRL	Incandescent reflector lamp
kW	Kilowatt (unit of electrical capacity)
kWh	Kilowatt-hour (unit of electrical consumption)
LED	Light-emitting diode, a type of lamp and lighting technology
MECS	Manufacturing Energy Consumption Survey
MW	Megawatt (unit of electrical capacity)
MWh	Megawatt-hour (unit of electricity consumption)
NECIA	Northeast Climate Impacts Assessment, a collaboration between the Union of Concerned Scientists and a team of independent experts to develop and communicate a new assessment of climate change, impacts on climate-sensitive sectors, and solutions in the northeastern United States

NCPs	Negotiated cooperative promotions (product buydowns, prior to retail sale, used by Efficiency Vermont)
NEMA	National Electric Manufacturers Association
OLED	Organic light-emitting diode, a type of lamp and lighting technology
PSB	Vermont Public Service Board
PV	Present value
RBES	Vermont Residential Building Energy Standard
RGGI	Regional Greenhouse Gas Initiative (cap-and-trade initiative in the northeastern United States to reduce greenhouse gas emissions)
RTUs	Rooftop HVAC units
SEER	Seasonal energy efficiency ratio
SIC	Standard Industrial Classification coding system
SO_2	Sulfur dioxide, a precursor of sulfuric acid, a key component of acid rain
SR	Switched reluctance (a type of motor technology)
SSL	Solid-state lighting (technology including LEDs)
T&D	Transmission and distribution (relating to costs of and services in delivering electricity to utilities)
TRC	Total resource cost
TRM	*Technical Reference Manual* (publication and data source of all efficiency measures used by Efficiency Vermont)
VELCO	Vermont Electric Power Company (statewide transmission company)
VSPC	Vermont Systems Planning Committee (a group established under a Board order and addressing systems reliability issues in Vermont's transmission system)

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I. Introduction

A. Summary

The Forecast 20 Final Report presents an analysis of energy efficiency savings expected to be achieved from 2008 through 2027 via the Vermont Energy Efficiency Utility's system-wide programs. The forecast is required under Paragraph 61 of the Memorandum of Understanding approved by the Public Service Board (Board) in its June 20, 2007, Order in Docket 7081. Paragraph 61 also requires that the estimates be based on the expected budget levels and service types for the system-wide programs at the time of the estimate. This Final Report is the fulfillment of those requirements. In general, it:

- summarizes the results of the Forecast 20 analysis;
- explains the underlying research, methods, data, assumptions, and judgments involved in the analysis;
- presents conclusions about the future contribution by energy efficiency to Vermont's electricity requirements; and
- makes recommendations concerning subsequent long-range energy efficiency forecasting efforts in Vermont.

There are four principal findings from the research and analysis conducted by Efficiency Vermont. The analysis forecasts the amount of electric energy savings and peak electricity demand reductions Vermont should expect from continuing to invest at a constant level of spending (in real terms) across the next 18 years. The findings are:

- **Reductions in electric energy requirements.** Continuing an annual investment of approximately $31 million for Efficiency Vermont and the Burlington Electric Department (BED; in constant 2009 dollars) in end-use efficiency improvements through 2027 will reduce Vermont's forecast electric energy requirements by 1,093 GWh / year, or 14.2% of expected 2027 total energy requirements of 7,692 GWh / year.
- **Peak demand reductions.** These energy savings would result in peak demand reductions of 204 MW in summer and 177 MW in winter, reducing forecast seasonal peak demand in 2027 by 14.0% and 13.4%**,** respectively.
- **Cost-effective electricity resources**. The cost of saving electric energy would be -3.7 cents per kWh in terms of total societal resources, compared with the costs of electricity supply that would otherwise have to be purchased. Counting only the costs supported by Vermont's electricity ratepayers, electricity savings

cost -2.0 cents per kWh saved, net of the generation, transmission, and distribution costs that would be avoided by electric efficiency investment.

- **Societal net benefits.** Nearly two more decades of efficiency investment by Efficiency Vermont—are estimated to result in societal net benefits of $1.301 billion over the expected lifetimes of all the efficiency measures installed through 2027.
- **Electric system net benefits.** After deducting the present worth of portfolio expenditures of $412 million, electric system net benefits are estimated at $1,016 million.

Because savings potential is constrained by a fixed annual portfolio budget, this analysis constitutes a budget-constrained, economically achievable potential study. A maximum economically achievable potential study, by contrast, would involve no such budget constraint.

Compared with previous long-range demand-side management (DSM) potential studies conducted in Vermont and elsewhere, Forecast 20 breaks new ground in addressing the profound and rapidly accelerating change taking place in the energy efficiency marketplace. Federal efficiency standards for different end uses, particularly lighting, will drastically change the baseline market conditions confronting DSM program design. New standards will have the dual effects of lowering forecasts of future electricity demand, and reducing the amount of savings that DSM programs can achieve beyond market forces. Operating in tandem with tightening building codes and equipment standards, technological change is expected to increase the efficiency of a wide variety of products and equipment available in the next two decades, reducing the energy intensity of major household and business electricity end uses.

Most profound are changes under way in the lighting market. These changes are expect to radically alter the mix of lighting products available to and chosen by consumers between now and 2027, with or without DSM programs. For example, roughly 6 out of the 45 lighting sockets in the typical Vermont household contain compact fluorescent lamps—currently the highest number for any state in the United States; the rest are incandescent with a small number of linear fluorescent fixtures. Solid-state lighting, such as that containing light-emitting diode (LED) technology, promises to provide the same level and quality of light as incandescent lamps at a tenth of the electricity input. Today, solid-state lighting is a niche technology in applications beyond traffic lighting and exit signage.

By the end of the forecast period, however, the conclusion of this study is that this situation will be inverted: The majority of Vermont household lighting sockets will contain solid-state lamps, with a significant minority containing CFLs. New incandescent technology will replace LEDs as a niche application by 2027. In the commercial sector, where lighting represents a significantly greater fraction of total electricity requirements, the situation will be similar. By 2027, solid-state lighting will replace fluorescent technology in linear fixtures, and will also replace incandescent and fluorescent technology in other lamps and fixtures.

Predicting the magnitude and timing of the changes in the costs, performance, and market penetration of lighting technologies over the next 20 years is extremely difficult. This complicates forecasting electricity demand, and forecasting savings from demand-side management programs designed to change market behavior from "business as usual." The same is true for other end uses, although to a far lesser degree.

Consequently, this study began with extensive secondary research into the conditions likely to prevail in the state. This research addressed not only efficiency technologies but also broader socioeconomic changes, such as the aging of the state's population and the repercussions of climate change. This study's initial research informed estimates of future market conditions, the costs and performance of numerous efficiency technologies, and the market penetration of these technologies over the next 20 years in the absence of future DSM programs.

The study also examined the 20-year statewide sales and peak demand forecast prepared by Itron, a data collections and communications systems provider, for the Vermont Electric Power Company (VELCO), to establish the size and composition of the electricity requirements by customers and their underlying end uses. The VELCO forecast is intended to represent future electricity requirements in the absence of continued investment in the efficiency market. Yet because the VELCO forecast is based on a statistically adjusted end-use model, this study found that the VELCO forecast's estimated equations automatically picked up the effects of EEU efficiency investment over the past ten years. As a result, electricity requirements predicted on the basis of VELCO's regression coefficients implicitly contain savings produced by prior investments. The present study therefore adjusted the VELCO residential and commercial / industrial electric energy forecast upward, based on regression analysis of sector-specific spending and savings by Efficiency Vermont.

The next step in the analysis was to characterize the costs and performance of hundreds of energy efficiency measures applicable to residential and commercial and industrial customers in three markets in each sector: new construction, new product and equipment purchases, and retrofits to existing buildings. The cost-effectiveness of these measures was assessed by comparing their societal costs to the societal benefits of their electricity and other non-electric resource savings, valued at long-run avoided marginal supply costs approved by the Board.

The study estimates total residential and non-residential efficiency savings by projecting market penetration rates over time for all the efficiency measures found to be cost-effective. Market penetrations are predicated on the success of market strategies in the EEU programs targeting these three markets over time. They in turn are based on the professional judgment of the study team, informed by the background research conducted at the outset of the study, and by the performance of similar programs in other jurisdictions. Total electricity savings were calculated by multiplying each measure's unit savings by the size of the eligible market population and its projected market penetration. The result is the achievable potential for electricity savings from continued investment at the fixed annual budget assumed in the analysis.

To maximize cost-effective electricity savings, the study used a second, iterative cost-effectiveness analysis to determine the best allocation of portfolio budget between programs serving each sector. This process resulted in the final aggregate savings forecast. The first step in this process was to establish the costs of the individual programs targeting each market. To develop program budgets, it was first necessary to subtract the amount of funds necessary to carry out the core functions of the EEU. To meet Board equity objectives, the remainder of the portfolio budget was split roughly 2:1 between the nonresidential and residential markets.

The next step in the cost-effectiveness analysis was to calculate the benefits of the savings from each program and compare these to its costs. Within each sector's budget, the study estimated the costs of implementing these programs each year over the forecast period. The amount of each sector's budget deployed between programs was fine-tuned to maximize net benefits in each sector. Total portfolio savings in each year are the sum of savings across the programs. The final step was to roll up all the costs and benefits from each program, add back in the core EEU-wide costs of fielding the entire program portfolio, and then calculate and compare the portfolio-wide costs and benefits.

Because BED developed its electricity requirements and DSM forecasts independently, this study analyzed only the non-BED portion of VELCO's forecast. To accomplish this, the analysis subtracted BED's forecast sales from each sector in the statewide energy forecasts that were used to analyze efficiency savings, and then added BED's estimates of future efficiency savings from continued efficiency investment.

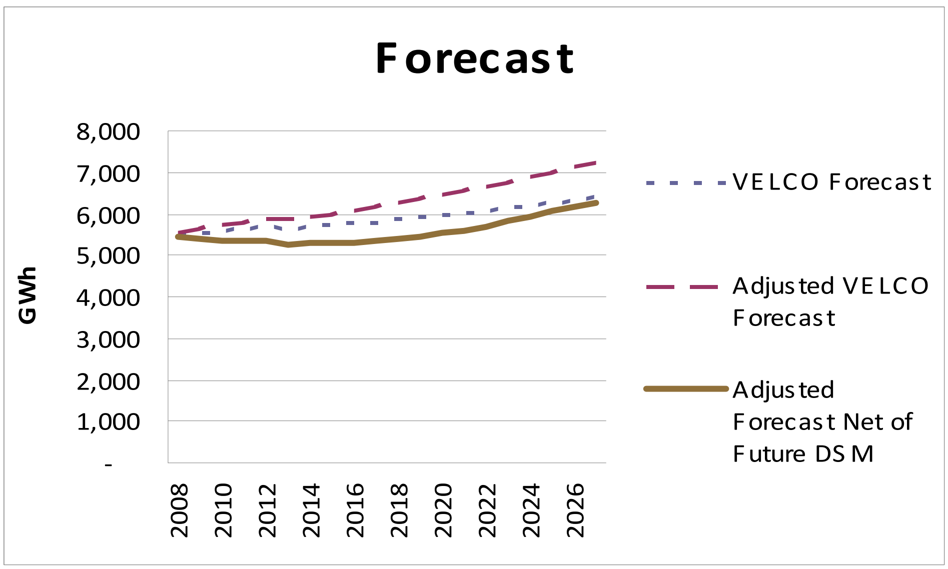
Table 1 provides VELCO's forecast of statewide electric energy requirements; this study's adjustment for endogenous efficiency contained in that forecast; the electric energy savings from continued EEU investment; and the forecast of electricity requirements net of forecast EEU investment savings. **Figure 1** portrays the same information graphically.

Table 1. Statewide electric energy requirements with forecast savings from continued EEU investment

Vermont Forecast (GWh)				
Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	5,903	5,956	125	5,831
2009	5,948	6,035	241	5,794
2010	5,993	6,114	362	5,752
2011	6,036	6,190	470	5,720
2012	6,084	6,271	554	5,717
2013	6,066	6,285	641	5,644
2014	6,096	6,347	703	5,644
2015	6,134	6,417	759	5,658
2016	6,186	6,500	845	5,655
2017	6,231	6,576	886	5,690
2018	6,284	6,678	950	5,728
2019	6,338	6,780	1,001	5,778
2020	6,393	6,883	1,017	5,865
2021	6,443	6,980	1,041	5,940
2022	6,505	7,090	1,054	6,036
2023	6,571	7,204	1,047	6,157
2024	6,647	7,328	1,050	6,278
2025	6,713	7,442	1,055	6,387
2026	6,789	7,565	1,065	6,501
2027	6,867	7,692	1,093	6,599

Growth Rates				
Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008-2012	0.8%	1.3%		-0.5%
2013-2017	0.7%	1.1%		0.2%
2018-2027	1.0%	1.6%		1.6%
2008-2027	0.8%	1.4%		0.7%

Figure 1. Statewide electric energy requirements with forecast savings from continued EEU investment



The study also estimated summer and winter peak demand savings associated with the electric energy savings from continued efficiency investment. **Table 2** and **Figure 2** (graphically) present annual summer peak demand forecasts before and after continued efficiency investment. **Table 3** and **Figure 3** (graphically) present winter peak demand forecasts.

Table 2. Total Vermont summer peak forecast, in MW

Total Vermont Summer Peak Forecast (MW)				
Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	1,094	1,102	15	1,087
2009	1,112	1,124	28	1,096
2010	1,125	1,142	43	1,099
2011	1,138	1,160	60	1,100
2012	1,148	1,175	76	1,100
2013	1,154	1,186	93	1,094
2014	1,163	1,200	108	1,092
2015	1,173	1,214	121	1,093
2016	1,183	1,229	136	1,093
2017	1,198	1,248	147	1,101
2018	1,211	1,268	159	1,109
2019	1,224	1,288	169	1,119
2020	1,235	1,306	178	1,128
2021	1,250	1,328	186	1,142
2022	1,265	1,350	193	1,157
2023	1,279	1,371	193	1,178
2024	1,293	1,392	195	1,196
2025	1,310	1,416	197	1,219
2026	1,327	1,439	200	1,240
2027	1,343	1,463	204	1,259
Growth Rates				
2008-2012	1.2%	1.6%		0.3%
2013-2017	0.9%	1.3%		0.2%
2018-2027	1.2%	1.6%		1.4%
2008-2027	1.1%	1.5%		0.8%

Figure 2. Summer peak forecast for Vermont

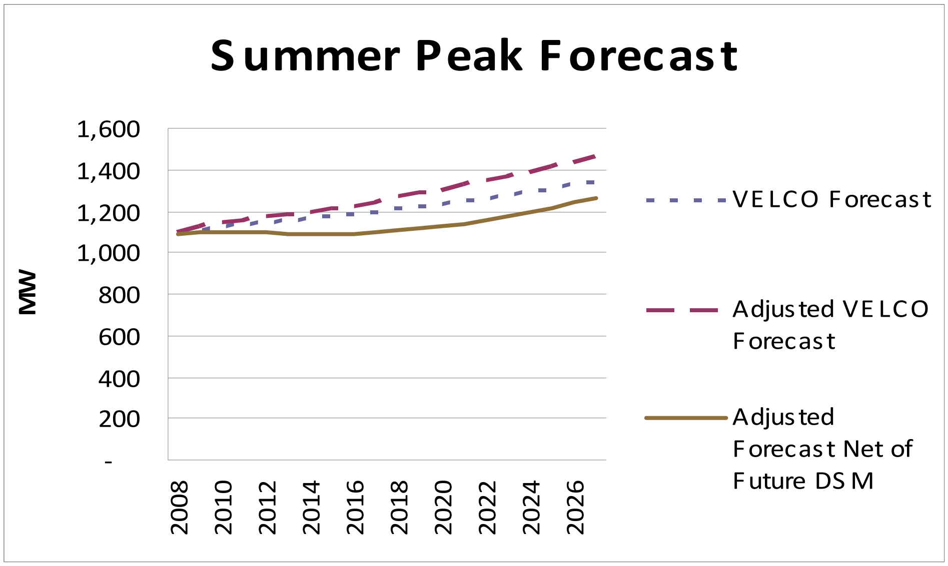


Table 3. Total Vermont winter peak forecast, in MW

Vermont Winter Peak Forecast (MW)				
Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	1,082	1,092	24	1,068
2009	1,092	1,102	45	1,057
2010	1,099	1,108	67	1,041
2011	1,105	1,114	90	1,024
2012	1,109	1,118	113	1,004
2013	1,106	1,113	137	976
2014	1,109	1,116	154	962
2015	1,115	1,120	167	953
2016	1,120	1,124	184	940
2017	1,131	1,133	189	944
2018	1,140	1,149	198	952
2019	1,149	1,166	200	966
2020	1,155	1,179	196	983
2021	1,167	1,198	194	1,004
2022	1,178	1,216	192	1,024
2023	1,189	1,235	181	1,053
2024	1,199	1,252	176	1,076
2025	1,215	1,275	173	1,102
2026	1,229	1,295	172	1,123
2027	1,243	1,317	177	1,140

Vermont Winter Peak Forecast (MW)				
Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
Growth Rates				
2008-2012	0.6%	0.6%		-1.5%
2013-2017	0.6%	0.4%		-0.8%
2018-2027	1.0%	1.5%		2.0%
2008-2027	0.7%	1.0%		0.3%

Figure 3. Winter peak forecast for Vermont

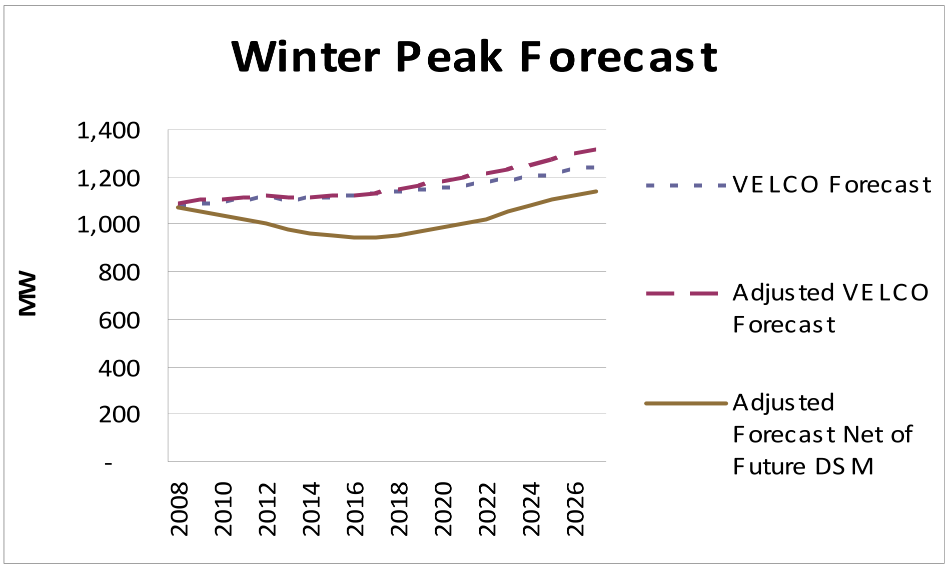


Table 4 summarizes the cost-effectiveness analysis of the entire portfolio and of each individual program. Results are presented according to two cost-effectiveness tests approved by the Board. The societal test counts all monetary costs and benefits of efficiency investment, including costs incurred or saved by participants, as well as the Board-approved value for the external environmental costs avoided by efficiency savings. The electric system test counts only the costs funded through the Energy Efficiency Charge (EEC), and the long-run marginal electricity supply costs avoided by saving electricity. The greater the net benefits, the more cost-effective the result. Likewise, benefit / cost ratios greater than 1.0 indicate the investment is cost-effective.[1]

[1] Because the choice of denominator in the benefit / cost ratio is arbitrary, a negative benefit / cost ratio can result when cost savings are represented as negative costs, as is the case in this study. In such cases, negative benefit / cost ratios are meaningless. Consequently, the magnitude of net benefits is the best indicator of cost-effectiveness.

Table 4. Cost-effectiveness of a 20-year EEU portfolio and programs, in millions of dollars

	Societal (in millions of $)				Electric Energy System (in millions of $)			
	Present Value		PV of Net	Benefit-Cost	Present Value		PV of Net	Benefit-Cost
	Benefit	Cost	Benefits	Ratio	Benefit	Cost	Benefits	Ratio
Residential								
Residential New Construction	$105	$50	$54	2.08	$21	$25	$(3)	0.86
Retail Products	$575	$(37)	$612	(15.39)	$469	$55	$415	8.58
Existing Homes	$33	$24	$9	1.37	$25	$26	$(1)	0.98
Commercial & Industrial								
Commercial New Construction	$242	$53	$189	4.60	$219	$25	$194	8.91
Commercial Efficient Equipment	$327	$67	$259	4.85	$299	$39	$260	7.59
Commercial Retrofit	$438	$162	$275	2.69	$394	$144	$250	2.73
Efficiency Vermont Core Supporting Services	-	$98	$(98)	-	-	$98	$(98)	-
Portfolio of Programs	$1,719	$418	$1,301	4.11	$1,428	$412	$1,016	3.47

The study's forecasts of future electric energy and peak demand savings were developed as a "50/50" scenario—meaning that it is equally likely that actual outcomes will exceed or fall short of the predicted values. Vermont's generation resource planning has traditionally been conducted on this basis. Vermont's transmission system planning is conducted on a "90/10" basis—that is, the likelihood is 90% that actual peak demand will equal or fall short of the predicted value, and 10% that actual load will surpass the prediction.

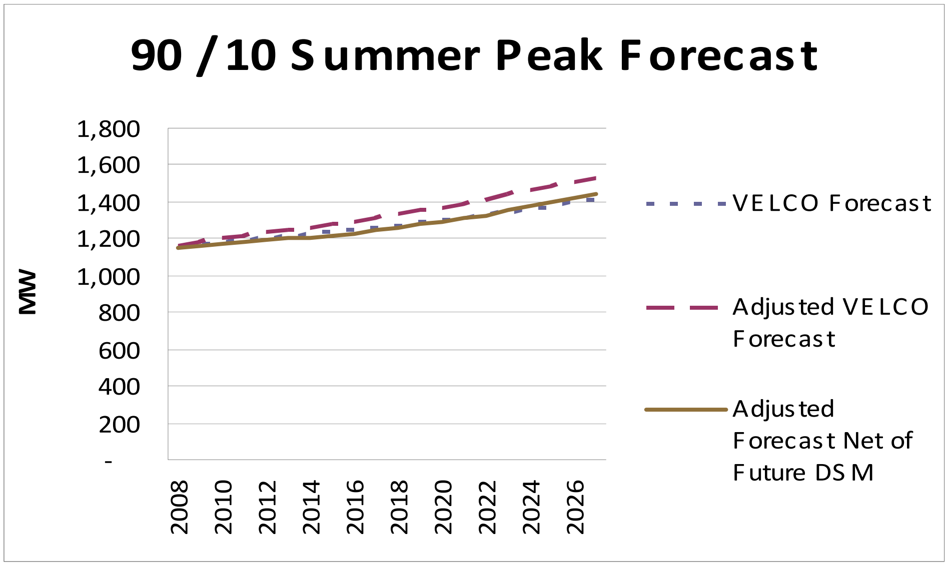
To make the efficiency peak demand savings forecast comparable with VELCO's, the study developed a comparable 90 / 10 scenario. This was done by exercising professional judgment to lower the trajectory of future investment yield rates (measured in terms of kWh per dollar of program expenditure) in each of the six major markets targeted by EEU programs to reflect greater pessimism about the future success of the efficiency program market intervention strategies. Professional judgment further guided the adjustments to energy savings load shapes to assume a 90/10scenario in terms of the overall mix of measures and coincidence of savings with the system peak resulting from measure adoption. The resulting 90/10 efficiency resource acquisition scenario produces peak demand savings of 89 MW by 2027, contributing 5.8% of projected total peak demand by then, assuming continuous annual efficiency investment of $31 million.

Table 5 presents the statewide 90/10 summer peak demand forecast, with and without the 90/10 forecast savings. **Figure 4** presents the information graphically.

Table 5. Statewide summer peak demand and EEU portfolio savings, assuming a 90% likelihood that peak demand will equal or fall short of prediction

Vermont 90 / 10 Summer Peak Forecast (MW)				
Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	1,151	1,159	12	1,147
2009	1,170	1,183	19	1,164
2010	1,183	1,201	27	1,173
2011	1,197	1,219	36	1,183
2012	1,208	1,235	43	1,193
2013	1,214	1,246	47	1,198
2014	1,224	1,261	54	1,206
2015	1,234	1,275	59	1,216
2016	1,245	1,291	64	1,227
2017	1,260	1,310	68	1,242
2018	1,274	1,331	72	1,259
2019	1,288	1,352	75	1,277
2020	1,299	1,370	79	1,291
2021	1,315	1,393	83	1,310
2022	1,330	1,415	87	1,328
2023	1,346	1,438	87	1,351
2024	1,360	1,459	87	1,372
2025	1,379	1,485	87	1,398
2026	1,396	1,509	87	1,421
2027	1,413	1,533	89	1,444
Growth Rates				
2008-2012	1.2%	1.6%		1.0%
2013-2017	0.9%	1.3%		0.9%
2018-2027	1.2%	1.6%		1.5%
2008-2027	1.1%	1.5%		1.2%

Figure 4. Statewide summer peak demand and EEU portfolio savings, assuming a 90% likelihood that peak demand will equal or fall short of prediction



Forecast 20 also examined the analysis results' sensitivity to changes in underlying assumptions. The study focused primarily on how savings would change if the avoided costs of electric energy and fossil fuel were to decline by 25%, compared to the base-case analysis inputs, while summer capacity avoided costs were set to zero and transmission and distribution (T&D) avoided costs were kept the same as the base case. The lower avoided costs caused only a small number of efficiency measures to fail, which were then removed from the analysis. This resulted in only a slight decline in energy savings and summer and winter peak demand reductions in 2008. That is, the percentage of energy savings and peak demand reductions accounted for approximately 99% of the results for the base-case analysis. Cumulative savings were essentially the same as the reference case after several years. Much more significant was the effect of slowing and lowering the trajectory of declining costs, improving performance, and rising market penetration of solid-state lighting.

The sensitivity of increasing all electric and capacity avoided costs by 25% was also examined. This resulted in only a few new measures passing cost-effectiveness and thus being added to the analysis. As a result, savings were only slightly increased, on the order of 1% over the base-case analysis. There could well be additional opportunities for savings from new efficiency measures that were not included in the base-case analysis. However the overall implication is that modest changes to the avoided costs would have a relatively small impact on the Forecast 20 results.

The study concludes that savings from continued efficiency investment are endogenous to the VELCO electricity demand forecast, and that these implicit savings must be added back in to the VELCO forecast to avoid double-counting the Forecast 20 savings estimates. The study further concludes that the future energy savings yield from continued EEU investment will decline as market baseline efficiencies advance, because of the combined effects of rising federal efficiency standards and rising market penetration of high-efficiency technology, particularly lighting. Moreover, this study concluded that its estimate of future household baseline lighting intensity is far below that contained in VELCO's residential lighting energy forecast. Consequently, it estimates a further adjustment to VELCO's forecast to calibrate the Forecast 20 savings estimate with VELCO's forecast of future residential lighting energy intensity.

For the first five years, the pace of savings from continued EEU investment roughly doubles forecast sales growth, leading to declining sales, net of DSM, through 2012. Efficiency savings cut the forecast peak demand growth rate during this period in three quarters. By the second half of the forecast period, incremental efficiency savings declines are outpaced by acceleration in underlying energy and summer peak demand growth forecast by VELCO. By 2027, the study concludes that energy sales net of DSM will be 0.2% lower than VELCO's unadjusted forecast growth rate. Continued efficiency investment will produce a 20-year summer peak demand growth rate of 0.8 percent, compared to the 1.1% predicted by VELCO's unadjusted forecast. Winter peak demand net of the effects of continued EEU investment is projected to grow by 0.3% annually, compared to VELCO's unadjusted forecast of 0.7%.

Forecast EEU savings in the latter half of the analysis period are much more uncertain than in the first decade. This is because the potential in the second decade will be highly dependent on the actual cost and performance trajectories of many new technologies (for example, LED lights and super-high-efficiency HVAC equipment). These trajectories are difficult to predict. For this reason, the assumptions about future availability of cost-effective new technologies are conservative. That is, technology advancement is assumed to keep pace at least with advancing achievements in efficiency and increasing baseline efficiency from natural market forces. In other words, technology advancement will ensure that cost effective efficiency potential will continue to exist in roughly similar proportional amounts in the future as they do now.

Other variables will also influence the trajectory of the cost, performance and market penetration projections underlying the Forecast 20 estimates of future savings from continued efficiency investment. Increased adoption of financing mechanisms and policy tools to leverage additional investments in efficiency measures could result in more savings by enabling the EEU to increase investment savings yields on its program expenditures in retrofit markets. For instance, Vermont recently passed enabling legislation that would allow for residential and business customers to invest in efficiency measures and repay those investments on their property tax bill over a period of up to 20 years. Significant use of this type of financing could result in greater savings, even within a constrained budget. In other instances, federal policy and budget decisions in the areas of energy and climate change (e.g., revenues from a carbon cap and trade regime) could lead to the availability of additional non-Efficiency Vermont resources that could be leveraged to achieve greater depths of efficiency within a constrained budget.

The study also forecasted peak demand savings for each of the sixteen load zones (all those except for BED, which BED assessed independently). This was done by apportioning statewide peak demand savings on the basis of VELCO's forecast of zonal peak load. Annual zonal savings values and analysis results are presented respectively in **Section III L** and in **Section V C** of this report.

Other variables may also affect the trajectory of the conservative estimates included in this forecast. Increased adoption of financing mechanisms and policy tools to leverage additional investments in efficiency measures could result in more savings. For instance, Vermont recently passed enabling legislation that would allow for residential and business customers to invest in efficiency measures and repay those investments on their property tax bill over a period of up to 20 years. Significant use of this type of financing could result in greater savings, even within a constrained budget. In other instances, federal policy and budget decisions in the areas of energy and climate change (for example, revenues from a carbon cap-and-trade regime) could lead to the availability of additional non-Efficiency Vermont resources that could be leveraged to achieve greater depths of efficiency within a constrained budget.

The study recommends that VELCO work with Vermont's distribution utilities and the EEU to identify and collect more information about customers and energy usage at the zonal level. Without this additional information, it will not be possible to estimate zonal efficiency savings with confidence. This constraint poses a major obstacle to integrating efficiency resource acquisition with transmission and distribution capacity planning.

B. Purpose and Scope

The Vermont Public Service Board hired VEIC to estimate the electric energy and peak demand savings that can be expected from a fixed (in real terms) annual investment in cost-effective end-use energy efficiency over twenty years.[2] This report presents the results of the budget-constrained energy efficiency potential study that was conducted to produce these estimates, and summarizes the research and analysis behind it. The forecast represents the authors' best estimates of the amounts of cost-effective electricity savings that can be achieved each year from a portfolio of programs serving residential and non-residential markets, within budgetary and other regulatory policy constraints established by the Board.

The analysis develops forecasts of achievable market penetration of cost-effective efficiency technologies at a 90/10 confidence level: Actual values will have, in the professional judgment of the study authors, a 90% probability of equaling or exceeding projected market penetration; and correspondingly, a 10% chance of falling short of projected values.

The analysis focuses exclusively on end-use energy efficiency improvements in residential and nonresidential markets, induced by programs designed and implemented using best industry practices. The analysis did not consider other non-transmission alternatives such as load management, demand response, and combined heat and power or other forms of customer-sited generation. Nor did it consider expansion in the scope of EEU service delivery, such as increased investment in non-electric energy efficiency beyond that built into historical EEU practice.

The scope of the Forecast 20 analysis is statewide, with results allocated to the sixteen load zones defined by the Vermont Systems Planning Committee (VSPC). The planning horizon is 2008 through 2027. The savings forecast is expressed in cumulative annual reductions in summer and winter peak-coincident kW load and annual MWh of electric energy requirements. These figures are intended to be directly comparable with statewide and zonal peak demand and energy forecasts prepared by VELCO.

The analysis developed a portfolio of energy efficiency programs designed to produce maximum cost-effective peak demand savings within the annual budget constraint, subject to key regulatory policy objectives for a major portion of the budget. Foremost among these equity and policy constraints are geographic equity, as well as intra- and inter-class equity, and a priority on lost-

[2] An amendment dated June 13, 2008, to the 2006 – 2008 contract between the Public Service Board and the Vermont Energy Investment Corporation for delivery of efficiency services as Efficiency Vermont, stipulated that the Contractor (VEIC) deliver a 20-year estimate of DSM savings to be provided through system-wide programs, pursuant to Docket 7081. Unless otherwise noted, all dollar figures in this report are stated in constant 2009 dollars.

opportunity efficiency resources. The PSB has directed that 60% of the budget be subject to these equity constraints; the remaining 40% of the budget is to be allocated with the sole purpose of maximizing net societal benefits from additional investment in efficiency. In practice, the study made 75% of this unconstrained funding available to the business sector, and the remaining 25% was provided for residential programs.

Residential and business sector savings were estimated for three major market, one or more of which all customers in both sectors will be eligible to participate over the 20-year forecast horizon:

- new construction and renovation
- new purchases of energy-using products, appliances, and/or equipment
- retrofits of existing facilities with supplemental efficiency measures and/or early retirement of existing inefficient equipment.

In addition to the 20-year electricity savings forecast, the analysis projected and compared the costs and benefits of the portfolio and its constituent programs using the societal cost-effectiveness test. It is longstanding Board policy for the EEU to apply the societal test in calculating the benefits and costs of efficiency investment. The societal test counts all the monetized values of efficiency investment costs and resource savings, as does the Total Resource Cost (TRC) test. The difference between the two is that the societal test also counts the estimated value of environmental benefits not reflected in market prices. The net societal benefits from the efficiency portfolio indicate the amount by which efficiency investment improves societal economic well-being. The analysis used the societal test to establish the relative cost-effectiveness of efficiency investment at three levels of aggregation: (1) measures, or measure bundles for an individual customer; (2) efficiency program, including the fixed costs of program delivery; and (3) the entire program portfolio across both residential and business sectors, including the EEU-wide service costs (customer service, marketing and business development, planning, administration).

The study also used the electric system test to ensure that the portfolio provides a fair and reasonable distribution of electric benefits in relation to funding provided at the residential and nonresidential sector levels. The analysis used the program and portfolio cost-effectiveness model developed by Optimal Energy. Benefits were valued using the long-range avoided costs approved by the Board for use by the EEU in planning and delivering efficiency services.

The analysis is predicated on long-range forecasts of sectoral peak demand and energy requirements at the state and zonal levels prepared by VELCO. The VELCO load forecast provided the source information for determining the size and characteristics of efficiency markets in which EEU market services will be deployed to increase market penetration of efficiency measures. Because the VELCO electric energy forecast extrapolates past trends based on actual electricity sales, this study finds that that it inadvertently contains future efficiency savings. The Forecast 20 analysis estimated upward adjustments to apply to VELCO's residential and commercial / industrial energy sales forecasts to account for these endogenous future efficiency savings, prior to applying savings estimates.

II. Background Research

The Forecast 20 study departs from previous long-range DSM potential studies conducted in Vermont and elsewhere, because it draws on wide-ranging research effort. This research yielded information about the profound and rapidly accelerating change taking place in the energy efficiency marketplace.

Key questions shaped the research approach, which ranged from big-picture inquiry to equipment-specific market sector considerations: How does climate change influence technical thinking about efficiency potential? How will global warming affect summer cooling load and efficiency opportunities? Is efficiency potential offset by increased market adoption of efficiency technologies because of cap-and-trade efforts, and if so, by how much? Did wider and deeper efficiency measures in snowmaking create higher levels of efficiency in that industry, such that there is now no more potential there? To what extent will emerging technology provide significant and cost effective new opportunities, and when?

The major unknowns for forecasting future efficiency savings over such a long horizon are:

- changes in future market conditions, such as market size or end use saturation
- future changes in efficiency technology and measure characteristics
- the identification and characterization of efficiency technologies likely to emerge in each major market

The rest of this section summarizes the results of the background research that informed the professional judgment regarding these future unknowns.

The background research also informed the quantitative analysis. In some cases, direct quantitative estimates have been drawn from the research. For example, an attempt was made to forecast the timing and extent of future cost and performance improvements for solid-state lighting. Similarly, specific assumptions about pending or expected new codes and standards were incorporated. In other cases, the extensive body of research as a whole shaped the professional judgment in making quantitative assumptions. In these cases, the link is less direct, but nonetheless it is informed by the research. An example is the assumption that the efficiency opportunities arising from emerging technologies will *at least* keep pace with the naturally occurring improvements in baseline efficiencies and those that result from the work of the EEU. In other words, whereas much of the known potential can be captured in the first decade, new opportunities at similar levels of cost and performance will emerge to sustain the level of Efficiency Vermont activity in the second decade.

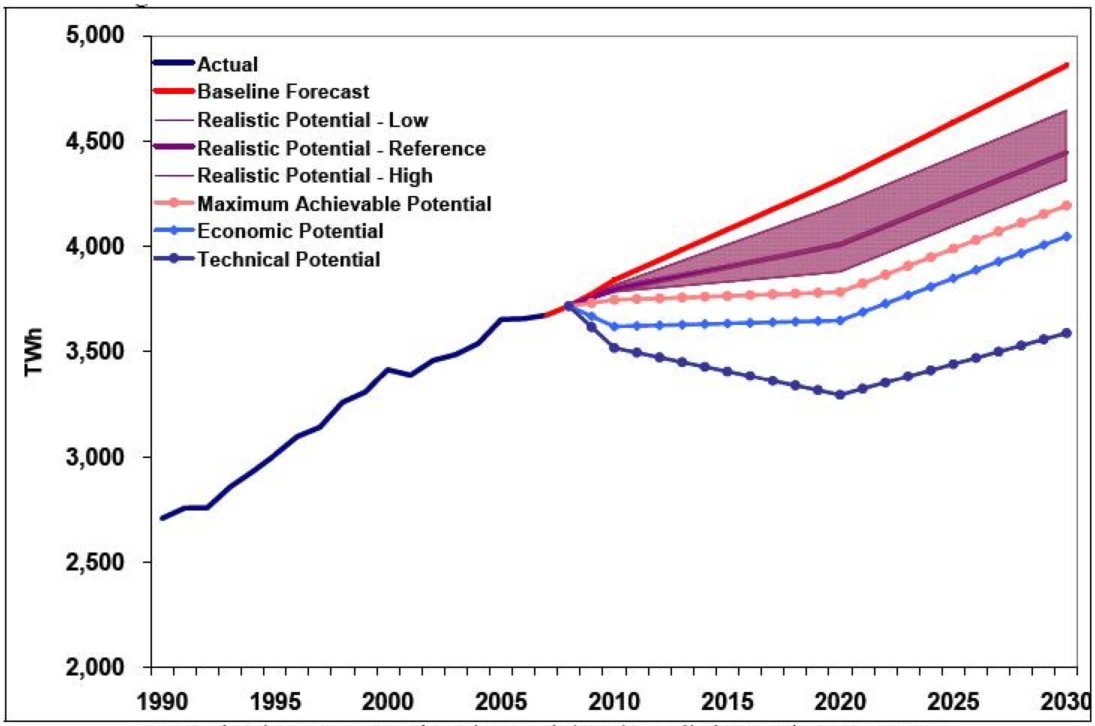
The remainder of this section presents a summary of the Forecast 20 background research.

A. Global Market Outlook

1. National electric energy requirements

U.S. energy consumption is expected to grow slowly and steadily. **Figure 5,** prepared by the Electric Power Research Institute (EPRI), presents a general base load growth prediction for the United States electricity market. The baseline forecast predicts a nearly 50% rise in base load growth over the next two decades. This figure also shows wide a range of savings the research arm of the U.S. electric industry foresees under different scenarios about future energy-efficiency investment potential. Even with reasonably achievable economic savings from efficiency investment, the EPRI forecast predicts substantial growth in national electric energy requirements.[3]

Figure 5. Potential estimates in context of baseline forecasts for the United States



Source: Electric Power Research Institute et al. (2008) – preliminary estimates June 2008

2. Effects of global warming on Vermont's climate

The earth as a whole is getting warmer, and since 1970, average temperatures have risen 1.5°F since 1970 in the northeastern United States. What does this mean for the future of Vermont?

a) Summer

The average summer heat index is a comfort indicator measuring how hot it actually feels, given temperature and humidity levels. The Northeast Climate Impacts Assessment (NECIA), a collaboration of the Union of Concerned Scientists and more than 50 independent experts, mapped how the average summer heat index in Vermont migrates over time, given a lower- and higher-emission scenario (**Figure 6**). The effects are stark. In twenty years, summer in Vermont might be like summer in Western Pennsylvania today.

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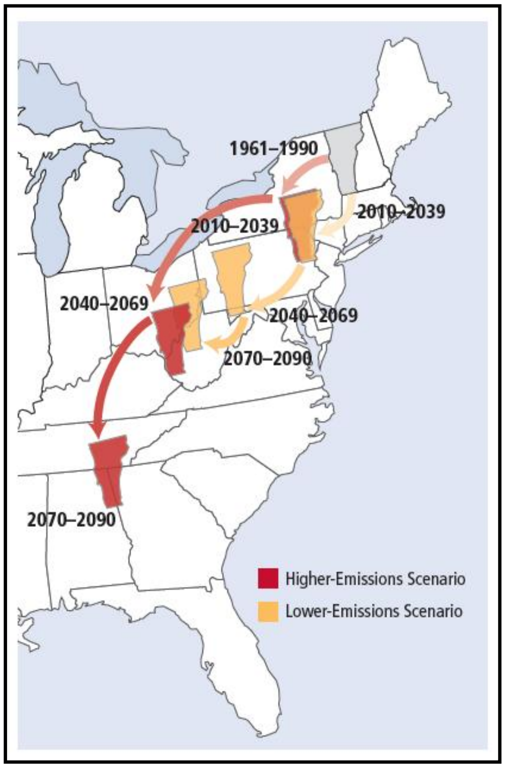
[3] EPRI's definition of reasonably achievable savings does not include early retirement of existing inefficient equipment, which ignores a major source of cost-effectively achievable efficiency investment included in the Forecast 20 study.

As average summer temperatures rise, so does the number of days above 90°F. Already, about 10% of new homes built in Vermont have central air conditioning installed, putting increased pressure on peak demand.

Figure 6. Vermont average summer heat index



b) Winter

Among other things, the impact of warmer winters poses a threat to the conditions needed for Vermont's $11 million maple syrup industry.[4] Winter in the Northeast is expected to undergo even more dramatic changes. Average temperatures have already seen a rise of 4°F from 1970 to 2000, and average winter temperatures in Vermont could swell to between 9°F and 14°F above historic levels by the end of the century. This means that Vermont's snow season could fall to approximately two-thirds of its historic levels. This has dire consequences for the recreation and tourism industry, which depend on snowfall for skiing and snowmobiling.[5]

The natural snow base will decrease due to higher average temperatures, and many ski areas in Vermont will see an increase of close to 40% in snowmaking operations over the next twenty years. Snowmobiling, a $3 billion-a-year industry, will also see dramatic reductions in season length.

[4] Peter C. Frumhoff. James J. McCarthy, Jerry M. Melillo, Susanne C. Moser, and Donald J. Wuebbles. "Confronting Climate Change in the U.S. Northeast: Science, Impact, Solutions," *Northeast Climate Impacts Assessment (NECIA)* (Cambridge, Mass.: Union of Concerned Scientists, July 2007).

[5] See note 2.

The season could shrink to 50% to 70% of its current length.[6] The above conditions have the potential to put a strain on already tight profit margins in Vermont's winter recreation and **tourism** industry.

3. Resource utilization and demographic shifts

a) Land and water use

Expansion of urban areas is expected to continue in the United States in the foreseeable future. By 2028, developed land in the United States is expected to increase by 79% over 2004 levels.[7] Heavily urbanized areas will continue to be the center of future expansion. Due to Vermont's lower level of urbanization and to its careful management of sprawl (with measures such as Act 250), land use change in Vermont should be moderate. The agriculture industry in Vermont faces the greatest threat from continued development, although warmer weather might lead to a longer growing season and more options for cash crops.

Approximately 80% of Vermont is forested. Forest-related manufacturing and tourism contribute approximately $1.4 billion to Vermont's economy. Temperature increases will mean the disappearance of cold-weather tree species such as spruce and fir. Further, development activities claim around 2,000 acres of forest a year.[8] This is in line with a national decline in timberland, with projections for a 4% decrease from 1997 levels by 2050.[9]

Current drains on Vermont's water supply indicate a need for infrastructure improvements. Recent droughts have seen Lake Champlain's water level drop to 30-year lows.[10] Increased snowmaking activity by ski areas, exacerbated by climate change, will further stress water supplies. In addition, the American Society of Civil Engineers (ASCE) estimates that approximately $450 million in improvements to drinking water and water treatment infrastructure are required in Vermont over the next twenty years.[11] Using infrastructure upgrades as opportunities to improve water usage could mitigate some of the projected strain.

b) People

Vermont has the third-smallest state population in the United States (only Wyoming and Washington D.C. have fewer people). In 2007, the population of Vermont was approximately 624,000, and it is estimated to increase to more than 711,000 by 2030. The U.S. Census Bureau's growth projections keep it ranked in the four lowest-population states (North Dakota slips below), with an expected 16.9% increase in total population from 2000 to 2030.

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[6] Daniel Scott, Jackie Dawson, and Brenda Jones, "Climate Change Vulnerability of the US Northeast Winter Recreation-Tourism Sector." *Mitigation and Adaptation Strategies for Global Change,* 13*(5-6),* 2008: 577-596.

[7] Alig R, Kline J, Lichtenstein M. "Urbanization on the U.S. Landscape: Looking Ahead in the 21st Century," in The Social Aspects of Landscape Change: Protecting Open Space Under the Pressure of Development issue of *Landscape and Urban Planning,* 69 (2-3) August 2004: 219-234.

[8] See note 2, above.

[9] U.S. Forest Service. General Technical Report PNW Land Use Change Involving Forestry Within the United States: 1952 to 1977, with Projections to 2050 n587 (2003 12 01): 1-77 Journal Code: USDA For. Serv. Gen. Tech. Rep. PNW.

[10] Federation for American Immigration Reform (FAIR). "Immigration Impact Facts," http://www.fairus.org/site/PageServer?pagename=research_research81a2

[11] http://www.asce.org/reportcard/2005/page.cfm?id=85 has ASCE's Vermont Report card.

VELCO's long-range electricity demand forecast is driven in part by future growth in population and economic activity. It projects that Vermont population will grow 0.25% annually through 2027. The number of households is expected to grow growing at more than twice that rate for the next 20 years, then slow to 0.2% thereafter. **Table 6** reproduces the annual forecasts of population, household formation, and economic activity.

Table 6. Annual forecasts of population, household formation, and economic activity

Year	Year-end Figures							Year	12-Month Average						
	Popu-lation	House-holds	Real Per-Capita Income	Gross State Product	Manufacturing Gross State Product	Em-ploy-ment	Manu-facturing Em-ployment		Popu-lation	House-holds	RPI	Gross State Product	Manufac-turing Gross State Product	Em-ploy-ment	Manufac-turing Employ-ment
2008	622.93	247.64	19,621.49	22,585.79	3,675.88	305.72	34.47	2008	622.42	247.00	19,480.75	22,240.80	3,637.70	305.86	34.74
2009	624.06	249.05	20,080.59	23,344.21	3,776.76	308.19	34.36	2009	623.54	248.40	19,890.15	23,003.08	3,729.61	306.98	34.40
2010	625.18	250.49	20,530.25	23,927.16	3,867.70	310.56	34.36	2010	624.66	249.84	20,334.93	23,679.63	3,828.13	309.62	34.39
2011	626.36	251.9	20,938.84	24,469.37	3,941.50	311.58	34.13	2011	625.82	251.26	20,747.71	24,215.66	3,907.90	311.12	34.25
2012	627.59	253.27	21,313.82	25,041.33	4,014.19	311.87	33.79	2012	627.02	252.64	21,146.40	24,777.13	3,980.95	311.76	33.95
2013	628.87	254.61	21,643.36	25,589.26	4,082.76	311.78	33.45	2013	628.28	254.00	21,494.27	25,338.48	4,051.74	311.82	33.60
2014	630.2	255.91	21,950.96	26,120.88	4,148.18	311.77	33.15	2014	629.59	255.32	21,811.46	25,879.69	4,118.08	311.78	33.29
2015	631.58	257.18	22,237.29	26,659.20	4,213.88	311.71	32.84	2015	630.94	256.60	22,107.58	26,416.76	4,183.70	311.75	32.98
2016	633.02	258.35	22,528.80	27,204.52	4,280.68	312.06	32.56	2016	632.35	257.83	22,392.01	26,950.12	4,249.87	311.81	32.69
2017	634.62	259.44	22,829.80	27,752.92	4,345.77	312.62	32.26	2017	633.87	258.94	22,691.69	27,501.83	4,316.30	312.37	32.40
2018	636.3	260.46	23,111.06	28,305.43	4,405.98	313.2	31.95	2018	635.53	260.00	22,984.75	28,051.01	4,378.59	313.00	32.10
2019	638.14	261.45	23,384.41	28,846.70	4,464.40	313.75	31.63	2019	637.28	261.00	23,256.32	28,596.97	4,437.55	313.46	31.78
2020	639.97	262.29	23,663.48	29,417.25	4,523.26	314.65	31.3	2020	639.14	261.92	23,536.47	29,158.76	4,496.23	314.24	31.45
2021	641.7	262.95	23,925.93	30,008.20	4,581.34	315.59	30.97	2021	640.90	262.66	23,804.72	29,736.52	4,554.76	315.13	31.13
2022	643.5	263.45	24,178.05	30,637.74	4,639.77	316.8	30.64	2022	642.66	263.23	24,060.63	30,348.17	4,612.74	316.22	30.80
2023	645.33	263.83	24,426.10	31,276.74	4,697.77	318.17	30.29	2023	644.51	263.68	24,314.03	30,984.34	4,671.37	317.53	30.45
2024	647.3	264.15	24,664.74	31,931.58	4,755.19	319.55	29.96	2024	646.37	264.00	24,552.96	31,630.93	4,728.67	318.90	30.11
2025	649.27	264.45	24,881.00	32,612.82	4,813.09	320.74	29.63	2025	648.39	264.33	24,789.89	32,301.27	4,786.58	320.28	29.78

	Year-end Figures								12-Month Average						
Year	Popu-lation	House-holds	Real Per-Capita Income	Gross State Product	Manufacturing Gross State Product	Em-ploy-ment	Manu-factur-ing Em-ployment	Year	Popu-lation	House-holds	RPI	Gross State Product	Manufac-turing Gross State Product	Em-ploy-ment	Manufac-turing Employ-ment
2026	651	264.64	25,048.73	33,323.18	4,870.21	321.49	29.29	2026	650.21	264.56	24,972.01	32,992.73	4,843.94	321.14	29.45
2027	652.78	264.82	25,221.75	34,064.61	4,927.50	322.51	28.96	2027	651.96	264.74	25,141.51	33,722.22	4,901.17	322.02	29.11
	Compound Annual Growth Rates								Compound Annual Growth Rates						
2008-2012	0.19%	0.56%	2.09%	2.61%	2.23%	0.50%	-0.50%	2008-2012	0.18%	0.57%	2.07%	2.74%	2.28%	0.48%	-0.58%
2008-2017	0.21%	0.52%	1.70%	2.32%	1.88%	0.25%	-0.73%	2008-2017	0.20%	0.53%	1.71%	2.39%	1.92%	0.23%	-0.77%
2018-2027	0.28%	0.18%	0.98%	2.08%	1.25%	0.33%	-1.09%	2018-2027	0.28%	0.20%	1.00%	2.07%	1.26%	0.32%	-1.08%
2008-2027	0.25%	0.35%	1.33%	2.19%	1.55%	0.28%	-0.91%	2008-2027	0.24%	0.37%	1.35%	2.21%	1.58%	0.27%	-0.93%

As the wave of baby boomers grows older in the next twenty years, the United States will see the number of workers per retiree approach 2.5, as opposed to 5 in 2005 and 7 in 1950.[12] Such a large demographic shift brings with it a host of problems, including increased healthcare costs, a declining tax base, and increased demand for social services. The risk to the capital markets is also great. As more people sell their wealth to support themselves in retirement, the supply of buyers for that wealth decreases and pushes down real asset prices (such as stocks, bonds, and real estate). After all, "investors cannot eat the factories or the machines of the businesses in which they have invested."[13]

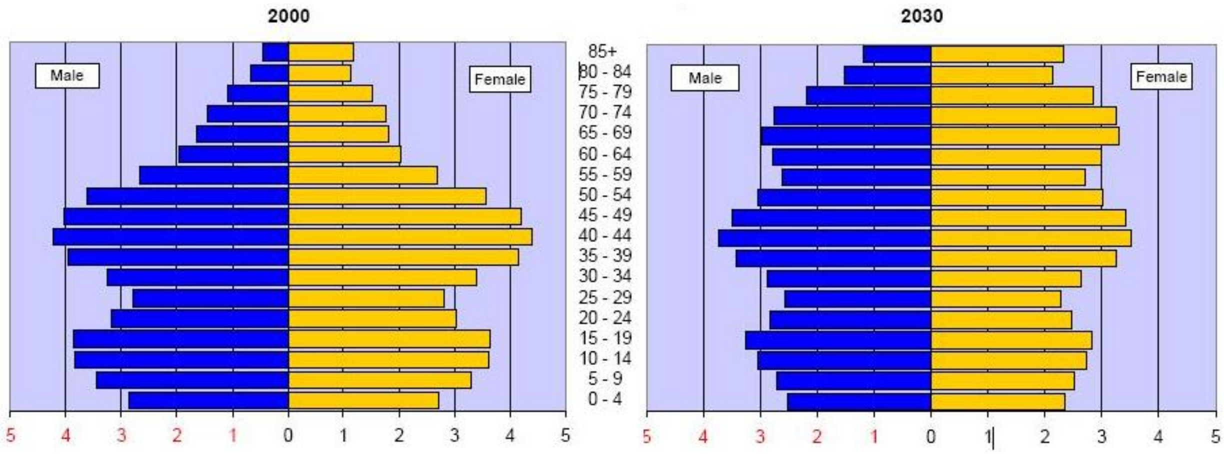
The population pyramid for Vermont, presented in **Figure 7,** shows a dramatic smoothing of age distribution by 2030. There is no doubt that Vermont is riding the age wave, and it will crash in the next twenty years. In fact, the percentage of the population in Vermont older than 65 in 2030 indicates a 124% increase over 2000 levels. Vermont's future population will be much older, and will probably

12 Jeremy J. Siegel and Russell E. Palmer, "Impact of an Aging Population on the Global Economy" *CFA Institute Conference Proceedings Quarterly,* September 2007.

13 See note 10, above.

include fewer workers. Price pressure on assets and later retirement will characterize the last stages of the baby-boomer generation, excacerbating the likely continuation of out-migration of young Vermonters.

Figure 7. Vermont population pyramids (% of population)[14]



4. Government action to combat global climate change

a) Carbon cap and trade

Government policy at the international, national, and state levels will be a key factor in shaping the future energy landscape. Many policy ideas have potentially wide impacts; however, for the sake of this analysis, this report focuses on one particular key policy tool that is poised to influence the energy efficiency field for many years to come, emissions trading.

Emissions trading has had a rocky history. It started as an application of the Clean Air Act of 1970 to curb acid rain by limiting sulfur dioxide (SO_2) emission. The Clean Air Act had roots in even earlier legislation from the 1950s. However, it was not until a series of amendments in 1990 that true emissions trading began. Before the 1990 amendments, the Clean Air Act was largely considered a failure.[15] Since the 1990 amendments, significant reductions in SO_2 and NO_x (components of acid rain) have been documented.

More recently, emissions trading has moved toward reducing greenhouse gases (GHG), primarily carbon dioxide (CO_2). In 1995, the European Union Greenhouse Gas Emission Trading System (EU ETS) was set up to trade CO_2. Currently, it is the cornerstone of the EU's strategy for reducing green house gases and is the most mature carbon-trading scheme in the world. Even now, however, allocation problems have caused massive volatility in carbon prices. The 2007 EU Allocations (EUA) were significantly over-allocated, which caused the price of carbon credits to collapse in 2007 (shown in **Figure 8**). Various structural issues, such as allocation strategies, continue to plague the EU-ETS.

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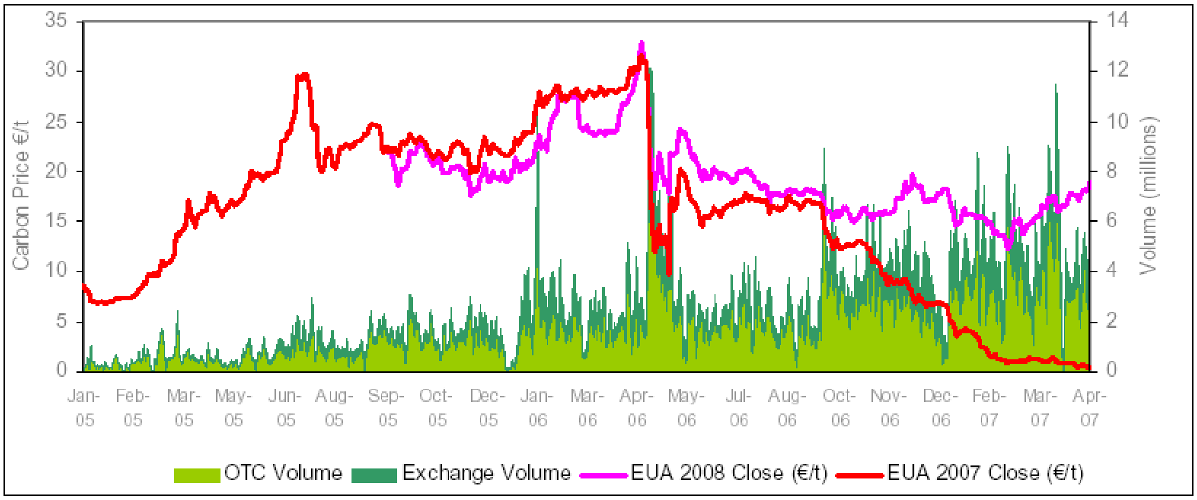
[14] Source: U.S. Census Bureau, Population Division, Interim State Population Projections, 2005 Internet Release.

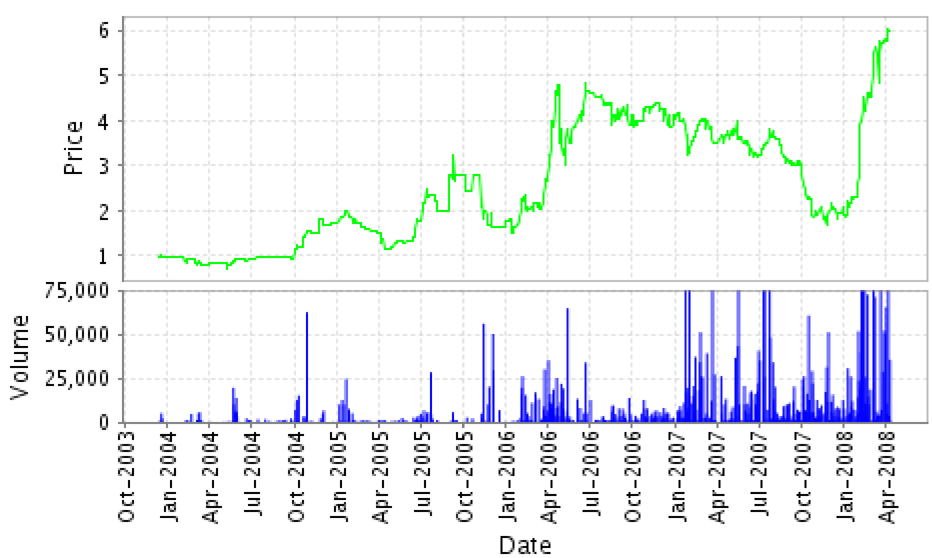
[15] Joel Sandersen, Ryan Holl, and Stephen Heins, "Energy Efficiency and Emission Trading Schemes." *2008 ACEEE Summer Study on Energy Efficiency in Buildings,* August 2008: 8-323 to 8-335.

Figure 8. European Union Allocations price and volume for 2005-2007[16]



In 2003, the Chicago Climate Exchange (CCX) launched as a voluntary North American trading system for the six major GHGs. CCX members must make a legally binding commitment to reduce their emissions; those who do not meet the targets must comply with the commitment requirement by purchasing CCX Carbon Financial Instrument® (CFI) contracts. CCX, unlike the Emission Trading Scheme, serves all industries. Currently, there are two phases of reductions: Phase I (projects in 2003-2006) and Phase II (projects in 2007-2010). The base contract for CCX is the CFI, for which the holder has the right to emit 100 tons of carbon equivalent for the defined year. The CCX scheme has been wildly popular, as is evident from the high volume and steep price increases for CFIs (**Figure 9**).

Figure 9. Chicago Climate Exchange Carbon Financial Instrument price and volume for 2003-2008[17]



[16] Source: Sandersen, 2008

[17] See note 17, above.

The Chicago Climate Exchange is important to Vermont for two reasons. First, it applies to North American projects. And, more important, it allows energy efficiency projects to qualify for trading. "Once American industry and politicians begin to understand the importance of 'throwing the kitchen sink at energy efficiency," (to quote Martin Kushler, Program Director at the American Council for an Energy-Efficient Economy (ACEEE), at a recent energy conference), "it is very likely to be the first and best investment in energy reduction."[18] In other words, carbon trading is quickly gaining momentum and will be a foundational element of future carbon emission reduction policy.

Efforts are under way to initiate more cap-and-trade programs in the United States. The Lieberman-Warner Climate Security Act of 2008 has proposed a national program to reduce GHGs to 1990 levels by 2020, and to 65% below 1990 levels for 2050.[19] The Regional Greenhouse Gas Initiative (RGGI), of which Vermont is a member, began auctioning credits on January 1, 2009.[20] To date, five auctions have taken place, with the sixth scheduled for December 2, 2009. RGGI aims to stabilize power sector CO_2 emissions for 2009-2014, and to reduce emissions at an annual rate of 2.5% for 2015-2018 through a mandatory cap-and-trade program for electricity generators. [21] It remains to be seen what will emerge as the dominant model for cap-and-trade. In the meantime, carbon markets will continue to proliferate.

b) Further action on climate change

As climate change and energy efficiency continue to permeate the public consciousness, new approaches to solving these problems present themselves. The following section highlights some of the most recent and well-known approaches to tackling greenhouse gas emissions. Interestingly, they both come to the same conclusion – that it is possible to make a huge impact without inventing anything new.

(1) Stabilization wedges

In their seminal paper in the journal *Science* (2004), Stephen Pacala and Robert Socolow presented 15 options that take a chunk, or wedge, out of projected growth in fossil fuel emission. By combining a portfolio of these wedges, the projected emission growth begins to flatten and eventually stabilizes. Most strikingly of all, they found that it was possible to reach a stable emissions projection with existing technology and methods.

The options proffered by Pacala and Socolow included elements such as increasingly efficient vehicles, nuclear power replacing coal power, and capturing CO_2 at base-load power plants. Energy efficiency is usually presented as an important wedge. Pacala and Socolow also emphasize the fact that the 15 options presented in the paper are by no means the limits of possible wedges. **Figure 10** indicates the stabilization wedges, graphically.

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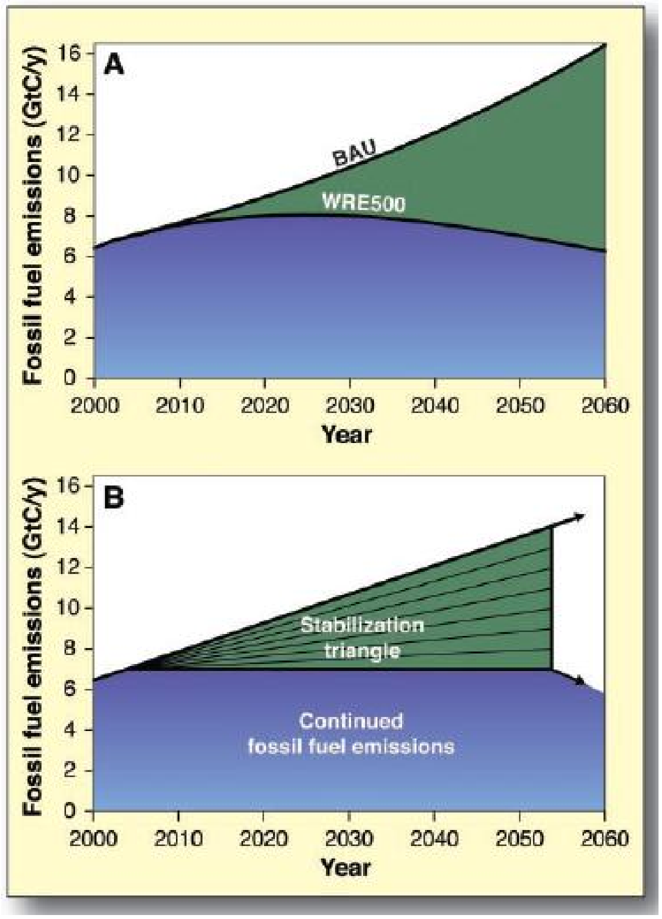
[18] See note 17, above.
[19] See note 178, above.
[20] Press release by RGGI on July 11, 2008. http://www.rggi.org/docs/20080711news_release.pdf
[21] Regional Greenhouse Gas Initiative (RGGI). *Overview of RGGI CO_2 Budget Trading Program, October 2007.* http://rggi.org/docs/program_summary_10_07.pdf.

Figure 10. Stabilization wedges



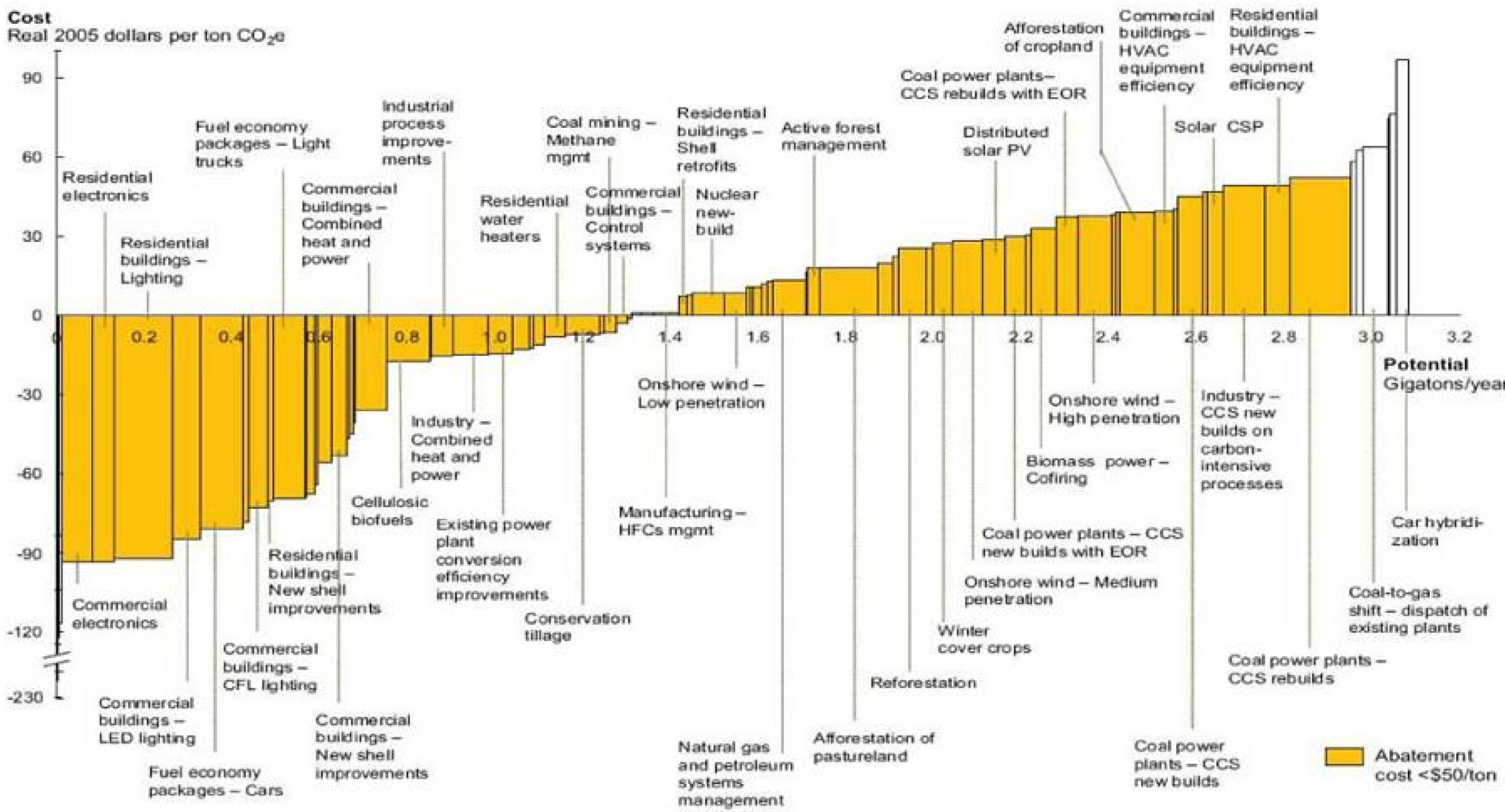
(2) McKinsey estimate of potential emission reductions from efficiency

In 2007, after two years of research, the global management consulting firm McKinsey & Company released a detailed examination of carbon abatement opportunities in the United States. McKinsey found that the United States could reduce GHG emissions in 2030 by 3.0 to 4.5 gigatons of CO_2 using tested approaches and high-potential emerging technologies."[22] They also highlighted the risks resulting from executing such a wide-ranging and detailed set of plans.

The report provided a wide array of abatement opportunities arranged according to cost (**Figure 11**). The graph shows a large amount of negative cost opportunities in energy efficiency, and is a key example of how the wider world is starting to pay more attention to energy efficiency.

[22] Jon Creyts, Anton Derkach, Scott Nyquist, Ken Ostrowski, Jack Stephenson, "Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?". New York: McKinsey & Company, December 2007..

Figure 11. McKinsey U.S. mid-range abatement curve – 2030



Source: McKinsey & Company

Vermont can look forward by 2027 to a warming climate, with people living in older, smaller houses located in more densely populated areas. The VELCO demand forecast reflects these expectations in terms of residential customer growth. It also projects significant growth in the market saturation of residential air-conditioning. This growth mirrors the expected trend in the rest of New England. The VELCO forecast does not anticipate any increase in the number of cooling degree-days that would be expected to accompany global warming. While initially skeptical of the VELCO forecast's prediction of future air-conditioner saturation, this study concluded that it is consistent with warmer summers, and consequently creates a reasonable basis for forecasting future efficiency.

Increasingly ambitious market intervention to avert irreversible climate change appears inevitable over the next twenty years. As is clear from the carbon abatement cost curve for the nation in **Figure 11,** improving the efficiency of building electricity usage is but a part of the more comprehensive challenge of improving the efficiency of all building end uses, particularly non-electric space, water, and process heating. Action to improve the energy efficiency of buildings in Vermont will almost certainly advance farther in the next ten years than it has in the past ten years. This study concludes that Vermont government leaders will by then have charted a clear path for completing the retrofit of the remaining inefficient housing stock over the subsequent decade. This conclusion influenced this study by leading the analysis to assume that the basic infrastructure supporting residential retrofits will eventually need to be funded increasingly from sources beyond electricity ratepayers, as fossil-fuel efficiency investment increases.

B. Technology Outlook

1. Building codes and standards

a) Overview

Codes and standards are intended to determine the minimum baseline criteria for efficient products in the marketplace. Even so, there is a disparity between expectation and implementation. Codes and standards have historically been applied to technologies and practices that have been accepted in the marketplace. These two factors might offer profitable opportunities for efficiency program savings.

One of the most significant changes in federal standards concerns lighting. These changes will go into effect in 2012. They are discussed both here and in the "Lighting" section.

b) Codes

The Vermont Energy Efficiency and Affordability Act (S.209 of 2009) coupled Vermont's building codes to the International Energy Conservation Code (IECC), charging the DPS Commissioner to "ensure that appropriate revisions are made promptly after the issuance of updated standards."[23] Vermont's Residential Building Energy Standard (RBES) is based on the 2000 IECC with state-specific amendments. The Commercial Building Energy Standards are based on the 2004 IECC, with amendments to incorporate the commonly used reference for state codes from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1-2004 and state specific amendments.

[23] 21 V.S.A. § 266(c) for the Residential Building Energy Standard (RBES) and 21 V.S.A. § 268 for Commercial Building Energy Standard (CBES).

Known changes for the short term. The US Department of Energy (DOE) is responsible for reviewing Standard 90.1 and determining the impact of revisions. If DOE finds that a revision will have a positive impact on energy efficiency, the states have two years to upgrade their codes to meet or exceed the Standard. The DOE reports that it will issue its determination on ASHRAE Standard 90.1-2004 soon.[24] In the meantime, ASHRAE 90.1-2007 is available. In the near term, the DPS updates are likely to lag code development by at least one code cycle. The level of efficiency improvements between subsequent code cycles will increase sharply in the near term, and level off as new construction requirements trend toward (but are not expected to reach) net-zero energy by 2030.

Future impacts of federal and state codes, either on the books or scheduled. The IECC typically is comparable to the Standard 90.1 in effect at the time of the update process. Vermont's code update process appears to be lagging both the IECC and Standard 90.1 by one version. The DPS website makes no mention of an update process at this time.[25] DOE reportedly is seeking an average improvement in efficiency of one to two percent per year, or three to six percent between code editions.[26] A reasonable estimate of the saving difference between code versions would be five percent if nothing changed. This would imply increasing baseline efficiency for new construction and major renovation in Vermont by 2028 of about 20 to 40%.

c) Standards

On October 13, 2009, the nation's leading manufacturers of residential central air conditioners, furnaces, and heat pumps signed an historic, voluntary agreement with the nation's leading energy efficiency advocacy organizations supporting new federal standards for those products. For the first time, the agreement calls for regional efficiency standards to replace a quarter-century of national standards, and it also recommends more stringent building code provisions for new construction.[27] The signatories (ACEEE; the Air Conditioning, Heating, and Refrigeration Institute [AHRI], and the Alliance to Save Energy) agreed to submit their agreement jointly as a legislative proposal to Congress for inclusion in the energy legislation currently under consideration. The groups will also recommend that the Department of Energy promulgate a rule adopting the agreed-upon regions and efficiency standards.[28]

Federal efficiency standards are essentially "manufacturing standards" that prohibit the production or importation of equipment that does not meet certain minimum criteria for efficiency. These take precedence over state standards, although states can acquire a waiver to implement standards that are stricter or higher than federal standards, where they exist. State standards relate to in-state sales, and thus are typically less stringent because of the effects of interstate commerce. Standards are typically increased through federal legislation and / or DOE rulemaking.

As of 2012, new national minimum energy efficiency requirements for light bulbs, announced in June 2009 by the Obama Administration, will save more energy than any other

24 http://www.energycodes.gov/implement/determinations_com.stm, November 26, 2008.
25 Accessed November 26, 2008.
26 Mark Halverson, Pacific Northwest Regional Laboratory, personal communication.
27 "HVAC Manufacturers, Efficiency Advocates Ink Historic Efficiency Standards Agreement -- Accord Would Yield $13 Billion in Net Savings from 2013 to 2030." Press release from Air-Conditioning, Heating, and Refrigeration Institute (AHRI), the American Council for an Energy-Efficient Economy (ACEEE), and the Alliance to Save Energy, October 13, 2009. http://www.aceee.org/press/0910ahri.htm.
28 See note 27, above.

standard ever issued by any administration.[29] These are covered in more detail under the "Lighting" section.

Known changes for the near term. Vermont has standards for the following equipment:

(1) Medium voltage dry-type distribution transformers.

(2) Metal halide lamp fixtures.

(3) Residential furnaces and residential boilers.

(4) Single-voltage external AC to DC power supplies.

(5) State regulated incandescent reflector lamps.

(6) Any other product that may be designated by the commissioner in accordance with section 2797 of this title." [9 V.S.A. § 2794][30]

Recent legislation having an effect on standards—the Energy Independence and Security Act of 2007 (EISA). This legislation will be phased in, beginning in 2012 and proceeding through 2014, enacting new standards for General Service Lamps and Reflector Lamps, essentially requiring 30% higher efficacy for all lamps in these two categories.

The legislation had many exemptions (loopholes), specifically with bulged reflector (BR) lamps, candelabras, globes, and other types, often called "specialty bulbs." It is worth noting that the BR lamp was exempted because DOE did not think they had the authority to regulate it.

> ***Impact on residential programs.*** Under the EISA, the baseline for standard CFLs will increase. Standard incandescent bulbs will begin to be phased out in 2012, starting with the 100W version, and continuing with additional, lower wattages through 2014. The standard incandescent bulb on product shelves will change to infra-red (IR) halogen or advanced incandescent around this time, and may potentially cost more than a comparable CFL bulb. As a result, standard CFL savings opportunities will be significantly reduced or eliminated. Opportunities with specialty bulbs will exist for a longer period, but may also be affected by future DOE rulemakings.
>
> ***Impact on Commercial Programs.*** This impact is expected to be less than with residential programs. This impact will be limited mostly to Business Energy Services savings claimed through Efficient Products.
>
> ***Other legislation expected: U.S. Senate Bill S598.*** Proposed to cover incandescent reflector lamp (IRL) exemptions. This particular piece of legislation has changed a lot, but the bottom line is that efficiency standards are a hot topic and could make their way into any energy or green legislation. Exemptions are well known and targeted.

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29 "President Obama announces new light bulb standards – Biggest energy saver in history of Energy Department," press release from the American Council for an Energy-Efficient Economy (ACEEE), Appliance Standards Awareness Project, and the Natural Resources Defense Council (NRDC), June 29, 2009. At http://www.aceee.org/press/0906lighting.htm

30 These standards were added after enactment of Act 152 of the 2005 – 2006 Vermont legislative session (H. 253), as Chapter 74 in Title 9, "Energy Efficiency Standards for Appliances and Equipment" (9 V.S.A. § 2791 et. seq.).

DOE Rulemaking on incandescent reflector lamps and general service fluorescent lamps (GSFLs). These new rules, announced June 2009 and going into effect on July 1, 2012, set a high standard for GSFLs and are described in the "Lighting" section. As part of this rulemaking, DOE reversed their earlier decision that they did not have the authority to regulate BR lamps, and announced a future rulemaking later in 2009 to address BR lamps and close the loophole.

> ***Impact on Residential Programs.*** Increasing baseline for Reflector CFLs. Elimination of BR loophole likely for 2012. The standard reflector bulb on product shelves will change to halogen PAR, and may potentially cost more than a comparable CFL Reflector bulb. As a result, reflector CFL savings opportunity will be significantly reduced or eliminated.
>
> ***Impact on Commercial Programs.*** Potentially rising baselines and lowered savings for all High-Performance T8 measures. All retrofits from T12s will become early replacements that would have occurred anyway, reducing effective measure life. This could have major impacts, depending on what happens with the future ballast rulemaking.
>
> ***Other Rulemaking scheduled: New fluorescent ballasts.*** Expected to be announced 2011. Expected to take effect 2014. It is very possible high-performance ballasts could become the minimum standard. If this happens, there will be significant impacts on BES Programs and Savings.
>
> ***Other rulemaking scheduled: BR Lamp standard.*** Later in 2009, expected to be effective in 2013

d) Future policy considerations

Long-term changes. The impact of standards and codes on efficiency programming in the long term may come from the following:

> ***New standards.*** Greater focus on climate change may result in more aggressive standard setting in the future. New standards are most likely to be developed: (1) for common items with high saturation, (2) when there is a clear distinction between the efficiency of the average unit and the more efficient units, or (3) when there is a substantial shift in technology.
>
> ***Code enforcement.*** To date, reliable code enforcement for efficiency has remained elusive because of chronic and ubiquitous understaffing at local levels for all but health and safety code enforcement. However, Washington State and other locations are using a promising approach in which a private building inspector verifies building compliance at the time of purchase or occupancy.[31]
>
> ***Expanded codes.*** Codes have traditionally applied to new construction or substantial renovation. Other market events, most commonly transfer, have received regulatory attention through time-of-sale ordinances or efficiency disclosure requirements. Considering the relative numbers of existing buildings to new construction, this market offers a tremendous opportunity for savings. Efficiency

[31] States discussing adoption of similar approaches include Maine, Massachusetts, Rhode Island, and New York.

programs may be able to capture these savings by leveraging disclosure requirements or even participation in upgrades beyond code requirements.

Expanded services. Recent potential studies by ACEEE have included combined heat and power (CHP) and demand response resources (DRR) in their efficiency potential studies.[32] Although beyond the scope of this report, it is noteworthy that these resources offer system benefits comparable to those offered through energy efficiency measure installations, and potentially offer economic and environmental benefits as well. Higher levels of saturation will likely spur code and standard development.

Type of equipment covered. ACEEE / ASAP has estimated the impact of standards on Vermont's energy use for a selection of products based on a 2006 model bill. While this bill was superseded by subsequent legislation, the estimate of energy savings from standards for this set of measures serves to validate a more comprehensive estimate presented later.

Table 7 presents a partial list of the findings for benefits from Energy Efficiency Standards.[33]

Table 7. ACEEE and ASAP – Energy Efficiency Standards benefits – 2006 model bill (partial list)

Products in Vermont	Annual savings per unit	Annual savings from 1-year sales	2020		2030	
			Energy Savings	Capacity Reduction	Energy Savings	Capacity Reduction
	kWh or [therms]	GWh or [million cubic feet]	GWh or [million cubic feet]	MW	GWh or [million cubic feet]	MW
Bottle-type water dispensers	266	0.1	0.6	0.01	0.6	0.1
Commercial boilers	[268]	[1.3]	[10.7]	0	[23.2]	0
Commercial hot food holding cabinets	1815	0.1	0.8	0.3	1	0.3
Compact audio products	53	0.8	4	0.5	1	0.5
DVD players and recorders	11	0.1	0.6	0.1	0.6	0.1

32 See ACEEE reports E085, E082, & E073

33 Personal communication with Andrew Delaski, ASAP, 11/25.08 – Document has been removed from website as outdated, file name a062_vt.pdf is available on request.

Products in Vermont	Annual savings per unit	Annual savings from 1-year sales	2020		2030	
			Energy Savings	Capacity Reduction	Energy Savings	Capacity Reduction
	kWh or [therms]	GWh or [million cubic feet]	GWh or [million cubic feet]	MW	GWh or [million cubic feet]	MW
Liquid-immersed distribution transformers	6	1.5	18.8	2.6	33.8	4.7
Medium voltage, dry-type	6 / kVa	0.1	1.2	0.2	2.1	0.3
Metal halide lamp fixtures	307	1.6	19.4	6.4	31.1	10.2
Pool heaters	[58]	[1.9]	[16.4]	0	[28.9]	0
Portable electric spas	250	0	0.4	0.1	0.4	0.1
Residential furnaces and boilers	792 [112]	2.5 [356]	21.4 [356]	0.4	45.2 [755.8]	0.9
Single-voltage external AC to DC power supplies	4	1.6	11.2	1.5	11.2	1.5
State-regulated incandescent reflector lamps	61	13.3	12.5	3.1	12.5	3.1
Walk-in refrigerators and freezers	8220	0.9	11.2	2.6	11.2	2.6
TOTALS		**23 [41.4]**	**102 [383.1]**	**18**	**154 [808]**	**24**

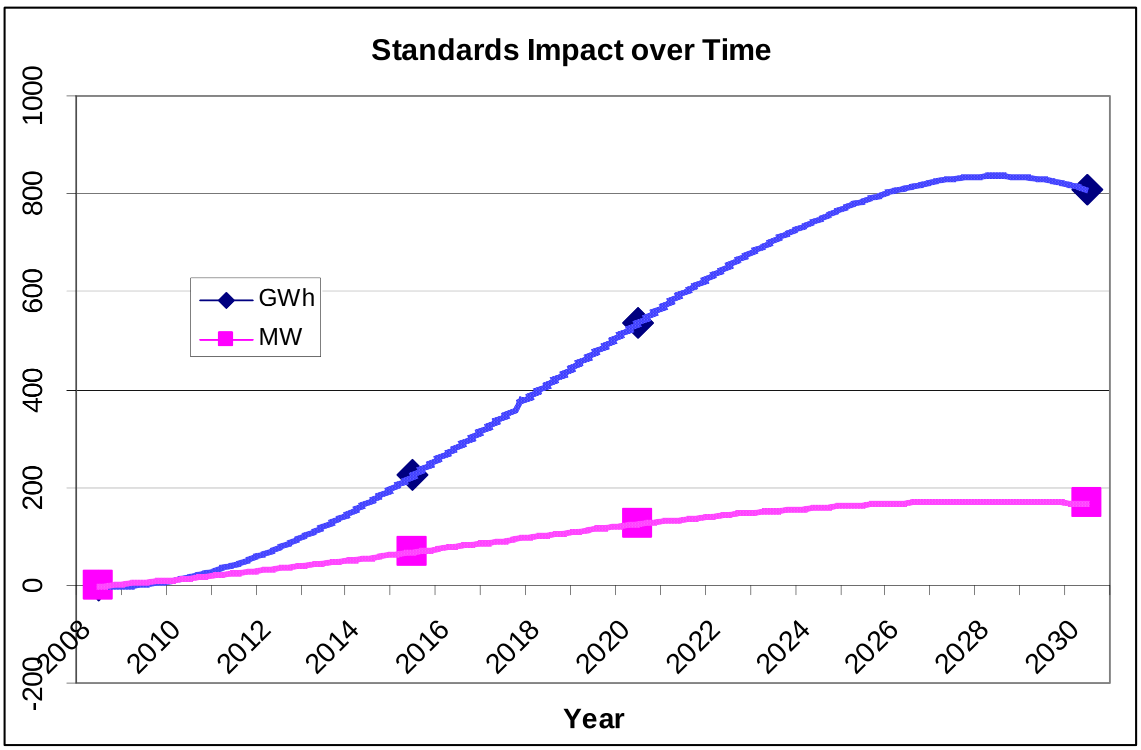
Table 8 captures estimates of standards impacts: The Vermont partial standards benefits of 2006 and a more comprehensive analysis based on a model developed by ACEEE for 2008, using nationwide data. **Figure 12** is a graphical depiction of the data in **Table 8.**

Table 8. Summary of savings estimates, comparing two sources of information

Summary of Standards Estimates over Time							
	Annual savings from 1 yr sales	2015		2020		2030*	
	GWh	GWh	MW	GWh	MW	GWh	MW
2006, based on partial list	23	N/A	N/A	102	18	154	24
2008 estimate using ACEEE methodology	169	225	69	536	126	809	168

* - 2008 estimates for 2030 generated from ratio of 2006 Partial 2020 to 2030.

Figure 12. Estimate of savings from federal standards for Vermont[34]



[34] Lines are the 3rd order polynomial, as generated by Microsoft Excel software.

e) Conclusions

Nationally, equipment and appliance standards over the study period, compared to the base case, are projected to reduce annual energy use by more than 800 gigawatt-hours (GWh), and reduce peak load by 168 gigawatts (GW). Construction codes are projected to reduce the energy use of new buildings by 70 to 80%, compared to the baseline in the same period. Based on historic patterns of development, technology will continue to develop at a rate sufficient to provide incremental energy efficiency opportunities.

2. Technology trends

a) Lighting

Research. The U.S. Energy Information Administration (EIA) Annual Energy Outlook (AEO) Report presents a biennial 20-year Technology Forecast Update, predicting the efficiency, cost, and market share of lighting technologies in both residential and commercial sectors. Efficiency Vermont uses EIA data and various reports—specific to certain technologies, such as LED—that predict future efficiency, cost, and potential. Since many of these reports use the EIA data, the Technology Forecast Update constitutes the most comprehensive data source available, and thus informs this Forecast 20 Final Report.

New market drivers in lighting—such as climate change, high energy costs, widespread energy efficiency programs, game-changing technologies, and even social change—are not only producing unprecedented changes in lighting, but are also lowering the confidence of any prediction that is based on historical data. This caveat predicates the following best estimates of lighting technology trends discussed below.

Lamp technology trends. Major improvements in lamp technology have already occurred in most types of lighting, with the exception of Solid-State Lighting. Major efficacy improvements are expected in both LED and organic light-emitting diode (OLED) technology, eclipsing the efficacy of all conventional lights sources in the next few years.

The relative cost of fluorescent and HID lighting technologies is expected to remain similar to what it is now. The relative cost of incandescent lamps is expected to increase as new federal standards begin taking effect in 2012. The relative cost of LED and OLED is expected to decrease rapidly over time.

Efficiency opportunities in lighting. The most significant opportunities in lighting efficiency in the future will be of two different types: technology efficacy (higher lumens per watt), and system efficiency (how overall lighting systems perform). LEDs will offer the most opportunity for technology efficacy opportunities in the future, initially in directional applications, and eventually with general lighting applications. Expected cost reductions in LEDs The move to system efficiency in program design is being called the next frontier in lighting energy savings, and will offer greater and deeper lighting efficiency opportunities far into the future.

Recent developments. New lighting standards announced by the Obama Administration and set to go into effect in 2012 call for more efficient fluorescent tube lamps, phase out conventional incandescent reflector lamps, effectively extending the 2007 congressional phase-out of inefficient incandescent products Highly efficient T8 lamps will replace T12 lamps; reflector lamps, standard incandescent and halogen technology will be replaced with highly efficient halogen infrared reflector technology. According to the DOE, lighting uses nearly 40 percent of all electricity used in commercial buildings.[35] The new standards will affect the more than 500 million fluorescent tube lamps and 265 million reflector lamps sold each year in the United States, and will save up to 1.2 trillion kilowatt-hours over thirty years, an amount about equal to the total consumption of all homes in the United States in one year.[36] Businesses and consumers will gain up to $35 billion in net savings and global warming carbon dioxide emissions will be cut by up to 594 million metric tons, an amount equal to the annual emissions of nearly 110 million cars.[37] Further, the DOE is slated to set a total of 25 new standards during the current presidential term.

b) Heating, ventilation, air conditioning, and refrigeration technology

Overview. Status and trends of current and emerging efficiency technologies in Heating, Ventilation, Air Conditioning and Refrigeration (HVAC / R) for Residential HVAC, Commercial HVAC, Commercial Refrigeration, and emerging technologies.

Residential HVAC. Improvements in residential cooling systems over the next 20 years will likely be delivered in the form of efficiency improvements in existing technologies such as compressors, heat exchangers, controls, and fans. Specifically, improvements in duct fitting and aerosol-based duct sealing appear to have the greatest savings potential, although available technology is proprietary, and the current limited market penetration suggests slow growth.[38] But low cost and relatively quick payback of this technology could improve growth and market penetration.

A Northeast Energy Efficiency Partnerships analysis indicates that incremental improvements in the efficiencies of central air conditioners, boilers, and furnaces have the greatest savings potential for the next 10 years.[39]

Commercial HVAC. Unitary packaged rooftop HVAC units (RTUs) provide cooling for nearly 50% of all commercial floor space in the Northeast; RTU market share is even higher in Vermont, given the relative lack of high-rise buildings here.[40] Although equipment efficiencies have increased substantially since 1980, progress is slowing because of refrigeration cycle limitations and

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35 "President Obama announces new light bulb standards – Biggest energy saver in history of Energy Department," press release from the American Council for an Energy-Efficient Economy (ACEEE), Appliance Standards Awareness Project, and the Natural Resources Defense Council (NRDC), June 29, 2009. At http://www.aceee.org/press/0906lighting.htm

36 Ibid.

37 Ibid.

38 Harvey Sachs, Steven Nadel, Jennifer Thorne Amann, Marycel Tuazon, Eric Mendelsohn, Leo Rainer, G. Todesco, D. Shipley, and M. Adelaar. *Emerging Energy-Saving Technologies and Practices for the Buildings Sector as of 2004*. (Washington, D.C.: American Council for an Energy-Efficient Economy), October 2004.

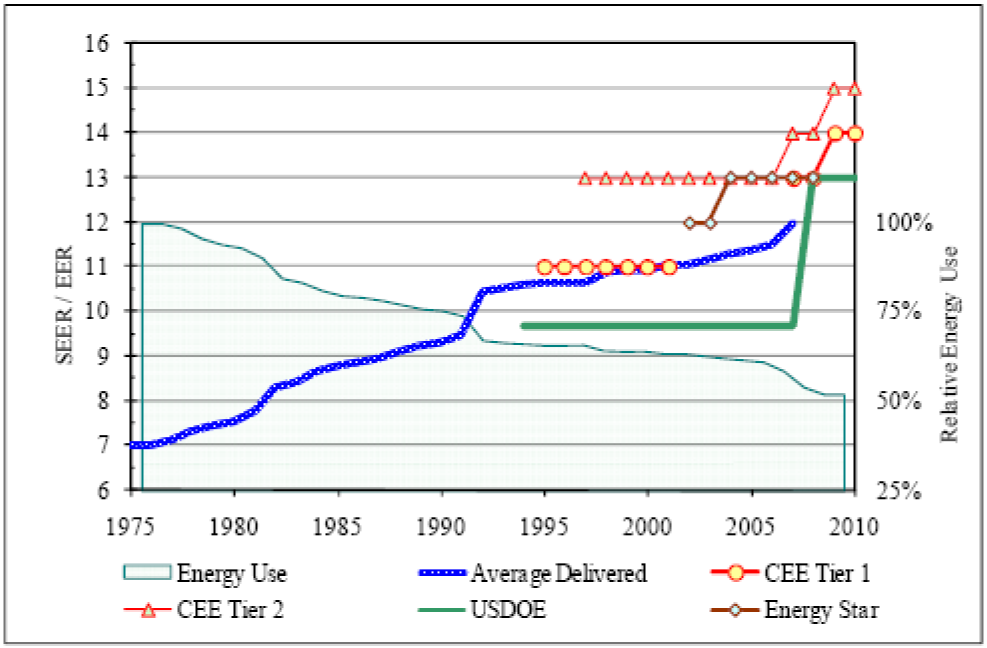
Aeroseal 2008. A-C Duct Contractor Locator – Aeroseal. Dec. 9, 2008. http://www.aeroseal.com/locatedealer.asp.

39 Elizabeth Titus, *Strategies to Increase Residential HVAC Efficiency in the Northeast.* Prepared for the National Association of State Energy Offices. May 2006. Lexington, Mass.: Northeast Energy Efficiency Partnerships.

40 CBECS 2006. Commercial Buildings Energy Consumption Survey 2003. – Table B41. Energy Information Administration. June, 2006. Washington, D.C.: U.S. Department of Energy.

increased material costs.[41] Figure 13 shows the average efficiency of light commercial units shipped since 1975.

Figure 13. Packaged unit efficiency improvement and standards (SEER)



SEER for unitary air conditioners under 65,000 Btu/hr; EER for 1975-1980.

(Original graphic from Hart et al., 2008)

Economizers. Outside air economizers have not reached their potential because of suboptimal operator practices and malfunctioning controls.[42] Improvements in control units that should result in a spike in sales in the next few years, leading to significant energy savings.[43]

Ground-Source Heat Pumps. A recent study concludes that the significance of ground source heat pumps (GSHP) in new construction applications will greatly increase in the coming years.[44] As the "green building" movement continues to gain momentum, GSHPs are likely to become more available, but analysis does not suggest cost reductions for residential systems in the near future.[45] Further, as loads are significantly reduced in new homes, the high capital costs for these systems yields long consumer paybacks.

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41 Reid Hart, Will Price, John Taylor, Daniel J. Morehouse, Howard Reichmuth, "Up on the Roof: From the Past to the Future." In *Proceedings of the ACEEE 2008 Summer Study on Energy Efficiency in Buildings*. (Washington, D.C.: American Council for an Energy-Efficient Economy), 2008.

42 Alan Cowan, Review of Recent Commercial Roof Top Unit Field Studies in The Pacific Northwest and California (White Salmon, Wash.: New Buildings Institute). Oct. 8, 2004.

43 Mark Cherniak and Howard Reichmuth. *Commercial Rooftop HVAC Energy Savings Research Program* (White Salmon, Wash.: New Buildings Institute). June 2008.

44 FMI. The HVAC and Sheet Metal Industry Futures Study. Raleigh, NC. 2008.

45 Efficiency Vermont, "Ground source heat pumps: The right choice for you?" 2008. http://www.efficiencyvermont.com/pages/Residential/Home_Heating/heating_systems/GSHP/.

Commercial Refrigeration. The widespread adoption of modulation compressors hold promise for savings and fall into the category of "emerging technologies" (see below).

Modulating Compressors. Variable speed scroll compressors can save from 25% to 50% over hermetic reciprocating compressors.[46] Compressor energy accounts for 28% of large supermarket energy use; this represents a large energy saving opportunity.[47]

Emerging Technologies

Solid State Cooling. The development of compact, solid-state heat pumps suggests a potential for reaching 55% of the maximum theoretical efficiency for heat pumps.[48] The technology is still in its infancy and has yet to be commercialized. If this technology were to mature and become cost competitive within the analysis period, it could have a significant impact on commercial refrigeration savings potential.

Magnetic Refrigeration. Magnetic refrigeration uses magnetocaloric materials to absorb heat from their surroundings, circulate them through magnetic fields, and transfer heat with heat exchangers.[49] This technology is closer to commercialization, but is still in a very early stage of development and unlikely to affect Vermont's commercial refrigeration market in the analysis period.[50]

Variable Refrigerant Flow Systems. These systems are a mature technology in use outside North America, but a lack of knowledgeable contractors and AHRI-certified rating procedures are major barriers to technology acceptance. Savings impacts are expected to be minimal.

Conclusions. The primary technologies employed to heat and cool Vermont's buildings are unlikely to change dramatically in the next 10 or even 20 years. Likewise, commercial refrigeration equipment of the future will likely be very similar to what is used today. While many new technologies are currently in the research and development phase, it is unlikely that they will attain significant market shares during the analysis period. Instead, HVAC&R will follow an evolutionary path with equipment efficiencies gradually increasing over time.

c) Motors and drives

Overview. Little documentation exists on efficiency trends in motors and drives. A federal best-practices manual has yet to be updated from 1997, and the majority of motors / drive systems

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[46] Sachs et al., 2004.

[47] ASHRAE 2006. *2006 ASHRAE Handbook – Refrigeration.* Atlanta, GA: American Society of Heating, Refrigeration, and Air-Conditioning Engineers.

[48] Sachs et al., 2004

Cool Chips 2008. Cool Chips™ Technology. Dec. 9, 2008.
<http://www.coolchips.gi/technology/index.shtml>

[49] Navigant, Notice of Proposed Rulemaking Technical Support Document: Energy Efficiency Standards for Commercial and Industrial Equipment. Navigant Consulting, Inc. (Washington, D.C.: U.S. Department of Energy). Aug. 22, 2008.

[50] Hanne Alvi, "Milestone in magnetic cooling," National Laboratory for Sustainable Energy. Technical University of Denmark. Dec. 9, 2008.
<http://www.risoe.dk/News_archives/News/2007/0820_magnetisk_koeling.aspx>

already function at a relatively high level of efficiency. Thus, most of the savings are gained from optimizing the use of the appliance itself.[51] Nevertheless, it is generally believed that a significant potential exists with variable-speed drive and adjustable-speed drive applications for larger motors. As drives become smaller and cheaper to produce and install, they may find a broader application, particularly in applications where variable power outputs are needed, and typically larger motors are run at less than optimum conditions for maximizing efficiency.[52]

The greatest potential to achieve savings in motors is via rotor construction, although there are many other components that are harder to address, but which contribute to overall efficiency in motors. Friction, heat generation and dissipation (although addressing rotors can help to deal with some of that), and vibration are areas where entropy occurs.[53] What is more, when one looks at applications outside the industrial sector, mostly commercial and residential appliances, motors account for only a portion of the total energy use of those appliances, and are often the least cost-effective component in achieving energy savings.[54]

Industrial Applications. The Copper Development Association (CDA) and National Electric Manufacturers Association (NEMA) have been pushing to replace the less-efficient, highly resistant aluminum rotors that are found in most motors with copper rotors. The high heat needed to cast copper rotors has, so far, proved elusive for mass production. Siemens is the only manufacturer of a cost-effective automotive product for use in hybrid vehicles and in certain specific industrial applications.[55]

No reliable data exist yet on incremental costs compared to baseline (aluminum rotor) technology, nor do savings or demand reduction data exist for these motors per input or output unit (hp, Hz, etc.).[56]

Motor / drive systems account for approximately 65% of industrial electrical usage. Other factors in greater efficiency in motors and drives include better motor management practices (supported by cheaper and easier monitoring and sensors), variable-frequency drives, high efficiency pumps and fans, and improved drive system design.

Residential Applications. According to ACEEE literature, the potential exists to achieve 60% motor power savings with DC permanent magnet (DCPM, sometimes referred to as electronically commutated motors or ECMs) and switched reluctance (SR) motors in variable load washing machines, and 15% for most other fixed-load appliances. However, while the clothes

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[51] "Analysis of Energy Conservation Standards for Small Electric Motors-Technical Support Document". June, 2006.
http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/small_motors_tsd.pdf

[52] Khandhediya, Dipen. "How to reduce Motor Drive Energy Cost." IEEMA Journal (Energy Conservation Week). December 21, 2004.

[53] Federal Register. Vol. 64, No. 192. II Discussion, Sec. C part 1.

[54] Sachs, Harvey, et al. Emerging Energy Saving Technologies & Practices for the Buildings Sector. ACEEE; October, 2004.

[55] Geremia, Ken. "Super-efficient Motors with Copper Rotors Enter U.S. Market." Copper Development Association. April 12, 2006. http://www.copper.org/about/pressreleases/2006/pr2006_12_06.html

[56] Kimmich, Rainer, et al. "Performance Characteristics of Drive Motors Optimized for Die-cast Copper Cages." Energy Efficiency in Motor Driven Systems, 4th International Conference, Heidelberg, Germany, 2005.

H-compact PLUS SH710 Motors. http://cmsapps.sea.siemens.com/motors/docs/ANEMAH-compactPLUS-SH710.pdf.

washers application is very cost effective ($0.002 / kWh), washing machines represent 0.06% of 2020 buildings energy use, an almost negligible amount.

There is also potential for improving fan motors in HVAC[57] and refrigeration[58] applications, however, those motors represent relatively small savings in overall energy usage of HVAC and refrigeration units, compared to the savings potential of the units themselves due to the use of such fans.

Conclusions. There are no clear indications that efficiency savings opportunities for motors and drives will change significantly in the foreseeable future. Copper rotor construction may increase motor efficiencies in the future, but increased materials cost may offset the efficiency gains. The range of applications available to drive controls may expand in the future due to smaller size and increase ease-of-use (according to manufacturer ABB's claims), which could increase those efficiency opportunities, but there is no independent analysis to support or quantify this claim. Given these findings, current motor efficiencies should be assumed for the 20-year forecast period. Less certain, and also not easily quantifiable, are drive efficiencies.

New Energy Industry Standards Act modifications in 2009 may substantially reduce the opportunity for the EEUs to capture future motor savings, unless more efficient motors are developed, beyond the (new baseline) standard.

III. ANALYSIS FRAMEWORK

A. Load Forecast Calibration

The study undertook two types of adjustments to the VELCO energy forecast. The first corrects for the effects of Vermont's 18-year history of DSM investment in energy efficiency savings. This investment has grown steadily in the last 10 years. These savings are embedded in the time series of residential and commercial / industrial electricity sales on which VELCO's statistically adjusted engineering model are based. Consequently, they are "endogenous" to VELCO's energy sales forecast and thus to the peak demand forecasts derived from it. **Subsection 1**, below, describes the statistical technique used to estimate the amount of endogenous efficiency investment by sector.

The second adjustment addresses divergent expectations between this study and the VELCO forecast about the speed of "natural" market adoption of efficient lighting products, regardless of continued EEU investment. This study's analysis of residential lighting program savings is predicated on a total household lighting load that is far below that assumed in VELCO's forecast. For these savings to be consistent with, and thus additive to VELCO's residential energy forecast (that is, subtracted from it), the residential energy sales forecast must be adjusted for the widening divergence over time between VELCO's and this study's predictions about future market conditions**. Subsection 2** explains the approach the study used to develop this second adjustment to the residential energy forecast.

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57 H-compact PLUS SH710, p. 68.

58 See note 57, p. 168.

1. VELCO forecast's endogenous effects of EEU investment

The VELCO energy forecast uses regression equation parameters estimated on the basis of historical electric sales, encompassing the previous decade of EEU efficiency investment, as well as the eight previous years' data, when Vermont's distribution utilities were responsible for efficiency investment. Since VELCO's econometric analysis uses electricity data series that did include the effects of external, or exogenous, energy efficiency investment, the effects of past efficiency investment are endogenous to its estimated regression coefficients and thus endogenous to the values predicted on the basis of those coefficients.

This study estimated the amount of annual incremental energy savings endogenous to the VELCO residential and C/I energy sales forecasts. Regression analysis was performed using annual sectoral savings as verified by the DPS as the dependent variable and sectoral spending as the independent variable.[59] The regression coefficients were applied to the mean spending level for the period 2000-2007 to predict mean incremental annual energy savings implicit in the VELCO energy sales forecast.

The regression coefficients allow calculation of predicted values at the level of spending used in the Forecast 20 analysis based on historical spending and savings. Because market and technological changes over the next 20 years are expected to depress investment savings yield below historical levels, this extrapolation represents an upper bound on the savings that could reasonably be expected from long-term efficiency investment in the future.

Table 9 provides the underlying data series used to estimate the regression coefficients which in turn were used to estimate the endogenous effects of continued EEU investment, both of which are presented in **Section V, Tables 21 and 22.**

[59] The final regression equation forced the intercept to zero as the constant term was not significant at the 95% confidence level. Nor were any independent time-dependent variables statistically significant.

Table 9. Estimation of endogenous efficiency utility savings in VELCO's sectoral energy forecast

Data

Efficiency Vermont Spending and Savings: 2000 - July 2009

	Efficiency Vermont Costs				Efficiency Vermont Costs in 2009$		Annual MWh Savings		
Year	BES	RES	Unallocated Admin and IT	Total	BES	RES	BES (including CC)	RES	Total
2000	$2,156,701	$3,011,708	$228,106	$5,396,515	$2,759,921	$3,854,069	11,767	11,027	22,794
2001	$3,486,817	$4,673,733	$347,475	$8,508,025	$4,341,075	$5,818,782	17,978	18,916	36,894
2002	$4,368,623	$5,730,079	$395,078	$10,493,780	$5,329,102	$6,989,886	18,436	19,926	38,361
2003	$7,243,964	$5,249,782	$464,157	$12,957,903	$8,594,575	$6,228,585	36,218	14,997	51,215
2004	$7,738,511	$5,703,131	$551,193	$13,992,835	$8,874,061	$6,540,009	29,248	22,614	51,862
2005	$8,710,891	$5,840,404	$544,269	$15,095,564	$9,637,703	$6,461,805	28,589	28,465	57,054
2006	$7,257,598	$6,977,303	$604,052	$14,838,953	$7,749,676	$7,450,376	26,437	29,633	56,070
2007	$10,174,753	$8,185,303	$974,664	$19,334,720	$10,593,043	$8,521,805	45,759	57,154	102,913
2008	$21,011,098	$8,907,392	$1,530,343	$31,448,833	$21,035,963	$8,917,933	65,883	78,542	144,425
through July 2009	$7,955,109	$4,386,459	$679,766	$13,021,334	$7,955,109	$4,386,459	21,799	24,523	46,322

VELCO SALES DATA									BES savings as % C&I sales	RES savings as % RES sales
Year	Total	Residential	Commercial	Industrial	Other	Non-Res		C&I		
2000	5,559,549	2,032,372	1,875,017	1,606,641	45,519	3,527,177		3,481,658	0.34%	0.54%
2001	5,647,907	2,058,460	1,935,112	1,610,713	43,622	3,589,448		3,545,826	0.51%	0.92%
2002	5,684,130	2,074,013	1,952,866	1,612,676	44,574	3,610,117		3,565,542	0.52%	0.96%
2003	5,412,162	2,016,771	1,890,767	1,460,014	44,610	3,395,391		3,350,781	0.74%	
2004	5,696,781	2,064,656	1,966,802	1,620,734	44,589	3,632,125		3,587,536	0.82%	1.10%
2005	5,871,338	2,153,936	2,049,325	1,623,487	44,589	3,717,402		3,672,813	0.78%	1.32%
2006	5,799,451	2,099,103	2,029,172	1,626,587	44,589	3,700,348		3,655,759	0.72%	1.41%
2007	5,906,919	2,180,651	2,053,162	1,628,516	44,589	3,726,268		3,681,679	1.24%	2.62%

2. Residential lighting

As explained further in **Section III B,** this study's residential efficiency analysis predicts that the opportunity for further program investment in residential lighting will diminish dramatically throughout the forecast horizon, as federal standards and technological advances rapidly increase the market share of compact fluorescent and solid-state lighting lamps and fixtures. VELCO's forecast similarly projects steady declines in the intensity of market activity in household efficient lighting, due to higher federal efficiency standards.

To gauge the consistency between the two studies' future residential market characterizations, this study constructed a prototypical household lighting configuration and matched it with the unit energy consumption VELCO projects for residential customers' lighting for 2008 (1410 kWh / year). This analysis then modified the mix of household lamps among incandescent, CFL, and SSL lamps for 2017 and 2027. Next, the analysis computed the resulting household lighting energy consumption, and compared the result with VELCO's projections for the same years. VELCO had projected residential lighting energy use at 931 kWh / year. That projection is more than double the amount of residential lighting energy (435 kWh / year) assumed by this study to be eligible for participation in the future Retail Products program. The discrepancy is even more pronounced by the end of the forecast period. By 2027, this study predicts average household lighting energy requirements at 194 kWh / year, compared with VELCO's forecast of 775 kWh / year.

To reconcile that discrepancy, this study developed a second adjustment to the VELCO residential forecast. The analysis interpolated estimates of household lighting energy requirements for the years between 2008 and 2017, and again between 2017 and 2027 to determine the differential for each year. The adjustment was calculated as the product of the annual differential and the number of residential customers forecast by VELCO in each corresponding year. This adjustment was then applied in combination with (and in the opposite direction to) the upward adjustment to correct for endogenous EEU investment captured by the VELCO forecast. The study then applied the residential lighting coincidence factors to the energy adjustment to correct the VELCO residential summer and winter peak demand forecasts.

Table 10 indicates the changing mix of lamp types and wattages and the resulting comparison of household lighting intensities between this study's and VELCO's forecasts.

Table 10. Comparison of household lighting intensities between VELCO forecast and Forecast 20 analysis

	Lamp mix									Comparison: Residential Analysis vs. VELCO Forecast									
	Incandescent / Halogen			CFL			SSL			Estimated Household			VELCO Forecast UEC						
Year	Watts / Lamp	Satur - ation	Lamps / House-hold	Watts / lamp	Satur - ation	Lamps / House-hold	Watts / Lamp	Satur - ation	Lamps / House-hold	Total Watt-age	Total kWh / yr	% Decline from 2008	Total kWh / yr	% De-cline from 2008	Resi-dential House-holds	VELCO vs. EVT kWh / yr	Lighting Forecast Over-stated MWh / yr	Summer Co-incident Peak MW 8.2%	Winter Coincident Peak MW 29.8%
2008	63	81%	37	15	18%	8	12	1%	0	3,477	1,410		1,410		312,351	0	0	0.0	0.0
2009													1,368		315,604	55	17,393	2.5	9.1
2010													1,340		318,857	110	35,145	5.1	18.4
2011													1,314		322,111	165	53,256	7.7	27.9
2012													1,288		325,373	220	71,727	10.3	37.5
2013													1,077		328,626	276	90,555	13.0	47.4
2014													1,012		331,880	331	109,742	15.8	57.4
2015													972		335,133	386	129,287	18.6	67.7
2016													950		338,395	441	149,195	21.5	78.1
2017	44	15%	7	13	70%	32	6	15%	7	764.29	435	-69%	931	-34%	341,648	496	169,458	24.4	88.7
2018													917		344,902	505	174,003	25.1	91.1
2019													898		348,155	513	178,604	25.7	93.5
2020													860		351,417	522	183,264	26.4	95.9
2021													832		354,670	530	187,975	27.1	98.4
2022													813		357,924	539	192,742	27.8	100.9
2023													800		361,177	547	197,564	28.5	103.4
2024													792		364,439	556	202,446	29.2	106.0
2025													783		367,693	564	207,379	29.9	108.5
2026													778		370,946	573	212,367	30.6	111.1
2027	13	5%	2	13	15%	7	6	80%	37	340.4	194	-86%	775	-45%	374,199	581	217,410	31.3	113.8

Ratio, cumulative decline in household UEC, Forecast 20 vs. VELCO forecast

Note: While SSL watts-per-lamp is held steady, it is assumed that lumens/watt more than doubles over analysis timeframe allowing SSL lamps to fill more sockets requiring higher lumen output

B. Savings Analysis Methodology

1. Residential market analysis

The residential analysis is based on developing and aggregating savings and costs from individual measures installed in existing and new homes in Vermont. For any given measure, savings are the product of the penetration of that measure across the analysis period, times the measure's respective per-unit savings—annual kWh, summer kW, and winter kW. The penetration of a measure is a function either of its planned replacement or installation—at or near the end of its useful life or during new construction—or of its accelerated retirement or replacement. The analysis estimates measure penetrations based on the constraints of the available program budgets in each year, as well as on existing opportunities. Costs are defined at both the measure level (per-unit installed costs and utility incentives) and at the initiative level (staff, marketing, program tracking, and reporting, etc.).

Measures considered in this analysis include a mix of efficient technologies (for example, high-efficiency appliances), improved practices (air conditioning charge and airflow), and fuel-switching activities (space and water heating and gas-burning appliances). Customer-sited renewable energy and combined heat and power systems were not considered part of this analysis. Many of the analyzed measures are currently being promoted by Efficiency Vermont, though several of the proposed measures—for example, heat pump water heaters and solid-state lighting—are either not currently available in the market or have limited distribution.

The residential analysis uses this "bottom-up" methodology by developing savings information for a each measure promoted by an initiative (for example, the installation of one compact fluorescent lamp), and then multiplying savings (kWh and kW) by the number of measures installed over the initiative's time horizon. For new construction and planned or accelerated replacement measures, savings are typically set to the measure's incremental savings, which is the difference between the baseline technology energy or demand usage and the measure's usage. The baseline technology for new construction or planned replacement measures is the less-efficient technology that would have been installed by the customer, had the efficient measure not been offered or installed. For accelerated replacement ("early retirement") or for measures installed where the baseline technology did not previously exist, the measure savings are typically calculated based on the usage of the technology or end use already in place.

The savings for all measures supported by a given initiative are summed annually in terms of incremental savings, and in terms of cumulative savings across the 20-year analysis timeframe.

The bottom-up approach determines societal costs by taking the cost of each measure and multiplying it by the number of installed measures. Incentive costs at the measure level are similarly calculated and then aggregated to the initiative level. For new construction and planned replacement measures, costs are typically set to the measure's incremental cost: the difference between the baseline technology cost and the full measure cost. For measures installed where the baseline technology did not previously exist, or when the replacement of the baseline technology is accelerated ("early retirement"), the measure cost is typically set equal to the full, installed cost for the measure.

Measure savings based on only direct program activity are referred to as "gross" savings and must be adjusted to reflect current and projected market conditions to determine the actual "net" savings impacts of the proposed Efficiency Vermont efforts. These calculated net savings are the values that are then used to adjust the VECLO forecast. The reported net savings reflect two adjustments. First, gross program impacts are adjusted downward to account for program *free-ridership*; those program participants that would have would installed the measure absent program activity. Second, gross savings area adjusted upwards for program *spillover* to quantify additional measure installations that are attributable to the program, but are not installed by program participants who received a rebate. That is, while the program induced the customer to install the measure, no rebate was paid.

The measure and penetration rate screening tool inputs are provided in **Appendix 2a and Appendix 2b.**

2. Business market analysis

This section describes the methodology used to evaluate C&I efficiency costs and benefits. This is fundamentally the same basic approach for the residential sector described above, however analytically relies more on a disaggregation of the forecast to identify the underlying timing and magnitude of efficiency opportunities. The business sector analysis combines (1) a "top-down" evaluation of energy efficiency, in which improvements in the baseline efficiencies of technologies are accelerated across broad efficiency markets, characterized by individual efficiency measure opportunities, with (2) a "bottom-up" approach that estimates the costs, performance, and other factors at the technology or practice level applicable to each market segment.

a) Business efficiency markets

From the perspective of the C&I analysis, markets are the arenas in which decisions are made affecting energy use. Broadly, there are two primary markets: existing facilities and new construction (including major renovation). Owners of existing facilities are faced with different decisions from those of potential owners of new or substantially renovated facilities. This is particularly the case when evaluating the costs timing and feasibility of different options that would affect energy use.

The existing facilities market can be subdivided into two main "submarkets":

Retrofit opportunities. In this market, building owners or tenants have existing equipment that provides needed lighting, heating, cooling, refrigeration, or other services. Whereas this equipment might not use energy efficiently or might have other disadvantages (for example, older age, questionable reliability, or low quality), the owner has the option of continuing to use this equipment. When considering energy efficiency, a building owner must compare the benefits of new equipment against the full cost of installation. However, short-term efficiency savings may be fairly large because savings compare new efficient equipment against older, inefficient equipment. Long-term savings might drop significantly, because at some point customers would have replaced this equipment anyway, obtaining standard efficiency new equipment. Such "early retirement" retrofit opportunities to improve efficiency are not time dependent, and thus can be pursued at any time.

Equipment replacement. In the replacement market, building owners decide to install new equipment when existing equipment fails, the building needs to be expanded, if there are performance concerns, for aesthetic reasons, or other drivers. For example, this could be the replacement of a failed motor, remodeling classroom lighting, or expansion of industrial capacity. Typically, the window of opportunity (in terms of time) to influence the energy efficiency of this decision is very narrow, much narrower than in the retrofit market. Success in this market relies heavily on the efforts of retailers, design professionals, trade allies (for example, contractors, vendors, suppliers), and procurement officers. The costs associated with efficiency improvements in this market reflect the *incremental* cost, over and above what purchase and installation of standard efficiency equipment would cost. Similarly, the efficiency savings are only the *incremental* efficiency improvement over standard new purchases.

A given efficiency measure might have different characteristics, depending upon the market. In a college cafeteria, a facilities manager would likely evaluate the full cost of new ENERGY STAR® cooking equipment when considering the replacement of old, inefficient but serviceable units. For a renovated or new cafeteria, where the purchase of new cooking equipment is required, the cost of the ENERGY STAR units are only the additional or "incremental" cost above standard-efficiency units. The energy and demand savings also differ—the savings for retrofit are compared to old, inefficient units (at least until the existing units in the kitchen would have needed to be replaced at the ends of their lives). In contrast, the savings for new construction are compared to new, standard units.

b) Markets and measures analyzed

The C&I sector analysis evaluated 80 efficiency technologies or practices across nine different commercial building types and street lighting. Each of these has also been analyzed across the relevant markets. **Appendix 3a** lists the measures included in the analysis. Not all commercial efficiency measures apply to all markets—for example, the High-performance T8 re-lamp / re-ballast measure was considered only for the retrofit market, while High-performance T8 fixtures were considered for the equipment replacement and new construction markets. The measures were analyzed over 2,109 combinations of technology, building type, and market, each with its own associated savings, costs, and benefits.

c) Measure savings methodology

The "top-down" methodology determines measure savings opportunities by forecasting total electric energy sales over the analysis time horizon, and through a disaggregation of the forecast determines the percentage of the sales associated with a given baseline technology that might be offset by the installation of a given energy efficiency measure in each year. The bottom-up approach develops costs relative to energy savings, as well as the percentage savings for each measure. These data are then applied to the forecast load available at a given time, to estimate the costs and savings for a given market and building type for each measure.

The following factors and central equation are used to determine the portion of end-use energy from the load forecast that can be saved by each measure:

Applicability is either the number of customers eligible for a given measure (bottom-up) or the fraction of each building type's end-use level sales that is attributable to equipment that could be replaced by the high-efficiency measure (top-down). In a top-down example for packaged air conditioners, it is the portion of total building type cooling electrical load consumed by packaged systems.

Feasibility is the fraction of the applicable number of customers or end-use sales for which it is technically feasible to install the high-efficiency technology. Numbers less than 100% reflect engineering or other technical barriers that would preclude adoption of the measure. Feasibility is not reduced for economic or behavioral barriers that would reduce penetration estimates. Rather, it reflects technical or physical constraints that would make measure adoption impossible or ill advised. For example, some lighting technologies might not be feasible in certain low-temperature applications.

Turnover is the percentage of existing equipment or number of systems that will be naturally replaced or modified each year, due to failure, renovation, remodeling, industrial process upgrades, or any planned investment. This applies only to the replacement and renovation markets (retrofit markets have a turnover factor of 1.0 representing that 100% of the time-discretionary opportunities exist at all times). In general, turnover factors for the replacement market are assumed to be 1 *divided by* the measure life (for example, assuming that 10% of existing stock of equipment is replaced each year for a measure with a 10-year estimated life)..

Retrofit not complete is the fraction of applicable end-use energy that is available for retrofit opportunities, and is applied only to the retrofit measures. In other words, it is 1 *minus* the percentage of load associated equipment that is already efficient.

Baseline adjustment lowers the savings in future years for retrofit measures, to account for the fact that during the new efficient measure's life, customers would have naturally replaced their old inefficient equipment with newer, standard efficiency equipment.

Savings fraction represents the percent savings (as compared to either existing stock or new baseline equipment for retrofit and non-retrofit markets, respectively) of high-efficiency technology. Savings fractions are calculated according to individual measure data and assumptions about existing stock efficiency, standard practice for new purchases, and high-efficiency options.

Penetration is the percentage of the total eligible opportunity at any given time that can be captured from Efficiency Vermont efforts. This percentage reflects gross penetration in Efficiency Vermont initiatives, and is then adjusted to estimate results, net of free-riders and spillover effects, as described above for the residential sector.

When these factors are applied to the total end-use energy associated with each measure, the result is the gross achievable savings opportunity for each measure, as shown by this equation:

Annual measure achievable potential = Building end-use MWh sales per year
x Applicability factor
x Feasibility factor
x Turnover
x Retrofit-not-complete factor (retrofit only)
x Baseline adjustment factor (retrofit only)
x Savings fraction factor
x Penetration factor

The following example in **Table 11** illustrates the application of this approach to estimating the savings potential for High-performance T8 fluorescent fixtures installed in lieu of a standard T8 fixtures at the time of natural replacement in office buildings. Note all figures were selected for illustrative purposes and do not necessarily represent the actual values in the analysis.

Table 11. Application of approach to estimating the savings potential for High-performance T8 fluorescent fixtures vs. standard T8 fixtures

Parameter	Description	Value	Cumulative Result
Building type / end-use electric forecast	Electricity sales for interior lighting for offices	100,000 MWh	100,000 MWh
Applicability factor	% of interior office lighting energy use from linear fluorescent fixtures	x 80%	80,000 MWh
Feasibility factor	% of linear fluorescent fixtures that could be replaced with High-performance T8 technology	x 100% (all linear fluorescents could feasibly be replaced with High-performance T8s)	80,000 MWh
Turnover factor	% of existing office space that will naturally replace lighting as a remodel in given year	x 6.7% (typical fixture life of 15 years result in 1/15 replacement per year on average)	5,333 MWh
Savings fraction factor	% energy savings from shifting from standard T8 to High-performance T8 technology (represents weighted average for different number of lamps)	x 17%	907 MWh
Program penetration	The increase in penetration of High-performance T8 fixtures as a result of the efficiency initiative.	x 10%	90.7 MWh

In this example, installing High-performance T8s in place of standard T8s in office buildings at the time of replacement, with 10% penetration offers 90.7 MWh of potential savings for the given year.

d) Peak demand reductions

To determine the coincident peak demand reduction associated with the efficiency potential, the Forecast 20 team relied on Efficiency Vermont's load shape library, consisting of end-use load shapes, kWh / kW ratios and associated peak coincidence factors that enabled determination of both summer and winter peak reductions from the annual kWh saved by measure.

e) Eligible stock

New measures can be installed in existing buildings either on an early retirement (retrofit) basis, at the time of natural replacement, or at the time of renovation or remodeling. To avoid double-counting, the model tracks the eligible stock of equipment over time, based on the assumed measure penetrations for each existing construction market. For example, if 5% of existing lighting fixtures are retrofitted with high-efficiency models in 2009, then only 95% of the original population of lighting remains eligible for efficiency upgrades in non-retrofit markets during 2010. However, assuming the fixtures had a 15-year measure life, the original 5% of lighting fixtures would again become eligible for replacement in 2023 (fifteen years after the original installation date). Similarly, when efficient equipment is installed to replace old equipment at the end of its life (in the replacement market), the opportunity for retrofit in future years is diminished.

f) Measure interactions

Individual measure savings are not strictly additive. Because of interactions between measures, the total potential for all measures is less than the sum of individual measure opportunities. For example, installing occupancy sensors to control new, efficient lighting will result in lower overall savings than if the occupancy sensors controlled older lighting that consumes more energy. The total potential estimates take into account the interactions between all measures.

In addition to the direct measure impacts, a "cooling bonus" and "heating penalty" were calculated for all interior lighting measures. These reflect the effects of reductions in waste heat generated within the building shell as a result of improved efficiency. The cooling bonus increases the kWh savings by 10.5% and summer peak kW savings by 25%, because of reductions in the cooling load. The heating penalty results in a 27% increased in the use of energy for heating, which is assumed to be met with fossil fuel-based heating equipment at an average of 75% efficiency. These factors were calculated according to an ASHRAE method, but taking into consideration Vermont weather characteristics, load profiles for lighting, cooling and heating, the portion of lighting savings that occur in conditioned floor space, and typical existing HVAC efficiencies.[60]

g) Mutually exclusive measures

Some measures are mutually exclusive, and cannot be installed concurrently in a given facility. For example, an incandescent lamp can be replaced with a screw-in compact fluorescent, a screw-in LED lamp, a screw-in halogen incandescent lamp, or other hard-wired fixtures with different technologies (for example, fluorescent, metal halide, or LED). However, in a mutually exclusive measures scenario, only one actual measure can be installed. Mutual exclusivity is accounted for through measure penetrations. So, for example, the higher one assumes the penetration of screw-in CFLs will be, the lower the opportunity for the other options to capture savings.

C. Market Characteristics

The study developed the characteristics for each of the three major markets in the residential and nonresidential sectors based on inputs, outputs, and intermediate results of the VELCO forecast. It

[60] Rundquist, R., "Calculating lighting and HVAC interactions", ASHRAE Journal, November 1993.

relied on additional research into other market characteristics not addressed explicitly by the VELCO forecast.

1. Residential market characteristics

a) Existing homes program

There are 235,000 single-family homes and 58,000 multifamily dwellings in Vermont. Of those, 44,000 households are low-income. In total, residential customers represent about 2.2 million MWh of electricity usage annually.

b) New construction

Over the past decade, an estimated 3,000 new homes have been built annually in Vermont by approximately 1,000 builders. This new construction adds an estimated 20,000 MWh annually to Vermont's electrical use. Energy efficiency programs have been offered statewide for twelve years, and in the past seven years, Vermont has maintained one of the highest shares of newly constructed energy-efficient homes in the country, ranging from approximately 20% to 34% annually.

Over the past two years, builders have successfully transitioned to new standards for energy-efficient homes. In general, the market for energy-efficient and "green" homes continues to increase, but it does so in an overall market that is experiencing significant downturns. Cost of materials and new green standards may compete for builders' attention to energy efficiency.

c) Retail efficient products

Lighting and appliances constitute 60% to 75%% of residential electrical energy use in Vermont's 293,000 residential households. Each year, appliance sales in Vermont are approximately:

- 3,600 gas cook stoves
- 5,700 electric cook stoves
- 12,200 clothes washers
- 9,400 electric dryers
- 1,600 gas dryers
- 11,900 refrigerators
- 1,000 freezers
- 14,100 room air conditioners
- 9,100 dishwashers
- 80,000 personal computers

In the past several years, higher federal standards have increased the baseline efficiency for appliances. Efficiency Vermont promotes appliance efficiency only for products that are significantly higher than market baseline efficiency. These standards are typically also much higher than the federal standards. The products include refrigerators and freezers; clothes washers; room air conditioners; and consumer electronics, such as televisions, personal computers, and monitors. Residential lighting alone represents 17% to 25% of residential electrical energy use. There are between 5 million and 8 million lighting sockets in Vermont homes. An additional 2 million sockets exist for businesses that regularly purchase their lighting from retail lighting suppliers. The *Overall Report for Existing Homes in Vermont* found that while most homes have at least one CFL (89% in owner-occupied homes and 70% of rental homes), CFLs are the product of choice in only about 18% of the screw-in sockets.[61] This means there are approximately 6.5 million sockets that continue to use incandescent lighting in Vermont.

New federal lighting standards that will go into effect in 2012 will have little impact on residential lighting efficiency in Vermont during the next two years. The standard spiral CFL is now a readily available product for general residential lighting. In fact, the study's projection of energy savings in 2009-2011 from standard CFL products has been reduced by 50%, compared to values used in 2008. This trend relates to the fact that CFLs installed now tend to be in sockets that have a lower average hourly use. Also, there are more customers who would have purchased standard CFLs in the absence of Efficiency Vermont promotional efforts.

However, there are many new opportunities for increased use of specialty CFL lamps to address residential and commercial needs as special products mature. Today, there is low penetration of dimmable, reflector, candelabra, encapsulated, and three-way CFLs. There is also a growing potential for LED lighting which, when the technology matures, will use half the energy of a CFL.

2. Business market characteristics

a) C & I load forecast disaggregation

The top-down C & I analysis relies on a disaggregation of energy sales by end use and building type. As a starting point for the commercial facilities, the proportional end-use breakout by building type was adopted from the 2003 Vermont electric potential study.[62] This was modified based on current commercial sector sales by building type, using Efficiency Vermont utility billing data. Utility sales data were adapted by mapping SIC codes to appropriate building types.

The VELCO "2008 Long-Term Peak Demand Forecast" was used to determine total electric sales by commercial and industrial sectors, as well street lighting sales. Furthermore, the VELCO study broke out the 2008 commercial sales for space heating and cooling end uses (4.5% and 1.9%, respectively). The Forecast 20 Team used these sales data to adjust the disaggregation further to match those projections, for consistency with the VELCO forecast.

For industrial sales, data from the 2002 Manufacturing Energy Consumption Survey (MECS) for the Northeast Census Region were adapted to proportionally distribute the VELCO industrial sales forecast into process, cooling, and lighting end uses.

Finally, the sales were adjusted to account for embedded DSM and remove the contributions from the Burlington Electric Department.

[61] *Overall Report for Existing Homes in Vermont*, Nexus Market Research, submitted to Vermont Department of Public Service, June 16, 2008.
[62] Optimal Energy, Inc., "Electric and Economic Impacts of Maximum Achievable Statewide Efficiency Savings 2003-2012", January 2003, prepared for the Vermont Department of Public Service.

The resulting sales disaggregation was used as the starting point for the measure savings methodology, as described above and in the following sections. **Table 12** shows the resulting sales disaggregation for the existing load in 2008.

Table 12. Commercial and industrial electric energy sales disaggregation

Existing End Use Sales Forecast for 2008, MWh at

	Office	Retail	Grocery	Warehouse	Education	Health	Lodging	Restaurant	Other Commercial	Streetlights	Industrial
Indoor	251,297	66,775	44,589	7,945	117,763	43,597	26,050	14,741	79,686	0	129,990
Outdoor	27,612	5,205	5,364	1,388	12,298	2,956	5,412	4,288	10,624	44,143	0
Cooling	24,054	13,797	5,098	225	7,765	8,879	3,556	2,300	11,668	0	165,464
Ventilation	66,159	52,884	8,789	4,457	48,826	13,846	19,593	5,363	28,863	0	0
Water	10,696	13,587	4,145	284	16,80	9,816	8,707	11,978	16,802	0	0
Refrigeration	3,768	24,552	117,175	24,912	5,849	4,849	2,769	23,503	93,333	0	0
Space	13,494	4,989	700	351	4,464	2,263	3,257	481	2,657	0	0
Office	72,664	5,434	1,843	656	11,227	3,017	3,323	691	7,491	0	0
Miscellaneous	51,983	7,784	3,071	1,187	9,795	32,530	5,816	2,490	17,833	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	1,063,910
Total	521,728	195,009	190,774	41,406	234,796	121,753	78,484	65,835	268,958	44,143	1,359,364

New Construction Sales Forecast for 2008, MWh at

	Office	Retail	Grocery	Warehouse	Education	Health	Lodging	Restaurant	Other Commercial	Streetlights	Industrial
Indoor	2,538	674	450	80	1,190	440	263	149	805	0	1,313
Outdoor	279	53	54	14	124	30	55	43	107	446	0
Cooling	243	139	51	2	78	90	36	23	118	0	1,671
Ventilation	668	534	89	45	493	140	198	54	292	0	0
Water	108	137	42	3	170	99	88	121	170	0	0
Refrigeration	38	248	1,184	252	59	49	28	237	943	0	0
Space	136	50	7	4	45	23	33	5	27	0	0
Office	734	55	19	7	113	30	34	7	76	0	0
Miscellaneous	525	79	31	12	99	329	59	2	180	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	10,747
Total	5,270	1,970	1,927	418	2,372	1,230	793	665	2,717	446	13,731

b) Fossil fuel markets

As described in **Section III, 2, Measure interactions,** efficient interior lighting generates less waste heat and thus results in increased fossil fuel consumption for heating. In addition, some other measures target heating or hot water systems and thus affect fossil fuel usage by the customer. For these measures, fossil fuel impacts from the end-user are estimated in terms of total MMBtu savings or increased usage, adjusted according to the portion of commercial facilities with fossil fuel heating and hot water systems. The MMBtu savings are then split among natural gas, oil, and propane, based on the fraction of each used in Vermont for heating and domestic hot water (DHW) in commercial facilities, as shown in **Table 13.** [63]

Table 13. MMBtu savings for heating and hot water, by fuel type

Fuel	Heating	DHW
Natural Gas	23%	34%
Oil	52%	32%
Propane	24%	34%

In the cost-effectiveness analysis, fossil fuel impacts affect only the Societal Cost Test, not the Electric System Test.

D. Efficiency Technology Characteristics

The study characterized efficiency technologies and technology bundles for application and promotion in the major markets in the following terms:

a. Installation year

b. Initial capital cost for retrofit measures and incremental costs for products and equipment purchases and for new construction/renovation

c. Winter and summer peak-coincident kW demand savings

d. Energy savings during winter and summer on- and off-peak costing periods

e. Total annual energy savings

f. Life expectancy

g. For early-retirement retrofit measures,
   - the remaining life of the existing technology
   - the estimated replacement cost at time of scheduled replacement
   - expected efficiency of baseline new equipment at the time of scheduled replacement

h. operation and maintenance costs or savings

[63] KEMA, "Business Sector Market Assessment and Baseline Study: Existing Commercial Buildings, Vol. 1 to 3, Final Report", July 10, 2009, prepared for the Vermont Department of Public Service, Tables 3-9 and 5-17, normalized to 100%.

i. non-electric energy costs or savings (including, but not limited to, water and fossil fuel savings)

Energy and peak demand savings by costing period were estimated on the basis of load shapes currently in use by the EEU. New load shapes were developed for new technologies and measures.

Costs and performance characteristics were estimated for efficiency measures or bundles thereof in each of the major markets analyzed. The analysis estimated changes in measure costs and characteristics over time to reflect expectations in future in markets and technologies. The analysis also identified and characterized new technologies expected to enter the market later during the forecast period.

1. Residential technology characteristics

The large majority of measures were characterized with information from the Efficiency Vermont *Technical Reference Manual* (TRM). The TRM is used by Efficiency Vermont and by the DPS to determine per-unit savings impacts, costs, and lifetimes of measures installed through Efficiency Vermont programs. These estimates are informed by both national and local data sources, including ongoing evaluations of Efficiency Vermont programs by the DPS. The TRM provides Vermont-specific savings estimates that were usually disaggregated at a level necessary for this analysis. For example, the TRM provides different space and water heating fuel-switching savings estimates, depending on what fossil fuel is being used. These savings estimates have been informed by several years of actual Efficiency Vermont program experience.

For measures not currently characterized in the TRM—for example, heat pump water heaters, and several consumer electronics measures—the Forecast 20 Team used the best available sources of information, including manufacturer data and information from the DOE, EPA, and relevant national laboratories. These data sources are provided in the measure characterization documentation in **Appendix 2a.**

For certain measures, particularly CFLs and solid-state lighting, an additional level of disaggregation was required to reflect accurately the projected changes in savings and cost characteristics of these measures over time. These projected changes included shifting baselines, costs, and measure efficiencies, as well as different current and planned incentive offerings. For the residential Efficient Products program analysis, more than a dozen discrete CFL and SSL measures were characterized to reflect projected changes in savings, costs, and incentives.[64] These multiple characterizations were necessary to capture accurately the impact of federal lighting standards as well as claimed savings for CFLs that were negotiated with the DPS for the current (2009-2011) contract period.

Federal residential lighting standards will be initially phased in from 2012 to 2014, and then a second and more stringent set of mandatory efficiency requirements become effective in 2020. The impact of these standards, as discussed more fully below, is to reduce the number of CFLs promoted by Efficiency Vermont over time, while increasing the number of SSL products supported.

[64] Note that some of the Efficient Products measure savings accrue to the business markets, and are included using a similar methodology in that sector's figures.

As discussed above, the efficiency of most other residential baseline and measure technologies is also expected to improve across the analysis period. However, these changes are largely expected to occur gradually, unlike the changes expected for residential (and commercial) lighting. Exceptions to this assumption are the large electricity savings likely to be realized when heat pump dryers and heat pump water heaters become commercially available.

To achieve the significant savings from the proposed portfolio of residential initiatives, incentive levels were typically set at or close to current Efficiency Vermont program offerings.

2. Business technology characteristics

The Forecast 20 analysis has characterized individual efficiency measures relative to a particular baseline, with regard to their savings (energy, demand, fossil fuel, water) and costs (incremental cost over baseline, and operation and maintenance). As with the residential sector, the primary source for these characterizations was Efficiency Vermont's *Technical Reference Manual*, supplemented by other sources, as needed. **Appendix 3a** provides detailed characteristics and data sources for the individual measures used in this study.

Efficiency opportunities in the business sector continue to be dominated by lighting technologies and, with the emergence of cost-effective LEDs, will continue to do so through the forecast period. The cost of LEDs (dollars per lumen) is expected to fall dramatically in the coming years, coupled with further increases in efficacy (lumens per watt) and quality.[65] With this combination, today's efficient fluorescent lighting will become the baseline during the forecast period, and will be replaced in turn by more efficient, cost-effective LEDs. Outdoor lighting provides excellent opportunities for savings with solid-state lighting technology, and will thus provide increased savings through the forecast period. In addition to higher lumens-per-watt technologies, the analysis expects lighting design for overall system efficiency will provide increasing opportunities for considerable savings, particularly for new construction and renovation projects.

LED costs, in terms of dollars per lumen, are projected to decrease dramatically in the coming years, decreasing 72% by 2015 relative to 2010 costs.[66] The Forecast 20 analysis assumes a more conservative cost reduction of no more than 15% per year, or 56% by 2015 relative to 2010, and constant costs thereafter.

SSL efficacy (lumens per watt) is projected to increase dramatically in coming years, doubling over the next decade. As LEDs become more efficient, the percent savings relative to the baseline would be expected to increase in step. However, the underlying assumption is that new technologies (for example, improved halogen or other incandescent lighting) will drive the baseline down over time. Thus a corollary assumption is that the percent savings for SSL installations will remain constant despite their increasing efficacy.

Another significant change in the lighting market is the pending federal standard that will eliminate the manufacture of T12 fluorescent technology in 2012. This affects the analysis in two significant ways. First, after 2012, it reduces substantially the retrofit opportunities because it is assumed that no one will still have this technology in place. Second, it recognizes that the elimination of availability of T12 products creates a unique opportunity for Efficiency Vermont to

[65] Navigant Consulting, Inc et al, "Multi-Year Program Plan FY'09-FY'15, Solid State Lighting Research and Development," March 2009, prepared for the U.S. Department of Energy.
[66] Ibid, Table 4.3.2, p. 70.

capture high penetration for lighting retrofits among remaining T12 users. These lamps still represent about half of all linear fluorescent lighting in place in Vermont businesses, according to Efficiency Vermont's latest business market assessment conducted by KEMA. As a result, it is assumed that these existing T12 users will be highly motivated to participate in Efficiency Vermont lighting initiatives, and will represent a somewhat larger share of linear fluorescent lighting retrofit activity in the first 3 years of the analysis—especially in direct installation services. After 2012 the analysis assumes no savings will be captured with a T12 baseline efficiency.

For all end uses, existing and emerging technologies are expected to keep pace with rising baselines for new equipment. As noted in **Section II, Technology Outlook, Technology trends,** general technological advances (for example, in materials science and nanotechnology), as well as emerging technologies for specific efficient equipment, could result in relatively rapid advancements in efficiency opportunities. Savings opportunities beyond SSL technologies are expected to continue for all end uses without dramatic changes through the 20-year forecast period (as reflected in the measure penetrations, as described below).

One technology of note with diminishing efficiency returns in coming years is high-efficiency motors, due to the relatively high efficiency of current motors and new standards that go into effect in December 2010. However, higher-efficiency motors that exceed the 2010 standard are available now, and there remain many retrofit opportunities, including both early replacement and the addition of variable frequency drives, more efficient fans and pumps, and other opportunities such as proper sizing and motor systems design that still offer large efficiency opportunities in the drive-power end-use.

a) Industrial measure characteristics

The industrial analysis uses the same methodology as the commercial analysis, but relies on specific aggregate measures for the industrial sector, as described in this section.

The industrial measure characterization is primarily based on a portfolio of industrial efficiency measures characterized and maintained by ACEEE. These characterizations reflect the findings of many technology-specific studies and have been employed in potential studies across the country.

The ACEEE industrial measures cover 39 unique technology types and range from space conditioning measures such as advanced HVAC to industrial process specific measures such as microwave processing. The savings potential of each of these measures varies depending on the specific industry sector to which it is applied. As a result, the analysis required estimating the total electric consumption by industry sector for Vermont. Detailed consumption data by industry sector at the state level are not available, thus the electric consumption by sector was estimated from state-level economic indices and electric consumption data at the national level.

National electric energy consumption per unit of output (value of shipments) was determined for all industry sectors using data from the Supplemental Tables to the *Annual Energy Outlook 2005*. With the inherent assumption that, within a given industry sector, energy consumption per unit output in Vermont is reasonably consistent with the nation as a whole, this data was localized to Vermont using the value of shipments data from the Vermont 2002 Economic Census and the 2002 Census of Agriculture. This yields an estimate of total annual electric energy use by industry type for the state.

Finally, the estimated percent savings for the individual measures were applied to the appropriate industry sector annual electric energy use estimates (applying applicability and feasibility factors) to determine the maximum achievable saving by measure. To simplify the presentation, the various industrial measures were consolidated into three measure "packages" reflecting industrial lighting, industrial HVAC, and industrial process measures.

E. Market Service Designs

This section describes the services and strategies envisioned to be provided by Efficiency Vermont for the various markets. In general, the analysis presumes a continuation of the general scope, types, and organization of financial and non-financial services currently offered or envisioned by Efficiency Vermont.

1. Residential market service designs

The residential analysis focused on three markets: Residential Products, New Construction, and Existing Homes (for both income and non-income qualified participants). Efficiency Vermont currently targets these three markets in the residential sector and the analysis assumes the approach will continue into the future.

a) Residential products

The Residential Products Program focuses on providing incentives or markdowns at the point of sale and the services will continue to draw on the established network of more than 300 retail partner stores. Efficiency Vermont will continue to leverage the ENERGY STAR brand as a way of raising consumer awareness and confidence in energy-efficient products. The Products Program measures and budgets were developed to utilize the follow three mechanisms to influence the market and achieve energy savings:

- Negotiated cooperative promotions (NCPs, also referred to as "product buydowns"), in which manufacturers and retailers mark down efficient product pricing for the consumer will continue to be the primary mechanism for promoting efficient lighting products.
- Instant rebate coupons for energy-efficient lighting products not covered by NCP promotions in retail locations statewide.
- Mail-in rebates for appliances that are at the upper end of efficiency within the ENERGY STAR qualifying product lines, including room air conditioners, refrigerators / freezers, dehumidifiers, and clothes washers available in more than 100 retail locations statewide.

The Program budget also assumed continued support of the manufacturer-distributor-retailer supply chain by providing:

- Consumer education on energy-efficient products;
- Displays of energy-efficient products;
- Cooperative advertising;
- Promotional incentives;
- Special targeting for underserved portions of the market; and
- Active participation and support for national efforts to improve energy-efficient product quality, particularly with compact fluorescent lamps.

b) New construction

Over the past decade, an estimated 3,000 new homes have been built annually in Vermont by approximately 1,000 builders. This new construction adds an estimated 20,000 MWh annually to Vermont's electrical use. Energy efficiency programs have been offered statewide for 12 years, and in the past seven years, Vermont has maintained one of the highest shares of energy-efficient homes in the country, ranging from approximately 20% to 34% annually.

This analysis assumes that Efficiency Vermont will continue to promote the Vermont ENERGY STAR Home as a standard of quality and performance in residential new construction. The budget includes funding to support and promote comprehensive attention to all end uses including electric and non-electric end uses, offer technical assistance with plan review, recommendations, testing, and inspections and provide technical assistance and certification of compliance with the Vermont Residential Energy Code.

c) Existing Homes program

The existing homes program measures and program budgets assume that Efficiency Vermont will continue to build on successful strategies from the past several years, including Home Performance with ENERGY STAR. Training and outreach efforts will strengthen the community of certified contractors able to provide comprehensive energy efficiency diagnostic and retrofit services for residential market.

The low-income single-family residential program will continue its relationship with the five community-based weatherization agencies to provide maximum cost-effective electric efficiency measures, at no cost to participants. These measures include direct installation of energy-efficient lighting and water conservation products, and the replacement of inefficient refrigerators and freezers with ENERGY STAR models, where determined to be cost-effective.

There are two program shifts worth noting. One is that during the first three years of this study, the Existing Homes program is assumed to move away from incentives for fuel switching measures (electricity to oil or propane). The exception to this shift is in Vermont Gas Systems, Inc., territory, where those measures remain cost effective. Also, the program discontinues using EEU money to provide incentives for insulation measures that reduce fossil fuel consumption only—for example, insulation in a non-electrically heated home. The measures continue to be promoted, but they are funded by other sources (for example, the Forward Capacity Market and Green Mountain Power Energy Efficiency Fund). The program budgets and measure characterizations in the analysis reflect those changes.

2. Business market service designs

It is a general assumption of this analysis that Efficiency Vermont will continue to deliver C&I efficiency services with the same established market services that are in use today. While new market service approaches (for example, on-bill financing) are recognized as potentially yielding additional savings, market penetrations and the resulting projections of costs and savings have assumed service delivery consistent with current practice.

Incentive levels have been set for each market based on Efficiency Vermont's current incentive rates, with some modifications throughout the forecast period. Efficiency Vermont's 2008 Annual Report indicates incentives as a percent of incremental costs are 28% for Business New Construction, and 49% for Business Existing Facilities. The 2008 Business New Construction incentive rate was consistent with the 2006-2007 period. However, the Business Existing Facilities incentive rate was considerably higher in 2008 because of the Lighting Plus direct installation initiative. Lighting Plus paid 100% of the cost of those measures in 2008. Efficiency Vermont's approach for the direct installation program in 2009 is to pay approximately 75% of the incremental cost, which should lower the overall incentive rate for Business Existing Facilities, relative to 2008. The retrofit penetrations reflect a weighted average of direct installation and other Efficiency Vermont strategies for this market.

Incentives will likely need to increase over time to maintain program participation levels. That is, existing opportunities will diminish and Efficiency Vermont will need to pursue new customers and deeper savings by relying more on costly and comprehensive measures. In the period 2015 - 2024, the analysis shows incentive rates increasing up to 75% for retrofit, 60% for efficient equipment, and 50% for new construction, as shown in **Table 14**.

Table 14. Business market incentives as a percent of incremental costs

	2008	2009-2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024-2027
Retrofit	75%	65%	66%	67%	68%	69%	70%	71%	72%	73%	74%	75%
Efficient Equipment	40%	40%	42%	44%	46%	49%	52%	55%	58%	60%	60%	60%
New Construction	30%	30%	32%	34%	36%	39%	42%	45%	48%	50%	50%	50%

F. Future Market Penetration of Efficiency Technologies

Annual market penetration rates of efficiency measures were developed as a percentage share of the eligible market or market segment in each year of the forecast period. Professional judgment informed the estimates of the market services designed to maximize customer acceptance, given barriers to market adoption. The analysis used current and historic Efficiency Vermont penetration data, as well as the success of other leading programs throughout North America

1. Residential market penetrations

Efficiency Vermont measure penetrations for the three-year contract period informed most of the estimates. The currently planned contract period measure penetrations forecast was used as a starting point for this analysis and then adjusted to reflect differences between the Efficiency Vermont 2009-2011 budgets and the program budgets used in this analysis. Whereas the 2009-2011 measure penetrations that are estimated for this analysis, and their corresponding energy savings, are similar to those initially developed by Efficiency Vermont for the current contract period, they do not match exactly. Differences exist in overall residential sector budgets, with adjustments made to better reflect more current Efficiency Vermont program implementation activities and plans, as well as changing market conditions. One example of this is the decrease in near-term new housing starts.

For the post-contract period the 2011 measure penetrations were used as a jumping-off point. As the 2011 and 2012 residential budgets vary only slightly (there is a small increase in 2012), initially there are no large changes in most measure penetrations. The two factors that most influence post-2011 measure penetrations are the change in lighting measure mix and, to a lesser extent, the introduction of new technologies over the 20-year forecast period.

As noted above, federal lighting standards will significantly affect the way in which CFLs are promoted by Efficiency Vermont over the 2012-2020 period. During this period, two tiers of federal residential lighting standards are implemented. This dramatically affects the assumed lighting measure mix. After 2014 it is assumed that spiral CFLs will no longer be promoted by the Efficiency Vermont Retail Products program, and that the program's CFL focus will be on only specialty CFLs: dimmables, three-ways, reflectors, etc. Note that the incentives for these specialty lamps are several times higher than they are for spiral CFLs. In 2020, when the second tier of federal lighting standards is implemented, CFLs will no longer be assumed to be part of the Efficiency Vermont program offering.

Concurrent with the change and eventual decrease in CFL penetration is the assumed declining cost and increased penetration of SSL. The cost for LEDs declines several-fold over the analysis period, and combined with increased product availability and functionality, LEDs yield a large increase in SSL numbers. However, even with dramatic reductions in estimated cost, the proposed higher SSL incentive levels limits the number of SSLs that are promoted through the program, given the constrained budget. **Figure 14** compares the change in the number of CFLs and SSL measures that are rebated though the Retail Efficient Products program over the 20-year analysis period. These assumptions flow through to the business sector for CFL / SSL activity through the Retail Efficient Products market initiative as well.

Figure 14. Comparison between rebated CFLs and SSL measures through the Retail Efficient Products market

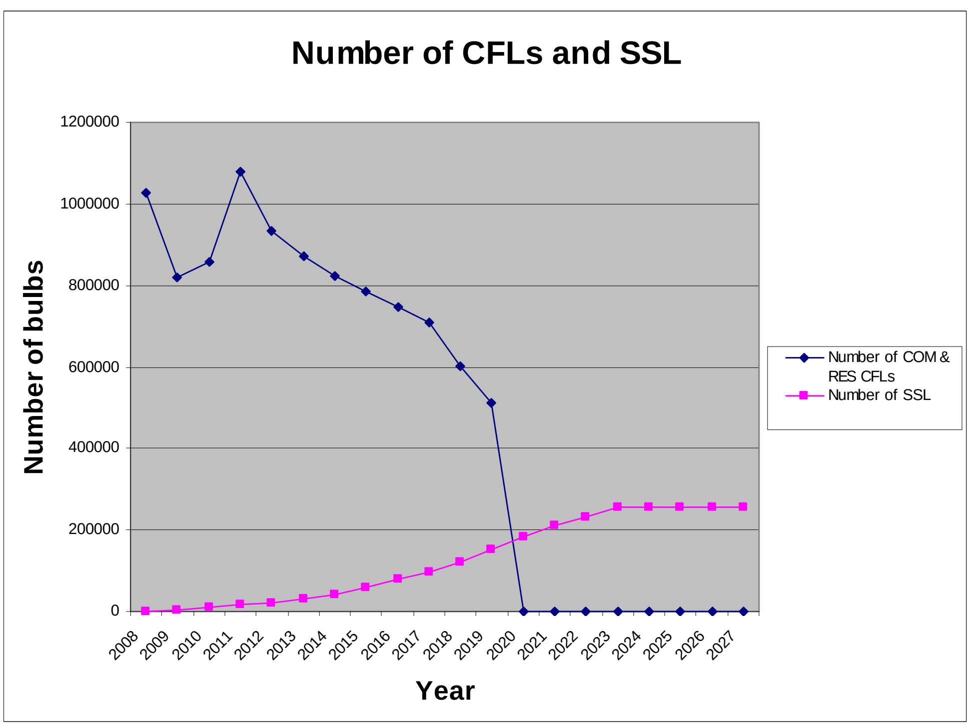
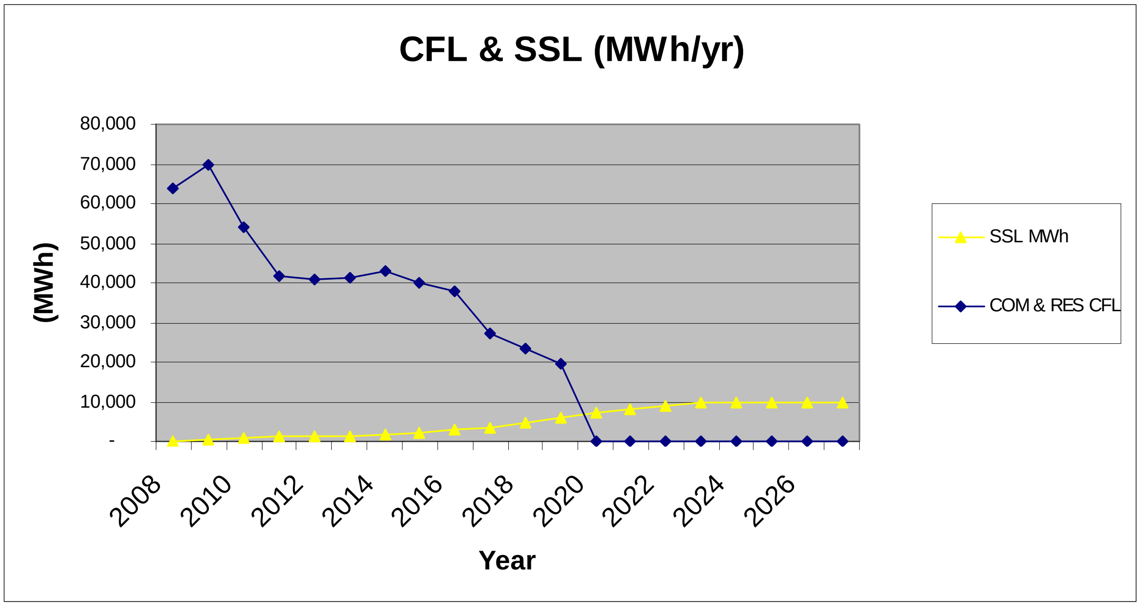


Figure 15 depicts savings achieved in the CFL and SSL market.

Figure 15. Comparison of energy savings from CFL and SSL installations, by year



Over the forecast period several new or emerging technologies not currently offered by Efficiency Vermont are included in the analysis. Most notable are the addition of heat pump water heaters, heat pump dryers, pool pumps, and several consumer electronics measures.

The analysis developed the characteristics for each of the three major markets in the residential and nonresidential sectors based on inputs, outputs, and intermediate results of the VELCO forecast. It also relied on additional research into other market characteristics not addressed explicitly by the VELCO forecast. The analysis relied on secondary sources as available to supplement VELCO forecast information. The analysis reconciled divergent information from these multiple sources as necessary with appropriate adjustments based on professional judgment.

2. Business market penetrations

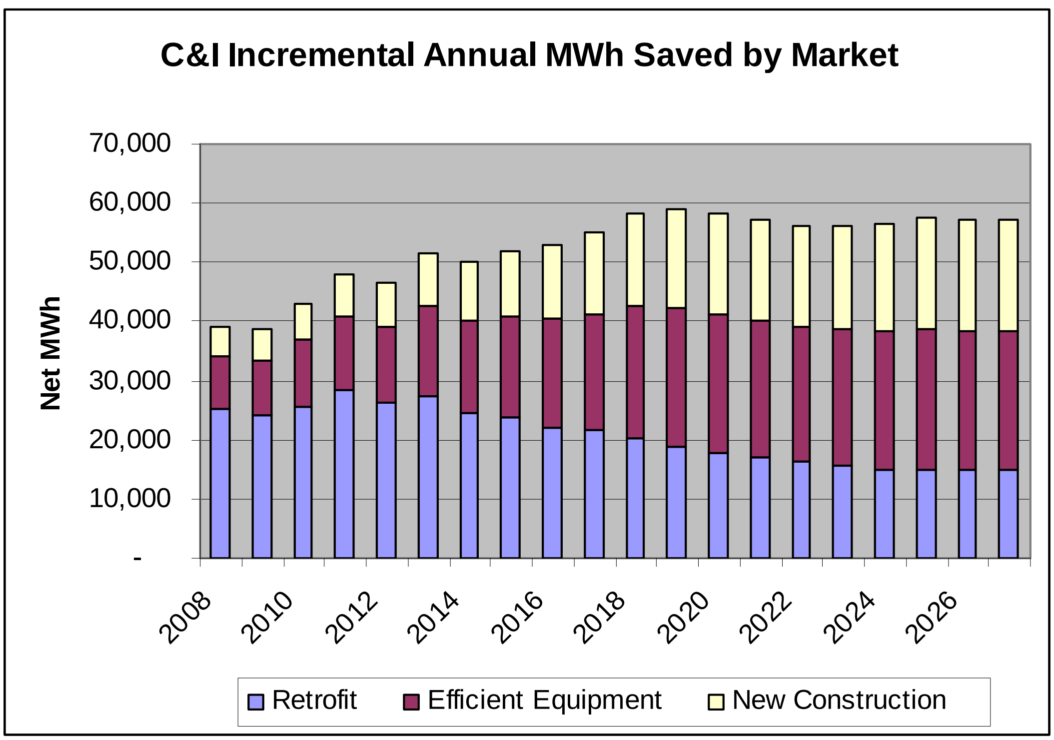
Both high-efficiency technologies and the baseline equipment to which they are compared have demonstrated increased efficiencies over several decades. As evidence of this, ASHRAE's Energy Standard for Buildings (ASHRAE Standard 90.1) is revised approximately every 3 years to reflect the advancement of technologies and practices in use in the marketplace. Similarly, the Consortium for Energy Efficiency (CEE) recently redefined their tiers for high-efficiency air conditioning, as their old Tier 1 was approaching current baselines for new equipment (CEE's new tiers were adopted in January 2009). In the course of these advances in technology and baseline efficiency, opportunities for cost-effective efficiency measures and associated savings have remained fairly constant over many years. In other words, high-efficiency technologies have been able to keep up with baseline technologies to yield similar savings. As noted in the section on business technology characteristics, this trend is expected to continue through the forecast period.

In general, the analysis does not attempt to project savings from specific emerging technologies, since insufficient solid data exist to support such projections (LED lighting is an exception). Instead, the general operating assumption is that savings available now from existing technologies and practices would continue to be achievable through the forecast period. This is reflected for some measures by consistent penetration levels through the forecast period, where in fact changes over time are expected with baselines, and in some cases with the actual technology. This approach has been applied particularly in the second ten years of the forecast, where it is most difficult to predict the state of efficient technologies and their impacts.

The penetrations for CFLs and LEDs reflect the market forces for those particular technologies., and the assumptions described above for the residential sector.

The analysis anticipates that retrofit measures will continue to represent a large portion of the C&I savings as the direct install program continues to acquire significant savings. However, over time, retrofit penetrations are expected to decline as the "easiest" retrofit opportunities are depleted, and as market-driven efficiency measures reduce the stock available for retrofit measures. As retrofit penetrations decrease, market-driven penetrations will increase to reflect the shift of resources to those market services. As penetrations shift from retrofit to market-driven opportunities, the savings from those markets will shift as well, as shown in the **Figure 16**.

Figure 16. C & I incremental annual MWh saved, by market



The analysis model uses Efficiency Vermont participant penetrations, or those receiving incentives for their installed efficiency measures. Participant penetrations result in gross savings, without regard to the effects of free ridership and spillover. To calculate net penetrations and savings, net-to-gross ratios by market and end use were used based on the Efficiency Vermont 2008 Annual Report, as shown in **Table 15.**

Table 15. Net-to-gross ratios by market and end use[67]

End Use	Business New Construction	Business Existing Facilities
Cooling	1.21	0.91
Electricity total	1.20	0.96
Indoor lighting	1.14	1.03
Industrial process	1.17	0.85
Miscellaneous	1.20	0.96
Other	1.20	0.96
Outdoor lighting	1.14	1.03
Refrigeration	1.21	0.94
Space heating	1.21	0.91
Ventilation	1.21	0.91
Water heating	1.20	0.83
Total	**1.17**	**0.98**

Some of the efficiency measures are mutually exclusive—that is, one or the other could be installed, but not both. For example, a linear fluorescent fixture could be retrofitted with High-performance T8 lamps and ballasts, or it could be replaced with an entirely new fixture. When two or more measures compete with one another, an estimate of the penetration of the measure offering the most per-unit savings was made first. The penetration of the next competing measure was then estimated, based on the remaining potential.

As with the residential sector, the starting point for penetrations is estimates of current and historic Efficiency Vermont penetrations. By calibrating the model to current Efficiency Vermont activity, the analysis ensures a relatively stable and accurate starting point. Relatively deep retrofit penetration is assumed in the early years from continued direct installation services supplementing other traditional Efficiency Vermont financial and technical services.

G. EEU Program and Portfolio Budget Development

Cost-effectiveness analysis at the program and portfolio levels requires non-measure budgets in addition to measure costs. The analysis developed budgets for fielding individual programs predicated on the market services developed for each major market, as well as for portfolio-wide services required to support the full set of programs.

[67] These net-to-gross ratios do not include any line losses. Losses from the customer meter to the voltage level of the VELCO forecast are calculated separately.

For each program, the study constructed program delivery and financial incentive budgets based on the market service design and the line and supporting service costs. The study developed EEU line and supporting service delivery budgets consistent with the market service design and market penetrations estimated for each program. These budgets used Efficiency Vermont's existing cost categories and direct and indirect costs, escalated as appropriate in reflect anticipated real cost increases. The portfolio budget includes program costs for providing services in all major markets within each sector. It is included in the cost-effectiveness analysis of the portfolio as a whole. Details of the application of these cost categories to establish annual budgets for the residential and business sectors are presented in **Section IV C.**

In the residential sector, the budgeting process recognized that the bulk of the economic value delivered by the Existing Homes retrofit program has historically originated from fossil fuel savings due to improvements in the efficiency of the building shell. This is not a sustainable long-term approach to setting electric ratepayer-funded budgets for acquiring efficiency savings. In other jurisdictions, best practice in residential retrofit programs is to design and implement programs to capture all cost-effective efficiency retrofits in homes heated with natural gas and cooled with electricity. Program budgets are then allocated between gas and electric customers in proportion to the benefits produced by the program.

In the future, the Vermont Legislature has called for long-term investment to retrofit all homes in the state. This study assumed that for the forecast period, residential program budget would only cover the electric share of total resource benefits generated by the residential retrofit program. This implies that the majority of non-measure costs for the home retrofit program will eventually be supported by funds dedicated to fossil-fuel efficiency programs. This had the effect of increasing the amount of fund available for residential efficiency investment on the part of the EEU.

This is different from but consistent with the approach to budgeting EEU programs for the business sector. In other jurisdictions where most nonresidential customers heat with natural gas and use electricity for most other end uses, natural gas efficiency programs generally "piggyback" on electric utility retrofit programs targeting commercial and industrial customers. Accordingly, it is appropriate to charge most if not all the program non-measure costs to the electric utility's ratepayers, charging back to the gas utility, where possible, its share of the non-measure costs in proportion to its share of total resource benefits.

While the approach adopted here for setting long-term residential program budgets is a departure from past EEU practice, it is, in effect, the practice currently followed in Vermont for the small portion of the residential retrofit market served by Vermont Gas. VGS operates its home retrofit programs in close coordination with Efficiency Vermont. As discussed in the concluding section of this report, this study concludes that Vermont will need to extend this approach into the realm of unregulated fuels to most effectively pursue the residential efficiency potential remaining during the second half of the forecast period.

H. Application of Benefit / Cost Tests

The Board recognizes two major cost-effectiveness tests. The societal test is the ultimate "litmus test" of whether a measure or program is economically worthwhile. It includes all resource costs and benefits, including environmental externalities. The electric system test indicates how cost-effective a program or measure is to electric ratepayers as a whole. It compares only the direct avoided costs to the electric system with the portion of DSM program costs supported by ratepayers through the Energy Efficiency Charge. The societal test is applied at all four levels of analysis – measure, program, sector, and portfolio. The electric system test applies to the program, sector, and portfolio analysis, but has no meaning at the measure level.

I. Sensitivity Analysis

The study investigated the sensitivity of the Forecast 20 electricity savings to changes in the future value of electricity savings. Sensitivity analysis was conducted by re-assessing the cost-effectiveness of all the analyzed measures, assuming avoided costs in the long run end up being lower than the reference case in the study. Lower avoided costs potentially lower the number of measures found to be cost-effective, and thus they reduce the amount of cost-effective savings achievable. Conversely, higher avoided costs potentially would result in a greater number of measures being cost-effective, thus raising electricity savings realized from continued efficiency investment.

The low scenario assumed that avoided costs had no summer generating capacity value, retaining the same avoided T&D capacity cost assumptions as the reference case, and that avoided electric energy and fossil fuel avoided costs are 25% lower. The high scenario raised all avoided costs by 25% above the reference case.

J. Confidence levels

The forecast of future efficiency savings is an engineering-based analysis. It is not an econometric analysis in which statistically-based estimates of confidence level apply to forecasted values. In such exercises, a forecast of predicted values are expressed in conjunction with a forecast error band, which is a function both of the desired confidence level and the underlying sample variance of demand and other explanatory variables. This error band widens the farther "out of sample" the forecast model is used to predict future outcomes.

Such statistically derived probability statements about forecast confidence levels and error bands are not possible with engineering estimates, which treat predicted outcomes as deterministic. Any probability statements about the forecast outcomes must necessarily be based on judgment of the analyst. Some of the same principles associated with econometric forecasts can be applied in exercising this judgment. One is that for any chosen confidence level, the forecast error band widens the farther into the future predictions extend. Another is that the higher desired confidence level for the forecast, the higher the desired likelihood of the prediction being equaled or exceeded by outcomes. In plain language, this means that the engineering based forecast of efficiency savings can achieve higher confidence levels by using relatively pessimistic judgment in projecting key variables such as achievable market penetration.

1. Statewide 90 / 10 savings forecast

To produce a savings forecast directly comparable to VELCO's 90/10 summer peak demand forecast, this study developed a scenario that could attach a probability of 90 percent that the actual outcomes would equal or exceed the forecast value. To do so, the study used professional judgment to lower two primary determinants of summer peak demand savings in the 50/50 reference scenario: The kWh yield per dollar invested in each of the six major markets addressed by this study; and the summer peak kW per kWh saved across all six markets. Lowering the yield from resulting values for each market reflects the possibility that the EEU will be less effective than expected. Lowering the peak kW per kWh ratio reflects the potential for the load shape of savings to be less favorable.

For residential programs, the study assumed that kWh-per-dollar ratios would fall by 40% in the Retail Products program, and by 30% in the other two markets. The C&I analysis used varying rates of yield deterioration over time across the three markets. The downward yield adjustment ranged from only 1% for Existing Facilities retrofit in 2009 to 64% for C&I new construction in 2027. The study further assumed that peak kW per kWh saved would be 25% lower than projected in the reference case on the basis of the 50/50 analysis for each sector.

This study's 90% forecast scenario for future peak demand savings is fundamentally distinct from the VELCO peak demand forecast. The VELCO 90% forecast reflects the peak demand to expect weather conditions with a 10% likelihood of occurring. This conceptual distinction renders this study's 90% savings forecast conservative, since high-efficiency cooling equipment will save more electricity during extremely hot and humid weather. In practice, the 90 / 10 savings forecast should be adjusted upward by the ratio of VELCO's 90 / 10 and 50 / 50 summer peak demand forecast for each year.

2. Zonal forecast confidence levels

Because the analysis takes place at the statewide level, F20 zonal savings forecasts are necessarily characterized by a wider forecast error band than statewide forecast values. This is because zonal characteristics such as customer building types and end-use mixes are likely to deviate from statewide averages.

This is analogous the difference in precision possible in forecasting savings from a population of customers compared to the reliability of the estimate for a single customer. The likelihood that the actual savings of an individual customer will deviate from the predicted value is much higher than that of the actual average savings from all customers to deviate from the prediction. The necessity of judgmentally assigning statewide market characteristics between the sixteen zones further reduces the precision of (that is, widens the forecast error band around) the zonal savings forecasts.

Zonal forecast uncertainty could be reduced significantly. Doing so would require sampling zonal customers to more accurately estimate their driving characteristics. Maximum confidence could be achieved by conducting a census of the entire population. Such research would be well beyond the scope of this study. Such efforts have been conducted in the past by CVPS in the Southern Loop NTA analysis. Future research by distribution utilities to validate and/or calibrate engineering estimates may be worthwhile for improving statistical confidence in engineering estimates of efficiency savings at the zonal level.

K. Statewide Savings Aggregation

The Forecast 20 analysis aggregated statewide savings in four steps. First, the study removed BED's forecast from the VELCO forecast. Second, the study adjusted the VELCO forecast for endogenous efficiency and for household lighting intensity. Third, the study used the adjusted non-BED forecast as the basis for forecasting savings from future efficiency investment outside BED's service area. Fourth, the study combined the BED and Forecast 20 estimates of future DSM savings from continued investment. Finally, the total DSM savings for each sector were compared with VELCO statewide forecast.

L. Zonal Savings Forecast

This study's zonal savings forecast is based on the statewide sector-level energy savings analysis. For each zone, this study apportioned statewide sector-level energy savings according to zonal energy sales, and then applied the sector-level ratios of statewide summer peak kW savings per kWh energy savings annually to determine the 50 / 50 zonal peak savings forecast. The zonal 90 / 10 forecast was computed by applying the annual 90 / 10 statewide percentage reductions at the zonal sector level. Details of the zonal analysis are presented in **Appendix 1h.**

The analysis for Zone G, Burlington Electric, was the one exception to this approach. In this instance, the study substituted BED's own forecast of economically achievable energy efficiency in place of the zonal analysis methodology specified here. The reason for doing so is that BED's forecast is more accurate, since it will be relying on the specific customer characteristics for its service territory.

Section VC provides the 90 / 10 summer peak demand savings estimated by zone. **Appendix 1h** provides the energy data by customer class, summer peak, and winter peak zonal and supporting calculations, based on the 50 / 50 forecast, used to estimate zonal peak demand savings.

The zonal savings were estimated based on the historical sector sales for each zone. For example: If zone x represented 10% of the statewide residential sales then its savings would be 10% of the estimated statewide residential savings.

IV. ASSUMPTIONS

A. Global Assumptions

1. Discount rate

The analysis used the real discount rate of 5.7 percent currently in use for EEU cost-effectiveness screening as recommended by the DPS and approved by the PSB. All dollar values are discounted to their 2009 present worth.

2. Inflation

All costs are expressed in real 2009 dollars, that is, without inflation. Any nominal dollar values relied on from external sources used a 2.6% inflation assumption to deflate them to 2009, unless different underlying inflation and real escalation rates are provided in the source document.

3. Loss factors

The individual measure electricity savings analysis was done at the customer voltage level. All savings forecasts at the portfolio level are stated at the same level as the VELCO forecast. The conversions use a 10% demand and energy loss factors between the customer and the VELCO system border, as recommended by VELCO.[68]

The BED load and DSM forecasts were provided at the BED border, which included 3.05% system losses. These forecasts were increased to include a total of 10% system losses for comparison with the VELCO forecast.

B. Avoided Costs

Avoided electricity and other resource costs used to value efficiency costs and benefits are the Vermont values from the 2007 regional analysis of avoided costs prepared by Synapse Energy Economics, recommended by the DPS, approved by the Board, and adopted by Efficiency Vermont starting in 2008.[69]

Table 16 presents the avoided electric energy and capacity costs by year for the 20-year planning horizon.

The costing period definitions are as follows:

- Winter peak energy: 6 am -10 pm, Monday - Friday, October - May
- Winter off peak energy: 10 pm – 6 am, Monday - Friday, all day weekends, October - May
- Summer peak energy: 6 am – 10 pm, Monday - Friday, June - September
- Summer off peak energy: 10 pm-6 am, Monday-Friday, all day weekends, June - September
- Summer Generating Capacity: 1 pm-5 pm, Monday-Friday, non-holiday, June - August
- Winter Generating Capacity: 5 pm-7 pm, Monday-Friday, non-holiday, December - January
- T&D Capacity: Based on a weighting of 60% Summer and 40% Winter capacity

Table 16. Electric avoided costs

	Winter Peak Energy	Winter Off-Peak Energy	Summer On-Peak Energy	Summer Off-Peak Energy	Summer Generating Capacity	T&D Capacity
Year	**$ / kWh**	**$ / kWh**	**$ / kWh**	**$ / kWh**	**$ / kW-yr**	**$ / kW-yr**
2008	0.102	0.076	0.095	0.071	-	174.19
2009	0.095	0.072	0.096	0.065	-	174.24
2010	0.095	0.069	0.094	0.065	71.99	174.29
2011	0.089	0.065	0.093	0.061	123.42	174.34
2012	0.090	0.066	0.094	0.064	123.42	174.25

[68] Email from Hantz Présumé to Francis Wyatt, October 6, 2009.
[69] The Public Service Board issued a memorandum, "Adoption of Revised Avoided Costs," on December 5, 2007, in response to a request by the Department of Public Service on November 5, 2007. A subsequent request was filed September 22, 2009. The Public Service Board responded with its memorandum, "Adoption of Revised Avoided Costs for Energy Efficiency Screening," on November 30, 2009.
http://psb.vermont.gov/sites/psb/files/docket/7523/2009_Avoided_Costs_memo.pdf.

	Winter Peak Energy	Winter Off-Peak Energy	Summer On-Peak Energy	Summer Off-Peak Energy	Summer Generating Capacity	T&D Capacity
Year	**$ / kWh**	**$ / kWh**	**$ / kWh**	**$ / kWh**	**$ / kW-yr**	**$ / kW-yr**
2013	0.086	0.061	0.093	0.061	123.42	174.17
2014	0.088	0.062	0.093	0.061	123.42	174.08
2015	0.087	0.062	0.094	0.062	123.42	173.99
2016	0.088	0.064	0.096	0.065	123.42	173.89
2017	0.093	0.066	0.098	0.064	123.42	173.85
2018	0.090	0.065	0.097	0.066	123.42	173.75
2019	0.089	0.063	0.099	0.065	123.42	173.66
2020	0.092	0.066	0.101	0.066	123.42	173.55
2021	0.095	0.067	0.104	0.065	123.42	173.48
2022	0.097	0.068	0.106	0.067	123.42	173.39
2023	0.098	0.069	0.108	0.068	123.42	173.30
2024	0.099	0.070	0.109	0.069	123.42	173.21
2025	0.101	0.071	0.111	0.070	123.42	173.13
2026	0.102	0.072	0.112	0.071	123.42	173.04
2027	0.104	0.073	0.114	0.072	123.42	172.95
2028	0.105	0.074	0.116	0.073	123.42	172.86
2029	0.107	0.075	0.117	0.074	123.42	172.77
2030	0.108	0.076	0.119	0.075	123.42	172.68
2031	0.110	0.077	0.121	0.077	123.42	172.59
2032	0.112	0.078	0.122	0.078	123.42	172.50
2033	0.113	0.079	0.124	0.079	123.42	172.41
2034	0.115	0.081	0.126	0.080	123.42	172.32
2035	0.117	0.082	0.128	0.081	123.42	172.23
2036	0.118	0.083	0.130	0.082	123.42	172.14
2037	0.120	0.084	0.132	0.083	123.42	172.05
2038	0.122	0.085	0.133	0.085	123.42	171.94
2039	0.123	0.087	0.135	0.086	123.42	171.85
2040	0.125	0.088	0.137	0.087	123.42	171.76

Notes:
Values expressed at the same level as the VELCO forecast.

C. Portfolio Budgets

The total EEU budget is fixed at $30.75 million in constant 2008 dollars, per the PSB's 5/29/08 memorandum. The Board further indicated that for purposes of this analysis, it should be assumed that $17.5 million of portfolio investment must meet certain Board policy objectives. These include priority for lost-opportunity efficiency investments in new construction and in product and equipment purchases. They also include an equitable distribution of efficiency investment benefits throughout the State and between major customer classes.

The study applied the unconstrained funds in pursuit of the Board's primary objective of maximizing achievement of societally cost-effective electricity savings. With no equity constraint, this analysis can consider disproportionate investment in nonresidential retrofit, for example, given the likely size and cost-effectiveness of savings achievable in this market.

The EEU must incur a base level of fixed costs to engage in core functions unrelated to the volume of activity. These include portfolio administration, customer service, and other functions and services no matter how much efficiency investment takes place. Such costs also include basic program management for residential and business services. The study developed an estimate of this annual budget amount to include in the portfolio analysis.

Program budgets include incentive and non-incentive costs. Non-incentive costs typically include costs for administration, marketing, training, general technical assistance and related costs. The C&I analysis assumes program non-incentive costs consistent with Efficiency Vermont's 2009 budgets. Based on these budgets, non-incentive costs were 82% of incentives for the retrofit market, 112% for efficient equipment, and 122% for new construction. As for the incentive levels, the analysis makes the conservative assumption that that non-incentive costs will need to increase in the future as Efficiency Vermont needs to pursue new customers and deeper savings. Thus for the second 10 years of the forecast period the analysis increased non-incentive program costs by 5%.

Table 17 shows the Efficiency Vermont 2009-2011 contract budget that formed the basis for determining the amount of funding available to each sector for program budgets. It details the budget deductions from the EEU contract that were made to determine the portion of funds available to the EEU, and from there, the development of the core portfolio administration costs, which are then deducted from the funds available to the EEU to establish the amount of funds available for program budgets.

Table 17. Derivation of funds available for program budgets

Services and Initiatives	Year 2009	Year 2010	Year 2011	2009-2011
6012 - Existing Buildings - Retrofit	$5,561,459	$6,167,662	$6,744,670	$18,473,791
6013 - Existing Buildings - Equipment Replacement	$2,605,056	$2,796,898	$3,042,912	$8,444,866
6014 - C&I New Construction	$2,032,038	$2,107,788	$2,203,381	$6,343,207
6015 - Customer Credit	$18,393	$19,195	$22,013	$59,601
6017 - Low Income MulitFamily Retrofit	$955,185	$821,021	$821,765	$2,597,971
6018 - Low Income MulitFamily New Construction	$305,402	$375,175	$410,463	$1,091,041
6019 - MultiFamily Market Rate New Construction	$238,491	$306,987	$333,413	$878,891
6020 - MultiFamily Market Rate Retrofit	$197,936	$214,974	$229,835	$642,744
BES FCM ALL FUELS	$233,100	$313,038	$254,700	$800,838
Sub-Total Business Sector	**$12,147,062**	**$13,122,737**	**$14,063,151**	**$39,332,950**
Lighting Plus	$4,236,537	$4,282,726	$4,330,715	**$12,849,977**
6032 - Efficient Products	$3,116,020	$3,121,576	$3,451,894	$9,689,491
6034 - Low Income Single Family	$947,594	$966,749	$1,070,244	$2,984,588
6036 - Residential Retrofit	$902,051	$955,622	$1,132,137	$2,989,810
6038 - Residential New Construction	$1,562,512	$1,661,894	$1,839,986	$5,064,393
RES FCM ALL FUELS	$554,922	$1,342,000	$1,085,945	$2,982,867
6040 - Residential Wide Administration	$188,679	$239,518	$248,171	$676,368
Sub-Total Residential Sector	**$7,271,779**	**$8,287,360**	**$8,828,378**	**$24,387,516**
Total Services and Initiatives	**$23,655,377**	**$25,692,823**	**$27,222,244**	**$76,570,444**
Supporting Services				
6800 - Information Technology	$773,749	$808,350	$866,319	$2,448,418
6800 - Information Technology: FCM ALL FUELS	$26,936	$37,640	$31,834	$96,409
6810 - Marketing	$2,253,686	$2,285,164	$2,464,388	$7,003,238
6810 - Marketing: FCM ALL FUELS	$86,853	$70,843	$57,573	$215,269
6830 - Business Development	$1,688,728	$1,718,460	$2,289,363	$5,696,551
6830 - Business Development: FCM ALL FUELS	$43,444	$53,240	$43,187	$139,871
6840 - Customer Service	$601,274	$586,844	$283,294	$1,471,412
6840 - Customer Service: FCM ALL FUELS	$77,164	$111,601	$85,695	$274,460
6860 - Conference	$314,179	$344,218	$354,890	$1,013,287
6890 - Administration/Mgmt	$2,007,541	$2,050,050	$2,123,759	$6,181,349
6890 - Administration/Mgmt: FCM ALL FUELS	$9,086	$9,541	$9,984	$28,610
Total Supporting Services	**$7,882,640**	**$8,075,950**	**$8,610,285**	**$24,568,874**
EEC Ops Fee	0.75%			
FCM Ops Fee	*2.00%*			
VEIC Operations Fee at:	**$249,429**	**$277,490**	**$288,355**	**$815,274**
Total EVT Budget	**$31,787,446**	**$34,046,262**	**$36,120,884**	**$101,954,592**

Table 18 presents sources of funds to the EEUs, minus administrative costs related to oversight activities and the Customer Credit Net Pay option, and other adjustments, including work related to Forecast 20 activity.

Table 18. EEU budget adjustments, with Forecast 20 costs through 2011

	Year 2009	Year 2010	Year 2011	2009-2011
TOTAL EEU UTILITY CONTRIBUTION BUDGET	$30,750,000	$35,400,000	$40,700,000	$106,850,000
PLUS Estimated ISO-NE Regional Capacity Payments Equal to Contractor's Total Costs to Participate in ISO-NE Regional Capacity Activities	$440,539	$397,906	$397,583	$1,236,028
LESS CA, FA and FA Audit	($169,000)	($172,000)	($173,000)	($514,000)
LESS DPS Monitoring & Evaluation	($708,000)	($814,000)	($936,100)	($2,458,100)
LESS BED Program & Evaluation Costs	($1,517,250)	($1,805,400)	($2,075,700)	($5,398,350)
LESS Customer Credit Net Pay Option	($1,200,000)	($1,400,000)	($1,600,000)	($4,200,000)
PLUS GMP EEF BEF FUNDING	$604,130	$808,894	$875,118	$2,288,142
PLUS ALL FUELS ISO-NE FMC EXCESS FUNDING	$1,169,461	$1,526,394	$1,881,717	$4,577,572
PLUS Home Performance Services (RES Initiatives)	$70,000	$80,000	$95,000	$245,000
PLUS BED Share for General Admin of Statewide Services	$169,000	$169,000	$169,000	$507,000
PLUS VGS Revenue for ratings @ $312 per rating	$45,000	$45,000	$45,000	$135,000
PLUS CONFERENCE revenue	$213,300	$220,000	$235,000	$668,300
PLUS Washington Electric Co-op Pledge Income	$145,000	$145,000	$145,000	$435,000
PLUS LEED-H/VBG Revenue for RNC	$25,000	$35,000	$50,000	$110,000
PLUS Misc. Non-Utility EEU Funds Received	$35,000	$35,000	$35,000	$105,000
Total Adjustments	($677,820)	($729,206)	($856,382)	($2,263,408)
Sub-Total net of Adjustments	$30,072,180	$34,670,794	$39,843,618	$104,586,592
Less Performance Award	($761,000)	($871,400)	($999,600)	($2,632,000)
Budgets Available to EVT	$29,311,180	$33,799,394	$38,844,018	$101,954,592
UNDER/(OVER)	($2,476,266)	($246,868)	$2,723,134	$0

	F-20 BUDGETS			
	Year 2009	Year 2010	Year 2011	Total
	$30,750,000	$35,400,000	$40,700,000	$106,850,000
LESS CA, FA and FA Audit	(169,000)	(172,000)	(173,000)	(514,000)
LESS DPS M & E	(708,000)	(814,000)	(936,100)	(2,458,100)
LESS BED Program & Evaluation Costs	(1,517,250)	(1,805,400)	(2,075,700)	(5,398,350)
LESS Customer Credit Net Pay Option				
PLUS 2008 Forcast 20 Carry-Over				
PLUS GMP EEF BEF FUNDING				
PLUS All Fuels ISO-NE FMC Excess Funding				
PLUS BED Share for General Admin of Statewide Services	169,000	169,000	169,000	507,000
Less Performance Award	(761,000)	(871,400)	(999,600)	(2,632,000)
TOTAL BUDGET	27,763,750	31,906,200	36,684,600	96,354,550
BES	19,229,038	21,614,682	24,787,509	65,631,228
RES	8,534,712	10,291,518	11,897,091	30,723,322

Table 19 shows the derivation of the program budget split between the residential and business sectors. First it applies a 60/40 split to the constrained portion of available funding in order to meet the Board's sectoral equity objective. Next, the study assigned 75% of the unconstrained funds to the business sector, on the presumption (borne out by subsequent program cost-effectiveness analysis) that additional investment in existing business facilities would yield higher levels of cost-effective electricity savings.

Table 19. Budget split between residential and business energy services

Total annual budget, 2008 $			$ 30.75	million								
Total annual budget, 2009 $			$ 31.37	million								
Constrained budget		70%	$ 21.96	million								
Unconsrained budget			$ 9.41	million								
						Millions of Constant 2009 Dollars						
Inflation assumption for 2009-2011			2%			Constrained budget		Unconstrained budget		TOTAL EVT BUDGET		
Year		BES share of constrained budget	BES share of unconstrained budget	BES share of total budget	RES share of total budget	BES	RES	BES	RES	BES	RES	EVT
2008	1 Actual	NA	NA	70%	30%					22.53	9.55	$32.08
2009	2 Contract	NA	NA	69%	31%					19.23	8.53	27.76
2010	3 Contract	NA	NA	68%	32%					21.19	10.09	31.28
2011	4 Contract	NA	NA	68%	32%					23.82	11.44	35.26
2012	5 Projected	60%	75%	65%	36%	13.17	8.78	7.06	2.35	20.23	11.13	31.37

Table 20 shows the resulting annual budget breakdown between core services, residential programs, and business programs.

Table 20. Core supporting services and business and residential markets

Millions of 2009 Dollars			Core Supporting Services				Remaining Budget for BES and RES Markets		
Year		Total Portfolio Budget	Admin/ Mgmt	Marketing & Outreach, Biz Dev, C/S	Non-resource acquisition activities	Total Core Supporting Services	Total BES and RES	BES Sector Budget	RES Sector Budget
2009	Contract	27.76	2.38	4.03	0.28	6.69	21.07	14.60	6.48
2010	Contract	31.28	2.69	4.54	0.31	7.54	23.74	16.08	7.66
2011	Contract	35.26	3.03	5.12	0.35	8.50	26.76	18.08	8.68
2012	Projected	31.37	2.69	4.55	0.31	7.56	23.81	15.36	8.45
2013	Projected	31.37	2.69	4.55	0.31	7.56	23.81	15.36	8.45
2014	Projected	31.37	2.69	4.55	0.31	7.56	23.81	15.36	8.45
2015	Projected	31.37	2.69	4.55	0.31	7.56	23.81	15.36	8.45
2016	Projected	31.37	2.69	4.55	0.31	7.56	23.81	15.36	8.45
2017	Projected	31.37	2.69	4.55	0.31	7.56	23.81	15.36	8.45
2018	Projected	31.37	2.69	4.55	0.31	7.56	23.81	15.36	8.45
2019	Projected	31.37	2.69	4.55	0.31	7.56	23.81	15.36	8.45
2020	Projected	31.37	2.69	4.55	0.31	7.56	23.81	15.36	8.45
2021	Projected	31.37	2.69	4.55	0.31	7.56	23.81	15.36	8.45
2022	Projected	31.37	2.69	4.55	0.31	7.56	23.81	15.36	8.45
2023	Projected	31.37	2.69	4.55	0.31	7.56	23.81	15.36	8.45
2024	Projected	31.37	2.69	4.55	0.31	7.56	23.81	15.36	8.45
2025	Projected	31.37	2.69	4.55	0.31	7.56	23.81	15.36	8.45
2026	Projected	31.37	2.69	4.55	0.31	7.56	23.81	15.36	8.45
2027	Projected	31.37	2.69	4.55	0.31	7.56	23.81	15.36	8.45

V. ANALYSIS RESULTS

A. Statewide Analysis Results

1. Calibration of EEU savings forecast with VELCO's load forecast

a) Endogenous EEU Investment

Table 20 presents the results of the regression analysis of the data presented for the residential and commercial / industrial sectors in **Section III. Table 21** presents the predicted values, both at mean 2000 - 2007 spending levels, and as an upper-bound estimate of incremental annual electric energy savings at the predicted values for each sector, resulting from this analysis.

Table 21. Regression analysis for residential and commercial / industrial sectors

Regression analysis results

BES

Regression Statistics	
Multiple R	0.98944321
R Square	0.97899787
Adjusted R Square	0.83614072
Standard Error	4442.81253
Observations	8

ANOVA

	df	SS	MS	F	Significance F
Regression	1	6440689350	6440689350	326.2994764	1.85216E-06
Residual	7	138170082.1	19738583.16		
Total	8	6578859432			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	0							
Spending	0.00369151	0.00020436	18.06376141	0.000%	0.003208278	0.004174748	0.003208278	0.00417475

RES

Regression Statistics	
Multiple R	0.94114623
R Square	0.88575623
Adjusted R Square	0.74289909
Standard Error	10353.1743
Observations	8

ANOVA

	df	SS	MS	F	Significance F
Regression	1	5817371441	5817371441	54.27248935	0.000320528
Residual	7	750317528.8	107188218.4		
Total	8	6567688970			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	0							
Spending	0.0040826	0.000554175	7.36698645	0.000153685	0.002772186	0.00539302	0.002772186	0.00539302

Table 22. Predicted values for residential and commercial / industrial sectors

Predicted Values							
BES							
Incremental savings embedded in forecast @ sample mean spending of				**$7,234,894**		**26,708**	
Average annual incremental sales growth rate without EEU spending						**0.74%**	
Predicted annual incremental savings if spending set at				$20,230,425	per sector split	74,681	
						2.03%	of 2007 C&I sales
VELCO forecast C&I sales growth rate	2008	-	2027			0.79%	
Adjusted forecast C&I sales growth rate, adding in embedded savings from 2000-2007 EVT investment						**1.53%**	
Forecast C&I sales growth rate, subtracting predicted savings based on 2000-2007 EVT investment at F20 sector spending						-0.50%	
RES							
Incremental savings embedded in forecast @ sample mean spending of				**$6,483,165**		**26,468**	
Average annual incremental sales growth rate without EEU spending						**1.27%**	
Predicted annual incremental savings if spending set at				$11,134,575	per sector split	45,458	
						2.08%	of 2007 residential sales
IVELCO forecast residential sales growth rate	2008	-	2027			0.83%	
Adusted forecast residential sales growth rate, adding in embedded savings from 2000-2007 EVT investment						**2.10%**	
Forecast residential sales growth rate, subtracting predicted savings based on 2000-2007 EVT investment at F20 sector spending						0.02%	

b) Residential lighting adjustment

The residential lighting adjustment has the effect of offsetting a growing portion of the endogenous residential DSM adjustment. By the end of the forecast period, the adjustment reaches 239 GWh / year, offsetting almost half the upward adjustment of 529 GWh / year for endogenous residential program investment. It has the largest effect on the winter peak forecast because of residential lighting's relatively high winter peak coincidence factor, compared with other efficiency measures analyzed in the study.

Detailed results for the residential lighting adjustment appear in **Appendix 2b.**

2. Electricity savings forecasts

Table 23 and **Table 24** contain the year-by-year electric energy savings for the forecast period for the residential and nonresidential sectors, respectively. Correspondingly, **Figure 17** presents the information graphically for the residential sector; **Figure 18** presents the information graphically for the non-residential sector.

Table 23. Vermont residential forecast, in GWh

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	2,166	2,193	81	2,112
2009	2,178	2,211	155	2,057
2010	2,195	2,236	228	2,008
2011	2,213	2,260	285	1,976
2012	2,235	2,288	323	1,966
2013	2,191	2,250	359	1,891
2014	2,195	2,260	372	1,888
2015	2,208	2,277	377	1,900
2016	2,232	2,307	411	1,896
2017	2,249	2,327	399	1,928
2018	2,273	2,373	411	1,962
2019	2,297	2,418	409	2,009
2020	2,321	2,463	372	2,092
2021	2,338	2,502	345	2,157
2022	2,366	2,551	314	2,237
2023	2,396	2,602	283	2,320
2024	2,435	2,663	264	2,398
2025	2,463	2,712	250	2,461
2026	2,499	2,768	244	2,523
2027	2,535	2,825	257	2,568

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
Growth Rates				
2008-2012	0.8%	1.1%		-1.8%
2013-2017	0.7%	0.8%		0.5%
2018-2027	1.2%	2.0%		3.0%
2008-2027	0.8%	1.3%		1.0%

Figure 17. Statewide residential electric energy requirements with forecast savings from continued EEU investment

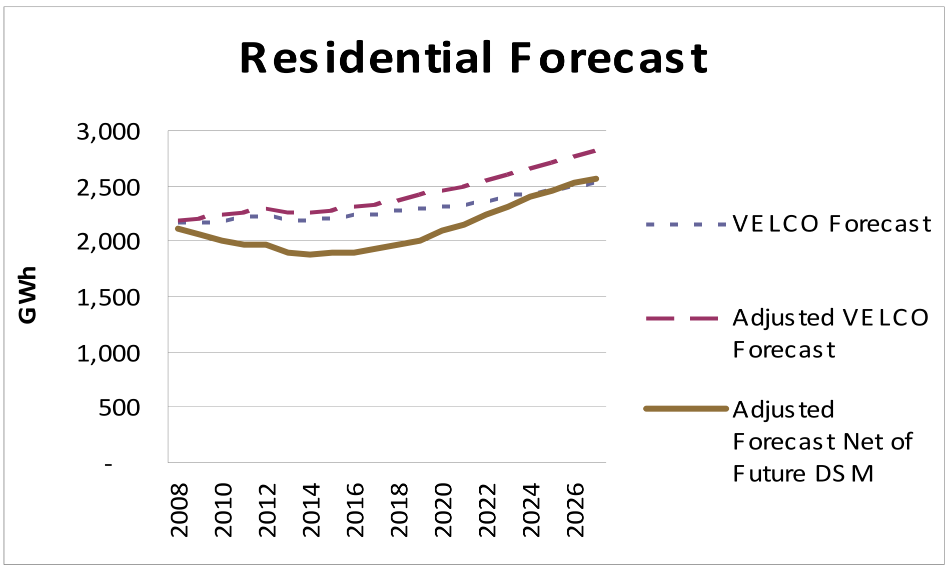


Table 24. Statewide commercial / industrial electric energy requirements with forecast savings from continued EEU investment

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	3,692	3,719	44	3,675
2009	3,725	3,779	86	3,692
2010	3,753	3,833	134	3,700
2011	3,779	3,885	185	3,700
2012	3,805	3,938	232	3,707
2013	3,830	3,991	282	3,708
2014	3,856	4,043	332	3,711
2015	3,882	4,095	382	3,713
2016	3,909	4,149	434	3,715
2017	3,937	4,205	487	3,718
2018	3,966	4,260	539	3,721
2019	3,996	4,317	593	3,724
2020	4,028	4,375	646	3,729
2021	4,060	4,434	695	3,738
2022	4,094	4,495	740	3,755
2023	4,130	4,557	764	3,793
2024	4,167	4,621	786	3,835
2025	4,205	4,686	805	3,881
2026	4,245	4,753	820	3,933
2027	4,288	4,822	836	3,986
Growth Rates				
2008-2012	0.8%	1.4%		0.2%
2013-2017	0.7%	1.3%		0.1%
2018-2027	0.9%	1.4%		0.8%
2008-2027	0.8%	1.4%		0.4%

Figure 18. Statewide commercial / industrial electric energy requirements with forecast savings from continued EEU investment

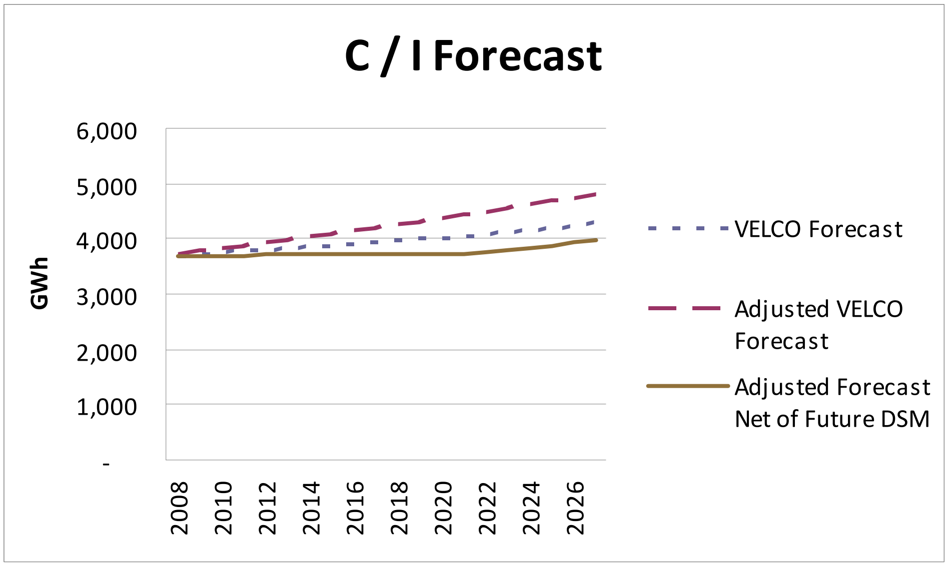


Table 25 provides the study's forecast of *incremental annual energy savings* by program over 20 years. **Figure 19** portrays this information graphically. **Table 26** provides the study's forecast of *cumulative annual energy savings* by program, and **Figure 20** presents the same information graphically.

Table 25. Incremental annual electric energy savings by program from continued EEU investment through 2027

Program	Incremental Annual Energy Savings (GWh/yr)																			
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Residential New Construction	1.2	1.0	1.2	1.1	0.9	0.9	0.8	0.8	0.9	0.9	0.9	0.7	0.8	0.8	0.8	0.9	0.8	0.9	0.9	0.9
Retail Products	73.4	75.9	74.2	74.8	72.2	70.6	71.2	66.6	65.0	52.7	48.9	45.8	19.5	20.8	21.5	22.3	22.5	22.8	23.1	23.4
Existing Homes	3.9	2.1	2.6	2.7	1.5	1.8	1.8	1.4	1.9	1.4	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6
Commercial New Construction	4.7	5.2	6.2	7.3	7.2	8.4	9.6	10.6	12.2	13.1	14.6	16.1	16.8	16.6	16.5	16.9	17.4	18.0	18.0	18.0
Commercial Efficient Equipment	8.5	9.1	10.7	12.4	11.7	13.7	15.1	15.6	17.5	18.4	20.2	21.8	22.4	21.8	21.2	21.4	21.7	22.0	22.0	21.9
Commercial Retrofit	24.4	23.9	25.5	28.1	25.3	26.6	24.4	23.4	22.1	20.9	19.3	18.6	17.6	16.6	15.7	15.1	14.6	14.5	14.5	14.4
Total Programs	**116.2**	**117.2**	**120.3**	**126.6**	**118.8**	**122.0**	**122.9**	**118.4**	**119.7**	**107.5**	**105.6**	**104.5**	**78.7**	**78.0**	**77.2**	**78.1**	**78.6**	**79.7**	**80.0**	**80.2**

Figure 19. Incremental annual electric energy savings by program from continued EEU investment through 2027

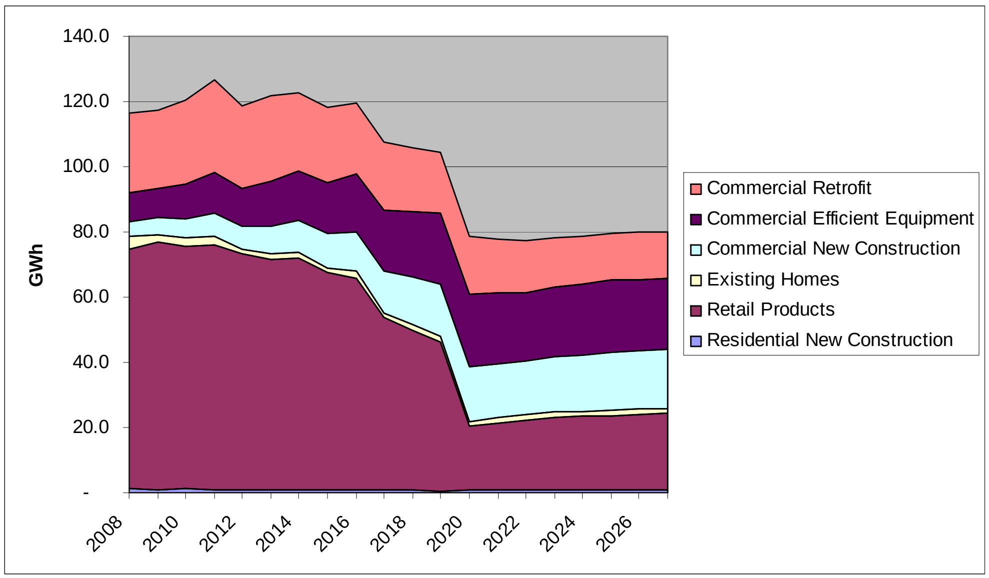


Table 26. Cumulative annual electric energy savings by program from continued EEU investment through 2027

Program	Cumulative Annual Energy Savings (GWh/yr)																			
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Residential New Construction	1.2	2.2	3.4	4.5	5.4	6.3	6.9	7.7	8.5	9.1	9.9	10.3	10.8	11.3	11.5	11.7	11.9	12.2	12.6	13.2
Retail Products	73.4	142.8	210.4	261.4	295.0	326.9	335.7	338.1	367.9	353.8	362.7	357.8	318.6	290.8	257.3	226.4	208.0	194.7	189.4	200.0
Existing Homes	3.9	6.1	8.7	11.3	12.6	14.1	15.6	16.3	17.3	18.0	18.7	19.3	19.5	19.2	19.5	18.2	16.6	14.5	12.4	12.7
Commercial New Construction	4.7	9.9	16.1	23.2	29.9	37.9	47.1	57.3	69.1	81.7	95.4	110.4	125.6	140.3	154.3	166.0	177.6	188.8	199.2	209.4
Commercial Efficient Equipment	8.5	17.6	28.3	39.7	49.2	60.9	73.9	87.6	103.6	120.4	138.7	158.5	178.2	196.6	212.7	225.4	237.3	248.1	257.7	266.4
Commercial Retrofit	24.4	48.3	73.8	101.3	125.4	150.7	172.7	193.8	213.4	231.7	246.5	260.7	273.9	286.1	296.4	291.2	285.1	277.5	268.2	260.9
Total Programs	**116.2**	**226.9**	**340.7**	**441.5**	**517.6**	**596.9**	**651.9**	**700.7**	**779.8**	**814.7**	**871.9**	**916.9**	**926.6**	**944.2**	**951.6**	**938.8**	**936.3**	**935.8**	**939.4**	**962.5**

Figure 20. Cumulative annual electric energy savings by program from continued EEU investment through 2027

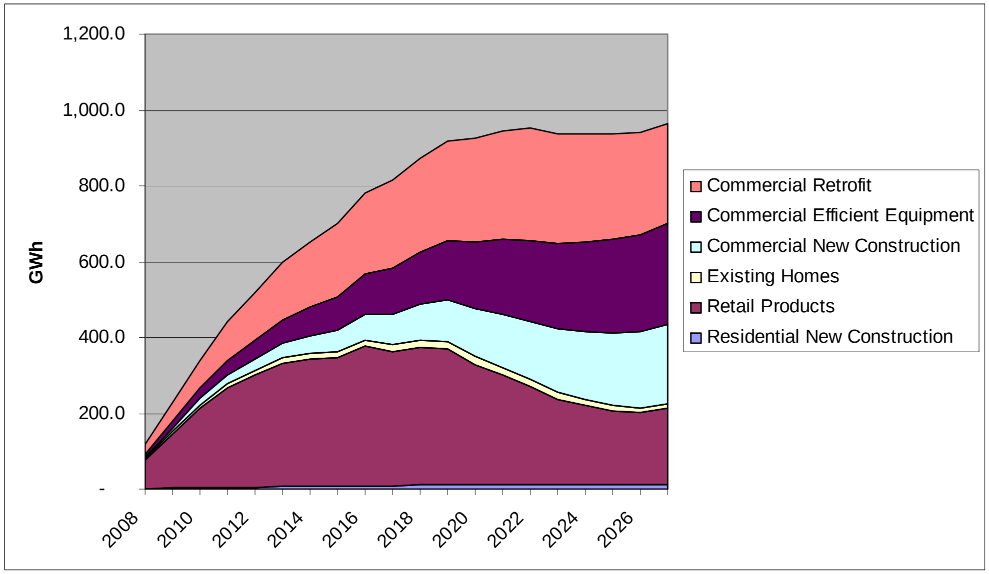


Table 27 and **Figure 21** present *incremental summer peak* demand savings by program in tabular and graphical form. For comparison, **Table 28** and **Figure 22** show *cumulative summer peak* demand savings, graphically.

Table 27. Incremental annual electric summer peak savings by program from continued EEU investment through 2027

Program	Incremental Annual Summer Peak Savings (MW/yr)																			
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Residential New Construction	0.29	0.20	0.26	0.27	0.19	0.23	0.25	0.18	0.23	0.26	0.19	0.21	0.25	0.18	0.22	0.26	0.19	0.23	0.27	0.20
Retail Products	4.69	3.96	4.29	5.68	6.55	7.02	7.19	6.48	6.93	6.21	6.01	6.22	4.81	4.95	3.92	3.98	4.03	4.08	4.14	4.20
Existing Homes	0.32	0.35	0.43	0.45	0.17	0.19	0.19	0.15	0.19	0.16	0.17	0.17	0.17	0.17	0.17	0.18	0.18	0.18	0.18	0.18
Commercial New Construction	1.16	1.25	1.47	1.73	1.69	1.98	2.25	2.42	2.74	2.90	3.20	3.48	3.60	3.52	3.46	3.53	3.61	3.68	3.69	3.70
Commercial Efficient Equipment	1.94	2.05	2.40	2.79	2.63	3.09	3.44	3.54	3.95	4.14	4.54	4.91	5.04	4.90	4.79	4.84	4.91	4.98	4.98	4.97
Commercial Retrofit	5.26	5.07	5.31	5.80	5.17	5.30	4.83	4.59	4.32	4.08	3.73	3.57	3.38	3.19	3.02	2.90	2.83	2.82	2.81	2.79
Total Programs	**13.65**	**12.87**	**14.16**	**16.72**	**16.41**	**17.80**	**18.15**	**17.36**	**18.36**	**17.74**	**17.86**	**18.57**	**17.26**	**16.91**	**15.59**	**15.69**	**15.75**	**15.97**	**16.06**	**16.04**

Figure 21. Incremental annual electric summer peak savings by program from continued EEU investment through 2027

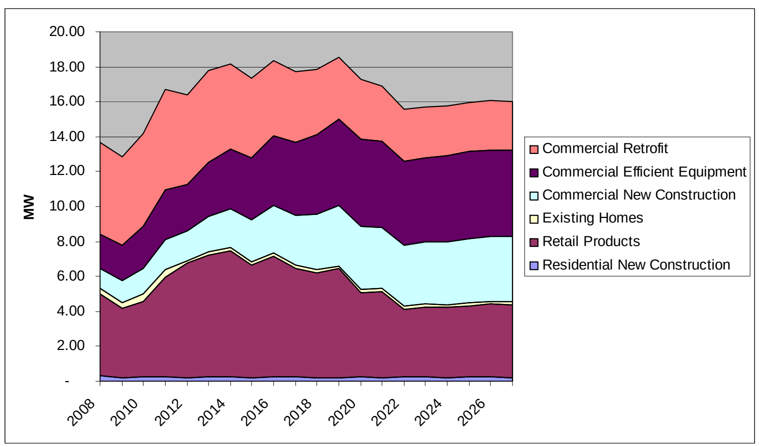


Table 28. Cumulative annual summer peak demand savings by program from continued EEU investment through 2027

Program	Cumulative Annual Summer Peak Savings (MW/yr)																			
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Residential New Construction	0.29	0.49	0.75	1.02	1.21	1.44	1.69	1.87	2.09	2.33	2.51	2.70	2.93	3.10	3.27	3.47	3.60	3.77	3.90	4.04
Retail Products	4.69	8.65	12.94	18.11	23.80	29.96	34.14	36.81	40.62	40.89	41.91	41.07	38.46	36.59	33.94	29.95	27.47	25.57	25.39	26.27
Existing Homes	0.32	0.67	1.09	1.53	1.67	1.83	1.98	2.04	2.13	2.20	2.28	2.35	2.40	2.39	2.44	2.22	1.94	1.58	1.21	1.25
Commercial New Construction	1.16	2.40	3.87	5.56	7.17	9.06	11.22	13.56	16.23	19.05	22.06	25.30	28.57	31.67	34.61	37.02	39.37	41.63	43.71	45.73
Commercial Efficient Equipment	1.94	3.99	6.39	8.95	11.13	13.80	16.80	19.97	23.63	27.49	31.66	36.15	40.64	44.82	48.53	51.52	54.33	56.92	59.24	61.37
Commercial Retrofit	5.26	10.33	15.64	21.32	26.26	31.33	35.62	39.67	43.39	46.82	49.36	51.80	54.02	56.04	57.68	56.35	54.97	53.42	51.57	50.12
Total Programs	**13.65**	**26.52**	**40.68**	**56.48**	**71.24**	**87.42**	**101.45**	**113.93**	**128.09**	**138.79**	**149.78**	**159.36**	**167.02**	**174.62**	**180.48**	**180.52**	**181.70**	**182.89**	**185.02**	**188.78**

Figure 22. Cumulative annual summer peak demand savings by program from continued EEU investment through 2027

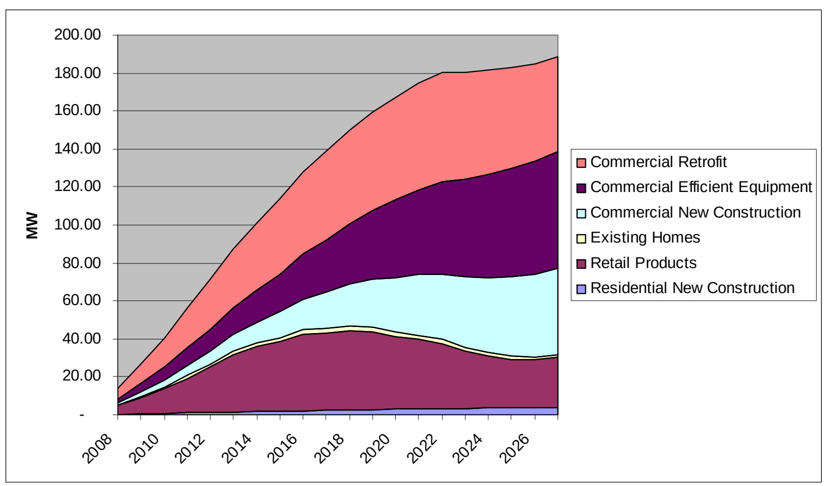


Table 29 and **Figure 23** contain comparable information for *incremental winter peak* demand savings, whereas **Table 29** and **Figure 24** present comparable information for *cumulative winter peak* demand savings..

Table 29. Incremental annual electric winter peak savings by program from continued EEU investment through 2027

Program	Incremental Annual Winter Peak Savings (MW/yr)																			
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Residential New Construction	0.32	0.28	0.34	0.32	0.25	0.25	0.22	0.20	0.23	0.24	0.22	0.16	0.20	0.18	0.19	0.21	0.19	0.20	0.22	0.20
Retail Products	15.84	12.36	13.17	15.64	17.99	18.45	18.94	16.17	16.46	13.61	12.70	12.58	6.89	7.19	5.99	6.23	6.42	6.64	6.89	7.18
Existing Homes	1.24	1.17	1.43	1.48	0.25	0.33	0.32	0.17	0.29	0.18	0.23	0.20	0.19	0.19	0.19	0.19	0.19	0.20	0.20	0.20
Commercial New Construction	0.68	0.74	0.88	1.04	1.01	1.19	1.37	1.52	1.76	1.90	2.14	2.37	2.49	2.47	2.47	2.55	2.64	2.74	2.74	2.74
Commercial Efficient Equipment	1.36	1.45	1.70	1.98	1.85	2.18	2.41	2.48	2.76	2.89	3.17	3.42	3.51	3.41	3.33	3.36	3.41	3.45	3.45	3.44
Commercial Retrofit	3.72	3.66	3.91	4.33	3.85	3.99	3.66	3.48	3.27	3.08	2.84	2.72	2.57	2.42	2.29	2.19	2.13	2.12	2.11	2.10
Total Programs	**23.17**	**19.66**	**21.43**	**24.79**	**25.21**	**26.39**	**26.91**	**24.01**	**24.78**	**21.91**	**21.30**	**21.45**	**15.84**	**15.85**	**14.46**	**14.74**	**14.98**	**15.35**	**15.61**	**15.86**

Figure 23. Incremental annual electric winter peak savings by program from continued EEU investment through 2027

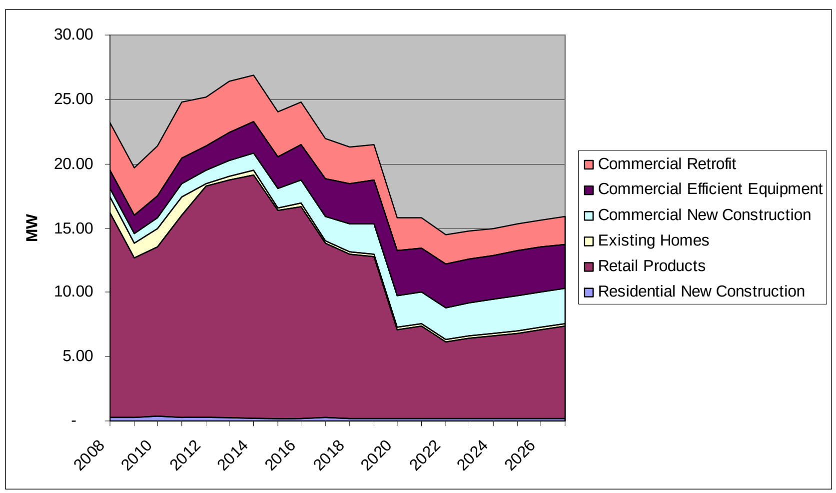
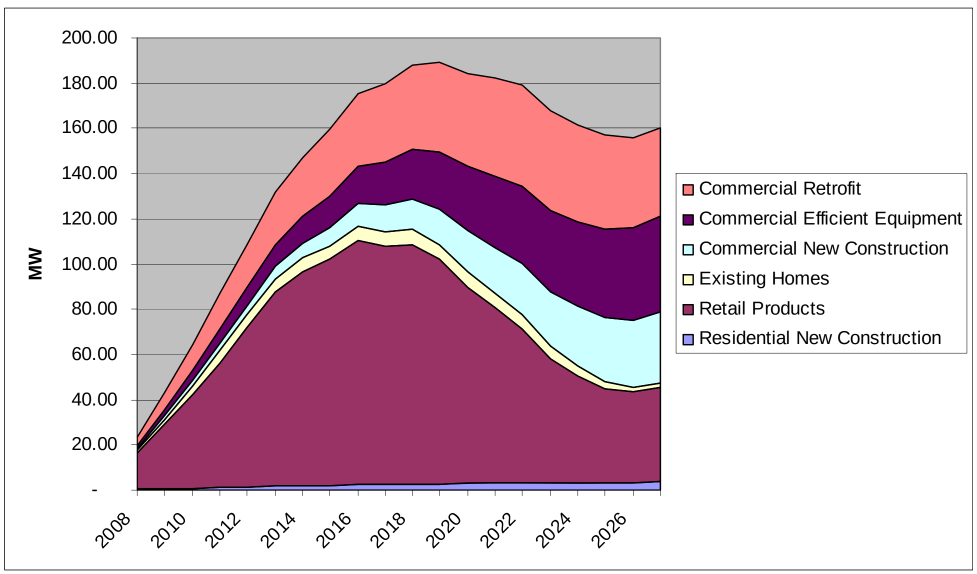


Table 30. Cumulative annual winter peak demand savings by program from continued EEU investment through 2027

Program	Cumulative Annual Winter Peak Savings (MW/yr)																			
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Residential New Construction	0.32	0.60	0.94	1.26	1.52	1.77	1.98	2.19	2.38	2.54	2.72	2.81	2.93	3.03	3.10	3.14	3.17	3.25	3.35	3.49
Retail Products	15.84	28.20	41.38	55.16	70.31	86.09	94.53	99.72	108.12	105.42	105.82	99.10	86.81	77.46	68.16	54.70	47.07	41.74	40.03	42.21
Existing Homes	1.24	2.42	3.84	5.31	5.54	5.83	6.11	6.20	6.39	6.48	6.61	6.70	6.70	6.60	6.64	5.74	4.60	3.18	1.74	1.78
Commercial New Construction	0.68	1.41	2.29	3.30	4.24	5.37	6.67	8.12	9.82	11.66	13.69	15.93	18.23	20.47	22.62	24.43	26.25	28.04	29.70	31.32
Commercial Efficient Equipment	1.36	2.81	4.51	6.31	7.81	9.64	11.70	13.86	16.37	19.03	21.96	25.13	28.32	31.29	33.85	35.90	37.81	39.55	41.10	42.48
Commercial Retrofit	3.72	7.39	11.30	15.53	19.18	22.95	26.23	29.33	32.24	34.93	37.19	39.37	41.40	43.26	44.73	43.82	42.83	41.65	40.21	39.12
Total Programs	**23.17**	**42.83**	**64.26**	**86.87**	**108.60**	**131.65**	**147.22**	**159.42**	**175.32**	**180.06**	**188.00**	**189.04**	**184.39**	**182.12**	**179.09**	**167.73**	**161.72**	**157.40**	**156.14**	**160.40**

Figure 24. Cumulative annual winter peak demand savings by program from continued EEU investment through 2027



The following tables and figures provide further information on the composition of Forecast 20 efficiency savings over time, by **end use**.

- **Part A** of each table and figure set provides *incremental* annual savings for the year indicated. This provides a snapshot view of the efficiency resources being acquired in that year.
- **Part B** provides *cumulative* annual savings through that year by end use. This indicates how much each end use has contributed to electricity savings over varying periods of time.

a) Energy savings – Part A (incremental savings)

Table 31. Residential incremental energy (MWh) saved, by end use

End Use	2008	2012	2017	2027
Clothes Fuel Switch	0.1%	0.1%	0.2%	0.9%
Consumer Electronics	0.7%	6.4%	10.7%	22.7%
Cooling	0.1%	0.1%	0.2%	0.3%
Heating/Cooling/DHW	0.1%	0.1%	0.1%	0.2%
Heating/DHW	0.1%	0.1%	0.1%	0.2%
Indoor Lighting	93.4%	81.9%	71.6%	24.8%
Kitchen/Laundry	0.1%	0.1%	0.2%	0.6%
Other Appliances	1.4%	2.0%	3.8%	21.0%
Outdoor Lighting	0.0%	0.0%	0.0%	0.1%
Refrigeration	0.8%	8.5%	11.9%	26.3%
Space Heating	2.7%	0.2%	0.2%	0.5%
Ventilation	0.0%	0.0%	0.1%	0.4%
Water Heating	0.6%	0.5%	0.8%	2.0%

Figure 25. Residential incremental MWh saved, by end use

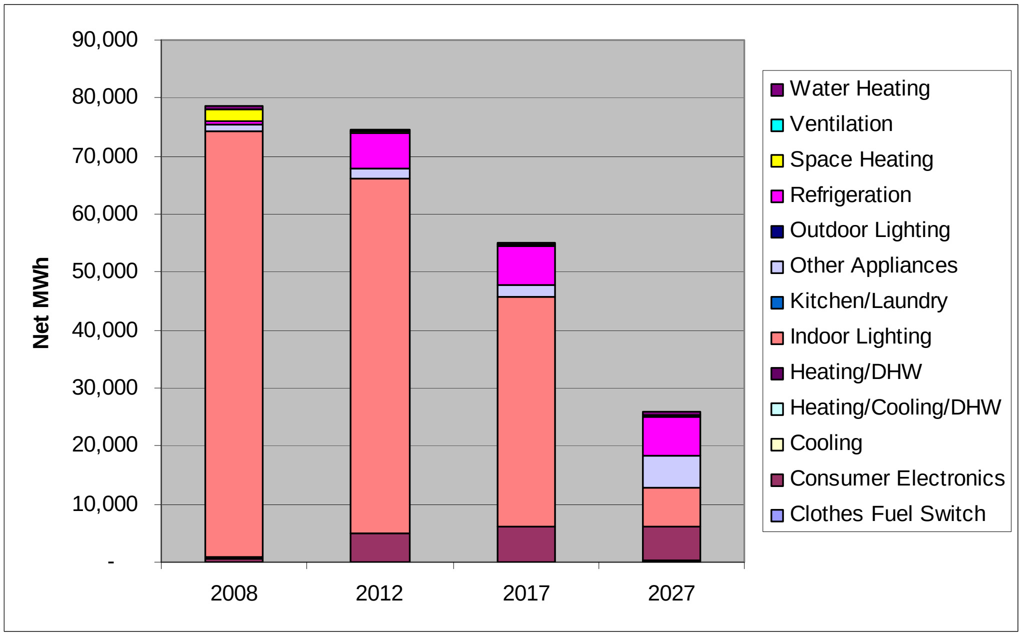
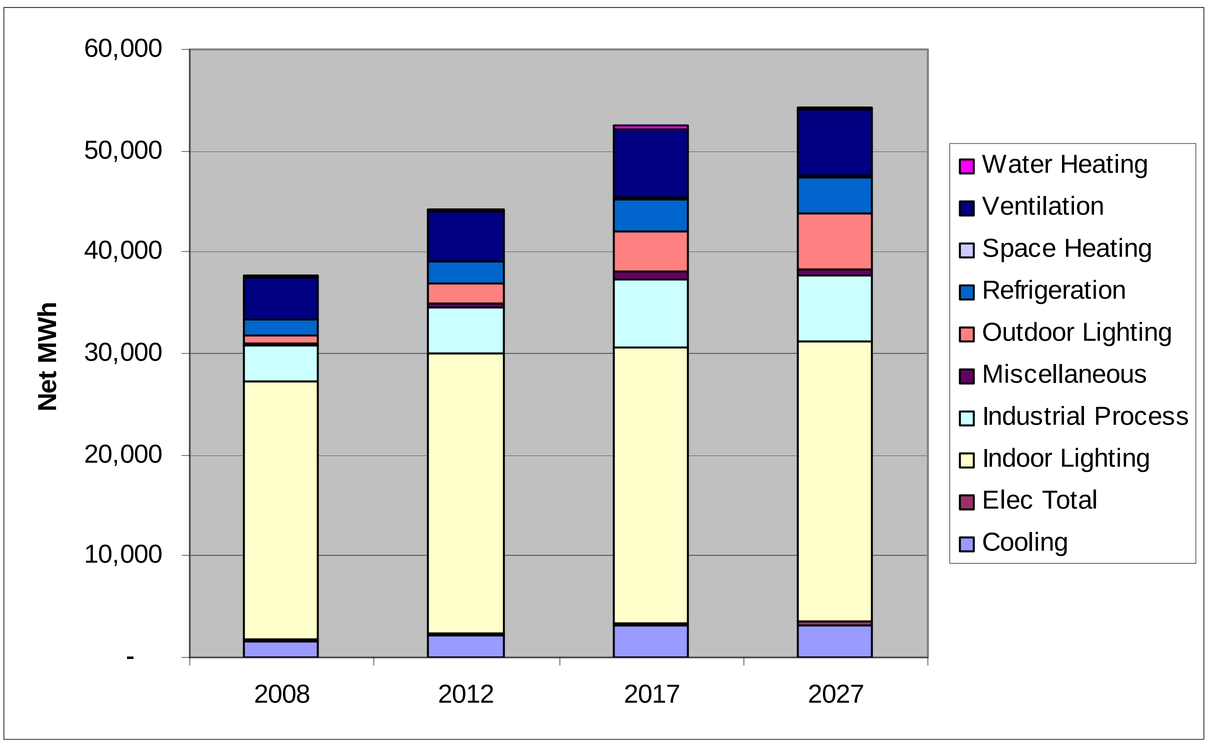


Table 32. C & I incremental energy (MWh) saved, by end use

End Use	2008	2012	2017	2027
Cooling	4.4%	4.9%	6.2%	6.0%
Electricity Total	0.3%	0.3%	0.4%	0.4%
Indoor Lighting	67.7%	63.0%	51.8%	51.0%
Industrial Process	9.3%	10.2%	12.9%	12.1%
Miscellaneous	0.2%	0.8%	1.4%	1.0%
Outdoor Lighting	2.4%	4.6%	7.6%	10.2%
Refrigeration	3.9%	4.6%	6.1%	6.7%
Space Heating	0.2%	0.2%	0.2%	0.2%
Ventilation	11.0%	10.9%	12.9%	12.2%
Water Heating	0.7%	0.5%	0.5%	0.2%

Figure 26. C & I incremental energy (MWh) saved, by end use



b) Energy savings – Part B (cumulative savings)

Table 33. Residential cumulative energy (MWh) saved, by end use

End Use	2008	2012	2017	2027
Clothes Fuel Switch	0.1%	0.2%	0.3%	1.0%
Consumer Electronics	0.7%	3.8%	7.3%	12.6%
Cooling	0.1%	0.1%	0.2%	0.5%
Heating/Cooling/DHW	0.1%	0.1%	0.1%	0.5%
Heating/DHW	0.1%	0.1%	0.1%	0.5%
Indoor Lighting	93.4%	86.8%	74.2%	34.9%
Kitchen/Laundry	0.1%	0.1%	0.2%	0.8%
Other Appliances	1.4%	1.9%	4.0%	20.1%
Outdoor Lighting	0.0%	0.0%	0.0%	0.0%
Refrigeration	0.8%	5.7%	11.9%	25.1%
Space Heating	2.7%	0.8%	0.8%	1.8%
Ventilation	0.0%	0.0%	0.1%	0.3%
Water Heating	0.6%	0.4%	0.8%	2.0%

Figure 27. Residential cumulative energy (MWh) saved, by end use

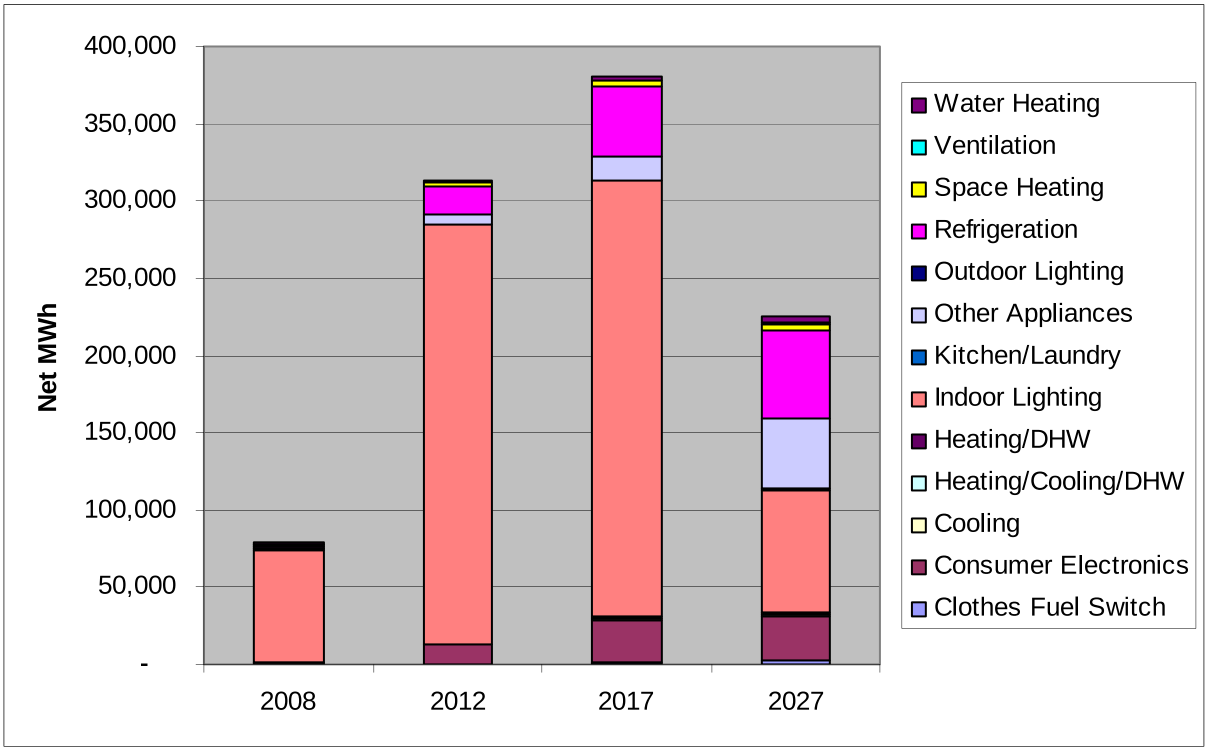
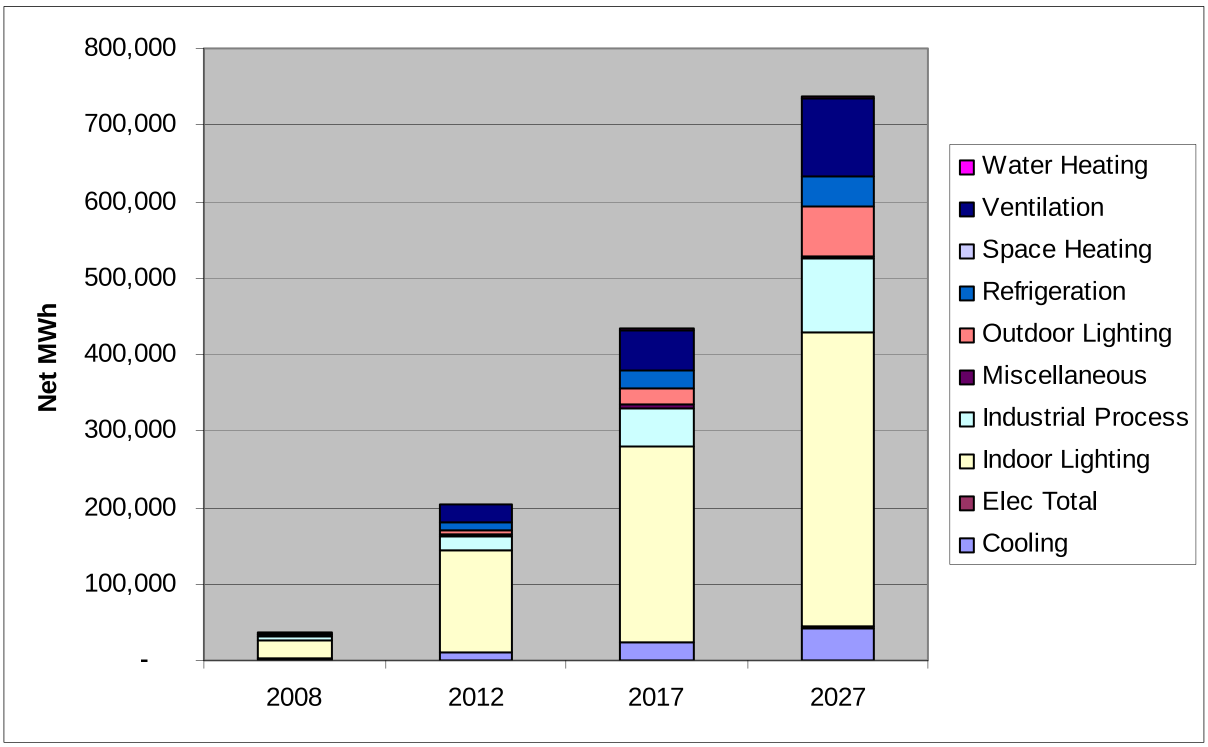


Table 34. C & I cumulative energy (MWh) saved, by end use

End Use	2008	2012	2017	2027
Cooling	4.4%	4.7%	5.3%	5.5%
Electricity Total	0.3%	0.3%	0.3%	0.4%
Indoor Lighting	67.7%	64.7%	58.7%	52.4%
Industrial Process	9.3%	9.9%	11.9%	12.9%
Miscellaneous	0.2%	0.5%	0.7%	0.6%
Outdoor Lighting	2.4%	3.6%	5.1%	8.9%
Refrigeration	3.9%	4.4%	5.1%	5.1%
Space Heating	0.2%	0.2%	0.2%	0.2%
Ventilation	11.0%	11.2%	12.1%	13.6%
Water Heating	0.7%	0.6%	0.6%	0.3%

Figure 28. C & I cumulative energy (MWh) saved, by end use



c) Summer peak – Part A (incremental savings)

Table 35. Residential incremental summer peak energy (MW) saved, by end use

End Use	2008	2012	2017	2027
Clothes Fuel Switch	0.3%	0.2%	0.3%	0.7%
Consumer Electronics	2.2%	23.4%	42.6%	53.8%
Cooling	2.4%	2.1%	2.7%	3.3%
Heating/Cooling/DHW	2.2%	1.4%	2.5%	2.1%
Heating/DHW	0.0%	0.0%	0.0%	0.0%
Indoor Lighting	86.0%	58.9%	35.6%	5.1%
Kitchen/Laundry	0.1%	0.1%	0.2%	0.4%
Other Appliances	2.4%	1.7%	2.8%	13.5%
Outdoor Lighting	0.0%	0.1%	0.1%	1.3%
Refrigeration	1.4%	11.4%	12.3%	18.4%
Space Heating	1.9%	0.4%	0.4%	0.5%
Ventilation	0.0%	0.0%	0.1%	0.3%
Water Heating	1.1%	0.3%	0.4%	0.6%

Figure 29. Residential incremental summer peak energy (MW) saved by end use

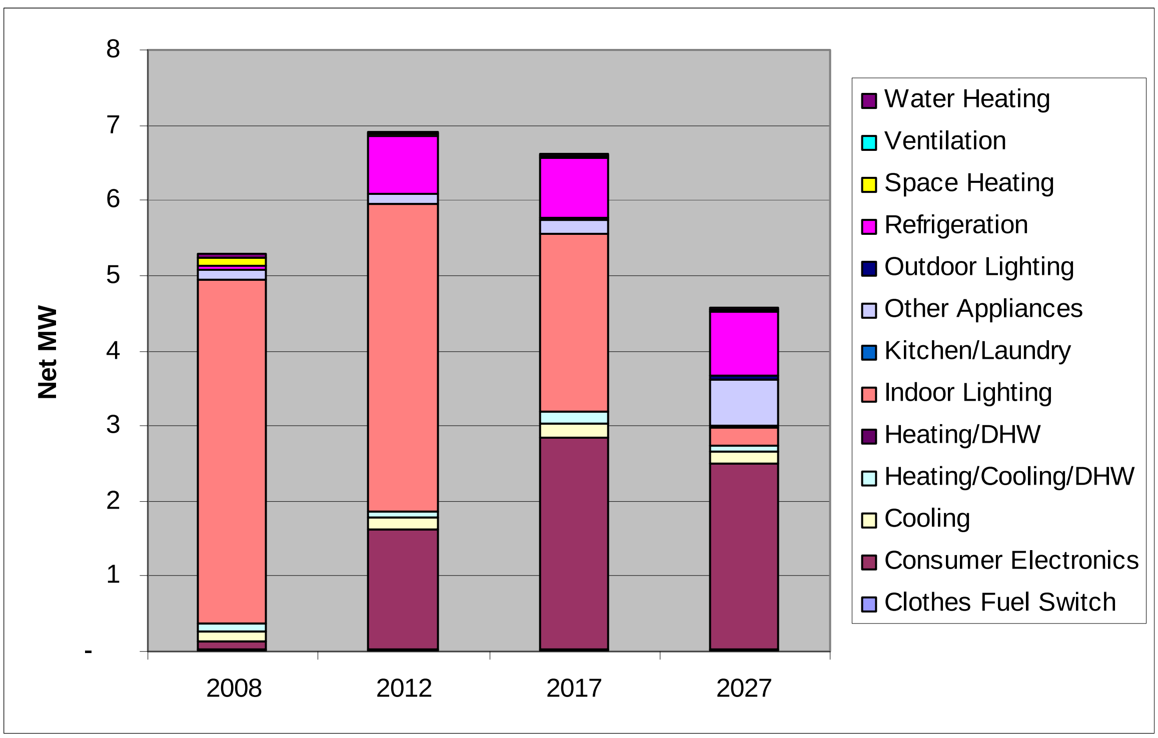
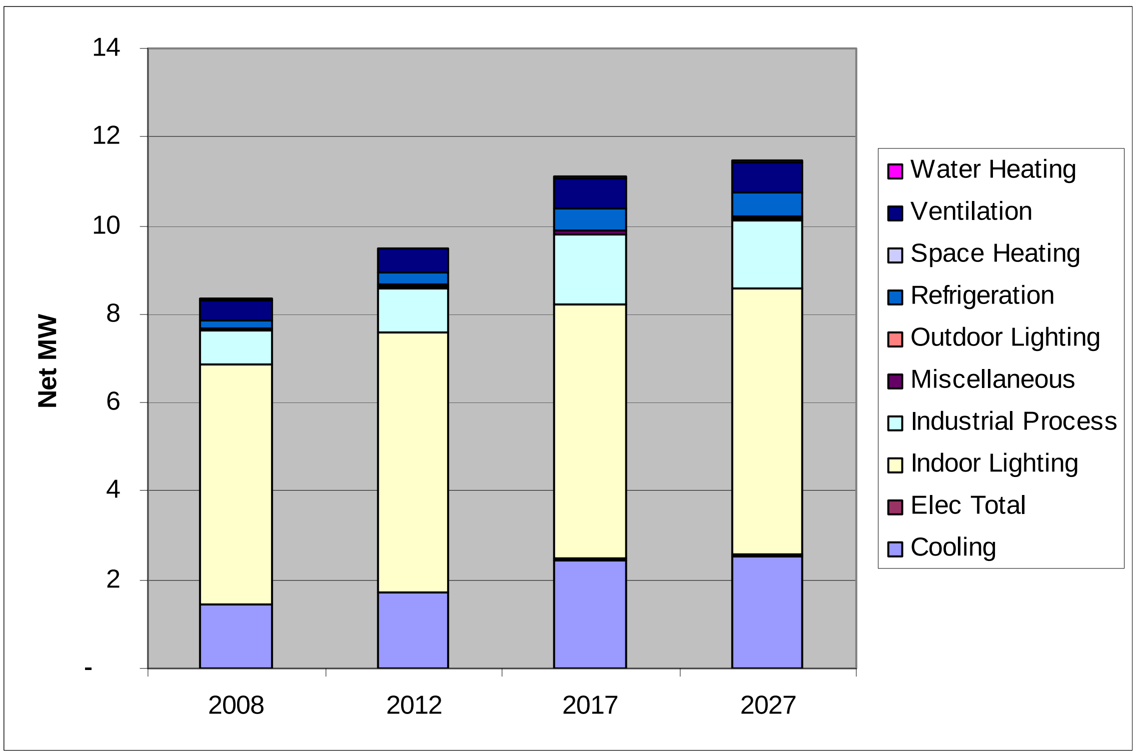


Table 36. Commercial and industrial incremental summer peak energy (MW) saved, by end use

End Use	2008	2012	2017	2027
Cooling	17.2%	17.9%	21.8%	22.1%
Electricity Total	0.3%	0.3%	0.4%	0.5%
Indoor Lighting	64.5%	61.4%	51.9%	52.5%
Industrial Process	9.6%	10.8%	13.9%	13.0%
Miscellaneous	0.1%	0.5%	0.9%	0.6%
Outdoor Lighting	0.1%	0.2%	0.3%	0.4%
Refrigeration	2.6%	3.1%	4.2%	4.6%
Space Heating	0.0%	0.0%	0.0%	0.0%
Ventilation	5.3%	5.3%	6.4%	6.1%
Water Heating	0.4%	0.3%	0.3%	0.2%

Figure 30. Commercial and industrial incremental summer peak energy (MW) saved, by end use



d) Summer peak - Part B (cumulative savings)

Table 37. Residential cumulative summer peak energy (MW) saved, by end use

End Use	2008	2012	2017	2027
Clothes Fuel Switch	0.3%	0.3%	0.4%	1.0%
Consumer Electronics	2.2%	13.3%	22.9%	32.3%
Cooling	2.4%	2.5%	3.2%	7.5%
Heating/Cooling/DHW	2.2%	2.3%	2.8%	8.1%
Heating/DHW	0.0%	0.0%	0.0%	0.0%
Indoor Lighting	86.0%	69.8%	53.8%	9.2%
Kitchen/Laundry	0.1%	0.1%	0.2%	0.6%
Other Appliances	2.4%	2.1%	3.0%	15.9%
Outdoor Lighting	0.0%	0.0%	0.1%	0.5%
Refrigeration	1.4%	8.3%	12.4%	22.2%
Space Heating	1.9%	0.7%	0.7%	1.4%
Ventilation	0.0%	0.0%	0.1%	0.3%
Water Heating	1.1%	0.4%	0.5%	1.0%

Figure 31. Residential cumulative summer peak energy (MW) saved, by end use

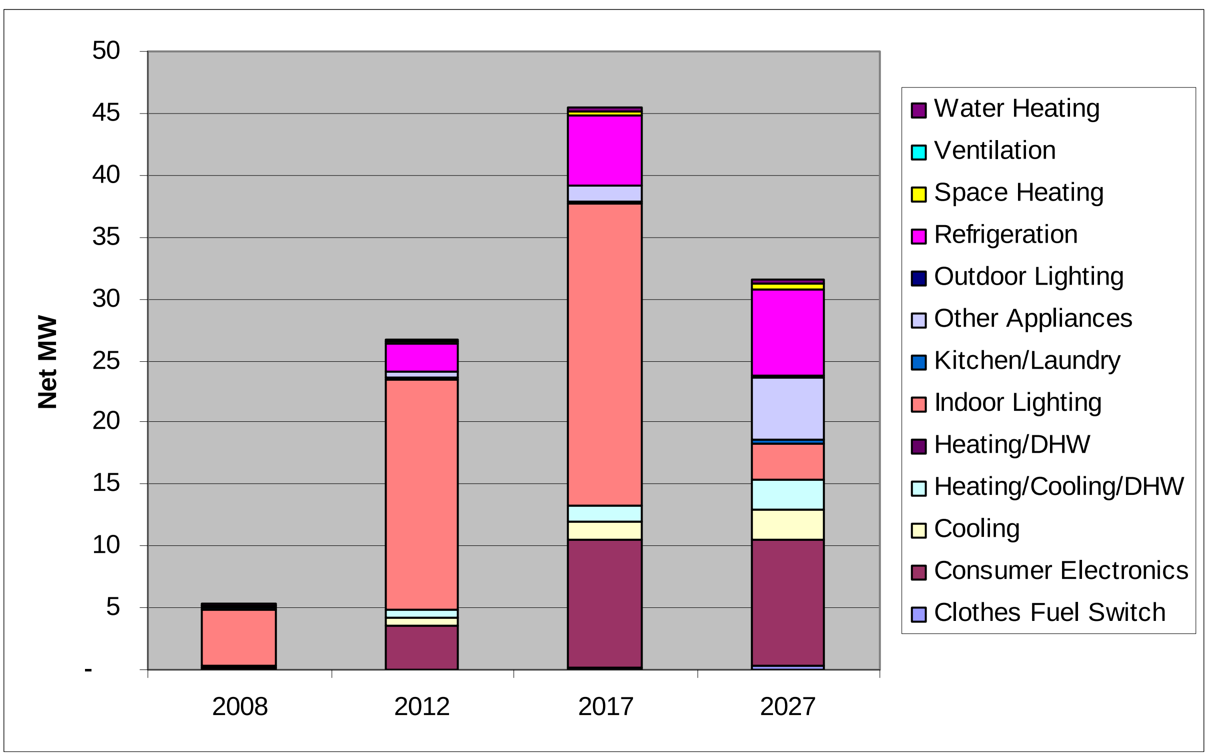
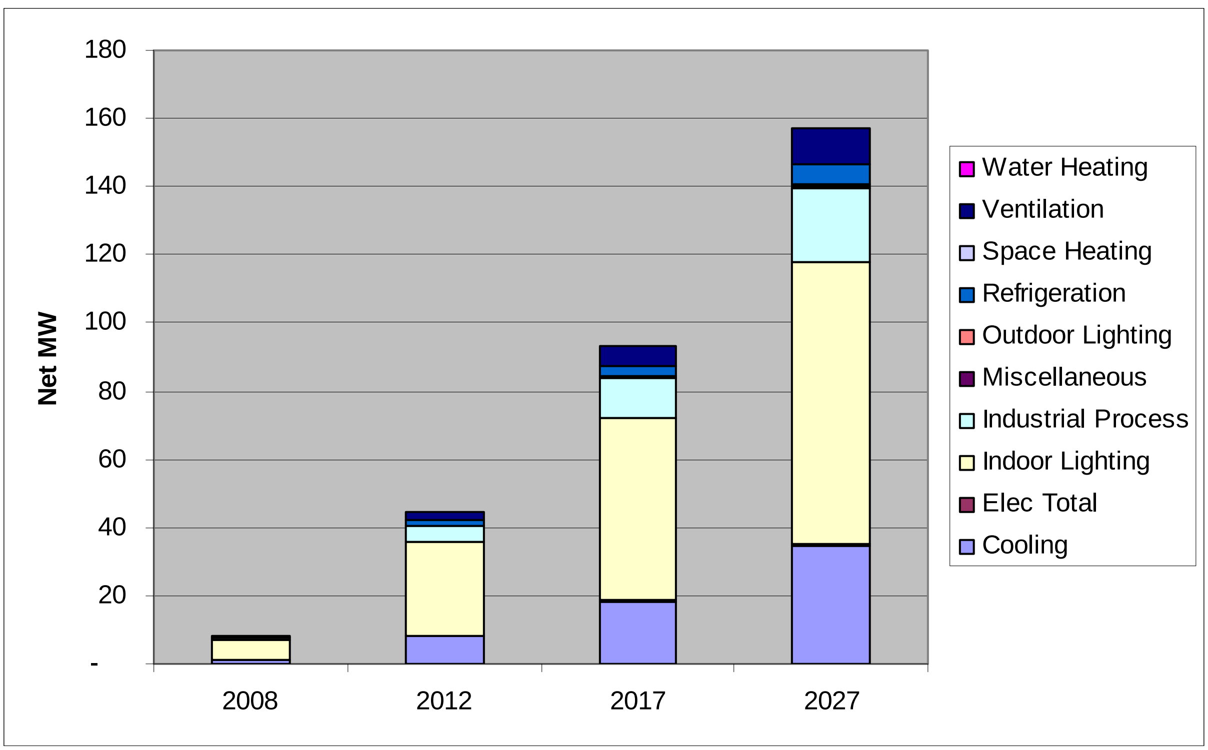


Table 38. Commercial and industrial cumulative summer peak energy (MW) saved, by end use

End Use	2008	2012	2017	2027
Cooling	17.2%	17.8%	19.5%	21.9%
Electricity Total	0.3%	0.3%	0.3%	0.4%
Indoor Lighting	64.5%	62.3%	57.2%	52.7%
Industrial Process	9.6%	10.4%	12.6%	13.8%
Miscellaneous	0.1%	0.3%	0.5%	0.4%
Outdoor Lighting	0.1%	0.2%	0.2%	0.4%
Refrigeration	2.6%	3.0%	3.4%	3.5%
Space Heating	0.0%	0.0%	0.0%	0.0%
Ventilation	5.3%	5.4%	5.9%	6.7%
Water Heating	0.4%	0.4%	0.4%	0.2%

Figure 32. Commercial and industrial cumulative summer peak energy (MW) saved, by end use



e) Winter peak – Part A (incremental savings)

Table 39. Residential incremental winter peak energy (MW) saved, by end use

End Use	2008	2012	2017	2027
Clothes Fuel Switch	0.1%	0.1%	0.2%	0.5%
Consumer Electronics	0.6%	11.9%	26.4%	43.6%
Cooling	0.0%	0.0%	0.0%	0.0%
Heating/Cooling/DHW	0.2%	0.1%	0.3%	0.3%
Heating/DHW	0.2%	0.1%	0.2%	0.3%
Indoor Lighting	95.2%	80.1%	61.1%	11.1%
Kitchen/Laundry	0.0%	0.0%	0.1%	0.3%
Other Appliances	0.8%	2.6%	4.2%	16.6%
Outdoor Lighting	0.0%	0.5%	1.3%	15.1%
Refrigeration	0.4%	4.1%	5.6%	10.7%
Space Heating	1.8%	0.2%	0.2%	0.5%
Ventilation	0.0%	0.0%	0.0%	0.2%
Water Heating	0.6%	0.2%	0.3%	0.8%

Figure 33. Residential incremental winter peak energy (MW) saved, by end use

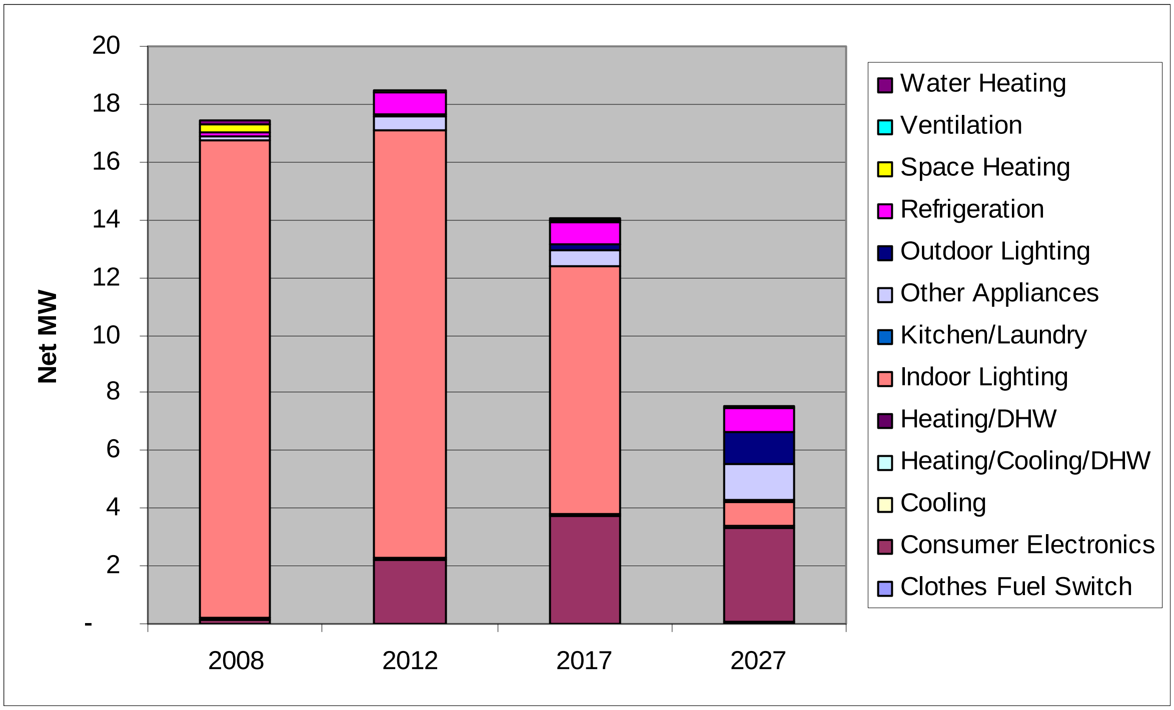
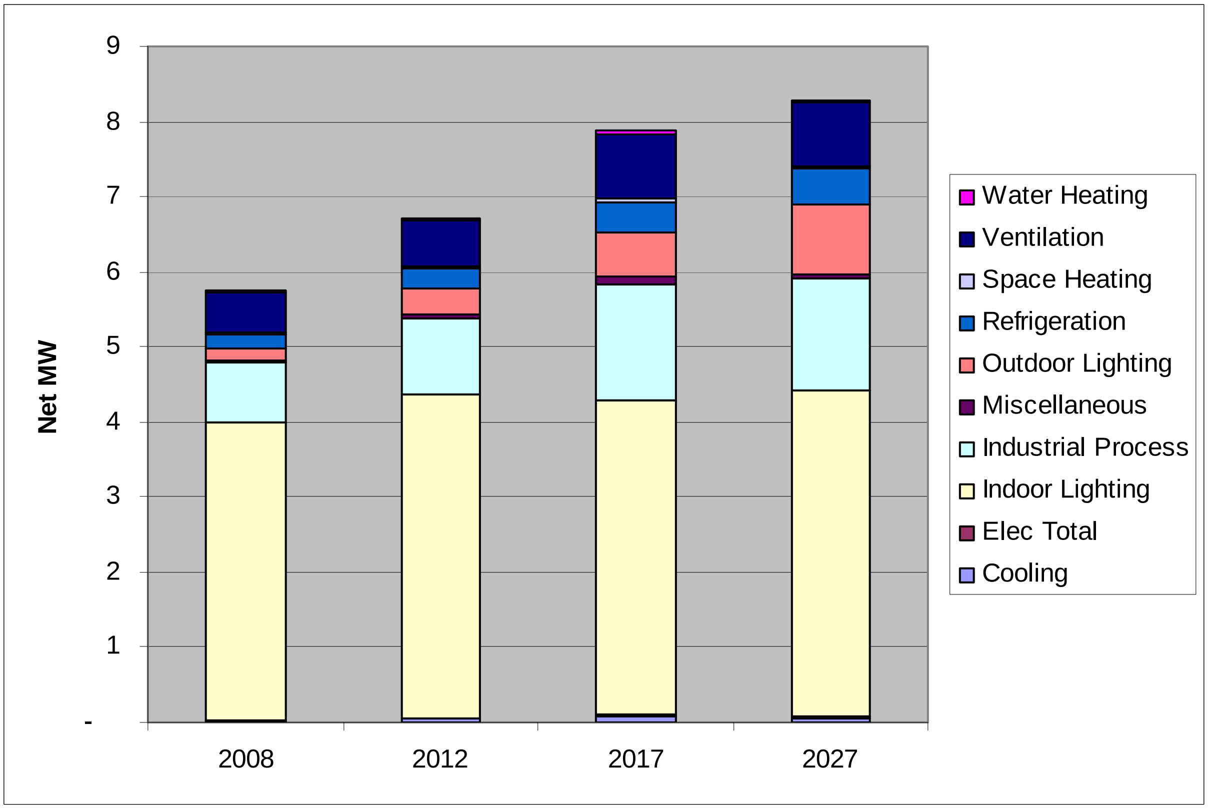


Table 40. Commercial and industrial incremental winter peak energy (MW) saved, by end use

End Use	2008	2012	2017	2027
Cooling	0.3%	0.6%	1.0%	0.7%
Electricity Total	0.2%	0.2%	0.3%	0.3%
Indoor Lighting	68.9%	64.0%	53.2%	52.2%
Industrial Process	13.9%	15.3%	19.6%	18.1%
Miscellaneous	0.1%	0.6%	1.2%	0.8%
Outdoor Lighting	3.0%	5.2%	7.4%	11.2%
Refrigeration	3.2%	3.9%	5.2%	5.6%
Space Heating	0.5%	0.5%	0.6%	0.6%
Ventilation	9.1%	9.1%	10.9%	10.2%
Water Heating	0.8%	0.6%	0.6%	0.3%

Figure 34. Commercial and industrial incremental winter peak energy (MW) saved, by end use



f) Winter peak – Part B (cumulative savings)

Table 41. Residential cumulative winter peak energy (MW) saved, by end use

End Use	2008	2012	2017	2027
Clothes Fuel Switch	0.1%	0.1%	0.2%	0.9%
Consumer Electronics	0.6%	6.0%	11.8%	28.2%
Cooling	0.0%	0.0%	0.0%	0.0%
Heating/Cooling/DHW	0.2%	0.2%	0.3%	1.3%
Heating/DHW	0.2%	0.2%	0.3%	1.2%
Indoor Lighting	95.2%	87.5%	77.6%	22.3%
Kitchen/Laundry	0.0%	0.1%	0.1%	0.6%
Other Appliances	0.8%	2.0%	3.7%	22.1%
Outdoor Lighting	0.0%	0.2%	0.4%	6.1%
Refrigeration	0.4%	2.8%	4.7%	14.2%
Space Heating	1.8%	0.5%	0.5%	1.7%
Ventilation	0.0%	0.0%	0.0%	0.2%
Water Heating	0.6%	0.3%	0.4%	1.2%

Figure 35. Residential cumulative winter peak energy (MW) saved, by end use

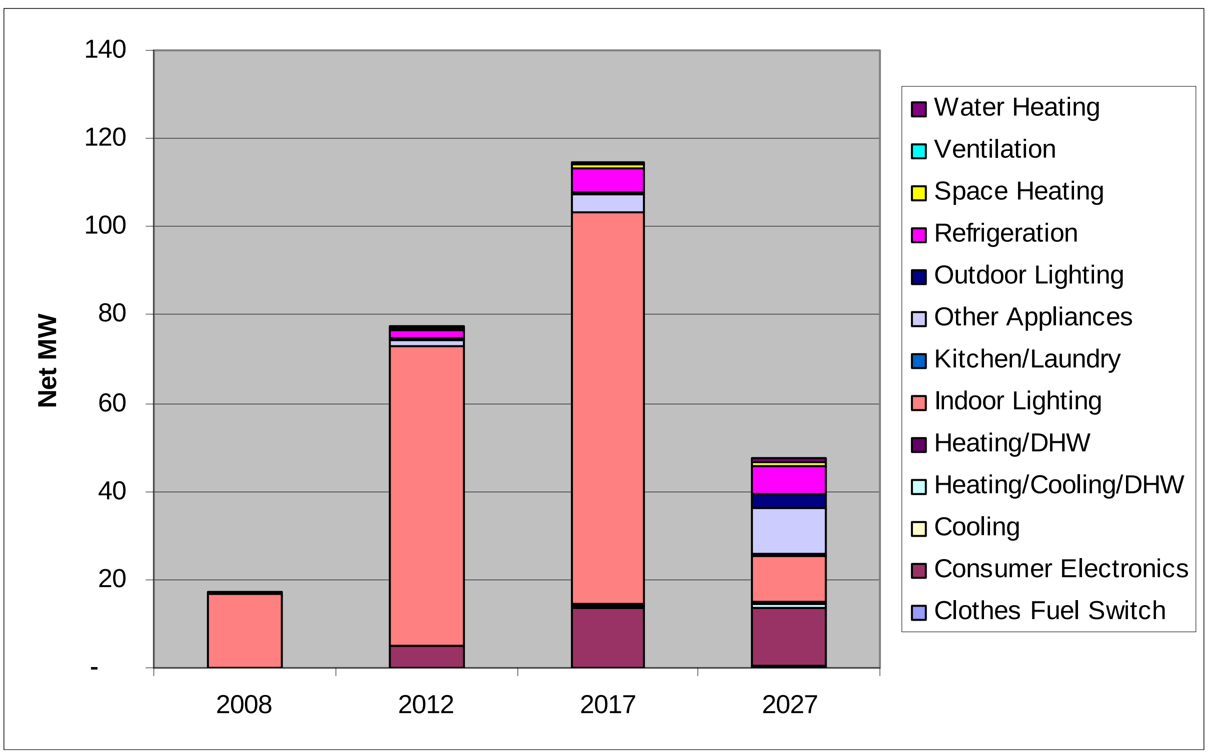
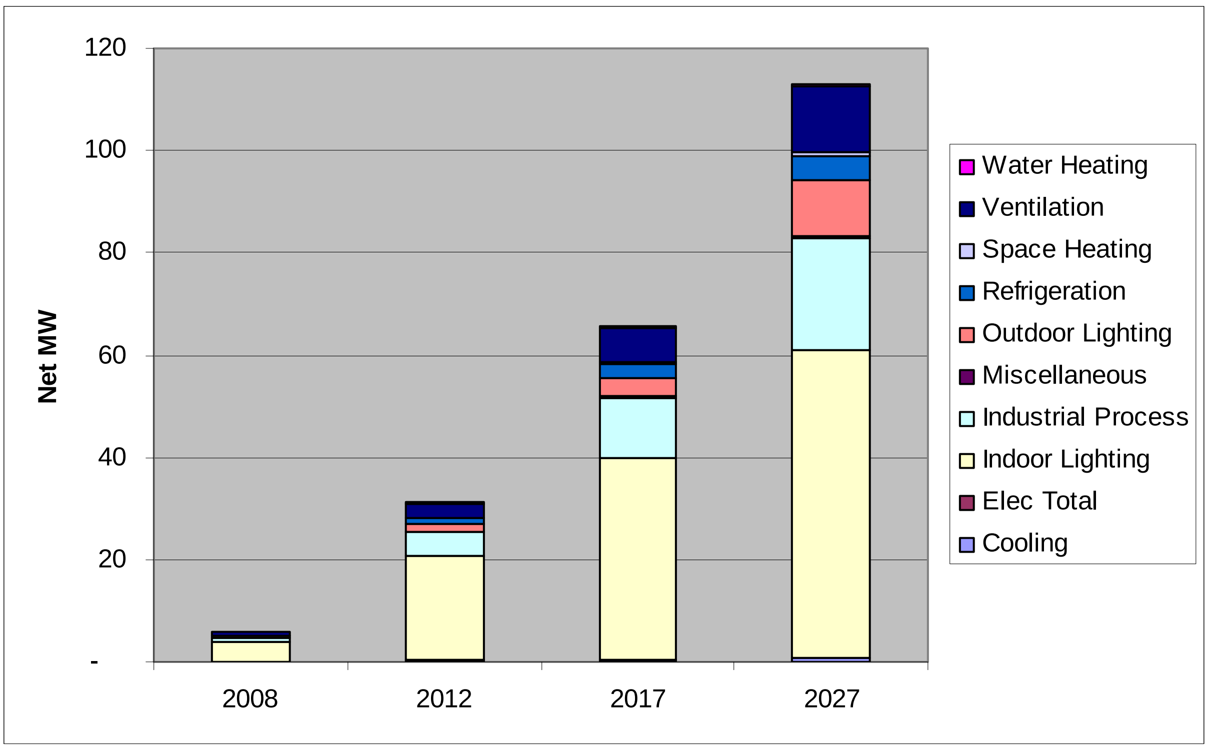


Table 42. Commercial and industrial cumulative winter peak energy (MW) saved, by end use

End Use	2008	2012	2017	2027
Cooling	0.3%	0.5%	0.6%	0.5%
Electricity Total	0.2%	0.2%	0.2%	0.3%
Indoor Lighting	68.9%	65.6%	59.8%	53.3%
Industrial Process	13.9%	14.9%	18.0%	19.3%
Miscellaneous	0.1%	0.3%	0.6%	0.5%
Outdoor Lighting	3.0%	4.4%	5.2%	9.5%
Refrigeration	3.2%	3.7%	4.2%	4.2%
Space Heating	0.5%	0.5%	0.5%	0.6%
Ventilation	9.1%	9.3%	10.1%	11.4%
Water Heating	0.8%	0.7%	0.7%	0.4%

Figure 36. Commercial and industrial cumulative winter peak energy (MW) saved, by end use



The foregoing tables and figures show that the amount of energy efficiency savings are subject to diminishing marginal investment returns the farther into the future the forecast extends. This is especially true in the residential sector, where opportunities for electricity savings per customer decline more rapidly than for commercial / industrial customers. They also indicate how the changes in composition of savings reinforce this trend. Lighting energy savings have always been the largest source of efficiency savings in the EEU portfolio, again particularly in the residential sector in the past five years. The end-use breakdowns show how dramatically this will change in the future. The downward trend in peak demand savings is less pronounced in the long term due to the relative increase in the proportion of savings from end-uses other than residential lighting.

3. Program and portfolio economic analysis

Table 43 decomposes the electricity benefits by program between energy and capacity. **Table 44** provides a breakdown of the portfolio costs by program by category.

Table 43. Electricity benefits by program and by category from continued efficiency investment through 2027

Present value (2009$)	Capacity		Energy					End-Use				
	Generation							Fossil Fuels				
Program Name	Summer Generating Capacity	T&D Capacity	Winter Peak Energy	Winter Off-Peak Energy	Summer On-Peak	Summer Off-Peak	Electric Extern-alities	Natural Gas	Non-Natural Gas	Extern-alities	Water Savings	Societal Benefits
Residential New Construction	$4,386,842	$6,193,918	$4,378,983	$2,877,785	$2,123,032	$1,379,493	$1,161,861	$11,709,539	$63,138,456	$4,552,092	$2,951,149	$104,853,149
Retail Products	$44,683,148	$103,771,010	$133,862,942	$87,340,552	$59,471,285	$40,253,012	$36,135,989	$521,008	$3,795,917	$293,369	$64,821,916	$574,950,149
Existing Homes	$2,705,790	$6,965,306	$7,080,158	$4,742,284	$2,361,369	$1,560,387	$1,776,514	$8,099	$3,667,621	$440,378	$2,146,062	$33,453,969
Commercial New Construction	$39,236,676	$48,026,986	$59,005,557	$22,093,664	$38,829,715	$11,744,205	$13,148,111	$1,080,275	$7,483,898	$793,957	$88,670	$241,531,715
Commercial Efficient Equipment	$53,276,569	$66,725,661	$89,028,388	$22,395,172	$55,568,487	$12,183,361	$17,632,944	$1,138,741	$7,898,364	$841,484	$120,589	$326,809,760
Commercial Retrofit	$65,035,782	$85,837,537	$111,378,216	$42,485,008	$68,064,260	$21,417,672	$25,354,216	$2,087,720	$14,370,846	$1,515,766	$53,578	$437,600,601
Portfolio Total	$209,324,808	$317,520,417	$404,734,245	$181,934,464	$226,418,149	$88,538,129	$95,209,635	$16,545,383	$100,355,102	$8,437,046	$70,181,965	$1,719,199,343

Table 44. Resource costs by program and by category from continued efficiency investment through 2027

Present value (2009$)	Total Measure Costs								Incentive Contributions		Non-Measure Costs
Program Name	Incremental Installed Cost (full cost for retrofit)	O&M Cost	Fossil Fuel Cost	Fossil Fuel Externalities	Retrofit Deferred Replacement Credit	Risk Discount	Total Measure Cost	Natural Gas Fuel Cost	Efficiency Utility	Participant Contribution	Non-Measure Efficiency Utility
Residential New Construction	$32,388,702	-$627,628	$1,416,703	$75,872	$0	-$3,380,540	$29,873,108	$206,936	$4,090,771	$28,297,930	$20,612,093
Retail Products	$96,066,271	-$140,586,075	$0	$0	$0	-$9,606,627	-$54,126,432	$0	$37,977,818	$58,088,453	$16,757,990
Existing Homes	$17,008,306	-$1,052,664	$1,983,770	$204,752	-$3,898,585	-$1,899,208	$12,346,372	$1,983,770	$13,854,402	$3,153,904	$12,120,589
Commercial New Construction	$32,132,542	-$7,148,097	$17,299,518	$1,589,475	$0	-$5,056,414	$38,817,024	$2,183,744	$10,873,095	$21,259,447	$13,685,639
Commercial Efficient Equipment	$35,615,754	-$8,150,542	$22,668,925	$2,081,111	$0	-$5,963,707	$46,251,541	$2,860,879	$18,304,671	$17,311,083	$21,110,595
Commercial Retrofit	$115,055,781	-$22,723,180	$30,035,736	$2,893,116	-$13,629,468	-$14,717,463	$96,914,521	$3,768,808	$78,900,442	$36,155,339	$65,476,585
EVT Core Supporting Services											$98,298,594
Portfolio Total	**$328,267,354**	**-$180,288,186**	**$73,404,653**	**$6,844,326**	**-$17,528,053**	**-$40,623,960**	**$170,076,134**	**$11,004,138**	**$164,001,199**	**$164,266,155**	**$248,062,085**

4. Statewide 90 / 10 Summer Peak Demand Forecast

The combination of the pessimistic assumptions developed and applied in **Section III** about future energy and peak demand yield from continued EEU investment result in a substantially reduced forecast of summer peak demand savings, compared to the forecasted expected values in the reference case. Compared with the 50 / 50 summer peak demand savings forecast of 202 MW, this study produces a peak demand forecast of only 87 MW. The study's authors believe there is a 90% probability that actual outcomes will equal or surpass these predicted values in **Table 5** in **Section I.**

B. Sensitivity Analysis Results

As expected, the program benefits and benefit / cost ratios vary considerably under the two scenarios involving higher and lower avoided costs, as described in **Section III.** However, while the monetized benefits vary considerably, the changes in avoided costs caused only a few additional measures to pass or fail cost-effectiveness. Thus, the savings and costs vary only slightly from the reference case.

For the low avoided cost scenario, only two residential measures failed that had passed for the reference case: "SSL lamp, 2009" and "Hot water pipe wrap." Several commercial measures failed that had passed for the reference case, though these accounted for a small portion of total peak demand reduction. Commercial measures that failed because of the lower avoided casts include:

- Ground source heat pump in five building types
- High-efficiency air conditioning, CEE Tier I and Tier II (retrofit) in two building types
- Energy Management Systems (EMS) and controls (retrofit) in three building types
- Water heat fuel switch (retrofit) in four building types
- Integrated Building Design—Tier II in 4 building types

For the high avoided cost scenario, there were no additional residential measures that passed relative to the reference case. For the commercial measures, several additional measures passed, including:

- Ground source heat pumps, in all building types
- EMS / controls (retrofit), in a majority of building types
- High-efficiency residential-sized refrigerator (market-driven)
- High-efficiency display coolers (retrofit)
- Booster water heat in dishwashing, in a majority of building types

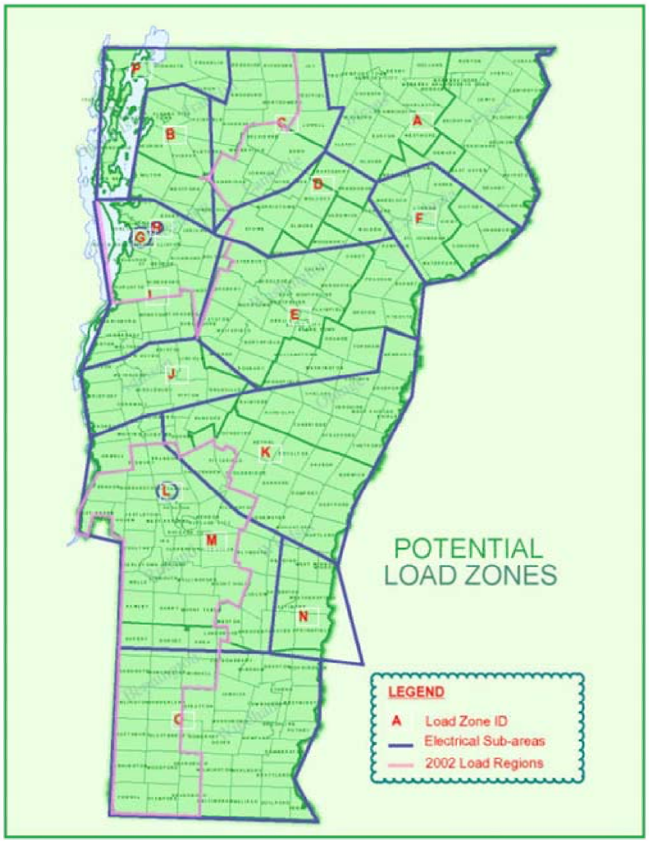
C. Zonal Analysis Results

The following tables present results from analyses of the 90/10 summer peak forecasts, using projected data from VELCO and showing adjusted forecasts, net of future demand-side management. The following zones are analyzed:

- Southern
- Ascutney
- Rutland
- Florence
- Central
- Middlebury
- Burlington (GMP territory)
- Burlington (BED territory)
- IBM
- Johnson
- Morrisville
- Montpelier
- St. Johnsbury
- St. Albans
- Highgate
- Newport

They are shown graphically in **Figure 37.**

Figure 37. Vermont's potential load zones



A	Newport
B	St. Albans
C	Johnson
D	Morrisville
E	Montpelier
F	St. Johnsbury
G	BED
H	IBM
I	Chittenden\Addison GMP
J	Middlebury
K	Central - Barnard
L	Proctor (Florence)
M	Rutland
N	Ascutney
O	Southern
P	Highgate

Table 45. Southern zone summer peak

Southern Zone Summer Peak Forecast (MW)

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	139	139	2	138
2009	142	142	3	140
2010	143	145	4	141
2011	145	147	5	142
2012	147	150	6	144
2013	148	151	7	144
2014	149	153	7	145
2015	150	155	8	147
2016	152	157	9	148
2017	154	160	9	150
2018	156	163	10	153
2019	158	166	10	156
2020	160	168	11	158
2021	162	171	11	160
2022	164	175	12	163
2023	167	178	11	166
2024	169	181	11	170
2025	171	185	11	174
2026	174	188	11	177
2027	176	192	11	180

Table 46. Ascutney zone summer peak

Ascutney Zone Summer Peak Forecast (MW)

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	78	78	0	78
2009	79	80	1	79
2010	80	81	1	80
2011	81	82	1	81
2012	82	83	1	82
2013	82	84	1	83
2014	83	85	2	83
2015	84	86	2	84
2016	84	87	2	85
2017	85	88	2	86
2018	86	90	2	88
2019	87	91	2	89
2020	88	92	2	90
2021	89	94	2	92
2022	90	95	2	93
2023	91	97	2	95
2024	92	98	2	96
2025	93	100	2	98
2026	94	102	2	99
2027	95	103	2	101

Table 47. Rutland zone summer peak

Rutland Zone Summer Peak Forecast (MW)

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	111	112	1	110
2009	113	114	2	112
2010	115	116	3	113
2011	116	118	4	114
2012	118	120	5	115
2013	118	121	5	116
2014	119	122	6	117
2015	120	124	6	118
2016	122	126	7	119
2017	123	128	7	121
2018	125	130	7	123
2019	126	132	8	125
2020	128	135	8	126
2021	129	137	8	129
2022	131	139	9	131
2023	133	142	9	133
2024	135	145	9	136
2025	137	147	8	139
2026	139	150	8	142
2027	141	153	9	144

Table 48. Florence zone summer peak

Florence Zone Summer Peak Forecast (MW)

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	31	31	0	31
2009	31	31	0	31
2010	32	32	0	32
2011	32	32	0	32
2012	32	33	0	33
2013	32	33	0	33
2014	33	33	0	33
2015	33	34	0	34
2016	33	34	0	34
2017	33	35	0	35
2018	34	35	0	35
2019	34	36	0	36
2020	34	36	0	36
2021	35	37	0	37
2022	35	37	0	37
2023	35	38	0	38
2024	36	38	0	38
2025	36	39	0	39
2026	37	40	0	40
2027	37	40	0	40

Table 49. Central zone summer peak

Central Zone Summer Peak Forecast (MW)

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	70	70	1	69
2009	72	72	1	71
2010	73	73	2	72
2011	74	75	3	72
2012	74	76	3	73
2013	75	76	3	73
2014	75	77	4	74
2015	76	78	4	74
2016	77	79	4	75
2017	78	81	5	76
2018	79	82	5	77
2019	80	83	5	78
2020	80	85	5	79
2021	81	86	5	81
2022	82	88	5	82
2023	83	89	5	84
2024	84	91	5	85
2025	86	92	5	87
2026	87	94	5	89
2027	88	95	5	90

Table 50. Middlebury zone summer peak

Middlebury Zone Summer Peak Forecast (MW)

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	41	41	0	40
2009	41	42	1	41
2010	42	42	1	41
2011	42	43	1	42
2012	43	44	1	42
2013	43	44	2	42
2014	43	44	2	43
2015	44	45	2	43
2016	44	46	2	43
2017	45	46	2	44
2018	45	47	2	45
2019	46	48	2	45
2020	46	49	3	46
2021	47	49	3	47
2022	47	50	3	47
2023	48	51	3	48
2024	48	52	3	49
2025	49	53	3	50
2026	50	54	3	51
2027	50	55	3	52

Table 51. Burlington zone (GMP service territory) summer peak

Burlington (GMP) Zone Summer Peak Forecast (MW)

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	185	185	2	183
2009	187	189	3	186
2010	189	191	4	187
2011	192	194	6	189
2012	193	197	7	190
2013	194	199	7	191
2014	196	201	8	193
2015	197	203	9	194
2016	199	206	10	196
2017	201	209	10	198
2018	203	212	11	201
2019	206	216	11	204
2020	207	218	12	206
2021	210	222	13	209
2022	212	225	13	212
2023	214	229	13	216
2024	217	233	13	219
2025	220	237	13	224
2026	222	240	13	227
2027	225	244	13	231

Table 52. Burlington (BED service territory) summer peak

BED Zone Summer Peak Forecast (MW)

Year	VELCO Forecast	BED Forecast	Future DSM	BED Forecast Net of Future DSM
2008	73	79	1	78
2009	74	80	2	78
2010	75	81	2	78
2011	75	82	3	78
2012	76	82	4	77
2013	76	83	5	77
2014	77	83	6	77
2015	78	84	7	77
2016	78	85	8	77
2017	79	86	8	77
2018	80	86	9	77
2019	81	86	10	76
2020	81	87	11	76
2021	82	88	11	77
2022	83	89	12	77
2023	84	90	13	77
2024	85	90	13	76
2025	86	90	14	76
2026	87	91	15	76
2027	88	92	15	76

Table 53. IBM zone summer peak

IBM Zone Summer Peak Forecast (MW)

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	72	72	0	71
2009	72	73	1	72
2010	73	73	1	72
2011	73	74	2	73
2012	73	75	2	73
2013	74	75	2	74
2014	74	76	2	74
2015	74	77	2	74
2016	74	77	3	74
2017	75	78	3	75
2018	75	78	3	75
2019	75	79	3	76
2020	76	80	4	76
2021	76	80	4	76
2022	76	81	4	77
2023	76	82	4	77
2024	76	82	4	78
2025	77	83	4	78
2026	77	83	4	79
2027	77	84	5	79

Table 54. Johnson zone summer peak

Johnson Zone Summer Peak Forecast (MW)

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	16	16	1	16
2009	17	17	1	16
2010	17	17	1	16
2011	17	17	2	16
2012	17	18	2	16
2013	17	18	2	16
2014	18	18	2	16
2015	18	18	2	16
2016	18	19	3	16
2017	18	19	3	16
2018	18	19	3	16
2019	19	20	3	16
2020	19	20	3	17
2021	19	20	4	17
2022	19	21	4	17
2023	20	21	4	17
2024	20	21	4	18
2025	20	22	4	18
2026	21	22	4	19
2027	21	23	4	19

Table 55. Morrisville zone summer peak

Morrisville Zone Summer Peak Forecast (MW)

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	40	40	0	39
2009	40	41	0	40
2010	41	41	1	41
2011	41	42	1	41
2012	42	43	1	41
2013	42	43	1	42
2014	42	43	1	42
2015	43	44	2	42
2016	43	45	2	43
2017	44	45	2	44
2018	44	46	2	44
2019	45	47	2	45
2020	45	48	2	46
2021	46	48	2	46
2022	46	49	2	47
2023	47	50	2	48
2024	47	51	2	49
2025	48	52	2	50
2026	49	53	2	51
2027	49	54	2	52

Table 56. Montpelier zone summer peak

Montpelier Zone Summer Peak Forecast (MW)

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	116	116	1	115
2009	118	119	2	117
2010	119	121	3	118
2011	121	123	3	119
2012	122	124	4	121
2013	123	125	4	121
2014	124	127	5	122
2015	125	129	5	123
2016	126	130	6	125
2017	128	132	6	126
2018	129	135	6	128
2019	131	137	6	131
2020	132	139	7	132
2021	134	142	7	134
2022	135	144	7	137
2023	137	147	7	139
2024	139	149	7	142
2025	141	152	7	145
2026	143	155	7	148
2027	145	157	7	150

Table 57. St. Johnsbury zone summer peak

St. Johnsbury Zone Summer Peak Forecast (MW)

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	32	32	0	32
2009	33	33	1	32
2010	33	34	1	33
2011	34	34	1	33
2012	34	35	1	33
2013	34	35	1	33
2014	34	35	2	34
2015	35	36	2	34
2016	35	36	2	34
2017	35	37	2	35
2018	36	37	2	35
2019	36	38	2	36
2020	37	39	2	36
2021	37	39	2	37
2022	37	40	2	38
2023	38	41	2	38
2024	38	41	2	39
2025	39	42	2	40
2026	39	43	2	40
2027	40	43	2	41

Table 58. St. Albans zone summer peak

St. Albans Zone Summer Peak Forecast (MW)

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	66	66	1	65
2009	67	67	1	66
2010	68	68	2	67
2011	68	69	2	67
2012	69	70	2	68
2013	69	71	3	68
2014	70	72	3	69
2015	70	73	3	69
2016	71	73	4	70
2017	72	75	4	71
2018	73	76	4	72
2019	73	77	4	73
2020	74	78	4	74
2021	75	79	5	75
2022	76	81	5	76
2023	77	82	5	77
2024	77	83	5	78
2025	78	85	5	80
2026	79	86	5	81
2027	80	87	5	82

Table 59. Highgate zone summer peak

Highgate Zone Summer Peak Forecast (MW)

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	46	46	0	45
2009	46	47	1	46
2010	47	47	1	46
2011	47	48	1	47
2012	48	49	1	47
2013	48	49	2	48
2014	48	50	2	48
2015	49	50	2	48
2016	49	51	2	49
2017	50	52	2	49
2018	50	52	2	50
2019	51	53	2	51
2020	51	54	2	51
2021	52	55	3	52
2022	52	56	3	53
2023	53	56	3	54
2024	53	57	3	55
2025	54	58	3	56
2026	55	59	3	56
2027	55	60	3	57

Table 60. Newport zone summer peak

Newport Zone Summer Peak Forecast (MW)

Year	VELCO Forecast	Adjusted VELCO Forecast	Future DSM	Adjusted Forecast Net of Future DSM
2008	36	36	0	36
2009	37	37	1	36
2010	37	38	1	37
2011	38	38	1	37
2012	38	39	2	37
2013	38	39	2	37
2014	39	40	2	38
2015	39	40	2	38
2016	39	41	2	38
2017	40	41	2	39
2018	40	42	3	40
2019	41	43	3	40
2020	41	44	3	41
2021	42	44	3	42
2022	43	45	3	42
2023	43	46	3	43
2024	44	47	3	44
2025	44	48	3	45
2026	45	49	3	46
2027	46	50	3	47

VI. CONCLUSIONS AND RECOMMENDATIONS

A. Future Electricity Savings from Continued Statewide Investment in the Energy Efficiency Utility

The size, shape, and composition of the demand-side resources provided by continuing Vermont's investment in EEU services at approximately $31 million annually will change substantially over the next two decades. These changes parallel and reinforce the underlying changes overtaking efficiency markets, especially advances in federal efficiency standards and digital technology, which together will influence the efficiency of Vermont's capital stock of electricity-using products, appliances, equipment, and buildings as this capital stock turns over during the next twenty years.

Changes are most pronounced in the residential sector. The pace of annual energy savings declines steadily over the forecast period. Residential lighting savings shrink dramatically, with increased savings from other end uses such as consumer electronics and appliances falling far short of making up the difference. More than offsetting this decline in EEU lighting savings, however, is the study's estimated increase in standards- and market-driven market saturation of CFLs and penetration of SSL technology, which in turn slows growth in residential energy requirements driven by rising air-conditioning saturation. Directing relatively more of the portfolio budget to commercial and industrial efficiency investment generated higher annual energy and peak demand savings, which offsets most but not all of the predicted savings reductions in the residential sector.

While energy savings from future statewide efficiency investment decline significantly, the diminution in summer peak demand is less severe. This is because the shift in the composition of the efficiency measures and the end uses they address. In the residential sector in particular, the ratio of summer peak demand savings to annual energy savings increases substantially.

Most of the decline in total annual energy savings is predicted to occur in the second half of the forecast period, which naturally is subject to greater uncertainty as the underlying variables are more difficult to predict.

This study concludes that two load forecast adjustments are necessary to ensure compatibility of Forecast 20 efficiency investment savings estimates and VELCO's forecast energy requirements and summer and winter peak demand. The first adjustment is necessary the VELCO forecast methodology unintentionally includes future effects of past efficiency investments, and that such effects must be removed from the forecast prior to applying independent savings estimates to avoid double-counting. In developing estimates of future residential lighting savings, this study also discovered that baseline assumptions for household lighting energy requirements differed markedly from VELCO's forecast lighting energy intensity, increasingly so over time. To make the Forecast 20 residential efficiency investment savings compatible with the VELCO load forecast, this study developed and applied a further adjustment to the residential sales and peak load forecasts.

This study concludes that, for the first ten years of the forecast period, the amount of electricity savings to expect from exogenous investment will exceed the amount of endogenous savings implicit in the VELCO load forecast. With the notable exception of winter peak savings, the EEU energy and peak demand savings forecast by this study are almost completely offset by the study's adjustment for endogenous efficiency investment savings.

Forecast 20 developed alternative scenarios to explore the sensitivity of projected electricity savings. Upward or downward changes by as much as 25% did not have a large impact on cumulative annual savings over the 20-year forecast period.

The study used engineering methods to make point estimates of the amount of electricity savings to expect under a "50/50" scenario—that is, actual outcomes are expected have a 50 percent chance of equaling or exceeding the predicted values. This is compatible with VELCO's energy and peak-demand forecasts, as adjusted. The study also developed estimates with a much more stringent confidence level to be directly comparable with VELCO's 90/10 summer peak demand forecast: The predicted values are pessimistic enough that the likelihood is 90 percent that actual outcomes will equal or exceed the 90/10 predicted values for summer peak demand savings. Summer peak demand savings under the 90/10 scenario are 75% lower by the end of the forecast horizon compared with the 50/50 forecast.

The study's results also provide insight into the largest sources of additional cost-effective savings potential from additional investment beyond the assumed $31 million per year. **Section V** results indicate that the vast majority of savings will come from four major markets. Three of these comprise the entire commercial / industrial sector across the next five, ten, and especially twenty years.

The single largest source of further cost-effective savings from additional efficiency investment is the C&I retrofit market. Increasing participation in the lost-opportunity markets will yield relatively little potential, given the high market penetration rates and efficiency levels built into the Forecast 20 savings analysis. Achieving deeper savings and higher market penetration in the commercial retrofit market may cost significantly more because savings and penetration require more aggressive program strategies. Among these could possibly be free, direct installation of all cost-effective measures for participants in some market segments.

Acquiring additional cost-effective electricity savings in the residential sector during the second half of the forecast period will require a higher budget and a re-configuring of program designs. By 2018, the retail products program will no longer be a viable platform for acquiring additional savings. To offset steep decline in savings in this program during the second half of forecast period, it might be possible to intensify and accelerate electric efficiency retrofits by packaging them with a targeted campaign to all remaining heating efficiency opportunities. Pursuing additional savings from existing homes through a targeted retrofit strategy would be possible if Vermont committed by then to retrofit all remaining fossil-heated homes in the state by 2027. If that were to happen, the EEU could "piggy-back" the direct installation of whole-house lighting makeovers with the latest in CFL and SSL technology, early replacement of inefficient appliances and air conditioners, and household power management controls.

B. Applying Study Results to Load Forecasts

Following are step-by-step instructions for applying the savings estimates resulting from this study to summer peak demand forecasts.

Statewide 50 / 50 energy and peak demand savings forecast for any year from 2010 to 2027:

1. Start with the statewide energy or summer or winter peak demand forecast.

2. Subtract the BED peak demand forecast. The result is the non-BED statewide forecast, the basis for this study's endogenous efficiency adjustment and exogenous efficiency savings estimates.
3. Add the Forecast 20 endogenous efficiency adjustment. The result is the VELCO non-BED statewide forecast adjusted for the future savings from continuation of past efficiency investment implicit in the VELCO forecast.
4. Subtract the Forecast 20 estimate of non-BED savings. The result is the forecast non-BED statewide load net of future efficiency investment at currently planned budgets.
5. Add the BED load forecast net of BED's forecast of future savings from continued efficiency investment. The result is the statewide load forecast net of future savings from continued investment in energy efficiency.

Statewide or zonal 90/10 summer peak demand savings for any year from 2010 to 2027:

1. Start with the statewide or zonal peak demand forecast.
2. Calculate the ratio of the VELCO 50/50 summer peak demand forecast and the 90/10 summer peak demand for the same year. Call this the "90/50" weather adjustment to the 90/10 Forecast 20 savings estimate.
3. For the statewide forecast, subtract the BED peak demand forecast. The result is the non-BED statewide forecast, the basis for this study's endogenous efficiency adjustment and exogenous efficiency savings estimates. (Skip this step for zonal analysis)
4. Multiply the Forecast 20 endogenous efficiency adjustment by the 90/50 weather adjustment to the 90/10 savings estimate. The result is the statewide or zonal load forecast adjustment for the future savings from continuation of past efficiency investment implicit in the VELCO forecast.
5. Add the result of the preceding step to the non-BED statewide or zonal peak load forecast. The result is the peak load adjusted for the future savings from continuation of past efficiency investment implicit in the VELCO forecast.
6. Multiply the Forecast 20 estimate of peak demand savings by the 90/50 weather adjustment for the Forecast 20 90/10 savings estimate.
7. Subtract the result of the preceding step from the adjusted peak load forecast. The result is the forecast load net of future efficiency investment at currently planned budgets, either for a particular non-BED zone or for the non-BED portion of statewide peak load.
8. To arrive at the entire statewide peak load net of future efficiency investment, add the BED 90/10 load forecast net of BED's forecast of future savings from continued efficiency investment.

The Forecast 20 savings estimates are scalable with the underlying VELCO forecast values. If VELCO were to update the underlying energy or peak demand forecasts, it should adjust the savings estimates proportionally. For example, if VELCO lowers its forecast of summer peak demand by 3 percent, it should likewise lower the Forecast 20 peak savings estimate by 3 percent. Any such adjustments should be done at the sectoral level for greatest accuracy.

Finally, the Forecast 20 savings estimates are not additive to independent estimates of peak demand savings from demand response or other forms of peak load management. Coincident peak demand reductions from instituting demand response in conjunction with efficiency investments will be lower than if such strategies are applied to less efficient loads. Future efforts to incorporate demand response with long-term efficiency resource planning should address the interactions between the two forms of demand management.

C. Future Research

This study recommends two areas of future research and analysis. First, it is recommended that the VSPC explore potential alternative methods for accounting and adjusting for the past effects of efficiency investment. Second, more work is necessary before it will be possible to provide more useful information about savings at the zonal level.

This study used a simple method to estimate sectoral energy savings built into the forecast of future energy requirements. It relied on annual spending and savings dating back only as far as 2000. Subsequent analysis should assemble and include sector-level statewide efficiency spending and savings data going back to 1993. Future analysis should also be more closely coordinated with the development and application of unit energy consumption (UEC) data for more end uses. The next VELCO load forecast should explore more sophisticated analytical approaches for estimating end-use energy consumption and peak demands so that efficiency baselines underlying efficiency savings estimates are transparently consistent.

The differences between household lighting intensity assumed in this study for projecting future program savings potential and that built into VELCO's residential energy sales forecast is ultimately the result of a difference in professional opinion about the future of a rapidly-changing market over a long forecast horizon. Subsequent analysis should address the discrepancies identified here using updated EIA data as well as further market assessments conducted by the EEU or the DPS.

Future research should seek to collect additional information about electric energy consumption, actual efficiency savings results and estimated savings potential for individual customers from Efficiency Vermont, and other customer information that corresponds to the MW demand data VELCO collects. This will enable future analysis to take advantage of the types of information CVPS developed in its analysis non-transmission alternatives for the Southern Loop. With such information it will be feasible to pinpoint DSM expenditures and benefits for each of sixteen load zones and for each customer class within each of the load zones.

(Appendixes are presented separately from the main body of this report.)