ENERGY CENTER OF WISCONSIN

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Energy Efficiency and Customer-Sited Renewable Energy: Achievable Potential in Wisconsin 2006-2015

A technical analysis of options for investment in energy efficiency and customer-sited renewable energy as an alternative to electric generation and natural gas usage.

Volume I: Study Results

Prepared on Behalf of The Governor's Taskforce on Energy Efficiency and Renewables

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STUDY-AT-A-GLANCE

Wisconsin has mandated programs to help its residents, businesses, and industry use energy more efficiently for over 15 years. The delivery mechanisms and spending levels for these programs have varied over the years. In fiscal year 2005, the spending level was $38 million. The right amount to spend on energy-efficiency and renewable energy programs is an important policy question for which achievable potential energy savings provides an important input. The Governor's Task Force on Energy Efficiency and Renewables commissioned the Energy Center of Wisconsin to estimate the achievable potential for energy efficiency and customer-sited renewable energy.

WISCONSIN CAN SUSTAIN ECONOMICALLY JUSTIFIABLE SPENDING OF UP TO A RANGE OF $75 TO $121 MILLION ANNUALLY ON ENERGY EFFICIENCY PROGRAMS

The results of our analysis suggest that, over the next five years, an average of up to $75 to $121 million per year could be spent cost-effectively on statewide programs aimed at improving energy efficiency in Wisconsin homes and businesses. These programs would save energy beyond that which would occur naturally in the absence of programs. For each year of operation, these programs could save up to:

- 320 to 482 million kilowatt-hours of electric energy (0.5 to 0.7 percent of annual statewide electricity use and 20 to 30 percent of annual growth) in the first year and 3.8 to 5.6 billion kilowatt-hours over the lives of the energy saving measures affected by the program;
- 44 to 70 megawatts of electric demand (0.3 to 0.5 percent of utility summer peak electric demand and 10 to 20 percent of annual growth) with half of the measures lasting 10 years or more; and
- 7 to 14 million therms of natural gas (0.2 to 0.4 percent of annual statewide natural gas consumption) in the first year and 120 to 220 million therms over the lives of the measures affected by the program.

After five years of program activities, the total effect of program efforts based on the maximum justifiable spending would be enough to:

- Defer the need for one average-size electric power plant;
- Save enough electricity to power between 170,000 and 240,000 Wisconsin homes; and
- Save the amount of natural gas used in 35,000 to 65,000 Wisconsin homes.

SIX CUSTOMER-SITED RENEWABLE ENERGY MARKETS COULD SUSTAIN SPENDING OF UP TO $7 TO $11 MILLION ANNUALLY

For the six renewable energy markets that we studied (which do not include utility-scale renewable energy projects), our analysis suggests that up to $7 to $11 million could be cost effectively spent on programs, with annual incremental savings of:

- 19 to 27 million kilowatt-hours of annual statewide electricity use;
- 1.9 to 2.7 megawatts of utility summer peak electric demand; and

- 800,000 to 1.3 million therms of annual statewide natural gas consumption.

Because the limited number of renewable energy markets in the analysis were not intended to cover all possible renewable opportunities, actual renewable potential may be greater than that reported here.

STUDY METHODOLOGY BASED ON AVOIDED COSTS OF GENERATION; NO ACCOUNTING OF NON-ENERGY BENEFITS

Our study examined 30 energy efficiency markets and six customer-sited renewable energy markets in Wisconsin. For each, we studied the nature and status of the market, sought input from Wisconsin experts and stakeholders, and examined achievements from programs in Wisconsin and in other parts of the country. We then outlined likely program approaches for each market, and assessed the probable costs and energy savings from the programs. Our overall goal was to ground our assessments in realistic notions of what can be achieved through statewide programs to promote energy efficiency and customer-sited renewable energy.

We used the program administrator test for our measure of cost-effective program activity. This standard stipulates that energy-efficiency programs are cost-effective if they provide energy savings at a lower program cost than the cost of a comparable amount of energy generation. This test provides a measure of the levelized cost of conserved energy from the program administrator's perspective that can be compared to the avoided cost of delivered or generated energy. This test does not take into consideration participation costs incurred by consumers and businesses. The impacts that we credited to the programs are *net* impacts: that is, they represent the net difference in statewide energy consumption and peak electricity demand with the program in place compared to a no-program scenario.

Our analysis does not take into account the environmental or broad economic benefits of saving energy versus consuming it in Wisconsin. However, we do include a summary of some environmental and economic effects of our combined potential results using metrics adopted by the Wisconsin Department of Administration. An accounting of the environmental and economic benefits in the energy efficiency and renewable energy investment decision would increase the value of energy savings, thereby increasing the maximum amount that could be spent cost-effectively.

Also, energy efficiency in many markets is improving due to federal standards and initiatives and other market forces: our analysis counts only the incremental impacts of state-level programs beyond what would naturally occur in these markets. Finally, our analysis did not identify programs specifically targeted toward low-income households.

RECOMMENDATIONS

The results of this study should be used to inform future investment levels in statewide programs designed to promote energy efficiency and customer-sited renewable energy. The specific market results should be used to identify opportunities to modify or expand existing state programs.

INTRODUCTION

The Energy Center of Wisconsin performed this study of the achievable potential of energy efficiency and customer-sited renewable energy at the request of the Governor's Task Force on Energy Efficiency and Renewables (Task Force) and the Public Service Commission of Wisconsin (PSCW). The study will provide information to Wisconsin policymakers, regulators, utilities and other stakeholders on the potential savings to be gained from state-level investment in energy efficiency and customer-sited renewable energy. We approached our analysis of energy efficiency potential from a market perspective, not a technology perspective. That is, we assessed the extent to which energy saving measures are likely to be implemented by market participants. We examined 30 markets for the residential and business sectors. In addition, we examined six markets for customer-sited renewables, focusing on those technologies most viable in Wisconsin. Other renewable market opportunities may also be viable but were beyond the scope of this study. Table 1 lists all markets included in the study. Full descriptions of these markets are included in Volume 2: Technical Appendix of this report. All renewable markets considered for inclusion are listed in Appendix H.

The study estimates the achievable program-induced savings in three key areas of energy use: electricity consumed, summer peak demand for electricity placed on the state's generation and transmission system, and natural gas consumed. We employed a probabilistic approach (Monte Carlo analysis) to account for uncertainty in our assumptions and we present the results of the study as 90% probability bands for aggregate potential for each of electric energy, electric demand, and natural gas therms at current utility avoided costs. In addition, we prepared supply curves for each resource across a range of avoided costs. We used the same approach for the renewable energy potential analysis and present the results separately. The study looks at both 5- and 10-year horizons for achievable potential.

LEGISLATIVE AND REGULATORY CONTEXT

This study is intended to provide information to policymakers, regulators, utilities and other energy stakeholders in Wisconsin to determine the appropriate level of investment in Wisconsin's energy efficiency and renewable energy "public benefits" programs.

For more than 15 years, Wisconsin has mandated or administered programs to help its residents, businesses, and industry use energy more efficiently. These programs save energy beyond that which would occur naturally through individuals' and businesses' choices. The delivery mechanisms and spending levels for these programs have varied over the years. Prior to 2000, Wisconsin's utilities administered and delivered their own programs to their customers. Since 2001, the State of Wisconsin has administered a suite of programs that are delivered to Wisconsin residents by various energy organizations and firms.[1]

Wisconsin's current energy efficiency programs were initiated as part of the "Reliability 2000" legislation addressing long-term energy reliability issues in the state. The legislation, 1999 Wisconsin Act 9, directed

[1] These programs are delivered under the common name brand "Focus on Energy" and are available to ratepayers of the utilities that contribute to the public benefits fund. Some municipal and cooperative utilities fund separate programs.

the Department of Administration to collect fees from Wisconsin's electric providers: investor-owned utilities which were mandated to join the public benefits program; and the municipal utilities and electrical cooperatives, which were allowed to "opt in." Funding levels for the public benefits programs were intended to match the 1998 levels of investment in energy efficiency by Wisconsin utilities as determined by the PSCW. The legislation set renewable and environmental program budgets at 4.5% and 1.75% of the total budget respectively. Beginning in fiscal year 2003, after a two-year ramp-up period, revenue for energy efficiency programs, including renewable and environmental research, was approximately $62 million collected from investor-owned utilities and from participating municipal and cooperative utilities. However, actual spending reached only $53 million in 2003. Low income energy and crisis assistance programs are funded by utilities and the Federal government and are not addressed in this study.

With the passage of the biennial budgets of fiscal years 2004-2005 and 2006-2007, the State of Wisconsin diverted a portion of the public benefits funds to help reduce the state budget deficit. Because of this funding diversion, Wisconsin's public benefits programs have not been funded at the level originally established in the legislation. Actual spending in fiscal years 2004 and 2005 was $42 million and $38 million respectfully.

In 2004, as part of a larger initiative to address Wisconsin's leadership in energy efficiency and renewable energy, the Governor's Task Force on Energy Efficiency and Renewables examined the structure and funding levels of the public benefits programs. The Task Force recommended that the PSCW be responsible for establishing future funding levels for Wisconsin's public benefits programs[2] and commissioned the Energy Center of Wisconsin to perform this study to aid in determining the appropriate funding levels.

METHOD AND SCOPE

The Energy Center team decided that a market opportunity approach would provide the best tool to estimate "achievable" energy efficiency savings. "Economic" potential is another measure which evaluates all cost effective measures, regardless of whether consumers and businesses would take action. The achievable potential provides a realistic estimate of how consumers and businesses in each market will adopt options offered by a statewide program. Each market is comprised of a portfolio of approaches to save energy at a time when customers consider retrofits, replacements or new purchases of energy using equipment and buildings.

We sought input from a wide group of stakeholders on the most cost effective markets based on results in Wisconsin and other states. We selected 30 markets for energy efficiency (15 commercial and industrial and 15 residential) and benchmarked this list against other energy efficiency studies to determine if there were any significant gaps or omissions. We determined that the 30 markets covered most major market opportunities. The benchmarking indicated that the missing markets together totaled between 10 to 25 percent of energy efficiency potential.

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[2] As this report is written, legislation has not yet been passed to shift this responsibility to the PSCW.

For the renewable market, we chose six technologies which have the best current promise in Wisconsin. We based our selection on stakeholder input as well as interests of the current statewide public benefits program participants. Other markets, not included, are listed in Appendix H.

For each of the 36 markets included in our analysis, we studied the nature and status of the market, sought input from Wisconsin experts and stakeholders,[3] and examined achievements from programs in Wisconsin and in other parts of the country. We then outlined likely program approaches for each market, assessed the probable costs and energy savings from the programs, and aggregated these results across energy efficiency and renewable markets. Our overall goal was to ground our assessments in realistic notions of what can be achieved through statewide programs to promote energy efficiency and customer-sited renewable energy.

The savings reported in this study comprise achievable potential. This potential encompasses those savings that are technically feasible, cost-effective when compared to the cost of generation, and likely to be accepted by the market with program interventions such as education and information, incentives and technical assistance. Our results identify net program-induced savings, which are those resulting directly or indirectly from program activity, excluding any free riders (participants in a program who would have undertaken the energy efficiency measure without a program) and including spillover effects (the ability of a program to induce other customers to invest in energy efficiency without a program incentive). This measure of results is the most accurate measure of the direct effects of program intervention and will provide the best estimate of the return on program investment. This measure is most directly comparable to the "verified net savings" reported in the evaluations for the current public benefits program.[4]

We used a program administrator test (similar to a utility test) for our measure of cost-effective program activity. This standard stipulates that energy-efficiency programs are cost-effective if they provide energy savings at a lower program cost than the cost of a comparable amount of energy generation. This test provides a measure of the levelized cost of conserved energy that is directly comparable to the cost of delivered or generated energy that policymakers use as a benchmark. Because the primary purpose of this study is to provide information on the appropriate level of statewide investment in energy efficiency and renewable energy, it is appropriate to provide a measure which is most comparable to the measures used in the regulatory process to evaluate the avoided cost of energy, demand and therms. This test and our analysis do not incorporate the investment that individuals and businesses make in the program-induced measures as customer costs are not typically accounted for in the cost of "supply side" options. Additionally, customer costs of participating in energy efficiency programs are not readily available. However, all customer participation rates and incentive levels used in the 36 markets indirectly reflect required participant investment.

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[3] Our experts and stakeholders included an Advisory Committee appointed by the Task Force and a stakeholder committee that included staff from the current Focus on Energy public benefits programs. Appendices D and E include a complete list of committee members and stakeholders.

[4] The Focus on Energy public benefits program often reports "verified gross savings" which is a measure that includes free riders and excludes spillover effects. Verified gross savings are generally higher than verified net savings.

Additionally, our study does not take into account the environmental or broad economic benefits of saving energy versus consuming it in Wisconsin. However, we do provide some information on the effects of saving energy on the environment and the economy using Department of Administration adopted formulas.

Also, energy efficiency in many markets is improving due to federal standards and initiatives and other market forces: our analysis counts only the incremental impacts of state-level programs beyond what would naturally occur in these markets. For example, we adjusted our baseline data for the new appliance standards mandated in the Energy Policy Act of 2005 so that we do not double count savings. Finally, our analysis did not include programs specifically targeted toward low-income households.

The structure, perspective and methodology of our study is intended to best match the anticipated decision-making process at the Public Service Commission of Wisconsin (PSCW). The PSCW will likely compare the cost of conserved energy to the cost of expanded production to arrive at the appropriate demand- and supply-side portfolio. Both of these costs are part of utility revenue requirements which are passed on to consumers through the ratemaking process. The use of the "program administrator" perspective, (rather than societal, total resource, or customer) and the "achievable" perspective (rather than the technical or economic) provides realistic, reliable, and comparable measures to balance against competing uses for utility (and ratepayer) funds in the regulatory rate-setting process. Other potential studies may use different combinations of perspectives that meet other purposes and objectives.

The avoided cost of electric energy and demand used as our target benchmark reflects avoided generating unit costs used for the We Energies Port Washington and Oak Creek ERGS projects as well as current tariffed buy-back rates on file for Wisconsin utilities. Specific allowances were not made to account for avoided costs of transmission and distribution (T&D) as the study did not analyze how energy efficiency would cause T&D expenses to decrease.

Energy efficiency in targeted areas could result in fewer or delayed upgrades to both transmission and distribution. Energy efficiency could also result in decreased operations and maintenance expenses for T&D. These effects could increase the value of the conserved energy. From the customer perspective, participation in energy efficiency and renewable programs will provide a greater value than the targeted avoided costs used in this study to the extent that they would also avoid T&D charges for saved energy.

A more thorough explanation of the methodology and scope of this study is included in Appendix A.

TABLE 1, MARKETS

Sector	Market
Commercial and Industrial	High Performance New Buildings
	Unitary HVAC Replacement and System Improvements
	Lighting Remodeling & Replacement Upgrades
	Boiler Replacement & Systems Improvements
	Lighting System Retrofit Improvements
	Chiller Replacement and System Improvements
	Ventilation System Improvements
	Refrigeration System Improvements
	Motors: New, Replacement and Repair Market
	Compressed Air Systems Improvements
	Fan and Blower Systems Improvements
	Pump Systems Improvements
	Manufacturing Process Upgrades
	Water & Wastewater System Improvements
	Agriculture Energy Efficiency Upgrades
Residential	Consumer Electronics
	Incentives for CFLs
	Multi-family Common Area Lighting – Direct Install Market
	Incentives for Variable Speed Furnaces
	Central AC
	Multi-family Heating System Replacement
	Room AC
	Homeowner Water Heater Purchases
	New Home Construction
	Remodeling
	Dehumidifier
	Direct Install Market
	Shell Improvements
	Incentives for Homeowner Clothes Washer Purchases
	Multi-family Fuel Switching
Renewables	Customer-sited, Grid-connected, Commercial Solar Photovoltaics (PV)
	Commercial Solar Thermal (Hot Water)
	Residential Solar Thermal (Hot Water)
	Wood Residue for Commercial/Institutional Heat
	Customer-sited, Grid-connected, Commercial Wind Energy
	Agriculture Anaerobic Digestion

RESULTS: ENERGY EFFICIENCY POTENTIAL

COMBINED RESOURCE POTENTIAL

For the combined analysis, we looked at the aggregate ability of the 30 energy efficiency markets to save electric energy, electric demand and natural gas at or below current utility avoided costs[5]. The overall results are extrapolated from the 30 markets included in the study to an estimate of all energy efficiency markets.

From this strict avoided-cost perspective, our analysis suggests that, over the next five years, annual program funding levels up to a range of $75 to $121 million per year could produce savings at or below the cost of generating or purchasing electricity and natural gas (Table 2). At this level of program funding, our model indicates that statewide electricity and natural gas use would be reduced by roughly 1.0 to 3.6 percent relative to 2004 usage levels after five years.

TABLE 2, ESTIMATED 5-YEAR OVERALL ENERGY EFFICIENCY POTENTIAL

	Average annual		**5-year total[a]**	
		(% of 2004)[b]		(% of 2004)[b]
Program Funding ($ millions)	75 to 121	(1.0 to 1.6)	373 to 607	(4.8 to 7.8)
Electric Demand (MW)	44 to 70	(0.3 to 0.5)	218 to 347	(1.6 to 2.6)
Electric Energy (millions of kWh)	320 to 482	(0.5 to 0.7)	1,638 to 2,437	(2.4 to 3.6)
Natural Gas Energy (millions of therms)	7 to 14	(0.2 to 0.4)	36 to 66	(0.9 to 1.7)

[a]Represents total savings that occur in Year 6, following five years of program operation.

[b]For energy and demand savings, figures are percent of 2004 annual statewide usage and summer peak demand. For program funding, figures are percent of 2004 statewide electricity and gas revenues.

Note: ranges are 90% probability boundaries from probabilistic uncertainty analysis.

Given the expected current growth rate in electricity consumption (2.2 percent for energy and 2.5 percent per year for peak summer demand), the figures above suggest that the energy efficiency programs could cut growth in summer peak demand by up to10 to 20 percent, and could reduce the growth in electric energy consumption by up to 20 to 30 percent.

Energy efficiency programs create savings that last over the lifetime of the measures that are implemented. Each subsequent year of program operation adds to the savings achieved from prior years, which tends to compound overall program achievements while programs are operating. On the other hand, aggregate savings begins to decline when the lives of the shortest-lived measures are exceeded. Figures 1 through 3 provide a sense of how total savings from five years of program operation play out over a 30-year period. A fast period of build-up in total savings while programs are operating is followed by a long period of continued but declining savings as various measure lives are exceeded. Natural gas savings are notably more persistent than electricity savings: this is due to the significant proportion of gas savings that derives from space heating savings from relatively permanent changes to building shells. The

[5] See Appendix A for specific assumptions.

savings results reported in Table 2 do not include the saving effects beyond the five-year study period. However the program funding does take into consideration the value of the measure life represented in each included market.

FIGURE 1, POTENTIAL IMPACTS OVER TIME FOR FIVE YEARS OF PROGRAM OPERATION, ELECTRIC PEAK DEMAND

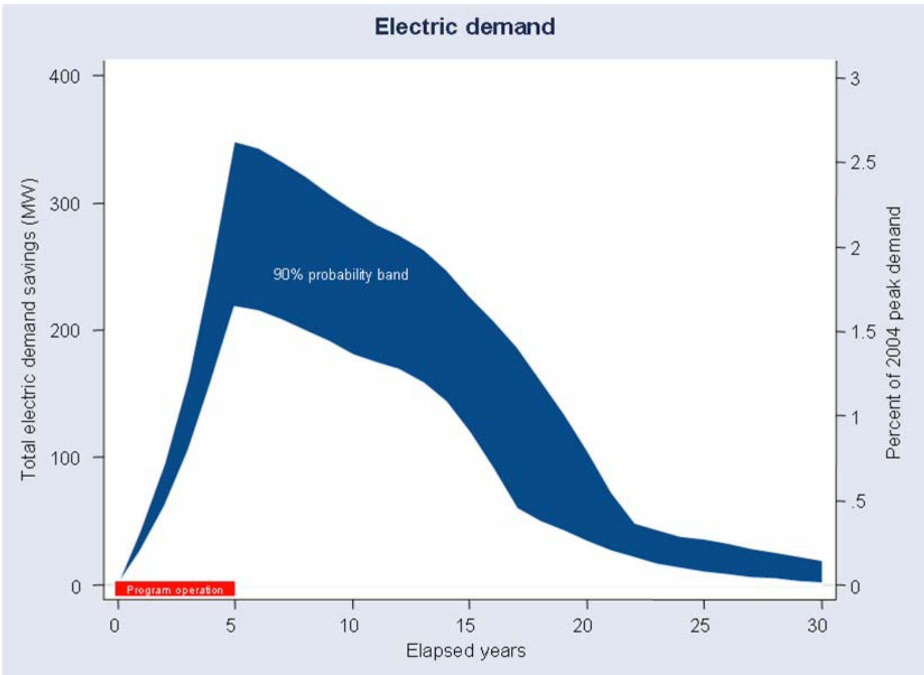


FIGURE 2, POTENTIAL IMPACTS OVER TIME FOR FIVE YEARS OF PROGRAM OPERATION, ELECTRIC ENERGY

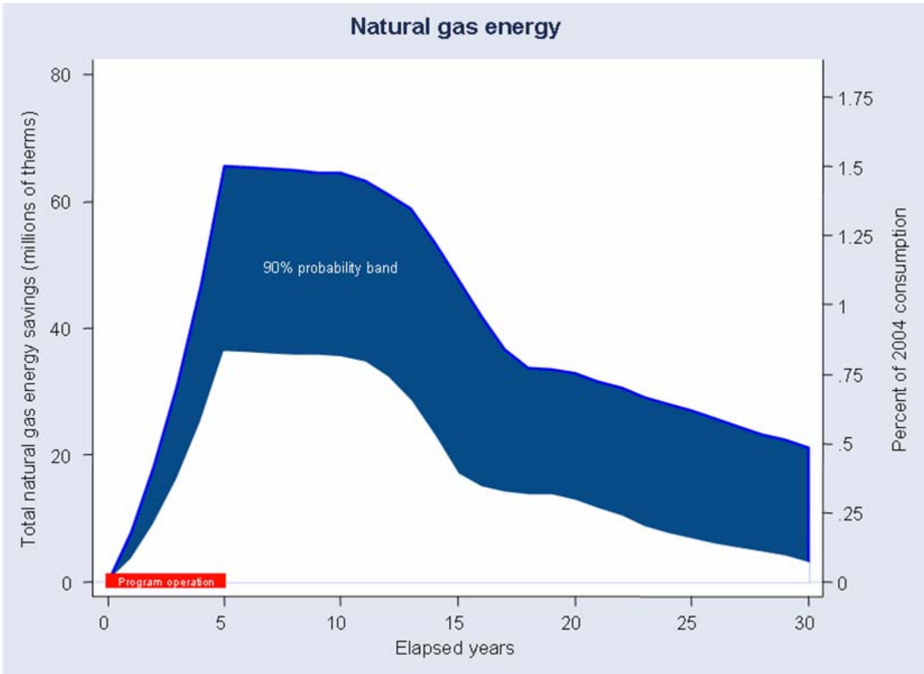
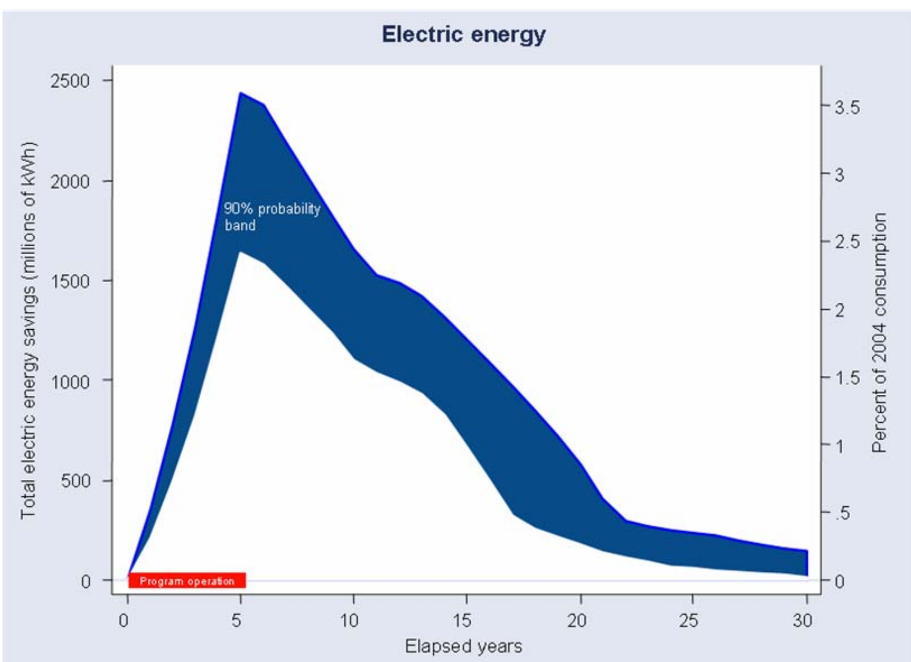


FIGURE 3, POTENTIAL IMPACTS OVER TIME FOR FIVE YEARS OF PROGRAM OPERATION, NATURAL GAS ENERGY



After five years of program activities, the total effect of program efforts would be enough to:

- Defer the need for one average-size electric power plant;
- Save enough electricity to power between 170,000 and 240,000 Wisconsin homes; and
- Save the amount of natural gas used in 35,000 to 65,000 Wisconsin homes.

The five-year analysis incorporates assumptions about program ramp-up and market response rates that limit achievable potential in the near term. To test the extent to which these assumptions affect the results, we conducted an alternative analysis with the artificial assumption that the Year 5 potential could be immediately realized. The results indicate program potentials that are 20 to 60 percent higher than those shown in Table 2. Similarly, over the longer 10-year period, our analysis suggests annual program potentials that are about 25 to 60 percent higher than the five-year results. Nonetheless, much could change over the course of the next 10 years, and these estimates therefore have more uncertainty. For this reason, we focus on the five-year estimates here; 10-year results are provided in Appendix B.

ENVIRONMENTAL AND ECONOMIC EFFECTS OF AVERAGE ANNUAL ENERGY EFFICIENCY POTENTIAL

While this study did not factor into benefits a dollar value for the environmental or economic effects of energy efficiency, the Wisconsin Department of Administration (DOA) has adopted conversion factors for these effects in calculating benefits of past energy efficiency results. Applying the DOA standards to these study results will provide a starting point for further analysis of the non-energy benefits. Table 3 provides a summary of non-energy benefit values for the five-year average annual combined potential for electric and natural gas energy. Non energy values for electric demand savings are not included.

TABLE 3, NON ENERGY BENEFITS OF COMBINED AVERAGE ANNUAL POTENTIAL FOR ENERGY EFFICIENCY

Annual kWh Saved (Millions)	Annual Therms Saved (Millions)
320 – 482	7 - 14

Metric Description	Annual Electric Benefits	Annual Gas Benefits	Total Annual Benefits
CO_2 (thousands of tons)[a]	380 – 580		380 – 580
NOx (millions of lbs.) [a]	1.8 – 2.7	.07 – 0.14	1.9 – 2.9
SO2 (millions of lbs.) [a]	3.9 – 5.9	negligible	3.9 – 5.9
HG (lbs.) [a]	16 – 24		16 – 24
Coal (thousands of tons)[b]	160 – 240		160 – 240
Jobs Years Created[c]	1,400 – 2,100		1,400 – 2,100

[a]CO_2, SOx, NOx, and Hg conversion factors are based on research by the Wisconsin Department of Administration's consultant for Focus on Energy Programs, PA Government Services.
[b]Assumes one pound of coal to generate one kWh.
[c]Job years are based on the PA Government Services report: "Economic Development Benefits: Interim Economic Impacts Report", March 31, 2003. Therm savings benefits are included.

The data show the potential for significant reductions in carbon dioxide, nitrogen oxide, sulfur dioxide, and mercury. We could eliminate the purchase of up to 160,000 to 240,000 tons of coal. Energy efficiency program savings would also create up to 2,000 jobs. These data could be further refined by modeling the study results on a hourly basis to better match environmental benefits with projected generation mix. The inclusion of a value for non-energy benefits in the analysis of future investment levels for energy efficiency would increase the maximum economic investment estimate.

SECTOR AND MARKET CONTRIBUTIONS TO ENERGY EFFICIENCY POTENTIAL

The energy efficiency potential estimates identified in Table 2 combine all 30 commercial, industrial and residential markets. At the sector level, our results suggest a reasonably even split between the commercial and industrial (C&I) sector and the residential sector, though the C&I sector tends to dominate peak demand savings.

FIGURE 4, SECTOR SPLIT FOR COMBINED POTENTIAL

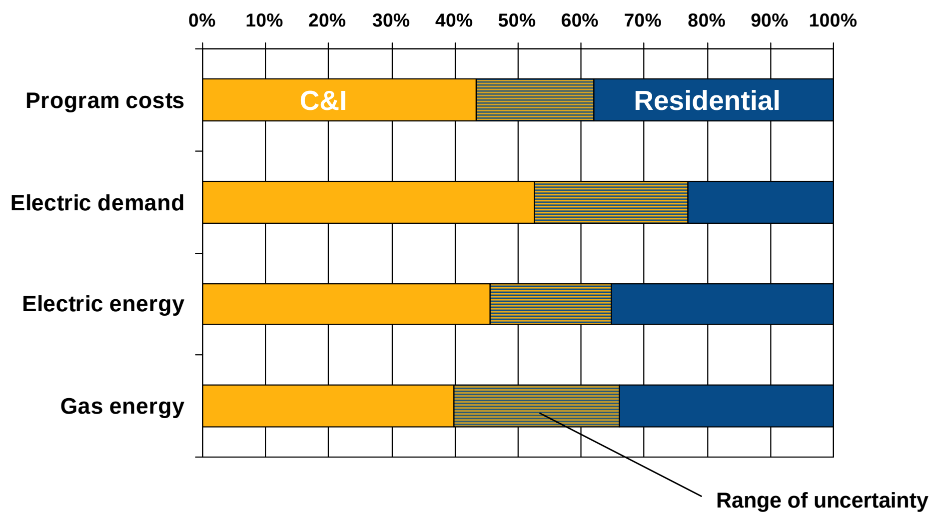


TABLE 4, ENERGY EFFICIENCY POTENTIAL BY SECTOR (5-YEAR ANALYSIS)

	Average annual	(% of 2004)[b]	**5-year total**[a]	(% of 2004)[b]
Commercial & Industrial				
Program Spending ($ millions)	38 to 65	(0.5 to 0.8)	190 to 325	(2.4 to 4.2)
Electric Demand (MW)	30 to 44	(0.2 to 0.3)	149 to 222	(1.1 to 1.7)
Electric Energy (millions of kWh)	177 to 264	(0.3 to 0.4)	887 to 1,313	(1.3 to 1.9)
Natural Gas Energy (millions of therms)	3.5 to 7.8	(0.09 to 0.2)	18 to 39	(0.5 to 1.0)
Residential				
Program Spending ($ millions)	31 to 63	(0.40 to 0.81)	157 to 313	(2.0 to 4.0)
Electric Demand (MW)	11 to 32	(0.08 to 0.24)	54 to 154	(0.4 to 1.2)
Electric Energy (millions of kWh)	121 to 246	(0.18 to 0.36)	640 to 1,261	(0.9 to 1.9)
Natural Gas Energy (millions of therms)	3.0 to 7.0	(0.08 to 0.18)	14 to 33	(0.4 to 0.8)

[a]Represents total savings that occur in Year 6, following five years of program operation.
[b]For energy and demand savings, figures are percent of 2004 annual statewide usage and summer peak demand. For program funding, figures are percent of 2004 statewide electricity and gas revenues.

Note: ranges are 90% probability boundaries from probabilistic uncertainty analysis.

While many program areas clearly contribute to the overall potential, there is considerable variation in the magnitude of these contributions, depending on the resource and sector in question (Figure 5 through 8).[6] The length of the bar for each market reflects the 90% probability boundaries. Lighting, industrial process improvements, commercial new construction and pump system improvements dominate the C&I sector contribution to overall potential. In particular, industrial process improvements represent a large fraction of the total identified gas savings potential in this sector. See Volume 2: Technical Appendix for more detail on the program areas and markets in our analysis.

[6] The reader should bear in mind however that, while the potential estimates at the program level are the building blocks for the assessment of aggregate potential, individually they are based on limited market analysis and, therefore, may not capture all aspects of the markets and programs.

FIGURE 5, RELATIVE PROGRAM CONTRIBUTIONS TO C&I SECTOR COMBINED 5-YEAR POTENTIAL, PROGRAM COSTS

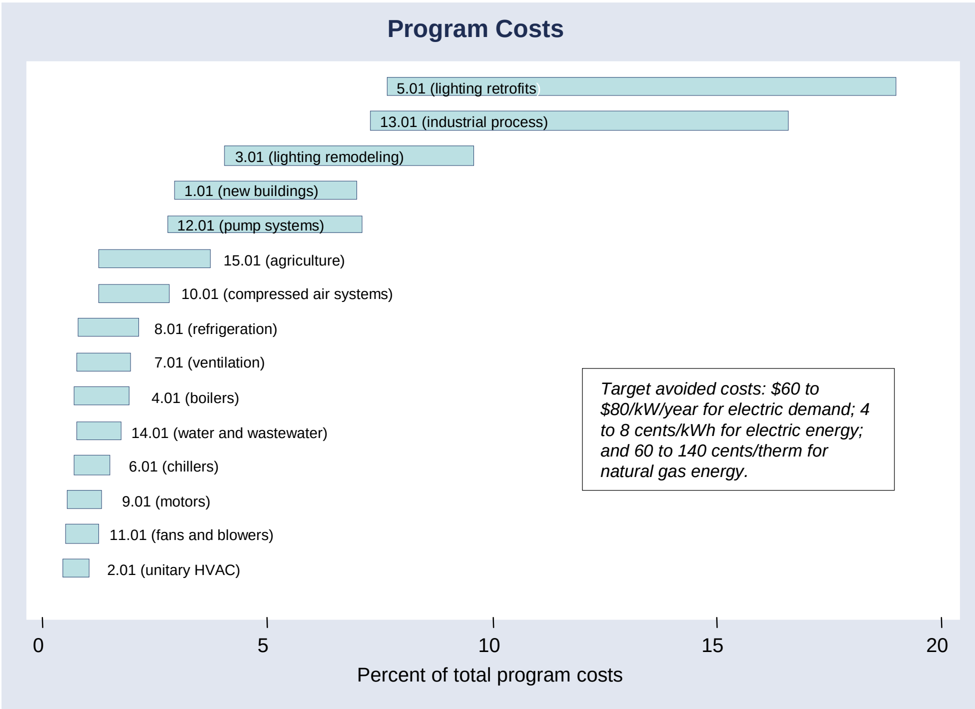


FIGURE 6, RELATIVE PROGRAM CONTRIBUTIONS TO C&I SECTOR COMBINED 5-YEAR POTENTIAL, ELECTRIC DEMAND

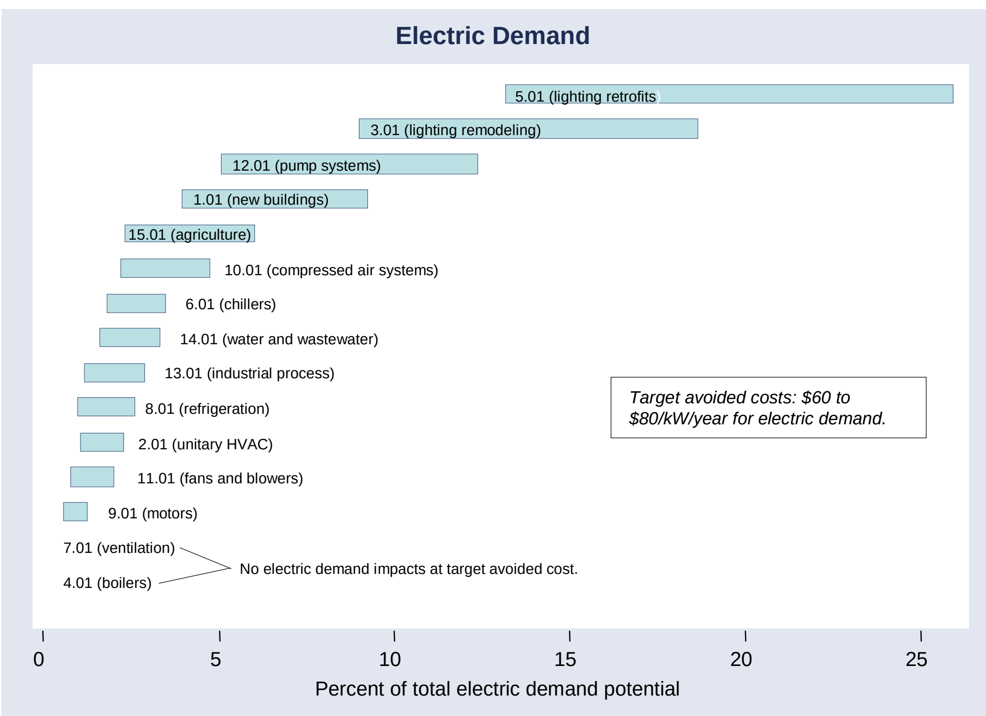


FIGURE 7, RELATIVE PROGRAM CONTRIBUTIONS TO C&I SECTOR COMBINED 5-YEAR POTENTIAL, ELECTRIC ENERGY

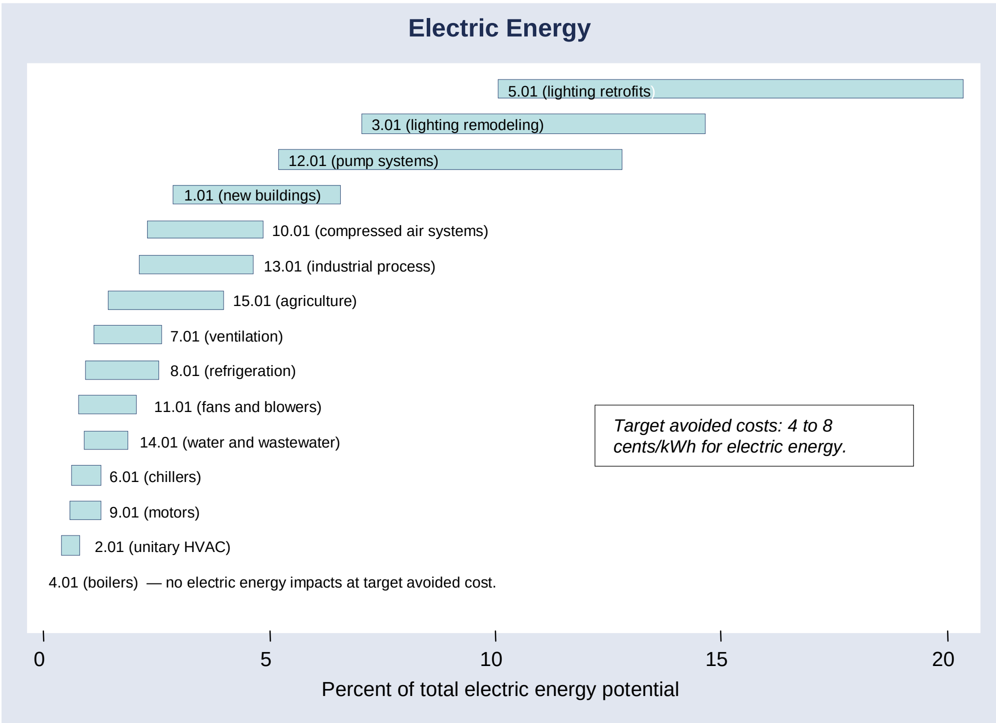
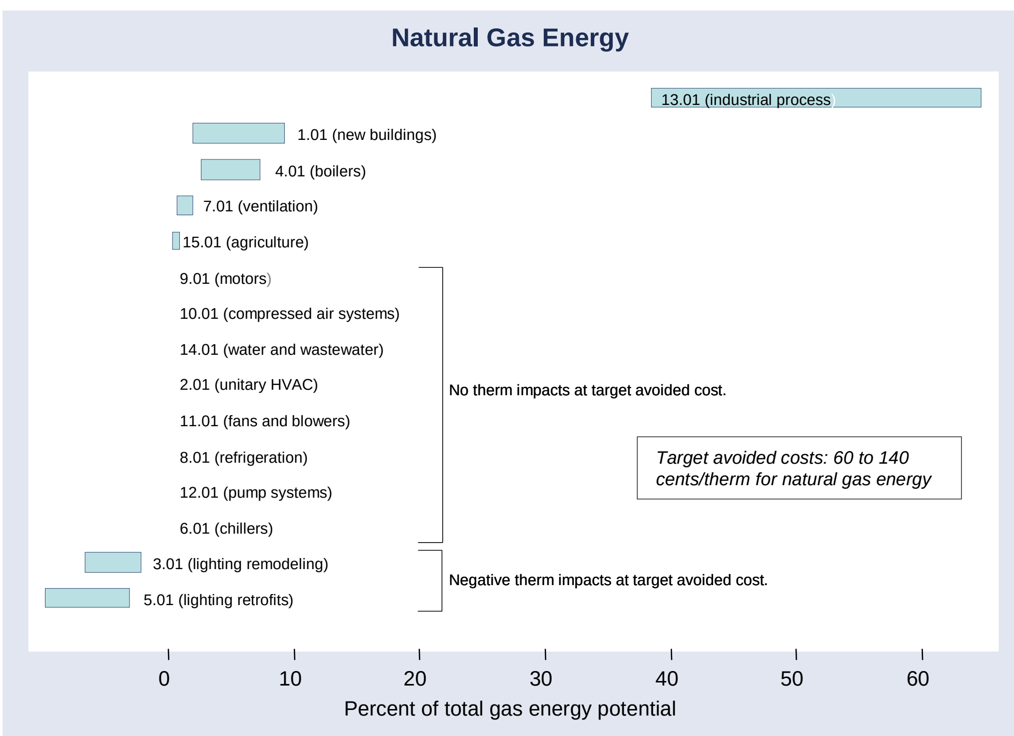


FIGURE 8, RELATIVE PROGRAM CONTRIBUTIONS TO C&I SECTOR COMBINED 5-YEAR POTENTIAL, NATURAL GAS ENERGY



In the residential sector, promotion of CFLs dominates the electric energy and peak demand potential. While most households do not use their electric lighting during the summer afternoons and early evening hours when system peak tends to occur, the *energy* savings potential from CFLs is so large (and cost effective) that the program accounts for the largest proportion of peak *demand* impacts in the residential sector. Savings from residential HVAC installation practices are also large, but also more uncertain.

Several of the program areas create negative gas savings that reduce the aggregate gas savings potential in this combined analysis. These are either direct fuel-switching programs that save electricity at the expense of increased natural gas consumption or programs that save electricity use in a way that reduces internal heat gains in buildings and indirectly increases gas heating loads. These negative impacts are accounted for in the aggregate estimates of combined resource potential.

FIGURE 9, RELATIVE PROGRAM CONTRIBUTIONS TO RESIDENTIAL SECTOR COMBINED 5-YEAR POTENTIAL, PROGRAM COSTS

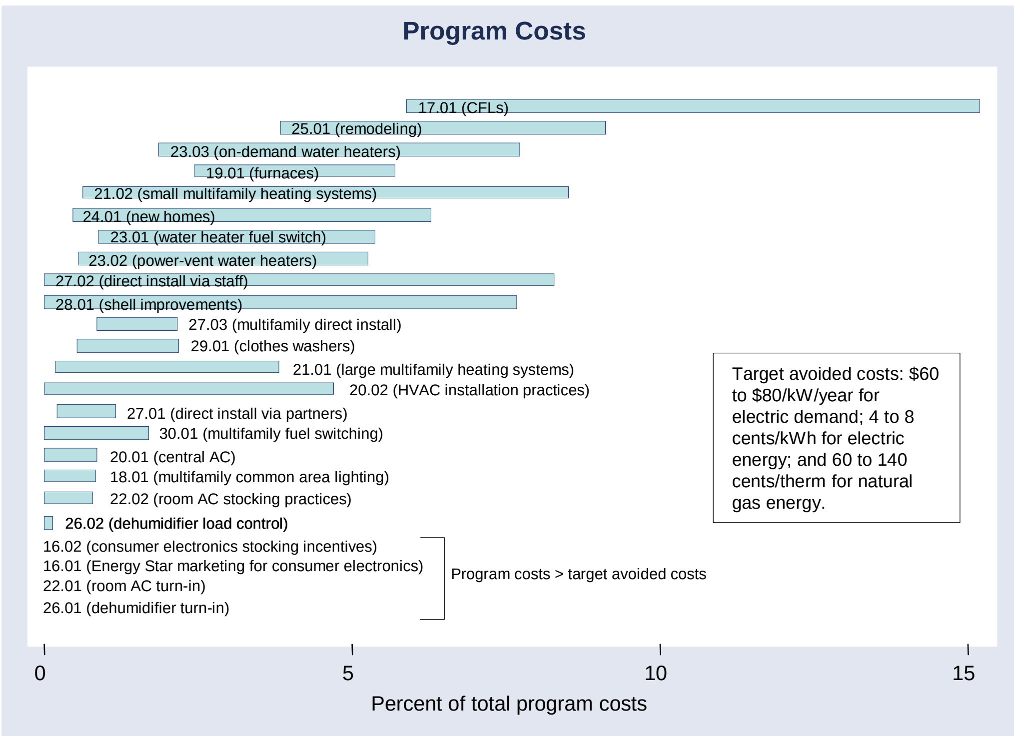


FIGURE 10, RELATIVE PROGRAM CONTRIBUTIONS TO RESIDENTIAL SECTOR COMBINED 5-YEAR POTENTIAL, ELECTRIC DEMAND

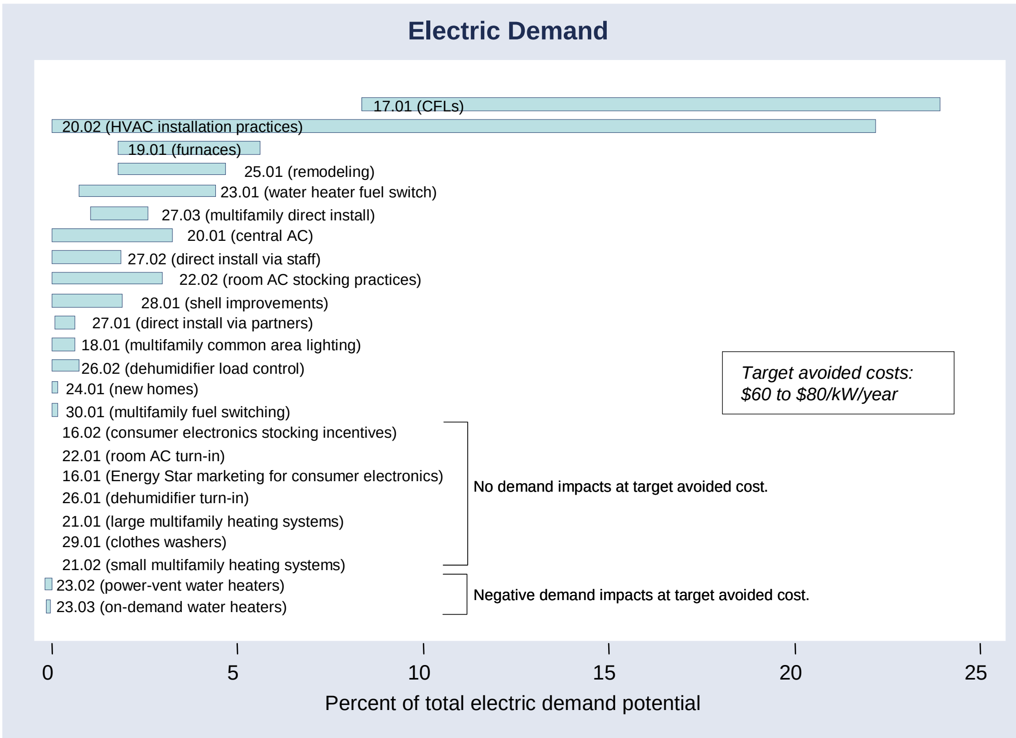


FIGURE 11, RELATIVE PROGRAM CONTRIBUTIONS TO RESIDENTIAL SECTOR COMBINED 5-YEAR POTENTIAL, ELECTRIC ENERGY

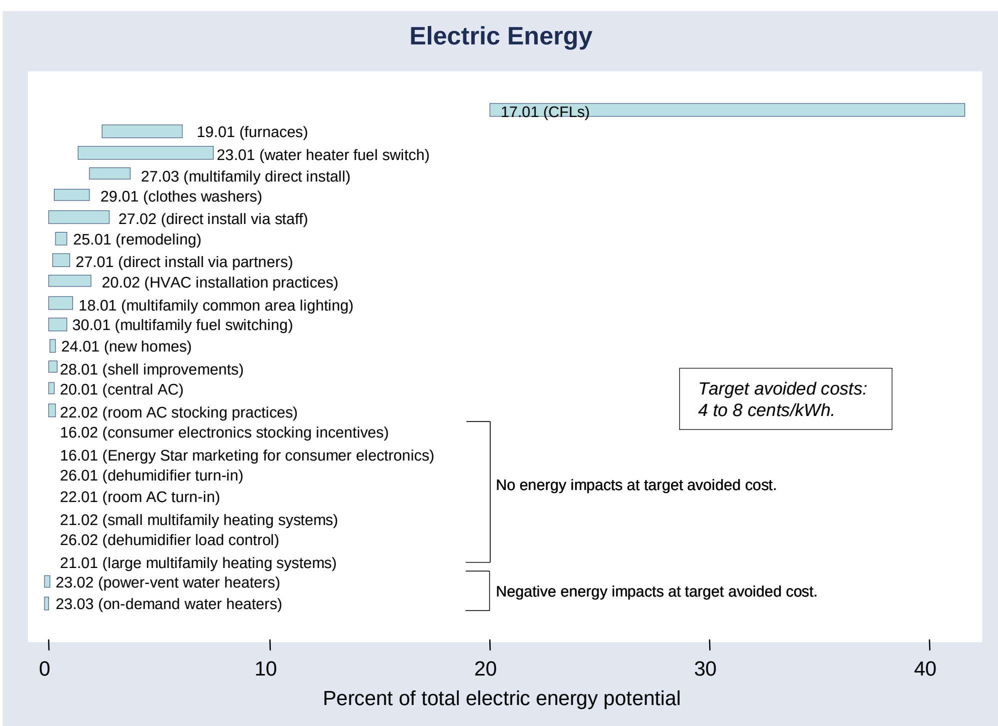
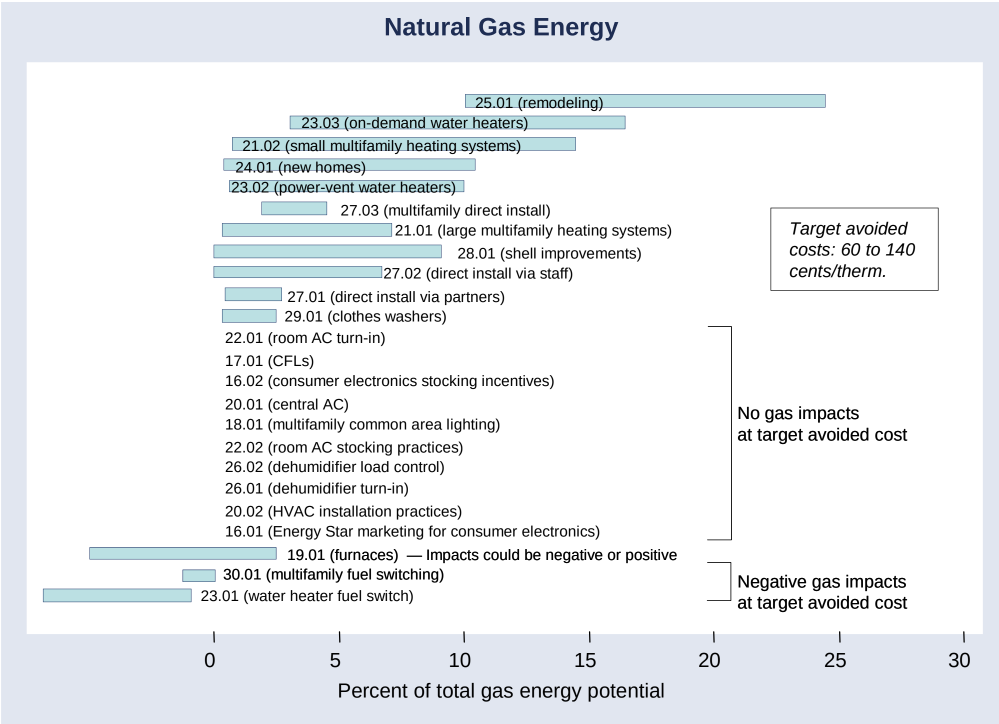


FIGURE 12, RELATIVE PROGRAM CONTRIBUTIONS TO RESIDENTIAL SECTOR COMBINED 5-YEAR POTENTIAL, NATURAL GAS ENERGY



Potential in K-12 Schools

During the stakeholder input process, we received a request to estimate the portion of the commercial sector savings represented by K-12 schools. We were able to accommodate this request through post-analysis of the study results. We first estimated the percentage of program costs and impacts attributable to K-12 schools (public and private) in eight commercial-sector markets in the analysis (Table 5), and then applied these percentages to the program area estimates from the model.

TABLE 5, ESTIMATED PROPORTION OF COMMERCIAL SECTOR PROGRAM COSTS AND POTENTIAL IMPACTS ATTRIBUTABLE TO K-12 SCHOOLS.

	Estimated proportion accounted for by K-12 schools[a]			
Market	**Program costs**	**Electric demand**	**Electric energy**	**Gas energy[b]**
High Performance New Buildings	3.5%	3.9%	3.7%	2.6%
Unitary HVAC Replacement & System Improvements	7.6%	7.6%	7.6%	0.0%
Lighting Remodeling & Replacement Upgrades	6.3%	6.3%	6.3%	3.2%
Boiler Replacement & System Improvements	7.6%	0.0%	0.0%	7.6%
Lighting System Retrofit Improvements	6.3%	6.3%	6.3%	3.2%
Chiller Replacement and System Improvements	7.3%	7.3%	7.3%	0.0%
Ventilation System Improvements	5.5%	0.0%	5.9%	3.9%
Refrigeration System Improvements	1.2%	1.2%	1.2%	0.0%

[a] Non-zero values assigned ± 25% uncertainty
[b] Gas energy impacts shown for lighting systems decrease net gas savings

Reflecting on the results and on actual results for school-focused programs, we expect efficiency programs would achieve a higher market penetration in Wisconsin K-12 schools than in the commercial sector as a whole. Since 2001, the Cooperative Educational Services Agency 10 (CESA 10) has managed the delivery of the Focus on Energy program through a contract with the State of Wisconsin. CESA 10 has approximately 10 employees around the state that deliver the Focus on Energy services to public schools, private schools, colleges and universities, and to counties, cities, villages, and towns. CESA service units have a tightly-integrated service relationship with Wisconsin school districts dating back 40 years. The K-12 schools and CESA already have a mature relationship that would not need a ramp up period. In addition we expect maximum market penetration levels to be higher than the overall commercial levels.

The results in Table 6 estimate the efficiency savings for K-12 schools included within the overall commercial sector results. We believe that Table 6 provides the minimum program savings available from K-12 schools. We expect higher savings than shown, given the maturity of service delivery in K-12 schools through CESA. Assuming CESA continued to deliver K-12 programs, few opportunities to implement efficiency projects would pass without an offer from CESA to facilitate participation in a program.

At a minimum, up to between $1 and $2 million in program funding directed at K-12 schools could yield an achievable potential of roughly 2.5 to 4 percent of all C&I sector electricity savings. Much of the gas savings potential identified for schools in our study was offset by increases in gas consumption from lighting improvements that indirectly increase gas consumption by reducing the heating effect of interior lighting. Our reporting of *net* gas savings potential is therefore small. Schools have additional gas saving opportunities not included within our 30 markets, such as swimming pools, gymnasiums, showers, and kitchens. Expansion of the study to address these markets would raise gas savings in schools substantially.

TABLE 6, MINIMUM ESTIMATED 5-YEAR VERIFIED NET ENERGY EFFICIENCY POTENTIAL IN K-12 SCHOOLS

	Average Annual	**5-year Total**
Program Funding ($ millions)	0.9 to 1.9	4.4 to 9.6
Electric Demand (MW)	0.9 to 1.6	4.4 to 7.9
Electric Energy (millions of kWh)	4.8 to 8.3	24.1 to 41.6
Natural Gas Energy (millions of therms)	0.0 to 0.04	0.0 to 0.19

Note: ranges are 90% probability boundaries from probabilistic uncertainty analysis.

INDIVIDUAL RESOURCE SUPPLY CURVES

In addition to the combined analysis of potential across all three resources, we also generated supply curves for each resource individually. A supply curve plots levels of energy efficiency investment against savings for each resource. For these analyses, we looked at the potential ability of each program area to provide impacts across a range of avoided costs. As with the other analyses for the study, we developed these supply curves probabilistically; that is, the data points from our probabilistic model represent a range of spending levels and savings potential at any particular avoided cost. To build up the supply curves we plotted ellipses that enclose the majority (90 percent) of the estimates at each avoided cost. The avoided cost value is marked at the top of each ellipse. The savings estimates are represented as points within each ellipse. The series of ellipses can be viewed as a supply "curve."

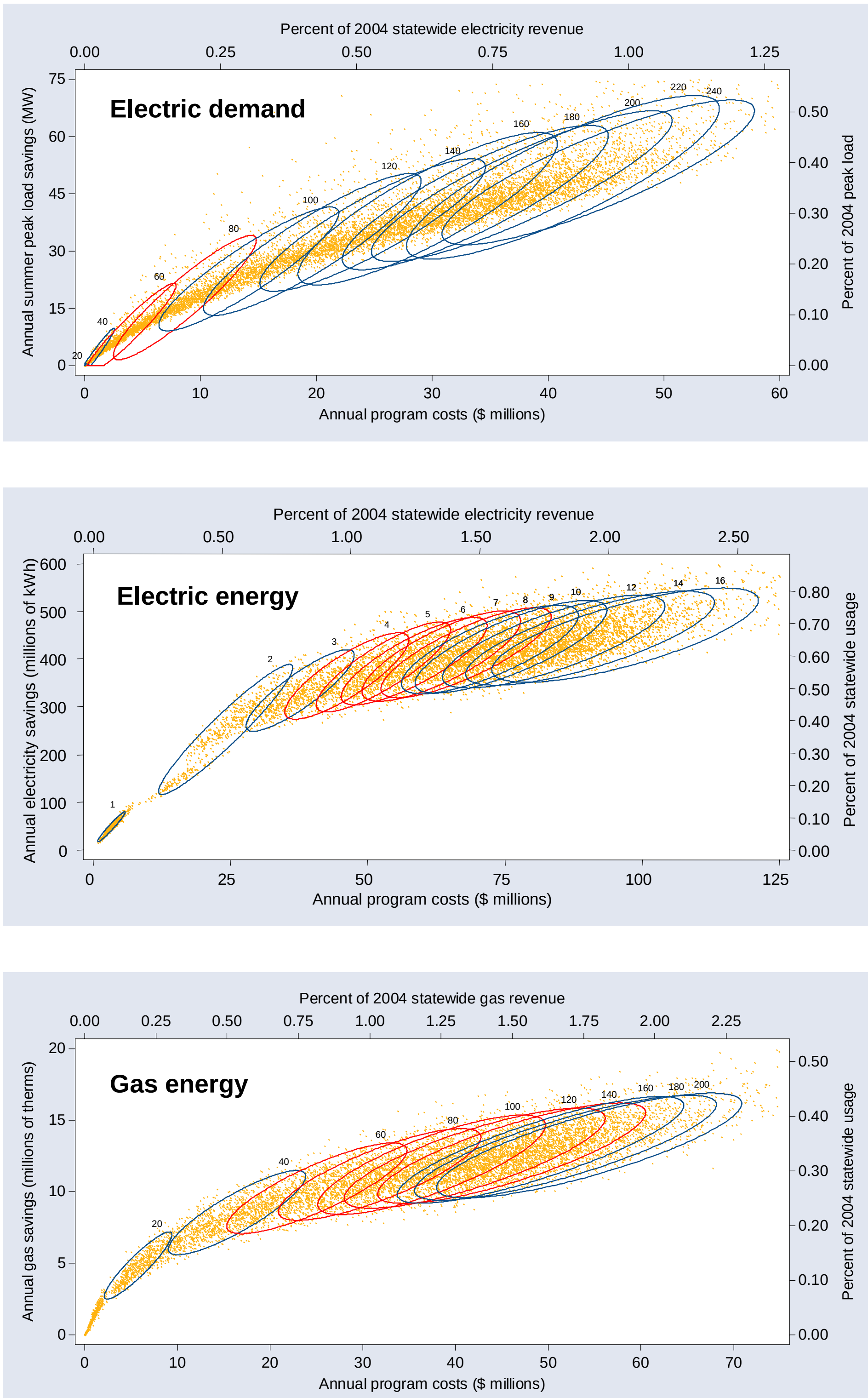
The figures on the following pages show the aggregate supply curve estimates for all energy efficiency resources, as well as for the C&I and residential sectors separately. For each sector, we generated three supply curves, representing the potential ability for energy efficiency programs to reduce electric peak demand, electric energy consumption, and gas energy consumption. As with the combined analyses, we extrapolated from the 30 markets included in the study to all energy efficiency markets, assuming that the markets in the study represent between 75 and 90 percent of all market opportunities.

Several observations can be made from these supply curves. First, the individual supply curves for peak demand suggest less potential savings than is indicated by the combined analysis at the avoided cost range of $60 to $80 per kilowatt used in the latter analysis. Specifically, the combined analysis identifies somewhere between about 30 and 50 megawatts of additional annual peak demand savings beyond what the aggregate supply curve for peak demand reductions would suggest for this range of avoided costs. As noted above, this is because the combined analysis includes ancillary demand impacts from programs that can be cost justified on the basis of electric energy savings, while the supply curve includes only potential demand impacts for programs that can be cost justified on the basis of demand impacts alone.

In contrast, the estimated savings potential for electric energy is about the same between the two analyses (at the 4–8 cents/kWh avoided cost range used in the combined analysis), and gas savings potential in the individual supply curves are actually slightly higher than those in the combined analysis, because the latter includes offsetting increases in gas consumption from programs that save electricity at the expense of increased gas consumption.

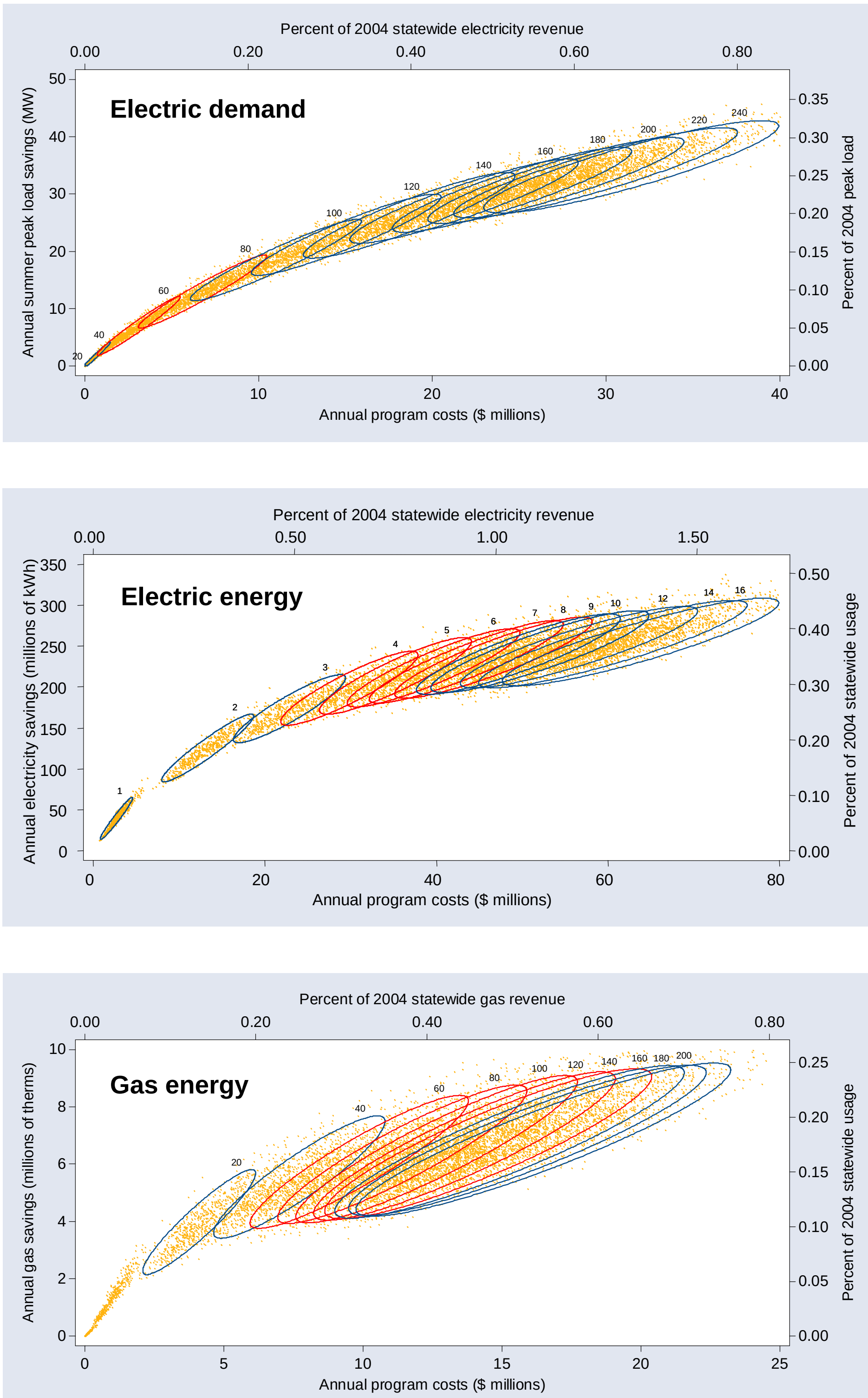
Second, the supply curves for electric energy savings show a large increase in potential savings when avoided costs cross 1 to 2 cents per kWh. Savings potential increases at a lower rate as avoided costs climb above 2 cents/kWh. This is because the base analyses for many of the key programs for electric energy savings produced savings estimates with levelized costs in the range of 1-2 cents/kWh. The jump is particularly pronounced in the residential sector, and is driven mainly by the large potential savings from CFLs, which enter the supply curve at between 1 and 2 cents per kWh.

FIGURE 13, OVERALL ENERGY EFFICIENCY SUPPLY CURVES (5-YEAR ANALYSIS)



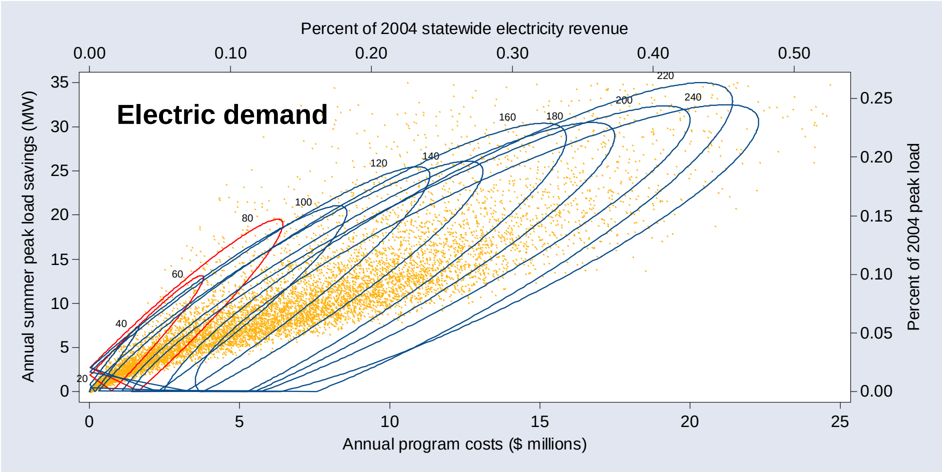
Key:
– Ellipses represent 90% probability region for program cost and savings at a given avoided cost noted above each ellipse
– Red ellipses depict avoided cost range used in combined analysis
– Points are individual iterations of probabilistic analysis (10% sample of iterations shown)

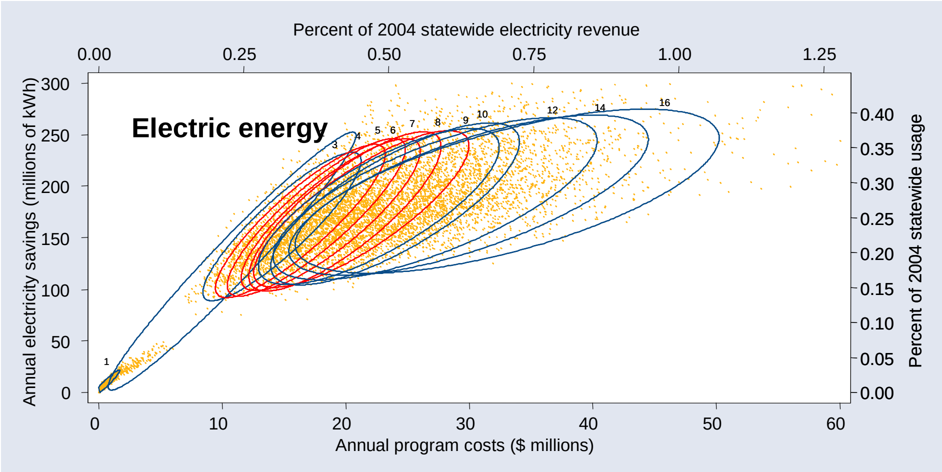
FIGURE 14, C&I SECTOR ENERGY EFFICIENCY SUPPLY CURVES (5-YEAR ANALYSIS)

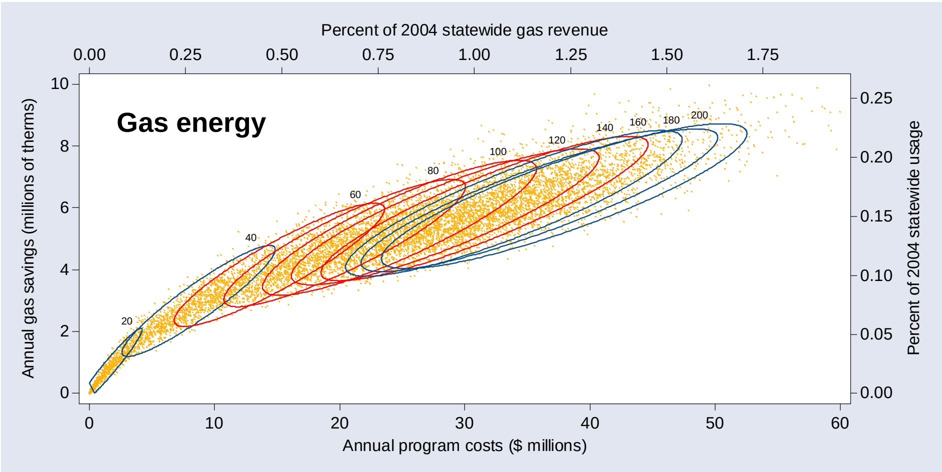


Key:
– Ellipses represent 90% probability region for program cost and savings at a given avoided cost noted above each ellipse
– Red ellipses depict avoided cost range used in combined analysis
– Points are individual iterations of probabilistic analysis (10% sample of iterations shown)

FIGURE 15, RESIDENTIAL SECTOR ENERGY EFFICIENCY SUPPLY CURVES (5-YEAR ANALYSIS)





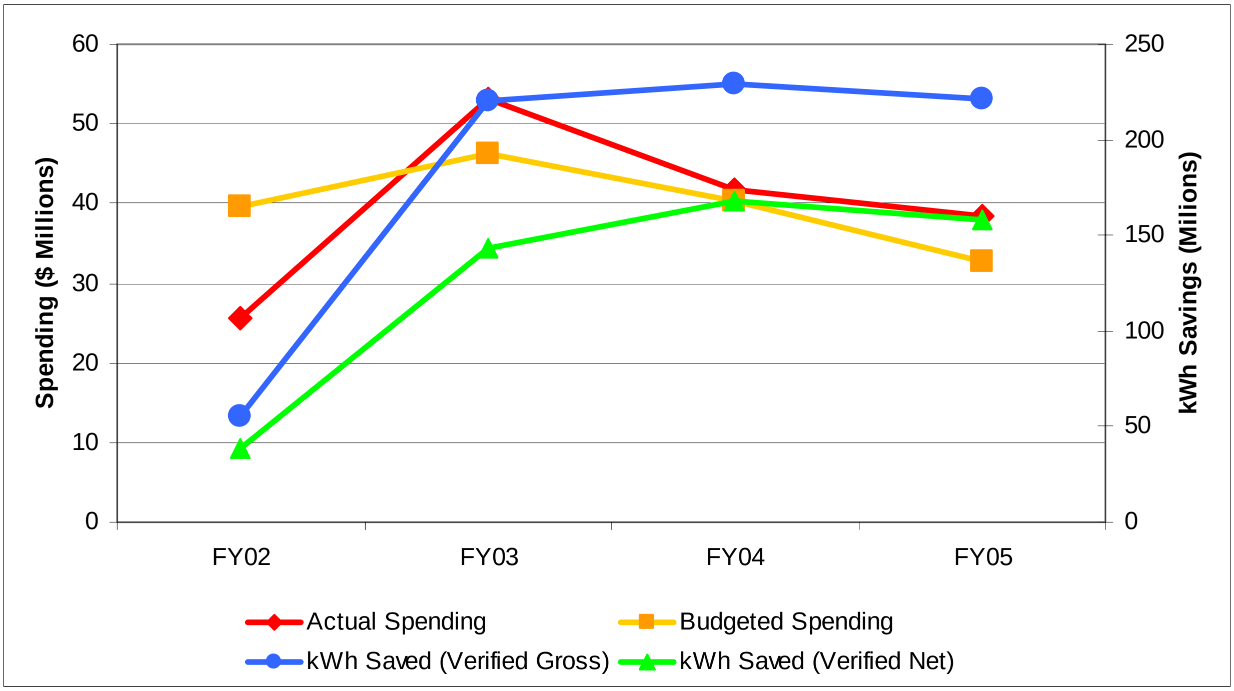


Key:
– Ellipses represent 90% probability region for program cost and savings at a given avoided cost noted above each ellipse
– Red ellipses depict avoided cost range used in combined analysis
– Points are individual iterations of probabilistic analysis (10% sample of iterations shown)

Benchmarking Results to Focus on Energy Program

The Focus on Energy Program has four years of performance results for the period FY2002-FY2005. The following figure shows the history of spending and savings.

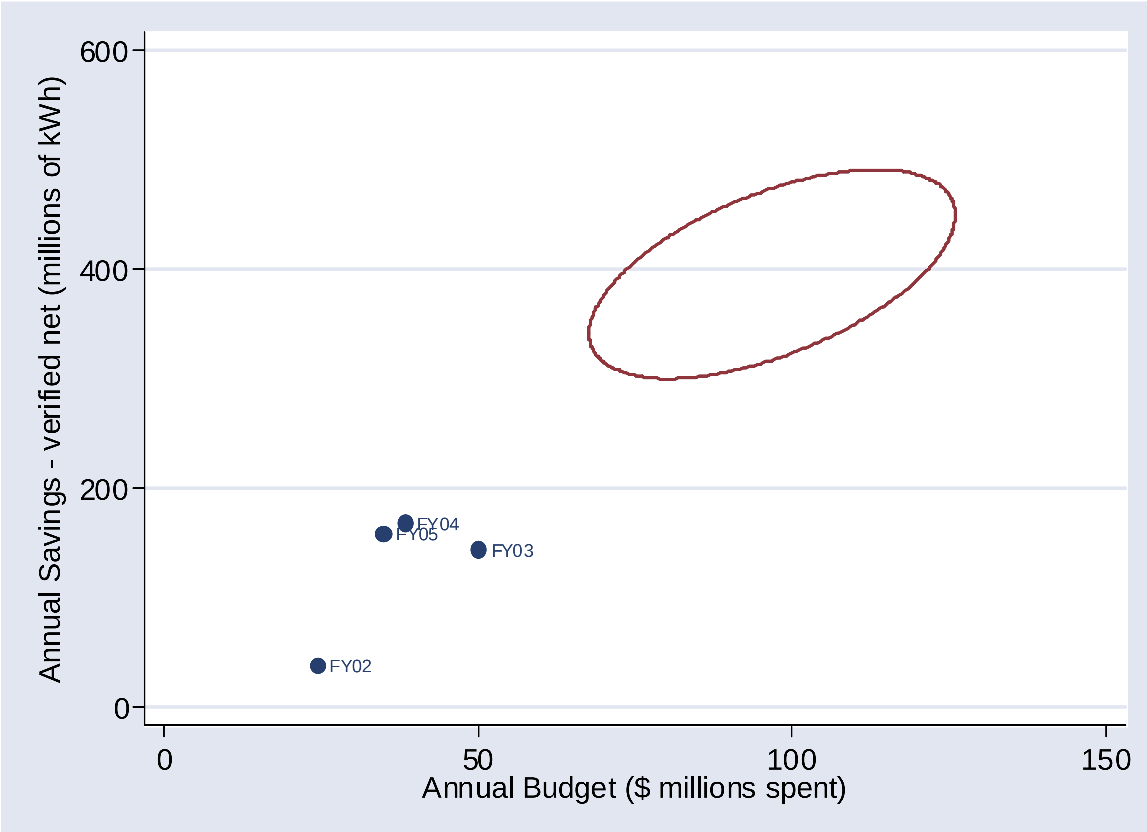
FIGURE 16, WISCONSIN FOCUS ON ENERGY PROGRAM RESULTS



Despite the reduction in budgeted spending in the FY04 and FY05 program years, savings declined only slightly due to the momentum of the initial program years. While the Focus on Energy program reports both verified gross and verified net savings, the data in this study are comparable to the verified net savings due to the exclusion of free riders. Figure 17 shows the five-year average study analysis compared to verified net Focus on Energy results for FY02 through FY05. The Focus on Energy results are comparable to the results of the combined analysis (Table 2). Note that both spending values represent total spending on a combined energy, demand, and therm programs; while results are measured in energy savings only.

This shows that, with some additional investment up to the range of $75 to $121 million, the Focus on Energy program could continue to provide positive net benefits. Focus on Energy results reflect actual spending for energy efficiency programs. (Renewable and Environmental Research expenditures are excluded from the Focus on Energy spending shown in Figure 17.) In addition, it is important to recognize that some municipal and cooperative utilities as well investor-owned utilities spend additional dollars on energy efficiency and conservation services. Savings data however is not available on comparable terms.

FIGURE 17, BENCHMARK RESULTS FOR WISCONSIN FOCUS ON ENERGY



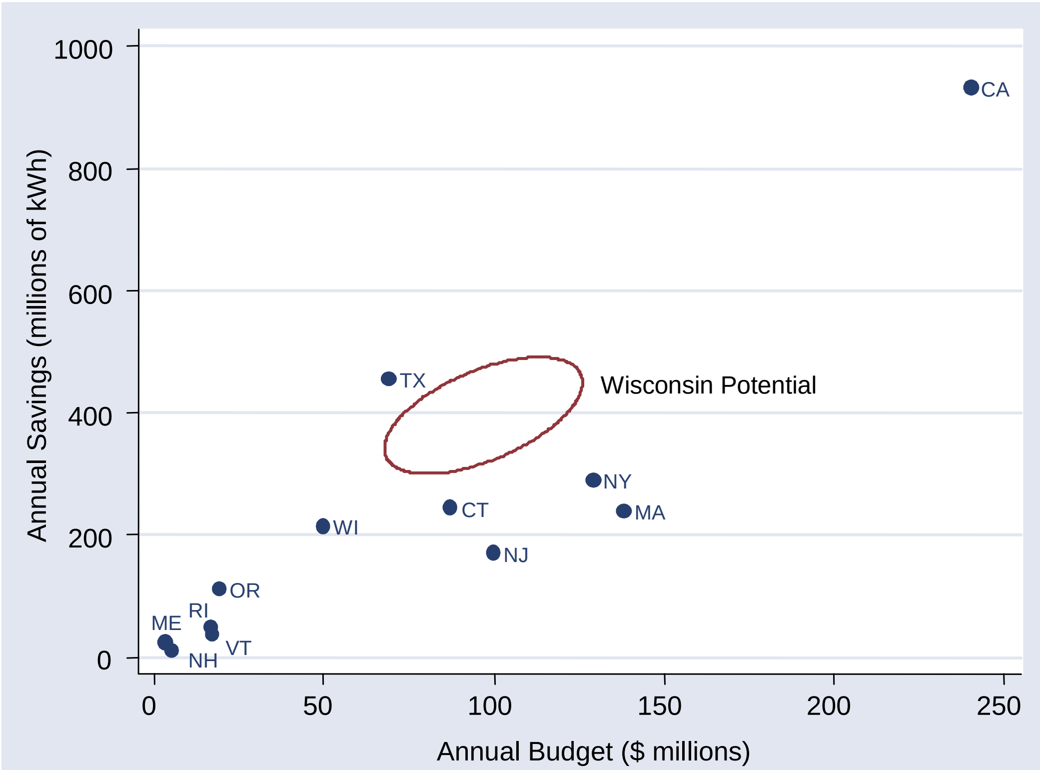
Benchmarking Results to Other State Programs

Eighteen other states offer statewide public benefits programs. Some are administered by utilities, some by state government, and some by independent organizations. While comparisons of expenditures and results across states must be reviewed cautiously, we found that the American Council for an Energy Efficient Economy (ACEEE) created a set of comparisons that is currently the best available. (Kushler et al, 2004). On the following figure we have plotted the actual budgets and savings for electric energy efficiency programs evaluated by ACEEE. Superimposed on this figure is the 90% probability ellipse which represents results of the five-year average combined analysis of this study.

The ACEEE data is taken from the years 2002 and 2003 and thus show the Wisconsin spending at a level higher than current budgets. The data has also been adjusted to reflect a calendar year. The rigor of evaluation applied to the results in each state varies greatly so comparisons must be made with caution.

Another caveat to this comparison is that the Wisconsin program reports verified gross savings rather than verified net numbers which are more comparable to our study results. Other states have indeterminate methods of measuring and evaluating savings so that precise comparisons are not reliable.

FIGURE 18, BENCHMARK RESULTS FOR ENERGY EFFICIENCY PROGRAMS, BUDGET TO SAVINGS



Source: ACEEE

The ACEEE data for electric energy savings shows Wisconsin (with 2002-2003 verified gross data) at a position below the ellipse representing annual potential. This suggests that there are gains to be made with additional investment that would move Wisconsin to a position of leadership over many states with respect to result per dollar invested.

As this study is being released, the California Energy Commission just announced an energy efficiency incentive to spend $1 billion over three years designed to eliminate 50 percent of annual growth. This is currently the most aggressive effort implemented by any state.

RESULTS: CUSTOMER-SITED RENEWABLE ENERGY POTENTIAL

The study examined the electricity and natural gas savings potential for six customer-sited renewable energy markets:

- Commercial solar photovoltaics
- Commercial solar thermal
- Residential solar thermal
- Wood residue for commercial/institutional heat
- Customer-sited commercial wind systems
- Agricultural anaerobic digestion

The six renewable energy markets in this study were chosen by stakeholder consensus as being most likely to exhibit the greatest potential over the next ten years in Wisconsin. They do not, however, represent the total customer-sited renewable energy potential in the state and make no attempt to estimate utility-scale renewable energy potential. Even the markets chosen are not all-inclusive for the technology they employ. For example, we looked at anaerobic digestion in the agricultural sector, but did not address its use with sewage treatment or food processing, which are two additional markets with promise in Wisconsin.

As with the energy efficiency markets, we conducted two related analyses: (1) a combined analysis that looked at the overall potential to offset conventional electricity and natural gas consumption at current avoided costs, and (2) a supply-curve analysis that estimates savings potential as a function of avoided cost. *Unlike* the energy efficiency analysis, given the small number of markets included, we did not extrapolate the results beyond the six markets in the study because it was not clear how representative the selected markets were of those not selected. The results that follow are thus confined to these six markets. Actual investment opportunities for customer-sited renewable energy will be higher than those reported herein.

COMBINED RESOURCE POTENTIAL

For the combined analysis, we looked at the aggregate ability of the six renewable energy markets to offset conventional electricity and natural gas at or below current utility avoided costs. The results suggest that across these six markets, program funding in the range of up to $7 to $11 million per year could be cost justified at current utility avoided costs (Table 7). Over five years, this level of funding in these markets has the potential to yield savings in conventional electricity and natural gas of up to 0.1 to 0.2 percent of 2004 statewide consumption. Over a 10-year period, the potential annual savings are roughly 80 to 85 percent higher for electricity, and 20 to 50 percent higher for natural gas: these are documented in Appendix B.

TABLE 7, ESTIMATED 5-YEAR RENEWABLE ENERGY POTENTIAL FOR SIX MODELED MARKETS

	Average annual	(% of 2004)[b]	5-year total[a]	(% of 2004)[b]
Program Funding ($ millions)	6.8 to 11.1	(0.09 to 0.14)	34.1 to 55.4	(0.44 to 0.71)
Electric Demand (MW)	1.9 to 2.7	(0.01 to 0.02)	9.6 to 13.4	(0.07 to 0.10)
Electric Energy (millions of kWh)	18.8 to 27.1	(0.03 to 0.04)	94.4 to 135.1	(0.14 to 0.20)
Gas Energy (millions of therms)	0.8 to 1.31	(0.02 to 0.03)	4.02 to 6.50	(0.10 to 0.17)

[a]Represents total savings that occur in Year 6, following five years of program operation.

[b]For energy and demand savings, figures are percent of 2004 annual statewide usage and summer peak demand. For program funding, figures are percent of 2004 statewide electricity and gas revenues.

Note: ranges are 90% probability boundaries from probabilistic uncertainty analysis.

At the program level, while several of the six markets contribute to the overall funding picture (Figure 19), most of the achievable electricity savings potential derives from anaerobic digestion and commercial wind systems. Similarly, wood residue and commercial solar thermal systems dominate the achievable gas savings potential.[7] Note that peak demand savings potential shown here is largely ancillary; that is, it represents peak demand impacts from programs that are cost effective in terms of saving energy, but not cost effective strictly from the standpoint of peak demand reductions.

The commercial photovoltaic market does not contribute to achievable potential in this analysis because our base model for that program area shows a levelized cost of energy in the range of 20 to 40 cents per kilowatt hour and peak demand impacts at $450 to $750 per annual kilowatt: these ranges are well in excess of the target utility avoided costs we used for the analysis. However, as the avoided costs of energy increase and as environmental costs of fossil generation are more fully accounted for, the potential for investment in PV and other renewable resources will increase.

[7] Anaerobic digestion also saves agricultural propane consumption, but that fuel is not covered in this study.

FIGURE 19, RELATIVE PROGRAM CONTRIBUTIONS TO RENEWABLE ENERGY COMBINED 5-YEAR POTENTIAL, PROGRAM COSTS

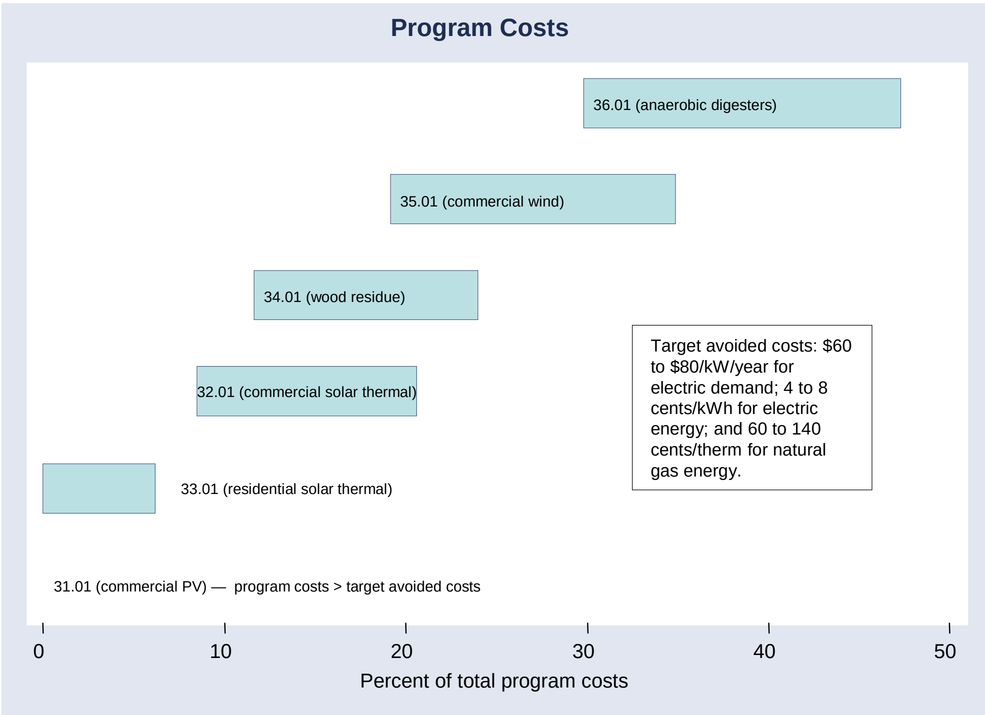


FIGURE 20, RELATIVE PROGRAM CONTRIBUTIONS TO RENEWABLE ENERGY COMBINED 5-YEAR POTENTIAL, ELECTRIC DEMAND

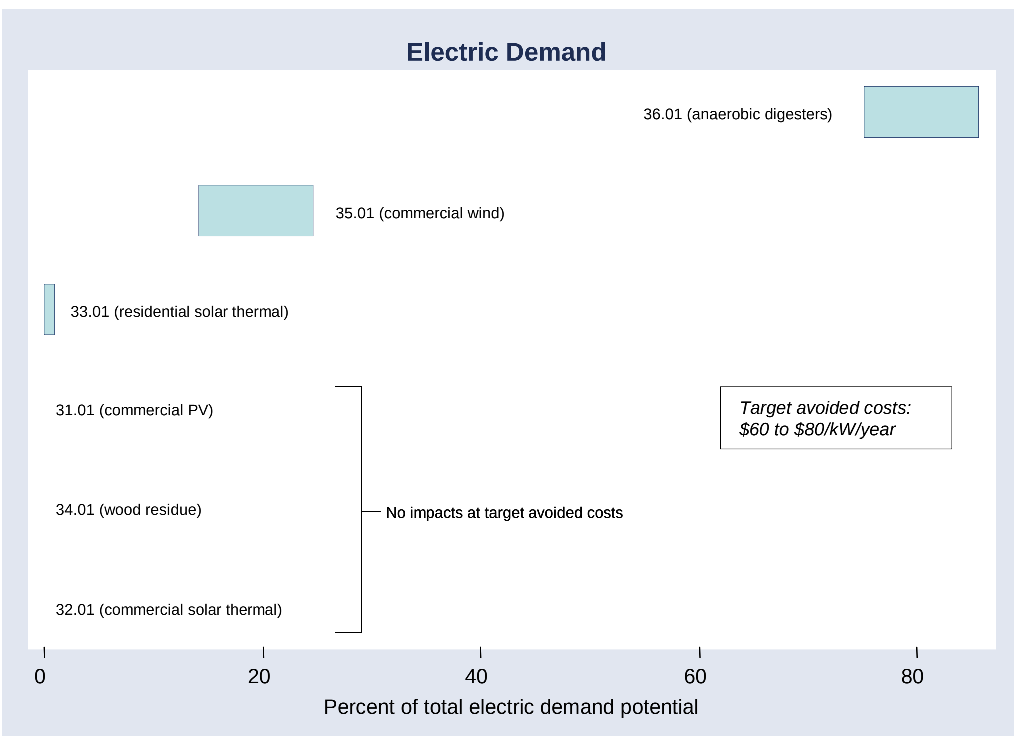


FIGURE 21, RELATIVE PROGRAM CONTRIBUTIONS TO RENEWABLE ENERGY COMBINED 5-YEAR POTENTIAL, ELECTRIC ENERGY

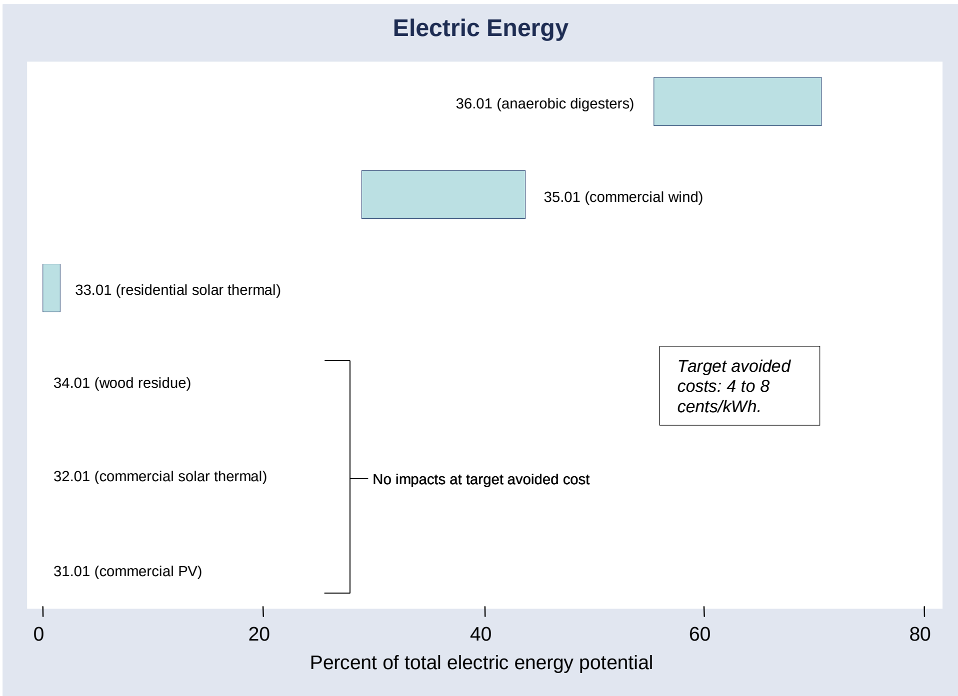
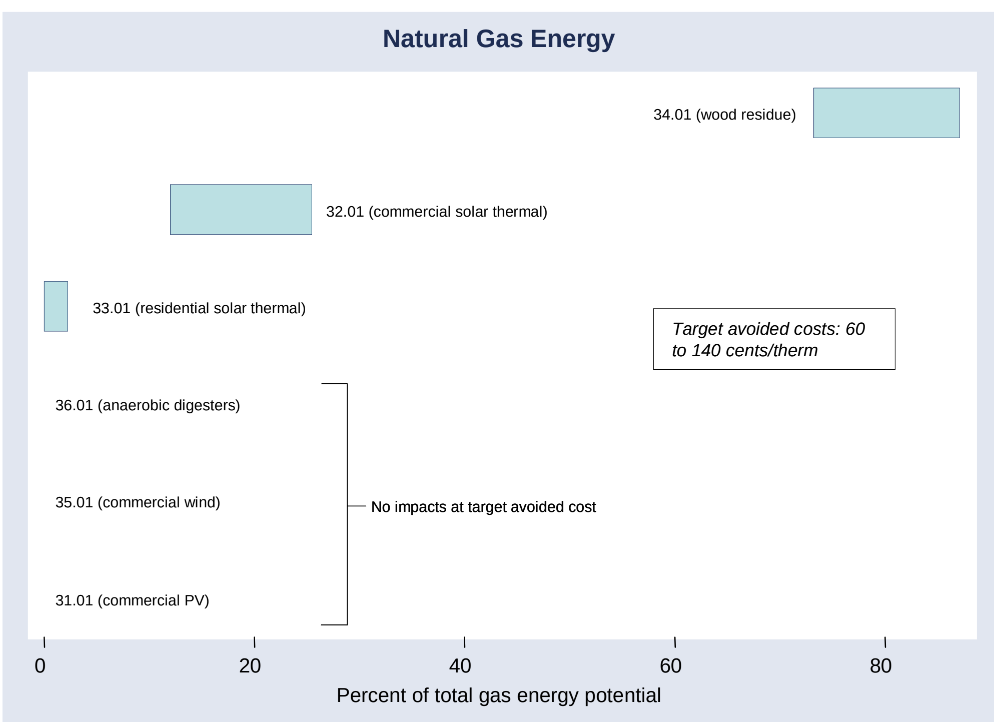


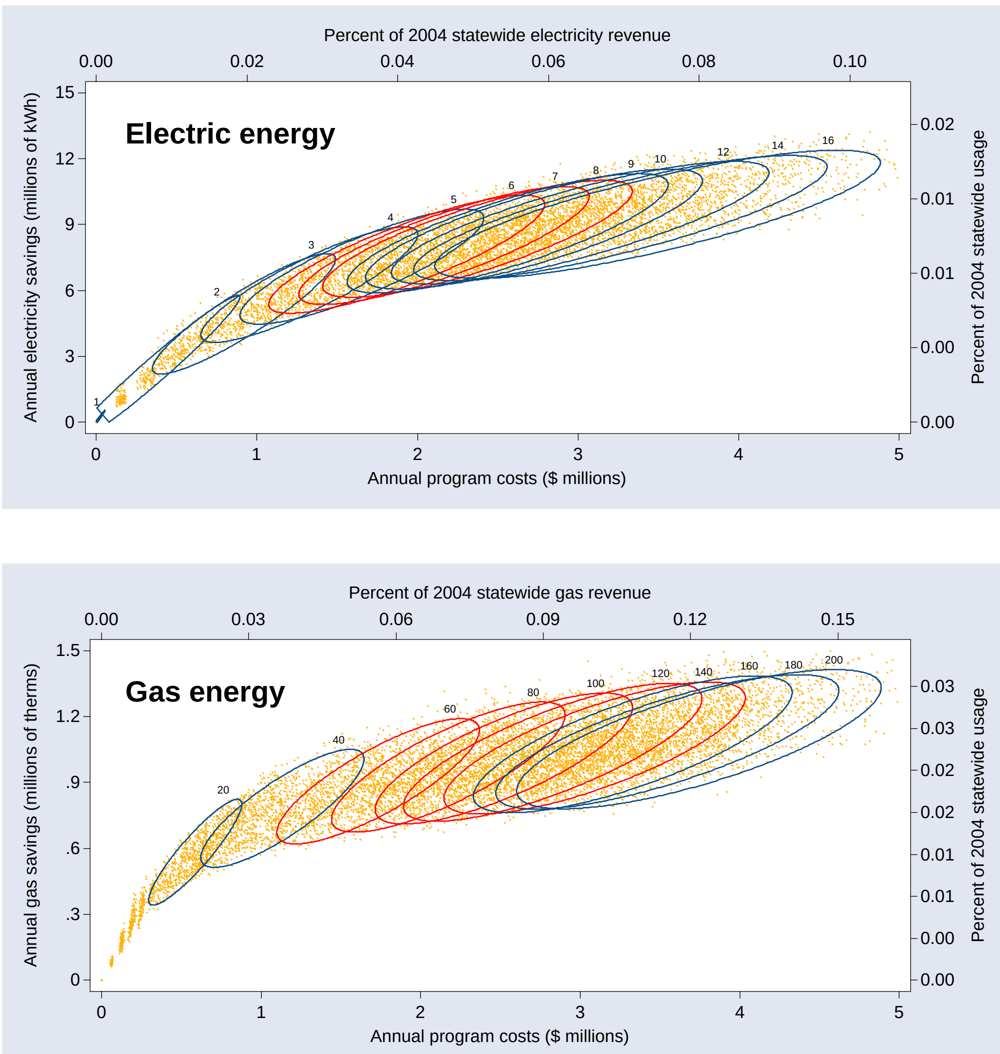
FIGURE 22, RELATIVE PROGRAM CONTRIBUTIONS TO RENEWABLE ENERGY COMBINED 5-YEAR POTENTIAL, NATURAL GAS ENERGY



INDIVIDUAL RESOURCE SUPPLY CURVES

Estimated five-year potential supply curves for the six renewable energy markets are shown in Figure 23. We omit a supply curve for peak demand savings here because—although we found ancillary peak demand savings for programs that save electric energy cost effectively—our analysis showed little or no potential from the six markets strictly on the basis of cost effective demand savings.

FIGURE 23, RENEWABLE ENERGY SUPPLY CURVES FOR SIX MARKETS (5-YEAR ANALYSIS)



Key:
– Ellipses represent 90% probability region for program cost and savings at a given avoided cost noted above each ellipse
– Red ellipses depict avoided cost range used in combined analysis
– Points are individual iterations of probabilistic analysis (10% sample of iterations shown)

CONCLUSIONS

Our analysis shows that, from a program administrator perspective, a statewide energy efficiency program funded up to a range of $75 to $121 million per year on average over the next five years could produce achievable savings at or below the cost of generating or purchasing electricity and natural gas in Wisconsin. Accounting for the environmental and broad economic benefits of saving energy would increase the value of energy savings, and would increase the investment level that could be spent cost-effectively from a broader resource perspective. The study results for the combined resource analysis are based on avoided energy and demand cost ranges which reflect current costs. Should actual avoided costs move above or below these ranges, the cost-effective level of investment will also move similarly. In addition, these results assume program ramp-up and market response rates that limit achievable potential in the near-term. If programs could be implemented which immediately realized the year 5 potential, results would be 20 to 60 percent higher than those reported here.

Our study also shows that, for six customer-sited renewable technologies, the state of Wisconsin could fund a program in the range of up to $7 to $11 million over the next five years to offset conventional electricity and natural gas at or below current utility avoided costs. Other renewable markets not included in the study may also show promise.

After five years of program investment at the levels found to be justified by avoided energy costs, the effect of combined program efforts would be enough to:

- Reduce growth in electric demand by 15 to 25 percent;
- Eliminate the need for one average-size electric power plant;
- Save enough electricity to power between 170,000 and 240,000 Wisconsin homes; and
- Save the amount of natural gas used in 35,000 to 65,000 Wisconsin homes.

These benefits can be achieved with annual program spending equal to 1 to 1.5 percent of total electric and natural gas revenues.

Potential estimates are inherently uncertain, since they involve projections about the future and about consumer and business responses for which little empirical data exist. In general, we believe that our estimates of potential are cautious from several standpoints:

- Avoided cost ranges are pegged to current price levels;
- Environmental and economic benefits of energy efficiency and renewable energy are not counted;
- Savings are counted only where a clear enunciation of a program approach can be made;
- Long-lasting market effects beyond the life of the analysis horizon are not counted; and
- Program ramp-up is built into the 5-year horizon.

Despite conservative aspects of the analysis, the results suggest that program funding in Wisconsin could be two to four times higher than the current funding levels for Focus on Energy, and still be cost effective based on the cost of conserved energy. Further analysis of non-energy benefits and long-lasting market effects would likely indicate that funding levels could be justified beyond those identified in this study. In addition, where markets for energy efficiency have existing well developed programs in Wisconsin, ramp-up of investment would not be necessary.

LIMITATIONS OF THE ANALYSIS

There are several aspects of the analysis that are difficult to model, even with explicit treatment of uncertainty. First, we used scaling curves to estimate the full achievable potential at a given avoided cost (see Appendix A for details.) This elicited comments from reviewers of the draft version of the study that were polar opposites: some said that the scaling curves caused us to significantly *underestimate* achievable potential, while others said that the same aspect of the analysis caused us to substantially *overestimate* potential. (This in itself is a good indicator of the degree to which professional judgment and subjectivity enter into this type of analysis.) While we acknowledge that these curves have little empirical basis, we did verify that they are roughly consistent with similar curves used to establish the relationship between incentive levels and market response in a recent study of energy efficiency potential in California. We also took care to ensure that the scaling curves did not result in estimates of impacts that exceed the technical or economic limits of the markets.

Second, energy price uncertainty and, in particular, increased volatility in natural gas prices create a moving target for this analysis. While it can be expected that higher energy prices will lead to increased interest in energy efficiency on the part of Wisconsin residents and businesses, the magnitude and nature of the response is difficult to predict. It has been argued that sticker shock from rapid spikes in prices – such as has occurred in natural gas markets due to the recent gulf-coast hurricanes – provides a greater stimulus for energy efficiency and conservation actions than does a gradual increase in prices over time. Moreover, an assessment of the potential for net program impacts must account for the fact that price shocks will increase naturally occurring market activity that would take place with or without government or utility-sponsored programs. Our analysis is based on a relatively static picture of energy prices as of mid-2005, and we have not tried to incorporate short- or long-term changes in energy prices.

Third, it is difficult for an analysis such as this to fully account for impacts from programs that create long-lasting changes to markets which persist beyond the duration of the program itself – so-called market transformation effects. The furnace market in Wisconsin provides a good example of such transformation effects. Utility rebates in the late 1980s and early 1990s pushed Wisconsin to the point where the vast majority of furnaces sold in the state were high efficiency condensing models. This high market share (which is well above that of neighboring states) has persisted for more than a decade after the phase-out of these rebates, and is arguably a persistent effect of the now defunct incentive programs.

The trouble is that it is difficult to identify these effects upstream, and interceding events may cut short market transformation gains. For example, more recently, incentives for central air conditioners have pushed up the market share for high efficiency models. But new federal efficiency standards for air conditioners in 2006 will effectively render at least some of these gains moot. Indeed cause and effect can be difficult to disentangle as changes in local codes and federal efficiency standards lock in efficiency gains that are often first incubated and nurtured through voluntary utility and state programs. While we have tried to include in our analysis all program-induced impacts that occur within our 5- or 10-year analysis timeframes, we have not attempted to account for program effects that occur beyond these periods. Given that some programs could be expected to have longer-lasting market effects, our results are therefore conservative.

Finally, while our analysis extrapolates program potential to funding levels and utility avoided costs that are higher than exist today, there are limits to this extrapolation. If policymakers contemplated, say a 10-fold increase in program funding, or if energy prices suddenly quadrupled, we would not expect our analysis to necessarily be a reliable indicator of the level of savings that could be achieved.

RECOMMENDATIONS

The study was designed to be used by the PSCW as an input to its decision on the future level of investment in energy efficiency and customer-sited renewable energy programs, should those decisions be returned to the PSCW through legislation. This study provides data and information on the benefits of increased funding over the current spending levels. We recommend that this information be incorporated into the PSCW's Strategic Energy Assessment or its successor. In this way energy efficiency investments can be carefully weighed against impending forecasts of demand and supply (proposed generation as well as availability of natural gas). We also recommend that this study be updated within three to five years so that subsequent investment levels can keep current with technological changes as well as with changes in avoided costs.

With respect to the renewable results, a state program's primary contributions toward these markets remains information, project facilitation, coordination of stakeholders and issues, and carefully modulated financial incentives. Incentives that are too aggressive may recreate the counterproductive situation that occurred in the 1970's when generous government subsidies pumped up consumer demand and were then withdrawn before the industry had gathered its own steam. The renewable energy industry is still recovering from the negative image that resulted. The investment levels suggested for the six renewable markets should provide the appropriate level of intervention to move these markets toward self-sufficiency.

The interpretation of the study results must be analyzed with reference to ratepayer impacts, the potential of other utility rate programs designed to save energy and demand such as load management, real-time or market pricing, buyback rates for customer-sited renewable generation, as well as broader environmental and economic benefits.

The study results should also be reviewed by current public benefit administrators to determine if current target markets may be modified or expanded based on cost-effectiveness demonstrated in the study.

FOLLOW-UPS AND ADDITIONAL RESEARCH

At the onset of this study, the Advisory Committee considered a number of additions to the scope. Due to time constraints, those additional features were not included in the scope but might properly be considered as appropriate and valuable follow-ups. First, the study results could be disaggregated by utility service territory to take into account different customer and climate mix. Second, the results for each study market could be mapped to time of day to get richer information about the ability of a program to avoid peak and about the ability of a program to reduce specific power plant emissions based on a projected dispatch order. Finally, the study could also be expanded to extract specific achievable energy efficiency potential results for a target group of customers or building types which incorporate parts of several markets in this study. One example might be government buildings or grocery stores.

In the course of performing this study, we became aware of several gaps in available information and data related to the potential for energy efficiency and renewable energy. We have documented those research gaps in Appendix F. More complete information would have allowed us to use more precise estimates of savings. We recommend that a public benefits program reserve a budget for independent research to provide data and information that will support continuous improvement and a richer understanding of customer participation in public benefits programs.

Although this study provided an estimate of the "achievable" rather than the "economic" potential, it may be useful to create an estimate of economic potential in future iterations of this study to provide a better understanding of the upper limits to potential. In addition, this study did not estimate the costs to residential and business customers of participating in programs. While it was not necessary to include customer costs in an estimate based on a program administration perspective, it would be useful to estimate direct customer expenses associated with program participation to help program administrators better understand the motivations and barriers to consumer participation in programs.

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APPENDIX A: METHOD AND SCOPE

The fundamental approach we used for this study was to:

- Identify 36 key markets for inclusion in the study (30 energy efficiency markets and 6 renewable energy markets
- Estimate potential electricity and natural gas savings based on identifiable program approaches;
- Aggregate the net, program-induced savings potential across these markets; and
- Expand these aggregated results to include all energy efficiency markets applicable to Wisconsin.

In each of these steps, we relied on an extensive set of empirical data and input from both an advisory committee and a large group of project stakeholders and market observers. Empirical data was based on past and existing programs in Wisconsin, experiences of model programs in other states, market and economic statistics, the Energy Policy Act of 2005 and state-level legislation, and other sources. For a list of sources used, please see the references in Volume II of this study.

In most respects, our method resembles those of potential studies conducted in other states, but our study was atypical in three respects:

1. We limited our analysis to energy savings associated with program approaches that could be clearly enunciated or identified. This limitation assumes that program approaches that have not been clearly enunciated would be unlikely to be implemented.
2. The impacts that we credited to the programs are *net* impacts; that is they represent the net difference in statewide energy consumption and peak electricity demand with the program in place compared to a no-program scenario.
3. Each of our approximately 1,200 model inputs includes an uncertainty range that acknowledges the varying degrees of precision in our estimates and whose aggregate effects are accounted for through the use of a Monte Carlo model to aggregate individual market results. Consequently, our results are shown as ranges, rather than specific numbers.

The remainder of this section describes the four fundamental steps of our methodology in more detail.

IDENTIFYING KEY MARKETS

The first step of our analysis was to identify the markets to be studied in detail. We chose 36 markets based, in part, on available budget and the belief that we could address 75-90 percent of the available potential by studying these markets. These markets were split among the residential sector (15 markets), the commercial/industrial sector (15 markets), and the renewable sector (6 markets). Individual markets comprised particular types of products, such as clothes washers, and functional activities that have an energy implication, such as construction of new buildings. Selection of the 36 markets was based on a review of potential studies in other states and input from the advisory committee and stakeholders.

TABLE 8, MARKETS

Sector	Market ID	Program Areas
Commercial & Industrial	1.01	High Performance New Buildings
	2.01	Unitary HVAC Replacement and System Improvements
	3.01	Lighting Remodeling & Replacement Upgrades
	4.01	Boiler Replacement & Systems Improvements
	5.01	Lighting System Retrofit Improvements
	6.01	Chiller Replacement and System Improvements
	7.01	Ventilation System Improvements
	8.01	Refrigeration System Improvements
	9.01	Motors: New, Replacement and Repair Market
	10.01	Compressed Air Systems Improvements
	11.01	Fan and Blower Systems Improvement
	12.01	Pump Systems Improvement
	13.01	Manufacturing Process Upgrades
	14.01	Water & Wastewater System Improvements
	15.01	Agriculture Energy Efficiency Upgrades
Residential	16.01	ENERGY STAR Marketing
	16.02	Retailer Promotion of ENERGY STAR Consumer Electronics
	17.01	Incentives for CFLs
	18.01	Multi-family Common Area Lighting – Direct Install Market
	19.01	Incentives for Variable Speed Furnaces
	20.01	Central AC Upgrade Incentives
	20.02	HVAC Installation Practices
	21.01	Multi-family Heating System Replacement – medium and larger buildings
	22.01	Room AC Early Retirement
	22.02	Room AC Retailer Stocking Incentives
	23.01	Incentives for Homeowner Water Heater Purchases – Fuel Conversion
	23.02	Incentives for Homeowner Water Heater Purchases – Power Vent/Close the Hole
	23.03	Incentives for Homeowner Water Heater Purchases – On-demand/Close the Hole
	24.01	Incentives for Energy Efficient (EE) New Home Construction
	25.01	Remodeling Shell Improvements
	26.01	Dehumidifier Early Retirement
	26.02	Dehumidifier Non-dispatchable Load Control
	27.01	Direct Install Market through Partners – Owner-occupied
	27.02	Direct Install Market by Program Staff – Owner-occupied
	27.03	Direct Install Market by Program Staff – Multi-family (5+ units)
	28.01	Shell Improvements
	29.01	Incentives for Homeowner Clothes Washer Purchases
	30.01	Multi-family Fuel Switching

Sector	Market ID	Program Areas
Renewable	31.01	Customer-sited, Grid-connected, Commercial Solar Photovoltaics (PV)
	32.01	Commercial Solar Thermal (Hot Water)
	33.01	Residential Solar Thermal (Hot Water)
	34.01	Wood Residue for Commercial/Institutional Heat
	35.01	Customer-sited, Grid-connected, Commercial Wind Energy
	36.01	Agriculture Anaerobic Digestion

ESTIMATING POTENTIAL ENERGY SAVINGS

Once the markets were established, we estimated costs and impacts for one or more program approaches for each market. These were based on stakeholder input, data on similar programs in other states, and our own secondary research into the nature of each market. The estimates are meant to represent aggressive—but achievable—levels of program activity.

The specific approach that we used varied from market to market, but generally involved the following steps:

1. Assess per-unit savings associated with the energy efficiency measures (or renewable energy technology) promoted by each program;
2. Project program participation trends across the 10-year analysis period;
3. Estimate program costs; and,
4. Estimate the life of the measures promoted by the program.

Additional details about the markets, program approaches we considered, and the specific inputs for the analysis are provided in Volume 2: Technical Appendix. Altogether; we assessed 44 program approaches for the 36 markets, and defined about 1,200 input variables.

The impacts that we credited to the programs are *net* impacts: that is, they represent the net difference in statewide energy consumption and peak electricity demand with the program in place compared to a no-program scenario. In this sense, the estimates are meant to take into account naturally occurring market trends, program free riders, and market transformation effects, during the analysis period. We did not, however, attempt to model market effects caused by the programs beyond the ten-year analysis horizon.

The costs that we estimated include only program-related costs such as financial incentives, marketing and administrative costs. We did not include the costs to consumers or businesses to purchase higher efficiency equipment or retrofit their buildings for energy savings: the analysis thus reflects the perspective of the cost effectiveness of program investment. This is often called the Program Administrator perspective.

We calculated the levelized resource costs for each program. This key calculation spreads the program costs over the life of the impacts from the program (using an appropriate discount rate). It provides a lifecycle measure of the cost of each saved kilowatt-hour of electricity, kilowatt of summer peak demand or therm of gas. These levelized resource costs can be directly compared to the levelized costs for generating or purchasing electricity and natural gas. In fact, the crux of the study is to estimate the potential for energy efficiency and renewable energy savings at or below these utility avoided costs.

For many programs, we found that the calculated resource cost was well below the current range of utility avoided costs—a finding that has been documented elsewhere as well. For these programs, the base analysis underestimates the full potential for the market to the extent additional funding could increase program impacts even if the marginal savings are not as great. If a program produces electricity savings at, say, two cents per kWh compared to a utility cost of 6 cents/kWh to generate electricity, then it is cost effective to spend additional money on the program up to the point where the marginal cost of savings equals the utility avoided cost.

Similarly, there may be instances where a program model may produce levelized savings that are above the avoided cost target, but where, if the program was scaled back (say be reducing incentives), it could produce impacts at or below the target avoided cost.

We addressed these situations by defining relative scaling functions that define the relationship between overall program spending and impacts. Our presumption was that, as program funding is increased, program impacts also increase, albeit at an ever declining rate. The curves also presume that there is a fundamental upper limit to the impacts that can be obtained from a given program even with infinite funding. We assigned a scaling curve to each program in the analysis to allow for increased – or decreased – program expenditures and impacts depending on how the base resource cost of the program compares to the target utility avoided cost.

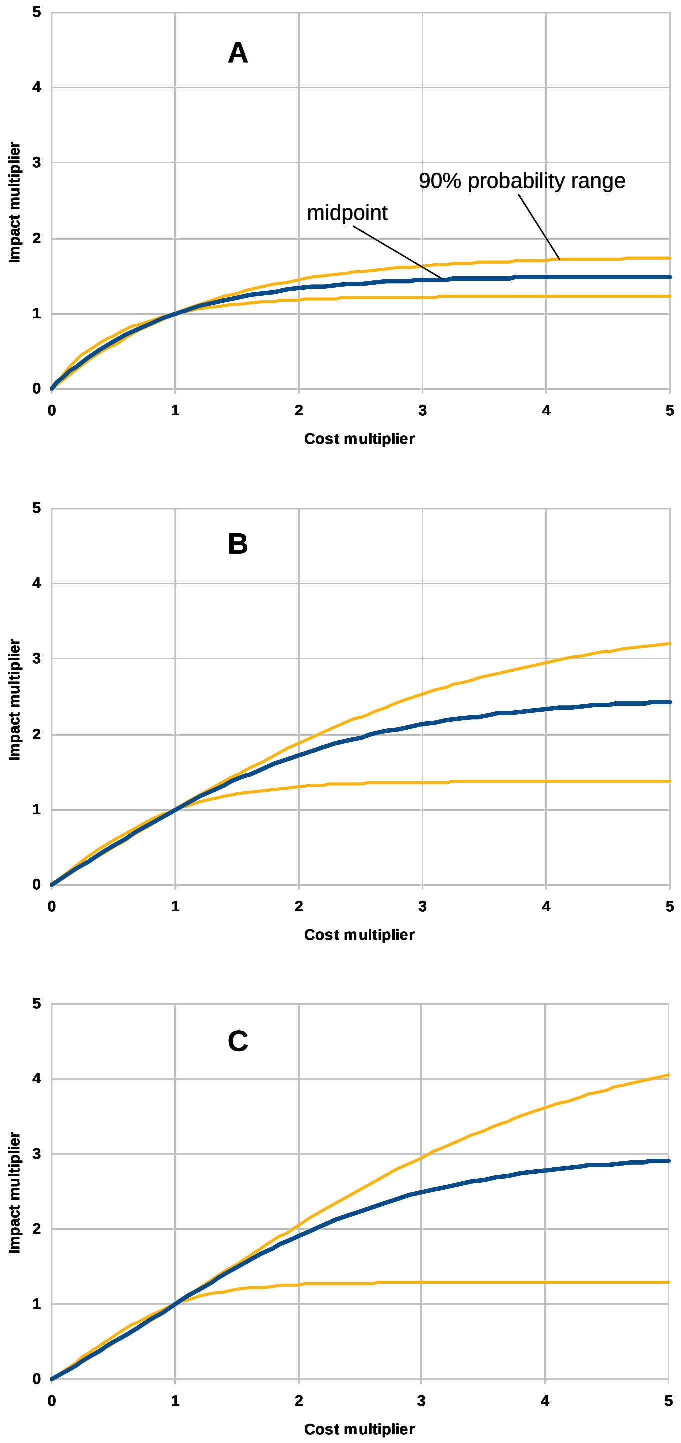
We used a logistic function to define the relationship between program spending and impacts for scaling program efforts. The curves are cast in terms of multipliers for program costs and impacts, such that a particular curve defines how much program impacts are multiplied for a given multiple of program spending. The base program models are mapped to these curves as corresponding to cost and impact multipliers of 1.0.

We assigned each program to one of three levels of impact scaling (A, B, or C) depending on our assessment of the maximum remaining achievable potential relative to the base program assessments. Since many programs were already defined as being quite aggressive to begin with—and since these programs often face fundamental limits in the size of the market—we assigned most programs to the 'A' category in order not to get scaled program impacts that exceeded fundamental market limits. Figure 24 shows the shapes of curves that we used, and TABLE 9 documents the assignments for all 44 program areas in the study.

As with all other inputs, the scaling functions incorporate uncertainty. Figure 24 shows the midpoint and 90% probability range for the three sets of curves that we defined. As the figure demonstrates, we assigned larger uncertainty for programs that we deemed to have higher scaling potential.

Note that these scaling curves are distinct from program ramp-up and market response curves over time. The scaling curves do not affect the time trend of impacts from a given program, but rather the overall size of the program funding and consequent impacts.

FIGURE 24, RELATIVE SCALING CURVES USED IN THE ANALYSIS



Note: Base program impact is at the point (1,1) on each curve.

TABLE 9, SCALING CURVE ASSIGNMENTS

Market ID	Market Name	Scaling Curve	Scaling Results: Program Costs	Scaling Results: Program Impacts
Commercial and Industrial Energy Efficiency				
01.01	High Performance New Buildings	A	1.2 to 2.4	1.1 to 1.5
02.01	Unitary HVAC Replacement and System Improvements	A	0.7 to 1.6	0.8 to 1.3
03.01	Lighting Remodeling & Replacement Upgrades	A	1.1 to 2.3	1.0 to 1.5
04.01	Boiler Replacement & System Improvements	A	1.6 to 3.3	1.2 to 1.6
05.01	Lighting System Retrofit Improvements	A	0.7 to 1.7	0.8 to 1.3
06.01	Chiller Replacement and System Improvements	A	1.0 to 2.1	1.0 to 1.4
07.01	Ventilation System Improvements	A	1.4 to 2.8	1.1 to 1.6
08.01	Refrigeration System Improvements	A	0.8 to 1.8	0.9 to 1.4
09.01	Motors: New, Replacement and Repair Market	A	0.9 to 2.0	1.0 to 1.4
10.01	Compressed Air Systems Improvement	A	1.3 to 2.5	1.1 to 1.5
11.01	Fan and Blower Systems Improvement	A	1.2 to 2.5	1.1 to 1.5
12.01	Pump Systems Improvement	A	1.3 to 2.6	1.1 to 1.5
13.01	Manufacturing Process Upgrades	A	1.5 to 3.0	1.1 to 1.6
14.01	Water and Wastewater System Improvements	A	1.0 to 2.0	1.0 to 1.4
15.01	Agriculture Energy Efficiency Upgrades	A	0.6 to 1.5	0.7 to 1.2
Residential Energy Efficiency				
16.01	ENERGY STAR Marketing	B	0.1 to 3.2	0.1 to 2.5
16.02	Retailer Promotion of ENERGY STAR Consumer Electronics	B	0.1 to 2.6	0.1 to 1.6
17.01	Incentives for CFLs	A	1.1 to 2.1	1.0 to 1.5
18.01	Multi-Family Common Area Lighting - Direct Install Market	A	0.2 to 1.0	0.3 to 1.0
19.01	Incentives for variable speed furnaces	A	0.9 to 2.1	0.9 to 1.4
20.01	Central AC Upgrade Incentives	B	0.4 to 2.8	0.4 to 2.3
20.02	HVAC installation practices	B	0.2 to 2.7	0.2 to 2.3
21.01	Multi-Family Heating System Replacement - medium and larger buildings	B	1.5 to 5.1	1.2 to 3.2
21.02	Multi-Family Heating System Replacement - small buildings	B	1.0 to 4.0	1.0 to 2.9
22.01	Room AC early retirement	B	0.1 to 0.8	0.1 to 0.8
22.02	Room AC Retailer Stocking Incentives	B	0.1 to 1.9	0.1 to 1.7
23.01	Incentives for Homeowner Water Heater Purchases - Fuel Conversion	B	1.5 to 5.4	1.2 to 3.2
23.02	Incentives for Homeowner Water Heater Purchases - Power Vent/Close the Hole	C	1.1 to 5.5	1.1 to 4.1
23.03	Incentives for Homeowner Water Heater Purchases - On-Demand/Close the Hole	A	0.8 to 2.3	0.9 to 1.5
24.01	Incentives for Energy Efficient (EE) New Home Construction	A	0.5 to 2.2	0.6 to 1.5
25.01	Remodeling shell improvements	A	1.0 to 2.4	1.0 to 1.5
26.01	Dehumidifier early retirement	B	0.1 to 0.9	0.1 to 0.9

Market ID	Market Name	Scaling Curve	Scaling Results	
			Program Costs	Program Impacts
26.02	Dehumidifier non-dispatchable load control	B	0.3 to 1.7	0.4 to 1.6
27.01	Direct Install Market through Partners - Owner-Occupied	B	0.6 to 3.2	0.7 to 2.6
27.02	Direct Install Market by Program Staff - Owner-Occupied	C	0.6 to 3.3	0.7 to 3.1
27.03	Direct Install Market by Program Staff - Multi-Family (5+ units)	A	1.2 to 2.6	1.1 to 1.5
28.01	Shell improvements	C	0.8 to 4.2	0.8 to 3.6
29.01	Incentives for Homeowner Clothes Washer Purchases	A	0.5 to 2.4	0.7 to 1.5
30.01	Multi-Family Fuel Switching	C	0.3 to 1.3	0.4 to 1.7
Renewables				
31.01	Customer-sited, Grid-connected, Commercial Solar Photovoltaics (PV)	A	N/A	N/A
32.01	Commercial Solar Thermal (Hot Water)	A	0.7 to 1.8	0.8 to 1.4
33.01	Residential Solar Thermal (Hot Water)	A	0.3 to 1.1	0.4 to 1.0
34.01	Wood Residue for Commercial/Institutional Heat	A	1.7 to 3.3	1.2 to 1.6
35.01	Customer-sited, Grid-connected, Commercial Wind Energy	A	1.0 to 2.2	1.0 to 1.5
36.01	Agricultural Anaerobic Digestion	A	1.2 to 2.4	1.1 to 1.5

AGGREGATION

We estimated the aggregate statewide potential by summing across the individual programs.

We looked at statewide potential in two ways. The first approach looks individually at each of the three resources (electric energy, electric demand and natural gas energy). For these analyses, we ran our model through a range of avoided costs for each resource, calculating the achievable potential and implied program funding at each target avoided cost. We then assembled these results into supply curves showing how program spending and savings vary with avoided cost.

The second approach looked simultaneously at the combined potential for savings (and the implied program funding levels) across all three resources. For this analysis, we fixed avoided costs at reasonable current values, and then tallied the potential impacts for all programs that provided cost effective savings for at least one of the three resources.

This combined analysis differs from the supply-curve approach in several ways. First, while the supply-curve approach focuses exclusively on one resource at a time, the combined analysis is more reflective of a balanced portfolio of programs to address natural gas and electric energy as well as peak electric demand.

Second, the combined analysis includes savings potential that would not be included if the sole focus was on an individual resource. For example, some programs produce electric energy savings quite cheaply, but are expensive when viewed solely in terms of peak electric demand reductions. In the combined analysis, the peak demand savings from programs that are cost effective on the basis of *energy savings* are included in the aggregate potential: in the supply-curve analysis, these peak demand savings would not be counted if they are not cost-effective on their own account.

Finally, the combined analysis accounts for negative impacts from programs that produce savings for one resource at the expense of increased use for another. Chief among these are fuel-switching efforts, such as a program to encourage homeowners to switch from electric to natural gas water heating. In the combined analysis the increased natural gas consumption from fuel-switching is deducted from the aggregate savings potential: in the supply-curve analysis, cross-resource effects are not counted, since the focus is on the potential for a single resource.

Uncertainty is inherent in this kind of study, requiring as it does projections of future program participation, estimates of how program impacts change with funding levels—as well as estimates of the impacts and lifetimes of the measures addressed by the program, not all of which are well-documented.

We addressed the issue of uncertainty explicitly for this study by defining uncertainty ranges for all inputs in the analysis. We then propagated the uncertainty in the inputs through to the results using a probabilistic approach known as Monte Carlo analysis. The essence of the technique is to re-run each analysis over many iterations (we typically used 1,000 to 5,000), while randomly varying the analysis inputs within their defined uncertainty bands. Each iteration produces a somewhat different result based on the random variation in the inputs, and this collection of results can be reported in probabilistic terms. Throughout, we report results in terms of 90 percent probability ranges from the Monte Carlo analyses: that is to say, if a particular Monte Carlo run produced a distribution of results from 1,000 random iterations, we would report the range representing the 5^{th} and 95^{th} percentiles, which would correspond to discarding the lowest and highest 50 iterations, and reporting the minimum and maximum of those that remain.

Although all 1,200 inputs to our analysis had uncertainty ranges assigned to them (these are detailed in the individual market write-ups in Volume 2: Technical Appendix) a significant proportion of the uncertainty in the overall results derives from a handful of global parameters that affect estimates for most or all of the markets. These are as follows (with our assigned uncertainty ranges):

1. **Discount rate** (3 to 7%) — we used this key value in calculating the levelized resource cost for each program. (Based on past PSCW practice.)
2. **Cost adder** (15 to 25%) — we increased the direct costs for each program by this percentage to account for portfolio-level administration, evaluation, research and other functions. (Based on review of several public benefits program budgets.)
3. **Energy efficiency extrapolation factor** (75 to 90%) — this factor represents our estimate of the percent of all energy efficiency markets accounted for in the 30 selected for the study, and derives from comparisons we made early in the study with potential studies from other states. We used this factor to extrapolate results from the 30 markets selected for the study to all energy efficiency markets. (Based on our Benchmark Study.)
4. **Avoided costs** ($60 to $80 per kW per year for electric demand, 4 to 8 cents per kWh for electric energy, and 60 to 140 cents/therm for natural gas energy) — we used these avoided cost ranges for the combined analysis of aggregate potential. (Based on review of past PSCW practice including recent construction cases, utility “buy-back” rates, and the SEA.)

We used uniform distributions for all inputs: that is, all valued in a input parameter's uncertainty range were considered to be equally likely. Some early analysis with alternative distributions (Gaussian and triangular) suggested that the choice of the distribution shape did not have a substantial impact on the output of uncertainties.

Finally, we also defined numerous correlations across inputs. In some cases the same input value was used in more than one market: we made sure that these were fully correlated. We also defined lesser degrees of correlation among input variables that were likely to vary up or down together.

EXPANDING AGGREGATED RESULTS

For estimates of statewide potential from energy efficiency programs, we applied a multiplier to extrapolate the results from the 30 markets included in the study to all energy efficiency markets. As noted above, the multiplier assumes that the markets included in the study represent 75 to 90 percent of all possible markets, based on our analysis of other potential studies.

For renewables, we did not feel that the six markets included in the study could be reasonably extrapolated to all renewable energy markets. The results presented here are therefore confined to the six markets included in the study. These markets were intended to represent the most cost effective opportunities. However, there are other renewable market opportunities not included in the study. Appendix H lists all markets considered for inclusion.

APPENDIX B: 10-YEAR ANALYSIS RESULTS

The table below shows estimates of combined achievable potential over a ten-year period beginning in 2006. These results are based on the same analysis reported in the main report, but with a 10-year analysis period rather than the 5-year results reported there. As with other reported results, the figures for energy efficiency below are extrapolated to all energy efficiency markets, but the renewables results are confined to the six markets included in the study.

TABLE 10, ESTIMATED 10-YEAR ACHIEVABLE POTENTIAL

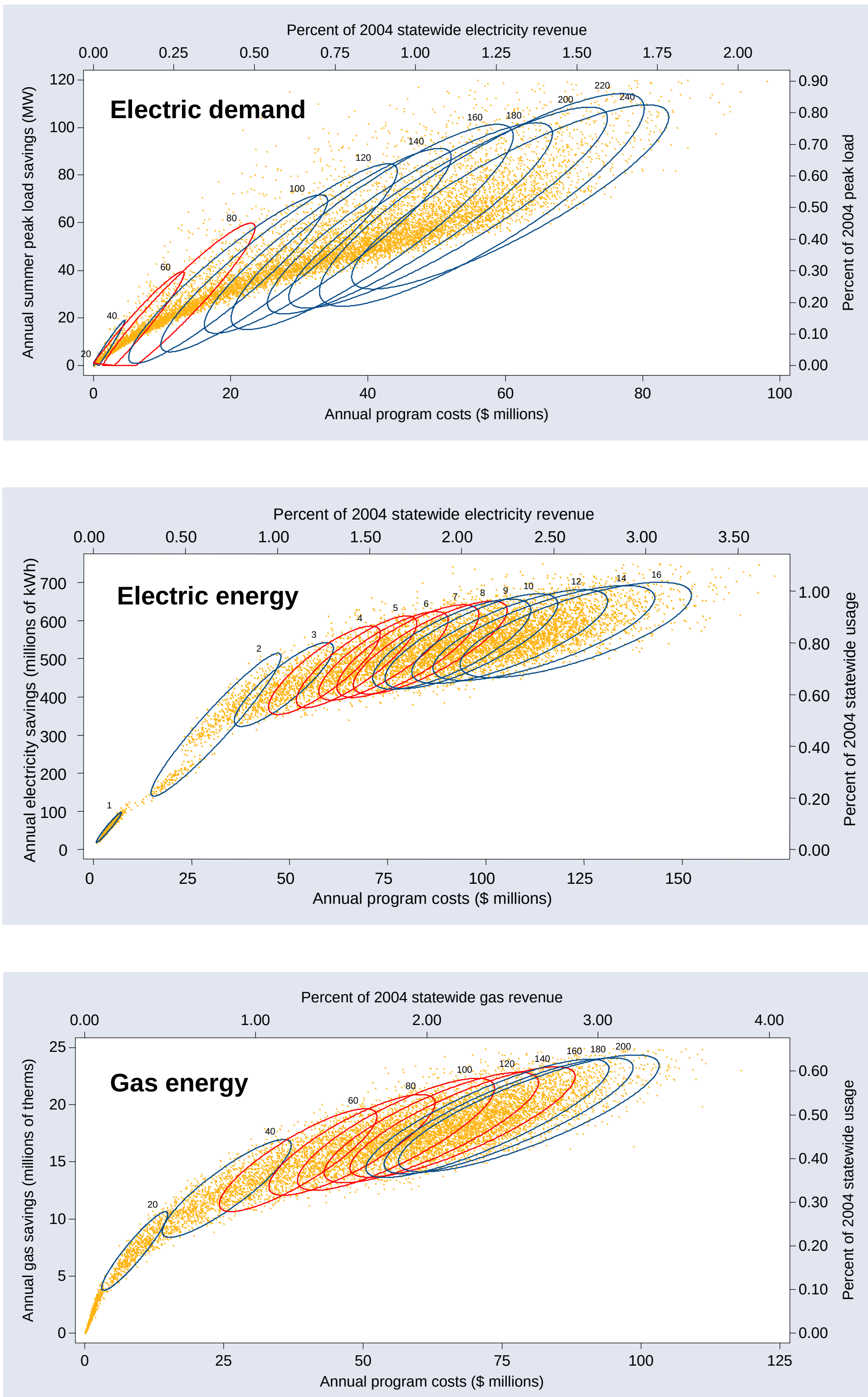
	Average annual	(% of 2004)[a]	**10-year total**	(% of 2004)[a]
Overall Energy Efficiency				
Program Funding ($ millions)	101 to 163	(1.3 to 2.1)	1,011 to 1,629	(13.0 to 21.0)
Electric Demand (MW)	56 to 106	(0.4 to 0.8)	560 to 1,061	(4.2 to 8.0)
Electric Energy (millions of kWh)	414 to 624	(0.6 to 0.9)	4,137 to 6,239	(6.1 to 9.2)
Natural Gas Energy (millions of therms)	11 to 20	(0.3 to 0.5)	114 to 197	(3.0 to 5.2)
C&I Sector Energy Efficiency				
Program Funding ($ millions)	47 to 80	(0.6 to 1.0)	468 to 798	(6.0 to 10.3)
Electric Demand (MW)	36 to 54	(0.3 to 0.4)	363 to 543	(2.7 to 4.1)
Electric Energy (millions of kWh)	221 to 326	(0.3 to 0.5)	2,207 to 3,262	(3.3 to 4.8)
Natural Gas Energy (millions of therms)	5 to 10	(0.1 to 0.3)	50 to 100	(1.3 to 2.6)
Residential Sector Energy Efficiency				
Program Funding ($ millions)	48 to 92	(0.6 to 1.2)	475 to 922	(6.1 to 11.9)
Electric Demand (MW)	15 to 60	(0.1 to 0.5)	153 to 599	(1.2 to 4.5)
Electric Energy (millions of kWh)	164 to 331	(0.2 to 0.5)	1,644 to 3,307	(2.4 to 4.9)
Natural Gas Energy (millions of therms)	5 to 11	(0.1 to 0.3)	52 to 114	(1.4 to 3.0)
Six Renewables Markets				
Program Funding ($ millions)	9 to 14.9	(0.12 to 0.19)	92 to 149	(1.18 to 1.92)
Electric Demand (MW)	3.5 to 4.9	(0.03 to 0.04)	35 to 49	(0.27 to 0.37)
Electric Energy (millions of kWh)	34.6 to 49.7	(0.05 to 0.07)	346 to 497	(0.51 to 0.73)
Natural Gas Energy (millions of therms)	1.1 to 1.8	(0.03 to 0.05)	11 to 18	(0.28 to 0.46)

[a]For energy and demand savings, figures are percent of 2004 annual statewide usage and summer peak demand. For program funding, figures are percent of 2004 statewide electricity and gas revenues.

Note: ranges are 90% probability boundaries from probabilistic uncertainty analysis.

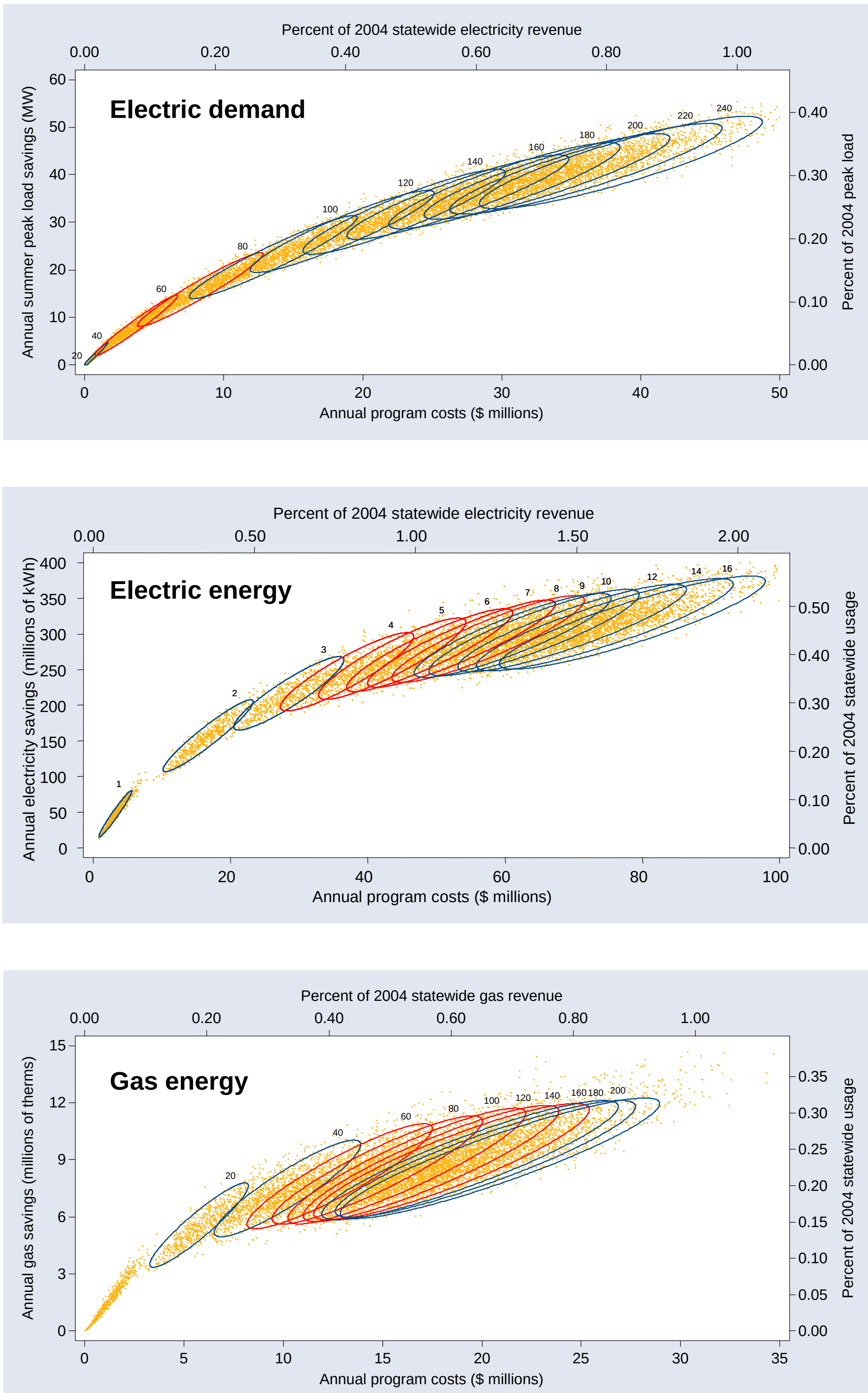
Individual supply curves by resource and sector for the 10-year analysis period are provided on the following pages. The derivation and nature of these curves are described in the main report.

FIGURE 25, OVERALL ENERGY EFFICIENCY SUPPLY CURVES (10-YEAR ANALYSIS)



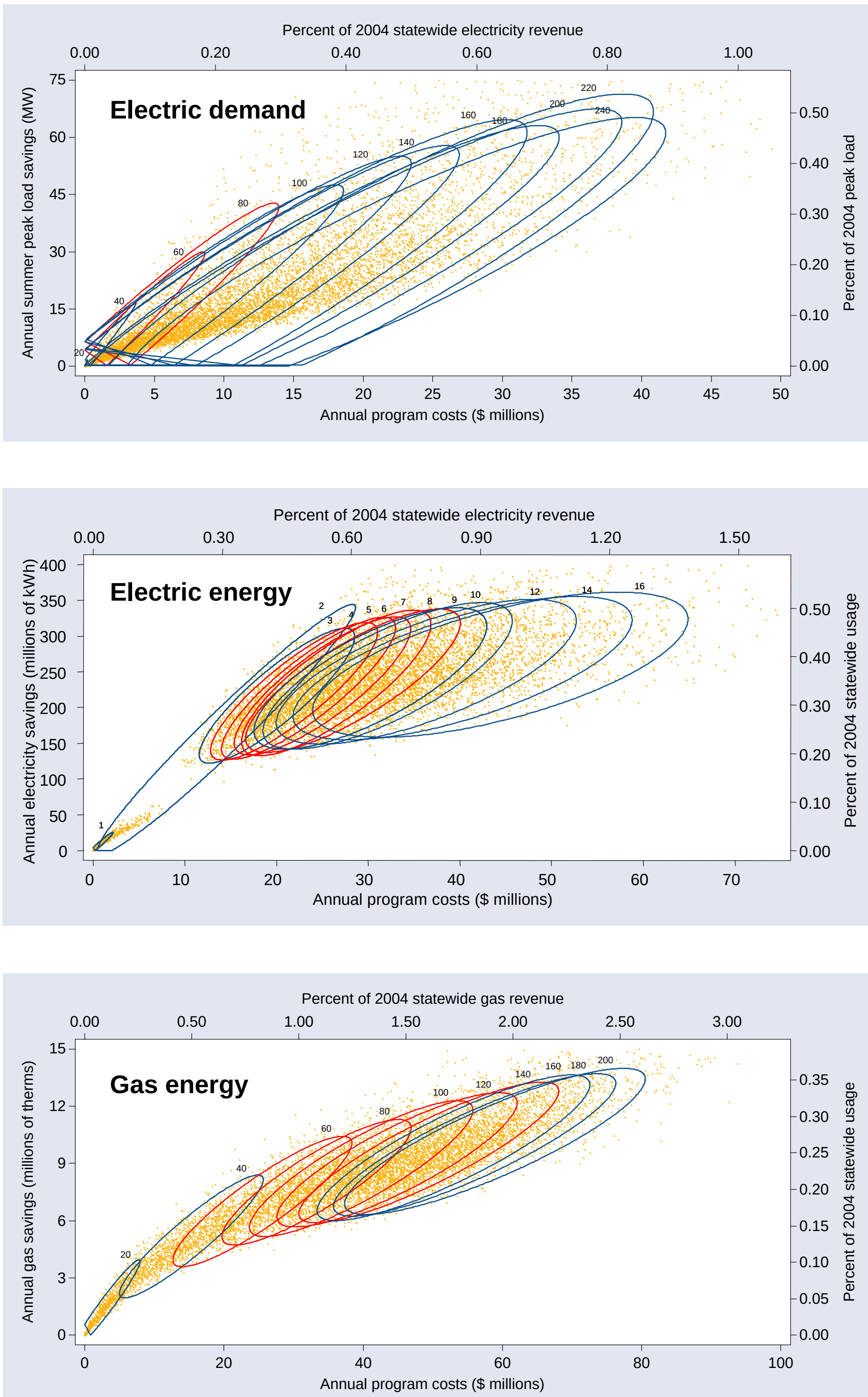
Key:
– Ellipses represent 90% probability region for program cost and savings at a given avoided cost noted above each ellipse
– Red ellipses depict avoided cost range used in combined analysis
– Points are individual iterations of probabilistic analysis (10% sample of iterations shown)

FIGURE 26, C&I SECTOR ENERGY EFFICIENCY SUPPLY CURVES (10-YEAR ANALYSIS)



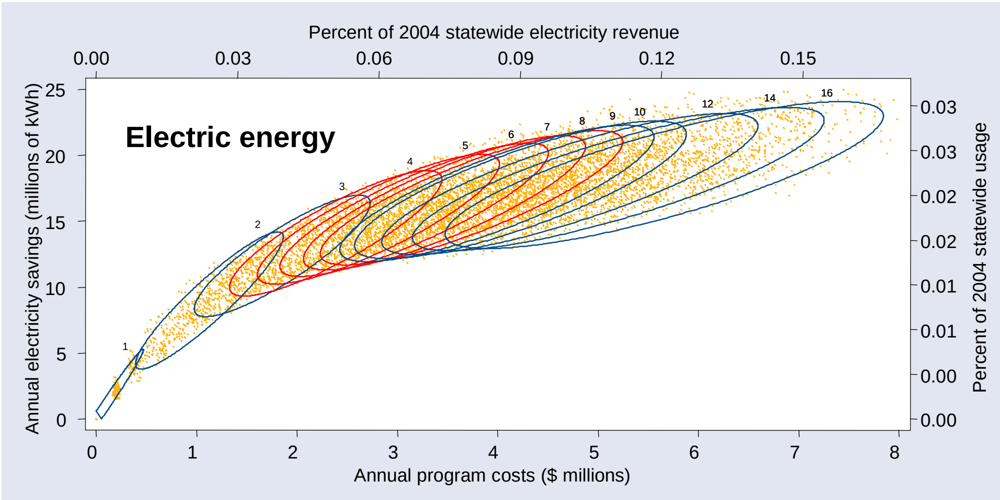
Key:
– Ellipses represent 90% probability region for program cost and savings at a given avoided cost noted above each ellipse
– Red ellipses depict avoided cost range used in combined analysis
– Points are individual iterations of probabilistic analysis (10% sample of iterations shown)

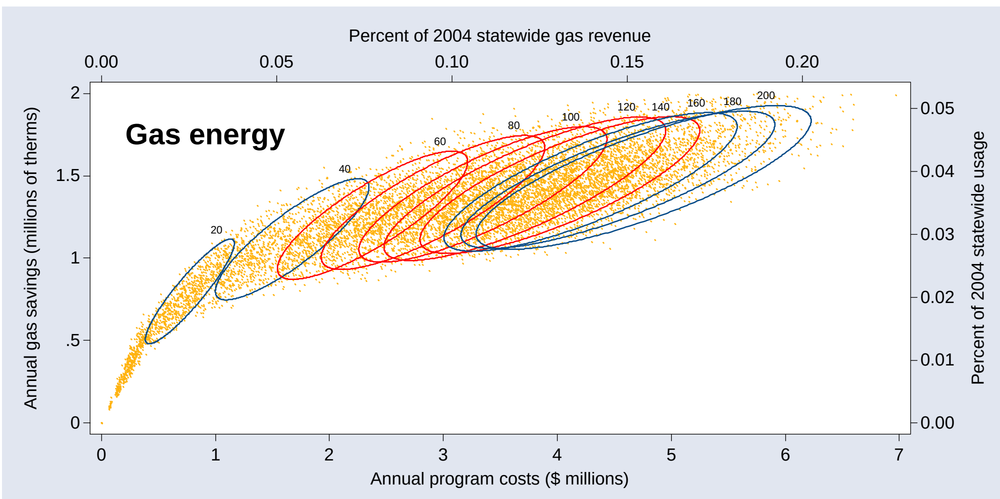
FIGURE 27, RESIDENTIAL SECTOR ENERGY EFFICIENCY SUPPLY CURVES (10-YEAR ANALYSIS)



Key:
– Ellipses represent 90% probability region for program cost and savings at a given avoided cost noted in each ellipse
– Red ellipses depict avoided cost range used in combined analysis
– Points are individual iterations of probabilistic analysis (10% sample of iterations shown)

FIGURE 28, RENEWABLES SUPPLY CURVES FOR SIX MARKETS (10-YEAR ANALYSIS)





Key:
– Ellipses represent 90% probability region for program cost and savings at a given avoided cost noted above each ellipse
– Red ellipses depict avoided cost range used in combined analysis
– Points are individual iterations of probabilistic analysis (10% sample of iterations shown)

APPENDIX C: SUMMARY OF GOVERNOR'S TASKFORCE ON ENERGY EFFICIENCY AND RENEWABLES RECOMMENDATIONS

Recommendations to Increase Energy Efficiency in Wisconsin:

- Reform the structure of the statewide energy-efficiency program known as Public Benefits (also known as Focus on Energy)[8]. The Public Service Commission of Wisconsin (PSCW) would set funding levels and energy-efficiency targets for the program while the Department of Administration (DOA) would continue to oversee the daily administration of the program and allocation of its funds. A cooperative agreement would be established between the PSCW and DOA to define specific responsibilities.
- At least annually notify customers of the benefits and costs of Public Benefits and any utility-administered programs that impact them.
- Better integrate Public Benefits efforts with the application of the Energy Priorities Law and the PSCW's Strategic Energy Assessment.
- Update and improve the state's commercial energy codes.
- Establish either a goal or requirement for state agencies to establish "beyond code" energy-efficiency policies for new and existing state facilities. Also require state agencies to purchase energy-efficient products and appliances.
- Establish a new standard for renewable energy use in the state, averaging 10% statewide by 2015. This new standard would be phased-in and would allow electric utilities to request temporary implementation delays from the Public Service Commission for circumstances beyond their control. The new standard would also be better integrated with the application of the Energy Priorities Law and the Strategic Energy Assessment.
- Establish a target for state agencies to purchase at least 10% of their electricity from renewable resources by 2006 and at least 20% by 2010.
- Create a sales and use tax exemption for customer-owned renewable energy systems such as small wind turbines, solar panels and solar water-heating services.
- Encourage the research and development of renewable energy systems, particularly anaerobic digestors, in rural Wisconsin. Recommendations include creating a bio-energy/bio-fuel coordinator position at the Department of Agriculture, Trade and Consumer Protection and targeted funding for anaerobic digestor research and development.

[8] See, generally, Sec. 16.957, Stats.

APPENDIX D: ADVISORY COMMITTEE

The following people were appointed by Lee Cullen, Chair of the Governor's Task Force on Energy Efficiency and Renewables to oversee the study:

Nino Amato, Wisconsin Industrial Energy Group

Phyllis Dubé, We Energies

George Edgar, Wisconsin Energy Conservation Corporation (chair)

Charles Higley, Citizens Utility Board

Charles McGinnis, Johnson Controls, Inc.

Jill Osterholtz, Alliant Energy

Keith Reopelle, State Environmental Leadership Program

Ilze Rukis, Wisconsin Public Service Corporation

Michael Vickerman, RENEW Wisconsin

Laura Williams, Madison Gas & Electric

Brian Zelenak, Xcel Energy

APPENDIX E: STAKEHOLDERS PARTICIPATING IN STUDY

The following people participated in stakeholder reviews of scope, inputs and assumptions:

Jerry Anderson, Superior Water Light & Power

Jolene Anderson-Sheil, Department of Administration, State of Wisconsin

Jeff Anthony, We Energies

Norman Bair, Department of Administration, State of Wisconsin

Rob Bedelis, Wisconsin Energy Conservation Corporation

David Blecker, Earth Energy Systems

Oscar Bloch, Department of Administration, State of Wisconsin

Colleen Blomgren

Janet Brandt, Wisconsin Energy Conservation Corporation

Dave Ciepluch, We Energies

Lee Cullen, Cullen, Weston, Pines and Bach

Wayne DeForest, Wisconsin Energy Conservation Corporation

Alex DePillis, Department of Administration, State of Wisconsin

David Donovan, Xcel Energy

Harvey Dorn, Alliant Energy

Phyllis Dubé, We Energies

Dan Ebert, Public Service Commission of Wisconsin

Sara Else, Alliant Energy

Jennifer Fagan, Wisconsin Energy Conservation Corporation

Charlie Fafard, Alliant Energy

Mark Faultersack, Madison Gas & Electric

Bobbi Fey

Mimi Goldberg, Xenergy, Inc.

Mindy Guilfoyle, Wisconsin Energy Conservation Corporation

Rich Hackner, GDS Associates

Linda Hajek, Cullen, Weston, Pines and Bach

Nick Hall, TecMRKT Works

Paul Helgeson, Public Service Commission of Wisconsin

Karl Hilker

Don Hynek, Department of Administration, State of Wisconsin

Jack Jenkins, Wisconsin Energy Conservation Corporation

Val Jensen, ICF Consulting

Bill Johnson, Alliant Energy

Scott Jones, Wisconsin Public Service Corporation

Roger Kasper, Department of Agriculture, Trade, and Consumer Protection, State of Wisconsin

John Katers, Solid and Hazardous Waste Education Center

Pat Keily, We Energies

Neil Kennebeck, Dairyland Power Cooperative

Jim Kerbel, Photovoltaic Systems

Eric Kostecki, Alliant Energy

Mary Klos, Madison Gas & Electric

Larry Krom, L & S Technical Associates, Inc.

Kathy Kuntz, Wisconsin Energy Conservation Corporation

Tracy LaHaise, Alliant Energy

Richard Lane

Jim Mapp, Department of Administration, State of Wisconsin

Rich Marshall, High Performance with ENERGY STAR®

Judy Mathewson, We Energies

John McWilliams, Dairyland Power Cooperative

Paul Meier, Energy Ed Software

Mary Meunier, Department of Administration, State of Wisconsin

Rick Morgan, Morgan Marketing Partners

Joe Nagan, Home Building Technology Service

John Ness, Xcel Energy

Gregg Newmann, Wisconsin Energy Conservation Corporation

John Nicol, SAIC

Terry Nicolai, Alliant Energy

Jake Oelke, Wisconsin Public Power, Inc.

Scott Olsen, Madison Gas & Electric

Tom Paque, Wisconsin Public Power, Inc.

George Penn, Global Energy Options

Ralph Prahl, Prahl Consulting

Doug Presny, SAIC

Bob Ramlow, Artha Renewable Energy

John Reed, TecMRKT Works

Doug Reinemann, University of Wisconsin – Madison

Ed Ritger

Ilze Rukis, Wisconsin Public Service Corporation

Mick Sagrillo

Barbara Samuel, Department of Administration, State of Wisconsin

Chuck Sasso, Wisconsin Energy Conservation Corporation

Charlie Schneidner, Cooperative Educational Service Agency #10

Dan Schoof, Public Service Commission of Wisconsin

Paul Schueller, Franklin Energy

Leslie Schulte, Wisconsin Energy Conservation Corporation

Carl Seigrist, We Energies

Carol Stemrich, Public Service Commission of Wisconsin

David Sumi, PA Consulting

Tom Talerico, Glacier Consulting Group LLC

Bobbi Tannenbaum, KEMA

Dan Tarrence, Franklin Energy

Bob Terrell, Alliant Energy

Dave Toso, Madison Gas & Electric

Leo Udee, Alliant Energy

Sara Van de Grift. Wisconsin Energy Conservation Corporation

Kimberly Walker, Department of Administration, State of Wisconsin

Don Wichert, Wisconsin Energy Conservation Corporation

Laura Williams, Madison Gas & Electric

Rick Winch, Glacier Consulting Group LLC

Niels Wolter, MSB Energy Associates, Inc.

Dan York, ACEEE

APPENDIX F: RESEARCH GAPS

In the course of this study we identified several areas where more complete information would have allowed us to use more precise estimates. We recommend that a public benefits program reserve a budget for independent research to provide data and information that will support continuous improvement and a richer understanding of customer participation in public benefits programs.

RESIDENTIAL ENERGY EFFICIENCY

Savings from compact fluorescent light bulbs — While field studies of the per-bulb savings from CFLs have been conducted in other states, none have been implemented in Wisconsin since the advent of public benefits funding. Given the dominant role of CFLs—both in the current Focus programs and in our study—we recommend additional research to better establish the per-bulb energy and peak demand savings in Wisconsin homes and businesses. We also see a need for additional market research to better elucidate naturally occurring trends in the CFL market and better estimate net program impacts.

Savings from residential shell improvements — Our analysis indicates significant achievable natural gas savings potential from adding insulation and reducing air leakage in the walls and ceilings of Wisconsin homes. However, field documentation of the savings from these improvements primarily derive from low-income weatherization programs, which may not fully reflect the savings in the rest of the population. There is a need for better estimates of per-square-foot savings from various shell improvements undertaken as part of non low-income energy efficiency programs. This area of research may take on additional significance if continued volatility in natural gas prices creates a surge of interest on the part of homeowners in these improvements.

Water heater savings — There is a need for additional field research into two aspects of achievable water heating savings potential. The “close the hole” space-heating savings from power-vented equipment has a large impact on the magnitude of the achievable potential, but is not well grounded in field research.

Residential HVAC installation practices — Our analysis suggests significant—but uncertain— peak demand savings potential from programs to encourage proper installation and tuning of residential central air conditioners. Additional research into the savings from best-practices programs is needed, as is research into the market potential for tune-ups of existing systems.

Potential market response to a furnace program for the small rental market — Upgrades of furnaces for 1-4 unit rental buildings offers large technical potential in our analysis, but market response to these programs is not well-researched. Program design and future studies of market potential would benefit from research into ways to reach and motivate the decision-makers for these small rental buildings.

Direct install program testing — Direct install programs for owner-occupied housing showed promising potential, but the wide range of effectiveness and cost of these programs elsewhere lead to high uncertainty of such a program’s total impact and cost. A more precise estimate of achievable potential would be possible with either empirical data from a pilot program in Wisconsin or testing of a program concept through market research.

Changes in the residential central air conditioning market - In January 2006, federal standards will take effect that will substantially increase the minimum efficiency of central air conditioners. How manufacturers and Wisconsin consumers respond to this change bears watching over the next several years, and will certainly shape the role of programs to promote energy efficiency in this market.

LED lighting - Though deemed by us as a bit too distant for inclusion in our study, there is a good chance that improvements in LED lighting technology will lead to products that begin to affect the lighting market in the next 5 to 10 years. Given the large improvement in efficiency (and product lifetime) of LED technology over even fluorescent lighting, this technology could significantly ratchet up the achievable savings potential for residential and business lighting.

Advances in water heating technology - The market for tankless water heaters (which we included in our analysis) bears watching, as this technology offers benefits that go beyond utility bill savings, and the price differential with conventional products appears to be declining. We also uncovered hints that additional products, such as high-efficiency, condensing water heaters may be introduced to the residential market in the near future.

COMMERCIAL AND INDUSTRIAL ENERGY EFFICIENCY

Components of Peak Demand - We estimated coincident peak demand for measures and programs using a combination of load data provided by the Public Service Commission, commercial billing data analyzed by Wisconsin Public Service Corporation, and literature review. We suggest further research to analyze the components of Wisconsin's peak coincident demand by end-use component and building or industry type. Additional research could estimate the impact of energy efficiency measures on coincident peak demand.

Manufacturing Process Measures - We suggest further research to estimate energy saving potential of industry-specific manufacturing process measures. This potential study has captured cross-cutting measures found in most industries including lighting, motors, pumps, fans, steam, process heat, and compressed air, as well as some process specific measures in the food and papermaking industries. Within these two industries and others, there are additional measures that involve improved alternatives for specific process equipment. We have found many instances where the literature describes a process measure and savings, but we lacked Wisconsin-specific data on current applicability, technology saturation, customer acceptance, and economics to make a reasonable estimate. Often, there can be tremendous savings for a measure, but there may be zero, one, or two feasible opportunities in the entire state.

Due to this lack of information on the achievability within Wisconsin industry, we did not pursue several process measures. This suggests specific process measure opportunities could be identified through secondary research and combined with primary research involving surveys of Wisconsin industrial facilities to estimate the achievable savings potential. For example, Focus on Energy released the *Pulp & Paper Industry Energy Best Practice Guidebook* in 2005 that provides detail on several process measures that have not been captured within this potential study. A follow-up field survey of Wisconsin papermakers could be used to estimate achievability of individual measures.

Baseline Update - Although Focus on Energy completed a market baseline characterization study in 2005, technology saturation and market practices change rapidly and have a huge impact on estimated potential. An updated baseline study should be completed prior to initiating an update of this potential study.

Commercial Ventilation - Further study should be conducted on the potential for energy saving opportunities within commercial space conditioning ventilation.

Incentive Response - The cost of program interventions is heavily driven by estimates of measure costs and the response of potential participants to various incentive levels. Research on measure cost and incentive response should be conducted on key technologies driving the potential estimate.

CUSTOMER-SITED RENEWABLES

Commercial Solar Thermal Hot Water - Commercial application of solar water heaters is a new idea for Wisconsin and the economic potential for this technology is relatively unknown. While certain categories of businesses and institutions have been identified, more information is needed about numbers and sizes of potential system applications. This would include numbers and water use of car washes, hotels, commercial laundries, restaurants, and other service industries, and institutional or municipal applications such as public recreational or correctional facilities, hospitals and nursing homes. In addition, there are a variety of industrial applications that need to be identified and quantified, such as various types of food processing, in order to accurately assess the economic potential for solar hot water in Wisconsin industries.

Wood Residue for Commercial/Institutional Heat- -A clearer understanding of the economic potential of this market in Wisconsin would make projections of adoption of any size installation less uncertain, but particularly installations over 50,000 therms. This market is unique in that a primary challenge identified by stakeholders is connecting the wide variety of wood waste sources with the broad cross section of potential customers. A study of particular value would be one that identified geographically both waste wood sources and customers with strong potential, perhaps using GIS technology. Program staff could then focus attention on the strongest potential projects and make more accurate projections about future installations.

Customer-Sited Commercial Wind Energy - Continued research is needed on Wisconsin's wind resource to identify more precisely general areas or land configurations where mid-sized turbines could potentially be economical. Most research to date has focused on utility-scale turbine siting, which requires higher and more consistent wind speed levels to be effective. While it will always be true that any specific site under consideration should be assessed for its wind resource before proceeding with an actual project, mapping Class 3 wind resources more accurately in Wisconsin would be very helpful for projecting development of this market and for allocating program resources.

Agricultural Anaerobic Digestion - The number of agricultural anaerobic digestion systems is likely to at least double over the next two years, attesting to its appeal for large farming operations in Wisconsin. Yet performance monitoring of systems already installed is minimal. Achieving the potential for this technology in the state would be greatly aided by a full-scale monitoring effort of how the currently operating systems are performing, both with regard to manure management and the production of electricity, including maintenance procedures. Monitoring could provide information for improving the predicted capacity factor of this technology in Wisconsin, making it more plausible that large farming operations would chose to include generation as part of their installation.

APPENDIX G: GLOSSARY

ACEEE – American Council for an Energy Efficient Economy

Achievable Potential -Amount of economic potential that will be accepted or implemented by the market with intervention.

CFL – Compact Fluorescent Lightbulb

DOA – Department of Administration

Economic (or Cost-effective) Potential – Amount of technical potential available at costs below the avoided cost of supply.

GWh – Gigawatt-hour; one billion watt-hours

Gross Reported Savings – Amount of energy savings reported by the program administrator, unverified by an independent evaluation.

kW – Kilowatt; one thousand watts

kWh – Kilowatt-hour; one kilowatt of electric power delivered for one hour (or the equivalent)

LED – Light emitting diodes

LNG – Liquefied natural gas

Monte Carlo Analysis – Means of assessing the uncertainty of an analysis comprising multiple inputs by randomly varying the inputs.

MW – Megawatt; one million watts

Naturally Occurring Potential – Amount of economic potential that will be accepted or implemented by the market without intervention.

Peak Electric Demand – The maximum amount of electricity necessary to supply customers. Peak periods fluctuate by season. Peak demand generally occurs in the morning during the winter and in the afternoon during the summer.

PSCW – Public Service Commission of Wisconsin

RFP – Request for Proposal

SEA – Strategic Energy Assessment

Technical Potential – Amount of energy efficiency theoretically possible without regard for cost.

Therm – Measure of the heat content of gas; 1 therm = 100,000 Btu

Verified Gross Savings – Amount of gross reported savings verified by independent program evaluators based on reviews of the number and types of implemented improvements, and the engineering calculations used to estimate the energy saved.

Verified Net Savings – Energy savings that can confidently be attributed to program efforts, verified by independent evaluation. Evaluators make adjustments to remove energy savings reported by the program administrator for participants who were not influenced by the program efforts.

APPENDIX H: OTHER WISCONSIN MARKETS FOR RENEWABLE ENERGY TECHNOLOGIES

The six renewable energy markets included in this study (commercial solar photovoltaics, commercial solar hot water, residential solar hot water, customer-sited commercial wind, commercial/institutional waste wood, and agricultural anaerobic digestion) do not characterize all possible markets for renewable energy technologies in Wisconsin. At the time the study was developed, stakeholders agreed that they do represent the markets of greatest promise at this time, but stipulated that there are many others that could be studied for their potential future impact. The following list, organized by sector, illustrates the variety of additional possible renewable energy markets in the state.

RESIDENTIAL SECTOR

Technology	Used for	Description
Geothermal	Heat	Ground source heat pumps for individual homes
Solar – passive design	Heat/light	Solar site orientation, daylighting and thermal storage design
Solar – Photovoltaics (PV)	Electricity	Roof or rack-mounted home systems; solar shingles or roofing
Solar – PV/Thermal	Electricity/heat	Zero-energy home concept: combining PV, solar hot water and energy efficiency
Wind	Electricity	Home-scale wind turbines
Wood (and other biomass for burning)	Heat	Fireplaces, wood stoves, pellet stoves

COMMERCIAL/INSTITUTIONAL SECTOR

Technology	Used for	Description
Geothermal	Heat	Ground source heat pumps for institutional applications
Solar – thermal air	Heat	Passive heating of warehouses
Solar – passive design	Heat/light	Solar site orientation, daylighting, thermal storage design
Solar – photovoltaics	Electricity	School demonstration systems

GOVERNMENTAL/MUNICIPAL SECTOR

Technology	Used for	Description
Biomass – anaerobic digestion	Electricity/heat	Municipal sewage treatment
Biomass – biodiesel	Vehicle fuel	Municipal fleet fuel
Solar – photovoltaics	Electricity	Remote systems for lighting, traffic signals, radio transmitters, bus shelters

AGRICULTURAL SECTOR

Technology	Used for	Description
Solar – photovoltaics	Electricity	Small remote systems for water pumping, fence recharging, lighting
Solar thermal – water	Heat	Greenhouse heating
Solar thermal – air	Heat	Heating for livestock barns, storage buildings

INDUSTRIAL SECTOR

Technology	Used for	Description
Biomass	Electricity/heat	Biodiesel and other biofuels for electrical generation and industrial processes
Solar thermal – water	Heat	Industrial process heating
Biomass – anaerobic digestion	Electricity/heat	Extracting methane from industrial process waste