ENERGY CENTER
OF WISCONSIN

PREPARED BY
Energy Center of Wisconsin

with the assistance of

- The American Council for an Energy-Efficient Economy
- GDS Associates, Inc.
- L&S Technical Associates

ENERGY EFFICIENCY AND CUSTOMER-SITED RENEWABLE RESOURCE POTENTIAL IN WISCONSIN

FOR THE YEARS 2012 AND 2018

August 2009

FINAL REPORT

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Public Service Commission of Wisconsin

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August 6, 2009

Last summer, the Public Service Commission of Wisconsin (Commission) retained the Energy Center of Wisconsin (Energy Center) for the purpose of preparing an assessment of the potential for the state as a whole to increase its use of electric and natural gas energy efficiency and customer-sited renewable resources. This report presents the findings of that assessment.

The Commission requested that the Energy Center estimate *maximum achievable* potential for these resources, rather than that which is merely theoretically possible. In further refining the task, the Commission asked that the Energy Center:

- Rely primarily on the Total Resource Cost (TRC) test to determine cost effectiveness of individual measures.
- Use locational marginal prices from the Midwest Independent Transmission System Operator as the primary avoided cost estimates.
- Use the forecasts provided by Synapse, Inc., as the most likely carbon prices to be included in future energy prices.

While debate will always accompany critical assumptions, the requested parameters represent a reasonable, conservative future that provides a sound base for policy-making decisions.

I am pleased to see that many interested parties provided input to the study, either through the Energy Center's formal Delphi process used to assemble expert opinion, or through written comments on the draft study that was released in April of this year. The active involvement of the large number of participants representing diverse interests helps to provide a broad-based perspective on these important issues.

This potential study does not represent the end of a process, but rather the beginning. The Commission plans to use it to help us guide our quadrennial planning review of energy efficiency programs and to assist the Legislature in implementing changes in statewide energy policy, where appropriate. I look forward to many discussions about the important topics set forth in this study.

Sincerely,

Eric Callisto
Chairperson

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ABSTRACT

ENERGY EFFICIENCY

By 2012 Wisconsin could obtain annual energy savings equivalent to:

- 1.6 percent of total electricity sales
- 1.6 percent of electricity peak demand
- 1.0 percent of total natural gas sales[1]

We estimate that achieving these results could require energy efficiency program investments[2] of up to $350 million per year (2008 dollars). If savings continue at these rates, by 2018, the cumulative efficiency savings impact will amount to:

- 13.0 percent of total electricity sales
- 12.9 percent of electricity peak demand
- 8.7 percent of total natural gas sales

Each year that these savings results are achieved, the State of Wisconsin will generate $900 million in net lifecycle energy cost savings (present value, 2008 dollars), and reduce utility-based greenhouse gas emissions by 1.3 million tons. Energy efficiency program investments and associated economic multiplier effects are projected to support 7,000 to 9,000 Wisconsin jobs.

These energy efficiency potential estimates do not include the full effect of new behavior-based efficiency programs, or the effect of advanced utility rate designs. The former could increase the energy savings potential and the latter could lead to greater reductions in peak electric demand.

CUSTOMER-SITED RENEWABLE RESOURCES

By 2012, customer-sited, customer-owned renewable energy systems in Wisconsin could produce the following:

- 31 to 36 million annual kilowatt hours (kWh) of renewable electric energy
- 13 to 17 megawatts (MW) of peak renewable electricity generation
- 1.6 to 1.7 million annual therms of renewable thermal energy

Achieving these results would require investment in state-sponsored renewable energy programs of around $15 million per year (2008 dollars). Each year that these results are achieved, the State of Wisconsin will generate up to $20 million in net energy cost savings (present value, 2008 dollars) and reduce utility-based greenhouse gas emissions by 39,000 tons. Renewable energy program investments and associated economic multiplier effects are projected to support 300 to 350 Wisconsin jobs.

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[1] Throughout this study, references to natural gas savings potential include natural gas and propane savings resulting from installation of energy efficient and renewable energy generating technologies.

[2] Energy efficiency program investments include programs administered by the State of Wisconsin, voluntary programs administered by Wisconsin utilities, and self-directed initiatives undertaken by large energy users.

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EXECUTIVE SUMMARY

The Public Service Commission of Wisconsin (PSCW) retained the Energy Center of Wisconsin (Energy Center) for the purpose of analyzing the potential for Wisconsin to increase its use of energy efficiency resources. In developing this energy efficiency potential estimate, the Energy Center drew on the expertise of our co-consultants on this project, the American Council for an Energy-Efficient Economy (ACEEE) and GDS Associates (GDS). We also obtained key technology forecasts from more than 30 Wisconsin-based energy efficiency experts. The assistance of these capable individuals resulted in a more thorough analysis, and allowed us to develop a study that transcends that which the Energy Center alone could have provided.[3]

The modeling of energy efficiency potential was technology-based and was conducted by sector. We employed a bottom-up approach for estimating energy efficiency potential in the residential sector, aggregating savings potential associated with individual types of energy-using equipment found in Wisconsin homes. For the commercial, industrial, and agricultural sectors, we employed a top-down approach, disaggregating savings estimates based on an assumed distribution of energy use within each market segment.

We analyzed a base case scenario focusing on the economic benefits from saving energy and the environmental benefits of avoided carbon emissions.[4] In addition, we conducted scenario analysis, varying key input assumptions to test the outer bounds of our potential estimates. In reporting the scenario analysis results, we focus on the scenario with the greatest deviation from the base case, referred to as the "environmental scenario." Under that scenario we: (1) quantified the value of avoided non-carbon emissions (sulfur dioxide, oxides of nitrogen, and mercury); (2) included measures that are marginally below the base case cost-effectiveness threshold; and (3) employed a lower discount rate to account for the fact that energy efficiency investments made today are likely to be more valuable to future generations in a carbon-constrained world.

In developing our estimates for all scenarios, including the base case, we viewed the term "potential" as representing a reasonable outer bound. In other words, our estimates do not reflect business-as-usual trends, but rather reflect what could be achieved under an aggressive program effort. Those interested in a comparison of the energy efficiency potential estimates developed through this study relative to those estimated in the Energy Center's 2005 Wisconsin potential study should refer to the Addendum at the end of the energy efficiency section of the report.

RESULTS: BASE CASE

Under the base case we estimate that by 2012, Wisconsin could save 1,200 GWh of electric energy per year, reduce peak electric demand by 250 MW, and save 37 million therms of natural gas/propane per

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[3] While the subcontractors and the individual experts provided useful input to this study, in the end, this report represents the explicit views and judgments of the Energy Center of Wisconsin. The fact that individuals or firms participated in the study does not imply that they necessarily agree with all statements contained in our report.

[4] We assumed that in the near future carbon emissions will be priced, either via a carbon tax or a cap-and-trade mechanism.

year.[5] Expressed as a percentage of projected baseline energy sales for 2012, these results are equivalent to 1.6 percent of electricity sales, 1.6 percent of peak electric demand, and 1.0 percent of natural gas/propane sales. Achieving these results would reduce greenhouse gas emissions by 1.3 million tons per year.

Under the assumed ramp-in from current energy efficiency program efforts to the aggressive efforts projected in this study, the cumulative energy efficiency potential from 2009 through 2012 is 3,300 GWh of electricity savings, 670 MW of demand reduction, and 100 million therms of natural gas/propane savings.

If savings continue at the annual rates projected for 2012, by 2018 the cumulative effect would amount to 11,000 GWh of electric savings, 2,200 MW of demand reduction, and 330 million therms of natural gas/propane savings. Expressed as a percentage of projected baseline energy sales for 2012, these results are equivalent to 13 percent of electricity sales, 13 percent of peak electric demand, and 8.7 percent of natural gas/propane sales.

RESULTS: SCENARIO ANALYSIS

As discussed above, the Energy Center conducted a number of scenario analyses, varying key input assumptions to test the outer bound of our potential estimates. We focus on the scenario which produces the greatest deviation from base scenario results, the "environmental scenario." Key assumptions under this scenario include higher avoided costs, a less-restrictive cost-effectiveness screen, and a lower discount rate.

Under the environmental scenario we estimate that by 2012, Wisconsin could save 1,400 GWh of electric energy per year, reduce peak electric demand by 300 MW, and save 47 million therms of natural gas/propane per year. Expressed as a percentage of projected baseline energy sales for 2012, these results are equivalent to 1.9 percent of electricity sales, 1.9 percent of peak electric demand, and 1.2 percent of natural gas/propane sales. Achieving these results would reduce greenhouse gas emissions by 1.5 million tons per year.

Under the assumed ramp-in from current energy efficiency program efforts to the aggressive efforts projected in this study, the cumulative energy efficiency potential from 2009 through 2012 is 4,000 GWh of electricity savings, 800 MW of demand reduction, and 126 million therms of natural gas/propane savings.

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[5] Throughout this study, references to natural gas savings potential include natural gas and propane savings resulting from installation of energy-efficient and renewable energy generating technologies.

If savings continue at the annual rates projected for 2012, by 2018 the cumulative effect would amount to 13,000 GWh of electric savings, 2,700 MW of demand reduction, and 400 million therms of natural gas/propane savings. Expressed as a percentage of projected baseline energy sales for 2012, these results are equivalent to 16 percent of electricity sales, 16 percent of peak electric demand, and 11 percent of natural gas/propane sales.

ECONOMIC IMPACTS

Achieving the increased levels of energy efficiency projected in this study will reduce energy-related expenditures for Wisconsin consumers and create Wisconsin jobs.

Under the base case scenario, achieving projected annual levels of energy efficiency potential will produce net savings of around $900 million in 2012 (present value, 2008 dollars). The corresponding 2012 net savings estimate under the environmental scenario is approximately $2 billion. Note, however, that the net savings estimates are not directly comparable because they were developed using different economic discount rates (five percent in the base case; two percent in the environmental scenario).[6]

Achieving the 2012 annual energy efficiency potential levels suggested by the base case scenario are estimated to produce between 7,000 and 9,000 new Wisconsin jobs. Achieving the savings suggested in the environmental scenario would produce between 11,000 and 13,000 new jobs.

ENERGY EFFICIENCY PROGRAM CHANGES

We estimate that annual energy efficiency program investments of up to $350 million per year would be necessary to achieve projected 2012 savings levels derived under the base case. [7] Achieving the 2012 savings levels derived in the environmental scenario would require approximately twice as much annual spending.

Increased spending alone will not deliver the achievable energy efficiency savings identified here. Innovation in energy efficiency program design for all market sectors will also be necessary. [8] Innovative program strategies could include:

- Aggressive strategies for capturing neglected opportunities through large-scale retrofits of existing buildings.
- Upstream incentives for equipment suppliers and retailers to affect net increases in the market share for efficient products without diverting large amounts of funding for purchases that would have occurred without program influence.

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[6] The difference in discount rates reflects different perspectives on the value of a dollar of energy saved in the future. For a given level of Btus saved, the associated dollar savings under a low discount rate will be higher than the savings under a high discount rate merely because the lower discount rate implies that future cash flows are relatively more valuable than that suggested by the higher discount rate. Thus, the estimate of dollar savings under various discount rates reflects different value judgments across individuals, and not necessarily that one scenario is preferable to the other on economic grounds.

[7] Energy efficiency program investments include programs administered by the State of Wisconsin, voluntary programs administered by Wisconsin utilities, and self-directed initiatives undertaken by large energy users.

[8] For illustrative purposes, the study discusses a number of innovative program strategies in Chapter EE-4. However, developing detailed program design guidance for the purposes of energy efficiency program planning is outside the scope of this study.

Though we did not develop quantitative estimates of potential energy savings and demand reduction from expansion of behavior-based approaches to motivating energy efficiency improvement, or from deployment of advanced rate designs that reduce peak electric demand, such strategies could deliver additional savings to Wisconsin residents and businesses.

The programmatic shifts above will likely also require some adjustments to program protocols.[9]

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[9] These issues are discussed in Chapter EE-5.

CHAPTER EE-1: OVERVIEW

STUDY SCOPE

The PSCW asked the Energy Center to develop estimates of the potential for economic efficiency improvements to reduce energy demand in Wisconsin. *Webster's Dictionary* defines potential as: "existing in possibility, not in actuality." (Emphasis added.) A proper potential study should tell us what *could* be achieved if we *change* policies relating to energy efficiency, and not what one would expect to occur under current policies.

Because this study is not an investigation of the impact of business-as-usual policies, the scenarios discussed in this study have little in common with the forecasts presented to the PSCW in rate proceedings and power plant construction hearings. Those forecasts assume that the political-economic structure that drove energy demand in the past will, for the most part, continue to drive it in the future.

The issue under review is what might happen if we change our energy policy to be as supportive as possible of energy efficiency. The important point to note here is that, in a potential study, we recognize that the utility sales forecast is to some extent a *choice* variable, not an exogenous event beyond the control of utility executives and policymakers. In keeping with this notion, we reiterate that the ultimate issue is not how much energy efficiency we should expect, but rather *how much energy efficiency we want to obtain*.

We spend little time in this study discussing pessimistic or even middle-of-the-road scenarios. In estimating achievable potential, our focus is on finding the reasonable upper bound—"potential" in the truest sense of the word. Rather than conducting scenario analyses of less aggressive policies, we stipulate that if policymakers do not fund energy efficiency programs at the levels suggested by this study, if energy efficiency program practices are not revised, or if consumer interest in energy efficiency wanes over time, then Wisconsin will obtain noticeably less energy efficiency improvement than we suggest is possible in this study. Spending time and resources analyzing such scenarios does not appear to be a good use of resources, and does not tell us much about energy efficiency *potential*.

With this perspective in mind, we view our energy efficiency potential estimates as representing the *reasonable upper limit* by assuming that policymakers want to achieve high levels of energy efficiency.

This study focuses on estimates of *achievable efficiency potential*, defined as "the amount of energy use that efficiency can realistically be expected to displace assuming the most aggressive program scenario possible."[10] The Energy Center also estimated technical and economic efficiency potential. *Technical potential* represents the theoretical maximum level of potential energy savings, assuming immediate implementation of all technologically feasible energy efficient technologies regardless of cost-effectiveness. *Economic potential*, typically a subset of technical potential, assumes immediate implementation of the most cost-effective energy efficient technology for any given application. As practical measures, estimates of technical and economic potential have limited usefulness, as they do not

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[10] Optimal Energy, Inc. (2007). *Guide for Conducting Energy Efficiency Potential Studies*. Prepared in connection with the National Action Plan for Energy Efficiency. Available at: www.epa.gov/eeactionplan.

account for capital constraints, the useful lifetime of existing installed equipment, or other barriers that inhibit adoption of energy efficiency measures.

The achievable potential estimates reflect those practical constraints. The principal considerations are that consumers do not typically replace equipment early, and they have limited budgets. Thus, the pace of acquiring energy efficiency gains is slower, and the amount of savings is lower than under economic potential estimates. Since the achievable potential estimate considers pragmatic factors, it is more useful to policy makers than the technical or economic potential estimate. We focus most of our discussion in this report on achievable potential.

We note that our achievable potential estimates could be higher if we were able to fully quantify the impacts of behavior-based programs and rate design innovations. Our potential estimates include some impacts of behavior-based program approaches, but approaches for quantifying the energy savings impacts of behavior change are still in their infancy. Some studies suggest that behavior programs can reduce energy use by 20 percent. If that is the case, then achievable efficiency potential may be higher than we suggest. The same is true for advanced rate design approaches which produce demonstrated reductions in peak demand, but quantitative estimates of peak demand reduction potential resulting from advanced rate designs were not developed for the purposes of this study.

METHODOLOGY

Energy Efficiency Potential Estimates

The results of this study are projections of achievable energy efficiency potential in Wisconsin in 2012 and 2018. Cost-effectiveness screening was conducted using the total resource cost (TRC) test, which compares the net present value of benefits achieved over the lifetime of the measure with the costs incurred by the program and the participant.[11] For the purposes of this analysis, quantified benefits include the avoided cost of conserved energy and the value of avoided carbon emissions. Other environmental benefits and non-energy benefits were not included. Costs include all expenses associated with measure installation, including equipment and labor costs, as well as program administrative costs. Measures with a benefit/cost ratio of 1.0 or greater are cost-effective and pass the TRC test. It is important to note that cost-effectiveness analysis was conducted at the measure (technology) level, and that modeling a bundle of energy efficient technologies at the program level could yield different cost-effectiveness results. See section entitled, *Global Assumptions,* below for a summary of the avoided costs used in evaluating cost-effectiveness.

Achievable energy efficiency potential estimates were developed for 2012 and represent annual cost-effective savings that could be achieved in that year. For 2018, we focus on cumulative potential—the sum of annual achievable potential estimates from 2009 through 2018. Thus, the 2012 estimate provides a sense of pace, while the 2018 figure represents an end result.

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[11] Detailed information on economic screening methodology is available in the *California Standard Practice Manual*, available at: http://drrc.lbl.gov/pubs/CA-SPManual-7-02.pdf.

We place greater emphasis on the 2012 estimates given the high level of uncertainty associated with a ten-year projection. Energy prices, technology costs, the state of the economy, and federal climate policy are all factors that will have a dramatic effect on energy efficiency potential in the coming decade, and in the current economic and political climate these factors are more difficult to predict than ever. Many of the policies and technologies that will have a significant impact on energy efficiency potential in four years are at least visible on the horizon today, which may not be the case for policies and technologies that will have a significant impact on energy efficiency potential in ten years.

There is another important uncertainty-related issue that should be noted. While the credibility of information for certain technologies is well-established, for other measures—especially emerging energy efficient technologies—the available data on savings, measure life, and other key assumptions may be less certain. There is, however, a portfolio effect associated with looking at a large number of measures in a potential study such as this one. If measurement error is not systematically biased to the high side or the low side, but rather tends to be randomly distributed around zero, overestimates of savings potential for some measures are likely offset by underestimates of savings potential for others.

The portfolio analogy is quite apt here. Financial research demonstrates that the aggregate risk of a stock portfolio can be *much lower* than even that of the *safest* individual stock in the portfolio.[12] This is due to the cancellation of simultaneous upward and downward price changes for the stocks in the portfolio. In a similar fashion, the uncertainty associated with the aggregate potential estimate could be quite low, even though the uncertainty associated with certain individual technologies is not, as the individual technology errors may move in opposite directions. As a result, the aggregate estimates of savings potential are more certain than individual estimates of potential for any given energy efficient technology.

We report estimates in terms of net savings, or savings resulting directly or indirectly from program activities. Net savings estimates exclude free riders (program participants who would have undertaken efficiency improvements without program intervention) and include spillover effects (individuals who did not directly participate in a program, but undertake efficiency improvements as a result of program influence). These estimates are roughly comparable to the "verified net savings" results reported in Focus on Energy evaluations,[13] with the caveat that limited evaluation resources are devoted to measuring spillover effects for Focus on Energy programs, so reported results generally do not include spillover effects. Net effects represent the difference in energy consumption and peak electricity demand that would occur under an aggressive program scenario and what would occur under a "no program" scenario.

Potential estimates exclude the impacts of naturally-occurring efficiency improvements, which are represented in the modeling baseline. "Naturally-occurring efficiency" encompasses general increases in the efficiency of buildings and equipment due to factors other than program influence. Naturally-occurring efficiency includes increases in lighting and appliance efficiency resulting from known changes in state or federal standards, as enacted through legislation such as the Energy Policy Act of 2005 (EPAct 2005) and the Energy Independence and Security Act of 2007 (EISA 2007). It also includes energy

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[12] Steven G. Kihm (June 2003). "How Improper Risk Assessment Leads to Overstatement of Required Returns for Utility Stocks." *NRRI Journal of Applied Regulation*.

[13] Focus on Energy is a state program that works with eligible Wisconsin residents and businesses to install cost effective energy efficiency and renewable energy projects. Additional information is available at: www.focusonenergy.com./

efficiency levels specified by energy-related building codes. However, any future changes to codes and standards that are not known at the time this study was conducted are not included in the baseline of naturally-occurring efficiency improvement.

Potential estimates include the effects of measure interaction, where installation of an energy efficiency measure that has a primary effect on one end use (such as lighting) produces a corresponding secondary effect on another end use (such as heating or cooling). Interactive effects can cause an increase or decrease in the energy consumption associated with the secondary end use. The majority of interactive effects considered in the analysis are associated with fuel switching measures (e.g., switching from an electric water heater to a natural gas water heater), heating penalties and cooling benefits associated with installation of energy efficient lighting and equipment, and insulation/air sealing measures that save electricity used for cooling and natural gas used for heating. Accounting for measure interaction, as we have done in this study, provides accuracy beyond the level achieved by many potential studies.

Delphi Process for Gathering Expert Input

As noted above, estimating what could be achieved under a future scenario of aggressive energy efficiency policy and program efforts involves projecting future conditions that represent a significant departure from business-as-usual. A key component of the Energy Center's approach to this analytical challenge was a Delphi process querying experts about what an aggressive energy efficiency future would look like in Wisconsin.

The Delphi technique is a forecasting tool that has been in use for several decades.[14] Researchers use the Delphi technique to tap into the collective wisdom of experts to inform forecasts of future conditions under various scenarios. It involves iterative rounds of revealed forecasts, a process which often allows for greater consensus among experts. For technology-related forecasts, such as those involved in this study, the Delphi technique has tended to outperform other approaches in terms of ultimate forecast accuracy.[15]

In the fall of 2008, the Energy Center distributed Delphi questionnaires to nearly 100 individuals who were identified by staff at the Energy Center and the PSCW as energy efficiency experts. Sector-specific Delphi questionnaires focused on key technologies that are expected to have a large impact on energy efficiency potential over the time period of the study. Participants were asked to estimate market share or retrofit rates under three scenarios: (1) in the absence of efficiency programs; (2) under existing program approaches and funding levels; and (3) under the most aggressive possible program approaches and funding levels. They were also asked to provide input on policy and programmatic changes that would be necessary to achieve this aggressive energy efficiency future in Wisconsin.

The Energy Center received 33 energy efficiency responses, as shown in Table EE-1. Appendix H includes a copy of Delphi survey instruments. Appendix I includes a transcript of individual Delphi responses.

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[14] For a brief description of the Delphi technique, see R. S. Duboff, "The Expert Wisdom of Crowds," *Harvard Business Review*, September 2007.

[15] G. Rowe and G. Wright, "The Delphi Technique as a Forecasting Tool: Issues and Analysis," *International Journal of Forecasting* (1999).

TABLE EE-1. DELPHI RESPONSES FROM ENERGY EFFICIENCY EXPERTS

Sector	Number of Responses
Agriculture	6
Commercial/Institutional	8
Industrial	7
Residential	12
TOTAL	**33**

After compiling results from the initial survey round, the Energy Center developed a summary of responses which presented maximum, minimum, and median responses for each technology-specific estimate. During a second survey round, participants were given the opportunity to revise their initial estimates after reviewing the summary of responses from other participants.

Following the conclusion of the second round, the Energy Center used Delphi responses to develop "achievable factors" for each energy efficiency measure addressed in the study. This achievable factor is broader than the typical achievable factor as defined in other potential studies. Here it accounts for convertibility (the technical/engineering feasibility of converting equipment to a more energy efficient alternative) and the amount of equipment that has not already been converted to a more energy efficient technology (sometimes referred to as a "remaining factor"), in addition to accounting for a program's ability to influence market penetration of the technology.

Since the Delphi questionnaires did not cover all technologies addressed in the potential study, achievable factors for non-Delphi technologies were derived using Delphi data, using a multi- step process. First, a "program lift delta" was calculated for each Delphi measure by calculating the difference in market share between the aggressive program and no-program scenarios, as provided by Delphi responses. Table EE-2 illustrates this approach.

TABLE EE-2. EXAMPLE OF PROGRAM LIFT DELTA APPROACH

	Delphi Response: Percent Market Share in 2012			
	No Program Scenario	Aggressive Program Scenario	Program Lift Delta	Rank
Delphi Measure X	10	15	5	Low
Delphi Measure Y	20	30	10	Medium
Delphi Measure Z	15	35	20	High

Next, we segmented the dataset of program lift deltas for all Delphi measures into quartiles,[16] Delphi measures within the first quartile were defined as "low-potential" measures, and Delphi measures within the fourth quartile were defined as "high-potential" measures. The remaining Delphi measures were defined as "medium-potential" measures.

Last, achievable factors for non-Delphi measures were derived by taking the median value within each of these three categories. The median value within the first quartile was selected as the default achievable factor for low-potential measures, the global median was selected as the default achievable factor for medium-potential measures, and the median value within the fourth quartile was selected as the default achievable factor for high-potential measures. The Energy Center then assigned each non-Delphi measure to one of these three categories based on a qualitative assessment of the impact aggressive programs are likely to have on the measure. Achievable factors derived from the Delphi process became key inputs in the energy efficiency potential model. Appendix B provides detailed information on the ranking for each measure, and the achievable factor that was used.

Energy Efficiency Potential Model

There are two primary analytical approaches to modeling energy efficiency potential: bottom-up or top-down. The bottom-up approach begins at the measure level, multiplying the costs and savings associated with deploying each energy efficient measure by the number of units of each measure expected to be installed during the study period, and aggregating the results. The top-down approach begins with a forecast of energy sales over the study period, and disaggregates this forecast within each sector by market segment and end use. Each energy efficient technology reduces the base forecast by a certain percentage, and the difference between the base forecast and the efficiency forecast represents efficiency potential.[17]

As end use energy consumption is relatively homogeneous within the residential sector, the Energy Center was able to use a bottom-up approach for the residential market. The commercial and industrial sectors require a top-down approach, given the variability in energy end use and technology installations across market segments and facility types.

Market sectors and segments addressed in the study are shown in Table EE-3.

TABLE EE-3. SECTORS AND SEGMENTS ADDRESSED IN POTENTIAL STUDY

SECTOR	SEGMENT
Residential	Single family owner-occupied
	Multifamily rental (1-4 units)
	Multifamily rental (5+ units)
	Mobile home

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[16] A quartile is one quarter of a data set that has been segmented into four parts with an equal number of data points in each. The lowest 25 percent of the data is within the first quartile, and the highest 25 percent of the data is within the fourth quartile. The remaining 50 percent of the data are within the second and third quartiles.

[17] Optimal Energy, Inc. (2007). *Guide for Conducting Energy Efficiency Potential Studies*. Prepared in connection with the National Action Plan for Energy Efficiency. Available at: www.epa.gov/eeactionplan.

SECTOR	SEGMENT
Commercial	Education
	Food sales
	Food service
	Health care
	Lodging
	Mercantile
	Office
	Other (including labs)
	Public assembly
	Public order and safety
	Religious worship
	Service (including some light industrial)
	Warehouse and storage
Industrial	Beverage & tobacco
	Chemicals
	Fabricated metals
	Food
	Machinery
	Metals – primary
	Other
	Plastics & rubber
	Pulp & paper
	Transportation equipment
	Wood products
	Water & wastewater treatment
Agriculture	

The Energy Center's efficiency potential model is a Microsoft Excel®-based tool that employs a straightforward, linear structure for analytical transparency. Individual worksheets for each sector calculate the savings potential using a bottom-up approach for residential measures, and a top-down approach for commercial, industrial, and agricultural measures. The model evaluates over 500 unique measures across the four sectors addressed in the study.

Key inputs in the energy efficiency potential model include: base energy consumption, disaggregated by market segment and end use; market saturations of the energy efficient technology; primary fuel savings; demand reduction for electricity-saving measures; secondary fuel impacts caused by measure interactions,[18] measure installation cost; useful life of equipment; and the Delphi-derived achievable

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[18] The primary measure interactive effects considered in the analysis include fuel switching (e.g., switching from an electric water heater to a natural gas water heater), and heating penalties/cooling benefits achieved through installation of energy-efficient lighting.

factor. GDS Associates provided technical assistance in the development of measure inputs, and inputs were benchmarked against values used in similar studies, including the Energy Center's 2005 Wisconsin potential study, a 2008 Quantec study of potential in Iowa,[19] and a 2007 study of Vermont potential conducted by GDS Associates.[20] A list of measure inputs is included in Appendix B.

Within the model, a stacking algorithm addresses the issue of mutual exclusivity, ensuring that potential savings are not over-estimated. The stacking algorithm ranks energy efficient technologies in order of cost-effectiveness; as each technology is ranked (from highest TRC ratio to lowest TRC ratio) the savings potential that it captures is no longer available to the remaining technologies.

Global Assumptions

A number of global assumptions were consistent across the residential, commercial, industrial, and agricultural components of the Energy Center's analysis.

Energy efficiency measures reduce energy consumption and associated costs, and avoided energy supply costs prices provide the primary basis for valuing energy savings benefits. For electricity, the avoided costs used in this analysis are based on recent locational marginal prices (LMPs) from the Midwest Independent Transmission System Operator (Midwest ISO). We developed average prices for on- and off-peak power based on 2005-2008 data from four nodes: Weston, Pleasant Prairie, Columbia, and Dairyland Power.

Midwest ISO LMPs reflect the cost of energy and the implied cost of generation capacity, but not the cost of transmission or distribution (T&D) capacity, nor do they reflect line losses. Therefore, we adjusted the prices to reflect those factors. An explicit value of $30/kW-year was used for avoided T&D capacity, which is in line with T&D values reported by Iowa investor-owned utilities in their 2009-2013 energy efficiency program plans.[21]

We also included an eight percent adjustment to reflect transmission and distribution line losses. This is consistent with the line loss factor used in Focus on Energy evaluation studies.[22] To value natural gas savings, we used an avoided cost of $0.84 per therm, which is used by the Focus on Energy evaluation team in conducting benefit-cost analysis and measure screening.[23]

While the costs associated with carbon emissions are not currently a direct cost, it is prudent to assume that this situation will change in the near future. Since our focus is primarily on the potential to garner energy efficiency opportunities in the future, a forward-looking carbon cost estimate is appropriate. We

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[19] Quantec (2008). *Assessment of Energy and Capacity Savings Potential in Iowa*. Prepared for the Iowa Utility Association in collaboration with Summit Blue Consulting, Nexant, Inc., A-TEC Energy Corporation, and Britt/Makela Group.

[20] GDS Associates (2007). *Vermont Electric Energy Efficiency Potential Study*. Prepared for the Vermont Department of Public Service.

[21] Interstate Power & Light Company (2008). *2009-2013 Energy Efficiency Plan*. Docket No. EEP-08-1. MidAmerican Energy Company (2008). *2009-2013 Energy Efficiency Plan*. Docket No. EEP-08-2.

[22] Personal communication with Bryan Ward, PA Consulting, November 3, 2008.

[23] Email communication from Miriam Goldberg, KEMA, Inc. to Public Service Commission of Wisconsin staff and the Focus on Energy evaluation team (February 6, 2007). *Final Assumptions for Focus BC Analysis and Measure Screening*.

relied on the 2008 levelized carbon cost estimate reported by Synapse Energy Economics under its medium-range forecast, which equates to \$30 per ton of carbon dioxide (CO_2) emitted.[24] Using carbon emissions factors for Wisconsin as reported in recent Focus on Energy evaluations (0.9 tons of CO_2 per MWh and 11.708 lbs CO_2 per therm),[25] this carbon price amounts to approximately \$0.025 per kWh and \$0.18 per therm.

Avoided cost and carbon values used in the Energy Center's analysis are summarized in Table EE-4.

TABLE EE-4. AVOIDED COSTS AND CARBON VALUE

	Summer Peak	Summer Off-Peak	Winter Peak	Winter Off Peak
Electricity (\$/kWh)	\$0.074	\$0.037	\$0.072	\$0.039
Avoided T&D capacity (\$/kW-year)	\$30.00		\$30.00	
Carbon surcharge for electricity (\$/kWh)	\$0.025	\$0.025	\$0.025	\$0.025
Natural gas (\$/therm)	\$0.840	\$0.840	\$0.840	\$0.840
Carbon surcharge for natural gas (\$/therm)	\$0.176	\$0.176	\$0.176	\$0.176

For the purposes of the TRC test, costs include expenses associated with measure installation as well as program administrative costs. Expenses associated with measure installation include the incremental cost of energy efficient equipment over standard efficiency equipment, and may also include labor costs associated with measure installation and maintenance. Since incentives are essentially a transfer payment from program to participant, they represent a portion of the measure cost and are not disaggregated for the purposes of the TRC test.

Program administrative costs include all costs associated with program implementation except incentives, such as expenditures for program planning and administration, marketing and outreach, education and training, and evaluation, measurement, and verification (EM&V). Administrative costs typically vary based on program design, target market, program maturity, and other factors.

To maintain a simple, transparent analytical structure, the Energy Center elected to develop and apply *pro rata* program administrative cost factors at the measure level, rather than bundling measures into programs, which can be a subjective and analytically opaque process. The Energy Center developed administrative program cost factors on a per-kWh and per-therm basis (based on lifetime energy savings) using historical program expenditures and savings results from Focus on Energy, as well as programs in Minnesota (Xcel Energy and Southern Minnesota Municipal Power Agency), Iowa (MidAmerican Energy and Alliant Energy), and Vermont (Efficiency Vermont). These program data showed relatively minor

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[24] Synapse Energy Economics, Inc. (2008). *Synapse 2008 CO_2 Price Forecasts*.

[25] The CO_2 emissions factor for electricity is from: PA Consulting Group Inc. (2008). *Quantifying Environmental Benefits of Focus on Energy: Emission-Rate Estimates 2002 to 2006.* Prepared for the Public Service Commission of Wisconsin.
The CO_2 emissions factor for natural gas is from: PA Consulting Group, Inc. (2008). *Focus on Energy Evaluation: Semi-Annual Report (First Half of 2008)*. Prepared for the Public Service Commission of Wisconsin by the Focus on Energy evaluation team (PA Consulting, Glacier Consulting Group, KEMA, and Patrick Engineering, Inc.).

variability across programs for the commercial and industrial (C&I) market, but some differences between programs for the residential market. Table EE-5 summarizes the administrative cost factors used in this analysis.

TABLE EE-5. ADMINISTRATIVE PROGRAM COST FACTORS

Measure Type	$/lifetime kWh	$/lifetime therm
Residential lighting and appliances	0.005	0.040
Residential new construction and building shell	0.009	0.140
Commercial, industrial, and agricultural	0.003	0.030

We used a five percent real discount rate to convert future costs and benefits to present values in the TRC test. This societal discount rate is consistent with values used in Focus on Energy evaluations.[26]

The efficiency potential model uses sector growth rates to project annual eligibility for equipment replacement based on failure of existing equipment (the "replace on burnout" market) or new construction. In light of the current economic downturn and uncertain timing of recovery, which affect these rates, we assumed a conservative one percent annual growth rate across all sectors. To benchmark this assumption, we compared these values with macroeconomic data from the Energy Information Administration's (EIA) *Annual Energy Outlook 2009 Early Release.*[27] Using historical values and projection data for 2006 through 2018, we determined annual growth rates for the following indicators: real Gross Domestic Product (2%), commercial floor space (1%), manufacturing value of shipments (1%), and housing starts (0.3%).[28] The Wisconsin Department of Revenue's Division of Research & Policy projects similar economic trends for the state, with employment falling two percent in 2009 before resuming a growth trend of 0.8 percent in 2010 and 1.4 percent in 2011.[29] Wisconsin housing starts are projected to hit bottom in 2009 and begin climbing again in 2010.

Future savings achieved by installed measures will decline over the lifetime of the measures due to factors such as early failure, removals of energy efficient equipment due to consumer dissatisfaction or other factors, or failure to maintain equipment at optimal performance levels. Instead of using a savings decay

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[26] PA Consulting Group, Inc. (2008). *Focus on Energy Evaluation: Semi-Annual Report (First Half of 2008)*. Prepared for the Public Service Commission of Wisconsin by the Focus on Energy evaluation team (PA Consulting, Glacier Consulting Group, KEMA, and Patrick Engineering, Inc.).

[27] U.S. Department of Energy, Energy Information Administration (December 2008). *Annual Energy Outlook 2009 Early Release*. Available at: http://www.eia.doe.gov/oiaf/aeo/.

[28] Our assumption for growth in housing starts is still conservative, as EIA projects annual growth in housing starts of ten percent from 2009 through 2018.

[29] Wisconsin Department of Revenue, Division of Research & Policy (December 2008). *Wisconsin Economic Outlook*. Available at: http://www.revenue.wi.gov/ra/0812/0812okma.pdf.

function, this decline is addressed by the fact that measure lifetimes used in the analysis are based on the median equipment lifetime. This practice reflects a conservative approach to estimating future savings.[30]

Program Innovation

The Energy Center's approach was to estimate levels of savings that could be achieved under an aggressive approach to energy efficiency program funding and delivery. Key modeling assumptions that reflect an aggressive approach to program delivery are summarized below. Though the modeling effort required defining some basic parameters for innovative programs, it is important to note that our analysis was primarily conducted at the measure level, rather than at the program level. Thus, the discussion of innovative program strategies are intended to be illustrative, and the potential study should not be viewed as a roadmap for program planning and design.

Across all sectors, the Delphi-derived achievable factors are the primary mechanism for estimating savings that could be achieved through aggressive approaches to energy efficiency. For key technologies, Delphi experts were asked to estimate levels of market penetration that could be achieved through continuation of business-as-usual funding levels and program approaches, and also to estimate levels of market penetration that could be achieved through aggressive funding levels and program approaches. Respondents included the effect of innovative program delivery in this aggressive scenario. Aggressive program scenario responses were the primary input for developing the measure-specific achievable factors discussed above.

In addition, some sector-specific modeling adjustments were made to reflect key innovative program approaches discussed in Chapter EE-4. In particular, to model the "neighborhood blitz" (a program strategy targeting retrofit opportunities in the residential market) we modified achievable factors for specific retrofit measures to reflect levels of market penetration that could be achieved through a community-based direct install initiative. Additional details on neighborhood blitz modeling assumptions are provided in Appendix A.

Upstream incentives are another innovative program strategy discussed in Chapter EE-4. The approach to modeling program costs reflects a shift in program emphasis from downstream consumer incentives to upstream incentives for equipment suppliers and retailers to affect net increases in the market share for efficient products. For example, consider an appliance where energy efficient models currently enjoy sixty percent market share. Using a downstream incentive strategy, a program could theoretically have to pay an incentive for every unit sold, so moving the market from sixty percent to seventy percent might not be cost-effective. However, for the purposes of this analysis we assume that the program could use an upstream approach and only pay incentives based on the ten percent increase in market share. This approach provides a basis for the increased penetration rates we modeled for energy efficiency measures that currently enjoy a significant market share in Wisconsin.

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[30] The most recent semi-annual evaluation of Focus on Energy employed a different approach to addressing savings decay, assuming an exponential decay function such that half of the savings remain after the measure life. Under a five percent discount rate, the two approaches produce equivalent savings results for measures with a lifetime of 15 years. However, the Energy Center's approach is more conservative for measures with a lifetime shorter than 15 years, as it excludes savings occurring from the 50 percent of installed measures which out-last the median equipment lifetime. The average savings-weighted lifetime for measures addressed in this study is 12 years.

Program Cost Estimation

The TRC test is a useful analytical tool for evaluating investments in energy efficiency and renewable energy against investment in traditional supply-side alternatives. However, from a policy perspective it is also useful to estimate the cost energy efficiency programs would incur in achieving estimated savings potential. Though the program administrator cost test was not used in this analysis, the Energy Center developed program cost curves to provide general information to policy makers. It is important to note that since this study was conducted from a total resource cost perspective, program cost estimates are intended as a general approximation. Comprehensive program planning would be necessary to develop a more precise estimate.

The Energy Center developed program cost curves by applying the general assumption that under an aggressive program scenario, programs would pay 50 percent of the cost of replace-on-burnout and new construction measures, and 90 percent of the cost of retrofit measures.[31] The cost of replace-on-burnout and new construction measures is typically the incremental cost difference between the energy efficient technology and the standard efficiency alternative. The cost of retrofit measures is typically the sum of capital and installation costs. Total resource cost and program cost curves are provided in Chapter EE-2, which includes a discussion of why higher incentive levels were assumed for retrofit measures.

Scenario Analysis

As with any projections of future conditions, potential studies entail a high degree of uncertainty. Uncertainty is driven by a variety of factors, including imperfect data on baseline market conditions and the fundamental challenges associated with predicting human behavior. Setting aside these obstacles, future trends of energy efficiency improvement will be affected by a number of factors that are also difficult to predict: energy costs; technology costs; rates of technology advancement; and federal policies that could be enacted, such as regulation of greenhouse gas emissions and adoption of increased efficiency codes and standards.

Our primary scenario analysis focuses on an environmental scenario that represents an upper bound for energy efficiency potential estimates. This scenario includes the following modifications to base scenario modeling inputs:

- **Increased Avoided Costs**: Utility avoided costs are increased by $0.02 per kWh and $0.25 per therm to reflect the cost of all non-carbon environmental externalities, such as sulfur dioxide (SO_2) emissions, oxides of nitrogen (NO_x) emissions, and mercury (Hg) emissions.
- **Relaxed TRC Screen:** The TRC threshold is relaxed from 1.0 to 0.75 to reflect distributional aspects of benefit-cost analysis.
- **Lower Discount Rate**: In a carbon-constrained future, it is likely that the value of energy efficiency investments made today will increase over time, rather than decrease, so we lowered the real discount rate from five percent to two percent.

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[31] Using incremental costs and program costs reported in the October 2008 semi-annual evaluation of the Focus on Energy program conducted by PA Consulting Group (Table 2-15), incentives currently cover around 30 percent of the incremental cost of energy efficiency measures, averaged across all programs and measures. This estimate assumes that incentives represent around 60 percent of Focus on Energy program costs, which is consistent with historical results.

In Chapter EE-3, we compare the results under this environmental scenario with the base scenario results. We also conducted additional scenario analyses to assess the individual impacts that modifying each one of the above inputs would have on efficiency potential estimates. Lastly, we conducted an additional scenario which removed the carbon cost adder from the avoided costs used in the base scenario. Supplementary scenario analysis results are summarized in Appendix E.

Supplementary Analyses

The Energy Center conducted three additional analyses to supplement baseline estimates of energy efficiency potential: (1) the impact of programs targeting energy efficiency improvement through behavior-based programs; (2) the impact of innovative rate design, demand response initiatives, and smart grid technologies; and (3) the impact of revisions to building codes and appliance standards.

These supplementary analyses provide qualitative and quantitative assessments of what could be achieved through these specific demand-side management (DSM) approaches. It is important to note that the results of these analyses are, for the most part, not additional to our baseline estimates of energy efficiency potential. Rather, quantitative estimates developed through these supplementary analyses represent a subset of the efficiency potential that could be achieved through aggressive policy and program approaches, which are assumed to be present in the final results of this study. In the case of codes and standards, mandatory approaches can achieve savings that are not available through voluntary program approaches. The approaches used in these supplementary analyses are discussed below, with additional information provided in Chapter EE-4.

Behavior-based programs are efforts to influence human choices that affect energy consumption. This diverse category of programs may seek to affect choices regarding purchase decisions, operational practices, equipment installation practices, or building design practices. Examples include informational efforts like the ENERGY STAR® brand awareness campaigns, social marketing efforts, and continuing education for architects and engineers. Many technology-focused programs include an informational/educational component, blurring the distinction between traditional energy efficiency programs and behavior-based programs.

Given the degree of overlap between technology-focused programs and behavior-based initiatives, we pursued a three-fold approach for addressing the energy-savings potential associated with behavior-based approaches. Our co-consultants, ACEEE, created a Wisconsin-specific version of a model they recently developed for estimating behavior-based energy efficiency potential at the national level. In addition, we estimated potential savings from a neighborhood-based plug load initiative that combines an appliance audit, consumer information, and viral marketing, with trained staff of "plug load specialists" that provide customized recommendations for each home they visit. Lastly, we conducted research into use of feedback techniques for reducing energy consumption. These preliminary analyses illustrate the degree to which behavior-based approaches could play a role in an aggressive energy efficiency program portfolio in Wisconsin.

We also provided a qualitative assessment of results that could be achieved through advanced rate designs that employ dynamic pricing, where the retail cost of electricity varies according to electric demand. We conducted a literature review, including a 2008 study that reviewed the findings from 17 recent experiments with dynamic pricing.[32] Based on this research, we drew qualitative conclusions on the potential energy saving and peak demand reduction impacts from wider deployment of dynamic pricing in Wisconsin.

The building codes and appliance standards component of our analysis assesses the amount of energy efficiency potential that could be achieved through mandatory requirements, rather than voluntary programs. We assessed the incremental impact of energy-related revisions to building codes and appliance efficiency standards by modifying key inputs in the energy efficiency potential model under the following assumptions:

- A 15 percent increase in the energy efficiency of new homes resulting from changes in the residential code.[33]
- A 15 percent increase in the energy efficiency of commercial new construction resulting from changes to the commercial code.[34]
- State energy efficiency standards for new residential furnaces, new commercial boilers, and commercial packaged air conditioning systems.[35]

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[32] A. Faruqui and S. Sergici (November 2008). *Household Response to Dynamic Pricing of Electricity: A Survey of Seventeen Pricing Experiments*. The Brattle Group.

[33] This code-based efficiency level is slightly higher than current levels required by the Wisconsin ENERGY STAR Homes program.

[34] This 15 percent increase is based on the approximate savings in switching from current code to an average of the 2007 and 2010 versions of ASHRAE 90.1

[35] The Governors Global Warming Task Force recommended establishment of state standards for residential gas furnaces and furnace fans, compact audio equipment, high efficiency commercial boilers, and industrial boilers. State standards can be established for equipment where there is no existing federal energy efficiency standard, or where a state has been granted authority to preempt the federal standard.

CHAPTER EE-2: STATEWIDE AND SECTOR RESULTS

ECONOMIC POTENTIAL

As previously noted, this analysis focuses on estimates of achievable energy efficiency potential, though estimates of economic potential were developed as well. Recall that as a practical measure, estimates of economic potential have limited usefulness, as they do not account for capital constraints, the useful lifetime of existing installed equipment, or other barriers that inhibit adoption of cost-effective energy efficiency measures. Figure EE-1 presents economic potential estimates by energy type.

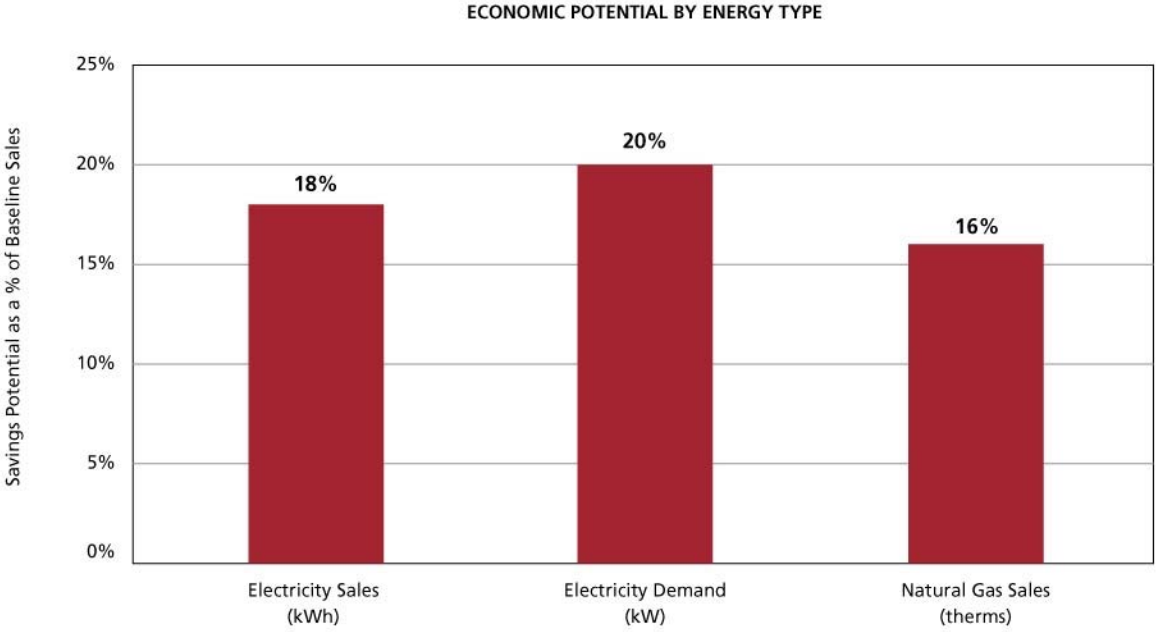

Figure EE-1: Economic Potential by Energy Type

Across the scenarios, economic potential represents between 16 and 20 percent of baseline energy consumption. In other words, if Wisconsin energy consumers immediately installed all cost-effective energy efficient measures, statewide energy use would decline to around 80 percent of existing levels.

ACHIEVABLE POTENTIAL

The primary focus of our modeling effort was to determine the *annual* savings that statewide energy efficiency programs could achieve in the year 2012. Figure EE-2 shows achievable potential estimates by energy type.

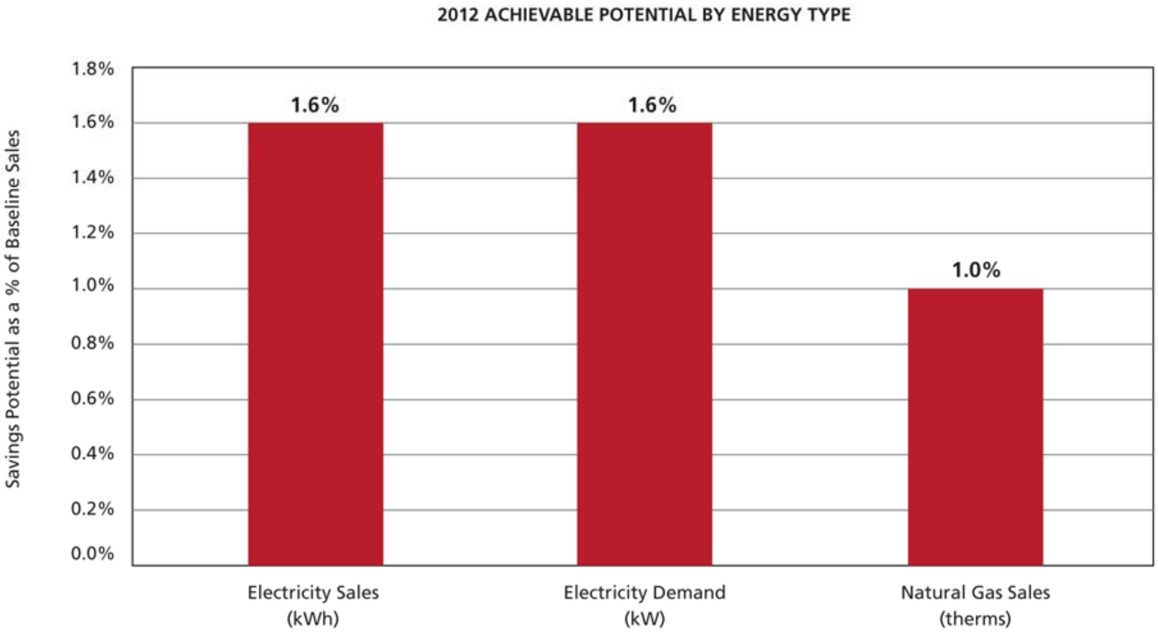

Figure EE-2: Annual Achievable Potential 2012

We also developed achievable potential estimates for 2018. However, as noted earlier, ten-year estimates are associated with a much higher degree of uncertainty than the 2012 estimates. We do not know how existing energy efficient technologies will advance over this time period, and what new technologies will emerge. Technology costs, energy prices, the state of the economy, and federal climate policy are other factors that will have a dramatic effect on energy efficiency potential in the coming decade. In the current political and economic climate these factors are more difficult to predict than ever.

In developing efficiency potential estimates for 2018, we considered two related but countervailing factors: technology advancement and technology maturity. As new technologies come on the market, older technologies fade away or become commonplace, which takes them out of the domain of program potential.

Though we know technology advancement and technology maturity are offsetting forces, it is difficult to say which one would have the larger impact over a ten-year time horizon. As a starting point, a simple way of considering both factors is to assume that they cancel each other out. Lacking compelling data to support an alternative forecast, we adopted this assumption.

This leaves the *annual* rate of efficiency gains in 2018 at the same level assumed for 2012. Over time, the *cumulative* impact continues to grow as the constant rate of annual savings accrues. Figure EE-3 shows the cumulative savings for each energy type that will be generated by the year 2018.

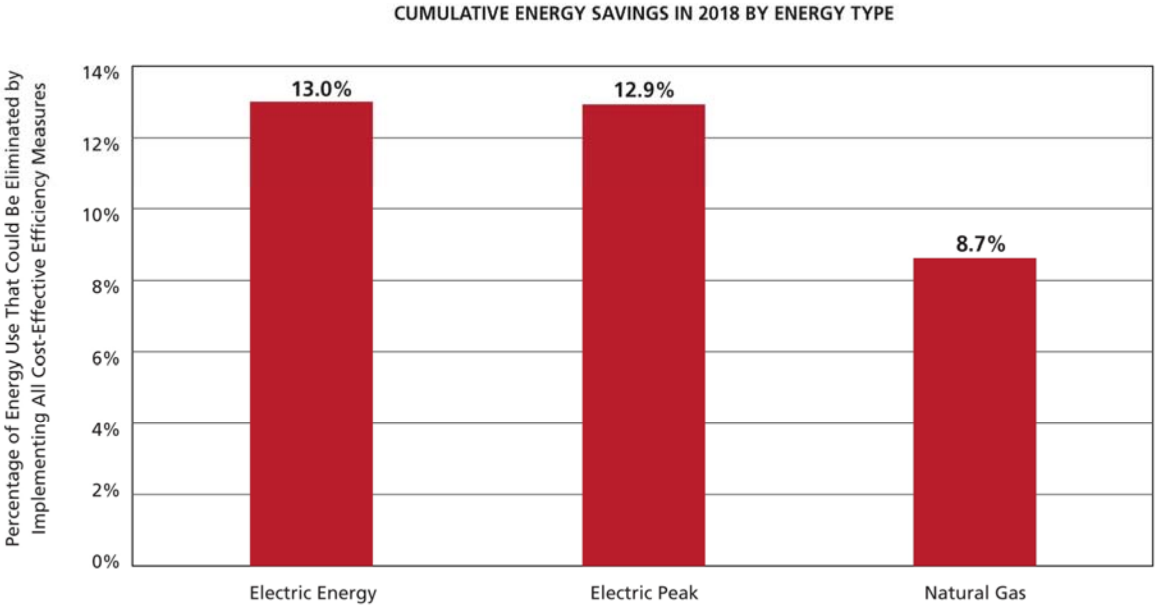

Figure EE-3: Cumulative Energy Savings in 2018 by Energy Type

PROGRAM AND TOTAL RESOURCE COST ESTIMATES

A critical consideration for policymakers is the cost Wisconsin energy efficiency programs would incur in achieving the aggressive energy savings projected in this study. This study was primarily conducted from a total resource cost perspective rather than a program administrator cost perspective. Costs and savings were evaluated at the measure level, rather than at the program level. However, the Energy Center applied some broad assumptions to provide a general approximation of the level of program investment that could be necessary to achieve the savings projected in this study. Comprehensive program planning would be necessary to develop a more precise estimate.

The Energy Center's estimates are based in part on the assumption of significant increases in program activity targeting the retrofit market. To achieve success in the retrofit market, programs must invest substantial resources to overcome consumer inertia and informational/awareness barriers. In addition to the administrative (non-incentive) costs associated with running a successful program (market research, program design and planning, marketing, outreach, education, training, technical expertise, etc),[36] we suggest that energy efficiency programs will have to pay for <u>most of the costs</u> associated with installing the measures. For retrofit measures, we assume that the program will incur 90 percent of the costs

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[36] We estimated administrative program costs (e.g., non-incentive costs) based on historical results from Focus on Energy and other programs, as described in Chapter EE-1. These costs were scaled proportionately to reflect the greater level of savings suggested in this study.

associated with measure installation. For equipment replacement and technologies installed in new construction, we assume the program will incur 50 percent of the incremental technology costs. As noted above, these broad assumptions are intended to provide a general approximation of necessary levels of program investment, and detailed program planning and cost estimation would be necessary to develop accurate estimates of program investment.

These assumptions lead to the following annual budget estimate for the year 2012 (2008 dollars):

RETROFITS	$305,000,000
EQUIPMENT REPLACEMENT	$36,000,000
NEW CONSTRUCTION	$12,000,000
GRAND TOTAL	**$353,000,000**

To reach these savings and spending levels in 2012, energy efficiency programs would need to ramp up quickly. That means that funding increases will be needed now to set us on a course that allows us to reach the estimated 2012 levels of achievable energy efficiency.

Figures EE-4 and EE-5 show the levels of electric and natural gas potential that can be achieved in 2012 under increasing levels of program investment (2008 dollars).

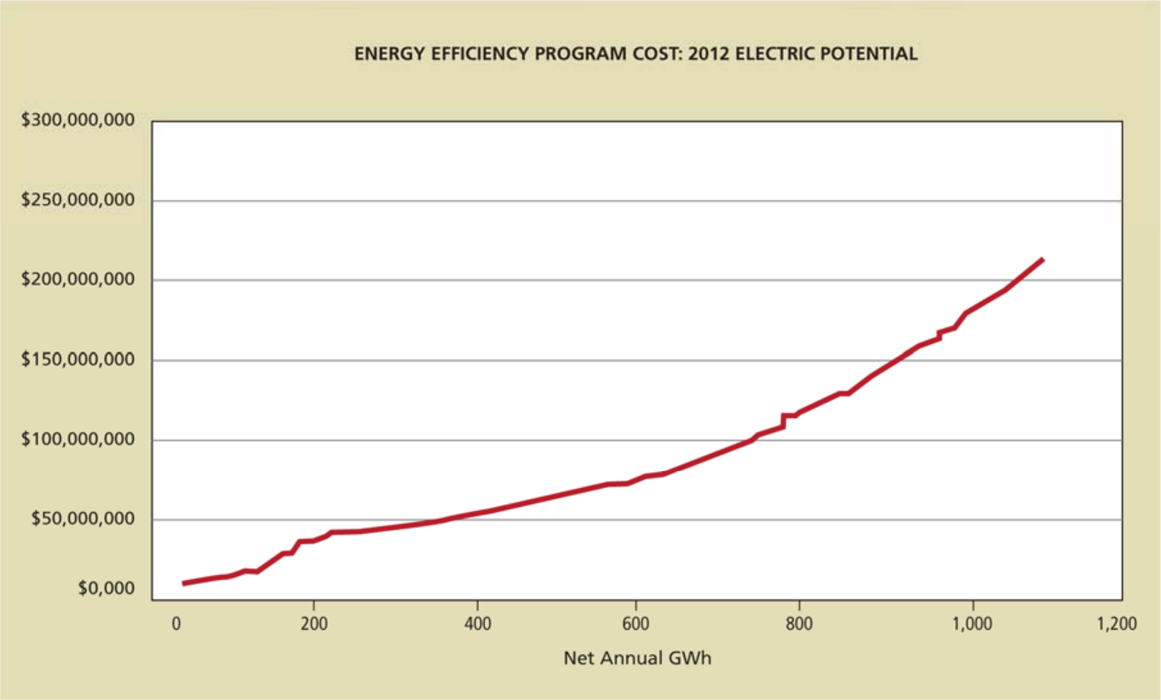


Figure EE-4: Program Cost Curve, 2012 Electric Efficiency Potential

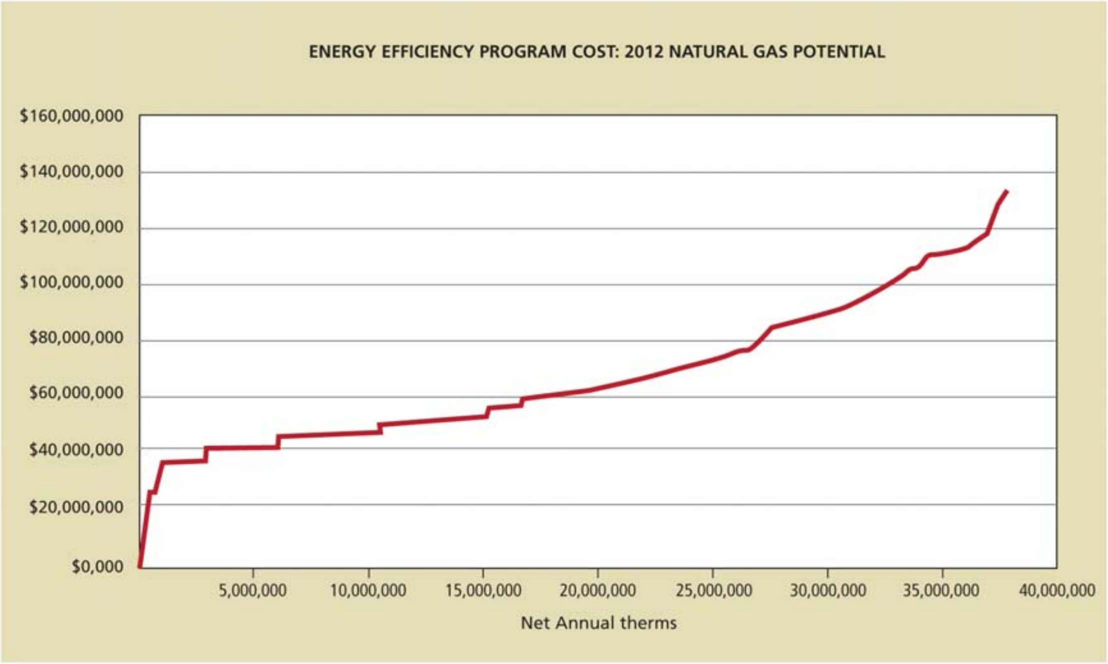


Figure EE-5: Program Cost Curve, 2012 Natural Gas Efficiency Potential

Evaluating costs from a total resource perspective (which includes both the cost to the program and the cost to the consumer) produces the cost curves shown in Figures EE-6 and EE-7. The total resource cost of achieving 2012 levels of energy efficiency is approximately $400 million (2008 dollars).

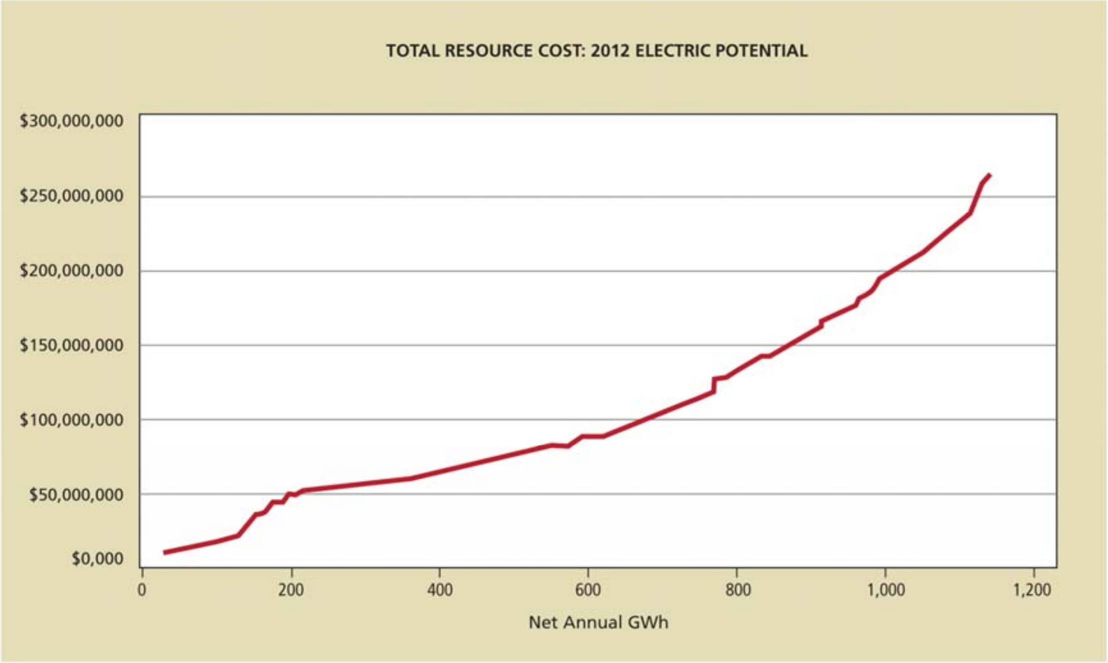


Figure EE-6: Total Resource Cost Curve, 2012 Electric Efficiency Potential

Figure EE-7: Total Resource Cost Curve, 2012 Natural Gas Efficiency Potential

ECONOMIC BENEFITS OF AGGRESSIVE ENERGY EFFICIENCY EFFORTS

The most direct impact of an aggressive energy efficiency policy would be the substantial energy cost savings for Wisconsin consumers. Figure EE-8 shows lifecycle cash inflows and outflows to Wisconsin based on a single year of increased program spending.

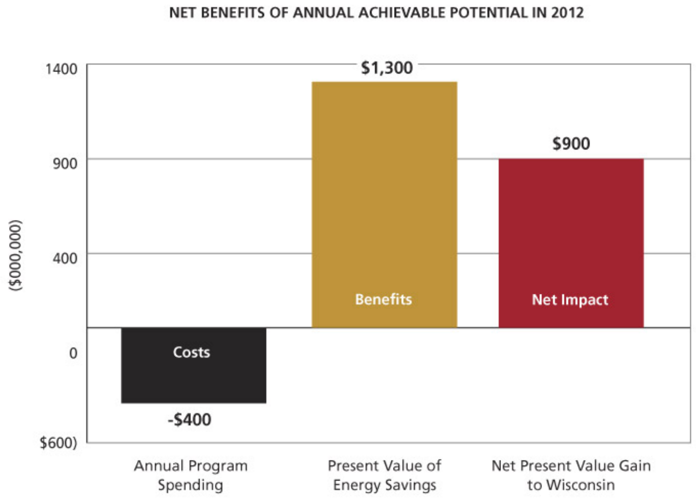


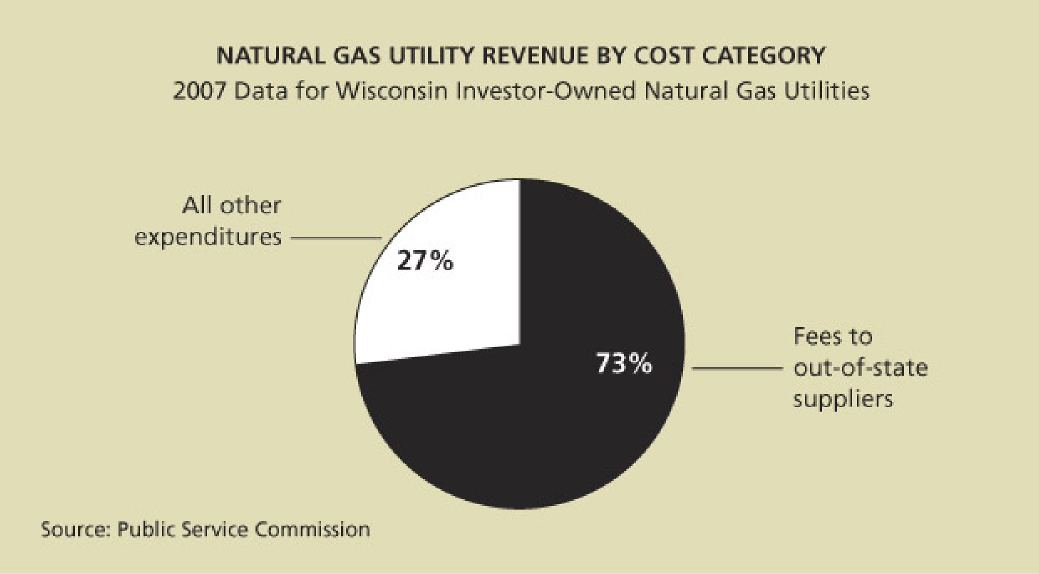
Figure EE-8: Aggregate Net Benefits of Aggressive Energy Efficiency Programs

It is important to interpret this chart correctly. It shows the lifecycle impact of *annual* energy efficiency spending. More specifically, each year that we spend $340 million on efficiency programs we obtain $1.3 billion in lifecycle energy savings. If we spend $340 million one year, and another $340 million the following year, we set the stage for a total of $2.6 billion in lifecycle energy cost savings: $1.3 billion from the first $340 million investment and another $1.3 billion from the second.

Energy efficiency program expenditures also bring employment benefits for Wisconsin's work force. The literature offers a range of approaches for estimating the employment benefits associated with energy efficiency initiatives. For the purposes of this study, we used job creation factors developed by Focus on Energy program evaluators, as well as factors published in a national study by the Center for American Progress.[37] Using these factors, achieving the 2012 energy efficiency levels projected in this study would produce between 7,000 and 9,000 new jobs for Wisconsin.

Spending money on utility service causes a noticeable cash outflow not only to consumers, but to the state as well. This is especially true for natural gas utilities. Reducing consumption of utility services reduces that cash outflow.

Wisconsin has no indigenous natural gas resources (nor any oil or coal resources for that matter). Therefore, any natural gas we burn must be imported. Figure EE-9 shows that, as a result, most of the customer's payment to a Wisconsin natural gas utility leaves the state immediately in the form of payments to gas producers (e.g., Chevron) and interstate pipelines (e.g., ANR Pipeline).



Source: Public Service Commission

Figure EE-9: Natural Gas Utility Revenue by Cost Category 2007 data for Wisconsin Investor-Owned Natural Gas Utilities

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[37] The Energy Center developed employment estimates using job creation factors developed by Focus on Energy program evaluators, as referenced in: PA Consulting Group, Inc. (October 2008). *Focus on Energy Evaluation: Semi-Annual Report (First Half of 2008)*. Prepared for the Public Service Commission of Wisconsin.
We also used job creation factors published in: Department of Economics and Political Economy Research Institute, University of Massachusetts-Amherst (2008). *Green Recovery: A Program to Create Good Jobs and Start Building a Low-Carbon Economy*. Prepared under commission with the Center for American Progress.

The drain of cash associated with electric utility sales is likely not as great as it for natural gas utilities. Nevertheless, of the three choices—energy efficiency, gas sales, or electricity sales—energy efficiency has the greatest positive economic development impact on the state.

ENVIRONMENTAL BENEFITS OF AGGRESSIVE ENERGY EFFICIENCY EFFORTS

Energy efficiency not only delivers net economic benefits, it also delivers environmental benefits. To measure the environmental impact of energy efficiency, we estimated avoided greenhouse gas emissions from utility-supplied energy.

If Wisconsin can achieve the energy savings levels set forth in this study, in 2012 it will reduce CO_2 emissions by 1.3 million tons per year, reduce SO_2 emissions by 12 million pounds per year, and reduce NOx emissions by 2.4 million pounds per year.[38]

If we shift our analysis to reflect a longer-term, environmentally-focused perspective, our results project even greater benefits. The Energy Center conducted an analysis to determine the impacts under an environmental scenario which assigned costs to emissions of other pollutants in addition to CO_2 (e.g., SO_2, NOx, and Hg), and reduced the economic discount rate to place a higher value on future energy savings generated by current program efforts, among other changes. (See Chapter EE-3 for a detailed comparison of the base scenario with the environmental scenario). Under the environmental scenario, the present value of energy efficiency investments increases, justifying additional spending on energy efficiency programs to achieve higher savings levels. This scenario produces estimated CO_2 emission reductions totaling 1.5 million tons per year, SO_2 emissions reductions totaling 14 million tons per year, and NOx emissions reductions totaling 2.8 million tons per year.

As we attempt to garner additional energy efficiency resources, however, we begin to encounter noticeable diminishing returns to scale. For example, to increase annual achievable electric savings potential from 1.6 percent of baseline sales under the base scenario to 1.9 percent under the environmental scenario (a 20 percent increase in energy savings), the program costs necessary to obtain those savings more than double. That is not to say that seeking out those additional savings is necessarily poor policy—the environmental scenario produces positive net benefits. However, it is important to note that achieving the emission reductions estimated under the environmental scenario is proportionately more expensive than obtaining the emission reductions associated with the base scenario.

IMPACT ON STATEWIDE UTILITY LOAD GROWTH

Figures EE-10 and EE-11 show the impacts of both the existing moderate and the proposed aggressive energy efficiency levels on the state's electric and natural gas utility sales. (The effect on electric peak demand is similar to that shown for electric sales.)

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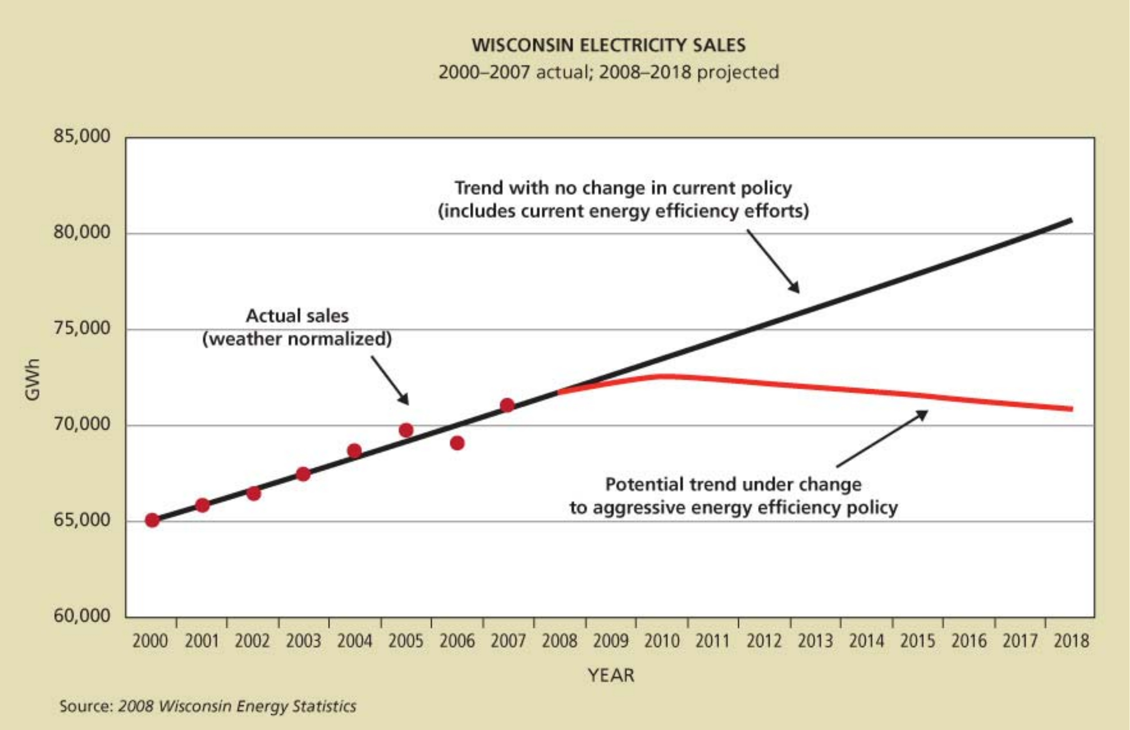
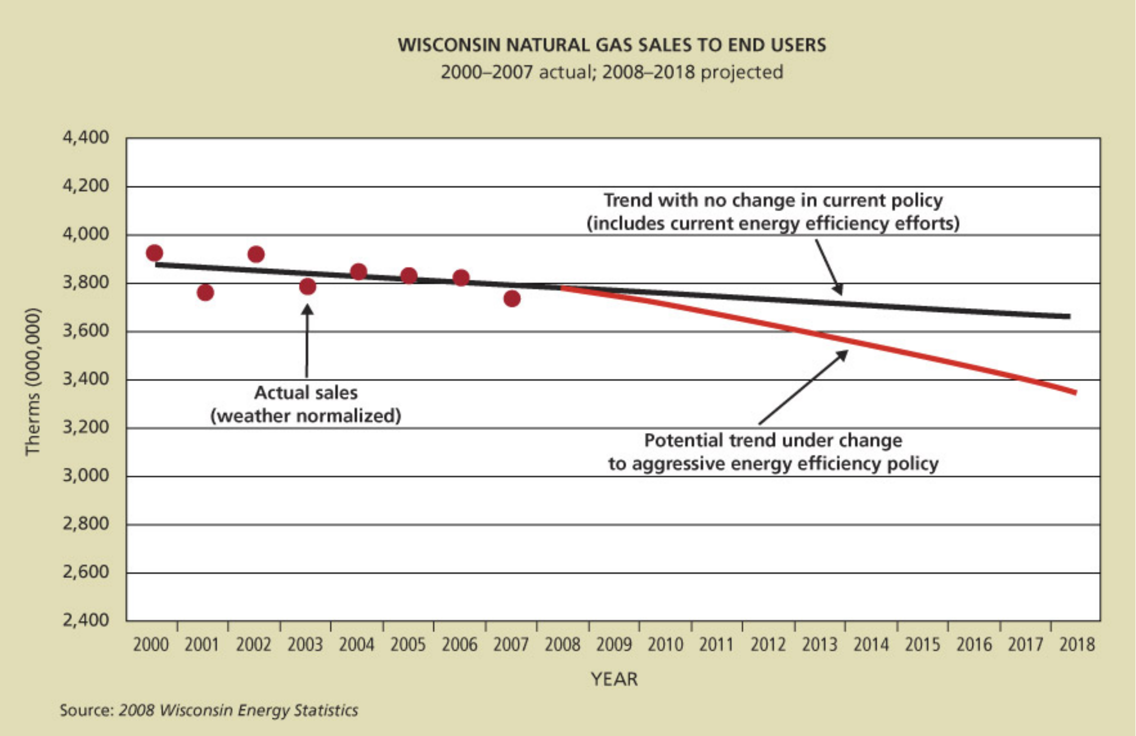
[38] The Energy Center calculated avoided environmental impacts using emissions factors developed by Focus on Energy program evaluators, as referenced in: PA Consulting Group (October 2008). *Quantifying Environmental Benefits of Focus on Energy: Emission-rate Estimates 2002 to 2006*. Final Report. Prepared on behalf of the Public Service Commission of Wisconsin.



Source: *2008 Wisconsin Energy Statistics*

Figure EE-10: Wisconsin Electric Sales 2000 – 2007 (Actual) and 2008 – 2018 (Projected)



Source: *2008 Wisconsin Energy Statistics*

Figure EE-11: Wisconsin Natural Gas Sales to End Users 2000 – 2007 (Actual) and 2008 – 2018 (Projected)

All other factors equal, if we meet the achievable levels of energy efficiency set forth in this study, Wisconsin electric utilities' energy sales begin a trajectory of gradual decline, as anticipated by the Governor's Task Force on Global Warming. Natural gas utilities' sales, already on a gradually declining path, will decline more rapidly.

The implications are significant. Examining the impact of those savings on utility load projections reveals that we will sever the link between electricity sales growth and economic progress. Note that the link has already been severed for natural gas utilities, as the state's economy has continued to grow while natural gas sales have declined.

We present the results on utility load growth to demonstrate the significance of the energy efficiency policy shift suggested in this study. Unlike the impacts suggested by the previous study of statewide energy efficiency potential conducted in 2005, which slightly altered the utilities' long-term sales trajectories, the savings estimates suggested here, if achieved, will change the future supply-side investment trajectory more noticeably.[39]

The PSCW has conducted an investigation of the impacts of energy efficiency programs on utility finances, and possible remedies to correct for any problems in that regard.[40] A discussion of that topic is beyond the scope of this study.

Also beyond the scope of this study is the strong possibility of rapid increases in electrification of cars and light duty trucks during the study period. This trend will likely add significant load to the electric grid, primarily during off-peak periods. This study has set aside any synthesis of this issue, and the countervailing effects of transportation electrification. Reductions cited here are for non-transportation energy consumption.

SECTOR RESULTS

While energy efficiency opportunities exist in all sectors, the magnitude of potential varies by sector. Figure EE-12 presents 2012 annual electricity savings potential by sector, expressed as a percentage of baseline sales.[41]

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[39] Energy Center of Wisconsin (November 2005). *Energy Efficiency and Customer-Sited Renewable Energy: Achievable Potential in Wisconsin 2006-2015*. ECW Report Number 236-1. Prepared on behalf of the Governor's Taskforce on Energy Efficiency and Renewables.

[40] See PSCW Docket 05-EI-114.

[41] For baseline annual sales by sector, we used 2007 sales data as reported in the Wisconsin Office of Energy Independence's *2008 Wisconsin Energy Statistics*.

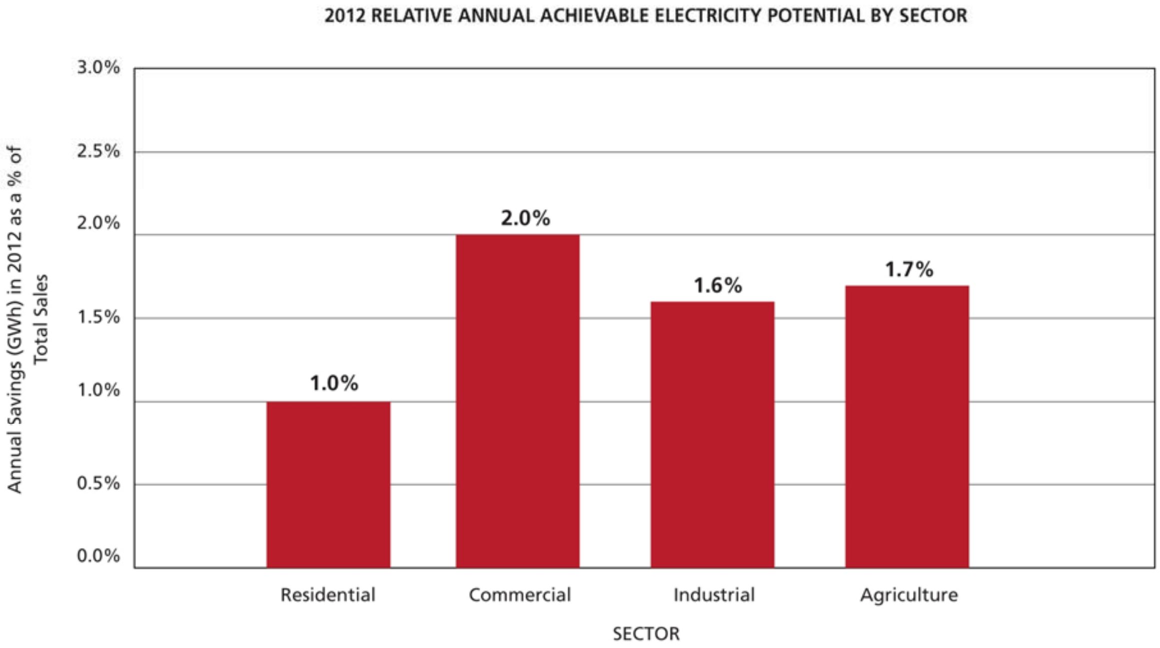

Figure EE-12: Relative Annual Electricity Savings Potential by Sector, 2012

As a percentage of current sales, we see that greater potential for electric energy savings exists in the business sectors, with the commercial, industrial, and agricultural areas all showing relatively more opportunity than the residential market.

Yet while the potential reduction as a fraction of baseline in the agricultural sector is large, the absolute amount of savings potential is not. The absolute electricity savings potential in the residential market dwarfs that of the agricultural sector. Figure EE-13 compares electricity savings potential in absolute terms for each sector. Under objectives of producing the greatest amount of energy bill savings and reducing aggregate greenhouse gas emissions, the absolute numbers matter more than relative reductions in annual sales.

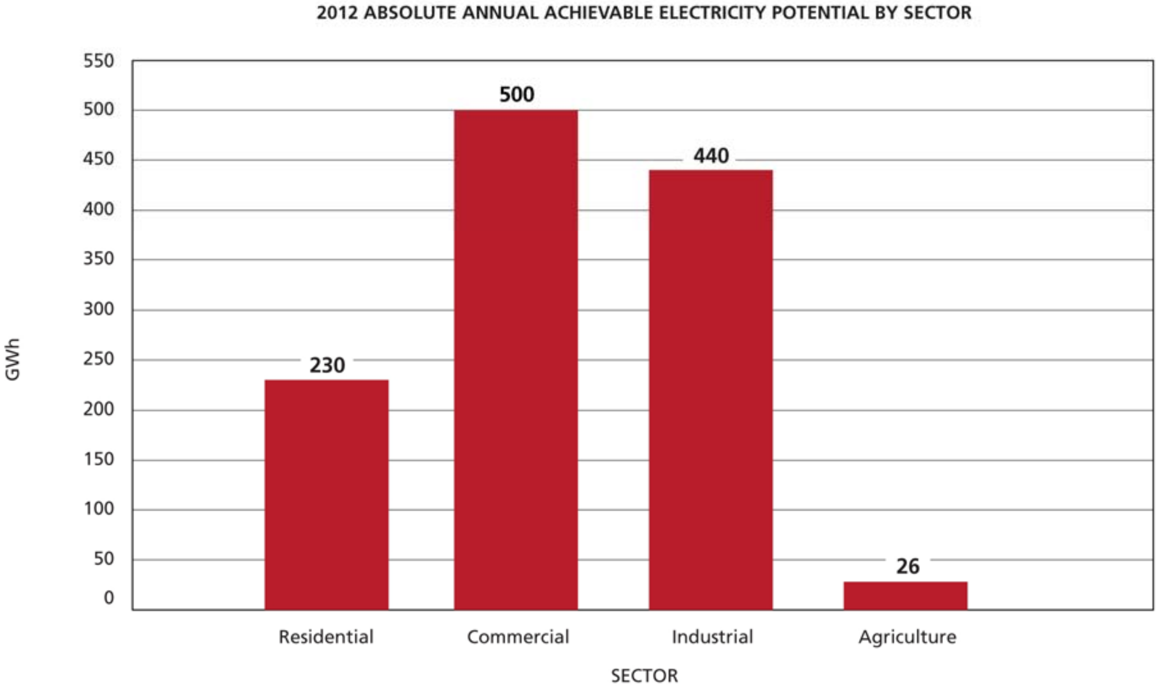

Figure EE-13: Absolute Annual Electricity Savings Potential by Sector, 2012

From this perspective, we see that potential savings in the residential sector lags that of the commercial and industrial sectors. Nevertheless, this figure shows that the residential sector has substantial aggregate electricity savings potential—significantly more than is available from the agricultural sector.

Figure EE-14 presents absolute demand reduction potential by sector. Similar to the results shown for electricity savings potential, the commercial and industrial sectors represent the largest opportunities for demand reduction, followed by the residential sector. Demand reduction potential in the agricultural sector is relatively small compared with other sectors.

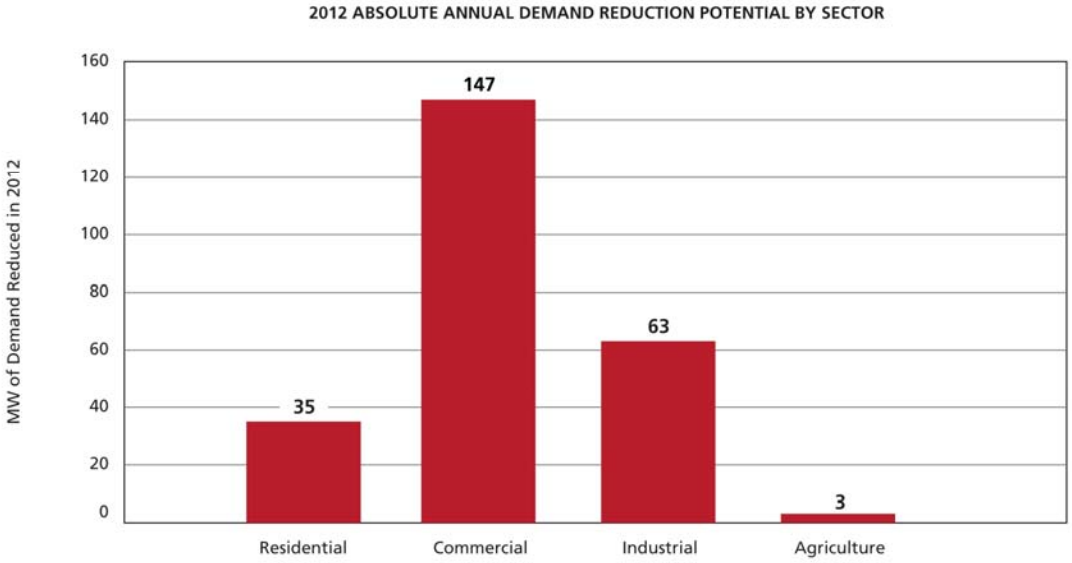

Figure EE-14: Absolute Annual Demand Reduction Potential by Sector, 2012

Figure EE-15 presents natural gas savings results by sector, expressed as a percent reduction in baseline sales.[42] Figure EE-16 shows the absolute natural gas savings potential by sector.

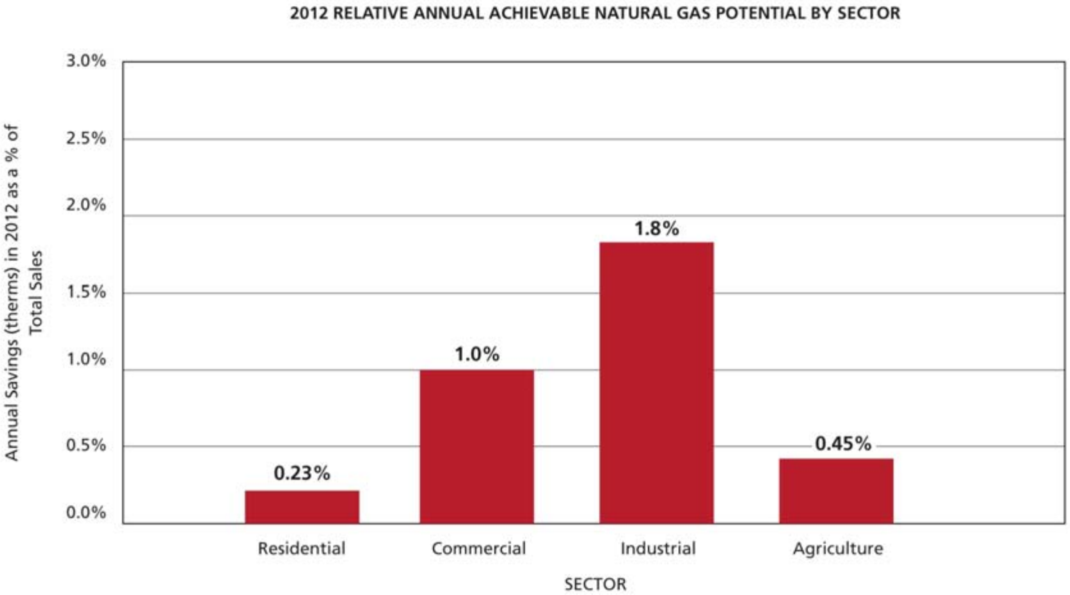

Figure EE-15: Relative Annual Natural Gas Savings Potential by Sector, 2012

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[42] Natural gas savings for the agricultural sector are primarily comprised of propane savings. In many cases, natural gas service is not available to farms.

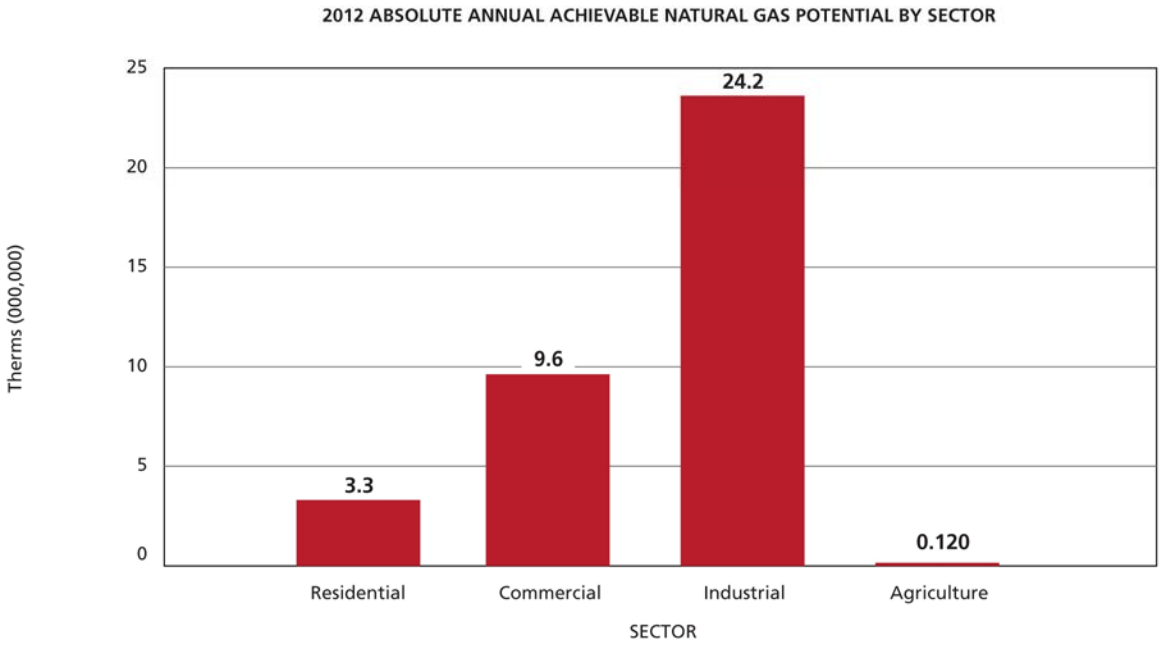

Figure EE-16: Absolute Annual Natural Gas Savings by Sector, 2012

Expressed as a percent reduction in baseline sales, the potential savings in the commercial, industrial, and agricultural sectors is greater than that of the residential sector. However, in comparing absolute energy savings potential across sectors, we see that the residential sector potential is much greater than the agricultural sector potential. At the same time, residential and agricultural savings potential are dwarfed by the magnitude of the savings potential in the commercial and industrial sectors.

MAJOR ENERGY EFFICIENCY OPPORTUNITIES BY SECTOR

Figures EE-17 through EE-28 present major opportunities for energy savings by sector. More detailed results are included in Appendix D.

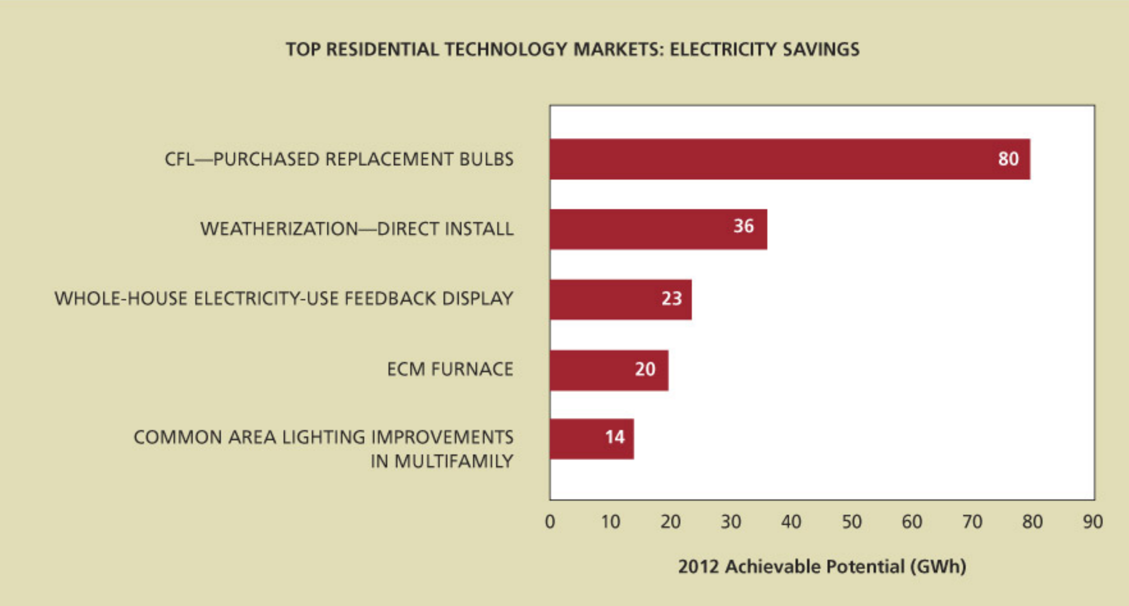

Figure EE-17: Top Residential Technology Markets: Electricity Savings

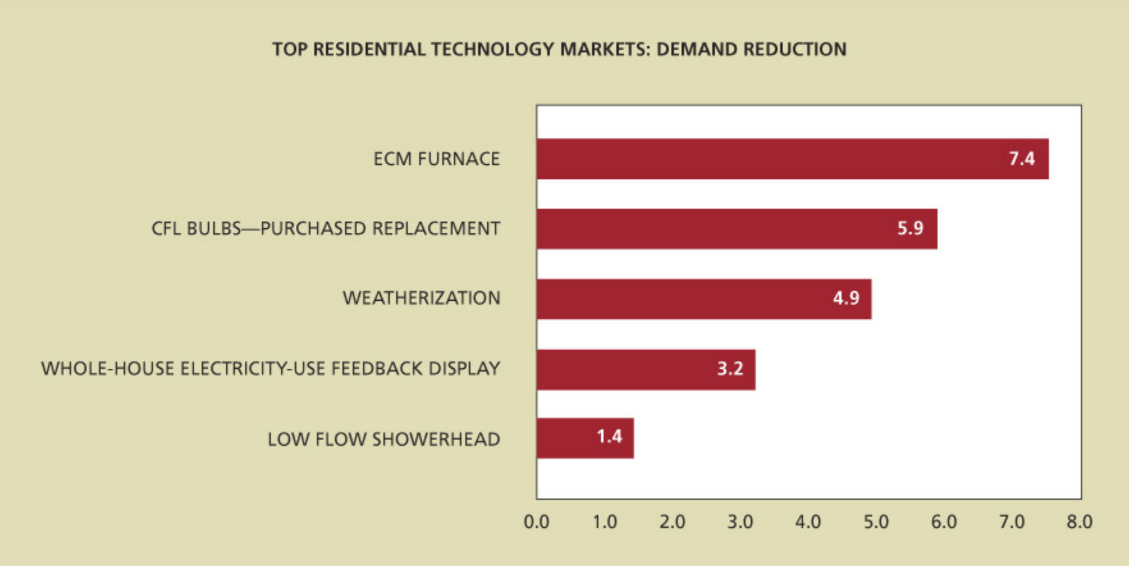

Figure EE-18: Top Residential Technology Markets: Electric Demand Reduction

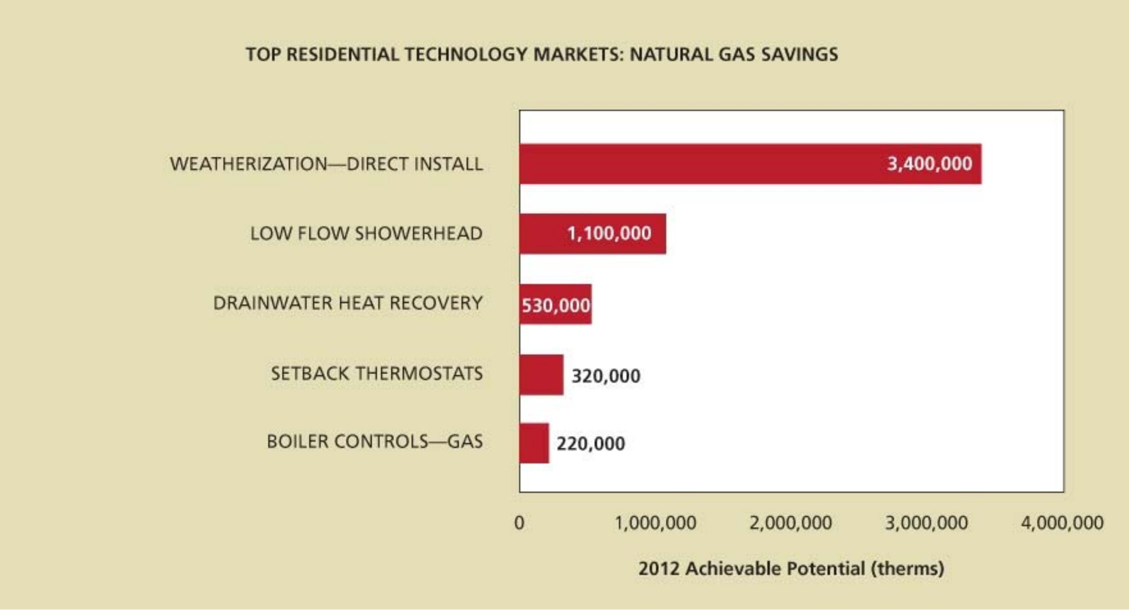

Figure EE-19: Top Residential Technology Markets: Natural Gas Savings

In the residential market, 2012 electricity savings potential is dominated by purchased replacement of CFL bulbs, with weatherization measures and in-home energy usage feedback displays representing other significant opportunities for electricity savings. Opportunities for demand reduction are similar, though furnaces with electronically commutated motors (ECM furnaces) represent the largest fraction of demand reduction potential. Weatherization improvements represent the largest component of natural gas savings potential, followed by hot water conservation measures such as low flow showerheads and drain water heat recovery.

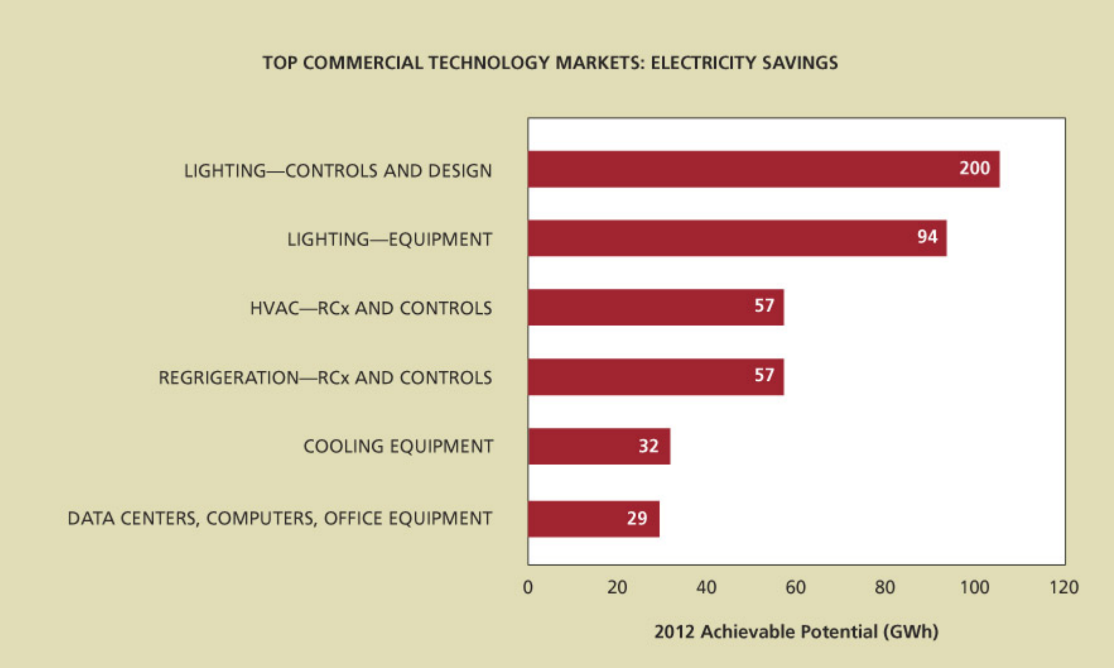

Figure EE-20: Top Commercial Technology Markets: Electricity Savings

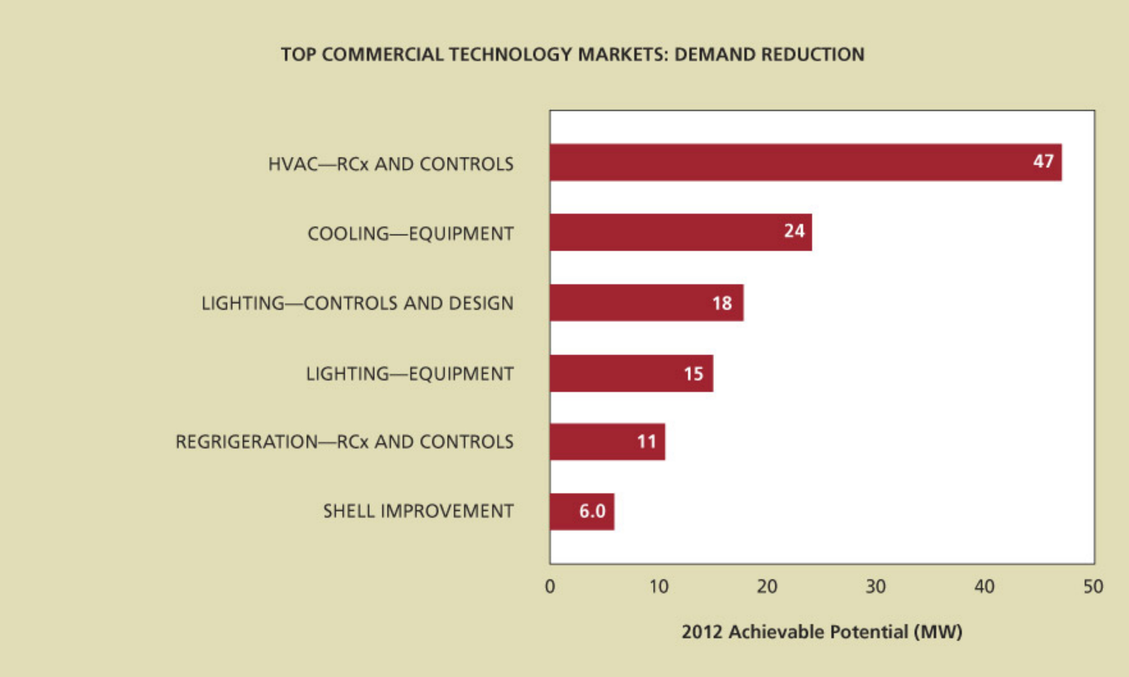

Figure EE-21: Top Commercial Technology Markets: Electric Demand Reduction

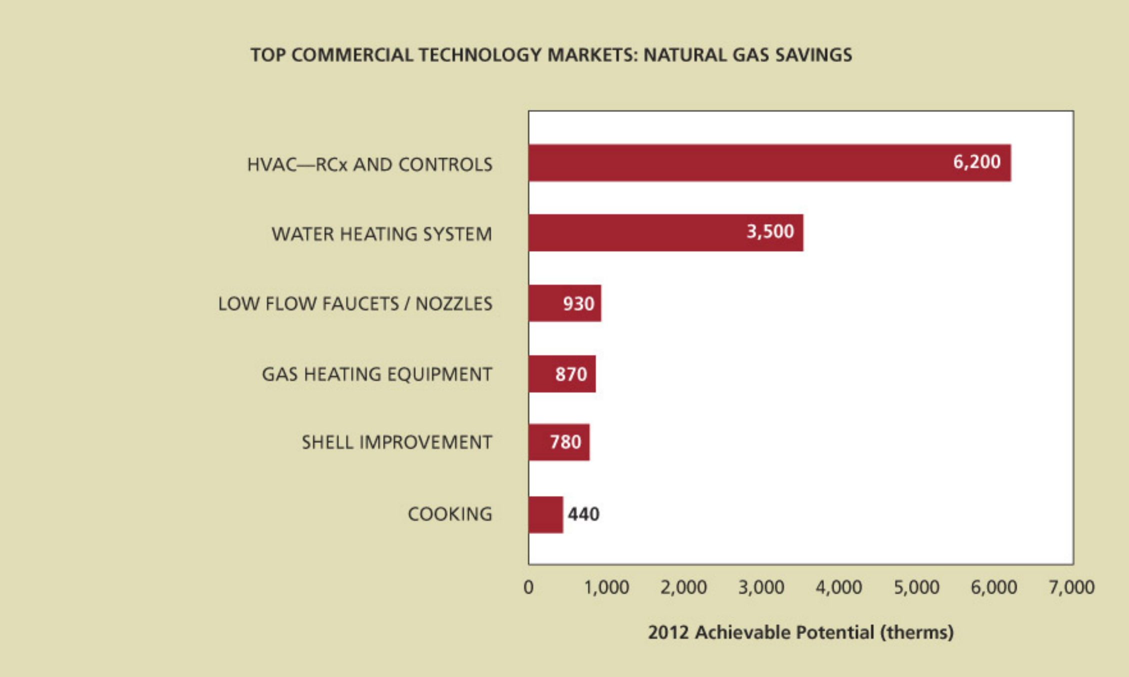

Figure EE-22: Top Commercial Technology Markets: Natural Gas Savings

In the commercial market, electricity savings potential is dominated by lighting—equipment, controls, and efficient lighting design. Retrocommissioning (RCx) and controls to optimize the operation of HVAC and refrigeration equipment also represent significant opportunities for electricity savings and demand reduction. Efficient cooling equipment also represents a substantial component of demand reduction potential. For natural gas efficiency, the largest areas of savings potential consist of HVAC RCx and controls for gas-fired systems, water heating systems, and water conservation measures such as low-flow devices.

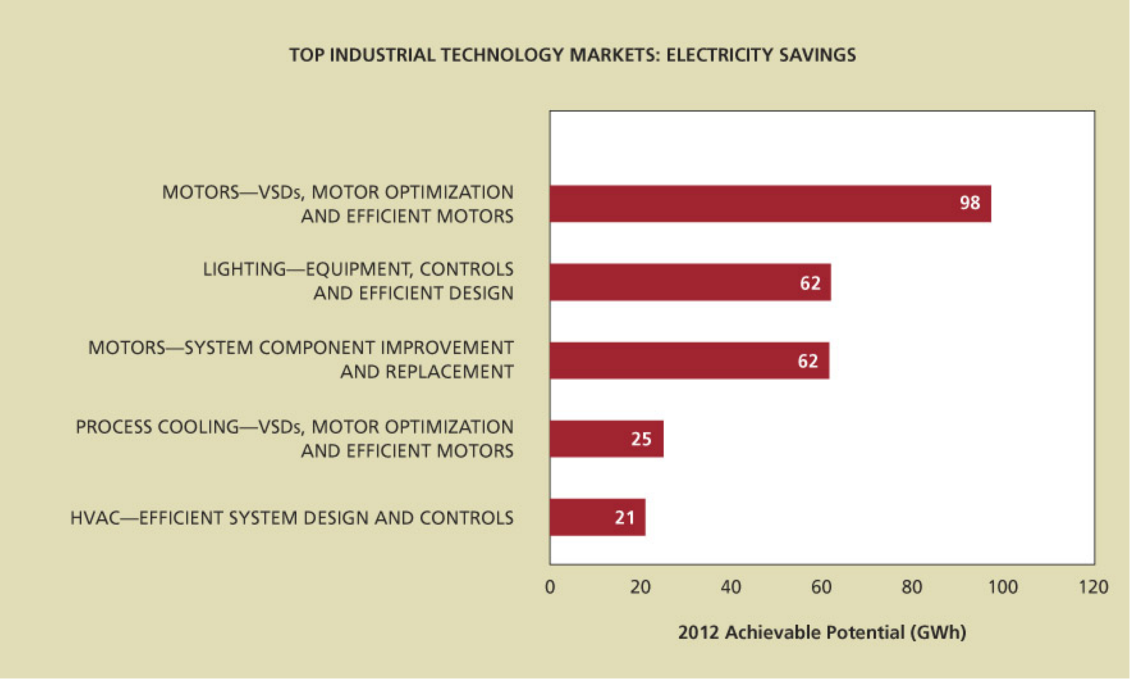

Figure EE-23: Top Industrial Technology Markets: Electricity Savings

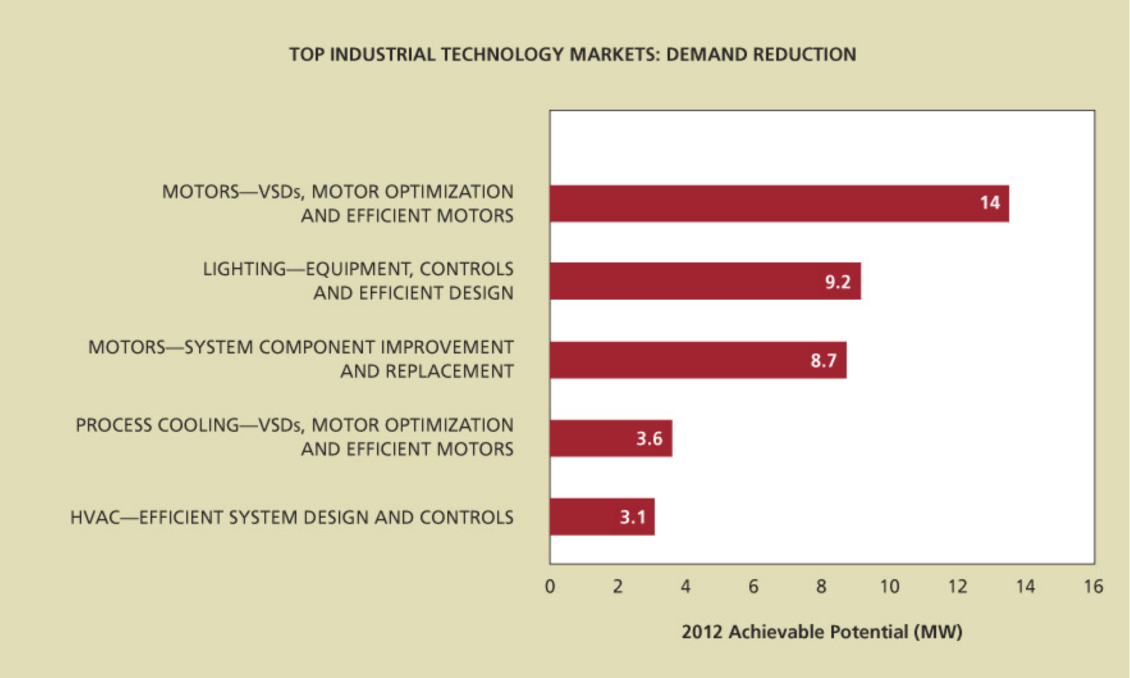

Figure EE-24: Top Industrial Technology Markets: Electric Demand Reduction

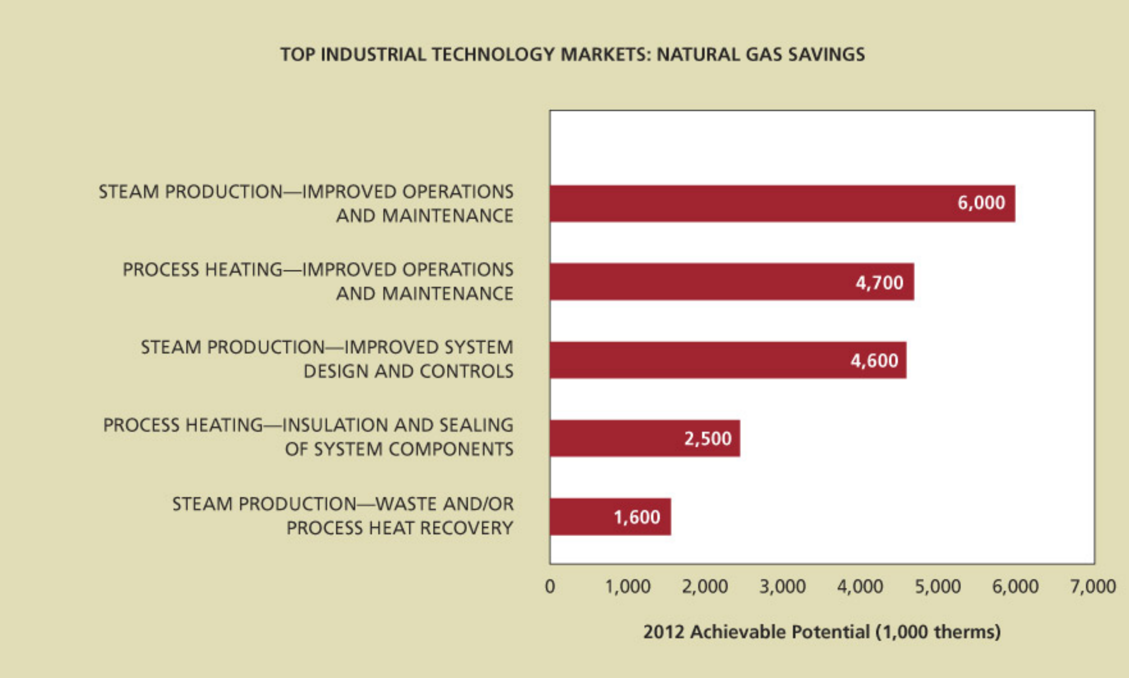

Figure EE-25: Top Industrial Technology Markets: Natural Gas Savings

In the industrial sector, motor system improvements and lighting efficiency upgrades represent the largest opportunities for electricity savings and peak demand reduction. Natural gas savings potential is dominated by improvements to steam systems and process heating equipment—including improved operational and maintenance practices as well as improved system design and controls.

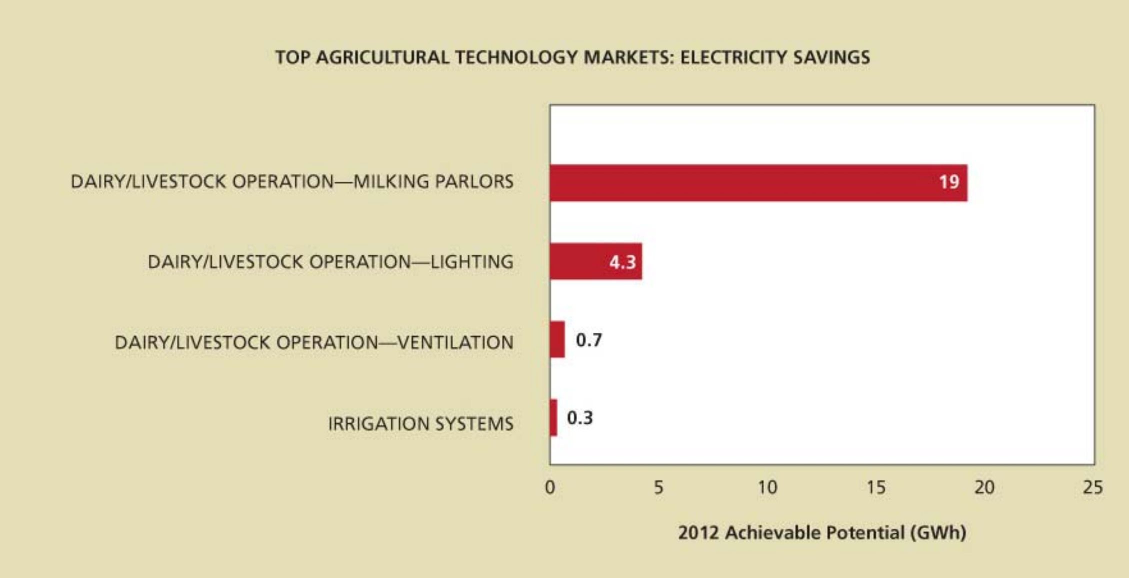

Figure EE-26: Top Agricultural Technology Markets: Electricity Savings

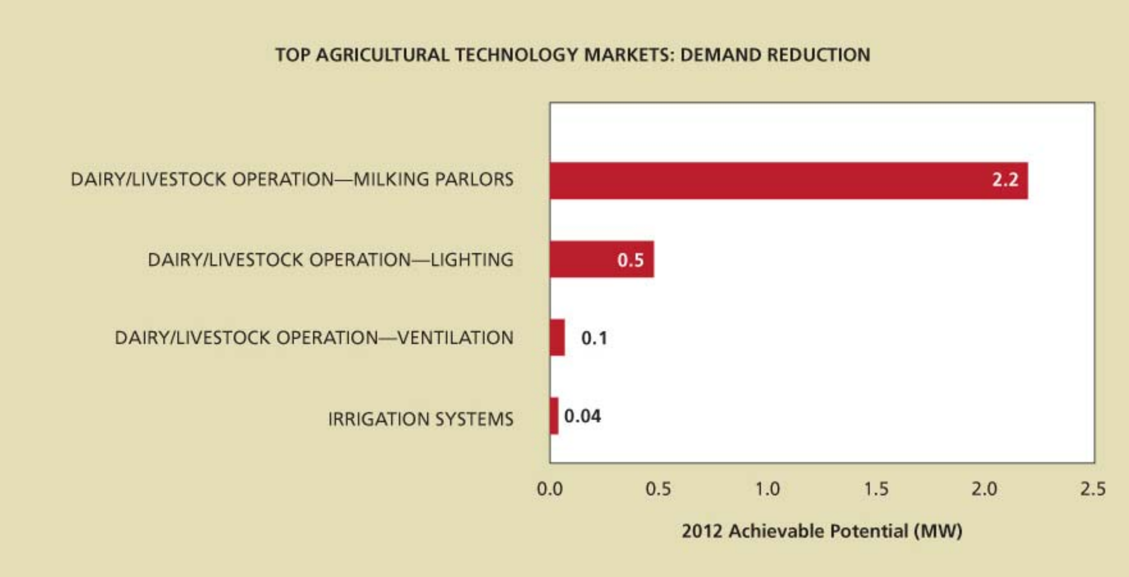

Figure EE-27: Top Agricultural Technology Markets: Electric Demand Reduction

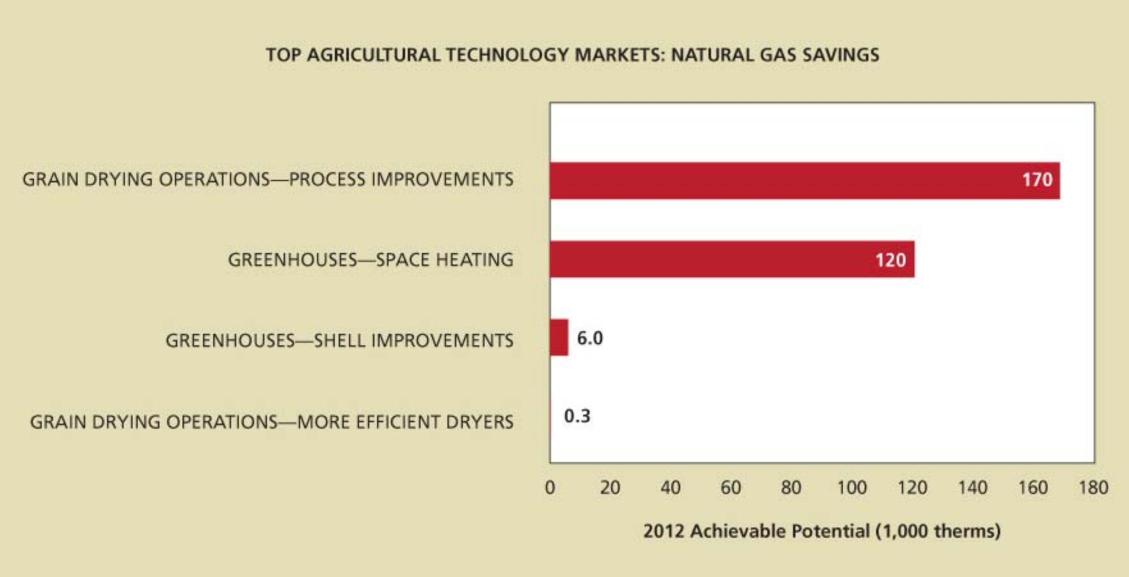

Figure EE-28: Top Agricultural Technology Markets: Natural Gas Savings

For electricity savings in the agriculture sector, the majority of the energy efficiency potential is associated with dairies and other livestock operations. Improvements to milking parlors represent the largest opportunity, including installation of high efficiency compressors (including scroll compressors), heat recovery tanks, plate coolers, variable speed drives for milk and vacuum pumps, pump re-sizing, and conversion of electric water heaters to gas water heaters. Other significant opportunities for electricity savings and peak demand reduction include lighting efficiency upgrades and ventilation system improvements.

For natural gas or propane efficiency, process improvements in grain drying operations and space heating efficiency upgrades in greenhouses represent the largest opportunities for savings.

CHAPTER EE-3: SCENARIO ANALYSIS

APPROACH

The Energy Center conducted scenario analysis by varying key input assumptions to test the outer bounds of energy efficiency potential estimates. In reporting the scenario analysis results, we focus on the scenario with the greatest deviation from the base case, referred to as the "environmental scenario," which includes the following modifications to base scenario modeling inputs:

- A charge of \$0.02 per kWh and \$0.25/therm is added to the utility avoided cost data to reflect the cost of all non-carbon-based externalities, such as emissions of SO_2, NO_x, and Hg.
- The TRC threshold is relaxed from 1.0 to 0.75 to reflect distributional aspects of benefit-cost analysis.
- The real discount rate is lowered from five percent to two percent.

The first change is straightforward in concept. Consumption of fossil fuels creates both direct and external costs. The \$0.02 per kWh figure is a rough proxy for costs associated with environmental externalities other than carbon emissions, which are included in the base scenario. Our goal was not to develop a precise estimate of non-carbon externality costs, as valuations of externality costs tend to range widely. Rather, we wanted to test the sensitivity of our results to the introduction of such a cost.

The TRC threshold is relaxed to 0.75 to account for the fact that the cost-effectiveness test represents the average costs and benefits of installing the measure. An energy efficiency measure with a benefit-cost ratio of 0.8 fails the benefit-cost test on average, but it could still be an economic choice in some cases. Relaxing the TRC provides some indication as to the amount of additional efficiency gains we could obtain if we included measures that just missed the cutoff in the base scenario.

The discount rate change is the most important of the three and deserves the most attention. Economic principles suggest that different discount rates can apply to consumption and to environmental costs.

> *[I]f conventional consumption is growing but the environment is deteriorating, then the discount rate for consumption would be positive but for the environment it would be negative.*[43]

This is not a new economic concept, but rather one that developed long ago in the mainstream literature. Most of us are comfortable in thinking about a positive discount rate. Using the five percent real rate that we employ in the base scenario for purposes of illustration, we note that \$1.00 saved 20 years from now is worth only \$0.38 to us today. That makes intuitive sense.

But what if the discount rate were -5%, rather than +5%? Then the value of \$1.00 saved 20 years hence is worth much more than \$1.00 today. In fact, that \$1.00 saved in the future is worth \$2.79 today.

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[43] United Kingdom, HM Government Economic Service (2006). *The Stern Review on the Economics of Climate Change*. Available at: http://www.hm-treasury.gov.uk/stern_review_report.htm.

Using a negative discount rate suggests that the interests of consumers in the future are more of a concern to us than are our own self interests. While seemingly counterintuitive, such an approach may be particularly relevant when considering strategies to address the risk of climate change. If a policy is established in an effort to mitigate the impacts of climate change, the action could reflect a desire to bear greater costs in the present, in order that future generations bear lower costs. A positive discount rate fails to capture the rationale for taking this action. To be conservative, we use a positive discount rate of two percent for the purposes of the scenario analysis. This rate still values the interests of current generations more than those of future ones, but it does give future citizens more consideration than they would have under a five percent discount rate.

We also examined the effects of varying each of these three inputs—increased avoided costs, lower TRC threshold, and lower discount rate—individually. Lastly, we conducted a final scenario which removed the carbon cost adder from the avoided costs used in the base scenario. These additional scenario analysis results are presented in Appendix E.

STATEWIDE SCENARIO RESULTS

Figure EE-29 contrasts the economic potential between the scenarios. Figure EE-30 does the same for achievable potential.

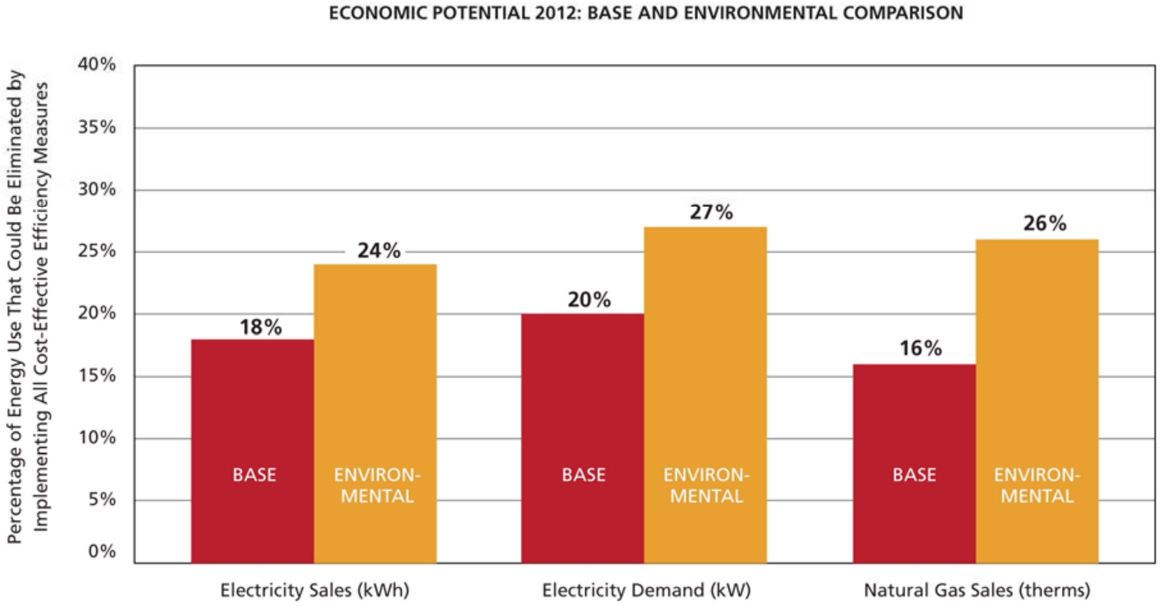

Figure EE-29: Comparison of Economic Potential Under Base and Environmental Scenarios

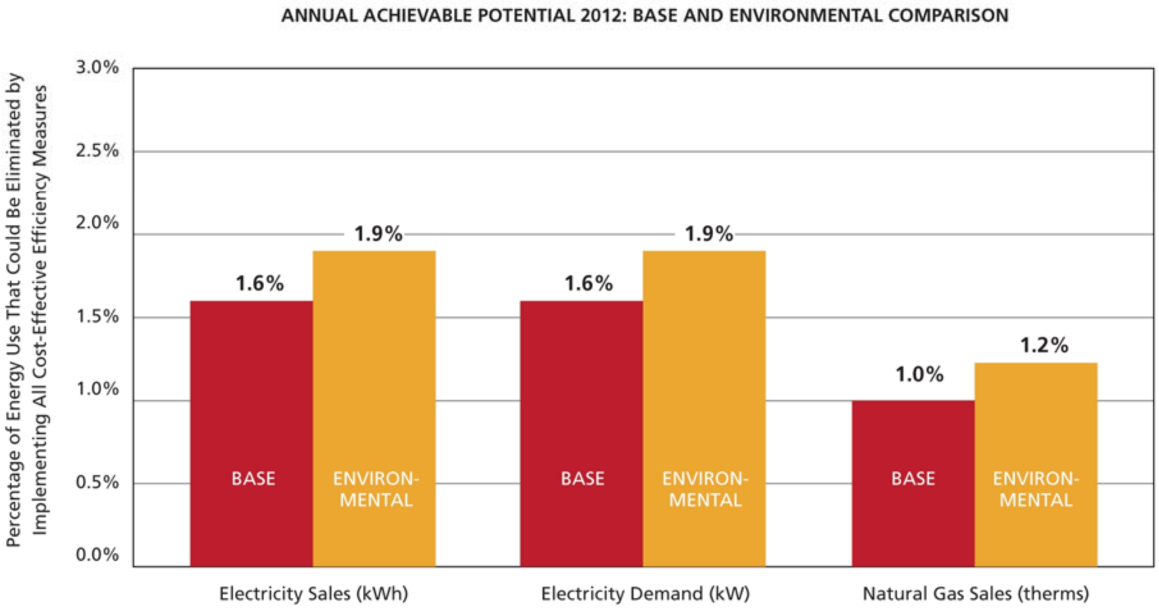

Figure EE-30: Comparison of 2012 Achievable Potential Under Base and Environmental Scenarios

Under the environmental scenario, electricity savings and peak demand reduction potential increase by around 20 percent and natural gas savings potential increases by around 25 percent, as compared with the base scenario. Emissions of CO_2, NOx, and SO_2 are also around 20 percent lower under the environmental scenario.

While there are clearly some differences between the two scenarios, the gap is not as wide as one might anticipate. A number of measures that are not cost-effective in the base scenario pass the TRC screen in the environmental scenario, but the aggregate efficiency potential of these measures is not large. This result makes intuitive sense, as marginally cost-effective technologies that are associated with large savings potential represent attractive opportunities for research and development, leading to technological improvements that increase cost-effectiveness.

SCENARIO RESULTS BY SECTOR

Figures EE-31 through EE-33 compare sector-level results under the base and environmental scenarios.

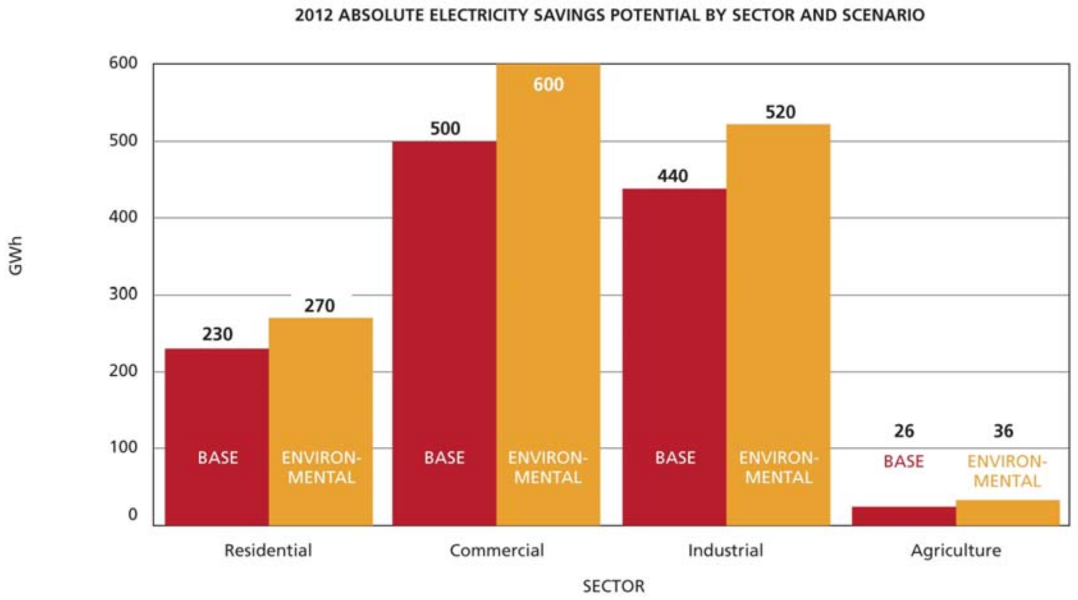

Figure EE-31: Comparison of 2012 Electricity Savings Potential by Sector, Base and Environmental Scenarios

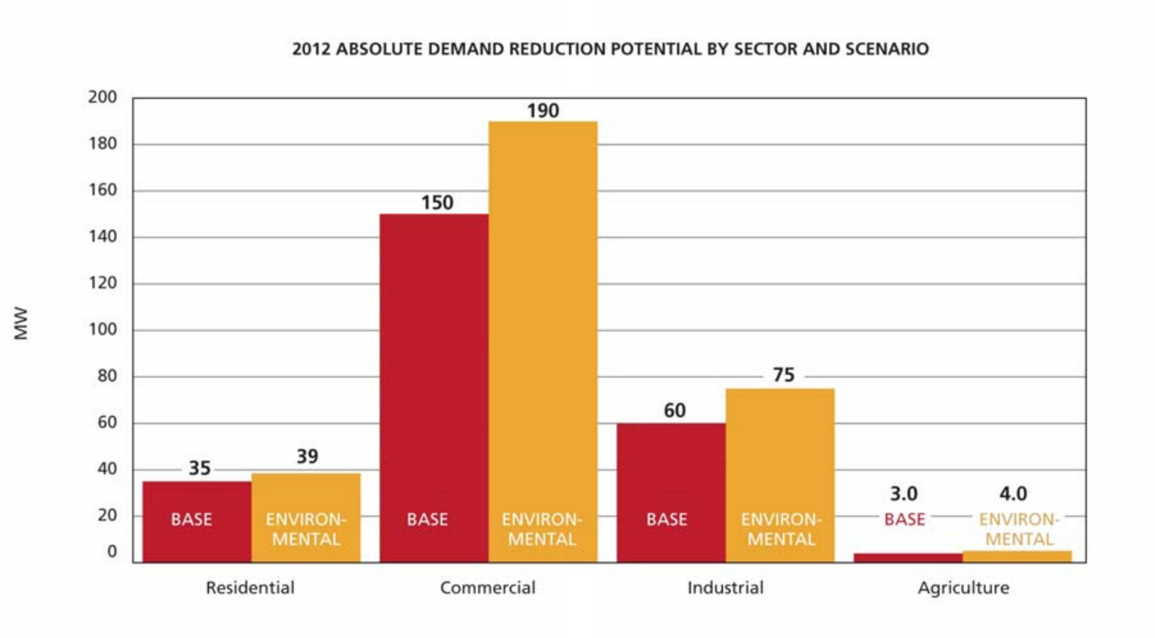

Figure EE-32: Comparison of 2012 Demand Reduction Potential by Sector, Base and Environmental Scenarios

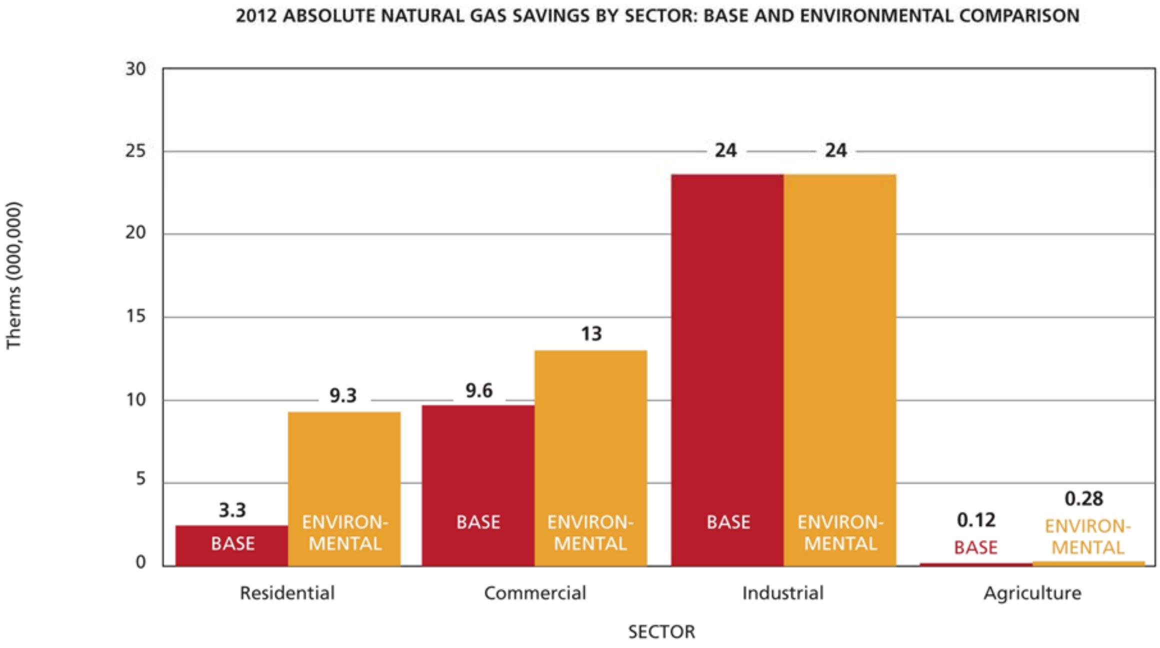

Figure EE-33: Comparison of 2012 Natural Gas Savings Potential by Sector, Base and Environmental Scenarios

The largest increase in savings potential between the base and environmental scenarios is found in the residential sector, where natural gas savings potential is over 180 percent higher under the environmental scenario. These results reveal that a large amount of natural gas savings potential lies just under the cost-effectiveness threshold in the base scenario. Relax the cost-effectiveness threshold a bit and we obtain significantly more natural gas savings, primarily due to increased shell improvements during remodeling, some additional energy efficient types of water heaters (tankless, heat pump, and condensing), and shower controls that save energy for water heating. Electricity savings potential is around 16 percent greater under the environmental scenario. Additional savings come primarily from heating system fuel switching from electric to gas, as well as from installation of ENERGY STAR qualified refrigerators, freezers and clothes washers.

In the commercial sector, electricity savings potential is around 20 percent higher under the environmental scenario, and natural gas savings potential is around 30 percent higher. Additional savings come primarily from lighting advancements such as electronic ballasts and high performance T8s (HPT8s) becoming cost-effective in additional market segments; installation of energy management systems in offices and schools; compressor retrofits in refrigerated storage facilities; insulation retrofits in offices and schools; LED exterior lighting; and water-side free cooling.

In the industrial sector, electricity savings potential increases by around 20 percent under the environmental scenario, while there is little change in natural gas savings potential between the two scenarios. Additional electric savings are primarily the result of lighting improvements (primarily T12 to HPT8/T5 retrofits and replacement of HID lighting with pulse start metal halides). Other sources of additional savings include motor optimization and use of variable speed drives and control systems in categories other than general process motors; improvements in process cooling, air compression and HVAC systems; and early retirement and replacement of inefficient machining and molding equipment with more efficient designs. Though the natural gas potential increase was minor, there were some additional savings from waste heat recovery applications in process heating and system isolation and controls in heating.

In the agriculture sector, electricity savings potential increases by around 40 percent, and natural gas savings potential increases by 140 percent under the environmental scenario. The increase in electric savings potential is primarily the result of introduction of variable frequency drives for manure pumps in milk houses, and more aggressive pump repairs in irrigation. Natural gas savings increase due to the introduction of radiant heating in greenhouses and heat recovery in grain drying operations.

Additional details on changes in energy savings potential and total resource costs between the base scenario and environmental scenario can be found in Appendix E.

CHAPTER EE-4: ENERGY EFFICIENCY PROGRAM CONSIDERATIONS

In this chapter, we discuss three program-related issues that affect Wisconsin's capacity for attaining the levels of energy efficiency projected in this study: energy efficiency program innovation; advanced rate design; and enactment of mandatory codes and standards.

In the area of program innovation, new strategies can be developed to influence broader adoption of energy efficient products and practices. Energy pricing affects decisions regarding energy use, and we discuss the potential for innovative energy pricing structures to support energy efficiency and peak demand reduction. Though the majority of this analysis focuses on voluntary approaches to promoting energy efficiency, we also estimate incremental energy savings that could be obtained through mandatory approaches such as changes to energy-related codes and standards.

INNOVATIONS TO MAXIMIZE ENERGY EFFICIENCY PROGRAM EFFORTS

Innovative program approaches across all sectors will be necessary to reach the aggressive energy efficiency results projected in this study. In some cases we have attempted to include the impacts of these efforts directly in our modeling. In other cases, we have not. (See the *Methodology* section of Chapter EE-1 for a discussion of how modeling efforts incorporate the effects of innovative program strategies).

The following sections discuss three innovative program strategies that have the potential to significantly increase the acquisition of cost-effective energy efficiency in Wisconsin:

- The retrofit market represents a major area of untapped efficiency potential, and the "neighborhood blitz" is one strategy for capturing greater savings from the retrofit market.
- Behavior-based programs seek to promote fundamental shifts in the way we make decisions regarding energy consumption.
- Upstream market approaches help to ensure the cost-effective use of program resources by paying incentives based on incremental increases in the market share of energy efficient equipment.

This analysis provides examples of a few potential areas of program innovation for the purposes of illustration. However, the strategies discussed in this report do not encompass all areas of program innovation that have the potential for delivering substantial energy savings in Wisconsin. For example, while this analysis does not discuss industrial program innovation in depth, one innovative model for the industrial sector is program funding to support energy management staff positions at manufacturing facilities. As noted above, program innovation across all sectors and market segments will be necessary to achieve the savings levels projected in this study.

Strategies for Capturing Retrofit Opportunities

Energy efficiency programs employ three primary strategies to induce consumers to undertake energy efficiency improvements:

1. Encouraging consumers to replace inefficient appliances or equipment with more energy efficient models when the inefficient model expires (an equipment replacement program strategy).

2. Persuading those involved in the construction of new buildings to use energy efficient construction practices and install energy efficient equipment (an efficient new construction program strategy).
3. Replacing installed but still working equipment with more energy efficient alternatives, or making efficiency improvements to building components such as adding insulation or sealing air leaks (a retrofit program strategy).

Past energy efficiency program efforts have achieved the greatest results in the equipment replacement market. It is easier to influence upgrade decisions at the time of purchase than it is to motivate consumers and businesses to implement possibly expensive improvements which they are likely unaware they need. However, equipment replacement markets have inherent limits in achievable energy savings because equipment stock turns over at a low annual rate. New construction opportunities are similarly constrained by the number of houses or buildings constructed each year. Retrofit improvements are not constrained in this way, but face barriers in terms of consumer motivation and awareness. Figure EE-34 shows the energy efficiency potential identified by market.

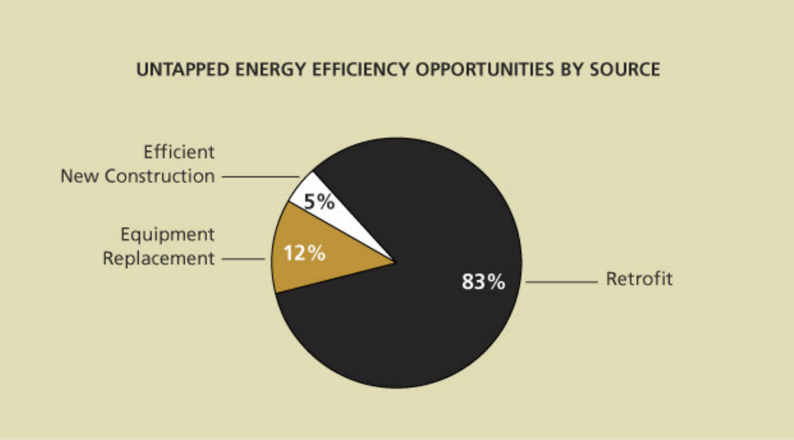

Figure EE-34: Untapped Energy Efficiency Opportunities by Market

Figure EE-35 illustrates why the difference between the economic potential estimate and the annual achievable potential estimate is so great for measures in the equipment replacement market.

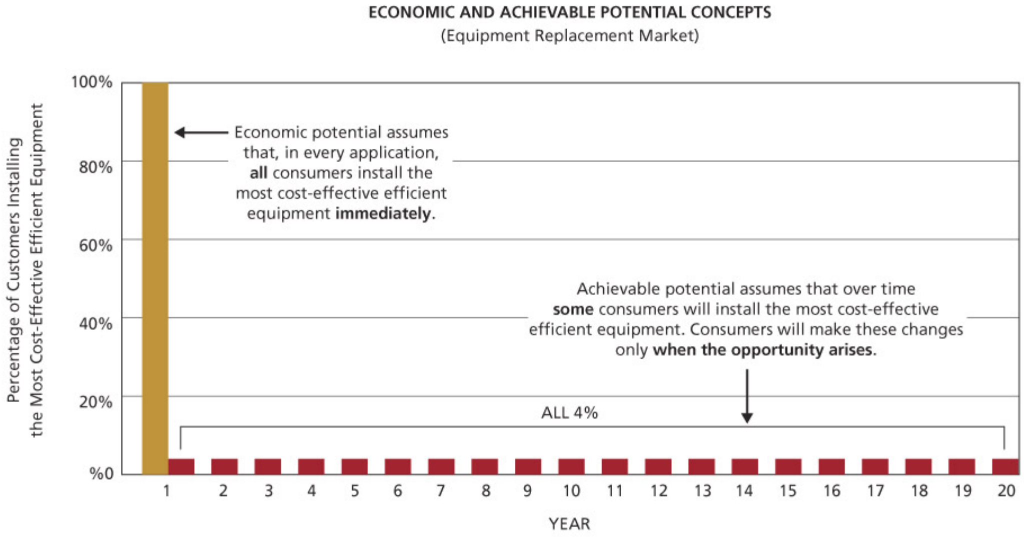

Figure EE-35: Economic and Achievable Potential Concepts: Equipment Replacement Market

This illustration shows that retrofit programs are scalable. If we are willing to spend more money, we can achieve more in the retrofit market. Programs targeting the equipment replacement and new construction markets are not scalable in the same way. Though higher incentives and more aggressive program strategies can certainly increase the effectiveness of equipment replacement and new construction program efforts, these approaches will not cause equipment to burn out faster, and will not cause more buildings to be built.

This is not to say that retrofit programs can move at lightning speed. The greatest challenge associated with retrofit programs is consumer inertia. When appliances burn out, or when a new building is being designed, motivating people to think about energy efficiency may take a relatively small nudge. But in the case of retrofits, the path of least resistance is to do nothing. Indeed, consumers and businesses may not be aware of significant energy-saving opportunities. While the energy efficiency opportunities under the retrofit model are vast, to overcome this inertial state, program managers need to work harder to get consumers' attention. They also need to pay consumers more to persuade them to take action. Other limiting factors include logistical challenges and the labor-intensive nature of retrofit initiatives. For example, it takes substantial training, man-power, time, and resources to retrofit more than one million homes.

As a result of these challenges, retrofit programs tend to be relatively more expensive to operate, particularly in comparison with equipment replacement programs. Nevertheless, because there is so much more untapped cost-effective energy efficiency opportunity in the retrofit category, expanding effort in this area is essential to increase energy savings significantly.

The "neighborhood blitz" is one example of a large-scale retrofit program that uses an innovative community-based approach to capture the substantial energy efficiency potential found in the residential retrofit market. It works as follows:

- All residences in a particular neighborhood receive information that an audit crew will be in their area during a given week, and residents can indicate their interest in receiving the audit services.
- The audit crew works its way through the neighborhood, identifying energy efficiency retrofit opportunities through walk-through audits as well as through comprehensive diagnostic tests based on building science. Such opportunities might include air sealing, increased wall and ceiling insulation, and replacement of inefficient HVAC equipment. Direct installation of low-cost measures such as low-flow showerheads, faucet aerators, and CFL bulbs can be offered during the initial walk-through.
- The innovation associated with the blitz approach is contained in the following offer—if the resident wishes, another crew of installers will return to the house at a later time to implement the higher-cost measures on the list.
- The program will pay for most of the cost of making the efficiency improvements.

The neighborhood blitz approach actually overcomes two barriers—it addresses the inertia problem by coming to the customer, and it addresses the lack of capital problem by paying the lion's share of the cost. We see a large potential for energy savings from this approach, and have included the impact associated with this concept in our achievable potential estimates. Similar efforts could be implemented in many segments of the commercial market.

Behavior-Based Programs

Behavior-based programs have attracted the attention of energy efficiency advocates and researchers in recent years as a way to supplement traditional program approaches. The great interest in behavior-based programs warranted their inclusion in this potential study. Because our collective understanding of behavior-based programs' potential energy savings is not yet as well-developed as that of more traditional program approaches, we examined behavioral potential separately from our base assessment of statewide energy efficiency potential.[44] Our goal in this analysis was to understand whether behavior-based programs warrant additional exploration as an area of significant energy savings opportunity.

DEFINING BEHAVIOR-BASED APPROACHES

Behavior-based programs are built around the understanding that decision-making is driven by numerous influencing factors beyond rational economic motivations. Traditional energy efficiency programs appeal to people's economic sense, making use of rebates and financial arguments to promote efficient technological solutions over inefficient ones. Behavior-based programs draw on research in the fields of psychology, sociology, and behavioral economics to provide additional tools to influence human choices. These tools include appeals to people's innate tendency to follow social norms, respond to feedback, avoid loss and waste, seek rewards, and be motivated by a myriad of psychological factors.

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[44] Two behavior change measures are included the base and environmental scenario modeling efforts: programmable thermostats and residential energy feedback displays that provide real-time information on household energy use. The effects of these measures are included in our quantitative estimates of energy savings potential.

Behavior-based programs can address both technology choices and also provide alternatives to technological solutions. Such approaches differ from traditional energy efficiency approaches not in the end goal, but in the means to achieve that goal. As such, there is some overlap between the end target of behavior-based programs and that of traditional program approaches. For example, behavior-based programs can:

- **Promote the use or acquisition of energy efficient equipment.** A behavior-based program might seek to educate consumers about the ways that efficient devices (like CFLs) relate to values that matter to them, like environmental concerns. Such programs might also provide information about the increasing prevalence of the technology in others' homes and businesses. Indeed, traditional energy efficiency programs are already using behavioral techniques to promote some products, in addition to traditional incentive strategies.
- **Promote non-technology alternatives to energy-intensive practices.** A behavior-based program might seek to encourage consumers to use alternatives to energy-using devices, such as clothes lines instead of electric clothes dryers or social and physical activities in lieu of electronic entertainment for their many (energy and non-energy) benefits.
- **Promote either of the above through non-targeted education and motivational practices**. Some behavior-based programs do not make specific recommendations at all, but appeal to people's choices at a higher level in ways that cause individuals to change the choices they make. Feedback programs are one such example. Research has shown that simply providing better feedback on energy consumption patterns (even without any change in the inherent economic incentive) has caused people to reduce their energy usage. Reductions in energy use could result from technology purchases or through non-technology changes in daily habits, or a combination of both.

These examples illustrate that traditional and behavior-based programs are not mutually exclusive. In fact, they have already been functioning side-by-side as traditional programs employ behavior-oriented messaging and benefit from general public awareness driven by environmental or public health concerns. Similarly, behavior-based programs benefit from the existence of traditional programs that stress the economic benefits of the desired actions and reduce the consumer's cost of engaging in those actions. As such, traditional and behavior-based programs may be most effective when they work together rather than as independent initiatives.

COMPARISONS TO TRADITIONAL POTENTIAL ESTIMATES ARE CHALLENGING

Initially, we sought to develop an estimate of the energy-savings potential of behavior-based programs that could be added to that of traditional programs. However, this approach proved to be infeasible for several reasons:

- **Traditional programs already include some behavior-based techniques.** As noted above, existing programs already use some behavioral techniques, and limited behavior-based programs are already being considered as part of traditional program portfolios. The dissemination of whole-house feedback displays—a behavioral strategy—is one of the measures included in our model of residential energy savings potential. To exclude the savings associated with such approaches from the base estimate would undercount what could be achieved even without a specific emphasis on behavioral approaches. Conversely, to exclude such savings from a stand-alone estimate of behavioral potential would undercount the value and need for behavioral approaches.

- **There is substantial overlap in the savings that could be addressed through either traditional program approaches or through behavior-oriented techniques.** Our co-consultants, ACEEE, developed a model for estimating energy savings potential that could be achieved in Wisconsin through deploying behavioral approaches in the residential market, and found substantial energy saving opportunities associated with efficiency upgrades and building shell measures. However, these opportunities are also included in our base model as they are largely addressed by traditional program approaches, albeit using a different strategy. In some cases, behavioral approaches offer an alternative or supplement to traditional programs, and may be more effective for some consumers. We do not currently have a thorough enough understanding of the interactive effects between behavioral and traditional program approaches to sort them out reliably.
- **We have less experience in quantifying and estimating the effects of behavior-based approaches.** Traditional programs have been in place for several decades, and we have developed numerous techniques to estimate their effects on energy consumption. While behavior-based approaches have also been in common use for many years, their application has generally been in other disciplines, such as public health. We do not yet have as strong a repertoire of knowledge and accepted assessment tools to determine the energy savings potential of behavior-based approaches with a similar degree of confidence that we have for traditional program approaches.
- **The role of cost-effectiveness in evaluating behavioral approaches is less clear.** Energy efficiency measures included in our base estimate were subject to a cost-effectiveness test, and some measures were screened out because they do not provide sufficient societal "payback." However, these screening criterion may not be appropriate for behavior-based approaches, where individuals may choose to take actions that do not make strictly economic sense, but that they deem worthwhile because they appeal to a more complex set of decision-making factors. Furthermore, in certain cases the participant costs associated with behavior-based actions are unclear or difficult to estimate. For example, is there any cost to the consumer associated with turning off the lights when leaving a room, or drying clothes on a line instead of in a dryer? At the same time, to apply cost-effectiveness screening for traditional measures but to not do so for behavioral approaches would result in two estimates of efficiency potential that cannot be compared.

SAVINGS POTENTIAL

As a result of the complications noted above, we chose to employ a three-fold approach for addressing the energy-savings potential associated with behavior-based approaches, illustrating the degree to which behavior-based approaches could play a role in an aggressive energy efficiency program portfolio in Wisconsin. One of these approaches attempted to estimate behavior-based energy efficiency for an entire sector, while the other two are more narrowly focused around a specific behavioral program strategy.

First, ACEEE created a Wisconsin-specific version of a model they have recently developed for estimating behavior-based energy efficiency potential at the national level. This model suggests that the savings potential for a behavior-based portfolio of programs in Wisconsin's residential sector alone is substantial—as much as 1,700 GWh of electricity savings and 323 million therms of natural gas savings in 2012.[45] This estimate is equivalent to around 8 percent of projected base electricity sales in 2012 and

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[45] ACEEE's model produces cumulative estimates of energy efficiency potential. Cumulative potential represents the sum of annual savings for the years 2009 through 2012.

around 20 percent of projected base natural gas/propane sales. However, as explained above, these estimates are not necessarily comparable or additive to the savings potential from traditional program approaches presented in our base analysis, and they were not subject to a cost-benefit screening. These estimates also do not include behavior-based program opportunities in non-residential sectors. Appendix F contains ACEEE's report on their findings from this modeling effort, and some additional discussion concerning ways to think about behavior change.

Second, we estimated potential savings from a neighborhood-based plug load initiative that combines an appliance audit, consumer information, and viral marketing, with trained staff of "plug load specialists" that provide customized recommendations for each home they visit. We estimate such efforts could result in around 370 MWh of savings per plug load specialist per year, or 3.7 GWh for a ten-person crew operating for one year. Such a program could send trained individuals into communities to provide house-specific feedback on the energy use of their plugged-in appliances, and provide customized strategies for reducing the energy consumption associated with household plug load. Likely energy-savings opportunities include the consolidation of refrigerators and freezers, use of power management settings on computers, habitual use of power strips to cut power to devices with a high stand-by load, and unplugging selected items. The auditors would also leave behind carefully designed materials with the households they visited, as well as in gathering places like community centers and libraries in those neighborhoods as part of a "viral marketing" campaign. Appendix G presents our assumptions and savings calculations for this analysis in more detail.

Third, we conducted research into the use of feedback techniques for reducing energy consumption. This research suggests that residential energy savings in the five to twenty percent range may be possible from feedback techniques. In a review of the literature, Oxford University researcher Sara Darby found that studies of feedback devices routinely provided energy savings from changed consumer choices in this range.[46] While we do not know what specific changes people made to reduce energy consumption, we do know that feedback approaches have had influence on their behavior. Supplementing the evidence from the Oxford study, a feedback pilot underway at the Sacramento Municipal Public Utility District appears to be yielding savings of two to three percent within the first few months.[47] This pilot incorporates academic research on social norms into usage reports provided to randomly selected households. Several other utilities, including at least one each in Minnesota and Illinois, are now beginning similar pilots with the same provider.

Though these three analytical approaches did not yield a definitive estimate of behavior-based energy efficiency potential for Wisconsin, the results suggest that there is significant potential to obtain energy savings through behavior-based program approaches.

NEXT STEPS

The potential savings from behavior-based tools, programs, and portfolios suggest that these approaches have a place in an aggressive energy efficiency program portfolio for Wisconsin. To explore these approaches more fully, Wisconsin could consider:

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[46] S. Darby (2006). *The Effectiveness of Feedback on Energy Consumption*. A review for DEFRA of the literature on metering, billing and direct displays. Environmental Change Institute, University of Oxford.
[47] Personal communication, Alex Laskey, Positive Energy (February 19, 2009).

- Including or broadening behavior-based techniques as a supplement to existing program strategies.
- Collaborating with programs in other jurisdictions that are also exploring behavior-based programs, sharing information and research findings.
- Encouraging experimentation with behavior-based program concepts, including those that do not meet traditional cost-benefit screening criteria or provide energy impacts that are easily measured using current evaluation tools.
- Conducting applied research (in conjunction with any program pilots and experiments) to build a clearer understanding of behavior-based programs' effects on consumer behavior, program opportunities, and energy savings.
- Developing new measurement tools that will allow the effects of behavior-based approaches to be included in program impact evaluations.

These issues are addressed in the Chapter EE-5 discussion on energy efficiency program challenges.

Upstream Market Approaches

The most common approach to encouraging consumers to be more energy efficient is to pay them to do so (e.g., offer an incentive to offset the higher cost of purchasing an energy efficient product over the cost of a similar, standard efficiency product). In many cases, consumer incentives work well. Nevertheless, offering incentives to retailers, equipment suppliers, or other upstream market actors may generate greater penetration rates at a lower program cost.

Under an upstream approach, the equipment supplier receives an incentive for every unit of energy efficient equipment they sell over and above a pre-established sales baseline, or for increasing sales by a certain percentage over baseline—i.e., rewarding the supplier for "market lift." This arrangement requires the supplier's willingness and ability to share current and historical sales data with the energy efficiency program manager.

The primary advantage of this upstream approach is that it allows for the cost-effective use of program resources. Under a downstream approach, everyone who purchases a qualifying product is eligible for an incentive, whether the incentive motivated their purchase or not. The upstream approach awards incentives based on incremental increases in equipment sales, reducing the problem of free riders and conserving program resources.

While we have not specifically modeled this program approach *per se* in our study, it does provide a basis for the increased penetration rates we expect in the future for energy efficiency programs, and our estimates of program costs. The program cost estimates discussed in Chapter EE-2 assume that incentives are paid on the basis of incremental increases in the market share of energy efficient equipment. For a more detailed discussion of our cost estimation approach, see the *Methodology* section in Chapter EE-1.

ADVANCED RATE DESIGN

Energy utility rate structures also play a role in consumer decision-making regarding energy use. Though we did not develop quantitative estimates of the impacts advanced rate designs can have on energy use and peak demand in Wisconsin, we provide a qualitative discussion of the potential for advanced rate design to affect changes in the timing and magnitude of energy consumption.

The term "advanced rate design" refers to rate structures that employ dynamic pricing, where the retail cost of electricity varies according to electric demand. The most common dynamic rate structures include:[48]

- **Time of Use (TOU) Rates**: Rate structures that employ standard differentiated prices for electricity consumed during on-peak and off-peak periods, which are consistent throughout the year. In some cases TOU rates also include seasonal price differentiation.
- **Real Time Pricing (RTP)**: Rate structures that vary continuously according to the wholesale price of electric power.
- **Critical Peak Pricing (CPP):** Rate structures that employ a high price that comes into effect during "critical peak" periods of high electric demand, typically with some advance notice to the customer (as much as one day ahead or in some cases only a few hours ahead).

Though some studies show energy savings impacts resulting from dynamic rate offerings, historically the primary objective of these rate structures has been reducing peak electric demand (demand response).

For example, a program that uses super-peak pricing signals to shift air conditioner use from the middle of the day to early evening reduces the 3 PM peak, but in so doing increases energy demand at 7 PM. When air conditioning is switched off on hot days, the temperature inside the building increases. When the air conditioner comes back on in the early evening, the building temperature will be higher than it would have been if the air conditioner had been allowed to cycle on and off as necessary earlier in the day. The air conditioner will then have to run longer to return the building temperature to the desired setting.

Thus, such programs typically *shift the timing of* energy use; they may not *reduce* energy use. That is not to say that such programs are unimportant. Controlling peak demand on critical days has historically been and will continue to be a key priority for utilities. However, with respect to greenhouse gas emissions, such programs can have negative impacts.

In the case of fossil fuel-based plants, the peaking plants that serve the mid-day summer loads are among the cleanest on the system. They tend to be fired with natural gas. The base load and intermediate load plants are usually coal-fired. Thus, shifting demand from the peak period to the shoulder period shifts generation responsibility from the natural-gas-fired plants to the coal-fired units. While combustion of either natural gas or coal leads to CO_2 emissions, those associated with burning coal are noticeably higher than those from natural gas facilities.

With this complication in mind, we review the general conclusions about the impact of rate design on utility peak demand based on numerous studies. Most of these studies relate to the impact on residential customers, as advanced pricing structures are already widely available to large commercial and industrial customers. The major studies conclude that:[49]

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[48] U.S. Department of Energy and the U.S. Environmental Protection Agency. *National Action Plan for Energy Efficiency* (2006) Available at: www.epa.gov/eeactionplan.

[49] These estimates come from A. Faruqui and S. Sergici (November 2008). *Household Response to Dynamic Pricing of Electricity: A Survey of Seventeen Pricing Experiments*. The Brattle Group.

- Introducing time-of-use rates with *broadly-defined* on-peak and off-peak periods can reduce peak demand by three to six percent.
- Introducing time-of-use rates with *more-specific critical period pricing* can reduce peak demand by 13 to 20 percent.
- Introducing time-of-use rates with *more-specific critical period pricing* along with *providing consumers with advanced technologies* so that they can react to those prices, can reduce peak demand by 27 to 44 percent.

One example of the advanced technologies mentioned in the third bullet above would be a home-based computer network that allows residents to program automatic adjustments to home appliances in response to possible utility price changes. Under this approach, the consumer does not have to respond manually to hour-to-hour price changes from the utility.

We see that if we narrowly define peak pricing periods and if we provide residents with the tools that enable them to react to price changes, the impacts on peak demand can be staggering. Widespread implementation of such a joint approach could have a major impact on peak demand growth. As we note above, however, it is likely to have little effect on overall energy use.

CODES AND STANDARDS

Though this study focuses on results that could be achieved through voluntary energy efficiency initiatives, another strategy for procuring energy efficiency is to mandate it. Mandatory approaches to promoting energy efficiency include revisions to the energy component of building codes, and the enactment of energy efficiency standards for appliances and other equipment.

We used our efficiency potential model to determine the effect of deploying a few select codes and standards in Wisconsin. The codes and standards chosen were based on the areas given priority by the Governor's Task Force on Global Warming. However, the assumptions used in estimating potential savings were based on the Energy Center's model inputs, rather than on the Task Force's calculations, so that results would be comparable to baseline potential estimates.

This analysis estimated the effects of the following codes and standards changes:

- A 15 percent increase in the energy efficiency of new homes resulting from changes in the residential code.[50]
- A 15 percent increase in the energy efficiency of commercial new construction resulting from changes to the commercial code.[51]
- State energy efficiency standards for new residential furnaces, new commercial boilers, and commercial packaged air conditioning systems.[52]

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[50] This code-based efficiency level is slightly higher than current levels required by the Wisconsin ENERGY STAR Homes program.

[51] This 15 percent increase is based on the approximate savings in switching from current code to an average of the 2007 and 2010 versions of ASHRAE 90.1

[52] The Governor's Task Force on Global Warming recommended establishment of state standards for residential gas furnaces and furnace fans, compact audio equipment, high efficiency commercial boilers, and industrial boilers. State standards can be established for equipment where there is no existing federal energy efficiency standard, or where a state has been granted authority to preempt the federal standard.

The revisions to residential and commercial building code by 2012 represent a faster ramp-up than has historically occurred, but they are well within the range of codes that have been adopted in other areas. However, the changes to equipment efficiency standards represent a fairly aggressive approach; these standards require preemption of the federal equipment standards. There is little precedent for preempting these standards. However, if preemption of standards were possible and aggressive building codes politically feasible, the efficiency potential for mandatory codes and standards could actually be above that estimated here.

Results for the estimated annual achievable potential in the three areas investigated are shown in Table EE-6.

TABLE EE-6: RESULTS OF CODES AND STANDARDS ANALYSIS: ACHIEVABLE POTENTIAL

		Electricity (GWh)	Electric Demand (MW)	Natural Gas (1000 therms)
Codes	Residential	0.4	1.5	1438
	Commercial	1.0	1.4	84
	CODES TOTAL		1.5	2.8
Standards	Residential	0.0	0.0	1619
	Commercial	10.1	7.4	75
	STANDARDS TOTAL		10.1	7.4
	Grand Total	**11.6**	**10.2**	**3216**

The results shown in Table EE-6 are incremental to the voluntary program impacts presented in Chapter EE-2 of this study. In other words, they represent the additional energy savings that could be achieved through enactment of codes and standards, on top of baseline potential estimates. However, it is important to acknowledge that there is overlap between savings that could be achieved through voluntary versus mandatory approaches. Improved codes and standards would make affected technologies ineligible for voluntary programs (e.g., a residential furnace program is not needed if high efficiency furnaces become the required standard).

From a program perspective, enacting a new code or standard would represent a less expensive approach to obtaining energy efficiency than a voluntary program approach. In effect, costs would shift from the program to the participant—or in some cases, to the home builder or other market actor, if they are unable to pass associated costs on to the consumer.

CHAPTER EE-5: ENERGY EFFICIENCY PROGRAM CHALLENGES

As previously noted, increasing energy efficiency program spending alone will not likely produce the potential savings estimates that we suggest are possible. To reach those levels, innovative program strategies will be required (see Chapter EE-4). Innovations in energy efficiency program design may necessitate adjustments to program cost-effectiveness analysis and evaluation methods.

VALUATION OF ENERGY EFFICIENCY BENEFITS

Underestimating the value of energy efficiency benefits has a fundamental effect on program design, as measures that could produce substantial aggregate savings are ruled out because they do not pass the cost-effectiveness screen. There are several components to this issue: (1) failure to value the savings accrued over the full lifetime of measures that last a long time; (2) the use of discount rates that devalue future savings produced by long-lived measures; and (3) the use of inappropriate supply-side avoided cost benchmarks that energy efficiency measures are valued against in benefit/cost tests.

The first two issues are closely related, and primarily affect long-lived measures like insulation or other components of energy efficient new construction. Focus on Energy uses a benefit/cost horizon of 25 years, where any benefits occurring after 25 years are ignored.[53] Even if benefits occurring after year 25 were considered, high discount rates fail to appropriately value the lion's share of the long-term savings. The cost-effectiveness calculation used in this study does not employ the 25 year constraint, but the base scenario does employ the five percent discount rate used in Focus on Energy program planning.

Assume, for example, that we wish to develop a program that encourages builders to add higher-than-required levels of wall insulation. Such measures could provide energy savings of $100 per year for 75 years. Let us assume that we are working in real terms. The discount rate is five percent. Figure EE-36 shows the benefits estimated under the current practice.

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[53] The measure lifetime is used for measures lasting fewer than 25 years.

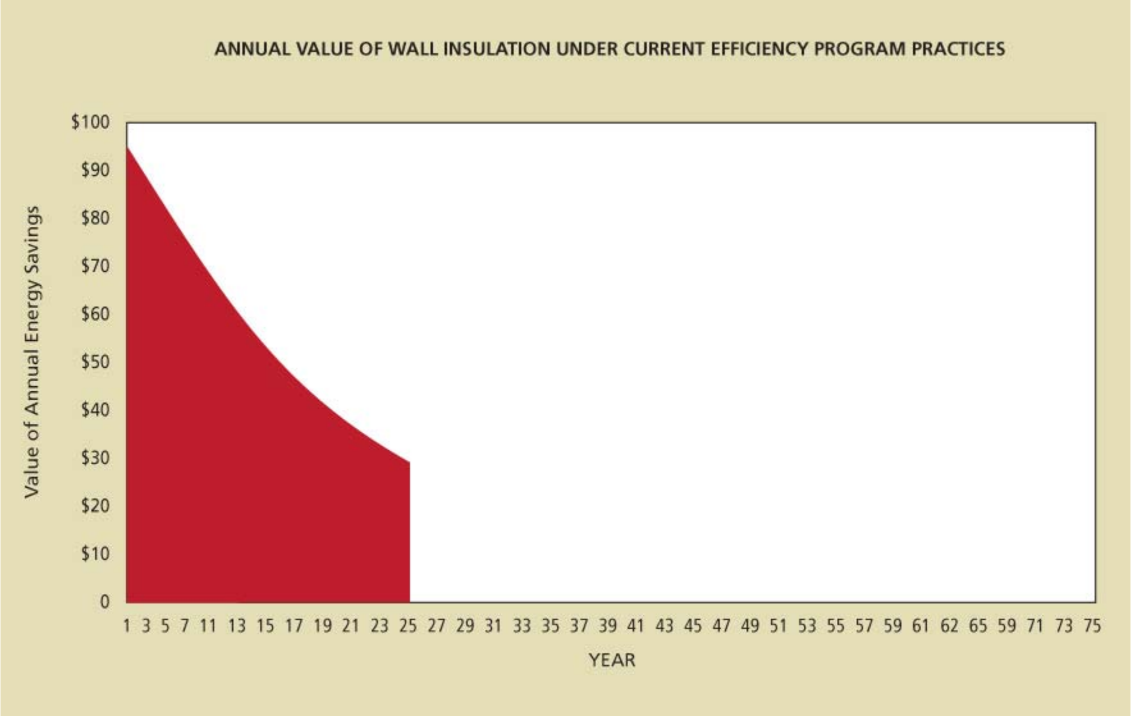

Figure EE-36: Annual Value of Wall Insulation Under Current Program Planning Practices

If we remove the artificial cap of 25 years, we value the additional savings shown in Figure EE-37.

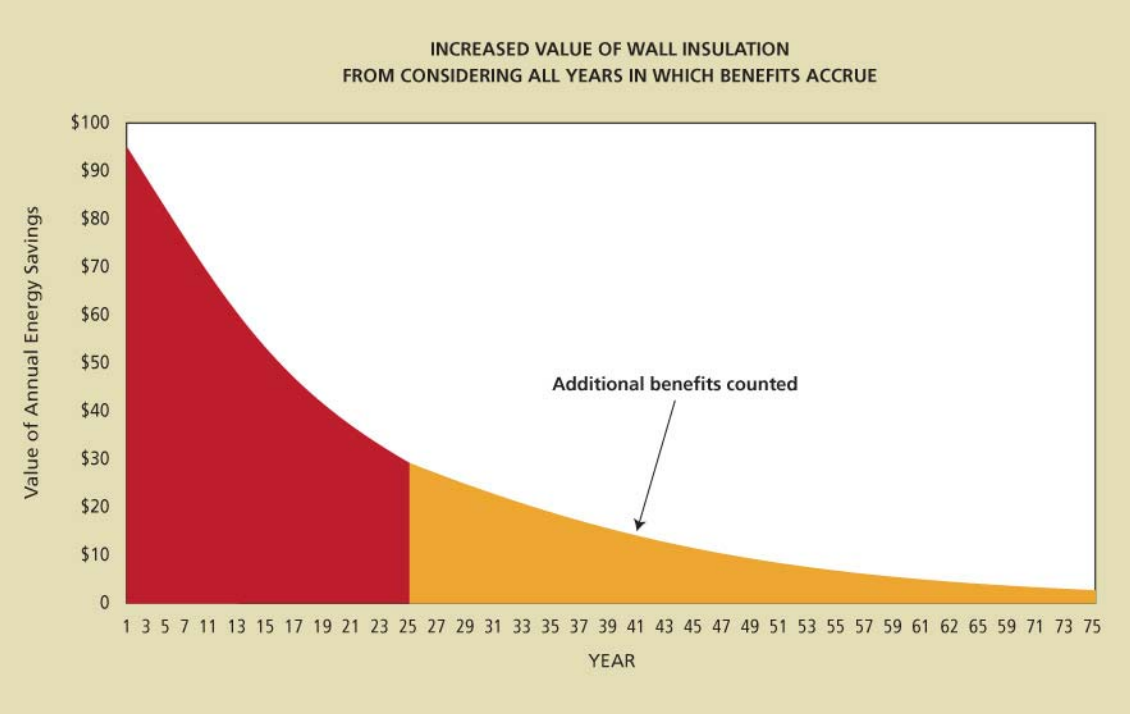

Figure EE-37: Increased Value of Wall Insulation from Considering All Years in which Benefits Accrue

Recall from the discussion of the environmental scenario in Chapter EE-2 that if a measure offers long-run environmental benefits, a higher discount rate could be viewed as devaluing the benefits associated with future savings. If we lower the discount rate to two percent to reflect the long-lived nature of the benefit stream, we place a higher value on future savings benefits, as shown in Figure EE-38.

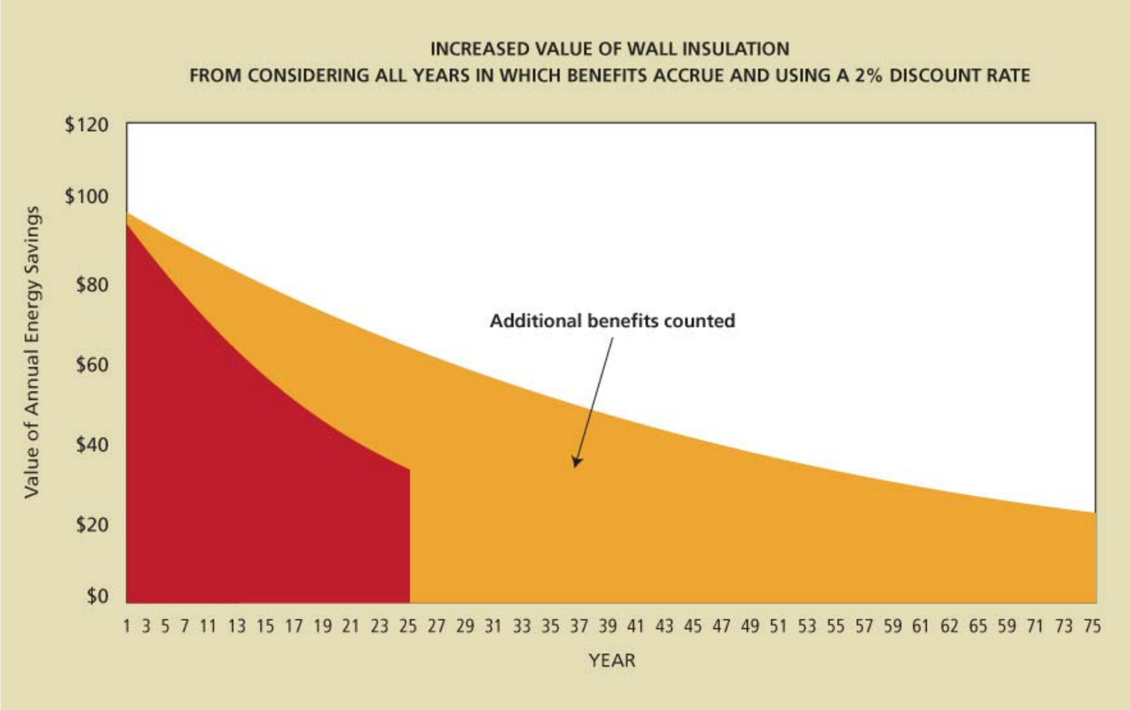

Figure EE-38: Increased Value of Wall Insulation from Considering All Years in which Benefits Accrue Using a 2% Discount Rate

Under the current approach, the present value of the savings benefits associated with wall insulation is $1,409. If we value the benefits accrued over the full lifetime of the insulation, the savings increase to $1,948. If we also lower the discount rate to two percent, the savings increase to $3,868. If the added insulation costs $1,500, under the current practice it is not cost-effective. Under either of the two other scenarios, it is. If we want to encourage energy efficiency programs to promote long-lived measures, such valuation issues may warrant reconsideration.

AVOIDED COSTS

Another valuation issue pertains to the appropriate supply-side cost benchmark against which energy efficiency measures compete on a benefit/cost basis. The avoided costs used in this study are based on Midwest ISO prices, which have a backward-looking flavor that is likely inappropriate for a carbon-constrained future. The Midwest ISO system is dominated by older coal-fired power plants. With increasing concerns about global climate change, it is unlikely that such plants could be built in the future.[54] This issue begs a question as to whether those plants should form the basis for a forward-looking evaluation or assessment. Some analysts have proposed that the appropriate benchmark is a utility-scale wind facility.[55] Such an approach would be consistent with the goal of meeting future energy demand while reducing greenhouse gas emissions, and would certainly change the cost-effectiveness calculations for a number of energy efficiency resources and program approaches. To the extent that Midwest ISO prices influence the selection of avoided costs used in Focus on Energy program planning efforts, the benefits associated with energy efficiency program efforts would be understated.

PROGRAM EVALUATION CONSTRUCT

In light of the program innovations proposed in this study, a reconsideration of the energy efficiency program evaluation construct may be appropriate. We are not challenging the work of the program evaluators. They, in fact, do a good job operating within the confines imposed on them. It is the confines that are at issue here.

As previously noted, this study is predicated upon an aggressive and innovative approach to energy efficiency policy and program design. Program screening criteria should accommodate experimentation with program efforts with limited track records, like the neighborhood blitz and behavior-based models. Innovative programs should be credited with reasonable energy savings estimates even if there are high degrees of uncertainty in both directions from those estimates. These changes will be necessary if we are to reach the aggressive energy efficiency levels projected in this study.

A key component of program evaluation is determining how much influence an energy efficiency program had on adoption of energy efficient technologies and practices (reported as “net” savings in program impact evaluations). Separating program influence from the myriad other factors that affect consumer decision-making is challenging, and evaluators typically use a combination of *ex post* surveys and econometric methods to analyze market effects. In particular, a number of recent critiques have pointed out the limitations of ex post survey approaches.[56]

Another important issue is the tendency of prevailing evaluation approaches to understate the true influence of the program on consumer behavior. The danger, in terms of achieving the aggressive energy savings potential presented in this study, is evaluation results that drive premature termination of program activities in markets where there is substantial remaining potential—or conversely, not initiating program activities in markets where there is significant energy savings opportunity.

Under the current construct, some evaluation studies have concluded that, because most program participants say they would have bought the energy efficient product without program intervention, the program has reached maturity and possibly should be discontinued. To provide an illustrative example, a

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[54] M. Warner (February 15, 2009). “Is America Ready to Quit Coal?” *The New York Times*.
[55] N. Hall, *et al* (2009). *Reaching our Energy Efficiency Potential and Our Greenhouse Gas Objectives - Are Changes to our Policies and Cost Effectiveness Tests Needed?* Proceedings of the Association of Energy Services Professionals 19th National Energy Services Conference and Expo, January 2009.
[56] J. S. Peters and M. McRae (2008), *Free-Ridership Measurement is Out of Sync with Program Logic…* or*, We've Got the Structure Built, But What's Its Foundation?* G. Cook (2008), *Attribution Methodology Wars: Self-Report Methods versus Statistical Number Crunching—Which Should Win?* Proceedings of the 2008 ACEEE Summer Study on Energy Efficiency in Buildings.

2007 Focus on Energy evaluation reported that around 70 percent of consumers who received a $2 incentive for a CFL bulb said they were somewhat or very likely to have purchased the product without the incentive.[57] But another recent study of CFL installation rates in Wisconsin found that CFLs were installed in only about 20 percent of eligible household sockets.[58] Does that seem like the CFL program has reached its capacity? One could argue that the program is just getting started.

If we are to achieve high levels of energy efficiency savings, we should consider whether current evaluation methods bias savings estimates to the downside. The PSCW could convene a workgroup to assess the current program evaluation construct, with the goal of developing a total market-based construct.

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[57] PA Government Services, Inc. (2007). *Residential Lighting Program: Compact Fluorescent Lighting Installation Rate Study*. Prepared on behalf of the Public Service Commission of Wisconsin by R. Winch and T. Talerico, Glacier Consulting.

[58] PA Consulting Group (2008). *FY08 CFL Customer Research—Draft Report*. Prepared on behalf of the Public Service Commission of Wisconsin by R. Winch and T. Talerico, Glacier Consulting.

CHAPTER EE-6: TOPICS FOR FUTURE RESEARCH AND DEVELOPMENT

The scope of this study focuses on developing estimates of achievable energy efficiency potential. In the course of this study, we identified several key areas where further research and development is necessary to support attainment of the aggressive energy savings estimates presented herein.

Most important is the need for program approaches that can significantly increase retrofit activity, and also increase penetration of energy efficient products in the equipment replacement market while minimizing payments to free riders. The neighborhood blitz, upstream market approaches, and behavior-change models presented in Chapter EE-4 are but a few examples of program approaches that address these objectives, and additional innovative program strategies will need to be developed.

Innovative program strategies should be preceded by market research in strategic areas and accompanied by a parallel research process when they are piloted. Separating research from program implementation and evaluation ensures efficient delivery of key functions. Research goals would include quantification of the energy impacts produced by these innovative program strategies. Even more importantly, such research would identify areas where the program innovations achieve success in affecting market actor and end user decision-making and where they fall short, and create a better understanding of why certain outcomes have occurred. Other parties within and outside Wisconsin are piloting innovative program approaches and conducting similar research, so it is also important to remain abreast of local, regional, and national activities on these fronts and avoid duplication of effort.

If energy efficiency programs are to increase many fold in size, and if we are to capture previously untapped energy efficiency resources in the retrofit market, we will have a great need for training a workforce that can deliver energy efficiency improvements. As we have seen in the weatherization arena, it takes approximately one week to train a new weatherization provider on the skills needed to do a competent job. Due to technology changes and the complex and interactive nature of the building energy system, continuing education is needed to keep a provider competent over the lifetime of his/her career. Program managers are not likely to have the time or resources to train people to do the work that needs to be done. Therefore, it will be important for local, state, or federal governments to fund training programs to create the workforce that will enable us to reach the energy efficiency levels projected in this study.

As energy efficiency plays an increasingly important role as an alternative to supply-side investments, there is a need for new research to validate critical assumptions about end use load shapes that are used in energy efficiency program planning efforts. Wisconsin-specific resources in this area are over a decade old, and updated information would be valuable, particularly in the areas of emerging energy efficient technologies and innovative program strategies such as behavior change.

Another promising area for future research relates to a joint assessment of water and energy savings. The largest expense incurred by municipal water and sewer utilities is the cost of electricity used in the pumping process. Saving water in turn saves electricity at the utility. Wisconsin data show that on average, it takes 2,000 kWh to pump one million gallons of water. A single household uses about 50,000 gallons of water a year, delivered at an energy cost of 100 kWh. Pre- and post-consumption water treatment also requires energy. The PSCW could sponsor research to determine the full amount of energy embedded in our water use, and then create program offerings to promote the joint advancement of water and energy efficiency objectives. Further, the energy associated with reductions in water use could be credited to energy savings goals.

The final research recommendation relates to rate design. Research shows that peak demand could be reduced by up to 44 percent with a combination of rate design and advanced technologies that facilitate consumer response to changing electric prices.[59] Savings of that magnitude are definitely worth pursuing to allow more effective use of supply-side resources, but research is needed to reduce the uncertainty associated with energy savings estimates, and identify the optimal technological components that maximize savings at the lowest cost.

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[59] There would be environmental consequences associated with such approaches. See Chapter EE-4 for a discussion of this issue.

ADDENDUM: CONTRASTING THE 2005 AND THE 2009 ENERGY EFFICIENCY POTENTIAL STUDIES

The Energy Center completed the previous assessment of statewide energy efficiency potential in 2005.[60] Since that time, there have been significant changes to the energy landscape that affect our analytical approach, and thus the magnitude of energy efficiency potential projected in this study as compared with the 2005 analysis.

Energy markets are in a considerable state of flux. Consider, for example, several key events that have occurred in the past two years:

- The U.S. Supreme Court ruled that CO_2 could be subject to regulation under the Clean Air Act.[61]
- More than 40 coal-fired power plants planned for the U.S. were cancelled.[62]
- In excess of 5,000 MW of wind generating capacity was installed nationwide.[63]
- Wisconsin convened a Task Force on Global Warming whose charge was to develop recommendations as to how the state can reduce its greenhouse gas emissions.[64]

We have seen related changes in corporate America too, as businesses begin to accept the likelihood of climate change regulation.[65] In 2007, Exxon announced that it would no longer provide financial support to the Competitive Enterprise Institute (CEI), whose work refuting carbon's climate impacts Exxon had previously funded. Even more surprising was the January 2009 speech of Exxon Chairman Rex Tillerson in which he called on Congress to enact a carbon tax to help reduce greenhouse gas emissions.

In light of these circumstances, many energy analyses now assign a cost to carbon emissions in recognition of the high likelihood of impending carbon regulation. The Energy Center's analysis includes a carbon cost of $30 per ton of CO_2 emitted.[66]

Additionally, our analysis assessed the increased potential that could result from significant innovations in energy efficiency program design, such as a "neighborhood blitz" approach for delivering comprehensive energy efficiency improvements to existing homes. We considered the impact of substantially higher incentives for implementation of energy efficiency measures. We also considered the impact of changes in the policy and evaluation framework governing energy efficiency program administration.

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[60] Energy Center of Wisconsin (November 2005). *Energy Efficiency and Customer-Sited Renewable Energy: Achievable Potential in Wisconsin 2006-2015*. ECW Report Number 236-1. Prepared on behalf of The Governor's Taskforce on Energy Efficiency and Renewables.

[61] *Massachusetts v. Environmental Protection Agency*, 549 U.S. 497 (2007). While the narrow issue in this case related to regulation of tailpipe emissions, a state Court in Georgia relied on this decision to deny a construction permit for a coal-fired power plant. See M. L. Wald (July 1, 2008). "Georgia Judge Cites Carbon Dioxide in Denying Coal Plant Permit," *The New York Times*.

[62] M. Clayton (March 4, 2008). "U.S. Coal Power Boom Suddenly Wanes." *The Christian Science Monitor*.

[63] American Wind Energy Association.

[64] *Wisconsin Executive Order 191*, April 5, 2007.

[65] J. Ball (January 11, 2007). "Exxon Mobil Softens Its Climate-Change Stance." *Wall Street Journal*.
R. Gold and I. Talley (January 9, 2009). "Exxon CEO Advocates Emissions Tax." *Wall Street Journal*.

[66] Synapse Energy Economics, Inc., *2008 Synapse Carbon Price Forecasts*. The price we report here is the 2008 levelized long-run cost of the Mid CO_2 Price Forecast.

The Energy Center's 2005 study estimated Wisconsin could achieve a 0.6 percent reduction in electricity consumption, a 0.4 percent reduction in electric demand, and a 0.3 percent reduction in natural gas consumption.

In this study, we estimate that in 2012 Wisconsin could obtain annual energy efficiency savings equivalent to:

- 1.6 percent of total electricity sales
- 1.6 percent of electricity peak demand
- 0.9 percent of total natural gas sales

Our current estimates of achievable energy efficiency are approximately three times greater than estimates reported in the 2005 study. The difference between the results of the two studies is partly due to the inclusion of the cost of carbon emissions. The more important driver, however, is the impact of innovative program strategies.

Figure EE-39 contrasts the base case results of the Energy Center's 2009 study with those of the 2005 study:

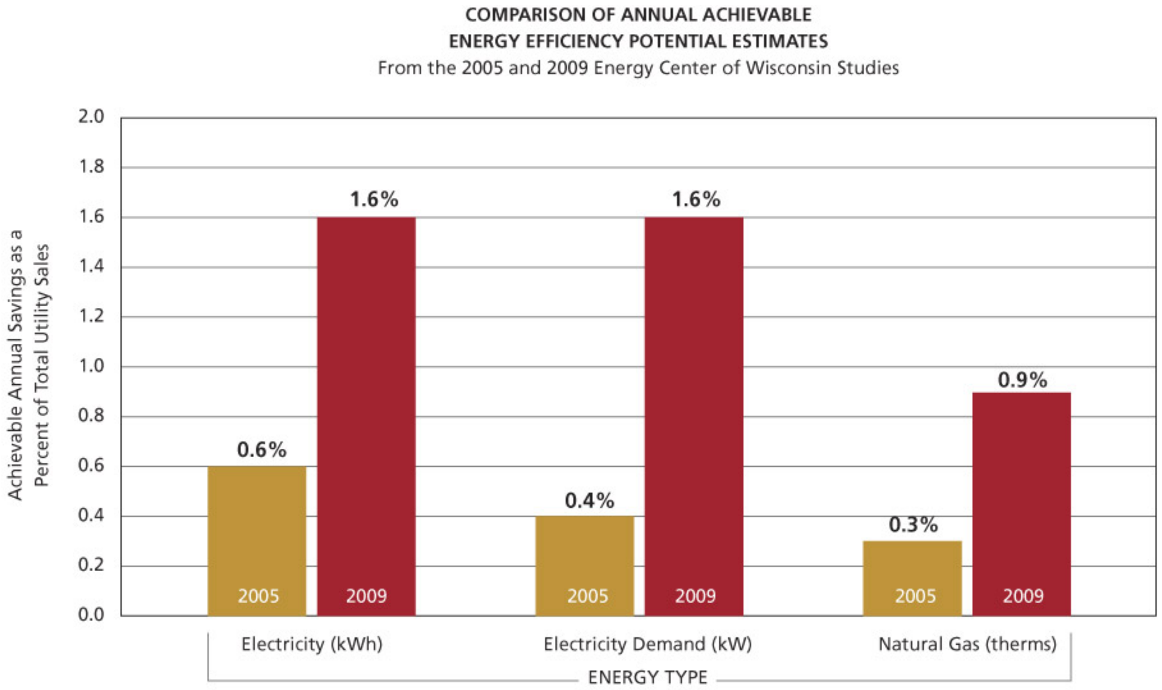

Figure EE-39: Comparison of Annual Achievable Energy Efficiency Potential Estimates from the 2005 and 2009 Energy Center Studies

To obtain this significant increase in energy efficiency improvement, the state's energy efficiency programs would need substantial funding increases. Figure EE-40 compares the estimated required annual funding levels from the 2005 and 2009 studies. (Note both figures are in 2008 dollars.)

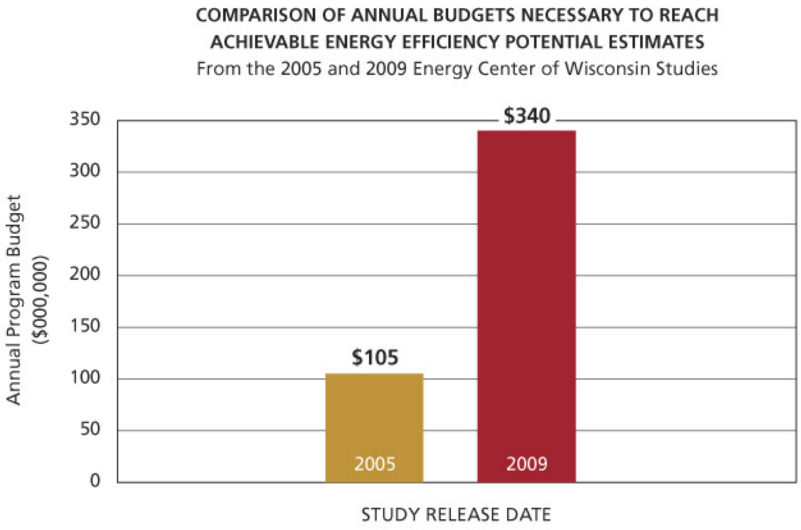

Figure EE-40: Comparison of Annual Budgets Necessary to Reach Achievable Energy Efficiency Potential Estimates from the 2005 and 2009 Energy Center Studies

To put these figures in perspective, the 2005 funding estimate represented about 1.1 percent of total electricity and natural gas sales revenues in the state. The 2009 figures would represent about 3.1 percent of total electric and gas revenues.

Though the 2009 estimates are significantly higher than the estimates produced in the 2005 study, we find that these results are consistent with the changed policy and economic realities brought about by increased focus on the problem of climate change.

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REFERENCES

ACEEE (2008). *Behavior, Energy and Climate Change: Policy Directions, Program Innovations, and Research Paths*. Report EO87.

ACEEE (2006). *Leading the Way: Continued Opportunities for New State Appliance & Equipment Efficiency Standards*. ACEEE Report ASAP-6/ACEEE-AO62.

ACEEE (2006). *Reducing Oil Use Through Energy Efficiency: Opportunities Beyond Cars and Light Trucks*. Report E061.

ACEEE (2004). *Emerging Energy Saving Technologies & Practices for the Buildings Sector as of 2004*. Report AO42.

ACEEE (2003). *Consumer Guide to Home Energy Savings*. 8th Edition.

J. T. Amann, ACEEE. Personal communication, February 2006.

J. Ball (January 11, 2007). “Exxon Mobil Softens Its Climate-Change Stance.” *Wall Street Journal*.

California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER), 2001 update. Available at: http://www.energy.ca.gov/deer/index.html.

California Energy Commission, Public Interest Energy Research Program. Technical Brief: *Design Guide: Big Energy Savings on Small HVAC Systems*. Available at: http://www.esource.com/esource/getpub/public/pdf/cec/CEC-TB-2.pdf.

California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects. (2002 edition). Available at: http://drrc.lbl.gov/pubs/CA-SPManual-7-02.pdf.

M. Clayton (March 4, 2008). “U.S. Coal Power Boom Suddenly Wanes.” *The Christian Science Monitor*.

Consortium for Energy Efficiency (2007). Data Centers and Servers Initiative. Available at: http://www.cee1.org/com/dcs/Data_Centers_Servers_Initiative.pdf.

Consortium for Energy Efficiency (2001). *A Market Assessment for Condensing Boilers in Commercial Heating Applications*. Available at: http://www.cee1.org/gas/gs-blrs/Boiler_assess.pdf.

G. Cook (2008), *Attribution Methodology Wars: Self-Report Methods versus Statistical Number Crunching—Which Should Win?* Proceedings of the 2008 ACEEE Summer Study on Energy Efficiency in Buildings.

S. Darby (2006). *The Effectiveness of Feedback on Energy Consumption*. A review for DEFRA of the literature on metering, billing and direct displays. Environmental Change Institute, University of Oxford.

Department of Economics and Political Economy Research Institute, University of Massachusetts-Amherst (2008). *Green Recovery: A Program to Create Good Jobs and Start Building a Low-Carbon*

Economy. Prepared under commission with the Center for American Progress. Available at: http://www.americanprogress.org/issues/2008/09/pdf/green_recovery.pdf.

R. S. Duboff (2007). "The Expert Wisdom of Crowds," *Harvard Business Review*.

Energy Center of Wisconsin (2005). *Energy Efficiency and Customer-Sited Renewable Energy: Achievable Potential in Wisconsin 2006-2015*. ECW Report 236-1. Prepared on Behalf of The Governor's Taskforce on Energy Efficiency and Renewables.

Energy Center of Wisconsin (2005). *Energy and Rental Housing: A Wisconsin Characterization Study*. Report 232-1.

Energy Center of Wisconsin with Quantum Consulting (2003). *Commercial and Industrial Equipment Supply Chains: Industrial Boilers, Compressed Air Systems, and Pump Systems.* Focus on Energy Business Programs Market Assessment. Prepared on behalf of the Wisconsin Department of Administration.

Energy Center of Wisconsin (2000). *Energy and Housing in Wisconsin: A Study of Single-Family Owner-Occupied Homes*. Volume 1: Report and Appendices. Report 199-1.

Energy Center of Wisconsin (2000). *Energy and Housing in Wisconsin: A Study of Single-Family Owner-Occupied Homes*. Volume 2: Databook. Report 199-2.

Electric Power Research Institute (2009). *Assessment of Achievable Potential from Energy Efficiency and Demand Response Programs in the U.S. (2010-2030).*

A. Faruqui and S. Sergici (November 2008). *Household Response to Dynamic Pricing of Electricity: A Survey of Seventeen Pricing Experiments*. The Brattle Group.

GDS Associates (2009). *Additional Opportunities for Energy Efficiency in New Hampshire: Final Report*. Prepared on Behalf of the New Hampshire Public Utilities Commission. Available at: http://www.puc.state.nh.us/Electric/GDS%20Report/GDS%20Final%20Report.htm.

GDS Associates (2007). *Vermont Electric Energy Efficiency Potential Study*. Prepared for the Vermont Department of Public Service.

GDS Associates (2007). *Equipment Suppliers Survey*.

GDS Associates (2005). *The Maximum Achievable Cost Effective Potential for Natural Gas Energy Efficiency in the Service Territory of PNM*.

Governor's Task Force on Global Warming (2008). *Wisconsin's Strategy for Reducing Global Warming*. Final Report to Governor Jim Doyle.

G. T. Gardner and P. C. Stern (2008). "The Short List: The Most Effective Actions U.S. Households can take to Curb Climate Change." *Environment* 50(5), 12-24.

R. Gold and I. Talley (January 9, 2009). "Exxon CEO Advocates Emissions Tax." *Wall Street Journal*.

N. Hall, *et al* (2009). *Reaching our Energy Efficiency Potential and Our Greenhouse Gas Objectives - Are Changes to our Policies and Cost Effectiveness Tests Needed?* Proceedings of the Association of Energy Services Professionals 19th National Energy Services Conference and Expo, January 2009.

Itron, Inc. and KEMA, Inc. (2008). *California Energy Efficiency Potential Study. Draft Final*. Prepared on behalf of Pacific Gas & Electric Company.

Itron, Inc. and KEMA, Inc. (2007). *2004/2005 Statewide Residential Retrofit Single-Family Energy Efficiency Rebate Evaluation*. CPUC-ID#: 1115-04. Prepared for California's Investor-Owned Utilities.

Interstate Power & Light Company (2008). *2009-2013 Energy Efficiency Plan*. Docket No. EEP-08-1.

J. A. Laitner, K. Ehrhardt-Martinez, V. McKinney (2009). *Examining the Scale of the Behaviour Energy Response Continuum.* Draft paper produced by ACEEE.

Keating of Chicago, Inc. (March 2007). *Technical specification for 24" MIRACLEAN® Gas Griddle*. Available at: http://www.keatingofchicago.com/media/spec/2007%20Specs/24mrcln2007.pdf.

KEMA, Inc. (2006). *Lighting and Motor/Drive Channel Market Effects Contract Metrics Assessment*. Prepared on behalf of the Wisconsin Department of Administration.

KEMA, Inc. and Quantum Consulting (2005). *Focus on Energy Business Programs: Supply Chain Characterization and Baseline Study*.

S. G. Kihm (June 2003). "How Improper Risk Assessment Leads to Overstatement of Required Returns for Utility Stocks." *NRRI Journal of Applied Regulation*.

McKinsey & Company (2007). *Wasted Energy: How the U.S. Can Reach its Energy Productivity Potential*.

MidAmerican Energy Company (2008). *2009-2013 Energy Efficiency Plan*. Docket No. EEP-08-2.

M. Warner (February 15, 2009). "Is America Ready to Quit Coal?" *The New York Times*.

Nexus Market Research (2004). *Impact Evaluation of the Massachusetts, Rhode Island, & Vermont: 2003 Residential Lighting Programs*.

Optimal Energy Inc. (2007). *Guide for Conducting Energy Efficiency Potential Studies*. Prepared in connection with the National Action Plan for Energy Efficiency. Available at: www.epa.gov/eeactionplan.

Pacific Gas & Electric Company, Emerging Technologies Program (2008). *LED Street Lighting: Oakland, California*. Application Assessment Report #0714. Available at: http://betaled.com/docs/Emerging%20Technology%20Report%20for%20LED%20Street%20Lighting.pdf.

PA Consulting Group (2008). *FY08 CFL Customer Research—Draft Report*. Prepared on behalf of the Public Service Commission of Wisconsin by R. Winch and T. Talerico, Glacier Consulting.

PA Consulting Group (2008). *Quantifying Environmental Benefits of Focus on Energy: Emission-rate Estimates 2002 to 2006*. Final Report. Prepared on behalf of the Public Service Commission of Wisconsin.

PA Consulting Group, Inc. (2008). Focus on Energy Evaluation: *Semi-Annual Report (First Half of 2008)*. Prepared for the Public Service Commission of Wisconsin by the Focus on Energy evaluation team (PA Consulting, Glacier Consulting Group, KEMA, and Patrick Engineering, Inc.).

PA Consulting Group, Inc. (2007). Focus on Energy Evaluation: *Residential Lighting Program: Compact Fluorescent Lighting Installation Rate Study*. Prepared for the Public Service Commission of Wisconsin by Glacier Consulting Group, LLC.

J. S. Peters and M. McRae (2008). *Free-Ridership Measurement is Out of Sync with Program Logic… or, We've Got the Structure Built, But What's Its Foundation?* Proceedings of the 2008 ACEEE Summer Study on Energy Efficiency in Buildings.

Quantec (2008). *Assessment of Energy and Capacity Savings Potential in Iowa*. Prepared for the Iowa Utility Association in collaboration with Summit Blue Consulting, Nexant, Inc., A-TEC Energy Corporation, and Britt/Makela Group.

G. Rowe and G. Wright (1999). "The Delphi Technique as a Forecasting Tool: Issues and Analysis," *International Journal of Forecasting,* Vol. 15 (1999) 353-375.

Summit Blue Consulting LLC (2008). *Energy Efficiency Potential Study for the State of Kansas: Final Report*. Prepared on behalf of the Kansas Energy Council.

Summit Blue Consulting, Quantec LLC, and Skumatz Economic Research Associates. (2006). *Midwest Residential Market Assessment & DSM Potential Study*. Prepared on behalf of the Midwest Energy Efficiency Alliance with sponsorship from Xcel Energy. Available at: http://www.mwalliance.org/image/docs/resources/MEEA-Resource-5.pdf.

Summit Blue & Wisconsin Energy Conservation Corporation (2007). *Duke Energy Indiana: SM Market Assessment & DSM Action Plan: Final Report*.

Synapse Energy Economics, Inc. (2008). *Synapse 2008* CO_2 *Price Forecasts*.

TheInductionSite.com. Internet source, available at: http://theinductionsite.com.

Touchstone Energy Home Program. *Indiana Program FAQ*. Internet source, available at: http://www.itehome.com/faqs.html#energystarfit.

United Kingdom, HM Government Economic Service (2006). *The Stern Review on the Economics of Climate Change*. Available at: http://www.hm-treasury.gov.uk/stern_review_report.htm.

U.S. Department of Energy, Energy Information Administration (2008). *Annual Energy Outlook 2009 Early Release*. Available at: http://www.eia.doe.gov/oiaf/aeo/.

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy (2008). *2008 Buildings Energy Data Book*. Available at: http://buildingsdatabook.eren.doe.gov/.

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. *Top-Mount and Side-by-Side Refrigerator-Freezers: Consumer Life-Cycle Cost and Payback Period Results*. Available at: http://www.eere.energy.gov/buildings/appliance_standards/residential/docs/refrigerators_freezers_llc.xls.

U.S. Department of Energy. *ENERGY STAR Residential Water Heaters: Draft Criteria Analysis*. Available at: www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/WaterHeaterDraftCriteriaAnalysis.pdf.

U.S. Department of Energy, Federal Energy Management Program (FEMP). *Federal Technology Alert: Residential Heat Pump Water Heaters*. Available at: http://www1.eere.energy.gov/femp/pdfs/FTA_res_heat_pump.pdf.

U.S. Environmental Protection Agency (2007). *2007 ENERGY STAR Qualified New Homes Market Indices for States*. Available at: http://www.energystar.gov/index.cfm?fuseaction=qhmi.showHomesMarketIndex.

U.S. Environmental Protection Agency (2006). "ENERGY STAR Program and Office Equipment Overview." Presentation by Katherine K. Osdoba, U.S. EPA, at the Federal Electronics Challenge Call. Available at: www.federalelectronicschallenge.net/resources/docs/energy_star_partcall_sept06.ppt.

U.S. Department of Energy and the U.S. Environmental Protection Agency. *National Action Plan for Energy Efficiency* (2006) Available at: www.epa.gov/eeactionplan.

U.S. Environmental Protection Agency and the U.S. Department of Energy. ENERGY STAR calculators for central air conditioners, home computers, dehumidifiers, residential refrigerators and freezers, air source heat pumps, programmable thermostats, and second refrigerator recycling. Available at: www.energystar.gov.

U.S. Environmental Protection Agency and the U.S. Department of Energy. *Formulas to Calculate the ENERGY STAR Criteria for each Refrigerator Product Category by Adjusted Volume using NAECA Levels*. Available at: http://www.energystar.gov/ia/products/appliances/refrig/NAECA_calculation.xls.

M. L. Wald (July 1, 2008). "Georgia Judge Cites Carbon Dioxide in Denying Coal Plant Permit." *The New York Times*.

Wisconsin Department of Revenue, Division of Research & Policy (2008). *Wisconsin Economic Outlook*. Available at: http://www.revenue.wi.gov/ra/0812/0812okma.pdf.

Wisconsin Office of Energy Independence. *2008 Wisconsin Energy Statistics*.

Wisconsin Office of Energy Independence. *2007 Wisconsin Energy Statistics*.

ENERGY CENTER
OF WISCONSIN

ENERGY EFFICIENCY AND CUSTOMER-SITED RENEWABLE RESOURCE POTENTIAL IN WISCONSIN
For the years 2012 and 2018

SECTION 2: RENEWABLE ENERGY

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EXECUTIVE SUMMARY

Renewable energy technologies generate heat or electricity using resources such as the sun, the wind, and biomass, rather than through combustion of fossil fuels. Unlike energy efficiency measures which reduce energy consumption, renewable energy technologies displace fossil fuels and associated pollutants and greenhouse gas emissions. Renewable energy technologies can be deployed in utility-scale installations, or in distributed applications for homes and businesses ("customer-sited" installations). This study estimates the potential for deployment of customer-sited renewable energy technologies in Wisconsin through 2018.

The Energy Center of Wisconsin (Energy Center) evaluated the cost-effectiveness of fifteen renewable energy technologies using the total resource cost test (TRC), which compares the cost of installing and maintaining the renewable energy system with the benefits of avoided utility-supplied energy.

A number of the renewable energy technologies evaluated in this study are cost-effective today, including distributed wind projects with utility-scale turbines, anaerobic digesters, biomass combustion systems (residential- and commercial-scale), and large-scale biomass combustion for electricity generation. For the technologies that do not pass the TRC test under current conditions, there is considerable economic option value associated with building and maintaining an infrastructure that enables Wisconsin to significantly ramp-up deployment of distributed renewable resources should conditions change in the future. This flexibility benefit of renewable resources may be much larger than the value associated with the technologies that are currently cost-effective.

Considering only those technologies that are cost-effective today, we estimate that by 2012, customer-sited renewable energy technologies could have a peak generating capacity of 12.5 megawatts (MW), displace around 31 million kilowatt hours (kWh) of grid-supplied electricity per year, and displace around 1.6 million therms of natural gas/propane per year. By 2018, estimated annual renewable electricity generation capacity increases to approximately 37 MW, displacing 77 million kWh per year. The growth in potential for electricity-generating technologies from 2012 to 2018 is substantial—a 300 percent increase in peak generating capacity over the period, and a 250 percent increase in electricity generation. Over the same time period, the capacity for displacement of natural gas/propane increases to around 2 million therms per year—an increase of 30 percent.

We note that even if Wisconsin promoted all of the renewable resource technologies addressed in this study *regardless of cost-effectiveness*, the total capacity pales in comparison to that available in the energy efficiency arena. The 2012 annual achievable potential for the technologies addressed in the energy efficiency component of this study is 30 times greater than the renewable potential estimate, or 1.1 billion kWh for energy efficiency compared with 36 million kWh for customer-sited renewables (includes those technologies that are not currently cost-effective as determined by the TRC). Similar comparisons can be made for peak generating capacity (231 MW for energy efficiency versus 17 MW for renewables) and for natural gas/propane displacement (37 million therms for energy efficiency versus 1.7 million therms for renewables).

While we expect the potential for energy efficiency to grow at a fairly even rate after 2012, the potential for renewable resources expands much more rapidly over the same period, particularly for electricity-generating technologies. These results suggest a different strategy for state support of customer-sited renewable resources as compared with energy efficiency resources. For energy efficiency measures that are cost-effective today, aggressive acquisition may be the appropriate path. *For renewable resources, the optimal strategy may be to develop the capability for large-scale expansion should future conditions warrant*.

The costs that a statewide renewable energy program would incur to achieve projected 2012 results are estimated to be between $13 million and $22 million per year (2008 dollars). These results would reduce utility-based greenhouse gas emissions by between 21,000 and 39,000 tons per year. They would also support between 240 and 350 Wisconsin jobs.

The renewable energy generating potential estimated in this study would generate as much as $21 million in net benefits for Wisconsin consumers (present value, 2008 dollars). Almost 90 percent of estimated net benefits are associated with thermal energy generating technologies. However, the electricity-generating renewable energy technologies addressed in this study are expected to experience faster growth than the thermal energy-generating technologies.

CHAPTER RE-1: OVERVIEW

To supplement the assessment of statewide energy efficiency potential, the Public Service Commission of Wisconsin (PSCW) retained the Energy Center to analyze the potential for deployment of customer-sited renewable energy resources through 2018.[1] We summarize the renewable energy analysis in this section of the report.

Our analysis reflects the knowledge of experts from both within and outside the Energy Center. We drew heavily on the technical knowledge of our renewable resource co-consultant, L&S Technical Associates. We also obtained key technology forecasts from more than 30 Wisconsin-based renewable energy experts who participated in a Delphi process.[2]

THE NATURE OF RENEWABLE ENERGY RESOURCES

Renewable energy resources are local in nature. Solar panels harvest local sunshine and wind turbines must be located where the wind blows to produce energy. Wisconsin's sun and wind offer average-to-good capability, but the state's most abundant renewable energy potential can be found in its northern forests, its agricultural biomass resources in the west and south, and other organic waste streams statewide. Wisconsin's dairy and food production industries offer opportunities to produce methane for both electricity and heat.

Wisconsin's forestry and agriculture industries can provide not only secondary products, but also primary products, such as new crops dedicated to energy production that can be used to produce electricity, heat, and transportation fuel (however, transportation fuel is not considered in this assessment). Since Wisconsin has no indigenous fossil fuel resources, how we manage our biomass resources will be the key to determining the state's potential for energy independence.

Our method for analyzing renewable resources was different from the approach used to analyze energy efficiency potential, in large part because the two resource types are distinct. For example, while there are around 500 unique energy efficiency measures considered in this study, only fifteen renewable energy technologies were addressed in this analysis.

While both energy efficiency and renewable resources are important components of a clean energy strategy for Wisconsin, they play two fundamentally different roles. Energy efficiency technologies lower energy use, ultimately reducing the need to generate kilowatt hours or therms. On the other hand, renewable energy technologies generate heat or electricity using resources such as the sun, the wind, forestry and agricultural products, rather than through combustion of fossil fuels. Renewable energy technologies do not save energy, but displace fossil fuels and associated pollutants and greenhouse gas emissions.

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[1] All references in this document to renewable resources refer to customer-sited renewable resources, and not utility-scale renewable resources, unless noted otherwise.

[2] As noted in the energy efficiency section, all opinions expressed in this document are those of the Energy Center of Wisconsin, and do not necessarily reflect the positions of others who contributed to the study.

Renewable resources offer one advantage that energy efficiency measures do not—they are energy supply sources. The entire demand on a utility system could conceivably be met with renewable resources. (Whether such an approach would be cost-effective is a separate matter.) However, the entire demand on a utility system could never be met with energy efficiency measures. Those measures reduce demand; they do not eliminate it.

CUSTOMER-SITED RENEWABLE ENERGY TECHNOLOGIES ADDRESSED IN THIS STUDY

This study considers fifteen non-transportation renewable energy applications appropriate to Wisconsin's climate and resources. These applications draw on four renewable energy resources: solar, wind, biomass and hydropower. Because these resources offer applications that vary in their likelihood of adoption or development in Wisconsin, we have allocated each technology into one of four categories:

- Technologies that are currently cost-effective under certain circumstances in Wisconsin.
- Technologies that have achieved considerable popularity among consumers despite the fact that traditional discounted cash flow (DCF) analyses show they are not cost-effective.
- Technologies that could make a substantial contribution to the state's renewable energy resource portfolio once technical challenges have been overcome and market conditions have developed further.
- Technologies with limited or problematic development potential in Wisconsin.

We provide a description of each technology within each category.

1. Technologies that are currently cost-effective under certain circumstances in Wisconsin include:

    Large-Scale Wind: Wind farms with utility-scale turbines are usually installed by developers or utilities, but individual turbines can be erected through community wind projects. Turbines sized up to 1.5 MW are included in this study as potentially customer-sited.

    Biogas Combined Heat and Power (CHP): Anaerobic digesters for combined heat and power harvest biogas from organic wastes such as animal manure, sewage or food processing waste to generate electricity. Waste heat from the generator can be used to regulate the digester temperature or for other processes. A number of farms in Wisconsin have partnered with their utility on ownership and maintenance of digester systems.

    Biomass Thermal: Technologies that burn wood or other biomass to produce heat include residential and small commercial-scale wood, pellet or corn stoves, wood-fired boilers for space and water heating in schools and manufacturing facilities, or wood burning for industrial process heat. Because of transportation costs associated with this fuel, cost-effectiveness depends on having a reliable fuel source nearby.

2. Technologies that have achieved considerable popularity among consumers despite the fact that they are not cost-effective as determined through a traditional DCF approach include:

    Small-Scale Solar Photovoltaics (PV): Solar PV systems sized under 20 kilowatts (kW) have become popular among home owners, small businesses, schools, churches and municipalities in Wisconsin. Despite the long payback for these systems, they have become a primary symbol of commitment to clean energy, and Focus on Energy is experiencing high demand for solar PV incentives.

    Small-Scale Solar Hot Water – Thermal: Solar water heaters that augment conventional natural gas water heaters (using less than 5,000 therms annually) are also popular among home owners and small businesses. On average, these systems are more cost-effective in the short run than solar PV, but their popularity is also attributable to similar non-economic reasons as those noted for PV.

    Small-Scale Solar Hot Water – Electric: Though this technology did not pass the TRC screen, solar water heating to augment an electric residential water heater is cost-effective in some cases based on the value of displaced electricity consumption. During Wisconsin winters, a solar water heater can provide 30 to 40 percent of hot water requirements, and an even higher percentage in summer. With appropriate solar access, solar pool heaters for seasonal outdoor pools can be highly cost-effective in Wisconsin.

    Large-Scale Solar Hot Water – Electric: Though this technology did not pass the TRC screen, solar water heating for commercial applications or industrial processes can also be cost effective if augmenting an electric water heater (greater than 7,300 kWh), and installed in facilities where there is year-round demand for hot water.

    Small-Scale Wind: Residential-scale wind turbines (less than 20 kW) continue to be attractive to rural property owners, both for reasons similar to those for buying solar PV, and for energy self-reliance in isolated locations.

3. Technologies that could make a substantial contribution to the state's renewable energy resource portfolio once technical challenges have been overcome and market conditions have developed further include:

    Biomass CHP: Biomass CHP technologies burn wood, crop waste, or other organic matter to generate electricity and heat. These technologies passed the cost-effectiveness test used in this analysis, and applications of biomass CHP are most economical where space or process heat is needed and electricity is a secondary product, such as in industrial processes. Like the biomass thermal technologies described above, close proximity of the fuel is important to ensuring economic viability.

Solar Thermal Air: This technology uses dark metal perforated panels that collect the sun's heat to preheat make-up air for ventilated spaces. Solar thermal air systems work well to reduce heating costs in both large, open buildings such as barns and warehouses, and in heavily populated buildings that are highly ventilated, such as schools. This technology is well established in Europe and Canada, but needs aggressive marketing to reach its potential in Wisconsin.

Biogas Renewable Natural Gas (RNG): Methane gas collected from anaerobic digesters and landfills can be cleaned of abrasive chemicals and injected into a natural gas pipeline. Challenges include improving reliability of current technology and establishing generally acceptable utility standards and interconnection rules. The ability to collect bio-methane from multiple sources for injection into the pipeline would make anaerobic digestion economical for farms too small to generate electricity with their methane on site.

Large-Scale Solar PV: Solar PV systems larger than 20 kW (the current net metering limit in Wisconsin) will become economical as PV panel prices drop, which they are expected to do worldwide over the next few years. Large solar arrays could be located on the roofs of big box stores and other large buildings, and potentially installed by a utility or a third party developer which would lease the space from the building owner.

Large-Scale Solar Hot Water – Thermal: There are many commercial and institutional applications for solar hot water yet to be explored in Wisconsin, particularly for systems using more than 5,000 therms annually. Potential sites include hotels, restaurants, athletic clubs, nursing homes and hospitals, car washes, correctional facilities and municipal pools, which could all save between 40 and 60 percent of the energy they need to heat the high volumes of water they use daily. A mature and readily available and reliable technology, this application will gain in popularity as natural gas prices rise and businesses and institutions learn of the potential for savings.

4. Technologies with limited or problematic development potential in Wisconsin include:[3]

Small-Scale Hydropower: Despite the fact that the first hydropower generation station in the country was built on the Fox River in Appleton, Wisconsin in 1882, hydropower is not a significant renewable resource in Wisconsin. Many small towns in Wisconsin had built hydropower plants on local rivers in the early twentieth century, but most have been closed due to operating costs or environmental concerns. There are few locations left where hydropower resources would be worth developing, although micro-hydro technology, which

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[3] The technologies in this category are unlikely to make a significant contribution to renewable energy in the state. We received no Delphi responses for either of these applications, and therefore did not include them in our renewable energy potential estimates.

harnesses the energy in small streams, is occasionally installed by interested landowners.

Landfill RNG: Many landfill operators collect methane gas and flare it to get rid of it, making the idea of collecting it for injecting into the natural gas pipeline an attractive one. However, there are only a limited number of landfills and new waste management techniques are attempting to reduce the magnitude of existing landfills. In addition, there are still technical challenges to cleaning the gas to meet pipeline standards. While it makes sense to harvest and use gas from landfills, it can often be more economically used on-site for heat or electricity generation rather than injected into the natural gas pipeline.

METHODOLOGY

Renewable Energy Potential Estimates

As discussed in the energy efficiency section of the report, it is important to note that the Energy Center's definition of achievable potential represents a departure from business-as-usual conditions. As was the case for the energy efficiency analysis, the renewable energy analysis focuses on what could be achieved under significant increases in program funding and support for deployment of customer-sited renewable energy technologies. Similar to the energy efficiency analysis, Delphi responses were critical to developing estimates of what could be achieved through an aggressive approach to renewable energy policies and programs. (Additional information on the Delphi process is provided below).

The results of the renewable component of the potential study are projections of annual renewable electric and thermal energy generation from customer-sited installations deployed in Wisconsin in 2012 and 2018. Achievable renewable energy potential estimates represent annual customer-sited generation that could be achieved in those years rather than cumulative values.

Renewable energy potential estimates are reported in terms of net generation, or generation that is directly or indirectly attributable to program activities. Net savings estimates exclude free riders (program participants who would have installed the system without program intervention) and include spillover effects (individuals who did not directly participate in a program, but install renewable energy systems as a result of program influence). These estimates are comparable to the "verified net" results reported in Focus on Energy evaluations.

Net achievable estimates were derived by applying a standard net-to-gross (NTG) ratio of 0.5 for all renewable energy technologies. We reviewed historical net-to-gross ratios from FY 2002 through the first 12 months of FY08, as published in the October 2008 Focus on Energy evaluation.[4] The average NTG ratio across renewable kWh, kW, and therms was 0.3. However, since more aggressive program strategies could potentially achieve lower free-ridership rates, we assumed an NTG ratio of 0.5 across the technologies addressed in this study.

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[4] PA Consulting Group, Inc. (October 2008). Focus on Energy Evaluation: *Semi-Annual Report (First Half of 2008)*. Prepared for the Public Service Commission of Wisconsin by the Focus on Energy evaluation team (PA Consulting, Glacier Consulting Group, KEMA, and Patrick Engineering, Inc.).

Cost-Effectiveness Analysis

The analytical foundation for the cost-effectiveness analysis of customer-sited renewable energy resources was developed by L&S Technical Associates, Inc. A benefit-cost model addressed fifteen technologies, with key inputs by technology summarized in Appendix B. Cost-effectiveness screening was conducted using the TRC test, which compares the net present value of benefits achieved over the lifetime of the technology with the costs incurred by the program and the participant.[5] Cost-effectiveness results are summarized in Table RE-1.

TABLE RE-1. COST-EFFECTIVENESS RESULTS FOR CUSTOMER-SITED RENEWABLE ENERGY TECHNOLOGIES

Energy Generated	Technology	TRC Ratio
Electric		
	Small-scale wind (<=20 kW)	0.29
	Mid-sized wind (>20 kW to 100 kW)	0.26
	Large-scale wind (>100 kW to 1.5 MW)	0.96
	Small-scale solar electric (<=20 kW)	0.23
	Large-scale solar electric (>20 kW)	0.23
	Small-scale solar hot water (<=7,300 kWh/year)	0.21
	Large-scale solar hot water (>7,300 kWh/year)	0.15
	Biogas CHP[6]	1.58
	Biomass CHP[7]	4.83
Thermal		
	Small-scale solar hot water (<=5,000 therms/year)	0.24
	Large-scale solar hot water (>5,000 therms/year)	0.36
	Solar thermal air	0.56
	Biogas RNG[8]	4.82
	Residential-scale biomass thermal	1.29
	Commercial/institutional-scale biomass thermal	4.19

For the purposes of this analysis, quantified benefits include the avoided cost of conserved energy (energy and capacity) and the value of avoided carbon emissions. Other environmental benefits and non-energy

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[5] Detailed information on economic screening methodology is available in the California Standard Practice Manual, available at: http://drrc.lbl.gov/pubs/CA-SPManual-7-02.pdf.

[6] This category includes anaerobic digester systems generating electricity only, as well as those generating both electric and thermal energy.

[7] This category includes biomass combustion systems generating electricity only, as well as those generating both electric and thermal energy.

[8] This category includes anaerobic digesters producing biogas for injection into a natural gas pipeline.

benefits were not included. Avoided cost and carbon values used in the Energy Center's analysis are summarized in Table RE-2.

TABLE RE-2. AVOIDED COSTS AND CARBON VALUE

Description	Value
Avoided electricity ($/kWh)[9]	$0.0546
Avoided T&D capacity ($/kW-year)	$30.00
Carbon surcharge for electricity ($/kWh)	$0.025
Avoided natural gas ($/therm)	$0.840
Carbon surcharge for natural gas ($/therm)	$0.176

The Energy Center used Midwest Independent Transmission System Operator (Midwest ISO) locational marginal prices (LMPs) as the basis for avoided electricity costs. We developed average prices for on- and off-peak power based on 2005-2008 data from four nodes: Weston, Pleasant Prairie, Columbia, and Dairyland Power. As the value of generation capacity is embedded in on-peak Midwest ISO prices, the only capacity value we included was for transmission and distribution (T&D), at $30/kW-year. This value was determined in consultation with PSCW staff, and is in line with values reported by Iowa investor-owned utilities in their 2009-2013 energy efficiency program plans.[10] We also included an eight percent adjustment to reflect transmission and distribution line losses. This is consistent with the line loss factor used in Focus on Energy evaluation studies.[11]

Natural gas avoided costs are consistent with values used in Focus on Energy program planning and evaluation.[12] The values for avoided carbon emissions were calculated based on average carbon prices in projections developed by Synapse Energy Economics, Inc. (medium range forecast)[13] and carbon emissions factors for utility-supplied electricity and natural gas as reported in recent Focus on Energy evaluations—0.9 tons of carbon dioxide (CO_2) per MWh and 11.708 lbs CO_2 per therm.[14] A real discount rate of five percent was used to obtain the net present value of future benefits.

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[9] In the energy efficiency analysis, avoided costs of on-peak and off-peak energy savings were developed. However, the renewable energy analysis averages these on- and off-peak prices into a single blended rate.

[10] Interstate Power & Light Company (2008). *2009-2013 Energy Efficiency Plan*. Docket No. EEP-08-1.
MidAmerican Energy Company (2008). *2009-2013 Energy Efficiency Plan*. Docket No. EEP-08-2.

[11] Personal communication with Bryan Ward, PA Consulting, November 3, 2008.

[12] Personal communication, PSCW staff.

[13] Synapse Energy Economics, Inc. (2008). *Synapse 2008 CO_2 Price Forecasts*.

[14] CO_2 emissions factor for electricity is from: PA Consulting Group Inc. (2008). *Quantifying Environmental Benefits of Focus on Energy: Emission-Rate Estimates 2002 to 2006.* Prepared for the Public Service Commission of Wisconsin.
CO_2 emissions factor for gas is from: PA Consulting Group, Inc. (2008). *Focus on Energy Evaluation: Semi-Annual Report (First Half of 2008).* Prepared for the Public Service Commission of Wisconsin by the Focus on Energy evaluation team (PA Consulting, Glacier Consulting Group, KEMA, and Patrick Engineering, Inc.).

The cost component of the TRC test includes system costs (minus the value of any tax incentives[15]), installation costs, operations and maintenance (O&M) costs, and program administrative costs. L&S Technical Associates developed average cost and renewable energy generation values based on past participation in the Focus on Energy program.

It is important to note that the TRC framework has significant shortcomings in terms of assessing the viability of renewable energy resources. Most importantly, the standard discounted cash flow (DCF) model does not capture the intangible benefits associated with renewable energy development. These benefits include increased energy security and the expanded opportunity to transition to a new energy economy. These types of benefits are often categorized as "resource flexibility" benefits.

Though DCF-based approaches like the TRC test offer no mechanism for valuing resource flexibility benefits, more sophisticated economic models such as real options pricing models can address this need. However, real options models are more complex and difficult to implement than the standard DCF approach. An in-depth explanation of the concepts supporting an options-based approach to valuing the flexibility benefits associated with renewable energy technologies is contained in Appendix A. However, developing an options-based model is beyond the scope of this analysis.

Due to the shortcomings of traditional DCF analysis when it comes to evaluating renewable energy resources, we rely on the TRC results to a lesser extent than we did in the case of energy efficiency resources. We developed a range of renewable energy potential estimates based on two scenarios: a conservative strategy and an aggressive strategy. The conservative renewable strategy, representing the low end of the range, targets only those customer-sited renewable energy resources that are currently cost-effective under the TRC test. The aggressive renewable strategy includes some additional renewable resources that are not currently cost-effective, as determined by the TRC test.

Delphi Process

By definition, estimating what could be achieved under a future scenario of aggressive renewable energy policy and program efforts involves projecting future conditions that represent a significant departure from business-as-usual. A key component of the Energy Center's approach to this analytical challenge was using a Delphi process to query more than 50 renewable energy experts about what an aggressive renewable energy future would look like in Wisconsin.

For the renewable energy component of the potential study, sector-specific Delphi questionnaires focused on key technologies that are expected to have a large impact on distributed renewable energy potential over the time period of the study. Participants were asked to share their perspective on future trends and market barriers for each renewable energy technology in their area of expertise, and were also asked to rate the relative importance of a number of market barriers and program components for addressing market barriers. Then they were asked to estimate future installation levels under four scenarios:

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[15] The value of tax incentives was calculated based on technology-specific rules and caps which were in effect prior to passage of the American Recovery and Reinvestment Act of 2009, on February 12, 2009.

- A continuation of the status quo with respect to program design and funding, and the current status quo for market barrier reduction.
- Optimal program design and funding, but a continuation of the current status quo for market barrier reduction.
- A continuation of the status quo with respect to program design and funding, but optimal market barrier reduction.
- Optimal program design and funding, and optimal market barrier reduction.

The Energy Center received responses from 32 renewable energy experts, as shown in Table RE-3. Appendix D includes a copy of Delphi survey instruments. Appendix E includes a transcript of individual Delphi responses.

TABLE RE-3. DELPHI REPSONSES RECEIVED FROM RENEWABLE ENERGY EXPERTS

Technology	**Responses**
Biomass thermal	7
Solar electric	6
Solar hot water	6
Biogas (CHP or RNG)	5
Wind	4
Biomass CHP	2
Solar thermal air	2
Total	**32**

After compiling results from the initial survey round, the Energy Center developed a summary of responses which presented maximum, minimum, and median responses for each technology-specific estimate. During a second survey round, participants were given the opportunity to revise their initial estimates after reviewing the summary of responses from other participants.

Estimates of achievable customer-sited renewable energy potential are based on Delphi responses. Given the four scenarios addressed in the survey, Delphi experts provided a range of potential estimates for customer-sited renewable energy development in 2012 and 2018. In developing a point estimate, we took a conservative approach and used the geometric mean of the highest and lowest Delphi values for each technology. (The geometric mean puts relatively more weight on the lower value and less weight on the higher figure.)

CHAPTER RE-2: RESULTS

AGGREGATE STATEWIDE POTENTIAL ESTIMATES

As noted in the previous chapter, we present a range of renewable energy potential estimates based on two alternative resource strategies: a conservative strategy toward development of customer-sited renewable resources in Wisconsin, and an aggressive strategy. The conservative strategy ignores the flexibility value associated with developing customer-sited renewable energy resources, and only includes those technologies that are currently cost-effective, as determined by the TRC test. As discussed in Chapter RE-1, this approach has serious limitations and undervalues development of distributed renewable energy capacity in Wisconsin. The aggressive strategy includes additional renewable resources that are not currently cost-effective, but which currently enjoy popularity among consumers due to the non-energy benefits they provide, and/or have the potential to make a substantial contribution to the state’s renewable energy resource portfolio once technical challenges have been overcome and market conditions have developed further.

The following customer-sited renewable energy technologies are included in the conservative strategy estimates. (Detailed descriptions and size criteria are included in Chapter RE-1).

- **Large-scale wind**: Distributed applications of utility-scale wind turbines[16]
- **Biomass CHP**: Large-scale biomass combustion for electric and potentially also thermal energy
- **Biogas CHP**: Anaerobic digesters generating biogas for electric and potentially also thermal energy
- **Biomass thermal**: Small- and large-scale biomass combustion for thermal energy
- **Biogas RNG**: Anaerobic digesters generating biogas for injection into a natural gas pipeline

There is demonstrable value in promoting these resources, as they can produce energy at comparable or lower cost than utility supply-side assets.

The following additional technologies are included in the aggressive strategy estimates:

- **Small-scale wind**: Wind turbines sized for residential/commercial applications
- **Solar PV**: Large- or small-scale solar electric systems
- **Solar hot water**: Water heating with solar energy, supplanting either electric or gas-heated water
- **Solar thermal air**: Systems that preheat make-up air for ventilated spaces in large commercial/institutional facilities

Under either strategy, the scale of potential associated with customer-sited renewable energy resources pales in comparison to the estimates presented in the energy efficiency section of this report. Figures RE-1 through RE-3 compare the potential for energy efficiency and customer-sited renewable energy technologies to displace utility-supplied electricity and natural gas/propane.

Note that even by 2018, the customer-sited renewable resource potential represents but a small fraction of the 2012 energy efficiency estimate. That is not to say that renewable resources should be ignored.

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[16] This technology has a TRC ratio of 0.96, which is rounded up to 1.0.

However, compared with energy efficiency resources, distributed renewable resources have a relatively small role to play in promoting a clean energy future for Wisconsin.

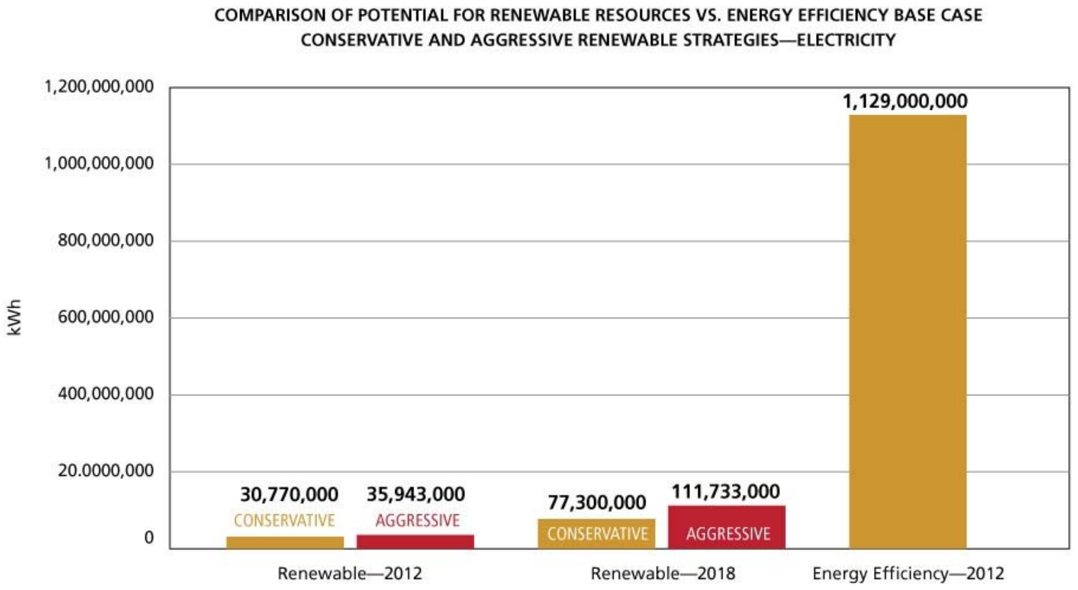

Figure RE-1: Comparison of Conservative and Aggressive Customer-Sited Renewable Resource Potential vs. Energy Efficiency Base Scenario – Electricity

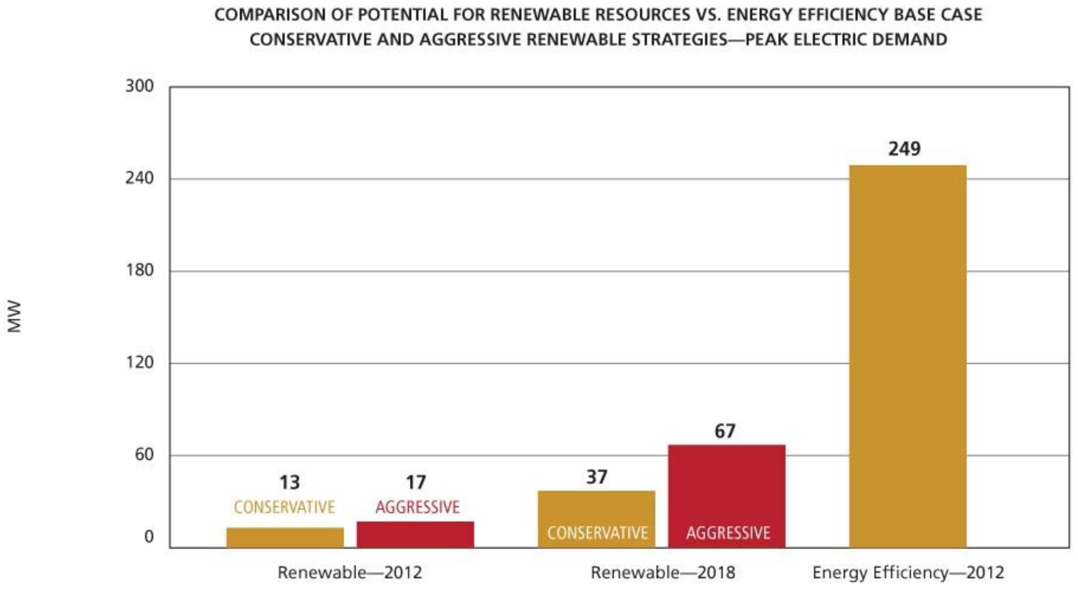

Figure RE-2: Comparison of Conservative and Aggressive Customer-Sited Renewable Resource Potential vs. Energy Efficiency Base Scenario – Peak Electric Demand

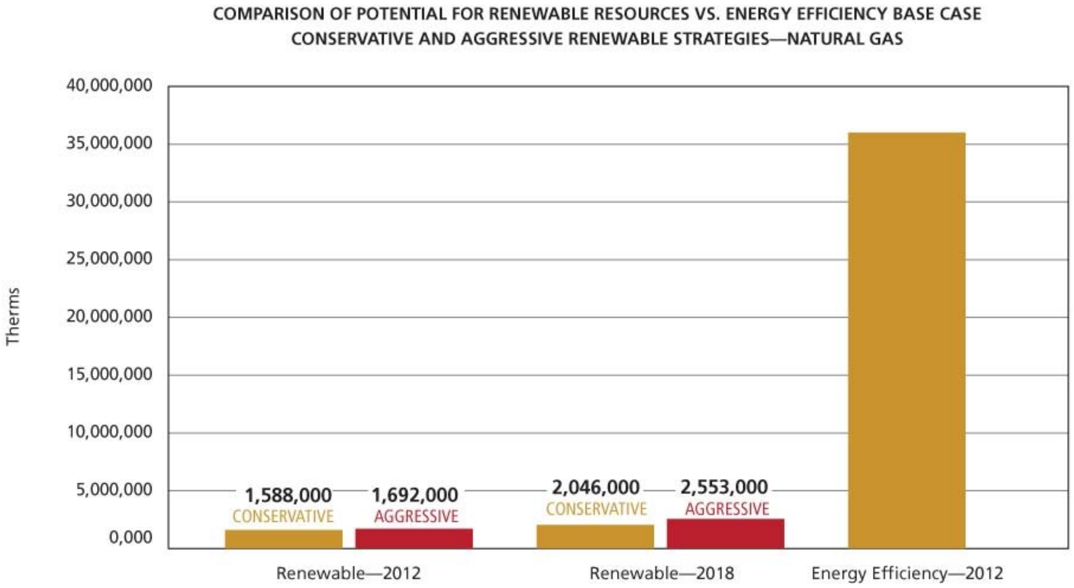

Figure RE-3: Comparison of Conservative and Aggressive Customer-Sited Renewable Resource Potential vs. Energy Efficiency Base Scenario – Natural Gas

Note that for either fuel, we do not obtain substantially more renewable resource capacity by moving from the conservative to the aggressive scenario. This is consistent with the idea that to maximize option value, one must have the *capability* to expand the acquisition of renewable resources, rather than pursuing them outright.

Our strategy analysis assumes that renewable resources would be promoted under existing programs. There is, however, a potential development afoot in Wisconsin that could remake the landscape for distributed renewable potential: utility-owned, customer-sited renewable energy installations. This model is discussed in Chapter RE-3.

TECHNOLOGY RESULTS

Figures RE-4 through RE-6 present customer-sited renewable energy generating potential by technology under the aggressive renewable strategy. Under the conservative renewable strategy, potential estimates are the same for cost-effective technologies, and the estimates associated with technologies that are not currently cost effective (small-scale wind, solar PV, solar hot water, and solar thermal air) are not included.

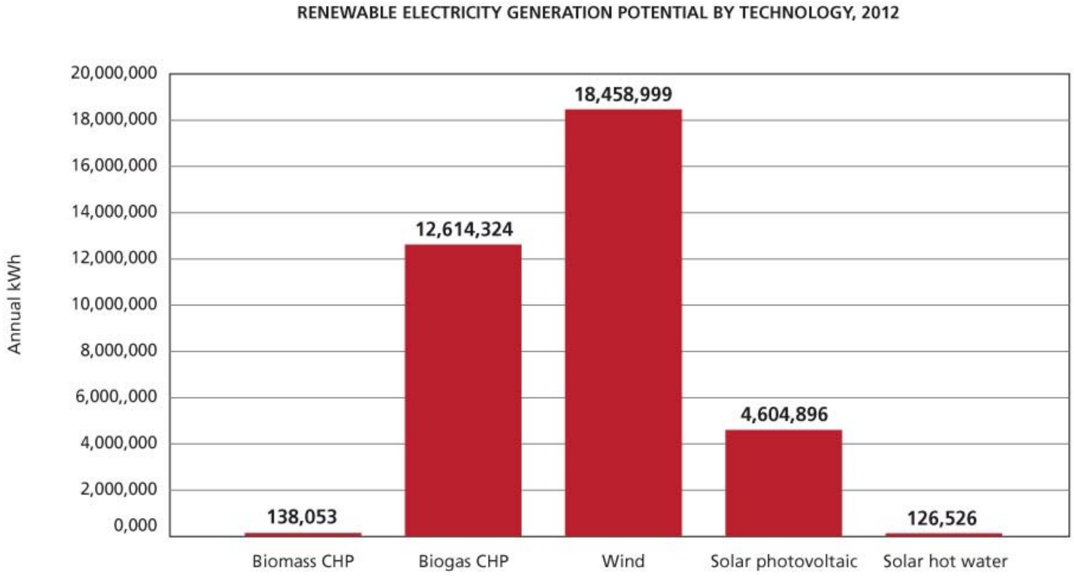

Figure RE-4: Renewable Electric Energy Potential by Technology in 2012, Aggressive Strategy

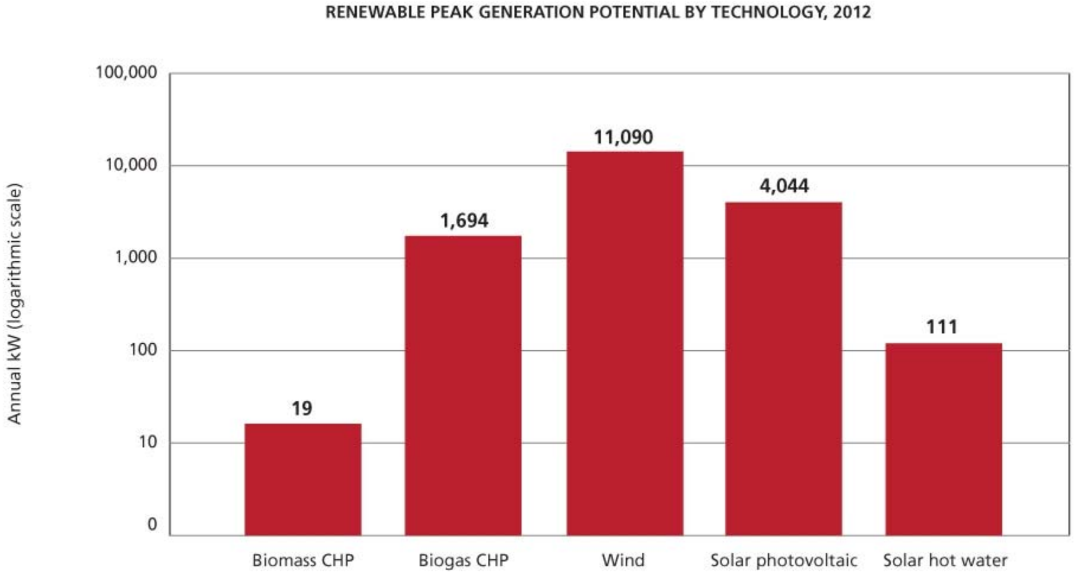

Figure RE-5: Renewable Peak Generating Capacity by Technology in 2012, Aggressive Strategy

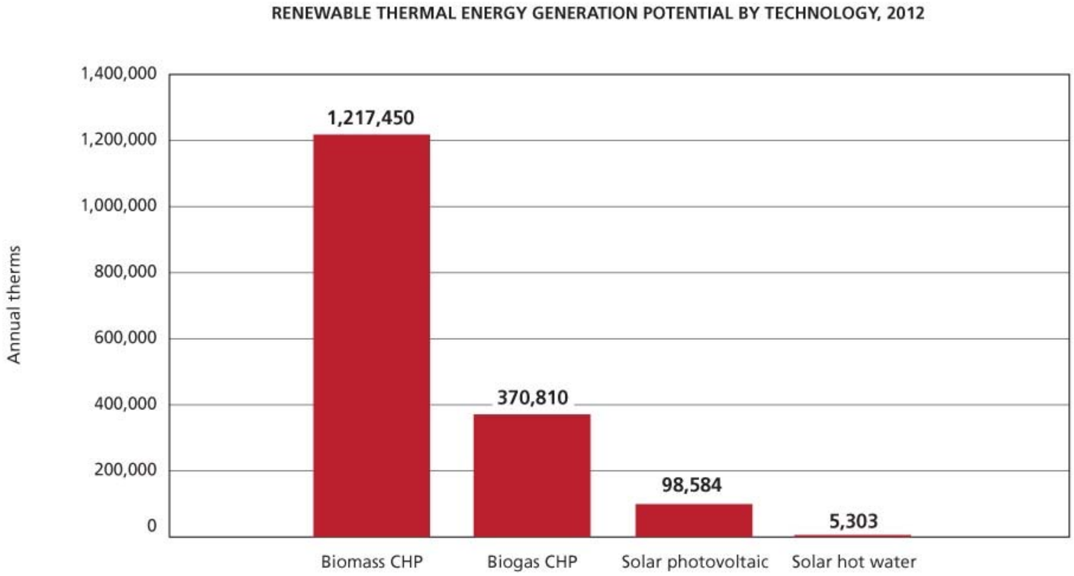

Figure RE-6: Renewable Thermal Energy Potential by Technology in 2012, Aggressive Strategy

Among electricity-generating technologies, wind turbines represent over half of the estimated annual potential for 2012. Anaerobic digesters producing biogas for electricity and possibly also thermal energy generation represent around 35 percent of the potential. Solar PV represents around 13 percent of the potential, however PV is only included under the aggressive renewable strategy as it is not currently cost-effective under the TRC framework. For peak demand reduction, wind represents around 65 percent of the potential, PV represents around 24 percent, and anaerobic digesters represent around 10 percent.

Among thermal energy generating technologies, the largest opportunities are associated with biomass combustion for residential-scale and commercial/institutional-scale applications. Anaerobic digester projects that inject biogas into a natural gas pipeline represent another area of substantial potential for renewable thermal energy generation.

PROGRAM AND TOTAL RESOURCE COST ESTIMATES

A critical consideration for policymakers is the cost Wisconsin's statewide renewable energy program would incur in achieving the potential estimates presented in this study. In this section we present cost estimates for state-sponsored support of renewable resource programs.[17]

To estimate program costs, the Energy Center assumed that incentives would cover 30 percent of the installed system cost. Incentives include cash-back rewards, grants, and other forms of financial support. Of course, Focus on Energy's current incentive structure varies by technology, generally covering a percentage of the installed cost up to a per-project cap. We made a simplifying assumption of 30 percent based on Focus on Energy's current "cash back reward" incentive levels for solar PV, solar thermal, wind, and biomass. Cash back rewards range between 25 and 35 percent of the installation cost for these technologies.

Program administrative costs were estimated using the technology-specific administrative cost factors shown in Appendix B. Program administrative costs include all costs associated with program implementation except incentives, such as costs associated with program planning and administration, marketing and outreach, education and training, and quality assurance.

It is important to note that even for the aggressive renewable strategy, we used lower incentive levels for renewable energy technologies than we did for energy efficiency technologies—those levels were 50 to 90 percent of the incremental cost. In part, this approach reflects the fact that with renewable energy, the idea is to preserve the "option" value—e.g., laying the groundwork for a future in which renewable energy technologies have the opportunity to expand rapidly. Thus, the incentive strategy is different than for energy efficiency technologies that are cost-effective today. In addition, a more conservative incentive approach may also be appropriate to avoid what happened in the 1970s and early 1980s, where high incentives attracted a number of opportunists who delivered inferior installation services, doing damage to the nascent industry in the process.

Figures RE-7 and RE-8 present the cost of achievable renewable electric and thermal energy potential for 2012 in terms of expenses that would be incurred by Wisconsin's renewable energy programs.

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[17] These estimates do not include any costs that might be associated with a customer-sited, utility-owned approach discussed in Chapter RE-3. Standard ratemaking methods would be used to recover the cost of such an approach, and estimating the cost to Wisconsin ratepayers is outside the scope of this study.

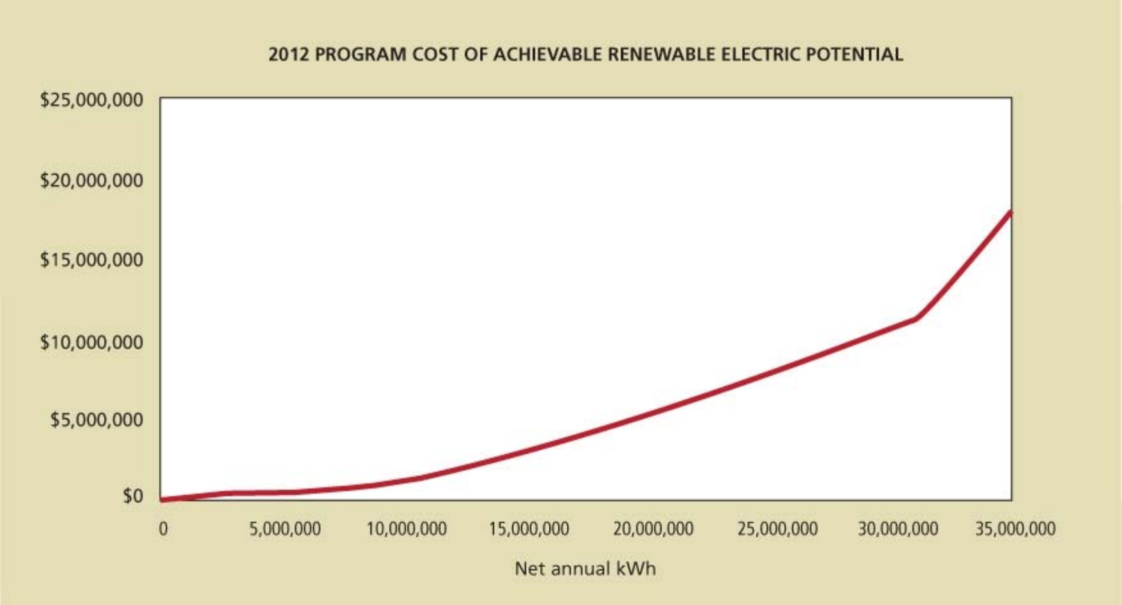

Figure RE-7: Program Cost of Achievable Renewable Electric Potential, 2012 – Aggressive Renewable Strategy

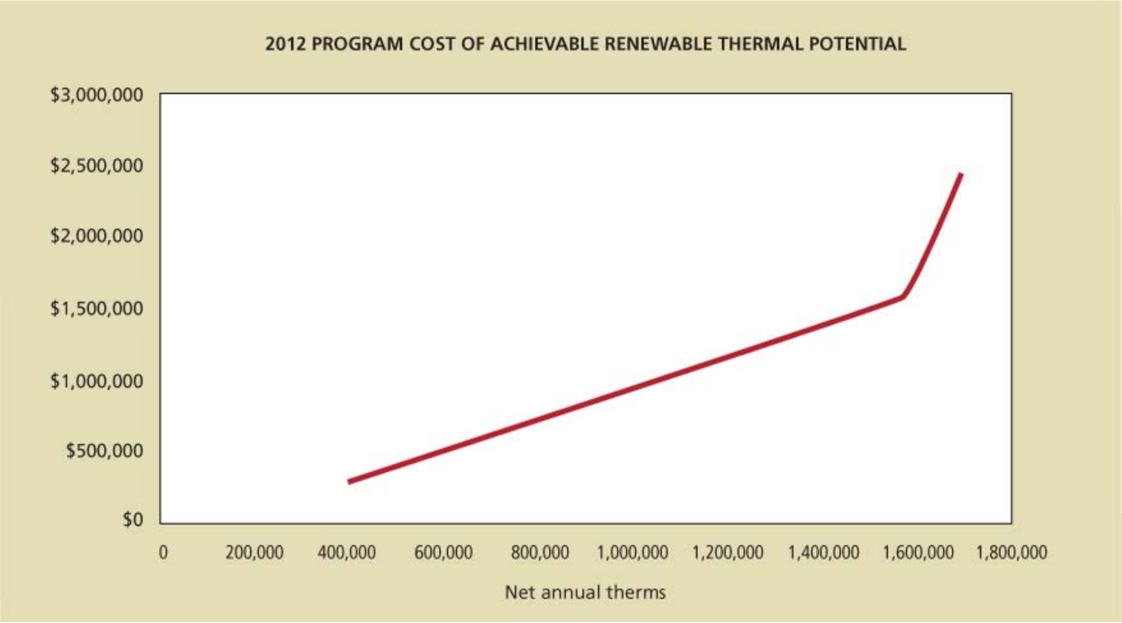

Figure RE-8: Program cost of Achievable Renewable Thermal Potential, 2012 – Aggressive Renewable Strategy

Using this information, an outer bound program cost estimate was developed based on the aggressive renewable energy strategy presented in Chapter RE-1. All program cost estimates are in 2008 dollars.

Year: 2012 (Aggressive Strategy)	
ELECTRICITY-GENERATING TECHNOLOGIES	$19,800,000
THERMAL ENERGY-GENERATING TECHNOLOGIES	$2,600,000
TOTAL	**$22,400,000**

We also estimated the program costs that would be incurred under the conservative renewable strategy, *i.e.*, the one in which we pursue only those resources that currently pass the TRC test. In that case, program budget estimates become $12.8 million.

Year: 2012 (Conservative Strategy)	
ELECTRICITY-GENERATING TECHNOLOGIES	$11,000,000
THERMAL-ENERGY-GENERATING TECHNOLOGIES	$1,800,000
GRAND TOTAL	**$12,800,000**

The appropriate funding level would be the one that captures available cost-effective renewable resources while retaining much of the flexibility to expand acquisition of other technologies that could become cost-effective in the future. This funding level is likely within the range offered by the two estimates presented above.

Figures RE-9 through RE-10 present estimated total resource costs of achieving 2012 renewable energy potential estimates. Total resource cost estimates include both program administrative costs and the cost of system installation to the consumer. Total resource costs are estimated at $36 million for the conservative renewable strategy and $76 million for the aggressive renewable strategy.

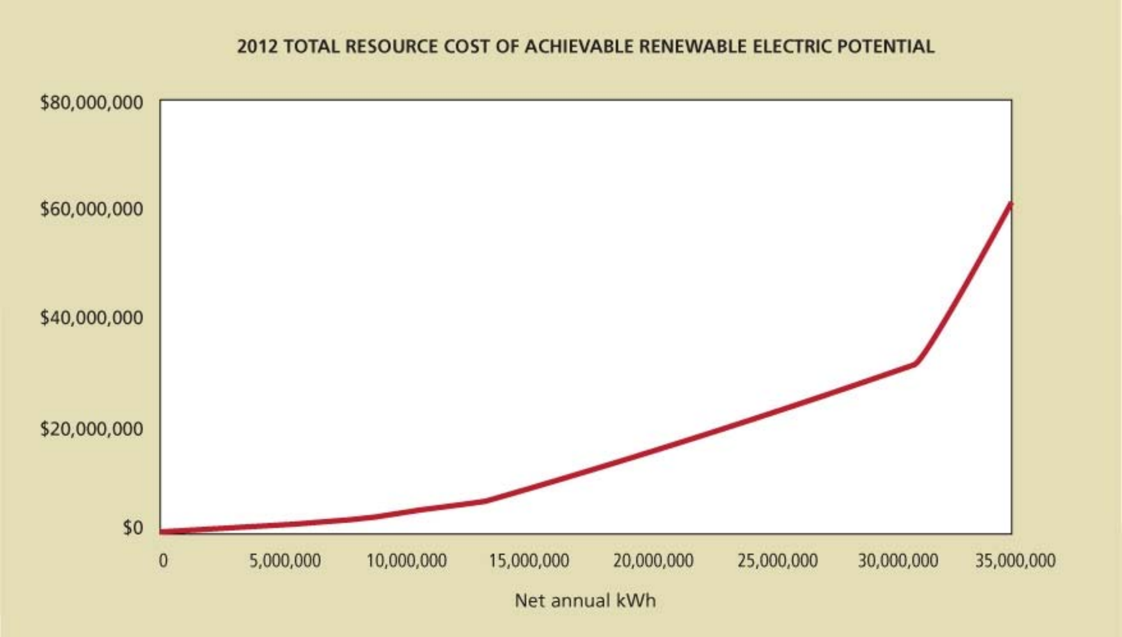

Figure RE-9: Total Resource Cost of Achievable Renewable Electric Potential, 2012

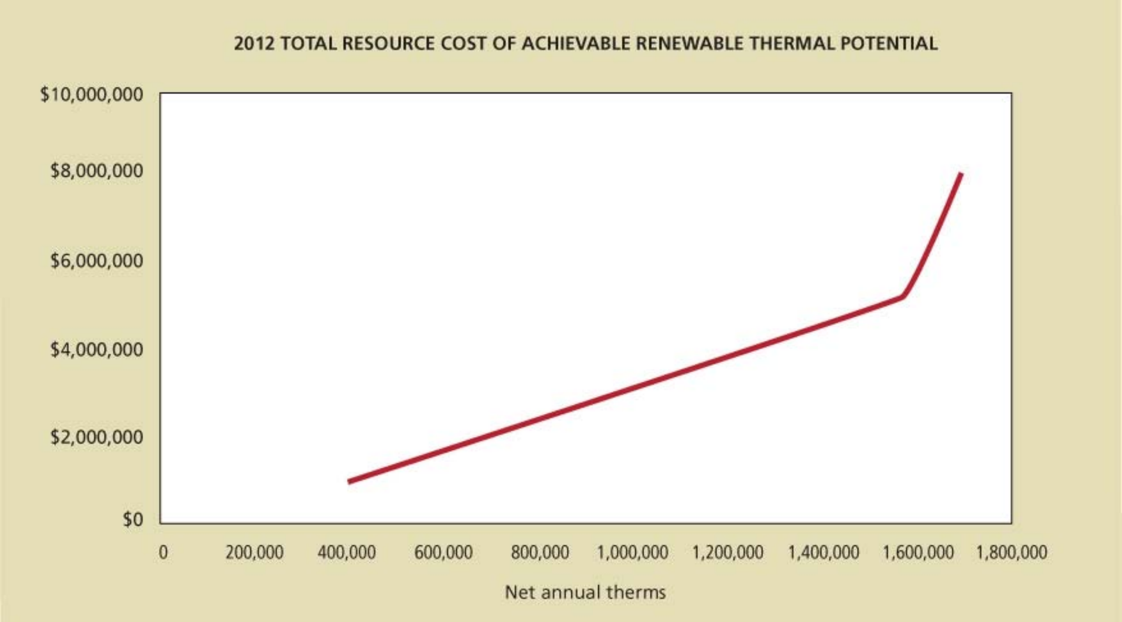

Figure RE-10: Total Resource Cost of Achievable Renewable Thermal Potential, 2012

ECONOMIC AND ENVIRONMENTAL BENEFITS

Figure RE-11 presents the net benefits associated with the technologies represented in the 2012 renewable resource potential estimates. The technologies with negative net benefits are those that do not pass the TRC screen. The conservative renewable strategy produces the largest aggregate net benefits—$21 million in 2012. Under the aggressive renewable strategy, aggregate net benefits are -$10 million.

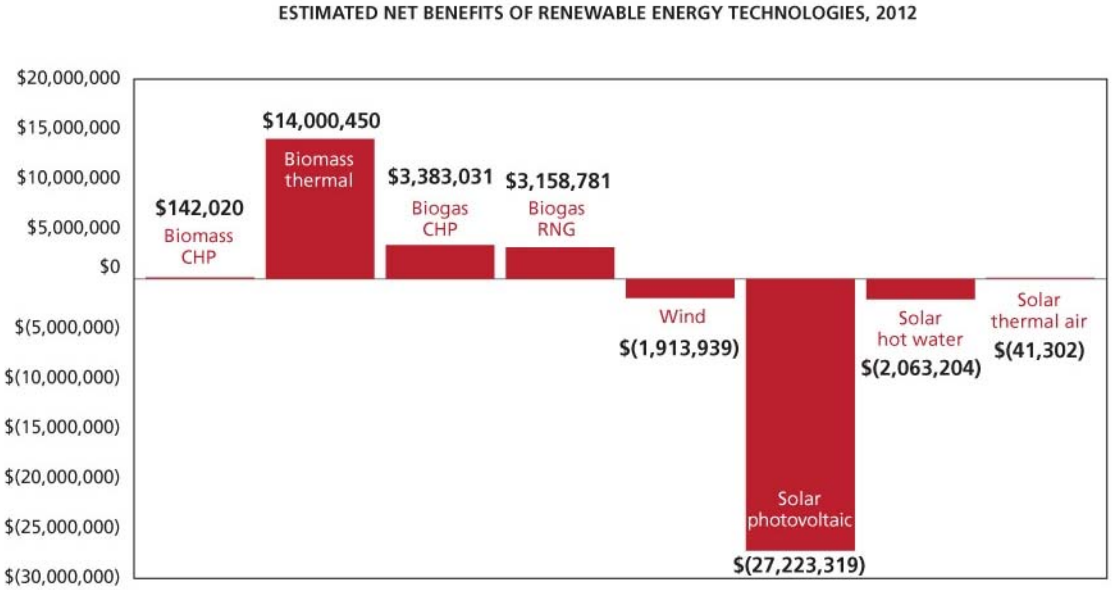

Figure RE-11: Net Benefits of Customer-Sited Renewable Energy Technologies, 2012

In the energy efficiency portion of this study, we estimated job-related impacts using factors developed by Focus on Energy evaluators, as well as national factors developed by the Center for American Progress.[18] To our knowledge, Focus on Energy has not developed similar factors for state investment in renewable energy resources. Applying the Focus on Energy factor for energy efficiency (jobs per Btu) to the renewable energy potential estimates results in an estimate of 350 Wisconsin jobs by 2012. The factor developed by the Center for American Progress produces a slightly lower estimate of 240 jobs. Figure RE-11 presents job creation estimates by technology.

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[18] PA Consulting Group, Inc. (October 2008). *Focus on Energy Evaluation: Semi-Annual Report (First Half of 2008)*. Prepared for the Public Service Commission of Wisconsin.
Department of Economics and Political Economy Research Institute, University of Massachusetts-Amherst (2008). *Green Recovery: A Program to Create Good Jobs and Start Building a Low-Carbon Economy*. Prepared under commission with the Center for American Progress.

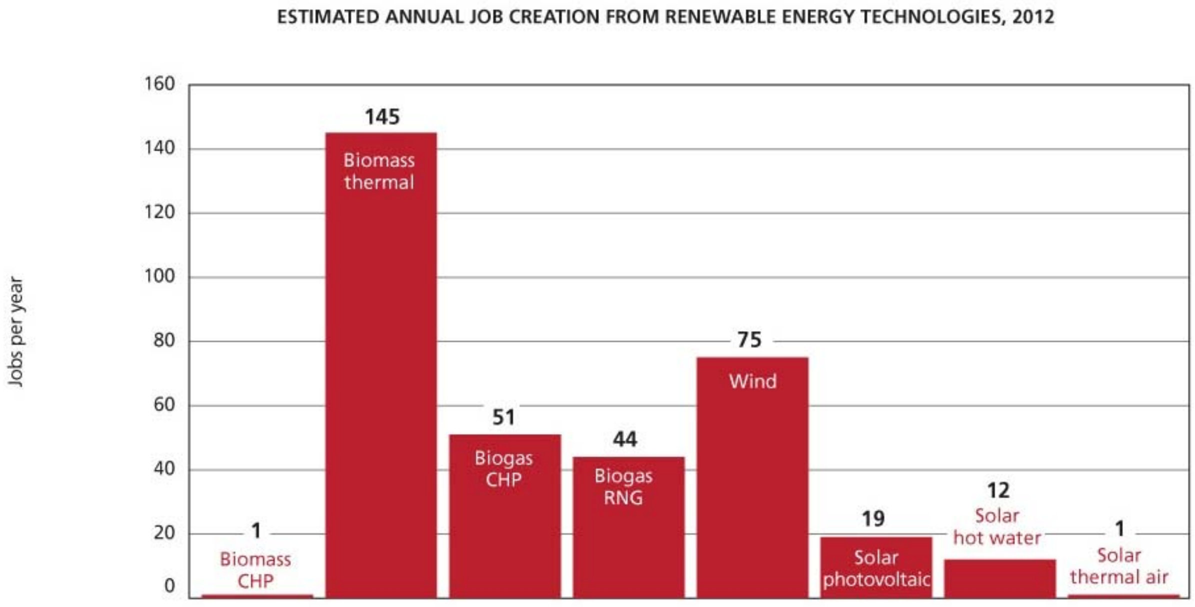

Figure RE-12: Estimated Job Creation Benefits by Technology, 2012

Lastly, Figure RE-13 presents estimated 2012 displacement of carbon emissions associated with utility-supplied energy. [19]

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[19] The CO_2 emissions factor for electricity is from: PA Consulting Group Inc. (2008). *Quantifying Environmental Benefits of Focus on Energy: Emission-Rate Estimates 2002 to 2006.* Prepared for the Public Service Commission of Wisconsin.
The CO_2 emissions factor for natural gas is from: PA Consulting Group, Inc. (2008). *Focus on Energy Evaluation: Semi-Annual Report (First Half of 2008)*. Prepared for the Public Service Commission of Wisconsin by the Focus on Energy evaluation team (PA Consulting, Glacier Consulting Group, KEMA, and Patrick Engineering, Inc.).

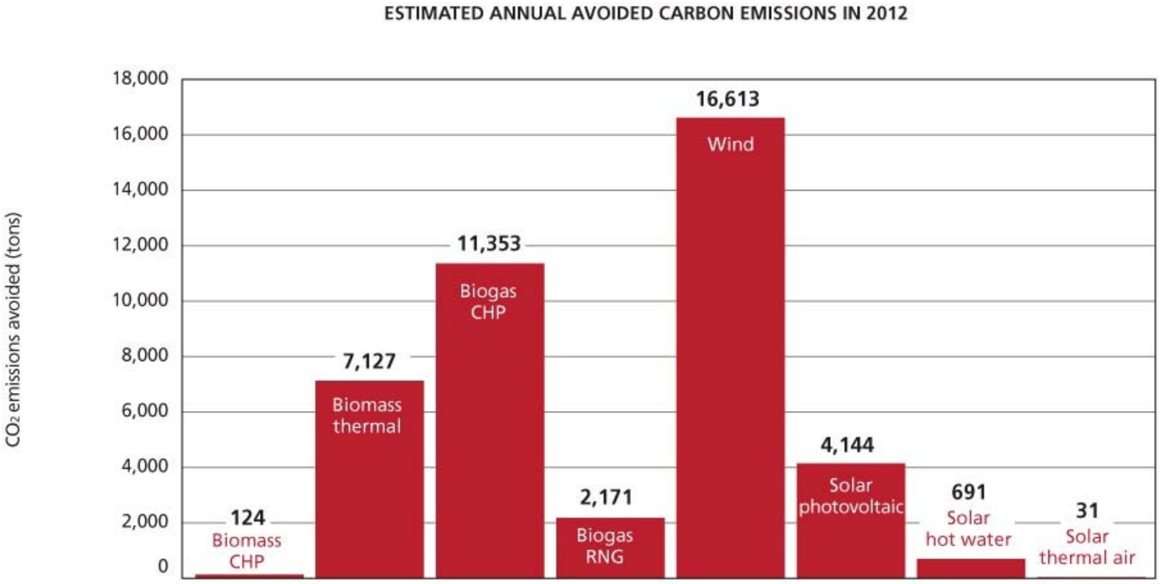

Figure RE-13: Estimated Avoided Carbon Emissions by Technology, 2012

CHAPTER RE-3: UTILITY-OWNED DISTRIBUTED RENEWABLE RESOURCES

The renewable energy potential estimates presented in Chapter RE-2 are based on the assumption that Wisconsin will continue to promote the acquisition of customer-sited renewable resources through a statewide renewable resource program. There is, however, an alternative model under consideration that could dramatically change the future outlook for distributed renewable energy technologies.

The PSCW has opened an investigation to consider the possibility of combining the concepts of customer siting and utility ownership of renewable energy technologies—specifically, solar PV. Under this approach, the utility locates viable sites where it could erect solar PV facilities within its service territory. Candidate sites could include customer-owned as well as utility-owned property. Prime examples include rooftops of large corporate facilities, although smaller sites, such as residential roofs, could also be included. The utility then rents the roof space from the building owner, which entitles the owner to a lease payment.

The only direct benefit customers receive is the lease payment. They receive no special rate for electricity service. Since they do not own the solar equipment, there is no buyback payment. The utility owns and maintains the system. The utility gets credit for all the power produced, which is applied toward its Renewable Portfolio Standard (RPS) requirement. The customer's role is simply to rent the space.

There are two primary advantages of this approach: (1) the cost of the facilities can be treated as conventional rate base assets in the utility ratemaking model; and (2) economies of scale can likely be achieved under such an approach, reducing per-system costs.

This model avoids financing challenges faced under the customer-ownership model. While consumers may experience capital access problems in today's economic climate, utilities, especially those in Wisconsin, do not have a significant problem in this regard.[20] In addition, this model does not require funding from Wisconsin's statewide renewable resource program. Systems would be financed as utility assets, and the costs associated with facilities could be recovered from ratepayers through standard ratemaking practices.

The second benefit is economies of scale. A utility initiative that installs 500 MW[21] of PV capacity can negotiate discounts that would not be available to one-off system installations.

If this approach is implemented as proposed, the resource potential is huge. Five hundred MW of installed PV capacity would generate more than 657 million kWh per year.[22] The maximum statewide renewable resource potential estimate under an aggressive program strategy for 2018 is 112 million annual kWh (see Chapter RE-2). Therefore, full deployment of the utility-owned model for solar PV represents about six times the potential we project under an aggressive approach to promoting customer-owned renewable energy systems.

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[20] Wisconsin Energy Corporation (December 8, 2008). "Wisconsin Electric Announces Agreement to Sell $250 Million Principal Amount of Debentures." Press Release.

[21] *Sierra Club's Initial Brief*, Wisconsin Public Service Commission Docket 6680-UR-116, October 9, 2008, p. 10. Sierra Club's experts suggest that the potential for Wisconsin Power & Light Company is 517 MW.

[22] Assumed capacity factor is 0.15 kWh/kW.

The PSCW has opened a docket to investigate the proposal,[23] and an in-depth assessment of this model is outside the scope of this study. Failure to at least mention this possibility, though, would be an oversight given the magnitude of the potential. If the PSCW concludes that this approach has merit, the utility-owned model has the potential to dwarf results that could be achieved under a customer ownership approach.

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[23] *Notice of Investigation*, Wisconsin Public Service Commission Docket 05-EI-147, January 16, 2009.

CHAPTER RE-4: INTEGRATING EFFICIENCY AND RENEWABLE ENERGY STRATEGIES

The development and promotion of energy efficiency technologies and renewable energy technologies have long traveled parallel but separate roads as options for creating a cleaner energy future. Recent emphasis on curbing carbon emissions has led to recognition that using less energy and using clean energy both contribute to the same goal. The practice of integrating both strategies in the same commercial building projects to potentially gain additional carbon emissions savings is well established in the US Green Building Council's LEED standards and other green building guidelines.

In the residential sector, a comparable example is the "zero energy home" concept where energy use is cut to a minimum with high performance building methods, and the reduced energy requirements are then met with renewable energy. The U.S. Department of Energy has been developing the zero energy home concept to include passive solar heating and cooling, energy-efficient construction, energy-efficient appliances and lighting, and solar water heating and photovoltaic systems, with grid connectivity to allow an exchange of power. The idea of making commercial and institutional buildings "net zero energy" as well is beginning to gain popularity, particularly among state and local governments.

While it is always more cost-effective to build energy efficiency and renewable energy into a new structure than to incorporate them into an existing one, integrating the two in a retrofit can save money as well. This is an excellent strategy for homeowners who are interested in installing solar PV or hot water panels. Reducing household electricity use by making relatively modest investments in energy efficiency can reduce the load to be handled by a PV system dramatically.

In an example scenario, Bob and Harriet's family uses about 12,000 kWh of electricity per year. They decide they are interested in installing PV panels that will generate all of their electricity. A well-sited PV array can produce about 1200 kWh every year from each kilowatt of panels installed, so Bob and Harriet will need to buy a 10-kW system to meet their needs. At a cost of about $8,500 per kilowatt for installation, their system would cost them approximately $85,000. However, let's say they took a close look at their appliances, their heating and cooling system, and their family's energy habits. They discover that by investing in an ENERGY STAR refrigerator ($1,100) and heating/cooling system ($3,000), and buying a gas water heater ($800), as well as installing compact fluorescent lights, a setback thermostat, and power strips for their electronics ($100), they can cut their electricity use by 30 percent. Additional attention to improving family energy habits yields another five percent. By investing $5,000 in energy efficiency they have reduced their electricity requirements by 35 percent to 7800 kWh per year. A 6.5 kilowatt solar PV system would now meet their needs, and it would cost $55,250.

Similarly, if Bob and Harriet are also interested in a solar water heater, they can cut their natural gas requirements by investing in water conserving fixtures and appliances. If less hot water is needed, less gas will be required. A solar water heater can reduce gas use even further by providing 40 to 50 percent of the load from the sun's heat. Reducing the amount of hot water required will either raise that percentage of savings, or reduce the initial water heater investment by reducing its size. Combining water conservation and solar water heating also works well in commercial and institutional settings. Low-flow showerheads, efficient washing machines and dishwashers can save both water and energy costs for hospitals, nursing homes, correctional facilities, health clubs, and the hospitality industry. And energy saving devices like heat recovery units can add to the natural gas savings as well.

Passive solar strategies such as south-facing windows combined with interior thermal mass to store solar heat and daylighting strategies that supply natural light are dependent on a highly efficient building shell to perform optimally. It is standard practice among renewable energy professionals to recommend maximizing energy efficiency improvements before renewable energy technologies are installed. This is true for both new construction and renovation of existing buildings, and for buildings of any type, from residential to institutional, commercial and industrial structures.

This example illustrates the benefits of pursing a complementary approach to energy efficiency and renewable energy development. Consumers can reap greater benefits from renewable energy installations if they have maximized energy efficiency potential. Program strategies that deliver energy efficiency and renewable energy solutions offer more value to Wisconsin consumers and businesses than could be achieved under a single resource approach.

Similarly, in a potential future that includes water efficiency initiatives, incorporating all efficiency and renewable resource strategies into a single integrated program strategy is ideal for consumers and businesses. Consumers should not have to understand the bureaucracy of program management; they simply need a “resource case worker” to help them create a plan of action.

CHAPTER RE-5: POLICIES SUPPORTING AGGRESSIVE ADVANCEMENT OF DISTRIBUTED RENEWABLE ENERGY TECHNOLOGIES

Policymakers interested in supporting significant expansion of Wisconsin's distributed renewable energy resource base may consider the opportunities listed below.

- **Increased program support for renewable energy technologies**

Incentives

There are several ways that increasing funding for renewable energy programs would move Wisconsin closer to its clean energy goals. Expanding existing incentive programs would give more people the opportunity to install renewable energy systems on their own property. The first-hand experience of owning a system will be shared with friends, family and community, invoking what marketing professionals agree is the most potent form of advertising: word of mouth. While the incremental addition of customer-sited kilowatts or therms to Wisconsin's renewable energy supply may not be as great as utility-scale installations can achieve, the resulting expansion of public awareness of renewable energy's viability and reliability through personal experience will be invaluable to further development and acceptance of utility-scale projects.

Education

Education to raise consumer awareness is an important component of the current Focus on Energy program, and program support for renewable energy development can also be increased through a broad range of educational initiatives.

Within the structure of the current Focus on Energy program, development of educational materials and training for professionals has not been fully explored. With increasing demand for skilled equipment installers and operators, a promising avenue involves directing program funding toward supporting and expanding the professional development programs emerging from the technical college and university systems in Wisconsin. Program support could include assistance with curriculum development and coordination with existing expertise and resources. Expansion of technical training opportunities could be directed toward recent high school graduates seeking a career as well as working plumbing, electrical or HVAC professionals wishing to broaden their skills. Program funding could also support development of academic certificate and degree programs in community energy planning and program design to provide a pool of candidates to head up municipal energy independence efforts.

Development of courses about renewable energy resources for established academic majors such as urban planning, engineering and architecture are also needed. There is also the need for more education and training for established professionals in these fields. Program resources could assist in coordinating these education efforts and helping to make them universally available to these professionals and to municipal officials and staff involved in community energy planning.

Research

There is still too little known about certain aspects of Wisconsin's renewable energy resources. Researchers are beginning to address such areas as life cycle costing and environmental impacts of biomass crops or waste, and some studies have been undertaken to understand the environmental impacts of wind farms. However, significant gaps in knowledge remain in the following areas: (1) level, availability, and technical potential of resources; (2) effectiveness of technology applications in Wisconsin; and (3) magnitude and characteristics of non-technical and behavioral barriers. Program funding directed toward economic, environmental and behavioral impacts and uses of renewable energy in the state would promote the design of more effective programs and policy for meeting Wisconsin's energy goals.

- **Develop consistent advanced renewable energy tariffs**

  The most important tool we have for encouraging the growth of renewable energy industries in Wisconsin is the regulation of buy-back rates for clean energy. The establishment of consistent and realistic tariffs for both customer-sited and utility-scale installations is vital to success.

  As a developing industry, the renewable energy sector needs a diversity of approaches in order to stimulate jobs and value for the state. Customer-sited renewable energy systems contribute their own value to the emerging industry, providing opportunities for demonstration and raising general public awareness of clean energy alternatives. They are also important in the growth of net-zero-energy homes and buildings, and contribute to energy security as manifested through a distributed generation system. Utility-scale installations will carry renewable energy industries into prime time, harnessing the state's renewable resources to generate grid power. To recognize the value of these two differing roles we will need to develop an advanced, two-tiered tariff system that encourages both sectors to flourish.

  Such a system might use the current cut-off definition for distributed generation which is 15 MW or less. Operators in this range have great difficulty existing under present tariffs based on the avoided costs of producing coal-fired power. An advanced tariff structure for small operators in Wisconsin might be based on the European tariff concept which uses the break-even cost for each separate technology to determine the rate, with the potential to include a profit margin as well. If structured after existing European models, this tariff structure would not be open-ended, and overall subscription caps would be imposed. With this system it would be necessary for regulators to stay current with technology costs and periodically adjust premium costs based on shifting break-even points. For utility-scale installations, the present tariff structure would serve the renewable energy industry better if a more consistent statewide approach were taken.

- **Address remaining interconnection barriers to distributed generation**

  PSC 119, Rules for Interconnecting Distributed Generation Facilities (adopted in 2004), went a long way toward establishing a consistent procedure for interconnecting a small renewable energy generator to the state grid. This rule has made it less frustrating for owners and installers of systems, and given utilities a set of statewide guidelines to incorporate into their process. Five years have elapsed since its adoption, and the rule could be revisited to determine what interconnection barriers remain. Discussion has also begun on the issue of interconnecting to the natural gas pipeline to inject biogas. This is another important policy to pursue because farms too small to generate electricity from their biogas could still sell it to the pipeline.

Incorporating distributed generation planning into the transmission and distribution discussion is another important issue for policy makers. This approach might include consideration of "smart grid technologies" that would help incorporate renewable energy generation systems, and the use of micro-grid planning of distributed generation to increase energy security.

- **Address local land use and community planning barriers**

  Local governments have a lot to say about renewable energy development and installation within their communities. Wind turbine ordinances, system permitting processes and fees or land use planning requirements all contribute to the likelihood that renewable energy installations will happen in a given community. Now that communities all over Wisconsin are setting goals to reduce carbon emissions or to be energy independent, these common political barriers to renewable energy development should be addressed. Statewide programs that encourage community energy planning can assist by opening this conversation across the state, finding best practices, and helping communities share their experiences with others.

- **Encourage economic development through renewable energy**

  Wisconsin's economy could greatly benefit from expansion of renewable energy industries in the state. This would be true both for harnessing renewable resources at the local level and for creating a renewable energy industrial base that would serve regional and national markets. This study recommends economic development efforts that foster renewable energy equipment manufacturing and resource processing capacity, and increase availability of skilled labor in Wisconsin through partnership with the state's technical college system.

- **Develop new protocols for defining value**

  As previously noted, the traditional, TRC-based approach for assessing cost-effectiveness has significant shortcomings when it comes to evaluating investments in renewable energy. These shortcomings mean that the value of renewable energy investments is likely understated. We recommend new approaches for quantifying the non-energy benefits associated with pollution prevention and economic development, as well as efforts to quantify the option value of renewable energy technologies, which could include an investigation of real options models.

- **Investigate the possibility of using the customer-sited, utility-owned model**

  Though in-depth analysis of this model is outside the scope of this study, and it is not yet possible to draw firm conclusions as to the viability of this model in Wisconsin, analysis by other parties suggests that the potential for renewable resource acquisition under this model is significant. The PSCW is currently investigating this concept.

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REFERENCES

Department of Economics and Political Economy Research Institute, University of Massachusetts-Amherst (2008). *Green Recovery: A Program to Create Good Jobs and Start Building a Low-Carbon Economy*. Prepared under commission with the Center for American Progress.

Interstate Power & Light Company (2008). *2009-2013 Energy Efficiency Plan*. Docket No. EEP-08-1.

MidAmerican Energy Company (2008). *2009-2013 Energy Efficiency Plan*. Docket No. EEP-08-2.

Osborne (2008). PV-Tech.org. "Massive 168% Photovoltaic Module Overcapacity to Cause Pricing Collapse in 2009." Internet source. Available at: http://www.pv-tech.org/news/_a/massive_168_photovoltaic_module_overcapacity_to_cause_pricing_collapse_in_2/.

PA Consulting Group, Inc. (2008). Focus on Energy Evaluation: *Semi-Annual Report (First Half of 2008)*. Prepared for the Public Service Commission of Wisconsin by the Focus on Energy evaluation team (PA Consulting, Glacier Consulting Group, KEMA, and Patrick Engineering, Inc.).

PA Consulting Group Inc. (2008). *Quantifying Environmental Benefits of Focus on Energy: Emission-Rate Estimates 2002 to 2006.* Prepared for the Public Service Commission of Wisconsin.

Sierra Club (October 9, 2008). *Sierra Club's Initial Brief.* Wisconsin Public Service Commission Docket 6680-UR-116 p. 10.

"Solar Module Retail Price Index, 125 Watts and Higher." Internet source. Available at: http://www.solarbuzz.com/.

J. St. John (December 31, 2008). "SolarWorld's Asbeck: Panel Prices to Drop 10% in 2009." Internet source, available at: http://seekingalpha.com/article/112741-solarworld-s-asbeck-panel-prices-to-drop-10-in-2009.

Synapse Energy Economics, Inc. (2008). *Synapse 2008* CO_2 *Price Forecasts*.

Wisconsin Energy Corporation (December 8, 2008). "Wisconsin Electric Announces Agreement to Sell $250 Million Principal Amount of Debentures." Press Release.