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

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

Volume II: Technical Appendix

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

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MARKET 1 — HIGH-PERFORMANCE NEW BUILDING DESIGN AND CONSTRUCTION

Market Scope

This market comprises high performance building design for commercial and industrial new construction, excluding industrial processes and equipment. The market model assumes projects will follow a high performance, whole-building design approach but install measures that are commercially available and designs that are widely adoptable. Although individual buildings can be built as much as 50 percent more efficient than current energy codes (Edelson & Johnson, 2003), our midpoint estimate assumes widely applicable strategies that result in buildings that are approximately 10 percent (natural gas) and 20 percent (electricity) more efficient than ANSI/ASHRAE/IESNA Standard 90.1-1999 (ASHRAE 90.1-1999), which serves as our baseline for current construction practices.

Market Characteristics

As provided in Comm Chapter 63 of the Wisconsin Administrative Code, the building code that dictates energy efficiency standards for nonresidential buildings in the state is the International Energy Conservation Code – 2000 (IECC 2000). The IECC 2000 code, with some state-specific modifications, was adopted by the state on July 1, 2002. The IECC 2000 and Wisconsin energy code rely substantially upon ASHRAE 90.1 – version 1989, although there are important differences for interior lighting power allowances. Our review of recent surveys indicates current building practices in Wisconsin roughly approximate ASHRAE 90.1-1999 standards (Energy Center of Wisconsin, 2005 and KEMA, 2005). Wisconsin plans no major code upgrade until 2007 or 2008. At that time the state may adopt the IECC edition 2006, which is still under development. The state has engaged a code development and review process for this major upgrade.

Energy codes are referred to as the least efficient building that can legally be built. State, national, and private efforts have demonstrated that substantial energy savings are possible from buildings constructed to be more efficient than code, as described by the National Energy Efficiency Best Practices Study (Quantum, 2004). For example a prototype office in Wisconsin saves $0.38 per square foot per year on energy costs from a whole building design approach at an added construction cost of $1.06 per square foot (Edelson & Johnson, 2003), exceeding code by about 30 percent.

In spite of the opportunities, many barriers and misconceptions regarding high performance new buildings limit widespread adoption of cost-effective energy savings. These include:

Barriers:

- Owners, developers, and some designers perceive that standard code practice is already energy efficient
- Extra costs up front make a high performance building unattractive
- Some design teams don't have the experience for a high performance project
- Many designers are unable to articulate the financial and non-energy benefits of energy efficiency
- Many design teams need to provide more information regarding building performance goals and strategies to achieve these goals
- Many designers believe that owners are unwilling to increase first costs

- Many owners and developers lack an understanding as to how to retain a design or construction firm with proper experience and background in designing high performance buildings
- High percentage of rented space with tenants who do not own the building but do pay the energy bill (split incentives)

Misconceptions:

- Energy enhancements do not make as much sense today as in years past
- Energy costs pass through to a tenant, so there is no business case for a developer to invest in high performance
- It is too difficult to predict the owner's share of energy savings if the building is an income-producing property
- Any energy efficiency enhancements in the design must pay for themselves in energy savings within two years to be worthwhile
- It is much riskier to design or build a high performance building
- High performance is not feasible on smaller projects
- Energy efficiency is LEED – and LEED costs too much

Numerous new construction research efforts document that many messages that encourage designers and owners to participate in energy efficiency programs are often not related to energy savings. Results show that cost savings and increased efficiency are important – but not necessarily the most important benefit – to potential program participants. Non-energy benefits – benefits not directly associated with energy bill savings – were more often key determinants to program participation or identification that participants received value from participating in the program (Hall, 2004). Market research shows that the following non-energy benefits are important:

- Decreased operating costs
- Increased net operating income
- Increased property value
- Reduced maintenance and risk
- A better work environment
- Increased tenant appeal
- Reduced environmental impacts
- Greater community appeal

Following are impressions and conclusions drawn from market actors serving Wisconsin regarding new construction program interventions (KEMA, 2005):

- Actively support providing financial incentives
- Recommend providing design grants
- Program needs to be very flexible to accommodate the needs of the design team – every project is different
- Early involvement in the design phase is crucial
- Building types most likely to be built to green or sustainable design standards include owner-occupied, public sector, companies with strong public image and public access, experienced owners, and companies with highly paid employees

A key element for success in any program intervention is securing the involvement of the professional design community early in the design process of construction projects. Programs employ targeted marketing, training and education, lunch and learn presentations, individual contact, and outreach through professional organizations to engage design professionals early (Quantum, 2004). An important focus of efforts will be moving the knowledge gained by designers and architects through program participation into their standard construction practices.

Program Approaches

Our analysis of this market considered these program components:

- Provide education and outreach on high performance building concepts to architects, engineers, construction contractors, developers, and owners.
- Offer financial incentives for design teams to include building measures that are more efficient than standard practice, and facilitate an integrated design process to improve the way buildings get designed and built with respect to energy and non-energy benefits.
- Support construction oversight, equipment acceptance testing, and commissioning to ensure buildings operate as intended

We modeled the program intervention to capture energy efficiency and peak load reduction opportunities through a comprehensive effort to influence building design and construction practices for non-residential new construction. The program would work with prospective building owners and developers, design professionals, and construction contractors to deliver high performance buildings that provide improved energy efficiency, systems performance, and comfort.

A secondary objective that realizes beneficial impacts that extend beyond the life and scope of the program can be achieved through market preparation activities. Market preparation entails working within natural, existing supply channels for design and construction services to permanently reduce barriers to creating high performance buildings by enhancing awareness, technical knowledge, and delivery capabilities in the market. If effective, a program would produce lasting market transformation effects including energy savings that result from a permanent change in design practices and greater availability of efficient equipment, as well as potentially more stringent energy codes.

Education, information, and outreach activities would be directed to key groups following a targeted marketing plan. Project assistance, design incentives, and measure incentives would be offered in varying degrees on individual projects to balance the program resources applied with the potential for saving energy. To minimize free-ridership, design team and measure incentive levels would cover between 50 percent and 100 percent of incremental cost. Incentives are set relative to a baseline for cost and energy performance that reflects current practice in Wisconsin.

PROGRAM AREA 1.01 — INCENTIVES AND EDUCATION FOR HIGH PERFORMANCE NEW CONSTRUCTION

Our analysis of the achievable potential for this program area is projected based on offering a whole-building incentive for high performance buildings whose overall energy consumption is lower than it would have been had the building been constructed to meet current practice. Energy efficiency incentives are coupled with education, information, and outreach activities directed to key groups.

TABLE 1.01.1. ESTIMATED VALUES FOR PROGRAM AREA 1.01, INCENTIVES AND EDUCATION FOR HIGH-PERFORMANCE NEW CONSTRUCTION

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$1,572 to $2,736	$2,079 to $3,108
	Incremental Impacts	peak kW	1,550 to 3,064	1,610 to 2,761
		annual kWh (000s)	7,833 to 15,636	8,135 to 13,967
		annual therms (000s)	132 to 562	586 to 1,067
	Levelized resource cost	per peak kW	$41 to $74	$52 to $93
		per kWh	0.8¢ to 1.4¢	1.1¢ to 1.8¢
		per therm	15.1¢ to 59.9¢	9.4¢ to 17.3¢
Scaling factors[a]		program costs	1.2 to 2.4	1.2 to 2.4
		impacts	1.1 to 1.5	1.1 to 1.5

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Program Area 1.01 — Incentives and Education for High-Performance New Construction

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 1.01.2. MODEL INPUTS FOR INCENTIVES AND EDUCATION FOR HIGH PERFORMANCE NEW CONSTRUCTION

Model Inputs (01.01)			Value	±
1		**Impacts**		
	a	2005 market size (GWh)	326	33
	b	2005 market size (peak MW)	64	6
	c	2005 market size (10^12 Btu)	1.8	0.2
	d	Annual electric market growth rate (2006-2015)	2.8%	0.2%
	e	Annual gas market growth rate (2006-2015)	1.9%	0.2%
	Efficiency improvement relative to forecast baseline with intervention under current code			
	f	Electric energy % savings (current code)	21.5%	1.5%
	g	Electric peak demand % savings (current code)	21.5%	1.5%
	h	Natural gas energy % savings (current code)	10.0%	7.0%
	Efficiency improvement relative to forecast baseline with intervention under new code			
	i	Year that new code affects load	2010	1
	j	Electric energy % savings (new code)	8.5%	2.5%
	k	Electric peak demand % savings (new code)	8.5%	2.5%
	l	Natural gas energy % savings (new code)	20.0%	2.5%
2		**Program Participation**		
	Intervention for old code			
	a	Participation in Year 1 under old code	10%	5%
	b	Ultimate annual participation rate	40%	10%
	c	Years to reach ultimate participation	6	1
	d	Net-to-gross ratio	0.81	0.12
	Intervention for new code			
	e	Participation in Year 1 under new code	25%	5%
	f	Ultimate annual participation rate	40%	10%
	g	Years to reach ultimate participation	3	1
	h	Net-to-gross ratio	0.81	0.12
3		**Program costs**		
	a	Administration start up cost premium (total over years 1 - 3)	$180,000	$30,000

	b	Base administrative costs (% of all intervention costs)	4%	1%
		Intervention for old code		
	c	Additional costs above variable costs for intervention (annual)	$70,000	$20,000
	d	Market management and field staff (% of variable costs)	15%	5%
	e	Incentive costs per annual kWh saved	$0.07	$0.01
	f	Incentive costs per peak kW reduced	$125	$25
	g	Incentive costs per annual therm reduced	$0.80	$0.10
		Intervention for new code		
	h	Additional costs above variable costs for intervention (annual)	$70,000	$20,000
	i	Market management and field staff (% of variable costs)	15%	5%
	j	Incentive costs per annual kWh saved	$0.07	$0.01
	k	Incentive costs per peak kW reduced	$125	$25
	l	Incentive costs per annual therm reduced	$0.80	$0.10
4		**Measure life (years)**	18	2
5		**Proportion of program costs allocated to electric impacts**	59%	5%

1. Per Unit Impacts

We estimated the size of the new construction market in Wisconsin over the 10 year study horizon by first estimating new construction activity for 2005, and then applying projected growth rates for the commercial and industrial sectors. We assumed that the growth rate of energy usage in new construction was equal to the corresponding growth rate of statewide total commercial and industrial energy sales. Only lighting and HVAC projected sales (EIA, 2005) were used in the industrial sector because industrial processes would typically not be part of the scope of high performance building design.

We estimated the size of the statewide new construction market in 2005 by scaling up an estimate made for the We Energies service territory (Energy Center of Wisconsin, 2005). As described in that study, data in We Energies' billing system for nonresidential accounts marked as new premises with service-on dates from mid-1999 to mid-2004 were surveyed to verify new premise status. The electric energy usage for new construction in 2005 was estimated to equal the average of annual energy usage by accounts deemed to have been new construction over the previous 5 years. For We Energies, new construction was estimated to add 130.5 GWh in 2005. We scaled this value by a factor of 2.5 to estimate statewide new construction activity. We calculated the peak load growth using the same ratio of peak load to energy that is provided in the statewide electricity forecast (PSC, 2004).

We estimated annual industrial electric lighting and HVAC growth to be 1.8 percent, and annual commercial electric growth to be 2.9 percent based on data from the Public Service Commission of Wisconsin (PSC, 2004 and Kliebenstein, 2005). The energy sales weighted combined growth rate is 2.8 percent. We estimated annual industrial HVAC natural gas growth to be 0.6 percent and commercial natural gas growth to be 2 percent, based on data obtained from Wisconsin Department of Administration (DOA, 2004). The combined growth rate for gas is 1.9 percent.

The We Energies study did not estimate the natural gas market size for new construction in 2005. Our estimate of industrial HVAC natural gas end-use consumption and annual growth rate of 0.6 percent implies about 0.05 x 10^{12} Btu usage added each year statewide. An annual commercial natural gas growth of 2 percent implies 1.7 x 10^{12} Btu added, for a combined total of 1.8 x 10^{12} Btu of natural gas load added in this market.

Although individual buildings can be built as much as 50 percent more efficient than current energy codes (Edelson & Johnson, 2003), our midpoint estimate assumes widely applicable strategies. From 2006 through 2010, we assume standard practice is equivalent to ASHRAE 90.1-1999 standards, and that energy savings for efficient design equates to ASHRAE standard 90.1-2004. We derived our savings estimates from work by Edelson and Johnson (2003) that used building prototype simulations to model this efficiency improvement in Wisconsin's climate zone. Applying the prototype results to our commercial building type breakdowns, average savings are approximately 10 percent for natural gas and 21.5 percent for electricity.

Wisconsin's Energy Code is expected to become more stringent in about 2008 (Energy Center of Wisconsin, 2005). Allowing for a delay between code adoption and impact on completed buildings, we assume that by 2010 standard practice will equal an upgraded code that is set at ASHRAE standard 90.1-2004. Currently, the U.S. Green Building Council defines silver certification in their LEED rating system as exceeding ASHRAE standard 90.1-1999 by 30 percent (USGBC, 2004). We have assumed that participating buildings occupied beginning in 2010 are designed and constructed so that overall energy consumption is at least 30 percent lower than it would have been had the building been constructed to meet ASHRAE 90.1-1999 standards. To achieve this savings relative to the upgraded code, incremental energy savings are 20 percent for natural gas and 8.5 percent for electricity. The 2004 version of the ASHRAE standard incorporates a substantial lowering of lighting power density limits, reducing opportunities for electric savings through lighting energy efficiency improvements.

2. Program Participation

We have modeled the interventions to achieve program participation for new construction beginning at 10 percent in year one, approximately double the activity projected by We Energies for their 2005 new construction pilot program (Energy Center of Wisconsin, 2005). Peak participation was estimated to ramp up such that it would reach 40 percent (+/- 10 percent) by Year 6 (+/- one year).

The basis for this participation level includes an estimate of 50 percent participation from National Grid for their Design 2000 program (York and Kushler, 2003). California has estimated that Savings by Design has reached 39.7 percent of new non-residential construction on a square foot basis (Quantum, 2005). By number of projects, California has reached only 13 percent (Quantum, 2005). This indicates that larger buildings are a disproportionate share of program activity, allowing penetration levels to reach high levels on a resource acquisition basis. At the beginning of year 5, buildings constructed to meet the new code begin occupancy. Participation continues at the original ramp up rate (25 percent for that year) and peaks at 40 percent within 3 years.

The net to gross ratio is assumed to be 0.81 (+/- 0.12), based on evaluations performed in California (.65), NSTAR (0.67), National Grid (0.81), and Northeast Utilities (0.93) (Quantum, 2004).

3. Program Costs

Program costs reflect approximations we made following review of costs for mature programs with similar approaches and participation levels (Quantum, 2004). Incentive costs are 81 percent of total program costs, while non-incentive costs are 19 percent. Start up costs of $180,000 over three years ($60,000 per year) are allocated to achieve a statewide effort, filling gaps in areas such as market research, information and outreach, demonstration projects, tools, and case studies. A general administrative cost of 4 percent of all intervention costs provides funding for management of the overall market effort, program specific tracking and reporting, planning meetings, and other expenses.

Costs for each intervention in the market are broken into three categories:

- Incentives for owners, developers, designers, suppliers, and other program allies;
- A market manager to handle day-to-day responsibilities and field staff to work with participants on specific projects; and
- Annual fixed costs for activities such as training, product and service development (tools, manuals, guides, software, etc.).

Incentives are paid for electric energy and demand savings. The overall incentive pool may be provided as participant rebates, designer incentives, technical assistance, or other project specific costs to influence participation. The incentive costs for this intervention were intended to cover approximately 50 percent to 100 percent of incremental measure costs, following the approach taken for We Energies (Energy Center of Wisconsin, 2005).

4. Measure Life

A measure life of 18 years (+/- 2 years) was used for new construction (Quantum, 2004).

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MARKET 2 — NEW AND REPLACEMENT COMMERCIAL UNITARY HVAC UNITS AND SYSTEM IMPROVEMENTS

Market Scope

This market comprises installation of unitary HVAC equipment, both as replacements for existing units and units installed in new buildings as well as system improvements such as proper sizing, tune ups, and premium (enthalpy based) economizers. This market addresses cooling energy savings only, not heating or ventilation.

Market Characteristics

Over 73 percent of commercial floor space in Wisconsin is cooled using unitary systems (EIA, 1999). According to a report completed by KEMA, Inc. (2005), as many as 10,229 units are sold each year in Wisconsin, accounting for 108,000 tons of cooling capacity. This equates to an average size of just over 10 tons per unit.

A study from Navigant Consulting (2004) found that most commercial rooftop units sold in 2004 had efficiencies of 10.1 EER or better, with the best available being 13.5 EER. According to that same study, the installed base of rooftop units have efficiencies of 8.9 EER or worse. Efficiencies have improved dramatically over the past 20 years. In addition, loss of efficiency due to equipment degradation over time results in older installed equipment being significantly less efficient than even the standard efficiency new units (Energy Market Innovations, 2004).

System improvements at the time of replacement or for their own sake can also significantly affect the efficiency of the system. Simply sizing equipment properly and tuning up existing units regularly can help reduce system consumption. Premium economizers that are based on outdoor air humidity as well as dry bulb temperature can also have a significant impact versus standard dry bulb economizers.

High efficiency rooftop units have been eligible for Focus on Energy custom rewards at the rates shown in Table 2.01.1 below. It is not known how this and direct utility programs have impacted sales of high efficiency units but, according to the KEMA study, 56 percent - 65 percent of installed packaged air conditioning units meet Consortium for Energy Efficiency Tier 1 efficiency levels (CEE, 2004).

TABLE 2.01.1. FOCUS ON ENERGY INCENTIVE LEVELS FOR ROOFTOP UNITS

Tier	< 65,000 Btu/h	Incentive	65,000 – 135,000 Btu/h	Incentive	135,000 – 240,000 Btu/h	Incentive
Tier 1	SEER ≥ 12.0	$25/unit	EER ≥ 10.3	$50/unit	EER ≥ 9.7	$100/unit
Tier 2	SEER ≥ 13.0	$100/unit	EER ≥ 11.0	$200/unit	EER ≥ 10.8	$400/unit

A recent study of the non-residential HVAC market in Wisconsin helped identify areas and aspects of the supply chain that are leverage points for current or refined program activities (Quantum, 2003). Recommendations and insights from that research that are most relevant to this market include:

- For planned replacements, supply-side intervention efforts should focus on contractors. Contractors are most likely to identify these projects in their earlier stages and have the greatest influence. Emergency replacement efforts should be directed toward distributors and contractors, as available stocking often drives equipment choice.
- Tools and services that help contractors and, to a lesser extent, distributors sell high efficiency equipment may be needed (for example, simple tools to accurately estimate paybacks and financial returns), particularly in emergency and some planned replacement situations.
- Identifying and addressing supplier concerns about the reliability of specific types of efficient products and services is critical, particularly in cases where perceptions may be based on unrepresentative anecdotal experiences or information.
- Case studies and demonstration projects can be particularly useful and effective education tools for high efficiency products and services that are relatively new or may be recovering from a previously poor track record.
- Working with manufacturers to promote and disseminate energy efficiency information and leveraging training activities may be an effective way to influence the large population of smaller contractors.
- Where appropriate, program efforts should support linkages between efficient products and services and distinguishing business characteristics of greatest import to suppliers (e.g., quality of work, reputation of firm, product reliability, etc.).
- Supply-side actors consistently perceive first-cost orientation to be the greatest end user obstacle to increased adoption of energy efficient HVAC systems in Wisconsin's C/I sector. Lack of knowledge, lack of capital, reliability, and bidding and design process structures were also mentioned as significant barriers. The cost barrier is especially significant in competitive bid situations that involve multiple supply-side actors.
- Suppliers believe that the keys to reducing end user barriers to adoption of efficient C/I HVAC systems are to improve and extend communication of payback and return-on-investment information to owners on a job-specific basis, generally improve end users understanding of the financial benefits of efficiency investments, buy-down initial costs with incentives, and achieve upstream price reductions by manufacturers. A few suppliers mentioned providing financing and case studies and demonstration projects.

The U.S. Congress (2005) passed a law mandating minimum energy efficiency levels for a variety of commercial package air conditioning and heating equipment manufactured after January 1, 2010. The Federal standards described in the Energy Policy Act of 2005 (U.S. Congress, 2005) mandate minimum efficiency levels essentially equal to CEE Tier 2. The impacts of these equipment standards are reflected in the input values.

Program Approaches

Our analysis of this market considered a program effort with two components:

- Increase the market share for higher efficiency units in years 1 through 5,

- Promote system practices and improvements that result in more efficient system operation

PROGRAM AREA 2.01 — INCENTIVES FOR NEW AND REPLACEMENT COMMERCIAL UNITARY HVAC UNITS AND SYSTEM IMPROVEMENTS

Our analysis of the achievable potential for this program area is projected from an incentive to cover 75 percent to 90 percent of the incremental cost for a new or replacement unit. As an add-on component, we provide training, tools and incentives to encourage system improvements at the time of installation or on their own.

TABLE 2.01.2. ESTIMATED VALUES FOR PROGRAM AREA 2.01, INCENTIVES FOR NEW AND REPLACEMENT COMMERCIAL UNITARY HVAC UNITS AND SYSTEM IMPROVEMENTS

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$414 to $585	$405 to $531
	Incremental Impacts	peak kW	520 to 870	465 to 696
		annual kWh (000s)	1,347 to 2,103	1,509 to 2,233
		annual therms (000s)	0	0
	Levelized resource cost	per peak kW	$62 to $108	$68 to $121
		per kWh	2.5¢ to 4.3¢	2.1¢ to 3.7¢
		per therm	NA	NA
Scaling factors[a]		program costs	0.7 to 1.6	0.7 to 1.6
		impacts	0.8 to 1.3	0.8 to 1.3

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Below, we document the technical assumptions we made for the cooling energy savings in the commercial unitary HVAC market.

Program Area 2.01 — Incentives for New and Replacement Commercial Unitary HVAC Units and System Improvements

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 2.01.3. MODEL INPUTS FOR INCENTIVES FOR NEW AND REPLACEMENT COMMERCIAL UNITARY HVAC UNITS AND SYSTEM IMPROVEMENTS

Model Inputs (02.01)			Value	±
1		**Impacts**		
	a	2005 market size (GWh)	1,238	62
	b	2005 market size (peak MW)	693	35
	c	Annual electric market growth rate (2006-2015)	2.9%	0.2%
		Efficiency improvement within 2006 inventory w/o program intervention		
	d	Annual market undergoing improvements (2006-2015)	6.7%	2.5%
	e	Electric energy % saved within failed systems	17.5%	3.5%
	f	Electric peak demand % saved within failed systems	17.5%	3.5%
		Identified savings potential for primary intervention within replacement inventory as of 1/1/2006		
	g	Annual market for intervention (2006-2010)	6.7%	2.5%
	h	Electric energy % savings (normal replacements)	7.1%	1.4%
	i	Electric peak demand % savings (normal replacements)	7.1%	1.4%
		Identified savings potential for add-on intervention within inventory as of 1/1/2006		
	k	Electric energy % savings	17.5%	3.5%
	l	Electric peak demand % savings	7.3%	1.5%
		Identified savings potential in new usage with primary intervention		
	m	Electric energy % savings	7.1%	1.4%
	n	Electric peak demand % savings	7.1%	1.4%
2		**Program Participation**		
		Primary intervention for 2006 existing		
	a	Participation in Year 1 (% of 2006 replaced inventory)	4%	1%
	b	Ultimate annual participation rate (% of replaced inventory)	20%	5%
	c	Year ultimate participation reached	5	1
	d	Net-to-gross ratio for primary intervention	0.85	0.05

		Add-on intervention for 2006 existing		
	e	Participation in Year 1 (% of 2006 total inventory)	0.1%	0.1%
	f	Ultimate annual participation rate (% of total inventory)	1.0%	0.1%
	g	Year ultimate participation reached	6	1
	h	Net-to-gross ratio for add-on component	0.95	0.05
		Primary intervention for new usage		
	i	Participation in Year 1 (% of annual new usage)	4%	1%
	j	Ultimate annual participation rate (% of annual new usage)	20%	5%
	k	Year ultimate participation reached	5	1
	l	Net-to-gross ratio for primary intervention	0.85	0.05
3		**Program costs**		
	a	Administration start up cost premium (total over years 1 - 3)	$60,000	$15,000
	b	Base administrative costs (% of all intervention costs)	4%	1%
		Primary intervention for 2006 existing		
	c	Additional costs above variable costs for intervention (annual)	$25,000	$5,000
	d	Market management and field staff (% of variable costs)	15%	5%
	e	Incentive costs per annual kWh saved	$0.08	$0.01
	f	Incentive costs per peak kW reduced	$200	$20
		Add-on intervention for 2006 existing		
	g	Additional costs above variable costs for intervention (annual)	$60,000	$10,000
	h	Market management and field staff (% of variable costs)	15%	5%
	i	Incentive costs per annual kWh saved	$0.08	$0.01
	j	Incentive costs per peak kW reduced	$200	$20
		Primary intervention for new usage		
	k	Additional costs above variable costs for intervention (annual)	$25,000	$5,000
	l	Market management and field staff (% of variable costs)	15%	5%
	m	Incentive costs per annual kWh saved	$0.08	$0.01
	n	Incentive costs per peak kW reduced	$200	$20
4		**Measure life (years)**	15	5

1. Per Unit Impacts

The size of the unitary air conditioning market in Wisconsin was estimated by first using data from a Wisconsin Public Service/McGraw Hill survey (2004) to break out cooling from other end uses in various commercial building types in Heating and Cooling Zone 1. Percentages of electric and gas use by commercial building type were obtained from a Focus on Energy baseline market research study (XENERGY, 2002). An estimate of unitary consumption in Wisconsin was then calculated using EIA/CBECS data tables (1999) to determine the percentage of building type square footage cooled by unitary systems versus chillers and other means. This number was then scaled to an estimated level for

2005 based on PSC-Wisconsin commercial electric forecast data for 2004-2015 (PSC, 2004 and Kliebenstein, 2005).

Wisconsin Public Service Corporation (WPSC) analyzed hourly commercial loads by building type and end-use to develop four end-use load factors (WPSC, 2005). The hourly load curves were calibrated to weather-adjusted estimates for commercial load in WPSC territory. Billing data and SIC codes were used for the energy estimates, and the load shapes were applied by building type to get the peak estimates. The load factor ratio for cooling was estimated to be 0.000560 GW/GWh.

Following this approach, we estimated the energy consumption of unitary systems in Wisconsin for 2005 to be 1,303 GWh of a total 21,934 GWh total commercial sales projected for 2005, with growth of 2.9 percent per year. To account for uncertainty between end-use shares while keeping the analysis within the overall commercial forecast, we estimated the market size for unitary equipment at 95 percent +/- 5 percent of the estimated end-use share. This translates to 1,238 GWh +/- 62 GWh. Applying the summer peak load to the annual energy usage ratio provided by WPS, we estimated the peak load for this market to be 693 MW +/- 35 MW.

Annual unit replacement rates were estimated by using the inverse of the average life of rooftop units. Rooftop units are estimated to have a 15 year life (Navigant, 2004), therefore the annual replacement rate is estimated at 1/15, or 6.7 percent.

Annual savings for naturally occurring replacements and program influenced replacements were calculated using the following average efficiencies:

- Base efficiencies were set at 8.5 EER for units under 10 tons, 8.0 EER for units between 10 and 20 tons, and 7.8 EER for units over 20 tons (Navigant, 2004).
- Naturally occurring replacement efficiencies were set at 10.3 EER for units under 10 tons, 9.7 EER for units between 10 and 20 tons, and 9.4 EER for units over 20 tons (Navigant, 2004).
- Program influenced replacement efficiencies were set at CEE Tier 2 levels which are 11.4 EER for units under 10 tons, 10.8 EER for units between 10 and 20 tons, and 10.0 EER for units over 20 tons (CEE, 2004).

Naturally occurring replacement savings was estimated to be 17.5 percent based on the efficiency levels described above. If all units replaced were replaced with CEE Tier 2 equipment, we determined that additional savings of 7.1 percent could be achieved.

Impact on natural gas use for heating due to electric usage reduction was estimated to be negligible as most systems will not be operated during the majority of the heating season, and units are often located on rooftops or otherwise outside of the building shell.

Additional system improvements, modeled as an Add-On component in the input table, included tune-ups (filter replacement, refrigerant charge, etc.), installation of properly sized units, and installation of a premium economizer (enthalpy based).

Tune-ups to correct a refrigerant charge that is out of range were estimated to save 2%, based on findings reported by the New Buildings Institute (Cowan, 2004). Significant over-sizing can result in a performance penalty of 18 percent on average (Trane, 1989), and approximately 30 percent of installed units are thought to be significantly over-sized (KEMA, 2005). This results in overall market savings potential of 5.4 percent. Installation of a premium economizer results in average savings of 11 percent over standard dry bulb temperature economizers (Odell, 2001). The overall energy savings potential for system add on measures was determined to be 17.5 percent (assuming that all add on measures are installed). Peak load reduction was estimated to be 7.3 percent because economizers were determined to not significantly impact peak summer demand.

2. Program Participation

We have modeled the interventions to achieve program participation for new or replacement unitary equipment beginning at 4 percent (+/- 1 percent) in year one and ramping up to peak participation of 20 percent (+/- 5 percent) by year 5 (+/- one year). Standards set in the Energy Policy Act of 2005 mandate minimum equipment efficiency levels essentially equal to our program level for equipment manufactured after January 1, 2010 (U.S. Congress, 2005). We assume the inventory of equipment manufactured before the Federal standard takes effect will be installed by the end of year 5.

Studies vary in their estimate of the number of units sold per year in Wisconsin, from as low as 4,000 (Navigant, 2004) to as high as 10,000 (KEMA, 2005). On this basis, the number of units participating in year 1 at 4 percent market share would be 160 to 400. At the peak of 20 percent participation, the participating units would be 800 to 2000. The lower range of participation estimate is intended to extrapolate from current activity in Wisconsin, while results from the Cool Choice program (York and Kushler, 2003) provide support for the higher range of participation levels. Net to gross program values of 0.85 for existing and new stock were used, based on data from the Northeast U.S. “Cool Choice” HVAC program (Quantum, 2004).

We have modeled the add-on intervention to achieve program participation for unitary system improvements beginning at 0.1 percent (+/- 0.1 percent) of the total stock, in year one and ramping up to peak participation of 1.0 percent (+/-0.1 percent) by year 6 (+/- one year). Assuming the total stock of units is 15 times the annual replacement quantity, this implies participation of 60 to 150 units in year 1, reaching 600 to 1,500 units at peak (saving 2.2 GWh annually). A net to gross program value of 0.95 (+/- 0.05) was used, based on data for a $1.75 million rooftop HVAC maintenance program operated by Avista that saved 13 GWh in 2001 (Quantum, 2004).

3. Program Costs

Program costs reflect approximations we made following review of costs for programs with similar approaches and participation levels (Quantum, 2004). Incentive costs are 69 percent of total program costs, while non-incentive costs are 31 percent. Start up costs of $60,000 over three years ($20,000 per year) are allocated to achieve a statewide effort, filling gaps in areas such as market research, information and outreach, demonstration projects, tools, and case studies. A general administrative cost of 4 percent of all intervention costs provides funding for management of the overall market effort, program specific tracking and reporting, planning meetings, and other expenses.

Costs for each intervention in the market are broken into three categories:

- Incentives for participants, suppliers, and other program allies;

- A market manager to handle day-to-day responsibilities and field staff to work with participants on specific projects; and
- Annual fixed costs for activities such as training, product and service development (tools, manuals, guides, software, etc.).

Incentives are paid for energy and demand savings. The overall incentive pool may be provided as participant rebates, supplier rebates, on-site evaluations, or other project specific costs to influence participation. The incentive costs for this intervention were intended to cover between 75 percent to 90 percent of incremental upgrade costs, approximately $65 per ton, and 50 percent to 100 percent of add-on component costs.

4. Measure Life

Measure life was based on data from a Navigant Consulting study (2004) of technology forecasts for residential and commercial buildings. A measure life of 15 years was used in the input model.

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MARKET 3 — COMMERCIAL AND INDUSTRIAL LIGHTING REMODELING AND REPLACEMENT UPGRADES

Market Scope

This market comprises upgrades to lighting systems in existing buildings at the time of remodel or natural replacement. These improvements include upgrading standard T8 fluorescent fixtures to high-performance "super" T8 or T5 fixtures, replacing incandescent fixtures with hard-wired compact fluorescent fixtures, replacing incandescent or fluorescent exit signs with LED exit signs, replacing high bay HID fixtures with fluorescent high bay fixtures in appropriate applications, and installing occupancy sensors in offices, classrooms, restrooms, and break rooms.

This market addresses savings and costs for end-users who need to make a lighting upgrade (regardless of program intervention) because of system age, failures, or remodeling, but may not upgrade to the most efficient system available. End-users retrofitting their existing equipment, acting primarily for the purpose of lowering energy bills after motivation by the program intervention, are addressed through Market 5, Lighting and Lighting Controls Retrofit. The savings and costs of Markets 3 and 5 are additive, because they target different market opportunities.

Market Characteristics

Lighting is the primary electric end use in commercial buildings, accounting for over 45 percent of total electric consumption in commercial buildings (WPS/McGraw Hill, 2004). Fluorescent fixtures make up the majority of lighting in commercial buildings. According to a report by KEMA, Inc. (2005), over 56 percent of total installed commercial fluorescent stock is made up of standard T8 fixtures with electronic ballasts, and nearly 90 percent of contractor installations involve T8 fixtures, high-performance T8 fixtures, or F28T5 fixtures. This suggests that end-users in the market for lighting will choose to install standard T8 fixtures without outside program intervention.

The high-performance or "super" T8 refers to an improved version of the T8 fluorescent lamp and ballast lighting system that provides lighting at lower input wattage (a higher system efficacy). A market definition of a high-performance T8 has been developed by the Consortium for Energy Efficiency (2005).

The existing stock incandescent application fixtures is also fairly heavily comprised of the energy efficient alternatives. Over 43 percent of incandescent application fixtures (wall sconces, task lighting, etc.) are compact fluorescent, and over 48 percent of exit signs are LED exit signs. There are, however, significant opportunities to install compact fluorescent lighting within older existing buildings (Mapp, 2005). These include bathrooms, hallways, cafeterias, outdoor lighting, and other areas where newer styles and generations of lamps may be appropriate for applications previously considered but rejected by building owners.

The U.S. Congress (2005) passed a law mandating exit signs manufactured after January 1, 2006 draw 5 watts or less, therefore, exit sign are included. The impacts of other lighting provisions in the Energy Policy Act of 2005 are reflected in the input values (U.S. Congress, 2005).

Occupancy sensors save between 40 percent and 60 percent in restrooms and between 17 percent and 29 percent in break rooms. Unfortunately, restrooms and break rooms are a relatively minor percentage of floor space in commercial and industrial buildings. Occupancy sensors in offices and classrooms are more modest at 6 percent to 13 percent in office areas and 10 percent to 19 percent in classrooms. (Von Neida, Maniccia and Tweed, 2000)

Program Approaches

Our analysis of this market considered these program efforts:

- Increase the market adoption of lighting alternatives such as high performance T8, F28T5, and F54T5HO fixtures that are more efficient than currently installed standard T8 fluorescent or HID fixtures.
- Increase the market adoption of compact fluorescent fixtures, and high-bay pulse start metal halide fixtures (for applications where fluorescent lighting high bay lighting is inappropriate).
- Increase the market adoption of occupancy sensors.

Lighting remodeling and replacement programs are targeted at customer segments that ultimately replace and upgrade lighting systems because they no longer provide the quality or reliability required in the space. There is some opportunity for design improvements in spaces that allow moving or reducing the number of lighting fixtures as part of a remodel.

PROGRAM AREA 3.01 — INCENTIVES FOR COMMERCIAL AND INDUSTRIAL LIGHTING REMODELING AND REPLACEMENT UPGRADES

Our analysis of the achievable potential for this program area is projected from upgrade (incremental cost) incentive levels for high efficiency lighting options such as high-performance T8 and T5 fixtures, compact fluorescent lighting, and pulse start metal halide. We assumed that 67 percent of lighting falls into the incremental lighting upgrades of Market 3, while the remaining 33 percent of lighting energy is addressed by the retrofits targeted by Market 5.

TABLE 3.01.2. ESTIMATED VALUE FOR PROGRAM AREA 3.01, INCENTIVES FOR COMMERCIAL AND INDUSTRIAL LIGHTING REMODELING AND REPLACEMENT UPGRADES

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$2,432 to $4,209	$3,300 to $5,772
	Incremental Impacts	peak kW	3,585 to 6,546	4,938 to 9,049
		annual kWh (000s)	19,686 to 36,138	27,078 to 50,199
		annual therms (000s)	-386 to -177	-537 to -245
	Levelized resource cost	per peak kW	$55 to $96	$54 to $95
		per kWh	1.0¢ to 1.7¢	1.0¢ to 1.7¢
		per therm	0.0¢	0.0¢
Scaling factors[a]		program costs	1.1 to 2.3	1.1 to 2.3
		impacts	1.0 to 1.5	1.0 to 1.5

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Below, we document the technical assumptions we made for the lighting energy savings in the commercial and industrial lighting remodeling and replacement upgrades market.

Program Area 3.01 — Incentives for Commercial and Industrial Lighting Remodeling and Replacements Upgrades

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 3.01.2. MODEL INPUTS FOR INCENTIVES FOR COMMERCIAL AND INDUSTRIAL LIGHTING REMODELING AND REPLACEMENTS UPGRADES

Model Inputs (03.01)			**Value**	**±**
1		**Impacts**		
	a	2005 market size (GWh)	11,401	570
	b	2005 market size (peak MW)	2,074	104
	c	Annual market growth rate (2006-2015)	2.8%	0.2%
	d	Nat gas increase from electric savings (therms/MWh-saved)	10	3
	Efficiency improvement within 2006 inventory w/o program intervention			
	e	Annual market undergoing improvements (2006-2015)	6.7%	1.4%
	f	Electric energy % saved within failed systems	9.1%	1.8%
	g	Electric peak demand % saved within failed systems	9.1%	1.8%
	Identified savings potential for primary intervention within replacement inventory as of 1/1/2006			
	h	Annual market for intervention (2006-2015)	6.7%	1.4%
	i	Electric energy % savings (normal replacements)	14.7%	2.9%
	j	Electric peak demand % savings (normal replacements)	14.7%	2.9%
	Identified savings potential for add-on intervention within inventory as of 1/1/2006			
	k	Annual market for intervention (2006-2015)	6.7%	1.4%
	l	Electric energy % savings	4.8%	1.0%
	m	Electric peak demand % savings	4.8%	1.0%
2		**Program Participation**		
	Primary intervention for 2006 existing			
	a	Participation in Year 1 (% of 2006 replaced inventory)	10%	2%
	b	Ultimate annual participation rate (% of replaced inventory)	40%	10%
	c	Year ultimate participation reached	5	1
	d	Net-to-gross ratio for primary intervention	0.81	0.12
	Add-on intervention for 2006 existing			

	e	Participation in Year 1 (% of 2006 replaced inventory)	10%	2%
	f	Ultimate annual participation rate (% of replaced inventory)	40%	10%
	g	Year ultimate participation reached	5	1
	h	Net-to-gross ratio for add-on component	0.81	0.12
3		**Program costs**		
	a	Administration start up cost premium (total over years 1 - 3)	$120,000	$20,000
	b	Base administrative costs (% of all intervention costs)	4%	1%
		Primary intervention for 2006 existing		
	c	Additional costs above variable costs for intervention (annual)	$70,000	$20,000
	d	Market management and field staff (% of variable costs)	15%	5%
	e	Incentive costs per annual kWh saved	$0.05	$0.01
	f	Incentive costs per peak kW reduced	$150	$25
		Add-on intervention for 2006 existing		
	g	Additional costs above variable costs for intervention (annual)	$50,000	$10,000
	h	Market management and field staff (% of variable costs)	15%	5%
	i	Incentive costs per annual kWh saved	$0.05	$0.01
	j	Incentive costs per peak kW reduced	$150	$25
4		**Measure life (years)**	15	3

1. Per Unit Impacts

Lighting is the primary electric end use in commercial buildings, accounting for over 45 percent of total electric consumption in commercial buildings (WPS/McGraw Hill, 2004). The size of the lighting market in Wisconsin was estimated by first using data from a WPS/McGraw Hill survey (2004) to break out lighting from other end uses in various commercial building types in Heating and Cooling Zone 1. Percentages of electric use by commercial building type were obtained from a Focus on Energy baseline market research study (XENERGY, 2002). These values were then scaled to an estimated level for 2005 (10,007 GWh) based on PSC-Wisconsin commercial electric forecast data for 2004-2015 (PSC, 2004 and Kliebenstein, 2005).

Wisconsin Public Service Corporation (WPSC) analyzed hourly commercial loads by building type and end-use to develop four end-use load factors (WPSC, 2005). The hourly load curves were calibrated to weather-adjusted estimates for commercial load in WPSC territory. Billing data and SIC codes were used for the energy estimates, and the load shapes were applied by building type to get the peak estimates. The load factor ratio for lighting was estimated to be 0.000191 GW/GWh.

In contrast, lighting is a fairly minor end use in the industrial sector based on total consumption, making up under 8 percent, or approximately 1,994 GWh in 2005 (EIA, 2005). We assumed that high bay fixtures make up a significantly higher percentage of fixtures in Wisconsin industrial facilities than in commercial facilities (Navigant, 2002). The percentages of electric usage for industry type and end-use were applied to the forecast of peak loads for Wisconsin industry.

We estimated the energy consumption of commercial and industrial lighting systems in Wisconsin for 2005 to be 12,001 GWh, with growth of 2.8 percent per year. To account for uncertainty between end-use shares while keeping the analysis within the overall forecasts, we estimated the market size at 95 percent +/- 5 percent of the estimated end-use share. This translates to 11,401 GWh +/- 570 GWh. Applying the summer peak load to annual energy usage ratio, we estimated the peak load for this market to be 2,074 MW +/- 104 MW.

We estimated the impact on natural gas use to be 50 percent of the lighting energy savings, for a six month period, and assuming an 85 percent efficient heating system; this results in an additional space heating requirement of 10 therms per lighting MWh saved.

Installed base lighting average wattage was determined using an estimated percentage of high efficiency fixture saturation versus standard efficiency options.

Fluorescent fixtures – T8 fixtures are estimated to comprise 56.7 percent of existing fluorescent fixtures (KEMA, 2005). T12 34 W fixtures are assumed to make up 30 percent of existing fixtures and T12 40 W fixtures are assumed to make up 13.3 percent. Base fixture wattages are assumed to be 2-lamp fixtures. T8 fixture wattage is estimated to be 62 W, T12 34 W fixture with energy saving ballast is assumed to be 66 W, and 40 W T12 fixture with magnetic ballast is assumed to be 88 W (Xcel 2004). The weighted average base fixture wattage is then 66.7 W.

Incandescent application fixtures – CFL bulbs or fixtures are estimated to comprise 43.6 percent of incandescent application fixtures, with 56.4 percent being incandescent or halogen (KEMA, 2005). To represent market averages, CFL wattage is assumed to be 25 W while incandescent wattage is assumed to be 60 W (Xcel, 2004). The weighted average base incandescent application fixture wattage is then 42.6 W.

High bay fixtures – High bay fluorescent fixtures are assumed to comprise less than 10 percent of the high bay fixture market, with the remainder being HID fixtures. HID wattage is assumed to be 460 W including the ballast, while high bay fluorescent wattage is assumed to be 270 W (Xcel, 2004). The weighted base high bay fixture wattage is then 441.8 W.

Exit signs – LED exit signs are estimated to comprise 48.3 percent of the in-place exit sign stock (KEMA, 2005). Fluorescent exit signs are estimated to be 35 percent of the stock and incandescent exit signs are estimated to be 16.7 percent of the stock. LED exit sign wattage is assumed to be 4 W, fluorescent exit sign wattage is assumed to be 26 W, and incandescent exit sign wattage is assumed to be 40 W (Xcel, 2004). The weighted base exit sign wattage is then 17.7 W.

Naturally occurring current practice replacement wattages are estimated as follows:

Fluorescent fixtures – T8 fixtures are estimated to comprise 87 percent of replacement fluorescent fixtures (KEMA, 2005). T12 34 W fixtures are assumed to make up 2 percent of existing fixtures and high-performance T8 or T5 fixtures are assumed to make up 11 percent. Base fixture wattages are assumed to be 2-lamp fixtures. T8 fixture wattage is estimated to be 62 W, T12 34 W fixture with energy saving ballast is assumed to be 66 W, and high-performance T8 or T5 wattage is assumed to be 54 W (Xcel, 2004). The weighted average base fixture wattage is then 61.2 W, resulting in 8.1 percent savings over base.

Incandescent application fixtures – CFL bulbs or fixtures are estimated to comprise 60 percent of incandescent application fixtures, with 40 percent being incandescent or halogen (KEMA, 2005). CFL wattage is assumed to be 25 W while incandescent wattage is assumed to be 60 W (Xcel, 2004). The weighted average base incandescent application fixture wattage is then 39 W, for an 8.4 percent savings over base.

High bay fixtures – High bay fluorescent fixtures are assumed to comprise 34 percent of high bay fixture installations, with the remainder being HID fixtures. HID wattage is assumed to be 460 W including the ballast, while high bay fluorescent wattage is assumed to be 270 W (Xcel, 2004). The weighted base high bay fixture wattage is then 395.4 W, for a 10.5 percent savings over base.

Exit signs – The U.S. Congress (2005) passed a law mandating exit signs manufactured after January 1, 2006 draw 5 watts or less. LED exit sign wattage is assumed to be 4 W (Xcel, 2004), and this serves as our baseline for standard replacements.

Overall standard practice replacement savings based on estimated fixture type installation proportions of total lighting electric sales (73.9 percent fluorescent tube, 13.4 percent incandescent application, 11.7 percent high bay, and 1.0 percent exit sign) is 9.1 percent.

Program wattages are as follows:

Fluorescent fixtures – Program savings assume high performance T8 or T5 fixtures, with wattage estimated to be 54 W (Xcel, 2004). The weighted average base fixture wattage is then 54 W, resulting in 11.8 percent savings over standard practice installations.

Incandescent application fixtures – Program savings assume hard-wired CFL fixtures with wattage estimated to be 25 W (Xcel, 2004). The weighted average base incandescent application fixture wattage is then 25 W, for a 25.1 percent savings over standard installation. It is also assumed that CFL fixtures would only be applicable in 70 percent of installations. Inappropriate installations would include certain retail applications and galleries where halogen is used exclusively for ideal color rendering.

High bay fixtures – Program savings is based on high bay fluorescent lighting, with wattage assumed to be 270 W (Xcel, 2004). The weighted base high bay fixture wattage is then 270 W, for a 22.2 percent savings over standard practice. It is also assumed that high bay fluorescent fixtures would only be applicable in 70 percent of installations. Inappropriate installations would include low temperature applications in which lumen output would be dramatically reduced, and dirty, dusty, or oily environments. Pulse start metal halide fixtures would be the alternative technology.

Exit signs – Program savings for exits signs are zero, given the Federal standard that exit signs draw 5 watts or less (U.S. Congress, 2005), and the finding from KEMA (2005) that LED exit signs have a 90% market share in new installations.

Overall savings based on estimated fixture type relative to base installation proportions of total lighting electric sales (73.9 percent fluorescent tube, 13.4 percent incandescent application, 11.7 percent high bay, and 1.0 percent exit sign) is 14.7 percent.

Lighting remodeling and replacement upgrade program savings is the difference between the standard replacement practice wattage and program wattage, or 14.7 percent.

Additional system improvements, described as an Add-On Component in the model input table included occupancy sensors. Occupancy sensors are estimated to result in an average of 4.8 percent savings from total electric lighting sales based on savings of 9 percent for offices, 47 percent for restrooms, 23 percent for break rooms, and 14.5 percent for classrooms (Von Neida, Maniccia and Tweed, 2000) and an estimated floors space percentage for each of those space types.

2. Program Participation

The program is assumed to target customer segments that ultimately replace and upgrade lighting systems because they no longer provide the quality or reliability required in the space. The target market for incremental upgrades is assumed to be 67 percent of the total lighting market opportunity that exists as of January 1, 2006.

We have modeled the interventions to achieve program participation beginning at 10 percent in year one, approximately consistent with activity levels for programs in Wisconsin in 2005. Peak participation was estimated to ramp up such that it would reach 40 percent (+/- 10%) by Year 5 (+/- one year).

The basis for the upper participation level includes an estimate of 50 percent participation from National Grid for their Design 2000 program (York and Kushler, 2003), which includes lighting remodel and replacement. California has estimated that Savings by Design, which also includes renovation and remodel, has reached 39.7 percent of non-residential construction on a square foot basis (Quantum 2005). By number of projects, California has reached only 13 percent (Quantum 2005). This indicates that larger buildings are a disproportionate share of program activity, allowing penetration levels to reach high levels on a resource acquisition basis.

The net to gross ratio is assumed to be 0.81 (+/- 0.12), based on evaluations performed on programs that cover new construction, renovation, and remodeling in California (.65), National Grid (0.81), and Northeast Utilities (0.93) (Quantum, 2004).

3. Program Costs

Program costs reflect approximations we made following review of costs for mature programs with similar approaches and participation levels (Quantum, 2004). Incentive costs are 81 percent of total program costs, while non-incentive costs are 19 percent. Start up costs of $120,000 over three years ($40,000 per year) are allocated to achieve a statewide effort, filling gaps in areas such as market research, information and outreach, demonstration projects, tools, and case studies. A general administrative cost of 4 percent of all intervention costs provides funding for management of the overall market effort, program specific tracking and reporting, planning meetings, and other expenses.

Costs for each intervention in the market are broken into three categories:

- Incentives for participants, lighting designers, suppliers, and other program allies;
- A market manager to handle day-to-day responsibilities and field staff to work with participants on specific projects; and

- Annual fixed costs for activities such as training, product and service development (tools, manuals, guides, software, etc.).

Incentives are paid for electric energy and demand savings. The overall incentive pool may be provided as participant rebates, designer incentives, supplier rebates, on-site evaluations, or other project specific costs to influence participation. The incentive costs for this intervention were intended to cover approximately 50 percent to 100 percent of incremental measure costs, following the approach taken for We Energies (Energy Center of Wisconsin, 2005). The modeled incentives reduce the payback of measures by about 1.3 years.

4. Measure Life

A measure life of 15 years (+/- 3 years) was used in the lighting input model (Quantum, 2004).

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MARKET 4 — NEW AND REPLACEMENT COMMERCIAL BOILERS AND SYSTEM IMPROVEMENTS

Market Scope

This market comprises new boiler equipment, both as replacements for existing units and units installed in new construction. It also includes system improvements such as steam pipe insulation, steam trap repair, tune ups, water loop temperature reset, oxygen trim controls, vent dampers, economizers, and blow-down heat exchangers. Energy impacts to electric auxiliary equipment are not included in this market.

Market Characteristics

Nearly 24 percent of commercial floor space in Wisconsin is heated using boiler systems (EIA, 1999). According to a report by KEMA, Inc. (2005), as many as 4,271 units are sold each year in Wisconsin, accounting for 218 MMBtu/h of heating capacity. This equates to an average of just over 500,000 Btu/h per unit.

A study by Navigant Consulting (2004) reports that most commercial boilers sold in 2004 had efficiencies of 80 percent or better, with the best available being 90 percent. According to that same study, the installed base of boilers has efficiencies of 76 percent or worse. Boiler efficiencies have not improved dramatically over the past 20 years, with the exception of condensing boilers, which average about 92 percent efficiency. System improvements at the time of boiler replacement or for their own sake can also significantly affect the efficiency of the system.

Small (150,000 Btu/h and smaller) high efficiency boiler units have been eligible for Focus on Energy standard rewards at the rate of $150 for 90 percent efficiency or better boilers in existing buildings and $50 for 90 percent efficiency or better boilers in new buildings. Boilers larger than 150,000 Btu/h are eligible for custom rewards at the rates shown in Table 4.01.1. It is not known how this has impacted sales of high efficiency units, but according to the KEMA, Inc. study, 65 percent of installed boilers under 1 MMBtu/h capacity have efficiencies of 87 percent or better, while 80 percent of boilers over 1 MMBtu/h capacity have efficiencies of 85 percent or better.

TABLE 4.01.1. FOCUS ON ENERGY CUSTOM INCENTIVE LEVELS FOR BOILERS

BOILER EFFICIENCY	INCENTIVE
82%-85%	$0.20/therm
86%-89%	$0.25/therm
90% or better	$0.30/therm
All non-boiler custom measures	$0.30/therm

A recent study of the non-residential HVAC market in Wisconsin helped identify areas and aspects of the supply chain that are leverage points for current or refined program activities (Quantum, 2003). Findings and recommendations from that research that are most relevant to this market include:

- Large new construction and renovation projects should be identified and tracked at their earliest stages to ensure and influence appropriate consideration of efficiency options. These projects offer the greatest potential for influencing designers and contractors and capturing the most cost-effective savings, which are often design related.
- Interventions for larger projects and those with central plants should focus on designers
- Efforts should be made to encourage more efficient boiler and chiller systems (as opposed to less efficient packaged systems) where appropriate. System optimization and controls should be reinforced.
- Efforts to work with suppliers should be personalized and sustained over time. Virtually all trade allies value committed long-term business relationships.
- Supply-side actors consistently perceive first-cost orientation to be the greatest end user obstacle to increased adoption of energy efficient HVAC systems in Wisconsin's C/I sector. Lack of knowledge, lack of capital, reliability, and bidding and design process structures were also mentioned as significant barriers. The cost barrier is especially significant in competitive bid situations that involve multiple supply-side actors.
- Suppliers believe that the keys to reducing end user barriers to adoption of efficient C/I HVAC systems are to improve and extend communication of payback and return-on-investment information to owners on a job-specific basis, generally improve end users understanding of the financial benefits of efficiency investments, buy-down initial costs with incentives, and achieve upstream price reductions by manufacturers. A few suppliers mentioned providing financing and case studies and demonstration projects.

Suggested practices for boiler selection and hot water reset (Olsen, 2005) include:

- When a boiler fails, consider replacing it with a high efficiency unit with no return water temperature limits. Check with an engineer or heating contractor to find out what kind of boiler and reset is right for the facility or how to optimize the existing outdoor air reset system
- For new construction, select a high efficiency variable output condensing boiler that has no restrictions on return water temperature. Alternatively, consider modular boilers with sequencing controls to approximate the control provided by variable output boilers. Insure the modular boiler(s) have hot water reset and set the reset range to allow return water as low as 100° F when the outdoor air temperature is above 50° F.
- In existing facilities without reset control, consider adding hot water reset controls. Check with the boiler manufacturer to verify the lowest acceptable return water temperature. Set the reset range accordingly. If the minimum return water temperature permitted by the manufacturer is 140° F or greater consider adding a primary/secondary loop pumping system to allow a greater reset range especially if there is summer use of reheat.

Program Approaches

Our analysis of this market considered two program components:

- increase the market share for modulating or variable output, high efficiency boilers with no/low minimum return water temperature requirements,
- promote system practices and improvements that result in more efficient system operation

PROGRAM AREA 4.01 — INCENTIVES FOR HIGH EFFICIENCY BOILERS AND SYSTEM IMPROVEMENTS

Our analysis of the achievable potential for this program area is projected from an increase in Focus on Energy incentive levels.

TABLE 4.01.2. ESTIMATED VALUES FOR PROGRAM AREA 4.01, INCENTIVES FOR HIGH EFFICIENCY BOILERS AND SYSTEM IMPROVEMENTS

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$274 to $530	$360 to $704
	Incremental Impacts	peak kW	0	0
		annual kWh (000s)	0	0
		annual therms (000s)	176 to 390	249 to 537
	Levelized resource cost	per peak kW	NA	NA
		per kWh	NA	NA
		per therm	9.0¢ to 15.3¢	8.5¢ to 14.3¢
Scaling factors[a]		program costs	1.6 to 3.3	1.6 to 3.3
		impacts	1.2 to 1.6	1.2 to 1.6

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Below, we document the technical assumptions we made for the energy savings in the commercial boiler systems market.

Program Area 4.01 — Incentives for Commercial Boiler Replacements and System Upgrades

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 4.01.2. MODEL INPUTS FOR INCENTIVES FOR COMMERCIAL BOILER REPLACEMENTS AND SYSTEM UPGRADES

Model Inputs (04.01)		Value	±
1	**Impacts**		
a	2005 market size (10^12 Btu)	11.5	0.6
b	Annual gas market growth rate (2006-2015)	2.0%	0.2%
	Efficiency improvement within 2006 inventory w/o program intervention		
c	Annual market undergoing improvements (2006-2015)	4.0%	0.8%
d	Natural gas energy % saved within failed systems	10.6%	2.1%
	Identified savings potential for primary intervention within replacement inventory as of 1/1/2006		
e	Annual market for intervention (2006-2015)	4.0%	0.8%
f	Natural gas energy % savings (normal replacements)	1.6%	0.3%
	Identified savings potential for add-on intervention within inventory as of 1/1/2006		
g	Natural gas energy % savings	12.2%	4.1%
	Identified savings potential in new usage with primary intervention		
h	Natural gas energy % savings	1.6%	0.3%
2	**Program Participation**		
	Primary intervention for 2006 existing		
a	Participation in Year 1 (% of 2006 replaced inventory)	5%	1%
b	Ultimate annual participation rate (% of replaced inventory)	40%	10%
c	Year ultimate participation reached	5	1
d	Net-to-gross ratio for primary intervention	0.81	0.12
	Add-on intervention for 2006 existing		
e	Participation in Year 1 (% of 2006 total inventory)	1.0%	0.5%
f	Ultimate annual participation rate (% of total inventory)	4.0%	1.0%
g	Year ultimate participation reached	5	1
h	Net-to-gross ratio for add-on component	0.80	0.10

	Primary intervention for new usage		
i	Participation in Year 1 (% of annual new usage)	5%	1%
j	Ultimate annual participation rate (% of annual new usage)	40%	10%
k	Year ultimate participation reached	5	1
l	Net-to-gross ratio for primary intervention	0.81	0.12
3	**Program costs**		
a	Administration start up cost premium (total over years 1 - 3)	$50,000	$10,000
b	Base administrative costs (% of all intervention costs)	4%	1%
	Primary intervention for 2006 existing		
c	Additional costs above variable costs for intervention (annual)	$20,000	$5,000
d	Market management and field staff (% of variable costs)	15%	5%
e	Incentive costs per annual therm reduced	$0.80	$0.10
	Add-on intervention for 2006 existing		
f	Additional costs above variable costs for intervention (annual)	$25,000	$5,000
g	Market management and field staff (% of variable costs)	15%	5%
h	Incentive costs per annual therm reduced	$0.80	$0.10
	Primary intervention for new usage		
i	Additional costs above variable costs for intervention (annual)	$10,000	$5,000
j	Market management and field staff (% of variable costs)	15%	5%
k	Incentive costs per annual therm reduced	$0.80	$0.10
4	**Measure life (years)**	25	5

1. Per Unit Impacts

The size of the boiler market in Wisconsin was estimated by first using data from a Wisconsin Public Service/McGraw Hill survey (2004) to break out heating from other end uses in various commercial building types in Heating and Cooling Zone 1. Percentages of electric and gas use by commercial building type were obtained from a Focus on Energy baseline market research study (XENERGY, 2002). An estimate of boiler energy consumption in Wisconsin was then calculated using EIA/CBECS data tables (1999) to determine the percentage of building type square footage heated by boiler systems versus forced air and other means. This number was then scaled to an estimated level for 2005 based on total commercial gas sales published in Wisconsin Energy Statistics (DOA, 2004). The energy consumption of large boilers systems in Wisconsin for 2005 was estimated to be 12.15 x 10^{12} Btu of a total 50.82 x 10^{12} Btu total commercial gas heating sales projected for 2005. To account for uncertainty between end-use shares while keeping the analysis within the overall commercial forecast, we estimated the market size for boilers at 95 percent (+/- 5%) of the estimated end-use share. This translates to 11.5 (+/- 0.6) x 10^{12} Btu.

Annual replacement rates were estimated by using the inverse of the average life of equipment. Boilers are estimated to have a 25 year life (Navigant, 2004), therefore the annual replacement rate is estimated at 1/25, or 4 percent. Improvement measures to existing systems may be applied at the time of replacement or on their own.

Annual savings for naturally occurring replacements and program influenced replacements were calculated using an average installed base efficiency of 75 percent, a naturally occurring replacement average efficiency of 85.7 percent for units under 1 MMBtu/h and 84 percent for units over 1 MMBtu/h, and an ideal replacement efficiency of 93 percent for condensing units under 1 MMBtu/h and 85 percent for units over 1 MMBtu/h (Navigant, 2004). For space heating applications, we have assumed that return water temperature limits the efficiency of the condensing boiler to 86 percent. We used 2,291equivalent full load heating hours in the calculation of energy savings for high efficiency units in Wisconsin.

Naturally occurring replacement savings was estimated to be 10.6 percent based on the efficiency levels described above. If all units replaced were replaced with the highest efficiency equipment, we determined that additional savings of 1.6 percent could be achieved.

Additional system improvements, described as an Add-On Component in the model input table included steam pipe insulation, steam trap repair, tune ups, water loop temperature reset, oxygen trim controls, vent dampers, economizers, and blow-down heat exchangers.

Savings from the Add-On components come from Acton and Taplin (2002). Steam pipe insulation was estimated to provide an average of 0.68 percent savings. Steam trap repair was estimated to provide 5.7 percent savings on average for the entire boiler market. Boiler tune-ups are estimated to save 2 percent. Boiler water loop temperature setback is estimated to save 7 percent, but applies only to water boilers, so overall market savings is estimated to be 4.2 percent. Oxygen trim combustion controls are estimated to save 2 percent. Vent dampers are estimated to save 2 percent. Boiler economizers (stack heat recovery) are estimated to save 2.8 percent. Blow-down heat exchangers are estimated to save 1.6 percent. The overall energy savings potential for boiler system add on measures ranged from 16.3 percent (assuming that all add on measures are installed), to 8.2 percent (assuming that only half the measures are installed). We used a midpoint estimate of 12.2 percent (+/- 4.1%) to describe the savings potential.

2. Program Participation

We have modeled the interventions to achieve program participation for new or replacement boilers beginning at 5 percent (+/- 1%) in year one and ramping up to peak participation of 40 percent (+/-10%) by year 5 (+/- one year). The lower range of participation estimate is intended to extrapolate from current activity in Wisconsin, while the basis for the upper participation level includes an estimate of 50 percent participation from National Grid for their Design 2000 program (York and Kushler, 2003). The Design 2000 program targets similar customer types for large electric chiller upgrades that our market targets for boiler upgrades. The net to gross ratio is assumed to be 0.81 (+/- 0.12), based on evaluations performed on programs that cover new construction, renovation, and remodeling in California (.65), National Grid (0.81), and Northeast Utilities (0.93) (Quantum, 2004a).

We have modeled the add-on intervention to achieve program participation for system improvements beginning at 1.0 percent (+/- 0.5%) of the total stock, in year one and ramping up to peak participation of 4.0 percent (+/-1.0%) by year 5 (+/- one year). On this participation schedule, 32 percent of commercial boiler load will participate in this market after 10 years. In support of this assumption, National Grid reports that 55 percent of eligible electric customers have participated in their Energy Initiative Custom retrofit program over a 10 year time frame (York and Kushler, 2003). The Energy Initiative program targets similar customer types on the electric side that our market targets for boiler improvements. A net to gross program value of 0.80 (+/- 0.10) was used, as reported by National Grid for their Energy Initiative Program (Quantum, 2004b).

3. Program Costs

Program costs reflect approximations we made following the review of costs for mature programs with similar approaches and customer targets (Quantum, 2004b). Incentive costs are 76 percent of total program costs, while non-incentive costs are 24 percent. Start up costs of $50,000 over three years ($16,667 per year) are allocated to achieve a statewide effort, filling gaps in areas such as market research, information and outreach, demonstration projects, tools, and case studies. A general administrative cost of 4 percent of all intervention costs provides funding for management of the overall market effort, program specific tracking and reporting, planning meetings, and other expenses.

Costs for each intervention in the market are broken into three categories:

- Incentives for participants, suppliers, and other program allies;
- A market manager to handle day-to-day responsibilities and field staff to work with participants on specific projects; and
- Annual fixed costs for activities such as training, product and service development (tools, manuals, guides, software, etc.).

Incentives are paid at a rate of $0.80 per annual therm saved. The overall incentive pool may be provided as participant rebates, supplier rebates, on-site evaluations, or other project specific costs to influence participation. The incentive costs for this intervention were intended to cover between 50 percent to 100 percent of incremental upgrade costs, and 50 percent to 75 percent of add-on component costs. The modeled incentives reduce the payback of measures by about one year.

4. Measure Life

Measure life was based on data from a Navigant Consulting study (2004) of technology forecasts for residential and commercial buildings. A measure life of 25 years was used in the boiler input model.

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MARKET 5 — COMMERCIAL AND INDUSTRIAL LIGHTING AND LIGHTING CONTROLS RETROFIT

Market Scope

This market comprises retrofit of lighting and lighting controls in existing buildings. These measures include retrofitting existing T12 or standard T8 fluorescent fixtures with high-performance "super" T8 or T5 fixtures or lamp and ballast retrofit kits, replacing incandescent fixtures with hard-wired compact fluorescent fixtures, replacing incandescent or fluorescent exit signs with LED exit signs, replacing high bay HID fixtures with fluorescent high bay fixtures in appropriate applications, and installing occupancy sensors in offices, classrooms, restrooms, and break rooms.

This market addresses savings and costs relative to the existing equipment within the building, with action taken primarily for the purpose of lowering energy bills. End-users who are committed to a lighting upgrade regardless of program intervention because of system age, failures, or remodeling, are addressed through Market 3, Lighting Remodel and Replacement. The savings and costs of Markets 3 and 5 are additive, because they target different segments of the market.

Market Characteristics

Lighting is the primary electric end use in commercial buildings, accounting for over 45 percent of total electric consumption in commercial buildings (WPS/McGraw Hill, 2004). Fluorescent fixtures make up the majority of lighting in commercial buildings, and according to a report by KEMA, Inc. (2005), over 56 percent of total installed commercial fluorescent stock is made up of standard T8 fixtures with electronic ballasts, and nearly 90 percent of contractor installations involve T8 fixtures, high-performance T8 fixtures, or F28T5 fixtures.

The high-performance or "super" T8 refers to an improved version of the T8 fluorescent lamp and ballast lighting system that provides lighting at lower input wattage (a higher system efficacy). A market definition of a high-performance T8 has been developed by the Consortium for Energy Efficiency (2005).

The existing stock of exit signs and incandescent application fixtures is also fairly heavily comprised of the energy efficient alternatives. Over 43 percent of incandescent application fixtures (wall sconces, task lighting, etc.) are compact fluorescent, and over 48 percent of exit signs are LED exit signs. There are, however, significant opportunities to install compact fluorescent lighting within older existing buildings (Mapp, 2005). These include bathrooms, hallways, cafeterias, outdoor lighting, and other areas where newer styles and generations of lamps may be appropriate for applications previously considered but rejected by building owners.

Although the U.S. Congress (2005) passed a law mandating exit signs manufactured after January 1, 2006 draw 5 watts or less, we continue to recommend exit sign retrofits because inefficient incandescent signs could otherwise remain in operation for many years. The impacts of other lighting provisions in the Energy Policy Act of 2005 are reflected in the input values (U.S. Congress, 2005).

Occupancy sensors save between 40 percent and 60 percent in restrooms and between 17 percent and 29 percent in break rooms. Unfortunately, restrooms and break rooms are a relatively minor percentage of floor space in commercial and industrial buildings (Von Neida). Occupancy sensors in offices and classrooms are more modest at 6 percent to 13 percent in office areas and 10 percent to 19 percent in classrooms (Von Neida, Maniccia and Tweed, 2000).

Program Approaches

Our analysis of this market considered these program efforts:

- Reduce the energy usage of lighting systems through alternatives such as high performance T8, F28T5, and F54T5HO fixtures or lamp and ballast retrofits that are more efficient than currently installed standard T12 fluorescent, standard T8 fluorescent, or HID fixtures.
- Reduce energy usage through installation of LED exit signs, compact fluorescent fixtures, and high-bay pulse start metal halide fixtures (for applications where fluorescent lighting high bay lighting is inappropriate).
- Reduce energy usage through installation of occupancy sensors.

The lighting retrofit program is assumed to target primarily customer segments that are harder to reach, including but not limited to small commercial and industrial businesses that seldom remodel or undertake efficiency upgrades on their own. Other targeted groups include schools, government, and distressed businesses.

PROGRAM AREA 5.01 — INCENTIVES FOR COMMERCIAL AND INDUSTRIAL LIGHTING AND LIGHTING CONTROLS RETROFITS

Our analysis of the achievable potential for this program area is projected from retrofit (total installed cost) incentive levels for high efficiency lighting options such as high-performance T8 and T5 fixtures or lamp and ballast retrofits, compact fluorescent lighting, pulse start metal halide, and LED exit signs. We assumed that 33 percent of lighting energy use falls into the harder-to-reach retrofit target market, with the remaining 67 percent addressed by the incremental lighting upgrades in Market 3.

TABLE 5.01.3. ESTIMATED VALUES FOR PROGRAM AREA 5.01, INCENTIVES FOR COMMERCIAL AND INDUSTRIAL LIGHTING AND LIGHTING CONTROLS RETROFITS

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$6,800 to $11,053	$7,927 to $12,696
	Incremental Impacts	peak kW	6,082 to 10,460	7,091 to 12,041
		annual kWh (000s)	33,369 to 57,760	39,147 to 66,219
		annual therms (000s)	-629 to -303	-720 to -354
	Levelized resource cost	per peak kW	$92 to $157	$92 to $156
		per kWh	1.7¢ to 2.7¢	1.7¢ to 2.7¢
		per therm	0.0¢	0.0¢
Scaling factors[a]		program costs	0.7 to 1.7	0.7 to 1.7
		impacts	0.8 to 1.3	0.8 to 1.3

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Below, we document the technical assumptions we made for the lighting energy savings in the commercial and industrial lighting retrofit market.

Program Area 5.01 — Incentives for Commercial and Industrial Lighting and Lighting Controls Retrofits

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 5.01.2. MODEL INPUTS FOR INCENTIVES FOR COMMERCIAL AND INDUSTRIAL LIGHTING AND LIGHTING CONTROLS RETROFITS

Model Inputs (5.01)			**Value**	**±**
1		**Impacts**		
	a	2005 market size (GWh)	11,401	570
	b	2005 market size (peak MW)	2,074	104
	c	Annual market growth rate (2006-2015)	2.8%	0.2%
	d	Nat gas increase from electric savings (therms/MWh-saved)	10	3
	Efficiency improvement within 2006 inventory w/o program intervention			
	e	Annual market undergoing improvements (2006-2015)	6.7%	1.3%
	f	Electric energy % saved within retrofitted systems	9.1%	1.8%
	g	Electric peak demand % saved within retrofitted systems	9.1%	1.8%
	Identified savings potential for primary intervention within inventory as of 1/1/2006			
	h	Electric energy % savings	23.8%	4.8%
	i	Electric peak demand % savings	23.8%	4.8%
	Identified savings potential for add-on intervention within inventory as of 1/1/2006			
	j	Electric energy % savings	4.8%	1.0%
	k	Electric peak demand % savings	4.8%	1.0%
2		**Program Participation**		
	Primary intervention for 2006 existing			
	a	Participation in Year 1 (% of 2006 inventory)	1.0%	0.5%
	b	Ultimate annual participation rate (% of 2006 inventory)	2.0%	0.5%
	c	Year ultimate participation reached	4	1
	d	Net-to-gross ratio for primary intervention	0.90	0.10
	Add-on intervention for 2006 existing			
	e	Participation in Year 1 (% of 2006 inventory)	1.0%	0.5%
	f	Ultimate annual participation rate (% of 2006 inventory)	2.0%	0.5%

	g	Year ultimate participation reached	4	1
	h	Net-to-gross ratio for add-on component	0.90	0.10
3		**Program costs**		
	a	Administration start up cost premium (total over years 1 - 3)	$150,000	$10,000
	b	Base administrative costs (% of all intervention costs)	7%	1%
	Primary intervention for 2006 existing			
	c	Additional costs above variable costs for intervention (annual)	$50,000	$10,000
	d	Market management and field staff (% of variable costs)	25%	5%
	e	Incentive costs per annual kWh saved	$0.09	$0.01
	f	Incentive costs per peak kW reduced	$225	$25
	Add-on intervention for 2006 existing			
	g	Additional costs above variable costs for intervention (annual)	$25,000	$5,000
	h	Market management and field staff (% of variable costs)	25%	5%
	i	Incentive costs per annual kWh saved	$0.09	$0.01
	j	Incentive costs per peak kW reduced	$225	$25
4		**Measure life (years)**	15	3

1. Per Unit Impacts

Lighting is the primary electric end use in commercial buildings, accounting for over 45 percent of total electric consumption in commercial buildings (WPS/McGraw Hill, 2004). The size of the lighting market in Wisconsin was estimated by first using data from a WPS/McGraw Hill survey (2004) to break out lighting from other end uses in various commercial building types in Heating and Cooling Zone 1. Percentages of electric use by commercial building type were obtained from a Focus on Energy baseline market research study (XENERGY, 2002). These values were then scaled to an estimated level for 2005 (10,007 GWh) based on PSC-Wisconsin commercial electric forecast data for 2004-2015 (PSC, 2004 and Kliebenstein, 2005).

Wisconsin Public Service Corporation (WPSC) analyzed hourly commercial loads by building type and end-use to develop four end-use load factors (WPSC, 2005). The hourly load curves were calibrated to weather-adjusted estimates for commercial load in WPSC territory. Billing data and SIC codes were used for the energy estimates, and the load shapes were applied by building type to get the peak estimates. The load factor ratio for lighting was estimated to be 0.000191 GW/GWh.

In contrast, lighting is a fairly minor end use in the industrial sector based on total consumption, making up under 8 percent, or approximately 1,994 GWh in 2005 (EIA, 2005). We assumed that high bay fixtures make up a significantly higher percentage of fixtures in Wisconsin industrial facilities than in commercial facilities (Navigant, 2002). The percentages of electric usage for industry type and end-use were applied to the forecast of peak loads for Wisconsin industry.

We estimated the energy consumption of commercial and industrial lighting systems in Wisconsin for 2005 to be 12,001 GWh, with growth of 2.8 percent per year. To account for uncertainty between end-use shares while keeping the analysis within the overall forecasts, we estimated the market size at 95 percent (+/-5%) of the estimated end-use share. This translates to 11,401 GWh (+/- 570 GWh). Applying the summer peak load to annual energy usage ratio, we estimated the peak load for this market to be 2,074 MW (+/- 104 MW).

We estimated the impact on natural gas use for heating to be 50 percent of the lighting energy savings, for a six month period, and assuming an 85 percent efficient heating system; this results in an additional space heating requirement of 10 therms per lighting MWh saved.

Installed base lighting average wattage was determined using an estimated percentage of high efficiency fixture saturation versus standard efficiency options.

Fluorescent fixtures – T8 fixtures are estimated to comprise 56.7 percent of existing fluorescent fixtures (KEMA, 2005). T12 34 W fixtures are assumed to make up 30 percent of existing fixtures and T12 40 W fixtures are assumed to make up 13.3 percent. Base fixture wattages are assumed to be 2-lamp fixtures. T8 fixture wattage is estimated to be 62 W, T12 34 W fixture with energy saving ballast is assumed to be 66 W, and 40 W T12 fixture with magnetic ballast is assumed to be 88 W (Xcel, 2004). The weighted average base fixture wattage is then 66.7 W.

Incandescent application fixtures – CFL bulbs or fixtures are estimated to comprise 43.6 percent of incandescent application fixtures, with 56.4 percent being incandescent or halogen (KEMA, 2005). Market average CFL wattage is assumed to be 25 W while incandescent wattage is assumed to be 60 W (Xcel, 2004). The weighted average base incandescent application fixture wattage is then 42.6 W.

High bay fixtures – High bay fluorescent fixtures are assumed to comprise less than 10 percent of the high bay fixture market, with the remainder being HID fixtures. HID wattage is assumed to be 460 W including the ballast, while high bay fluorescent wattage is assumed to be 270 W (Xcel, 2004). The weighted base high bay fixture wattage is then 441.8 W.

Exit signs – LED exit signs are estimated to comprise 48.3 percent of the in-place exit sign stock (KEMA, 2005). Fluorescent exit signs are estimated to be 35 percent of the stock and incandescent exit signs are estimated to be 16.7 percent of the stock. LED exit sign wattage is assumed to be 4 W, fluorescent exit sign wattage is assumed to be 26 W, and incandescent exit sign wattage is assumed to be 40 W (Xcel, 2004). The weighted base exit sign wattage is then 17.7 W.

Naturally occurring current practice replacement wattages are estimated as follows:

Fluorescent fixtures – T8 fixtures are estimated to comprise 87 percent of replacement fluorescent fixtures (KEMA, 2005). T12 34 W fixtures are assumed to make up 2 percent of existing fixtures and high-performance T8 or T5 fixtures are assumed to make up 11 percent. Base fixture wattages are assumed to be 2-lamp fixtures. T8 fixture wattage is estimated to be 62 W, T12 34 W fixture with energy saving ballast is assumed to be 66 W, and high-performance T8 or T5 wattage is assumed to be 54 W (Xcel, 2004). The weighted average base fixture wattage is then 61.2 W, resulting in 8.1 percent savings over base.

Incandescent application fixtures – CFL bulbs or fixtures are estimated to comprise 60 percent of incandescent application fixtures, with 40 percent being incandescent or halogen (KEMA, 2005). Market average CFL wattage is assumed to be 25 W while incandescent wattage is assumed to be 60 W (Xcel, 2004). The weighted average base incandescent application fixture wattage is then 39 W, for an 8.4 percent savings over base.

High bay fixtures – High bay fluorescent fixtures are assumed to comprise 34 percent of high bay fixture installations, with the remainder being HID fixtures. HID wattage is assumed to be 460 W including the ballast, while high bay fluorescent wattage is assumed to be 270 W (Xcel, 2004). The weighted base high bay fixture wattage is then 395.4 W, for a 10.5 percent savings over base.

Exit signs – The U.S. Congress (2005) passed a law mandating exit signs manufactured after January 1, 2006 draw 5 watts or less. LED exit sign wattage is assumed to be 4 W (Xcel, 2004), and this serves as our baseline for standard replacements.

Overall standard practice replacement savings based on estimated fixture type installation proportions of total lighting electric sales (73.9 percent fluorescent tube, 13.4 percent incandescent application, 11.7 percent high bay, and 1.0 percent exit sign) is 9.1 percent.

Program wattages are as follows:

Fluorescent fixtures or lamp and ballast retrofits – Program savings assume high performance T8 or T5 lighting, with wattage estimated to be 54 W (Xcel, 2004). The weighted average base fixture wattage is then 54 W, resulting in 11.8 percent savings over standard practice installations.

Incandescent application fixtures – Program savings assume hard-wired CFL fixtures with wattage estimated to be 25 W (Xcel, 2004). The weighted average base incandescent application fixture wattage is then 25 W, for a 25.1 percent savings over standard installation. It is also assumed that CFL fixtures would only be applicable in 70 percent of installations. Inappropriate installations would include certain retail applications and galleries where halogen is used exclusively for ideal color rendering.

High bay fixtures – Program savings is based on high bay fluorescent lighting, with wattage assumed to be 270 W (Xcel, 2004). The weighted base high bay fixture wattage is then 270 W, for a 22.2 percent savings over standard practice. It is also assumed that high bay fluorescent fixtures would only be applicable in 70 percent of installations. Inappropriate installations would include low temperature applications in which lumen output would be dramatically reduced, and dirty, dusty, or oily environments. Pulse start metal halide fixtures would be the alternative technology.

Exit signs – Program savings are based on LED exit signs, with wattage assumed to be 4 W (Xcel, 2004).

Overall savings based on estimated fixture type relative to base installation proportions of total lighting electric sales (73.9 percent fluorescent tube, 13.4 percent incandescent application, 11.7 percent high bay, and 1.0 percent exit sign) is 14.7 percent.

Retrofit program savings is the difference between the base wattage and program wattage, or 23.8 percent (9.1 percent + 14.7 percent).

Additional system improvements, described as an Add-On Component in the model input table included occupancy sensors. Occupancy sensors are estimated to result in an average of 4.8 percent savings from total electric lighting sales based on savings of 9 percent for offices, 47 percent for restrooms, 23 percent for break rooms, and 14.5 percent for classrooms (Von Neida, Maniccia and Tweed, 2000) and an estimated floors space percentage for each of those space types.

2. Program Participation

The program is assumed to target primarily customer segments that are harder to reach, including but not limited to small commercial and industrial businesses that seldom remodel or undertake efficiency upgrades on their own. Other targeted groups include schools, government, and distressed businesses. The target market for retrofit efforts is assumed to be 33 percent of the total lighting market opportunity that exists as of year 1 of the program.

For these interventions, it is assumed that 1 percent of the remaining energy savings potential is captured in year 1, ramping up to 2 percent per year of the potential after 4 years, where it levels off. On this participation schedule, 18 percent of commercial and industrial customers will participate in this market after 10 years, which is 54 percent of the 33 percent targeted for retrofit. In support of this assumption, National Grid reports that 55 percent of eligible customers have participated in their Energy Initiative Custom retrofit program over a 10 year time frame (York and Kushler, 2003). The Small Business Services Program operated by National Grid reports 33 percent participation of the eligible population of customers with a demand less than 100 kW (York and Kushler, 2003).

The net to gross ratio is assumed to be 0.90 with an uncertainty of 0.10. This allows a net-to-gross as high as 1.0, reported by some programs serving small businesses (Quantum, 2004a), or as low as 0.80, reported by National Grid for their Energy Initiative Program (Quantum, 2004b).

3. Program Costs

Program costs reflect approximations we made following the review of costs for mature programs with similar approaches and participation levels (Quantum, 2004a). Incentive costs are 74 percent of total program costs, while non-incentive costs are 26 percent. Non-incentive costs are relatively higher than other markets due to the need to provide greater implementation assistance to this market. Start up costs of $150,000 over three years ($50,000 per year) are allocated to achieve a statewide effort, filling gaps in areas such as market research, information and outreach, demonstration projects, tools, and case studies. A general administrative cost of 7 percent of all intervention costs provides funding for management of the overall market effort, program specific tracking and reporting, planning meetings, and other expenses.

Costs for each intervention in the market are broken into three categories:

- incentives for participants, suppliers, and other program allies;
- a market manager to handle day-to-day responsibilities and field staff to work with participants on specific projects; and
- annual fixed costs for activities such as training, product and service development (tools, manuals, guides, software, etc.).

Incentives are paid for electric energy and demand savings. The overall incentive pool may be provided as participant rebates, supplier rebates, on-site evaluations, or other project specific costs to influence participation. The incentive costs for this intervention were intended to cover approximately 50 percent to

75 percent of retrofit measure costs. The modeled incentives reduce the payback of measures by about 2.1 years.

4. Measure Life

A measure life of 15 years was used in the lighting input model with an uncertainty of +/- 3 years (Quantum, 2004a).

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MARKET 6 — NEW AND REPLACEMENT COMMERCIAL CHILLERS AND SYSTEM IMPROVEMENTS

Market Scope

This market comprises new commercial chillers, both as replacements for existing units and units installed in new construction. It also includes system improvements such as variable frequency drives for chilled water pumps, floating head pressure controls, tune ups, and water side economizers (plate and frame heat exchangers).

Market Characteristics

Almost 27 percent of commercial floor space in Wisconsin is cooled using chilled water produced by centrifugal, reciprocating, or screw chillers (EIA, 1999). According to a report by KEMA, Inc. (2005), as many as 816 units are sold each year in Wisconsin, accounting for 82,000 tons of cooling capacity. This equates to an average size of just over 100 tons per unit.

A study by Navigant Consulting (2004), reports that most water-cooled chillers sold in 2004 had efficiencies of 0.60 kW/ton or better, with the best available being 0.48 kW/ton. According to that same study, the installed base of chillers has efficiencies of 0.75 kW/ton or worse. Air-cooled and water-cooled chiller efficiencies have improved dramatically over the past 20 years, and some models now come equipped with electronic adjustable speed drives. In addition, loss of efficiency due to equipment degradation over time results in older installed equipment being significantly less efficient than even the standard efficiency new chillers.

Chiller system improvements at the time of chiller replacement or for their own sake can also significantly affect the efficiency of the system. The chiller compressor motor obviously accounts for the majority of energy consumption and peak demand impact of the chillers system, but primary and secondary chilled water pumps, condenser water pumps, and cooling tower fans can account for 30 percent or more of the total system energy consumption, and the way they are utilized in the system can also affect the performance of the chiller itself. Another source of energy savings is operating improvements made through the energy management control system, such as scheduling, chilled water temperature reset, and condenser water temperature reset. Opportunities at the cooling tower include variable speed drives or two-speed motors for fans.

High efficiency chillers have been eligible for Focus on Energy custom rewards at the rate of $0.03/kWh and $45 per peak kW. It is not known how this and programs offered directly by utilities have impacted sales of high efficiency chillers, but according to the KEMA, Inc. study (2005), 50 percent to 70 percent of distributors, contractors, and designers “almost always” promote energy efficiency.

A recent study of the non-residential HVAC market in Wisconsin helped identify areas and aspects of the supply chain that are leverage points for current or refined program activities (Quantum, 2003). The findings and recommendations from that research that are most relevant to this market include:

- Large new construction and renovation projects should be identified and tracked at their earliest stages to ensure and influence appropriate consideration of efficiency options. These projects offer the greatest potential for influencing designers and contractors and capturing the most cost-effective savings, which are often design related.

- Interventions for larger projects and those with central plants should focus on designers
- Efforts should be made to encourage more efficient boiler and chiller systems (as opposed to less efficient packaged systems) where appropriate. System optimization and controls should be reinforced.
- Efforts to work with suppliers should be personalized and sustained over time. Virtually all trade allies value committed, long-term business relationships.
- Supply-side actors consistently perceive first-cost orientation to be the greatest end user obstacle to increased adoption of energy efficient HVAC systems in Wisconsin's C/I sector. Lack of knowledge, lack of capital, reliability, and bidding and design process structures were also mentioned as significant barriers. The cost barrier is especially significant in competitive bid situations that involve multiple supply-side actors.
- Suppliers believe that the keys to reducing end user barriers to adoption of efficient C/I HVAC systems are to improve and extend communication of payback and return-on-investment information to owners on a job-specific basis, generally improve end users understanding of the financial benefits of efficiency investments, buy-down initial costs with incentives, and achieve upstream price reductions by manufacturers. A few suppliers mentioned providing financing and case studies and demonstration projects.

Program Approaches

Our analysis of this market considered two program components:

- increase the market share for high efficiency chillers,
- promote chiller system practices and improvements that result in more efficient system operation

PROGRAM AREA 6.01 — INCENTIVES FOR HIGH EFFICIENCY CHILLERS AND CHILLER SYSTEM IMPROVEMENTS

Our analysis of the achievable potential for this program area is projected from an incentive to cover 50 percent to 100 percent of the incremental cost for a new or replacement chiller. As an add-on component, our model assumes training, tools and incentives are provided to encourage system improvements at the time of installation or on their own.

TABLE 6.01.1. ESTIMATED VALUES FOR PROGRAM AREA 6.01, INCENTIVES FOR HIGH EFFICIENCY CHILLERS AND CHILLER SYSTEM IMPROVEMENTS

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$469 to $667	$618 to $889
	Incremental Impacts	peak kW	768 to 1,196	1,092 to 1,693
		annual kWh (000s)	1,849 to 3,028	2,615 to 4,247
		annual therms (000s)	0	0
	Levelized resource cost	per peak kW	$38 to $65	$35 to $60
		per kWh	1.6¢ to 2.6¢	1.5¢ to 2.4¢
		per therm	NA	NA
Scaling factors[a]		program costs	1.0 to 2.1	1.0 to 2.1
		impacts	1.0 to 1.4	1.0 to 1.4

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Below, we document the technical assumptions we made for the cooling energy savings in the commercial chiller market.

Program Area 6.01 — Incentives for New and Replacement Commercial High Efficiency Chillers and Chiller System Improvements

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 6.01.2. MODEL INPUTS FOR INCENTIVES FOR NEW AND REPLACEMENT COMMERCIAL HIGH EFFICIENCY CHILLERS AND CHILLER SYSTEM IMPROVEMENTS

Model Inputs (06.01)			**Value**	**±**
1		**Impacts**		
	a	2005 market size (GWh)	452	23
	b	2005 market size (peak MW)	253	13
	c	Annual market growth rate (2006-2015)	2.9%	0.2%
	Efficiency improvement within 2006 inventory w/o program intervention			
	d	Annual market undergoing improvements (2006-2015)	4.3%	1.0%
	e	Electric energy % saved within failed systems	20.5%	4.1%
	f	Electric peak demand % saved within failed systems	20.5%	4.1%
	Identified savings potential for primary intervention within replacement inventory as of 1/1/2006			
	g	Annual market for intervention (2006-2015)	4.3%	1.0%
	h	Electric energy % savings (normal replacements)	17.9%	3.6%
	i	Electric peak demand % savings (normal replacements)	17.9%	3.6%
	Identified savings potential for add-on intervention within inventory as of 1/1/2006			
	j	Electric energy % savings	14.4%	4.8%
	k	Electric peak demand % savings	6.1%	1.2%
	Identified savings potential in new usage with primary intervention			
	l	Electric energy % savings	17.9%	3.6%
	m	Electric peak demand % savings	17.9%	3.6%
2		**Program Participation**		
	Primary intervention for 2006 existing			
	a	Participation in Year 1 (% of 2006 replaced inventory)	10%	1%
	b	Ultimate annual participation rate (% of replaced inventory)	40%	10%
	c	Year ultimate participation reached	5	1
	d	Net-to-gross ratio for primary intervention	0.81	0.12

		Add-on intervention for 2006 existing		
	e	Participation in Year 1 (% of 2006 total inventory)	1.0%	0.5%
	f	Ultimate annual participation rate (% of total inventory)	4.0%	1.0%
	g	Year ultimate participation reached	5	1
	h	Net-to-gross ratio for add-on component	0.80	0.10
		Primary intervention for new usage		
	i	Participation in Year 1 (% of annual new usage)	10%	1%
	j	Ultimate annual participation rate (% of annual new usage)	40%	10%
	k	Year ultimate participation reached	5	1
	l	Net-to-gross ratio for primary intervention	0.81	0.12
3		**Program costs**		
	a	Administration start up cost premium (total over years 1 - 3)	$75,000	$15,000
	b	Base administrative costs (% of all intervention costs)	4%	1%
		Primary intervention for 2006 existing		
	c	Additional costs above variable costs for intervention (annual)	$30,000	$10,000
	d	Market management and field staff (% of variable costs)	15%	5%
	e	Incentive costs per annual kWh saved	$0.06	$0.01
	f	Incentive costs per peak kW reduced	$125	$25
		Add-on intervention for 2006 existing		
	g	Additional costs above variable costs for intervention (annual)	$40,000	
	h	Market management and field staff (% of variable costs)	15%	5%
	i	Incentive costs per annual kWh saved	$0.08	$0.01
	j	Incentive costs per peak kW reduced	$200	$20
		Primary intervention for new usage		
	k	Additional costs above variable costs for intervention (annual)	$15,000	$5,000
	l	Market management and field staff (% of variable costs)	15%	5%
	m	Incentive costs per annual kWh saved	$0.06	$0.01
	n	Incentive costs per peak kW reduced	$125	$25
4		**Measure life (years)**	23	5

1. Per Unit Impacts

The size of the chiller market in Wisconsin was estimated by first using data from a Wisconsin Public Service/McGraw Hill survey (2004) to break out cooling from other end uses in various commercial building types in Heating and Cooling Zone 1. Percentages of electric and gas use by commercial building type were obtained from a Focus on Energy baseline market research study (XENERGY, 2002). An estimate of chiller consumption in Wisconsin was then calculated using EIA/CBECS data tables (EIA, 1999) to determine the percentage of building type square footage cooled by chillers versus other means such as unitary systems. This number was then scaled to an estimated level for 2005 based on PSC-Wisconsin commercial electric forecast data for 2004-2015 (PSC, 2004 and Kliebenstein, 2005).

Following this approach, the energy consumption of chillers in Wisconsin was estimated to be 475 GWh of a total 21,934 GWh total commercial sales projected for 2005. To account for uncertainty between end-use shares while keeping the analysis within the overall commercial forecast, we estimated the market size for chillers at 95 percent (+/- 5%) of the estimated end-use share. This translates to 452 GWh (+/- 23 GWh).

Wisconsin Public Service Corporation (WPSC) analyzed hourly commercial loads by building type and end-use to develop four end-use load factors (WPSC, 2005). The hourly load curves were calibrated to weather-adjusted estimates for commercial load in WPSC territory. Billing data and SIC codes were used for the energy estimates, and the load shapes were applied by building type to get the peak estimates. The load factor ratio for cooling was estimated to be 0.000560 GW/GWh. Applying the summer peak load to annual energy usage ratio provided by WPSC, we estimated the peak load for this market to be 253 MW (+/- 13 MW).

Annual chiller replacement rates were estimated by using the inverse of the average life of a chiller. Chillers are estimated to have a 23 year life (Navigant, 2004), therefore the annual replacement rate is estimated at 1/23, or 4.3 percent. System improvement measures to existing systems may be applied at the time of replacement or on their own.

Annual savings for naturally occurring replacements and program influenced replacements were calculated using an average installed base efficiency of 0.78 kW/ton, a naturally occurring replacement average efficiency of 0.62 kW/ton, and an ideal replacement efficiency of 0.48 kW/ton (Navigant, 2004).

Impact on natural gas use for heating from electric load reduction was estimated to be negligible as most chiller systems will not be operated during the majority of the heating season, and chiller plants are often located remotely, in penthouse suites, or in vented basements.

Naturally occurring replacement savings was estimated to be 20.5 percent based on the efficiency levels described above. If all chillers replaced were replaced with the most efficient units we determined that additional savings of 17.9 percent could be achieved.

Additional chiller system improvements, described as an Add-On Component in the model input table included a chiller tune-up (de-scaling, water treatment, etc.), installation of variable frequency drives on secondary chilled water pumps, floating head pressure controls (made possible by increased fan operation or up-sizing of the cooling tower), and installation of a water side economizer (plate and frame heat exchanger).

Tune-ups were estimated to provide an average of 2 percent savings based on data seen for boilers and rooftop units. Variable frequency drives on chilled water pumps were estimated to provide an average of 4 percent savings (assuming that chilled water pumps account for roughly 12 percent of chiller system energy consumption and that those pumps could be run at an average of 85 percent speed based on common system over-sizing). Floating head pressure controls were estimated to provide an average of 8 percent savings (assuming that a 10° F reduction in average condenser water temperature was possible with a 2 percent penalty for increased cooling tower fan use). Installation of water side economizers was estimated to provide 6.5 percent savings (based on 1,257 hours with Dry Bulb Temperatures between 32° F and 45° F and Wet Bulb Temperatures below 40° F). Water side economizers are only appropriate in buildings that require cooling for the majority of the year (such as hospitals and large office buildings with significant heat generated by computer equipment). This was factored into the savings percentage.

The overall energy savings potential for boiler system add on measures ranged from 19.2 percent (assuming that all add on measures are installed), to 9.6 percent (assuming that only half the measures are installed). We used a midpoint estimate of 14.4 percent (+/- 4.8%) to describe the savings potential. Peak load reduction was estimated to be 6.1 percent because water side economizers and floating head pressure control were determined not to impact peak summer demand.

2. Program Participation

We modeled the interventions to achieve program participation for new or replacement chillers beginning at 10 percent (+/- 1%) in year one and ramping up to peak participation of 40 percent (+/- 10%) by year 5 (+/- one year). The lower range of participation estimate is intended to extrapolate from current activity in Wisconsin, while the basis for the upper participation level includes an estimate of 50 percent participation from National Grid for their Design 2000 program (York and Kushler, 2003). The Design 2000 program targets similar customer types for large electric chiller upgrades. The net to gross ratio is assumed to be 0.81 with an uncertainty of 0.12, based on evaluations performed on programs that cover new construction, renovation, and remodeling in California (.65), National Grid (0.81), and Northeast Utilities (0.93) (Quantum, 2004a).

We modeled the add-on intervention to achieve program participation for system improvements beginning at 1.0 percent (+/- 0.5%) of the total stock, in year one and ramping up to peak participation of 4.0 percent (+/-1.0%) by year 5 (+/- one year). On this participation schedule, 32 percent of commercial chiller load will participate in this intervention after 10 years. In support of this assumption, National Grid reports that 55 percent of eligible electric customers have participated in their Energy Initiative Custom retrofit program over a 10 year time frame (York and Kushler, 2003). The Energy Initiative program targets similar customer types that our market targets for chiller improvements. A net to gross program value of 0.80 (+/- 0.10) was used, as reported by National Grid for their Energy Initiative Program (Quantum, 2004b).

3. Program Costs

Program costs reflect approximations we made following the review of costs for mature programs with similar approaches and customer targets (Quantum, 2004b). Incentive costs are 73 percent of total program costs, while non-incentive costs are 27 percent. Start up costs of $75,000 over three years ($25,000 per year) are allocated to achieve a statewide effort, filling gaps in areas such as market research, information and outreach, demonstration projects, tools, and case studies. A general administrative cost of 4 percent of all intervention costs provides funding for management of the overall market effort, program specific tracking and reporting, planning meetings, and other expenses.

Costs for each intervention in the market are broken into three categories:

- Incentives for participants, suppliers, and other program allies;
- A market manager to handle day-to-day responsibilities and field staff to work with participants on specific projects; and

- Annual fixed costs for activities such as training, product and service development (tools, manuals, guides, software, etc.).

Incentives are paid for energy and demand savings. The overall incentive pool may be provided as participant rebates, supplier rebates, on-site evaluations, or other project specific costs to influence participation. The incentive costs for new and replacement chiller intervention were intended to cover 75 percent to 90 percent of incremental upgrade costs, or approximately $25 per ton. The incentive for the add-on system improvements component provides approximately $16 per ton cooling capacity or a buy-down of two years of energy savings.

4. Measure Life

Measure life was based on data from a Navigant Consulting study (2004) of technology forecasts for residential and commercial buildings. A measure life of 23 years was used in the chiller input model.

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MARKET 7 — COMMERCIAL VENTILATION SYSTEM IMPROVEMENTS

Market Scope

This market comprises improvements to ventilation systems through controls enhancements, variable frequency drives on fan motors, and fine tuning of equipment schedules. The savings are additive to systems improvements included within boilers, chillers, and unitary HVAC.

Market Characteristics

This market encompasses the broad array of technologies and practices that can be applied to reduce ventilation energy use in commercial buildings, while maintaining indoor air quality. Annual savings were estimated from a subset of potential measures: fan motors with variable speed drives installed versus constant speed systems, as well as heating and cooling savings resulting from modifying equipment schedules and improved controls. Recent advances in control and sensor technology combined with cost reductions, as seen with demand-controlled ventilation, allow more efficient matching of ventilation with variable occupancy patterns.

Additional research is recommended to quantify the opportunities in detail for Wisconsin. For example, a specific area of ventilation not included that has savings potential is kitchen exhaust options for variable volume hoods. These controls would apply to restaurants, groceries, hotels with kitchens, hospitals and schools – a large range of the commercial market. Additionally, this market does not quantify the savings for heat and energy recovery opportunities in ventilation.

A recent study of the non-residential HVAC market in Wisconsin helped identify areas and aspects of the supply chain that are leverage points for current or refined program activities (Quantum, 2003). Recommendations and insights from that research that are most relevant to this market include:

- Interventions for larger projects and those with central plants should focus on designers, while those for smaller jobs featuring packaged units should target contractors. In addition, efforts should be made to encourage more efficient boiler and chiller systems (as opposed to less efficient packaged systems) where appropriate. System optimization and controls should be reinforced for both types of systems.
- Identifying and addressing supplier concerns about the reliability of specific types of efficient products and services is critical, particularly in cases where perceptions may be based on unrepresentative anecdotal experiences or information.
- Case studies and demonstration projects can be particularly useful and effective education tools for high efficiency products and services that are relatively new or may be recovering from a previously poor track record.
- Supply-side actors consistently perceive first-cost orientation to be the greatest end user obstacle to increased adoption of energy efficient HVAC systems in Wisconsin's C/I sector. Lack of knowledge, lack of capital, reliability, and bidding and design process structures were also mentioned as significant barriers. The cost barrier is especially significant in competitive bid situations that involve multiple supply-side actors.
- Suppliers believe that the keys to reducing end user barriers to adoption of efficient C/I HVAC systems are to improve and extend communication of payback and return-on-investment information to owners on a job-specific basis, generally improve end users understanding of the

financial benefits of efficiency investments, buy-down initial costs with incentives, and achieve upstream price reductions by manufacturers. A few suppliers mentioned providing financing and case studies and demonstration projects.

Program Approaches

Our analysis of this market considered two program components:

- Increase installation of variable frequency drives for supply and return fans, and digital controls to accurately meet desired set-points and equipment schedules
- Promote retro-commissioning efforts and fine tuning of equipment schedules to minimize outdoor air mixing during unoccupied or low-occupancy hours

PROGRAM AREA 7.01 — VENTILATION SYSTEM IMPROVEMENTS

Our analysis of the achievable potential for this program area is projected from an incentive to cover 50 percent to 100 percent of the cost for ventilation system improvements.

TABLE 7.01.1. ESTIMATED VALUES FOR PROGRAM AREA 7.01, INCENTIVES FOR VENTILATION SYSTEM IMPROVEMENTS

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		\$341 to \$646	\$448 to \$880
	Incremental Impacts	peak kW	0	0
		annual kWh (000s)	2,889 to 5,893	4,133 to 8,317
		annual therms (000s)	46 to 97	65 to 137
	Levelized resource cost	per peak kW	NA	NA
		per kWh	0.8¢ to 1.4¢	0.7¢ to 1.3¢
		per therm	11.1¢ to 21.9¢	10.6¢ to 20.8¢
Scaling factors[a]		program costs	1.4 to 2.8	1.4 to 2.8
		impacts	1.1 to 1.6	1.1 to 1.6

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Below, we document the technical assumptions we made for the energy savings in the commercial ventilation system market.

Program Area 7.01 — Incentives for Commercial Ventilation System Improvements

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 7.01.2. MODEL INPUTS FOR INCENTIVES FOR COMMERCIAL VENTILATION SYSTEM IMPROVEMENTS

Model Inputs (07.01)			Value	±
1		**Impacts**		
	a	2005 market size (GWh)	1,680	84
	b	2005 market size (peak MW)	332	17
	c	2005 market size (10^12 Btu)	8.2	0.4
	d	Annual electric market growth rate (2006-2015)	2.9%	0.2%
	e	Annual gas market growth rate (2006-2015)	2.0%	0.2%
	Efficiency improvement within 2006 inventory w/o program intervention			
	f	Annual market undergoing improvements (2006-2015)	6.7%	2.5%
	g	Electric energy % saved within failed systems	18.9%	3.8%
	h	Electric peak demand % saved within failed systems	0.0%	0.0%
	i	Natural gas energy % saved within failed systems	7.5%	1.5%
	Identified savings potential for primary intervention within inventory as of 1/1/2006			
	j	Annual market for intervention (2006-2015)	6.7%	2.5%
	k	Electric energy % savings (normal replacements)	12.6%	2.5%
	l	Electric peak demand % savings (normal replacements)	0.0%	0.0%
	m	Natural gas energy % savings (normal replacements)	5.0%	1.0%
	Identified savings potential in new usage with primary intervention			
	n	Electric energy % savings	12.6%	2.5%
	o	Electric peak demand % savings	0.0%	0.0%
	p	Natural gas energy % savings	5.0%	1.0%
2		**Program Participation**		
	Primary intervention for 2006 existing			
	a	Participation in Year 1 (% of 2006 replaced inventory)	10%	1%
	b	Ultimate annual participation rate (% of replaced inventory)	40%	10%
	c	Year ultimate participation reached	5	1
	d	Net-to-gross ratio for primary intervention	0.80	0.10

		Primary intervention for new usage		
	e	Participation in Year 1 (% of annual new usage)	10%	1%
	f	Ultimate annual participation rate (% of annual new usage)	40%	10%
	g	Year ultimate participation reached	5	1
	h	Net-to-gross ratio for primary intervention	0.81	0.12
3		**Program costs**		
	a	Administration start up cost premium (total over years 1 - 3)	$75,000	$15,000
	b	Base administrative costs (% of all intervention costs)	4%	1%
		Primary intervention for 2006 existing		
	c	Additional costs above variable costs for intervention (annual)	$30,000	$10,000
	d	Market management and field staff (% of variable costs)	15%	5%
	e	Incentive costs per annual kWh saved	$0.06	$0.01
	f	Incentive costs per peak kW reduced	$175	$25
	g	Incentive costs per annual therm reduced	$0.80	$0.10
		Primary intervention for new usage		
	m	Additional costs above variable costs for intervention (annual)	$20,000	$5,000
	n	Market management and field staff (% of variable costs)	15%	5%
	o	Incentive costs per annual kWh saved	$0.04	$0.01
	p	Incentive costs per peak kW reduced	$100	$25
	q	Incentive costs per annual therm reduced	$0.80	$0.10
4		**Measure life (years)**	15	5
5		**Proportion of program costs allocated to electric impacts**	80%	5%

1. Per Unit Impacts

The size of the ventilation market in Wisconsin was estimated by first using data from a Wisconsin Public Service/McGraw Hill survey (2004) to break out ventilation from other end uses in various commercial building types in Heating and Cooling Zone 1. This end use includes supply and return fan motor energy use, but does not include impacts on heating and cooling loads due to outdoor makeup air added to return air in air handling units. Percentages of electric and natural gas use by commercial building type were obtained from a Focus on Energy baseline market research study (XENERGY, 2002). Total commercial natural gas sales for 2005 were taken from energy statistics published by the Wisconsin Department of Administration, Division of Energy (DOA, 2004).

An estimate of ventilation equipment consumption in Wisconsin from the baseline study was then calculated and scaled to an estimated level for 2005 based on PSC-Wisconsin commercial electric forecast data for 2004-2015 (PSC, 2004 and Kliebenstein, 2005). The electric consumption for ventilation equipment in Wisconsin was estimated to be 1,466 GWh out of 21,934 GWh total commercial sales projected for 2005.

Efficiency measures that reduce excess ventilation will also reduce the heating and cooling energy used to condition outdoor air. In order to estimate the impact of outdoor air on heating and cooling systems, it was necessary to investigate the percentage of total heating and cooling loads made up of mechanical ventilation versus internal loads, conduction through building shells, direct solar gain, and infiltration. This investigation indicated that approximately 17 percent of heating and cooling loads in commercial buildings are the result of scheduled mixing of outdoor air with return air to provide fresh air for building occupants (APS and Reddy 2002). Applying this percentage to the derived electric and natural gas sales for heating and cooling results in estimates of heating and cooling usage attributed to ventilation. Cooling usage attributed to ventilation is estimated to be 302 GWh (of 1,778 GWh cooling sales).

Therefore, the target market for ventilation measures is the sum of the energy for ventilation equipment and the cooling component (1,466 + 302 = 1,768 GWh), plus the estimated heating sales attributed to ventilation, estimated to be 8.6×10^{12} Btu (of 50.8×10^{12} Btu heating sales). To account for uncertainty between end-use shares while keeping the analysis within the overall commercial forecast, we estimated the market size for ventilation measures at 95 percent (+/- 5%) of the estimated end-use shares. This translates to 1,680 GWh (+/- 84 GWh).

Wisconsin Public Service Corporation (WPSC) analyzed hourly commercial loads by building type and end-use to develop four end-use load factors (WPSC, 2005). The hourly load curves were calibrated to weather-adjusted estimates for commercial load in WPSC territory. Billing data and SIC codes were used for the energy estimates, and the load shapes were applied by building type to get the peak estimates. The load factor ratio for cooling was estimated to be 0.000560 GW/GWh, while ventilation was estimated to be 0.000123 GW/GWh. Applying the summer peak load to annual energy usage ratios provided by WPSC, we estimated the peak load for this market to be 332 MW (+/- 17 MW).

Annual ventilation system replacement rates were estimated by using the inverse of the average life of a rooftop unit. In this case, rooftop units were used as a surrogate for ventilation fans. Rooftop units are estimated to have a 15 year life (Navigant, 2004), therefore the annual replacement rate is estimated at 1/15, or 6.7 percent.

To calculate fan savings, we assumed that ventilation fans could be expected to run at 85 percent of full speed when averaged over the entire building stock and operating hours. It is expected that the fan would run at 70 percent speed at certain times and at other times it would run at 100 percent speed, but on average the speed reduction would be about 15 percent. Taking into account approximately 5 percent energy consumption by the variable frequency drive, energy savings for a fan running at an average of 85 percent speed would be 35.5 percent compared with a constant speed fan. The disproportionate energy savings (35.5 percent energy reduction for 15 percent speed reduction) are due to the fact that power varies by the speed of the motor cubed.

An approximation of the potential savings from improved controls on ventilation systems and fine tuning of equipment schedules is achieved by assuming that the equivalent of two hours could be eliminated from a sixteen hour occupied schedule for air handling equipment. This would reduce the intake of outdoor air by 2/16, or 12.5 percent. Additional research may be necessary to evaluate this savings estimate.

Savings that occur absent any intervention assume 60 percent of the system savings potential will occur naturally. Averaged across the entire market, this is an electric energy reduction of 18.9 percent and a gas reduction of 7.5 percent. The remaining savings potential may be captured through intervention, yielding 12.6 percent electric energy savings, and 5.0 percent gas energy savings.

2. Program Participation

We have modeled the intervention for new usage to achieve program participation for ventilation measures beginning at 10 percent (+/- 1%) in year one and ramping up to peak participation of 40 percent (+/-10%) by year 5 (+/- one year). The lower range of participation estimate is intended to extrapolate from current activity in Wisconsin, while the basis for the upper participation level includes an estimate of 50 percent participation from National Grid for their Design 2000 program (York and Kushler, 2003). The Design 2000 program targets similar customer types for large electric HVAC upgrades. The net to gross ratio is assumed to be 0.81 with an uncertainty of 0.12, based on evaluations performed on programs that cover new construction, renovation, and remodeling in California (.65), National Grid (0.81), and Northeast Utilities (0.93) (Quantum, 2004a).

We have modeled the intervention for existing usage to achieve program participation for ventilation measures beginning at 10 percent (+/- 1%) in year one and ramping up to peak participation of 40 percent (+/-10%) by year 5 (+/- one year). The lower range of participation estimate is intended to extrapolate from current activity in Wisconsin, while National Grid reports that 55 percent of eligible electric customers have participated in their Energy Initiative program over a ten year time frame (York and Kushler, 2003). The Energy Initiative program targets similar customer types that our market targets for ventilation measures. A net to gross program value of 0.80 (+/- 0.10) was used, reported by National Grid for their Energy Initiative Program (Quantum, 2004b).

3. Program Costs

Program costs reflect approximations we made following the review of costs for mature programs with similar approaches and customer targets (Quantum, 2004b). Incentive costs are 76 percent of total program costs, while non-incentive costs are 24 percent. Start up costs of $75,000 over three years ($25,000 per year) are allocated to achieve a statewide effort, filling gaps in areas such as market research, information and outreach, demonstration projects, tools, and case studies. A general administrative cost of 4 percent of all intervention costs provides funding for management of the overall market effort, program specific tracking and reporting, planning meetings, and other expenses.

Costs for each intervention in the market are broken into three categories:

- Incentives for participants, suppliers, and other program allies;
- A market manager to handle day-to-day responsibilities and field staff to work with participants on specific projects; and
- Annual fixed costs for activities such as training, product and service development (tools, manuals, guides, software, etc.).

Incentives are paid for therms, electric energy and demand savings. The overall incentive pool may be provided as participant rebates, supplier rebates, on-site evaluations, or other project specific costs to influence participation. The incentive costs for these interventions were intended to cover between 50 percent to 75 percent of measures costs, with a buy-down of approximately one year for new usage, and 1.5 years for existing usage.

4. Measure Life

Measure life was based on data from a Navigant Consulting study (2004) of technology forecasts for residential and commercial buildings. A measure life of 15 years was used in the ventilation input model.

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MARKET 8 —COMMERCIAL REFRIGERATION IMPROVEMENTS

Market Scope

This market comprises installation of higher efficiency commercial refrigeration equipment, both as replacements for worn existing units and new units installed in new construction or store renovations. System types include built-up, central refrigeration systems commonly seen in groceries and supermarkets, and packaged or "self-contained" systems that incorporate the refrigeration system with the refrigerated compartment as a single unit. This market also includes add-on efficiency measures for existing equipment such as tune ups, replacing door gaskets, adding strip curtains to walk-in coolers, adding controls, and other energy saving actions. This model addresses only refrigeration energy savings, not the interactive impacts on heating, cooling, or ventilation from improving system efficiency.

Market Characteristics

The two major categories of commercial refrigeration are packaged and built-up systems (Kubo, 2002):

- Packaged systems, also called "self-contained" systems, incorporate the refrigeration system along with the refrigerated compartment in a single package. The whole component is built at the factory and then shipped to the site. Examples of packaged refrigeration systems include commercial refrigerators and freezers, vending machines, ice-makers, beverage merchandisers, and walk-in refrigerators and freezers.
- Built-up systems, also called "remote" or "centralized" systems, typically involve a single compressor or compressor rack that serves a number of refrigerated cases and are usually custom designed and built on-site. These systems are extensively used in supermarkets.

Refrigeration is a significant energy user in Wisconsin. The size of the commercial refrigeration market in Wisconsin was estimated to be 2,028 GWh out of 21,934 GWh total commercial sales projected for 2005, or 9 percent of commercial energy use. A recent survey by KEMA (2005) found that at least 2/3 of commercial users surveyed in all business types reported some refrigeration, including 100 percent of restaurants surveyed, 94 percent of grocery stores, 83 percent of health care, and 71 percent of education. Within groceries, 66 percent of electric energy is used for refrigeration (WPS/McGraw Hill, 2004). Restaurants consume 32 percent for refrigeration, health care 6 percent, lodging 4 percent, retail 3 percent, and schools 2 percent. For the state overall, 85 percent of the 2,208 GWh of refrigeration energy is used within two business types: groceries use 56 percent of the total and 29 percent is used in restaurants.

Although considerable attention has been given to the energy usage of built-up systems, packaged systems account for 2/3 of commercial refrigeration energy usage (ADL, 1996). After evaluating results from the detailed technical study done for the U.S. Department of Energy (ADL, 1996), Kubo and Nadel (2002) have concluded that the energy use of most packaged refrigeration systems can be reduced by 20 percent to 50 percent with simple payback periods of under three years. Common efficiency improvements identified include high efficiency compressors, ECM motors for condenser and evaporator fans, variable speed compressors, thicker insulation, more efficient lighting, improved fan blades, and non-electric anti-sweat heaters (ADL, 1996).

Market research has identified a number of market barriers that limit the adoption of refrigeration efficiency measures, including the following:

- When owners are making equipment purchasing decisions, refrigeration contractors say efficiency ranks below reliability, first cost, and effect on sales (KEMA, 2005).
- The importance of loyalty and trust in the relationship that businesses (mainly restaurants and groceries) have with their contractors and distributors requires that program interventions work closely with buyers and sellers. If a contractor or distributor does not offer an efficient model of a piece of equipment, buyers will be hesitant to shop elsewhere, given the lower priority placed on efficiency (Guilfoyle & Fagan, 2005).
- Manufacturers believe that some stores see risks associated with some technologies, such as lack of ability to maintain sophisticated controls, sanitation concerns, or the cost of a service call for a malfunctioning efficiency measure overwhelming the energy savings (KEMA, 2005).
- Limited availability of information on comparative energy use of products (Kubo, 2002), and vendor unfamiliarity and bias regarding some efficiency measures (Guilfoyle & Fagan, 2005).
- Third-party decision makers (Kubo, 2002).
- Manufacturer and purchaser emphasis on first cost (Kubo, 2002).
- Sales of used equipment are a large part of the refrigeration market. Failed equipment is not always replaced with new equipment, and all equipment for new grocery stores and restaurants is not new equipment. The lower first cost of used equipment is especially important with restaurants and groceries as they operate on low margins, and restaurants have a high failure rate (Guilfoyle & Fagan, 2005).

To increase the adoption of refrigeration efficiency measures, refrigeration contractors had the following suggestions; listed from higher to lower priority (KEMA, 2005):

- Tools to analyze payback
- Cash incentives to customers
- Sales training to contractors
- Training for contractors in energy efficiency
- Cash incentives for vendors
- Training for customers in energy efficiency

The U.S. Congress (2005) passed a law mandating minimum energy efficiency levels for a variety of commercial refrigeration equipment manufactured after January 1, 2010. The impacts of these equipment standards, described in the Energy Policy Act of 2005 (U.S. Congress, 2005), are reflected in the input values. National efforts that could benefit from local involvement include development of energy testing standards, compilation of a database of comparative energy use, involvement in EPA Energy Star initiatives, and continued upgrades to codes and standards (Kubo, 2002).

Program Approaches

Our analysis of this market considered two program efforts:

- Increase the market share for new and replacement refrigeration equipment with high efficiency features, targeting larger players on the supply (contractors, manufacturers, designers) and demand side (chains, supermarkets) with incentives and other assistance.

- Promote best practices and install retrofit improvements to existing systems that result in more efficient system operation. As suggested by KEMA (2005), this effort could target smaller stores and independents for low cost measures (strip curtains, gasket repair, door closers, alarms, and anti-sweat heater controls) using rebates to bring down the payback.

PROGRAM AREA 8.01 — INCENTIVES FOR NEW AND REPLACEMENT COMMERCIAL REFRIGERATION EQUIPMENT AND OTHER SYSTEM IMPROVEMENTS

Our analysis of the achievable potential for this program area is projected from an incentive to cover 50 percent to 100 percent of the incremental cost for a more efficient new or replacement refrigeration packaged or built-up system. As an add-on component, we provide incentives and assistance for retrofit of existing equipment.

TABLE 8.01.1. ESTIMATED VALUES FOR PROGRAM AREA 8.01, INCENTIVES FOR NEW AND REPLACEMENT COMMERCIAL REFRIGERATION EQUIPMENT AND OTHER SYSTEM IMPROVEMENTS

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		\$626 to \$1,075	\$878 to \$1,549
	Incremental Impacts	peak kW	439 to 963	642 to 1,422
		annual kWh (000s)	3,003 to 6,486	4,385 to 9,557
		annual therms (000s)	0 to 0	0 to 0
	Levelized resource cost	per peak kW	\$115 to \$237	\$110 to \$227
		per kWh	1.8¢ to 3.2¢	1.8¢ to 3.1¢
		per therm	NA to NA	NA to NA
Scaling factors[a]		program costs	0.8 to 1.8	0.8 to 1.8
		impacts	0.9 to 1.4	0.9 to 1.4

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Below, we document the technical assumptions we made for the energy savings in the commercial refrigeration market.

Program Area 8.01 — Incentives for New and Replacement Commercial Refrigeration Equipment and Other System Improvements

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 8.01.2. MODEL INPUTS FOR INCENTIVES FOR NEW AND REPLACEMENT COMMERCIAL REFRIGERATION EQUIPMENT AND OTHER SYSTEM IMPROVEMENTS

Model Inputs (08.01)			Value	±
1		**Impacts**		
	a	2005 market size (GWh)	1,825	203
	b	2005 market size (peak MW)	268	30
	c	Annual electric market growth rate (2006-2015)	2.9%	0.2%
		Efficiency improvement within 2006 inventory w/o program intervention		
	d	Annual market undergoing improvements (2006-2015)	8.3%	2.2%
	e	Electric energy % saved within failed systems	12.8%	3.0%
	f	Electric peak demand % saved within failed systems	12.8%	3.0%
		Identified savings potential for primary intervention within replacement inventory as of 1/1/2006		
	g	Annual market for intervention (2006-2015)	8.3%	2.2%
	h	Electric energy % savings (normal replacements)	15.7%	4.0%
	i	Electric peak demand % savings (normal replacements)	15.7%	4.0%
		Identified savings potential for add-on intervention within inventory as of 1/1/2006		
	j	Annual market for intervention (2006-2015)	8.3%	2.2%
	k	Electric energy % savings	8.0%	4.0%
	l	Electric peak demand % savings	8.0%	4.0%
		Identified savings potential in new usage with primary intervention		
	m	Electric energy % savings	15.7%	4.0%
	n	Electric peak demand % savings	15.7%	4.0%
2		**Program Participation**		
		Primary intervention for 2006 existing		
	a	Participation in Year 1 (% of 2006 replaced inventory)	5%	1%
	b	Ultimate annual participation rate (% of replaced inventory)	30%	10%
	c	Year ultimate participation reached	5	1

	d	Net-to-gross ratio for primary intervention	0.80	0.10
		Add-on intervention for 2006 existing		
	e	Participation in Year 1 (% of 2006 replaced inventory)	5%	1%
	f	Ultimate annual participation rate (% of replaced inventory)	30%	10%
	g	Year ultimate participation reached	5	1
	h	Net-to-gross ratio for add-on component	0.80	0.10
		Primary intervention for new usage		
	i	Participation in Year 1 (% of annual new usage)	5%	1%
	j	Ultimate annual participation rate (% of annual new usage)	30%	10%
	k	Year ultimate participation reached	5	1
	l	Net-to-gross ratio for primary intervention	0.80	0.10
3		**Program costs**		
	a	Administration start up cost premium (total over years 1 - 3)	$75,000	$15,000
	b	Base administrative costs (% of all intervention costs)	4%	1%
		Primary intervention for 2006 existing		
	c	Additional costs above variable costs for intervention (annual)	$30,000	$5,000
	d	Market management and field staff (% of variable costs)	15%	5%
	e	Incentive costs per annual kWh saved	$0.05	$0.01
	f	Incentive costs per peak kW reduced	$125	$25
		Add-on intervention for 2006 existing		
	g	Additional costs above variable costs for intervention (annual)	$30,000	$5,000
	h	Market management and field staff (% of variable costs)	15%	5%
	i	Incentive costs per annual kWh saved	$0.09	$0.01
	j	Incentive costs per peak kW reduced	$225	$25
		Primary intervention for new usage		
	k	Additional costs above variable costs for intervention (annual)	$30,000	$5,000
	l	Market management and field staff (% of variable costs)	15%	5%
	m	Incentive costs per annual kWh saved	$0.05	$0.01
	n	Incentive costs per peak kW reduced	$125	$25
4		**Measure life (years)**	12	3

1. Per Unit Impacts

The size of the commercial refrigeration market in Wisconsin was estimated by first using data from a Wisconsin Public Service/McGraw Hill survey (2004) to break out refrigeration from other end uses in various commercial building types. Percentages of electric use by commercial building type were obtained from a Focus on Energy baseline market research study (XENERGY, 2002). This number was then scaled to an estimated level for 2005 based on PSC-Wisconsin commercial electric forecast data for 2004-2015 (PSC, 2004 and Kliebenstein, (2005).

Following this approach, the energy consumption of refrigeration systems in Wisconsin for 2005 was estimated to be 2,028 GWh out of 21,934 GWh total commercial sales projected for 2005, or 9 percent of commercial energy use. Data from the Energy Information Administration from 1995 indicates refrigeration consumption is 7 percent of commercial usage (EIA, 1998). To account for uncertainty between end-use shares while keeping the analysis within the overall commercial forecast, we estimated the market size for refrigeration systems at 90 percent (+/- 10%) of the estimated end-use share. This translates to 1,825 GWh (+/- 203 GWh).

Wisconsin Public Service Corporation (WPSC) analyzed hourly commercial loads by building type and end-use to develop four end-use load factors (WPSC, 2005). The hourly load curves were calibrated to weather-adjusted estimates for commercial load in WPSC territory. Billing data and SIC codes were used for the energy estimates, and the load shapes were applied by building type to get the peak estimates. The load factor ratio for refrigeration was estimated to be 0.000147 GW/GWh. Applying the summer peak load to the annual energy usage ratio provided by WPSC, we estimated the peak load for this market to be 268 MW (+/- 30 MW).

Annual unit replacement rates were estimated by using the inverse of the average life of refrigeration equipment. Equipment was estimated to have a 9 year life by Kubo (2002). Studies report equipment life as low as 5 to 7 years or as high as 10 to 15 years, (ADL, 1996 and KEMA, 2005). The employment of used equipment increases the equipment service life therefore we assumed a life of 12 years (+/- 3 years). Therefore the annual replacement rate is estimated at 1/12, or 8.3 percent

Annual energy savings for naturally occurring improvements and program influenced new and replacement equipment were derived from bundles of measures applied to major equipment types, as presented in a detailed technical study by the U.S. DOE (ADL, 1996). After evaluating results from the U.S. DOE study and more recent work, Kubo and Nadel (2002) have identified energy savings in most packaged refrigeration systems of 20 percent to 50 percent with simple payback periods of fewer than 3 years. Built up systems can reduce energy savings by 14 percent (ADL, 1996). A breakout of energy use by equipment type was used to weight the savings ranges to calculate a combined averaged. The values used in the calculation are provided in Table 8.01.3 below.

TABLE 8.01.3. ENERGY SAVINGS FOR REFRIGERATION EQUIPMENT TYPES

	SPLIT	TOTAL USE GWH	ENERGY SAVINGS (LOW)	ENERGY SAVINGS (HIGH)	ENERGY SAVINGS (LOW)	ENERGY SAVINGS (HIGH)
ALL COMMERCIAL REFRIGERATION		1,825	22%	35%	397	644
BUILT-UP SYSTEMS	34%	621	14%	14%	87	87
PACKAGED SYSTEMS	66%	1,205				
Walk-ins	18%	329	33%	33%	110	110
Refrigerated vending machines	13%	237	20%	70%	47	166
Ice makers	10%	183	20%	45%	37	82
Reach-in Freezers	7%	128	35%	68%	45	87
Reach-in Refrigerators	5%	91	35%	68%	32	62
Beverage Merchandisers	5%	91	44%	55%	40	50
Others	8%	146	0%	0%		

Common efficiency improvements identified include high efficiency compressors, ECM motors for condenser and evaporator fans, improved fan blades, variable speed compressors, thicker insulation, more efficient lighting, and non-electric anti-sweat heaters (ADL, 1996). The recent market survey by KEMA (2005) was used to estimate the naturally occurring adoption of refrigeration efficiency measures. KEMA provides a table of contractor estimates of measure penetration, which show wide variation. We estimated an average adoption of 45 percent (+/- 15%).

Combining the savings with the adoption rates, we estimated the naturally occurring replacement savings at 12.8 percent (+/- 3%), and the additive program savings at 15.7 percent (+/- 4%). Additional retrofit system improvements, described as an Add-On Intervention in the model input table could include strip curtains, gasket repair, door closers, alarms, anti-sweat heater controls, and other measures. We reviewed the U.S. DOE study (ADL, 1996) to identify measures that could be installed as retrofits. The savings ranged from 1.3 percent to 20 percent, but we estimated that a savings of 8 percent (+/- 4%) was representative of the majority of opportunities.

2. Program Participation

We modeled the interventions to achieve program participation for refrigeration beginning at 5 percent (+/- 1%) in year one and ramping up to peak participation of 30 percent (+/-10%) by year 5 (+/- one year). The lower range of participation estimate is intended to extrapolate from current activity in Wisconsin, while the 30 percent peak participation reflects significant market barriers. On this participation schedule, 23 percent of commercial refrigeration load will participate in this market after 10 years. In support of this assumption, National Grid reports that 55 percent of eligible electric customers have participated in their Energy Initiative Custom retrofit program over a ten year time frame (York and Kushler, 2003). The Energy Initiative program targets similar customer types that our market targets for refrigeration improvements. A net to gross program value of 0.80 (+/- 0.10) was used, reported by National Grid for their Energy Initiative Program (Quantum, 2004b).

3. Program Costs

Program costs reflect approximations we made following the review of costs for mature programs with similar approaches and customer targets (Quantum, 2004b). Incentive costs are 77 percent of total program costs, while non-incentive costs are 23 percent. Start up costs of $75,000 over three years ($25,000 per year) are allocated to achieve a statewide effort, filling gaps in areas such as market research, information and outreach, demonstration projects, tools, and case studies. A general administrative cost of 4 percent of all intervention costs provides funding for management of the overall market effort, program specific tracking and reporting, planning meetings, and other expenses.

Costs for each intervention in the market are broken into three categories:

- incentives for participants, contractors, designers, and other program allies;
- a market manager to handle day-to-day responsibilities and field staff to work with participants on specific projects; and
- annual fixed costs for activities such as training, product and service development (tools, manuals, guides, software, etc.).

Incentives are paid for energy and demand savings. The overall incentive pool may be provided as participant rebates, supplier rebates, on-site evaluations, or other project specific costs to influence participation. The incentive costs for this intervention were intended to cover 50 percent to 100 percent of incremental upgrade costs, and approximately 50 percent of add-on component costs, using cost data presented by Kubo and Nadel (2002). The incentive for the incremental upgrade markets provide a buy-down of about one year of energy savings, while the incentive for the add-on component reduces payback by about two years.

4. Measure Life

Equipment was estimated to have a 9 year life by Kubo (2002). Studies report equipment life as low as 5 to 7 years or as high as 10 to 15 years, (ADL, 1996 and KEMA, 2005). The employment of used equipment increases the equipment service life so we assumed a life of 12 years (+/- 3 years).

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MARKET 9 — INDUSTRIAL MOTORS: NEW, REPLACEMENT AND REPAIR MARKET

Market Scope

This industrial market comprises the replacement of integral horsepower, polyphase, general purpose, low voltage AC, NEMA Design B induction motors at the time of failure, and new motor purchases. The model addresses the following measures and practices to improve efficiency: purchase a new or replacement premium efficiency motor rather than a minimum standard efficiency motor, replace a normally rewound motor with a new premium efficiency motor, follow quality repair practices when rewinding motors, and choose a smaller motor to replace an oversized motor at time of failure. This market includes only efficiency actions taken with the motor itself, not changes to connected system loads. Therefore, energy savings in this market are additive to the savings identified in the pump, fan, and compressed air systems market.

Market Characteristics

The energy usage of all industrial motors, including those used for driving fans, pumps, compressed air, process cooling and other equipment in Wisconsin at the end of 2005 was estimated to be 16,816 GWh or 65 percent of 25,924 GWh total industrial electric sales projected for 2005. Of the total Wisconsin industrial motor load, it is estimated that 62.9 percent consists of integral horsepower, polyphase, general purpose, low voltage AC, NEMA Design B induction motors (XENERGY, 1998) that use 10,577 GWh or 41 percent of all industrial load. This value represents the market of "existing" inventory of industrial motors. Motor types not targeted in this market include special purpose, fractional horsepower, synchronous, medium voltage, and DC motors, even though efficient alternatives exist for many of these motors.

For this study, estimates of energy saving potential for a motors management approach to motor efficiency make use of a national motor systems market opportunities assessment prepared for the U.S. Department of Energy by XENERGY, Inc. (1998). This market assessment developed a detailed profile of the then current stock of motor-driven equipment in U.S. industrial facilities, and characterized and estimated the magnitude of opportunities to improve energy efficiency. Field data collection was carried out during most of calendar year 1997. Interim and final results were reviewed by national experts.

The national motor market assessment evaluated energy savings potential and market applicability for individual measures bundled into measure categories that address component and system level improvements. The categories included for motors were:

- Replacement of failed motors to efficiency levels that meet or exceed the NEMA Premium specification
- Motor downsizing, where appropriate when motor loading is below 40 percent
- Improving rewind practices to decrease motor efficiency degradation
- Improving motor management to increase the number of motors replaced rather than rewound

Although the national assessment is a snapshot of potential as of 1997, it provided a rigorous estimate. We have adjusted the results of the study to account for natural turnover and improvement of the motor stock between 1997 and 2005, using more recent market assessments.

There is extensive experience with motor programs (CEE, 2004), and numerous studies have examined the supply chain of the motors market, providing insights into the barriers and achievability of energy savings (Nadel, 2002). A recent market assessment for Wisconsin reported the following findings (KEMA, 2005):

- The reported share of NEMA Premium motors by Wisconsin dealers, estimated at 36 percent, is consistent with national figures
- Reported drivers for NEMA Premium motors include greater customer awareness, fuller product lines, and concern over energy prices
- Barriers from the supplier perspective include perceived lack of customer interest in the economics of premium motors, higher first costs, and perception that additional sales revenues are not worth the additional sales effort
- Accelerating replacement is the biggest contribution dealers and end-users can make to motor fleet efficiency
- Supplier recommendations include cash incentives, life cycle costing tools, and support of local and national programs

Program Approaches

Key findings from recent market assessments in Wisconsin suggest the following objectives:

- Include market transformation as a primary goal of the program and quantify specific market effects when defining objectives
- Increase the operating efficiency of in-place motors through adoption of comprehensive motor management practices
- Increase the number of motors that are replaced with new NEMA Premium motors instead of being rewound/reconditioned
- Downsize motors when appropriate
- Reduce the efficiency losses associated with motor reconditioning by promoting the use of quality rewind/reconditioning practices
- Work to ensure that there is an adequate supply of qualified repair shops and support business development of service centers and consultants
- Operate an extensive education program including seminars, on-site industry training, and other resources
- Initiate a motor systems strategy targeting specific industrial sectors, and contributing to the pool of technical knowledge for key industries and processes in Wisconsin
- Assist suppliers and design engineers in reaching and selling to decision makers within end-user organizations that are most receptive to life-cycle cost analysis
- Leverage national efforts to improve motor management, including those from *Motor Decisions Matter,* the Consortium for Energy Efficiency, and NEMA.

To estimate the achievable market potential, the program model consists of:

- A *primary approach* for existing motors that follows *Motor Decisions Matter* as a framework. The program would promote NEMA Premium motors and sound motor management (including improving rewind/replace decisions) across the multiple markets served by offering technical and financial assistance for individual projects. Market transformation would be a primary goal.

- An *add-on component* for existing motors to improve rewind/reconditioning practices and downsize when appropriate, supported by a program effort offering information, training, and financial incentives. Market transformation would be a primary goal.
- A *primary approach* for new motors that follows the primary approach for existing motors. Market transformation would be a primary goal.

Table 9.01.4 summarizes estimated values of program costs and achievable impacts for applying the program approach above to the industrial general purpose motor market. Supporting details are provided in the technical documentation

TABLE 9.01.4. ESTIMATED VALUES FOR PROGRAM AREA 9.01, INDUSTRIAL MOTOR REPLACEMENT AND REPAIR MARKET

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$371 to $611	$534 to $915
	Incremental Impacts	peak kW	241 to 424	373 to 663
		annual kWh (000s)	1,777 to 3,096	2,733 to 4,817
		annual therms (000s)	0	0
	Levelized resource cost	per peak kW	$123 to $198	$117 to $188
		per kWh	1.7¢ to 2.6¢	1.6¢ to 2.5¢
		per therm	NA	NA
Scaling factors[a]		program costs	0.9 to 2.0	0.9 to 2.0
		impacts	1.0 to 1.4	1.0 to 1.4

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Below, we document the technical assumptions we made for a managed approach to energy efficiency in industrial general purpose induction motors.

Program Area 9.01 — Industrial Motors: New, Replacement and Repair Market

Model inputs for this program area are summarized in Table 9.01.5 below, and described on the following pages.

TABLE 9.01.5. MODEL INPUTS FOR INDUSTRIAL MOTORS: NEW, REPLACEMENT AND REPAIR MARKET

Model Inputs (09.01)			Value	±
1		**Impacts**		
	a	2005 market size NEMA Design B motors (GWh)	10,048	502
	b	2005 market size NEMA Design B motors (peak MW)	1,377	69
	c	Annual market growth rate (2006-2015)	1.8%	0.2%
	Efficiency improvement within 2006 inventory w/o program intervention			
	d	Annual market undergoing improvements (2006-2015)	3.9%	0.7%
	e	Electric energy % saved within failed systems	4.3%	0.9%
	f	Electric peak demand % saved within failed systems	4.3%	0.9%
	Identified savings potential for primary intervention within replacement inventory as of 1/1/2006			
	g	Annual market for intervention (2006-2015)	6.2%	1.2%
	h	Electric energy % savings (normal replacements)	1.9%	0.4%
	i	Electric peak demand % savings (normal replacements)	1.9%	0.4%
	j	Electric energy % savings (accelerated replacements)	5.5%	1.1%
	k	Electric peak demand % savings (accelerated replacements)	5.5%	1.1%
	Identified savings potential for add-on intervention within inventory as of 1/1/2006			
	l	Annual market for intervention (2006-2015)	6.2%	1.2%
	m	Electric energy % savings	2.0%	0.4%
	n	Electric peak demand % savings	2.0%	0.4%
	Identified savings potential in new usage with primary intervention			
	o	Electric energy % savings	1.9%	0.4%
	p	Electric peak demand % savings	1.9%	0.4%
2		**Program Participation**		
	Primary intervention for 2006 existing			
	a	Participation in Year 1 (% of 2006 replaced inventory)	4%	1%
	b	Ultimate annual participation rate (% of replaced inventory)	20%	5%
	c	Year ultimate participation reached	6	1
	d	Net-to-gross ratio for primary intervention	0.64	0.10

		Add-on intervention for 2006 existing		
	e	Participation in Year 1 (% of 2006 replaced inventory)	4%	1%
	f	Ultimate annual participation rate (% of replaced inventory)	20%	5%
	g	Year ultimate participation reached	6	1
	h	Net-to-gross ratio for add-on component	0.80	0.10
		Primary intervention for new usage		
	i	Participation in Year 1 (% of annual new usage)	4%	1%
	j	Ultimate annual participation rate (% of annual new usage)	20%	5%
	k	Year ultimate participation reached	6	1
	l	Net-to-gross ratio for primary intervention	0.64	0.10
3		**Program costs**		
	a	Administration start up cost premium (total over years 1 - 3)	$45,000	$15,000
	b	Base administrative costs (% of all intervention costs)	4%	1%
		Primary intervention for 2006 existing		
	c	Additional costs above variable costs for intervention (annual)	$20,000	$5,000
	d	Market management and field staff (% of variable costs)	15%	5%
	e	Incentive costs per annual kWh saved	$0.08	$0.01
	f	Incentive costs per peak kW reduced	$250	$25
		Add-on intervention for 2006 existing		
	g	Additional costs above variable costs for intervention (annual)	$20,000	$5,000
	h	Market management and field staff (% of variable costs)	15%	5%
	i	Incentive costs per annual kWh saved	$0.06	$0.01
	j	Incentive costs per peak kW reduced	$150	$25
		Primary intervention for new usage		
	k	Additional costs above variable costs for intervention (annual)	$10,000	$5,000
	l	Market management and field staff (% of variable costs)	15%	5%
	m	Incentive costs per annual kWh saved	$0.08	$0.01
	n	Incentive costs per peak kW reduced	$250	$25
4		**Measure life (years)**	16	3

1. Impacts

The size of the motor market in Wisconsin was estimated as a percentage portion of the overall electric energy usage (GWh and MW) in manufacturing statewide. The approach started with a statewide electricity forecast, segmented overall sales by 22 industry types, and then broke down the electric sales within each industry type by primary industrial end uses. This “top down” approach to estimating market size was taken due to inadequate data on equipment sales and operating parameters required for a “bottom up” estimate of full achievable potential.

The statewide electricity forecast for industrial electric energy sales (GWh), peak load (MW), and growth rate from 2005 through 2015 was derived using data from the Public Service Commission of Wisconsin (PSC, 2004 and Kliebenstein, 2005). Overall electric sales were segmented into the industry types shown in Table 9.01.3, based on utility sales data for 2004 where available, or other sources as a default (WCDSR, 1994). Industry types were classified following the U.S Census Bureau's Standard Industrial Classification (SIC) system, or the more recent North American Industrial Classification System (NAICS). Natural gas sales and growth rate were derived from 2004 Wisconsin Energy Statistics (DOA, 2004). Segmentation of sales by industry type relied upon national data (EIA, 2005)

TABLE 9.01.3. INDUSTRY TYPE SEGMENTATION AND ENERGY USE (ELECTRIC AND GAS)

SIC CODE	INDUSTRY TYPE	GWH	THERMS
10-14	Mining	0.3%	0.0%
20	Food & Kindred	11.1%	14.8%
21	Tobacco (included in SIC 20)	0.0%	0.0%
22	Textiles	0.2%	0.2%
23	Apparel	0.1%	0.1%
24	Lumber & Wood Products	1.9%	1.0%
25	Furniture	0.5%	0.2%
26	Paper & Allied	30.4%	38.2%
27	Printing	2.3%	1.0%
28	Chemicals & Allied	5.9%	10.5%
29	Petroleum	0.0%	0.2%
30	Rubber & Plastics	5.4%	1.9%
31	Leather	0.3%	0.2%
32	Stone, Clay & Glass	3.6%	6.1%
33	Primary Metals	8.4%	9.5%
34	Fabricated Metals	9.6%	6.8%
35	Machinery	9.4%	5.0%
36	Electrical Equipment	3.4%	1.7%
37	Transportation Equip	3.6%	2.0%
38	Instruments	0.6%	0.1%
39	Miscellaneous	1.2%	0.6%
46	Pipelines	1.8%	0.0%

A break out into ten electric end-uses and four gas end-uses (Table 9.01.4), based on the characteristics of each industry type, was applied to the electric sales segmented by industry type. The end use break outs by industry type were derived using data available from the United States Energy Information Administration (EIA), "1998 Manufacturing Energy Consumption Survey" (2005). The sales data for each end use was summed across each industry type to provide the estimated electricity and gas used by that end use. The end-use fractions in Table 9.01.4 provide results averaged across all Wisconsin industry included in the market.

TABLE 9.01.4. INDUSTRY ELECTRIC AND NATURAL GAS END USE BREAK OUTS

ELECTRIC END USES	FRACTION (ALL INDUSTRY)	NATURAL GAS END USES	FRACTION (ALL INDUSTRY)
Fan Systems & Motors	9.4%	Boilers	46%
Pump Systems & Motors	15.3%	Direct Process Heat	36%
Compressed Air Systems & Motors	7.6%	Facility HVAC	9%
Process Cooling Systems & Motors	5.8%	Other	9%
Other Process Motors	26.8%		
Process Heat	10.6%		
Other Process	2.2%		
Facility Lighting	7.7%		
Facility HVAC	9.2%		
Other Facility	5.5%		

Following the approach outlined above, the energy usage of all industrial motors, including those for driving fans, pumps, compressed air, process cooling and other equipment in Wisconsin at the end of 2005 (start of 2006) was estimated to be 16,816 GWh or 65 percent of 25,924 GWh total industrial sales projected for 2005. Of the total motor load, it is estimated that 62.9 percent consists of integral horsepower, polyphase, general purpose, low voltage AC, NEMA Design B induction motors (XENERGY, 1998) that use 10,577 GWh. To account for uncertainty between end-use shares while keeping the analysis within the overall industrial forecast, we estimated the size for this market at 95 percent (+/- 5%) of the estimated end-use share. This translates to 10,048 GWh (+/- 502 GWh).

The percentages of electric usage for industry type and end-use were applied to the forecast of peak loads for Wisconsin industry. The peak load of industrial NEMA Design B induction motors in Wisconsin at the end of 2005 (start of 2006) was estimated to be 1,450 MW or 41 percent of 3,553 MW total industrial load projected for 2005. Natural gas usage for motors is zero. Depending on the location of the affected electrical equipment and facility HVAC approach, a reduction in electrical usage within a facility could raise natural gas space heating by 0 percent to 100 percent of the equivalent delivered heat; however, we have chosen to exclude this effect in the model. To account for uncertainty between end-use shares while keeping the analysis within the overall industrial forecast, we estimated the size for this market at 95 percent (+/- 5%) of the estimated end-use share. This translates to 1,377 MW (+/- 69 MW).

As outlined in the market description, the interventions in this market consist of the following measures and practices to improve efficiency: purchase new or replacement premium efficiency motor rather than a minimum standard efficiency motor, replace a normally rewound motor with a new premium efficiency motor, follow quality repair practices when rewinding motors, and choose a smaller motor to replace an oversized motor at time of failure.

To calculate the potential for energy savings in these markets, it is necessary to establish the baseline forecast conditions against which to measure the savings potential. This requires an estimate of the efficiency level of existing systems, and the future energy efficiency improvements that would occur absent all program interventions.

The natural, annual rate of motor replacement, absent any program, was estimated to be 3.9 percent of the market (on an energy usage basis). This estimate is a weighted average result that combines motor life at failure data with energy use weighting by motor size, as shown in Table 9.01.5. The energy use by motor size category was provided by the national motor market assessment (XENERGY, 1998). Motor life by size at ultimate failure, accounting for average operating hours and multiple rewind cycles of larger motors, is provided by ACEEE (Nadel, 2002).

TABLE 9.01.5. ULTIMATE MOTOR LIFE AND REPLACEMENT RATE, NO INTERVENTION

SIZE RANGE	ENERGY USE	AGE AT FAILURE	REPLACE RATE
1 - 5 hp	4.8%	17.1	5.8%
6 - 20	10.4%	19.4	5.2%
21 - 50	12.7%	21.8	4.6%
51 - 125	12.7%	28.5	3.5%
>125 hp	59.4%	29.3	3.4%
weighted avg=>	100.0%	26.6	3.9%

As of October 1997, all motors in our market definition sold in the U.S. that are from 1 to 200 horsepower must meet minimum efficiency standards set through the Energy Policy Act of 1992 (EPAct), which are based on the NEMA standards MG-1 Table 12-10. The standards do not cover Definite and Special Purpose motors, nor do they cover integral horsepower motors over 200 horsepower. The motors covered by the standards account for 50–70 percent of all integral horsepower motors sold (XENERGY, 1998). The energy weighted savings for upgrading from pre-EPAct motors to the EPAct standard, across the distribution of motor size and operating hours seen nationally was estimated at 13,043 GWh/yr from 362,215 GWh/yr of Design B motors, or 3.6 percent savings (XENERGY, 1998).

The EPAct minimum standard left room for NEMA to define a more efficient “NEMA Premium” efficiency level, also adopted by the Consortium for Energy Efficiency. The national motor market assessment estimated savings of 19,799 GWh/yr from 362,215 GWh/yr of Design B motors, or 5.5 percent savings (XENERGY, 1998) for the jump from pre-EPAct to NEMA Premium efficiency. By subtraction, the savings between the EPAct minimum and the NEMA Premium efficiency level is 1.9 percent. At the time of the national assessment study, 9 percent of the motor stock had been converted to the EPAct standard or better (XENERGY, 1998). Between 1997 and 2006, at 3.9 percent per year, an additional 35 percent of the motor stock would turn over to EPAct or better, leaving 56 percent of the motor stock as the target market of inefficient pre-EPAct motors.

A recent market characterization and baseline study in Wisconsin found that the share of motors meeting NEMA Premium is 36 percent of sales (KEMA, 2005). Using this data as the baseline for a future no-intervention scenario, the average efficiency increase for pre-EPAct motor replacements is 5.5 percent for the 36 percent converting to NEMA Premium, and 3.6 percent for the remainder that only reach EPAct, for an average of 4.3 percent.

Participants in the intervention will be persuaded to make motor rewind or replace decisions based on life cycle costs. As a result, we assume existing motors less than 125 hp will be replaced rather than rewound at their next failure. With this strategy, the rate of replacement increases from 3.9 percent to 6.2 percent, based on motor life to failure and operating hours from the national motor market assessment (XENERGY, 1998). The energy savings for the 3.9 percent of motors replaced on their normal schedule is 1.9 percent. The energy savings for the previously rewound motors that are now accelerated replacements in the intervention is 5.5 percent, the difference between pre-EPAct motors and NEMA premium. For new motor purchases, the savings is 1.9 percent, the difference between EPAct and NEMA Premium.

An additional program component provides energy savings by downsizing motors when appropriate (1.2 percent savings), and eliminating avoidable damage to motors by using quality repair practices (0.8 percent savings). Both savings estimates are taken from the national motor market assessment, and together the add-on component provides 2 percent savings in addition to the primary intervention (XENERGY, 1998). The participation rate is based on the replacement rate for the intervention scenario, 6.2 percent, meaning that downsizing and quality repair are only pursued when a motor fails.

The savings from downsizing are based on the difference in operating efficiency of motors in specific horsepower categories at 25 percent load and 75 percent part load. This assumes that oversized motors are running at an average of 25 percent part load and that the properly sized motors will run at 75 percent part load. The savings difference is applied to the fraction of motors estimated to be operating at less than 40 percent load. Improved rewind practices involve the use of low burn-out temperatures to remove old windings and careful attention to the original winding pattern to minimize efficiency degradation.

2. Program Participation

We have modeled the interventions to achieve program participation for new or replacement motors beginning at 4 percent (+/- 1%) in year one and ramping up to peak participation of 20 percent (+/-5%) by year 6 (+/- one year). The lower range of participation estimate is intended to extrapolate from current activity in Wisconsin, while the higher participation level was derived from a review of experiences in the Pacific Northwest, Minnesota, Massachusetts, and Connecticut (CEE, 2004).

The net to gross ratio of 0.64 for new and replacement motors reflects the estimated current 36 percent market share of NEMA premium motors for Wisconsin dealers (KEMA, 2005). The add-on component has a 0.80 net-to-gross ratio, more consistent with a retrofit program, represented by National Grid for their Energy Initiative Program (Quantum, 2004b).

3. Program Costs

Program costs reflect approximations we made following the review of costs for mature programs with similar approaches and customer targets (Quantum, 2004b). Incentive costs are 77 percent of total program costs, while non-incentive costs are 23 percent. Start up costs of $45,000 over three years ($15,000 per year) are allocated to achieve a statewide effort, filling gaps in areas such as market research, information and outreach, demonstration projects, tools, and case studies. A general administrative cost of 4 percent of all intervention costs provides funding for management of the overall market effort, program specific tracking and reporting, planning meetings, and other expenses.

Costs for each intervention in the market are broken into three categories:

- Incentives for participants, motor suppliers, and other program allies;
- A market manager to handle day-to-day responsibilities and field staff to work with participants on specific projects; and
- Annual fixed costs for activities such as training, product and service development (tools, manuals, guides, software, etc.).

Incentives are paid for energy and demand savings. The overall incentive pool may be provided as participant rebates, supplier rebates, downsizing studies, conducting motor inventories, supporting quality repair, or other project specific costs to influence participation. The incremental cost for choosing a premium motor over standard efficiency varies with motor size, speed, and enclosure type, as well as the volume of the order. A recent assessment of the Wisconsin motors market identified an 8 percent to 17 percent cost premium for selecting the higher efficiency NEMA premium motor, and Wisconsin motor dealers recently reported that incentives in the range of $6/hp would be effective (KEMA, 2005). Incentives for this intervention were set to approximate these levels.

4. Measure Life

Participants in the intervention will be persuaded to make current and future motor rewind or replacement decisions based on life cycle costs. As a result, existing motors less than 125 hp will be replaced rather than rewound at their next failure. With this strategy, the rate of replacement is 6.2 percent, based on motor life to failure and operating hours from the national motor market assessment (XENERGY, 1998). The inverse of a 6.2 percent replacement rate is a measure life of 16 years. The uncertainty of 3 years is developed from motor life variability data presented by Nadel (2002). Although savings from downsizing could persist indefinitely assuming motors are replaced with like motors, we conservatively assume that downsizing may need to be re-evaluated at failure due to changes in process and product lines over time.

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MARKET 10 — INDUSTRIAL COMPRESSED AIR SYSTEMS MARKET

Market Scope

This market comprises currently available products and services that can improve the performance of new and existing industrial compressed air systems. The market includes the prime mover and air compressor on the supply side of the system, and distribution piping, hoses, and uses on the demand side. Although efficiency improvements in the compressed air system will reduce energy usage by the prime mover that drives the compressor (nearly always an electric motor), this market does not include efficiency upgrades within the motor itself. Drive motors are addressed in a separate market dealing with efficiency improvements and repair/replacement practices, so that the savings in that market are additive to the savings identified in this compressed air market.

Market Characteristics

Almost every industrial plant uses compressed air. It powers pneumatic tools, packaging and automation equipment, and conveyors. Many manufacturing industries also use compressed air and gas for combustion and process operations such as oxidation, fractionation, cryogenics, refrigeration, filtration, dehydration, and aeration. Systems can vary in size from small, 5 horsepower units to large systems of multiple units using several thousand horsepower.

A modern industrial compressed air system is composed of several major sub-systems and many sub-components. Major sub-systems on the supply side include the compressor, prime mover, controls, and treatment equipment and accessories. Distribution systems are analogous to wiring in the electrical world—they transport compressed air to where it is needed. Compressed air storage can also serve to improve system performance and efficiency.

Using compressed air systems efficiently can have a significant impact on costs as well as increase productivity and reliability. Inefficiencies in compressed air systems can be significant. In poorly managed systems, energy savings from system improvements can range from 20 to 50 percent or more of electricity consumption (Resource Dynamics, 2003). Improving and maintaining peak compressed air system performance requires addressing both the supply and demand sides of the system and how the two interact (a “systems approach”). For many facilities this is equivalent to thousands, or even hundreds of thousands of dollars of potential annual savings, depending on use.

For this study, estimates of energy saving potential for a systems approach to compressed air efficiency make use of a national motor systems market opportunities assessment prepared for the U.S. Department of Energy by XENERGY, Inc. (1998). This market assessment developed a detailed profile of the then current stock of motor-driven equipment in U.S. industrial facilities, and characterized and estimated the magnitude of opportunities to improve energy efficiency. Field data collection was carried out during most of calendar year 1997. Interim and final results were reviewed by national experts.

The national motor market assessment evaluated energy savings potential and market applicability for individual measures bundled into measure categories that address component and system level improvements. The categories included for compressed air systems were:

- Reduce overall system requirements

- Match compressor size to load
- Compressor control
- Improve compressor components
- Operations and maintenance

Although the national assessment is a snapshot of potential as of 1997, it provided a rigorous estimate, and was consistent with the stakeholder group's opinion of current energy saving potential in Wisconsin. The appropriateness of this assumption is supported by recently completed surveys conducted in Wisconsin on suppliers and customers (Energy Center of Wisconsin, 2003 and KEMA, 2005). The studies found that attention paid to a systems approach is increasing, but that this is a recent trend: "Two years ago 2 percent of customers were interested in the systems approach. Now it is 10 percent, and three years from now, we're looking at 40-45 percent," as one supplier stated (KEMA, 2005).

Recent studies examined the supply chain of the Wisconsin compressed air market, providing insights into the barriers and achievability of energy savings (Energy Center of Wisconsin, 2003 and KEMA, 2005). This research indicates that:

- The market structure of the compressed air industry is relatively narrow, with a few manufacturers and distributors tending to control much of the supply chain. Manufacturers and distributors play larger roles in the supply chain for compressed air than they typically do in other end-use industries. Compressed air distributors, in particular, carry out a wide variety of supply chain functions including selling compressors, installing compressors, providing design services, and providing maintenance services (Energy Center of Wisconsin, 2003).
- Especially important in compressed air (and other industrial systems) efficiency considerations is that there are excellent opportunities for existing system optimization and maintenance. These optimization considerations shift the focus of efficiency improvements away from the individual components of the compressed air system to the total system performance (Energy Center of Wisconsin, 2003).
- More so than other industrial processes, major retrofits can be made to compressed air systems without affecting core process equipment. Identifying and influencing projects at the earliest possible stage is important, especially for those that involve design/major redesign or even planned replacement. (Energy Center of Wisconsin, 2003).
- New construction offers the greatest flexibility in system design and lowest incremental cost (KEMA, 2005).
- Barriers to the systems approach include suppliers offering quick, low-cost "component fixes," informational barriers, front-end costs of a full-service systems approach, established relationships with suppliers that do not possess expertise with a systems approach, and economic conditions in manufacturing (KEMA, 2005).

Program Approaches

Considerable research has been carried out across the country, focusing on improving compressed air system performance. Several programs are underway that use compressed air audits, incentives, and turnkey implementation services to achieve high customer participation. Recent market assessments in Wisconsin conclude:

- Wisconsin should consider a program model that provides subsidies to compressed air specialists for audit services and the turnkey implementation of audit-based recommendations. By helping providers to build a thriving business based on turnkey compressed air system optimization, a program intervention might help to create competition for those specialized compressed air services within the existing supply chain (Energy Center of Wisconsin, 2003). The turnkey approach would need considerable investigation with regards to success achieved by other programs and the ultimate benefit-cost ratio for the approach.
- Program implications include: continue promoting the systems approach, provide training to corporate decision makers, continue supporting feasibility studies through incentives, streamline the incentive application process, and review the trade-off between incentive levels and program requirements (KEMA, 2005).
- Include market transformation goals in program design and implementation

To estimate the achievable market potential, the program model consists of:

- A *primary approach* for existing compressed air systems that follows a systems retrofit approach to performance improvement by providing information and training, financial support for feasibility studies, and incentives for measure installation.
- An *add-on component* for existing compressed air systems to improve operations and maintenance practices through leak detection and repair, improved compressor maintenance, and regular filter changes supported by a program effort offering information, training, and subsidized leak detection equipment or services.
- A *primary approach* for new compressor systems that combines system design and specification with support of improved operations and maintenance, using information and financial incentives as in existing customers.

Table 10.01.1 summarizes midpoint estimates of program costs and achievable impacts for applying the program approach above to the industrial compressed air systems market. Supporting details are provided in the technical documentation.

TABLE 10.01.1. ESTIMATED VALUES FOR PROGRAM AREA 10.01, INDUSTRIAL COMPRESSED AIR SYSTEMS MARKET

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$653 to $1,026	$793 to $1,217
	Incremental Impacts	peak kW	872 to 1,503	1,099 to 1,843
		annual kWh (000s)	6,309 to 10,988	7,985 to 13,430
		annual therms (000s)	0	0
	Levelized resource cost	per peak kW	$70 to $123	$67 to $119
		per kWh	1.0¢ to 1.6¢	1.0¢ to 1.5¢
		per therm	NA	NA
Scaling factors[a]		program costs	1.3 to 2.5	1.3 to 2.5
		impacts	1.1 to 1.5	1.1 to 1.5

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Below, we document the technical assumptions we made for a "systems approach" to energy efficiency in industrial compressed air systems.

Program Area 10.01 — Industrial Compressed Air Systems Market

Model inputs for this program area are summarized in Table 2 below, and described on the following pages.

TABLE 10.01.2. MODEL INPUTS FOR INDUSTRIAL COMPRESSED AIR MARKET

Model Inputs (10.01)			Value	±
1		**Impacts**		
	a	2005 market size (GWh)	1,861	93
	b	2005 market size (peak MW)	255	13
	c	Annual market growth rate (2006-2015)	1.8%	0.2%
	Efficiency improvement within 2006 inventory w/o program intervention			
	d	Annual market undergoing improvements (2006-2015)	2.0%	1.0%
	e	Electric energy % saved within retrofitted systems	17.1%	5.5%
	f	Electric peak demand % saved within retrofitted systems	17.1%	5.5%
	Identified savings potential for primary intervention within entire inventory as of 1/1/2006			
	g	Electric energy % savings	9.6%	3.8%
	h	Electric peak demand % savings	9.6%	3.8%
	Identified savings potential for add-on intervention within entire inventory as of 1/1/2006			
	i	Electric energy % savings	7.5%	1.8%
	j	Electric peak demand % savings	7.5%	1.8%
	Identified savings potential in new usage with primary intervention			
	k	Electric energy % savings	17.1%	5.5%
	l	Electric peak demand % savings	17.1%	5.5%
2		**Program Participation**		
	Primary intervention for 2006 existing			
	a	Participation in Year 1 (% of 2006 inventory)	2.0%	1.0%
	b	Ultimate annual participation rate (% of 2006 inventory)	4.0%	1.0%
	c	Year ultimate participation reached	5	1
	d	Net-to-gross ratio for primary intervention	0.80	0.10
	Add-on intervention for 2006 existing			
	e	Participation in Year 1 (% of 2006 inventory)	2.0%	1.0%
	f	Ultimate annual participation rate (% of 2006 inventory)	4.0%	1.0%

	g	Year ultimate participation reached	5	1
	h	Net-to-gross ratio for add-on component	0.80	0.10
		Primary intervention for new usage		
	i	Participation in Year 1 (% of annual new usage)	10%	2%
	j	Ultimate annual participation rate (% of annual new usage)	40%	10%
	k	Year ultimate participation reached	5	1
	l	Net-to-gross ratio for primary intervention	0.80	0.10
3		**Program costs**		
	a	Administration start up cost premium (total over years 1 - 3)	$75,000	$15,000
	b	Base administrative costs (% of all intervention costs)	4%	1%
		Primary intervention for 2006 existing		
	c	Additional costs above variable costs for intervention (annual)	$30,000	$5,000
	d	Market management and field staff (% of variable costs)	15%	5%
	e	Incentive costs per annual kWh saved	$0.04	$0.01
	f	Incentive costs per peak kW reduced	$125	$25
		Add-on intervention for 2006 existing		
	g	Additional costs above variable costs for intervention (annual)	$30,000	$5,000
	h	Market management and field staff (% of variable costs)	15%	5%
	i	Incentive costs per annual kWh saved	$0.04	$0.01
	j	Incentive costs per peak kW reduced	$125	$25
		Primary intervention for new usage		
	k	Additional costs above variable costs for intervention (annual)	$20,000	$5,000
	l	Market management and field staff (% of variable costs)	15%	5%
	m	Incentive costs per annual kWh saved	$0.04	$0.01
	n	Incentive costs per peak kW reduced	$125	$25
4		**Measure life (years)**	12	2

1. Impacts

The size of the compressed air systems market in Wisconsin was estimated as a percentage portion of the overall electric energy usage (GWh and MW) in manufacturing statewide. The approach started with a statewide electricity forecast, segmented overall sales by 22 industry types, and then broke down the electric sales within each industry type by primary industrial end uses. This “top down” approach to estimating market size was taken due to inadequate data on equipment sales and operating parameters required for a “bottom up” estimate of full achievable potential.

The statewide electricity forecast for industrial electric energy sales (GWh), peak load (MW), and growth rate from 2005 through 2015 was derived using data from the Public Service Commission of Wisconsin (PSC, 2004 and Kliebenstein, 2005). Overall electric sales were segmented into the industry types shown in Table 10.01.3, based on utility sales data for 2004 where available, or other sources as a default (WCDSR, 1994). Industry types were classified following the U.S Census Bureau’s Standard Industrial

Classification (SIC) system, or the more recent North American Industrial Classification System (NAICS). Natural gas sales and growth rate were derived from 2004 Wisconsin Energy Statistics (DOA, 2004). Segmentation of sales by industry type relied upon national data (EIA, 2005)

TABLE 10.01.3. INDUSTRY TYPE SEGMENTATION AND ENERGY USE (ELECTRIC AND GAS)

SIC CODE	INDUSTRY TYPE	GWH	THERMS
10-14	Mining	0.3%	0.0%
20	Food & Kindred	11.1%	14.8%
21	Tobacco (included in SIC 20)	0.0%	0.0%
22	Textiles	0.2%	0.2%
23	Apparel	0.1%	0.1%
24	Lumber & Wood Products	1.9%	1.0%
25	Furniture	0.5%	0.2%
26	Paper & Allied	30.4%	38.2%
27	Printing	2.3%	1.0%
28	Chemicals & Allied	5.9%	10.5%
29	Petroleum	0.0%	0.2%
30	Rubber & Plastics	5.4%	1.9%
31	Leather	0.3%	0.2%
32	Stone, Clay & Glass	3.6%	6.1%
33	Primary Metals	8.4%	9.5%
34	Fabricated Metals	9.6%	6.8%
35	Machinery	9.4%	5.0%
36	Electrical Equipment	3.4%	1.7%
37	Transportation Equip	3.6%	2.0%
38	Instruments	0.6%	0.1%
39	Miscellaneous	1.2%	0.6%
46	Pipelines	1.8%	0.0%

A break out into ten electric end-uses and four gas end-uses (Table 10.01.4), based on the characteristics of each industry type, was applied to the electric sales segmented by industry type. The end use break outs by industry type were derived using data available from the United States Energy Information Administration (EIA), "1998 Manufacturing Energy Consumption Survey" (2005). The sales data for each end use was summed across each industry type to provide the estimated electricity and gas used by that end use. The end-use fractions in Table 10.01.4 provide results averaged across all Wisconsin industry included in the market.

TABLE 10.01.4. INDUSTRY ELECTRIC AND NATURAL GAS END USE BREAK OUTS

ELECTRIC END USES	FRACTION (ALL INDUSTRY)	NATURAL GAS END USES	FRACTION (ALL INDUSTRY)
Fan Systems & Motors	9.4%	Boilers	46%
Pump Systems & Motors	15.3%	Direct Process Heat	36%
Compressed Air Systems & Motors	7.6%	Facility HVAC	9%
Process Cooling Systems & Motors	5.8%	Other	9%
Other Process Motors	26.8%		
Process Heat	10.6%		
Other Process	2.2%		
Facility Lighting	7.7%		
Facility HVAC	9.2%		
Other Facility	5.5%		

Following the approach outlined above, the energy usage of industrial compressed air systems in Wisconsin at the end of 2005 (start of 2006) was estimated to be 1,959 GWh or 7.6 percent of 25,924 GWh total industrial sales projected for 2005. To account for uncertainty between end-use shares while keeping the analysis within the overall industrial forecast, we estimated the size for this market at 95 percent (+/- 5%) of the estimated end-use share. This translates to 1,861 GWh (+/- 93 GWh).

The percentages of electric usage for industry type and end-use were applied to the forecast of peak loads for Wisconsin industry. The peak load of industrial compressed air systems in Wisconsin at the end of 2005 (start of 2006) was estimated to be 269 MW or 7.6 percent of 3,553 MW total industrial load projected for 2005. Natural gas usage for compressed air systems is zero. Depending on the location of the affected electrical equipment and facility HVAC approach, a reduction in electrical usage within a facility could raise natural gas space heating by 0 percent to 100 percent of the equivalent delivered heat, however, we have chosen to exclude this effect in the model. Heat recovery from the compressed air system is a viable measure for reducing space heat that was not included in this model. To account for uncertainty between end-use shares while keeping the analysis within the overall industrial forecast, we estimated the size for this market at 95 percent (+/- 5%) of the estimated end-use share. This translates to 255 MW (+/- 13 MW).

As outlined in the market description, the interventions in this market consist of system retrofits and improved O&M for existing systems, and improvements for systems associated with new electric usage. To calculate the potential for energy savings in these markets, it is necessary to establish the baseline conditions against which to measure the savings potential. This requires an estimate of the efficiency level of existing systems, and the future energy efficiency improvements that would occur absent all program interventions.

The natural, annual rate of systems approach installations, absent any program, is assumed to be 2 percent of the market (on an energy usage basis). This estimate is derived from results of a recent supply chain study in Wisconsin that found system design capabilities to be widely available, and that system audits are performed 4 percent to 5 percent of the time (Energy Center of Wisconsin, 2003) (although system retrofits are not installed following all audits). This is supported by results in the national motor market assessment that found at least one systems approach measure being undertaken by industry from 2 percent to 4 percent per year for equipment, and 10 percent per year for fixing leaks (XENERGY, 1998).

The energy and peak demand savings for those customers receiving systems improvements is 17.1 percent (XENERGY, 1998), divided into design and equipment measures (9.6 percent savings), and improved O&M practices (7.5 percent). These values were taken from the national motor market assessment study that evaluated energy savings potential and market applicability for individual measures bundled into measure categories that address component and system level improvements. Energy savings and applicability factors reflected the opinions of a group of experts on the percentage of systems that could be cost-effectively retrofitted, and the resulting savings. The applicability factors define what is “achievable” and, we assume, fully acceptable by the market. The applicability factors are provided as a range with a low, midrange, and high estimate, which we used to define savings uncertainty. The individual measures included within each measure category are listed in the national assessment study. The savings reflect measures that could be implemented at a payback of three years or less. The categories included for compressed air systems are provided in Table 10.01.5.

TABLE 10.01.5. ENERGY SAVINGS FOR MEASURE CATEGORIES

MEASURE CATEGORY	% SAVINGS OF BUNDLE	SAVINGS APPLICABILITY (LOW, MIDRANGE, HIGH)	OVERALL SAVINGS (MIDRANGE)
Reduce overall system requirements	20%	20-30%-40	6.0%
Match compressor size to load	3%	5-10%-15	0.3%
Compressor control	10%	15-25%-40	2.5%
Improve compressor components	5%	5-15%-20	0.8%
Operations and maintenance	10%	50-75%-85	7.5%
TOTAL			17.1%

The market size of new usage is the difference between the forecast for all compressed air systems and the usage of the existing year 1 inventory over time. The energy savings potential for new systems, 17.1 percent, reflects an installation with a comprehensive set of measures, including O&M practices.

2. Program Participation

We have modeled the existing primary and add-on interventions to achieve program participation for system improvements beginning at 2.0 percent (+/- 1.0%) of the total stock in year one and ramping up to peak participation of 4.0 percent (+/-1.0%) by year 5 (+/- one year). On this participation schedule, 34 percent of the market will participate in this intervention after 10 years. In support of this assumption, National Grid reports that 55 percent of eligible electric customers have participated in their Energy Initiative Custom retrofit program over a ten year time frame (York and Kushler, 2003). The Energy Initiative program targets similar customer types that our intervention targets for improvements. A net to gross program value of 0.80 (+/- 0.10) was used, reported by National Grid for their Energy Initiative Program (Quantum, 2004b)

We have modeled the interventions to achieve program participation for new systems beginning at 10 percent (+/- 2%) in year one and ramping up to peak participation of 40 percent (+/-10%) by year 5 (+/- one year). The lower range of participation estimate is intended to extrapolate from current activity in

Wisconsin, while the basis for the upper participation level includes an estimate of 50 percent participation from National Grid for their Design 2000 program (York and Kushler, 2003). The net to gross ratio is assumed to be 0.80 with an uncertainty of 0.10.

3. Program Costs

Program costs reflect approximations we made following the review of costs for mature programs with similar approaches and customer targets (Quantum, 2004b). Incentive costs are 76 percent of total program costs, while non-incentive costs are 24 percent. Start up costs of $75,000 over three years ($15,000 per year) are allocated to achieve a statewide effort, filling gaps in areas such as market research, information and outreach, demonstration projects, tools, and case studies. A general administrative cost of 4 percent of all intervention costs provides funding for management of the overall market effort, program specific tracking and reporting, planning meetings, and other expenses.

Costs for each intervention in the market are broken into three categories:

- incentives for participants, designers, and other program allies;
- a market manager to handle day-to-day responsibilities and field staff to work with participants on specific projects; and
- annual fixed costs for activities such as training, product and service development (tools, manuals, guides, software, etc.).

Incentives are paid for energy and demand savings. The overall incentive pool may be provided as participant rebates, feasibility studies, design grants, or other project specific costs to influence participation. Incentives are intended to provide up to approximately half the installed project cost for retrofit and O&M interventions in existing customers, and 50 percent to 100 percent of incremental costs for new systems. The incentives reduce the simple payback on measures by 1.3 years.

4. Measure Life

We assume an average lifespan of 12 years for system performance measures included in our analysis, with an uncertainty of 2 years. This reflects literature that places the life between 10 and 15 years. Operations and maintenance measures require annual attention to achieve persistence of energy savings. We assumed that through a combination of incentives, information, training, and periodic oversight, improved O&M procedures will become standard practice for participants. We set the measure life for O&M to be equal to the equipment measure life of 12 years with the same uncertainty.

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MARKET 11 — INDUSTRIAL FAN AND BLOWER SYSTEMS IMPROVEMENT MARKET

Market Scope

This market comprises currently available products and services that can improve the performance of new and existing industrial fan and blower systems. The market includes the prime mover and fan on the supply side of the system, and distribution ducts, air stream filters and coils, diffusers, and end uses on the demand side. Although efficiency improvements in the system will reduce energy usage by the prime mover (electric motor) that drives the fan, this market does not include efficiency upgrades within the motor itself. Drive motors are addressed in a separate market dealing with efficiency improvements and repair/replacement practices, so that the savings in that market are additive to the savings identified in this market.

Market Characteristics

Fans are widely used in industrial applications. From shop ventilation to material handling to boiler applications, fans are critical for process support and human health (Resource Dynamics, 2003). In the national manufacturing sector, fans use about 78.7 billion kilowatt-hours of energy each year (XENERGY, 1998). This consumption represents 15 percent of the electricity used by motors. Performance may range from “free air” to several pounds per square inch gage (psig), with airflow from a few cubic feet per minute (cfm) to more than 1 million cfm. Pressures above 15 psig generally require air compressors, which are addressed in a separate market.

In manufacturing, fan reliability is critical to plant operation. For example, where fans serve material handling applications, fan failure will immediately create a process stoppage. In industrial ventilation applications, fan failure will often force a process to be shut down. In each case, fan operation has a significant impact on plant production. Concerned about being responsible for under-performing systems, designers tend to compensate for uncertainties in the design process by adding capacity to fans. Unfortunately, oversizing fan and blower systems creates problems that can increase system operating costs while decreasing fan reliability (Resource Dynamics, 2003).

A typical fan or blower system consists of a fan, an electric motor, a drive system, ducts or piping, flow control devices, and air conditioning equipment (filters, cooling coils, heat exchangers, etc.). To effectively improve the performance of the system, designers and operators must understand how other system components function as well. A “systems approach” analyzes both supply and demand sides of the system and how they interact; shifting the focus from individual components to total system performance. The systems approach usually involves the following types of interrelated actions (Resource Dynamics, 2003):

- Establishing current conditions and operating parameters;
- Determining present and estimating future process production needs;
- Gathering and analyzing operating data and developing load duty cycles;
- Assessing alternative system designs and improvements;
- Determining the most technically and economically sound options, taking into consideration all of the subsystems;
- Implementing the best option;

- Assessing energy consumption with respect to performance;
- Continuing to monitor and optimize the system; and
- Continuing to operate and maintain the system for peak performance.

For this study, estimates of energy saving potential for a systems approach to efficiency improvement make use of a national motor systems market opportunities assessment prepared for the U.S. Department of Energy by XENERGY, Inc. (1998). This market assessment developed a detailed profile of the then current stock of motor-driven equipment in U.S. industrial facilities, and characterized and estimated the magnitude of opportunities to improve energy efficiency. Field data collection was carried out during most of calendar year 1997. Interim and final results were reviewed by national experts.

The national motor market assessment evaluated energy savings potential and market applicability for individual measures bundled into measure categories that address component and system level improvements. The categories included for fan and blower systems were:

- Reduce overall system requirements
- Reduce or control fan speed
- Improve fan components
- Operations and maintenance

Although the national assessment is a snapshot of potential as of 1997, it provided a rigorous estimate, and was consistent with the stakeholder group's opinion of current energy saving potential in Wisconsin.

Studies sponsored by the U.S Department of Energy examined the supply chain of the fan systems market, providing insights into the barriers and achievability of energy savings (XENERGY, 1998 and Resource Dynamics, 2003):

- The fan marketplace is relatively complex, because of the wide range of applications. Fan manufacturers sell fans through two primary channels: original equipment manufacturers (OEMs) and manufacturer representatives (Resource Dynamics, 2003).
- The key points of influence for promoting market transformation in the process fan systems market are: fan manufacturers and their internal sales staffs; manufacturers' representatives; specifying engineers and mechanical contractors; fan users; standards and trade associations; engineering societies (Resource Dynamics, 2003).
- There are three principal opportunities in the life cycle of a system that can be used to improve fan or blower system performance: during initial system design and fan selection; during troubleshooting to solve a system problem; and during a system capacity modification (Resource Dynamics, 2003).
- In many applications, fan and blower systems are conservatively designed, which results in the selection of oversized fans. A common perception is that the costs of oversizing fans are small relative to the cost of insufficient fan output. However, this practice overlooks the life-cycle cost components of energy use, maintenance requirements, and risk of failure, all of which are increased by operating a fan that is improperly sized for its system (Resource Dynamics, 2003).
- It is easier to convince an owner to add a variable speed drive than to limit the size of the fan because of potential risks related to capacity constraints (Sasso and Nicol, 2005). In circumstances where oversizing is prudent to allow for future growth and variable production rates, emphasize integration with variable speed drives.

- Although some fan users are sufficiently knowledgeable about system operation to know the problems associated with poor system design practices, many do not recognize the penalties of inefficient fan operation (Resource Dynamics, 2003).
- Often, a fan type is chosen for nontechnical reasons, such as price, delivery, availability, or designer or operator familiarity with a fan model (Resource Dynamics, 2003).
- As part of surveys conducted for the national motors market assessment, customers were asked whether they had undertaken any of a long list of system efficiency measures over the past 2 years. Of the customers reporting fan systems in their facility, 65 percent reported no improvements had been made (XENERGY, 1998).

Program Approaches

Key findings from market assessments of fan and blower systems suggest the following program approach:

- Customer-specific design assistance, with information and incentives for both the facility owner and design team upon installation of an optimized system, appears to be appropriate for the fan and blower systems market.
- Emphasize integration of variable speed drives to minimize impacts of oversizing. Education efforts are needed that focus on reducing gross oversizing, matching of fans to load requirements, and integration with variable speed drives. Helping suppliers to make this case using well-documented evidence of the benefits of proper sizing and control integration could be beneficial.
- Recent surveys of the compressed air and pump systems markets found that contributing to the pool of technical system knowledge for key industries and processes in Wisconsin provides value to suppliers (Energy Center of Wisconsin, 2003). Suppliers point to the need to stay informed about specific industry technologies in order to remain competitive. They also emphasized the value of case studies and testimonials. Suppliers report that existing information and training opportunities are valuable and come from a variety of sources. Although not covered in the study, we expect the fan system market would have similar needs.
- Assisting fan suppliers and design and specifying engineers in reaching and selling to decision makers within end-user organizations that are most receptive to life-cycle cost analysis may also be helpful.
- Leveraging emerging national efforts to improve fan system efficiency is likely to be worthwhile.
- Include market transformation goals in program design and implementation

To estimate the achievable market potential, the program model consists of:

- A *primary approach* for existing systems that follows a systems approach to performance improvement by providing information and training, financial support for design teams, cost sharing for feasibility studies, and incentives for measure installation. Emphasize integration of variable speed drives to minimize impacts of oversizing.
- An *add-on component* for existing fan and blower systems to improve operations and maintenance practices through proper adjustment of belts, cleaning fans, and filter changes supported by a program effort offering information, training, and financial incentives.
- A *primary approach* for new fan and blower systems that follows the same basic approach that is used for existing fans.

Table 11.01.1 summarizes midpoint estimates of program costs and achievable impacts for applying the program approach above to the industrial fan and blower systems market. Supporting details are provided in the technical documentation.

TABLE 11.01.1. ESTIMATED VALUES FOR PROGRAM AREA 11.01, INDUSTRIAL FAN AND BLOWER SYSTEMS IMPROVEMENT MARKET

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$256 to $463	$302 to $544
	Incremental Impacts	peak kW	289 to 663	364 to 814
		annual kWh (000s)	2,088 to 4,809	2,659 to 5,877
		annual therms (000s)	0	0
	Levelized resource cost	per peak kW	$68 to $154	$65 to $146
		per kWh	1.0¢ to 1.8¢	1.0¢ to 1.7¢
		per therm	NA	NA
Scaling factors[a]		program costs	1.2 to 2.5	1.2 to 2.5
		impacts	1.1 to 1.5	1.1 to 1.5

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Below, we document the technical assumptions we made for optimization of industrial fan systems.

Program Area 11.01 — Industrial Fan and Blower Systems Improvement Market

Model inputs for this program area are summarized in Table 11.01.2 below, and described on the following pages.

TABLE 11.01.2. MODEL INPUTS FOR INDUSTRIAL FAN AND BLOWER SYSTEMS MARKET

Model Inputs (11.01)			**Value**	**±**
1		**Impacts**		
	a	2005 market size (GWh)	2,320	116
	b	2005 market size (peak MW)	318	16
	c	Annual market growth rate (2006-2015)	1.8%	0.2%
	Efficiency improvement within 2006 inventory w/o program intervention			
	d	Annual market undergoing improvements (2006-2015)	1.25%	0.6%
	e	Electric energy % saved within retrofitted systems	5.5%	2.6%
	f	Electric peak demand % saved within retrofitted systems	5.5%	2.6%
	Identified savings potential for primary intervention within entire inventory as of 1/1/2006			
	g	Electric energy % savings	4.5%	2.3%
	h	Electric peak demand % savings	4.5%	2.3%
	Identified savings potential for add-on intervention within entire inventory as of 1/1/2006			
	i	Electric energy % savings	1.0%	0.4%
	j	Electric peak demand % savings	1.0%	0.4%
	Identified savings potential in new usage with primary intervention			
	k	Electric energy % savings	5.5%	2.6%
	l	Electric peak demand % savings	5.5%	2.6%
2		**Program Participation**		
	Primary intervention for 2006 existing			
	a	Participation in Year 1 (% of 2006 inventory)	2.0%	1.0%
	b	Ultimate annual participation rate (% of 2006 inventory)	4.0%	1.0%
	c	Year ultimate participation reached	5	1
	d	Net-to-gross ratio for primary intervention	0.80	0.10
	Add-on intervention for 2006 existing			
	e	Participation in Year 1 (% of 2006 inventory)	2.0%	1.0%
	f	Ultimate annual participation rate (% of 2006 inventory)	4.0%	1.0%
	g	Year ultimate participation reached	5	1
	h	Net-to-gross ratio for add-on component	0.80	0.10

		Primary intervention for new usage		
	i	Participation in Year 1 (% of annual new usage)	10%	2%
	j	Ultimate annual participation rate (% of annual new usage)	40%	10%
	k	Year ultimate participation reached	5	1
	l	Net-to-gross ratio for primary intervention	0.80	0.10
3		**Program costs**		
	a	Administration start up cost premium (total over years 1 - 3)	$60,000	$15,000
	b	Base administrative costs (% of all intervention costs)	4%	1%
		Primary intervention for 2006 existing		
	c	Additional costs above variable costs for intervention (annual)	$20,000	$5,000
	d	Market management and field staff (% of variable costs)	15%	5%
	e	Incentive costs per annual kWh saved	$0.04	$0.01
	f	Incentive costs per peak kW reduced	$125	$25
		Add-on intervention for 2006 existing		
	g	Additional costs above variable costs for intervention (annual)	$20,000	$5,000
	h	Market management and field staff (% of variable costs)	15%	5%
	i	Incentive costs per annual kWh saved	$0.04	$0.01
	j	Incentive costs per peak kW reduced	$125	$25
		Primary intervention for new usage		
	k	Additional costs above variable costs for intervention (annual)	$10,000	$5,000
	l	Market management and field staff (% of variable costs)	15%	5%
	m	Incentive costs per annual kWh saved	$0.04	$0.01
	n	Incentive costs per peak kW reduced	$125	$25
4		**Measure life (years)**	12	2

1. Impacts

The size of the fan and blower systems market in Wisconsin was estimated as a percentage portion of the overall electric energy usage (GWh and MW) in manufacturing statewide. The approach started with a statewide electricity forecast, segmented overall sales by 22 industry types, and then broke down the electric sales within each industry type by primary industrial end uses. This “top down” approach to estimating market size was taken due to inadequate data on equipment sales and operating parameters required for a “bottom up” estimate of full achievable potential.

The statewide electricity forecast for industrial electric energy sales (GWh), peak load (MW), and growth rate from 2005 through 2015 was derived using data from the Public Service Commission of Wisconsin (PSC, 2004 and Kliebenstein, 2005). Overall electric sales were segmented into the industry types shown in Table 3, based on utility sales data for 2004 where available, or other sources as a default (WCDSR, 1994). Industry types were classified following the U.S Census Bureau’s Standard Industrial Classification (SIC) system, or the more recent North American Industrial Classification System

(NAICS). Natural gas sales and growth rate were derived from 2004 Wisconsin Energy Statistics (DOA, 2004). Segmentation of sales by industry type relied upon national data (EIA, 2005)

TABLE 11.01.3. INDUSTRY TYPE SEGMENTATION AND ENERGY USE (ELECTRIC AND GAS)

SIC CODE	INDUSTRY TYPE	GWH	THERMS
10-14	Mining	0.3%	0.0%
20	Food & Kindred	11.1%	14.8%
21	Tobacco (included in SIC 20)	0.0%	0.0%
22	Textiles	0.2%	0.2%
23	Apparel	0.1%	0.1%
24	Lumber & Wood Products	1.9%	1.0%
25	Furniture	0.5%	0.2%
26	Paper & Allied	30.4%	38.2%
27	Printing	2.3%	1.0%
28	Chemicals & Allied	5.9%	10.5%
29	Petroleum	0.0%	0.2%
30	Rubber & Plastics	5.4%	1.9%
31	Leather	0.3%	0.2%
32	Stone, Clay & Glass	3.6%	6.1%
33	Primary Metals	8.4%	9.5%
34	Fabricated Metals	9.6%	6.8%
35	Machinery	9.4%	5.0%
36	Electrical Equipment	3.4%	1.7%
37	Transportation Equip	3.6%	2.0%
38	Instruments	0.6%	0.1%
39	Miscellaneous	1.2%	0.6%
46	Pipelines	1.8%	0.0%

A break out into ten electric end-uses and four gas end-uses (Table11.01.4), based on the characteristics of each industry type, was applied to the electric sales segmented by industry type. The end use break outs by industry type were derived using data available from the United States Energy Information Administration (EIA), “1998 Manufacturing Energy Consumption Survey” (2005). The sales data for each end use was summed across each industry type to provide the estimated electricity and gas used by that end use. The end-use fractions in Table 11.01.4 provide results averaged across all Wisconsin industry included in the market.

TABLE 11.01.4. INDUSTRY ELECTRIC AND NATURAL GAS END USE BREAK OUTS

ELECTRIC END USES	FRACTION (ALL INDUSTRY)	NATURAL GAS END USES	FRACTION (ALL INDUSTRY)
Fan Systems & Motors	9.4%	Boilers	46%
Pump Systems & Motors	15.3%	Direct Process Heat	36%
Compressed Air Systems & Motors	7.6%	Facility HVAC	9%
Process Cooling Systems & Motors	5.8%	Other	9%
Other Process Motors	26.8%		
Process Heat	10.6%		
Other Process	2.2%		
Facility Lighting	7.7%		
Facility HVAC	9.2%		
Other Facility	5.5%		

Following the approach outlined above, the energy usage of industrial fan systems in Wisconsin at the end of 2005 (start of 2006) was estimated to be 2,443 GWh or 9.4 percent of 25,924 GWh total industrial sales projected for 2005. To account for uncertainty between end-use shares while keeping the analysis within the overall industrial forecast, we estimated the size for this market at 95 percent (+/- 5%) of the estimated end-use share. This translates to 2,320 GWh (+/- 116 GWh).

The percentages of electric usage for industry type and end-use were applied to the forecast of peak loads for Wisconsin industry. The peak load of industrial fan systems in Wisconsin at the end of 2005 (start of 2006) was estimated to be 269 MW or 9.4 percent of 3,553 MW total industrial load projected for 2005. Natural gas usage for fan systems is zero. Depending on the location of the affected electrical equipment and facility HVAC approach, a reduction in electrical usage within a facility could raise natural gas space heating by 0 percent to 100 percent of the equivalent delivered heat; however, we have chosen to exclude this effect in the model. To account for uncertainty between end-use shares while keeping the analysis within the overall industrial forecast, we estimated the size for this market at 95 percent (+/- 5%) of the estimated end-use share. This translates to 318 MW (+/- 16 MW).

As outlined in the market description, the interventions in this market consist of system retrofits and improved O&M for existing systems, and improvements for systems associated with new electric usage. To calculate the potential for energy savings in these markets, it is necessary to establish the baseline conditions against which to measure the savings potential. This requires an estimate of the efficiency level of existing systems, and the future energy efficiency improvements that would occur absent all program interventions.

The natural, annual rate of systems approach installations, absent any program, is assumed to be 1.25 percent of the market (on an energy usage basis). This is supported by results in the national motor market assessment that found at least one systems approach measure being undertaken by industry from less than 1 percent to just 2 percent per year (XENERGY, 1998). At this annual rate of systems upgrade, we estimate 15 percent of all systems would be optimized over the life cycle of this market.

The energy and peak demand savings for those customers receiving systems improvements is 5.5 percent (XENERGY, 1998), divided into design and equipment measures (4.5 percent savings), and improved O&M practices (1.0 percent). These values were taken from the national motor market assessment study that evaluated energy savings potential and market applicability for individual measures bundled into measure categories that address component and system level improvements. Energy savings and applicability factors reflected the opinions of a group of experts on the percentage of systems that could be cost-effectively retrofitted, and the resulting savings.

The applicability factors define what is "achievable" and, we assume, fully acceptable by the market. The applicability factors are provided as a range with a low, midrange, and high estimate, which we used to define savings uncertainty. The individual measures included within each measure category are listed in the national assessment study. The savings reflect measures that could be implemented at a payback of three years or less. The categories included for fan systems are provided in Table 11.01.5.

TABLE 11.01.5. ENERGY SAVINGS FOR MEASURE CATEGORIES

MEASURE CATEGORY	% SAVINGS OF BUNDLE	SAVINGS APPLICABILITY (LOW, MIDRANGE, HIGH)	OVERALL SAVINGS (MIDRANGE)
Reduce overall system requirements	10%	5-15%-25	1.5%
Reduce or control fan speed	20%	5-10%-15	2.0%
Improve fan components	5%	15-20%-25	1.0%
Operations and maintenance	2%	25-50%-60	1.0%
TOTAL			5.5%

The market size of new usage is the difference between the forecast for all fan systems and the usage of the existing year 1 inventory over time. The energy savings potential for new systems, 5.5 percent, reflects an installation with a comprehensive set of measures, including O&M practices.

2. Program Participation

We have modeled the existing primary and add-on interventions to achieve program participation for system improvements beginning at 2.0 percent (+/- 1.0%) of the total stock in year one and ramping up to peak participation of 4.0 percent (+/- 1.0%) by year 5 (+/- one year). On this participation schedule, 34 percent of the market will participate in this intervention after 10 years. In support of this assumption, National Grid reports that 55 percent of eligible electric customers have participated in their Energy Initiative Custom retrofit program over a ten year time frame (York and Kushler, 2003). The Energy Initiative program targets similar customer types that our intervention targets for improvements. A net to gross program value of 0.80 (+/- 0.10) was used, reported by National Grid for their Energy Initiative Program (Quantum, 2004b)

We have modeled the interventions to achieve program participation for new systems beginning at 10 percent (+/- 2%) in year one and ramping up to peak participation of 40 percent (+/-10%) by year 5 (+/- one year). The lower range of participation estimate is intended to extrapolate from current activity in Wisconsin, while the basis for the upper participation level includes an estimate of 50 percent participation from National Grid for their Design 2000 program (York and Kushler, 2003). The net to gross ratio is assumed to be 0.80 with an uncertainty of 0.10.

3. Program Costs

Program costs reflect approximations we made following the review of costs for mature programs with similar approaches and customer targets (Quantum, 2004b). Incentive costs are 72 percent of total program costs, while non-incentive costs are 28 percent. Start up costs of $60,000 over three years ($15,000 per year) are allocated to achieve a statewide effort, filling gaps in areas such as market research, information and outreach, demonstration projects, tools, and case studies. A general administrative cost of 4 percent of all intervention costs provides funding for management of the overall market effort, program specific tracking and reporting, planning meetings, and other expenses.

Costs for each intervention in the market are broken into three categories:

- Incentives for participants, designers, and other program allies;
- A market manager to handle day-to-day responsibilities and field staff to work with participants on specific projects; and
- Annual fixed costs for activities such as training, product and service development (tools, manuals, guides, software, etc.).

Incentives are paid for energy and demand savings. The overall incentive pool may be provided as participant rebates, feasibility studies, design grants, or other project specific costs to influence participation. Incentives are intended to provide up to approximately half the installed project cost for retrofit and O&M interventions for existing customers, and 50 percent to 100 percent of incremental costs for new systems. The incentives reduce the simple payback on measures by 1.3 years.

4. Measure Life

We assume an average lifespan of 12 years for system performance measures included in our analysis, with an uncertainty of 2 years. This reflects literature that places the life of process equipment in industrial environments at between 10 and 15 years. While individual components can last for decades, one expert interviewed estimated that optimization in pump systems usually lasts five years, after which the system may need to be tuned-up again (Energy Center of Wisconsin, 2003). We expect the case is similar for fans. For this reason, a program supported O&M component is needed. Operations and maintenance measures require annual attention to achieve persistence of energy savings. We assumed that through a combination of incentives, information, training, and periodic oversight, improved O&M procedures will become standard practice for participants. We set the measure life for O&M to be equal to the equipment measure life of 12 years with the same uncertainty.

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MARKET 12 — INDUSTRIAL PUMP SYSTEMS IMPROVEMENT MARKET

Market Scope

This market comprises currently available products and services that can improve the performance of new and existing industrial pump systems. The market includes the prime mover and pump on the supply side of the system, and piping, valves, and end uses on the demand side. Although efficiency improvements in the pump system will reduce energy usage by the prime mover that drives the pump (nearly always an electric motor), this market does not include efficiency upgrades within the motor itself. Drive motors are addressed in a separate market dealing with efficiency improvements and repair/replacement practices, so that the savings in that market are additive to the savings identified in this market.

Market Characteristics

Pumps are widely used in industry to provide cooling and lubrication services, to transfer fluids for processing, and to provide the motive force in hydraulic systems. Since they serve such diverse needs, pump sizes range from fractions of a horsepower to several thousand horsepower. This study estimates that pumps represent 15 percent of all electricity used by industry, or 25 percent of electricity used by industrial motors.

Pump reliability is often critical. In cooling systems, pump failure can result in equipment overheating and causing catastrophic damage. In lubrication systems, inadequate pump performance can destroy equipment. In many plants, pump downtime can cause a substantial loss in productivity. The importance of pumps to the daily operation of many facilities promotes the practice of conservatively sizing pumps to ensure that the needs of the system will be met under all conditions. Unfortunately, this practice results in higher-than-necessary system operating and maintenance costs.

Typical pumping systems contain five basic components: pumps, prime movers (nearly always AC electric motors), piping, valves, and end-use equipment (e.g. heat exchangers, tanks, and hydraulic equipment). Pumps are available in a wide range of types, sizes, and materials, but they can be broadly classified into two categories – positive displacement and centrifugal. Although many applications can be served by both positive displacement and centrifugal pumps, centrifugal pumps are more common due to their simple and safe operation, low maintenance requirements, and characteristically long operating lives (Resource Dynamics, 1999).

Upon identifying the service needs of a pumping system, the pump/motor combination, pipe sizes, layout, and valve requirements must be engineered. The most challenging aspect of the design process is cost-effectively matching pipe size and pump and motor characteristics to the needs of the system. This process is often complicated by wide variations in flow and pressure requirements. Ensuring that system needs are met during worst case conditions can lead to specifying equipment that is oversized for normal operation. Unfortunately, specifying larger than necessary pipes and pumps increases material, installation, and operating costs (Resource Dynamics, 1999).

The cost-effective operation and maintenance of a pumping system requires attention to the needs of individual equipment and the entire system. A “systems approach” analyzes both supply and demand sides of the system and how they interact; shifting the focus from individual components to total system performance. The systems approach usually involves the following types of interrelated actions (Resource Dynamics, 1999):

- Establishing current conditions and operating parameters;
- Determining present and estimating future process production needs;
- Gathering and analyzing operating data and developing load duty cycles;
- Assessing alternative system designs and improvements;
- Determining the most technically and economically sound options, taking into consideration all of the subsystems;
- Implementing the best option;
- Assessing energy consumption with respect to performance;
- Continuing to monitor and optimize the system; and
- Continuing to operate and maintain the system for peak performance.

For this study, estimates of energy saving potential for a systems approach to pumping efficiency make use of a national motor systems market opportunities assessment prepared for the U.S. Department of Energy by XENERGY, Inc. (1998). This market assessment developed a detailed profile of the then current stock of motor-driven equipment in U.S. industrial facilities, and characterized and estimated the magnitude of opportunities to improve energy efficiency. Field data collection was carried out during most of calendar year 1997. Interim and final results were reviewed by national experts.

The national motor market assessment evaluated energy savings potential and market applicability for individual measures bundled into measure categories that address component and system level improvements. The categories included for pumping systems were:

- Reduce overall system requirements
- Match pump size to load
- Reduce or control pump speed
- Improve pump components
- Operations and maintenance

Although the national assessment is a snapshot of potential as of 1997, it provided a rigorous estimate, and was consistent with the stakeholder group's opinion of current energy saving potential in Wisconsin. The appropriateness of this assumption is supported by recently completed surveys conducted in Wisconsin with suppliers and customers indicating that a systems approach is not standard practice.

- Suppliers and design engineers often deal primarily with plant personnel or procurement departments that tend to look only at first cost and look very conservatively on any proposed changes to business-as-usual designs or sizing factors. (Energy Center of Wisconsin, 2003)
- The efficiency of the pump system often gets lost within the production maximizing/cost-minimizing framework of large industrial plant procurement. (Energy Center of Wisconsin, 2003)

Recent studies examined the supply chain of the Wisconsin pump systems market, providing insights into the barriers and achievability of energy savings (Energy Center of Wisconsin, 2003, and KEMA, 2005):

- The pump market is highly segmented to serve the diverse applications in industrial processes. It is not uncommon for a few large manufacturers or pump designers to control a significant amount of the market for a specific process. These suppliers report being in business for many years and having longstanding relationships with end-users in their target industries (Energy Center of Wisconsin, 2003).

- After functionality (choosing the right pump for the job) most of their customers' primary concern is reliability. It is expensive in terms of downtime and product loss to have any part of the process fail during production.
- Pump over-sizing is a primary contributor to pump system inefficiency. In addition, the integration of a pump into an overall pumping system also has a significant effect on overall efficiency. Selecting the right piping size, tank size, control strategy and correct pump size can significantly reduce total energy consumption at a site.
- In circumstances where oversizing is prudent to allow for future growth and variable production rates, emphasize integration with variable speed drives.
- A change in the process or a major redesign is one of the best times to improve pumping efficiency. This is the only time owners are willing to spend the engineering effort to determine the correct pump load, speed and flow rates that are necessary to choose the correct size of pump and control strategy.
- Pump efficiency, when it is addressed, is generally considered for the largest and longest running pumps. Owners are generally not interested in spending time and money on designing an efficient pump system if they do not perceive that it will result in a quick payback.
- Education efforts are needed that focus on reducing gross oversizing, matching of pumps to load requirements, and integration with variable speed drives. Helping suppliers to make this case using well-documented evidence of the benefits of proper sizing and control integration could be beneficial.
- Education and other interventions may need to be customized to the unique process requirements of specific industries.

Program Approaches

Key findings from recent market assessments in Wisconsin suggest the following program approach:

- Customer-specific design assistance, with information and incentives for both the facility owner and design team upon installation of an optimized system, appears to be appropriate for the pumping system market.
- Emphasize integration of variable speed drives to minimize impacts of oversizing (Sasso and Nicol, 2005).
- Contributing to the pool of technical pump system knowledge for key industries and processes in Wisconsin provides value to suppliers. Suppliers point to the need to stay informed about specific industry technologies in order to remain competitive. They also emphasized the value of case studies and testimonials.
- Assisting pump suppliers and design engineers in reaching and selling to decision makers within end-user organizations that are most receptive to life-cycle cost analysis may also be helpful.
- Leveraging emerging national efforts and industry associations such as the Hydraulics Institute to improve pump system efficiency is likely to be worthwhile.
- Suppliers report that existing information and training opportunities are valuable and come from a variety of sources.
- Include market transformation goals in program design and implementation

To estimate the achievable market potential, the program model consists of:

- A *primary approach* for existing systems that follows a systems approach to performance improvement by providing information and training, financial support for design teams, cost sharing for feasibility studies, and incentives for measure installation. Emphasize integration of variable speed drives to minimize impacts of oversizing.
- An *add-on component* for existing pumping systems to improve operations and maintenance practices through replacement of worn impellers, inspecting and repairing bearings, lip seals, packings, and other mechanical seals supported by a program effort offering information, training, and financial incentives.
- A *primary approach* for new pumping systems that follows the same basic approach that is used for existing pumps.

Table 12.01.1 summarizes midpoint estimates of program costs and achievable impacts for applying the program approach above to the industrial pump systems market. Supporting details are provided in the technical documentation

TABLE 12.01.1. ESTIMATED VALUES FOR PROGRAM AREA 12.01, INDUSTRIAL PUMP SYSTEMS MARKET

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$1,363 to $2,629	$1,687 to $3,160
	Incremental Impacts	peak kW	1,850 to 4,100	2,366 to 5,006
		annual kWh (000s)	13,468 to 30,055	17,185 to 36,485
		annual therms (000s)	0	0
	Levelized resource cost	per peak kW	$59 to $132	$58 to $128
		per kWh	0.9¢ to 1.6¢	0.9¢ to 1.5¢
		per therm	NA	NA
Scaling factors[a]		program costs	1.3 to 2.6	1.3 to 2.6
		impacts	1.1 to 1.5	1.1 to 1.5

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Below, we document the technical assumptions we made for a "systems approach" to energy efficiency in industrial pump systems.

Program Area 12.01 — Industrial Pump Systems Market

Model inputs for this program area are summarized in Table 12.01.2 below, and described on the following pages.

TABLE 12.01.2. MODEL INPUTS FOR INDUSTRIAL PUMP SYSTEMS MARKET

Model Inputs (12.01)			Value	±
1		**Impacts**		
	a	2005 market size (GWh)	3,763	188
	b	2005 market size (peak MW)	516	26
	c	Annual market growth rate (2006-2015)	1.8%	0.2%
		Efficiency improvement within 2006 inventory w/o program intervention		
	f	Annual market undergoing improvements (2006-2015)	1.25%	0.6%
	g	Electric energy % saved within retrofitted systems	21.0%	8.4%
	h	Electric peak demand % saved within retrofitted systems	21.0%	8.4%
		Identified savings potential for primary intervention within entire inventory as of 1/1/2006		
	j	Electric energy % savings	20.0%	8.0%
	k	Electric peak demand % savings	20.0%	8.0%
		Identified savings potential for add-on intervention within entire inventory as of 1/1/2006		
	m	Electric energy % savings	1.0%	0.4%
	n	Electric peak demand % savings	1.0%	0.4%
		Identified savings potential in new usage with primary intervention		
	p	Electric energy % savings	21.0%	8.4%
	q	Electric peak demand % savings	21.0%	8.4%
2		**Program Participation**		
		Primary intervention for 2006 existing		
	a	Participation in Year 1 (% of 2006 inventory)	2.0%	1.0%
	b	Ultimate annual participation rate (% of 2006 inventory)	4.0%	1.0%
	c	Year ultimate participation reached	5	1
	d	Net-to-gross ratio for primary intervention	0.80	0.10
		Add-on intervention for 2006 existing		
	e	Participation in Year 1 (% of 2006 inventory)	2.0%	1.0%
	f	Ultimate annual participation rate (% of 2006 inventory)	4.0%	1.0%

	g	Year ultimate participation reached	5	1
	h	Net-to-gross ratio for add-on component	0.80	0.10
		Primary intervention for new usage		
	i	Participation in Year 1 (% of annual new usage)	10%	2%
	j	Ultimate annual participation rate (% of annual new usage)	40%	10%
	k	Year ultimate participation reached	5	1
	l	Net-to-gross ratio for primary intervention	0.80	0.10
3		**Program costs**		
	a	Administration start up cost premium (total over years 1 - 3)	$125,000	$25,000
	b	Base administrative costs (% of all intervention costs)	4%	1%
		Primary intervention for 2006 existing		
	c	Additional costs above variable costs for intervention (annual)	$40,000	$5,000
	d	Market management and field staff (% of variable costs)	15%	5%
	e	Incentive costs per annual kWh saved	$0.04	$0.01
	f	Incentive costs per peak kW reduced	$125	$25
		Add-on intervention for 2006 existing		
	g	Additional costs above variable costs for intervention (annual)	$30,000	$5,000
	h	Market management and field staff (% of variable costs)	15%	5%
	i	Incentive costs per annual kWh saved	$0.04	$0.01
	j	Incentive costs per peak kW reduced	$125	$25
		Primary intervention for new usage		
	k	Additional costs above variable costs for intervention (annual)	$40,000	$5,000
	l	Market management and field staff (% of variable costs)	15%	5%
	m	Incentive costs per annual kWh saved	$0.04	$0.01
	n	Incentive costs per peak kW reduced	$125	$25
4		**Measure life (years)**	12	2

1. Impacts

The size of the pump systems market in Wisconsin was estimated as a percentage portion of the overall electric energy usage (GWh and MW) in manufacturing statewide. The approach started with a statewide electricity forecast, segmented overall sales by 22 industry types, and then broke down the electric sales within each industry type by primary industrial end uses. This “top down” approach to estimating market size was taken due to inadequate data on equipment sales and operating parameters required for a “bottom up” estimate of full achievable potential.

The statewide electricity forecast for industrial electric energy sales (GWh), peak load (MW), and growth rate from 2005 through 2015 was derived using data from the Public Service Commission of Wisconsin (PSC, 2004 and Kliebenstein, 2005). Overall electric sales were segmented into the industry types shown in Table 12.01.3, based on utility sales data for 2004 where available, or other sources as a default (WCDSR, 1994). Industry types were classified following the U.S Census Bureau’s Standard Industrial

Classification (SIC) system, or the more recent North American Industrial Classification System (NAICS). Natural gas sales and growth rate were derived from 2004 Wisconsin Energy Statistics (DOA, 2004). Segmentation of sales by industry type relied upon national data (EIA, 2005)

TABLE 12.01.3. INDUSTRY TYPE SEGMENTATION AND ENERGY USE (ELECTRIC AND GAS)

SIC CODE	INDUSTRY TYPE	GWH	THERMS
10-14	Mining	0.3%	0.0%
20	Food & Kindred	11.1%	14.8%
21	Tobacco (included in SIC 20)	0.0%	0.0%
22	Textiles	0.2%	0.2%
23	Apparel	0.1%	0.1%
24	Lumber & Wood Products	1.9%	1.0%
25	Furniture	0.5%	0.2%
26	Paper & Allied	30.4%	38.2%
27	Printing	2.3%	1.0%
28	Chemicals & Allied	5.9%	10.5%
29	Petroleum	0.0%	0.2%
30	Rubber & Plastics	5.4%	1.9%
31	Leather	0.3%	0.2%
32	Stone, Clay & Glass	3.6%	6.1%
33	Primary Metals	8.4%	9.5%
34	Fabricated Metals	9.6%	6.8%
35	Machinery	9.4%	5.0%
36	Electrical Equipment	3.4%	1.7%
37	Transportation Equip	3.6%	2.0%
38	Instruments	0.6%	0.1%
39	Miscellaneous	1.2%	0.6%
46	Pipelines	1.8%	0.0%

A break out into ten electric end-uses and four gas end-uses (Table 12.01.4), based on the characteristics of each industry type, was applied to the electric sales segmented by industry type. The end use break outs by industry type were derived using data available from the United States Energy Information Administration (EIA), “1998 Manufacturing Energy Consumption Survey” (2005). The sales data for each end use was summed across each industry type to provide the estimated electricity and gas used by that end use. The end-use fractions in Table 12.01.4 provide results averaged across all Wisconsin industry included in the market.

TABLE 12.01.4. INDUSTRY ELECTRIC AND NATURAL GAS END USE BREAK OUTS

ELECTRIC END USES	FRACTION (ALL INDUSTRY)	NATURAL GAS END USES	FRACTION (ALL INDUSTRY)
Fan Systems & Motors	9.4%	Boilers	46%
Pump Systems & Motors	15.3%	Direct Process Heat	36%
Compressed Air Systems & Motors	7.6%	Facility HVAC	9%
Process Cooling Systems & Motors	5.8%	Other	9%
Other Process Motors	26.8%		
Process Heat	10.6%		
Other Process	2.2%		
Facility Lighting	7.7%		
Facility HVAC	9.2%		
Other Facility	5.5%		

Following the approach outlined above, the energy usage of industrial pump systems in Wisconsin at the end of 2005 (start of 2006) was estimated to be 3,961 GWh or 15.3 percent of 25,924 GWh total industrial sales projected for 2005. To account for uncertainty between end-use shares while keeping the analysis within the overall industrial forecast, we estimated the size for this market at 95 percent (+/- 5%) of the estimated end-use share. This translates to 3,763 GWh (+/- 188 GWh).

The percentages of electric usage for industry type and end-use were applied to the forecast of peak loads for Wisconsin industry. The peak load of industrial pump systems in Wisconsin at the end of 2005 (start of 2006) was estimated to be 543 MW or 15.3 percent of 3,553 MW total industrial load projected for 2005. Natural gas usage for pump systems is zero. Depending on the location of the affected electrical equipment and facility HVAC approach, a reduction in electrical usage within a facility could raise natural gas space heating by 0 percent to 100 percent of the equivalent delivered heat; however, we have chosen to exclude this effect in the model. To account for uncertainty between end-use shares while keeping the analysis within the overall industrial forecast, we estimated the size for this market at 95 percent (+/- 5%) of the estimated end-use share. This translates to 516 MW (+/- 26 MW).

As outlined in the market description, the interventions in this market consist of system retrofits and improved O&M for existing systems, and improvements for systems associated with new electric usage. To calculate the potential for energy savings in these markets, it is necessary to establish the baseline conditions against which to measure the savings potential. This requires an estimate of the efficiency level of existing systems, and the future energy efficiency improvements that would occur absent all program interventions.

The natural, annual rate of systems approach installations, absent any program, is estimated to be 1.25 percent of the market (on an energy usage basis). This estimate is derived from results of a recent supply chain study in Wisconsin that found, according to pump designers, only about 15 percent of their clients specifically request high efficiency systems (Energy Center of Wisconsin, 2003).The same study also found that about 10-15 percent of the systems large manufacturers sell include design assistance as part of the sale (Energy Center of Wisconsin, 2003). At a 15 percent penetration of a systems approach to ongoing business, we assume 15 percent of all systems would be optimized over the life cycle of this market. This is supported by results in the national motor market assessment that found at least one systems approach measure being undertaken by industry from less than 1 percent to just 3 percent per year (XENERGY, 1998).

The energy and peak demand savings for those customers receiving systems improvements is 21.0 percent (XENERGY, 1998), divided into design and equipment measures (20.0 percent savings), and improved O&M practices (1.0 percent). These values were taken from the national motor market assessment study that evaluated energy savings potential and market applicability for individual measures bundled into measure categories that address component and system level improvements. Energy savings and applicability factors reflected the opinions of a group of experts on the percentage of systems that could be cost-effectively retrofitted, and the resulting savings.

The applicability factors define what is "achievable" and, we assume, fully acceptable by the market. The applicability factors are provided as a range with a low, midrange, and high estimate, which we used to define savings uncertainty. The individual measures included within each measure category are listed in the national assessment study. There is an exception; the applicabilities of the pump O&M measures match those of fan systems, as given in the assessment study. The applicability factors for O&M in the data summary table for pumps were given as 2 percent to 7 percent. The low values were inconsistent with other data in the assessment study. The savings reflect measures that could be implemented at a payback of three years or less. The categories included for pump systems are provided in Table 12.01.5.

TABLE 12.01.5. ENERGY SAVINGS FOR MEASURE CATEGORIES

MEASURE CATEGORY	% SAVINGS OF BUNDLE	SAVINGS APPLICABILITY (LOW, MIDRANGE, HIGH)	OVERALL SAVINGS (MIDRANGE)
Reduce overall system requirements	10%	40-50%-65	5.0%
Match Pump Size to Load	20%	10-20%-30	4.0%
Reduce or Control Pump Speed	30%	15-35%-45	10.5%
Improve Pump Components	5%	5-10%-15	0.5%
Operations and maintenance	2%	25-50%-60	1.0%
TOTAL			21.0%

The market size of new usage is the difference between the forecast for all pump systems and the usage of the existing year 1 inventory over time. The energy savings potential for new systems, 21.0 percent reflects an installation with a comprehensive set of measures, including O&M practices.

2. Program Participation

We have modeled the existing primary and add-on interventions to achieve program participation for system improvements beginning at 2.0 percent (+/-1. 0%) of the total stock in year one and ramping up to peak participation of 4.0 percent (+/-1.0 %) by year 5 (+/- one year). On this participation schedule, 34 percent of the market will participate in this intervention after 10 years. In support of this assumption, National Grid reports that 55 percent of eligible electric customers have participated in their Energy Initiative Custom retrofit program over a ten year time frame (York and Kushler, 2003). The Energy Initiative program targets similar customer types that our intervention targets for improvements. A net to gross program value of 0.80 (+/- 0.10) was used, reported by National Grid for their Energy Initiative Program (Quantum, 2004b)

We have modeled the interventions to achieve program participation for new systems beginning at 10 percent (+/- 2%) in year one and ramping up to peak participation of 40 percent (+/-10%) by year 5 (+/- one year). The lower range of participation estimate is intended to extrapolate from current activity in Wisconsin, while the basis for the upper participation level includes an estimate of 50 percent participation from National Grid for their Design 2000 program (York and Kushler, 2003). The net to gross ratio is assumed to be 0.80 with an uncertainty of 0.10.

3. Program Costs

Program costs reflect approximations we made following the review of costs for mature programs with similar approaches and customer targets (Quantum, 2004b). Incentive costs are 79 percent of total program costs, while non-incentive costs are 21 percent. Start up costs of $125,000 over three years ($15,000 per year) are allocated to achieve a statewide effort, filling gaps in areas such as market research, information and outreach, demonstration projects, tools, and case studies. A general administrative cost of 4 percent of all intervention costs provides funding for management of the overall market effort, program specific tracking and reporting, planning meetings, and other expenses.

Costs for each intervention in the market are broken into three categories:

- incentives for participants, designers, and other program allies;
- a market manager to handle day-to-day responsibilities and field staff to work with participants on specific projects; and
- annual fixed costs for activities such as training, product and service development (tools, manuals, guides, software, etc.).

Incentives are paid for energy and demand savings. The overall incentive pool may be provided as participant rebates, feasibility studies, design grants, or other project specific costs to influence participation. Incentives are intended to provide up to approximately half the installed project cost for retrofit and O&M interventions for existing customers, and 50 percent to 100 percent of incremental costs for new systems. The incentives reduce the simple payback on measures by 1.3 years.

4. Measure Life

We assume an average lifespan of 12 years for system performance measures included in our analysis, with an uncertainty of 2 years. This reflects literature that places the life of process equipment in industrial environments at between 10 and 15 years. While individual components can last for decades, one expert interviewed estimated that optimization usually lasts five years, after which the system may need to be tuned-up again (Energy Center of Wisconsin, 2003). For this reason, a supported O&M program component is needed. Operations and maintenance measures require annual attention to achieve persistence of energy savings. We assumed that through a combination of incentives, information, training, and periodic oversight, improved O&M procedures will become standard practice for participants. We set the measure life for O&M to be equal to the equipment measure life of 12 years with the same uncertainty.

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MARKET 13 — MANUFACTURING PROCESS UPGRADES

Market Scope

This industrial market for upgrades to manufacturing processes is comprised of several submarkets: process cooling, industrial boilers and steam systems, and direct process heating. The energy savings in these industrial submarkets are additive to the savings identified in the lighting, motor, pump, fan, and compressed air systems markets. These submarkets are of particular importance to key Wisconsin industries including food processing, papermaking, metal casting, and metal finishing, but the results have been extended to other industries where appropriate.

Market Characteristics

A recent evaluation of industrial equipment supply channels (XENERGY, 2002) found a great deal of variation in the degree to which OEMs active in the vertical markets for paper, food, and metal casting equipment integrate energy efficiency into their sales and design efforts. The study did, however, find the following consistencies in practices and approach.

- ***In a number of key Wisconsin industries such as paper and food processing, most energy is consumed by specialized production machinery manufactured by OEMs or custom fabricated for the site.*** According to industry specific technical analyses, most of the available savings potential in these industries can be found in proper matching of this custom production equipment to the requirements of the facility. The delivery channel for this equipment consists of specialized design engineering firms, OEMs, and component manufacturers, as well as some specialty installation and maintenance companies.
- ***Energy efficiency ranks low in terms of customers' overall criteria for investments in major production equipment.*** Industrial customers rank consistency of product quality, first cost, flexibility, waste reduction, and ease of use and maintenance ahead of energy efficiency in selecting or custom-designing production equipment.
- ***Procurement of production equipment is a multi-stage, collaborative process.*** For production equipment that is built up of a number of components, the typical procurement process involves a number of iterations and negotiations. Often the customer will issue general performance guidelines to competitors and use the responses to narrow down both the field of potential suppliers and the range of design options. After further negotiations and financial modeling of alternative designs, a second stage of competitive bids or proposals based on fixed specifications is typical. Both the extended time frame of this kind of procurement process, as well as the use of long-term investment analysis may offer "hooks" for program intervention to raise the profile of energy efficiency in production equipment design and purchase.

The XENERGY supply channel study (2002) of industry segments found the barriers to energy efficiency are consistent with those from studies of general industrial customers, with some elements unique to each industry. The key barriers are as follows (XENERGY, 2002):

Papermaking

- ***Technical and engineering staff shortages.*** Consolidation and volatile profitability have led to general reductions in the level of engineering and maintenance staff in paper mills. This reduces plant-level capacity to plan and execute energy-saving investments.
- ***Competition with other investments.*** Paper companies face a wide range of investment needs as international competition accelerates. In addition to production capacity, these needs include environmental compliance, supply chain management (IT), and marketing.
- ***Absence of information and benchmarking.*** Currently there is no systematic reporting of energy use in the pulp and paper industry (except for total usage industry-wide).
- ***Competition with on-site generation processes.*** Paper manufacturers produce 55–60 percent of their electricity needs by burning wood wastes and spent pulping liquors. The high portion of cogeneration in the energy supply mix effectively reduces the costs of electricity and steam to the mill operators, and thus reduces their incentive to implement end-use efficiency measures.

Food Processing

- ***There are over 300 firms in the food processing equipment industry in Wisconsin alone***. These actors, as well as their customers in the food processing and packaging businesses, each have some voice in the design of process systems.
- ***Although they are in a low margin industry and consume a great deal of energy, food processors are loath to change or adapt new technology to their processing system***s. The food processing industry is highly concerned with consistency in their product. They fear that a change in the food product's appearance, taste, or texture will have negative ramifications in the marketplace.
- ***A major barrier to implementation is the inability to verify energy savings***. Others mentioned a general lack of technical understanding and disinterest in educating themselves about energy efficiency, given the low priority for energy costs in system design.

Metal Casting

- ***Most metal casting operations are small shops.*** The smallness of most metal casting operations means that few foundries are capable of absorbing high upfront costs with long payback periods.
- ***Foundry equipment has to be flexible in order to respond to the demands of the market.*** Despite their high-energy costs, foundry owners tend to be primarily concerned with performance and flexibility of the equipment, to be able to respond more effectively to the demands of the casting market.
- ***A major barrier is lack of knowledge.*** One main barrier to foundries choosing the most efficient melting technology may be knowledge of available alternative technologies.

Process cooling and heating are fundamental components in the manufacture of most consumer and industrial products. We estimate that process cooling consumes 5.8 percent of electricity in the industrial sector, while electric process heating (furnaces, ovens, etc.) consumes 10.6 percent of industrial electricity. Industrial usage of natural gas is dominated by process heating, where we estimate 46 percent of natural gas is used for boilers and steam systems, and 36 percent is used for direct process heating to temperatures from 300 F to over 2,300 F.

The food industry in particular relies heavily on refrigeration, primarily ammonia-based systems. The basic technology used in mechanical refrigeration systems has not changed in decades, yet the development of new products and government regulations aimed at reducing the environmental impacts of refrigerants have placed higher demands and stricter requirements on the technology. These demands and requirements have raised issues regarding the safety, efficiency, environmental impact, and design of industrial refrigeration systems.

Most industrial refrigeration systems are "one-of-a-kind" systems. They rely on large vapor compression cooling systems that operate as needed throughout the day. Several factors affect the efficiency of these systems, including initial design, maintenance, product flow, defrost schemes, system-level operating strategies, and weather.

The refrigeration process removes and relocates heat. There are three main components in mechanical refrigeration systems: 1) compressor— performs the work; 2) evaporator— removes heat from the refrigerated space; and 3) condenser— rejects the heat to the outside air.

The first step to improving the energy efficiency of an industrial refrigeration system is to establish its baseline performance and to compare it to performance standards or benchmarks. A good time to evaluate a system is in conjunction with proposed expansions, at times when upgrading, or on a regularly established schedule. Potential opportunities for improving efficiency include:

- Floating head pressure control— takes advantage of excess evaporator condenser capacity during cool outside air conditions
- Compressor selection and load allocation— the operation and sequencing of compressors within a systems context is critical to maximizing their performance and energy efficiency
- Multi-stage systems— when does a 2-stage system make sense?
- Maintenance— preventive maintenance is required by law and maximizes system reliability
- Reduce on-peak electrical demand— reduce operating costs of cold storage
- Defrosting— implement improved methods and reduce moisture to improve efficiency and reduce costs

Manufacturers use steam to heat raw materials and treat semi-finished products. The best opportunities for reducing operating costs come from considering the whole system, rather than just the parts. Opportunities for savings are found in:

- **Steam Generation** through boiler controls and water treatment;
- **Steam Distribution** through checking steam leaks, installing insulation and proper steam trap maintenance;
- **Steam End Use** through equipment and controls to optimize steam pressure, heat exchange, and blow-through; and
- **Steam Recovery** through condensate return.

With each direct process heating application, the system sizes, configurations, and operating practices range widely throughout industry. For a given system, there are usually a variety of individual improvement opportunities, and many different ways to improve the system performance. In order to achieve maximum improvement at the lowest cost, a systems approach should be used.

Common to all process heating systems is the transfer of energy to the material to be treated. Direct heating methods generate heat within the material itself (microwave, induction), whereas indirect methods transfer energy from a heat source (electric or fuel combustion) to the material by conduction, convection, radiation, or a combination of these (LBNL, 2004).

In most processes, an enclosure is needed to isolate the heating process and the environment from each other. Functions of the enclosure include the containment of radiation (microwave, infrared), the confinement of combustion gases and volatiles, the containment of the material itself, the control of the atmosphere surrounding the material, and combinations thereof.

The main goal of the performance optimization is reduction of energy losses, and the increase of the energy transferred to the load. Performance and efficiency improvement opportunities can be grouped into the following categories (LBNL, 2004):

- Heat generation: the equipment and the fuels used to heat a product
- Heat containment: methods and materials that can reduce energy loss to the surroundings
- Heat transfer: methods of improving heat transferred to the load or charge to reduce energy consumption, increase productivity, and improve quality
- Waste heat recovery: sources of energy loss that can be recovered for more useful purposes
- Enabling technologies: common opportunities to reduce energy losses by improving material handling practices, effectively sequencing and scheduling heating tasks, and seeking more efficient process control and improving the performance of auxiliary systems.

Program Approaches

The following potential strategies to encourage equipment suppliers to promote energy efficiency in major production equipment were among those cited in recent market studies conducted in Wisconsin:

- Paper mills tend to focus on lowest installed costs versus ROI and payback. To better market energy efficiency, explore creating **incentives for vendors to market new and more efficient technologies by replicating what has worked in other markets**. Suppliers and independent research groups have already done most of the research. The next step is making the connections for end users rather than assuming they will draw logical cost/benefit assumptions based on system details they may not have the time or capacity to digest (XENERGY, 2002).
- Create **more incentives for plants to perform system audits**. There may be a perception that energy efficiency requires installing very big, very expensive replacements or upgrades. Case studies demonstrate that a number of energy-saving approaches, coupled with consideration of incremental improvements can offer end users benefits they can see in their day-to-day operations, thereby de-mystifying some of the latent conceptions that energy efficiency is a code word for the government to impose new requirements on them or for suppliers to market high end products (XENERGY, 2002).
- **Improved marketing strategy and a one-stop shop for resources.** The nature of bidding on projects can create a situation where energy efficient options are not prioritized. Relying on suppliers to take on the totality of that risk is not a proactive or reliable strategy to address the barriers to promoting energy efficiency (XENERGY, 2002).

- Supply-side actors suggest that machines are being refurbished rather than replaced, as mills strive to reduce operating costs while maintaining a reasonable level of competitiveness (Quantum, 2003).
- **An approach based on audit and optimization of production processes similar to that employed by the Industrial Assessment Center program may be appropriate for the Wisconsin pulp and paper industry**. Rather than focusing exclusively on energy, the IAC program approaches energy efficiency in the context of the overall production process, evaluating medium sized industrial plants for a variety of process upgrades and waste reduction opportunities (Quantum, 2003).
- **In part because it is a long established industry, food processing relies heavily on personal relationships**, and the vast majority of both design contracts and equipment purchases are made through invitation-only bids or direct selection by the plant owner rather than through an open bid process. **Efforts to influence end-users through the supply chain should focus on those equipment and design firms with strong, longstanding relationships and significant market share.** Similarly, organizations seeking to intervene in the market should be prepared to develop and cultivate long-term relationships with end-users and suppliers (ECW, 2003a).
- **Existing processes may be modified or redesigned as a result of food industry consolidation or changes in product mix.** An opportunity may therefore exist to encourage consideration of energy efficiency as part of a broader process optimization effort (ECW, 2003a).
- **While buyers are very first-cost oriented in new plants, they may be more receptive to lowest life-cycle cost solutions in retrofit applications.** Replacement equipment selection is rarely done through a competitive bid process that emphasizes price alone (ECW, 2003a).
- **Suppliers (as well as their customers) value the availability of rebates or other incentives**. Incentives address the first cost issue raised by so many of the manufacturers and designers interviewed, and have the additional value of demonstrating the funding source's commitment to the specific measure and to the pulp and paper industry overall (Quantum, 2003).

To estimate the achievable market potential in each submarket, the program model consists of:

- A *primary intervention* for existing systems that follows a systems approach to performance improvement by providing information and training, financial support for design teams, cost sharing for feasibility studies, and incentives for measure installation.

Table 13.01.1 summarizes midpoint estimates of program costs and achievable impacts for applying the program approach above to the manufacturing process upgrades market. Supporting details are provided in the technical documentation.

TABLE 13.01.1. ESTIMATED VALUES FOR PROGRAM AREA 13.01, MANUFACTURING PROCESS UPGRADES

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$3,055 to $5,223	$3,667 to $6,203
	Incremental Impacts	peak kW	435 to 877	547 to 1,041
		annual kWh (000s)	5,418 to 10,154	6,633 to 12,147
		annual therms (000s)	2,258 to 4,229	2,769 to 5,060
	Levelized resource cost	per peak kW	$80 to $198	$81 to $188
		per kWh	0.7¢ to 1.6¢	0.7¢ to 1.5¢
		per therm	11.4¢ to 17.5¢	11.3¢ to 17.3¢
Scaling factors[a]		program costs	1.5 to 3.0	1.5 to 3.0
		impacts	1.1 to 1.6	1.1 to 1.6

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Below, we document the technical assumptions we made for a managed approach to energy efficiency in manufacturing process upgrades.

Program Area 13.01 — Manufacturing Process Upgrades

Inputs for this program model are summarized in Table 13.01.2 below, and described on the following pages.

TABLE 13.01.2. MODEL INPUTS FOR MANUFACTURING PROCESS UPGRADES MARKET

Model Inputs (13.01)			Value	±
1		**Impacts**		
		Process Cooling		
	a	2005 market size (GWh)	1,435	72
	b	2005 market size (peak MW)	197	10
	c	2005 market size (10^12 Btu)	0.0	0.0
		Boilers and Steam Systems		
	d	2005 market size (GWh)	169	8
	e	2005 market size (peak MW)	23	1
	f	2005 market size (10^12 Btu)	62.7	3.1
		Direct Process Heating		
	g	2005 market size (GWh)	2,614	131
	h	2005 market size (peak MW)	358	18
	i	2005 market size (10^12 Btu)	49.0	2.5
		Average Growth rates		
	j	Annual elec market growth rate (2006-2015)	1.8%	0.2%
	k	Annual gas market growth rate (2006-2015)	0.6%	0.1%
		Efficiency improvement within 2006 inventory w/o program intervention		
	l	Annual market undergoing improvements (2006-2015)	8.3%	1.7%
	m	Electric energy % saved within upgraded systems	2.0%	1.0%
	n	Electric peak demand % saved within upgraded systems	2.0%	1.0%
	o	Natural gas energy % saved within upgraded systems	4.0%	2.0%
		Identified savings potential for process cooling within entire inventory as of 1/1/2006		
	p	Electric energy % savings	14.3%	2.9%
	q	Electric peak demand % savings	14.3%	2.9%
	r	Natural gas energy % savings	0.0%	0.0%
		Identified savings potential for boilers and steam systems within entire inventory as of 1/1/2006		
	s	Electric energy % savings	0.0%	0.0%
	t	Electric peak demand % savings	0.0%	0.0%
	u	Natural gas energy % savings	15.3%	3.8%

		Identified savings potential for direct process heating within entire inventory as of 1/1/2006		
	v	Electric energy % savings	5.1%	2.7%
	w	Electric peak demand % savings	0.0%	0.0%
	x	Natural gas energy % savings	9.3%	4.9%
2		**Program Participation**		
		Primary intervention for existing process cooling		
	a	Participation in Year 1 (% of 2006 inventory)	2.0%	1.0%
	b	Ultimate annual participation rate (% of 2006 inventory)	5.0%	1.0%
	c	Year ultimate participation reached	5	1
	d	Net-to-gross ratio for primary intervention	0.80	0.10
		Primary intervention for existing boilers and steam systems		
	e	Participation in Year 1 (% of 2006 inventory)	2.0%	1.0%
	f	Ultimate annual participation rate (% of 2006 inventory)	5.0%	1.0%
	g	Year ultimate participation reached	5	1
	h	Net-to-gross ratio for add-on component	0.80	0.10
		Primary intervention for existing direct process heating		
	i	Participation in Year 1 (% of annual new usage)	2.0%	1.0%
	j	Ultimate annual participation rate (% of annual new usage)	5.0%	1.0%
	k	Year ultimate participation reached	5	1
	l	Net-to-gross ratio for primary intervention	0.80	0.10
3		**Program costs**		
	a	Administration start up cost premium (total over years 1 - 3)	$125,000	$25,000
	b	Base administrative costs (% of all intervention costs)	4%	1%
		Primary intervention for Process Cooling		
	c	Additional costs above variable costs for intervention (annual)	$40,000	$5,000
	d	Market management and field staff (% of variable costs)	15%	5%
	e	Incentive costs per annual kWh saved	$0.04	$0.01
	f	Incentive costs per peak kW reduced	$125	$25
	g	Incentive costs per annual therm reduced	$0.00	$0
		Primary intervention for Boilers and Steam Systems		
	h	Additional costs above variable costs for intervention (annual)	$40,000	$5,000
	i	Market management and field staff (% of variable costs)	15%	5%
	j	Incentive costs per annual kWh saved	$0.00	$0.00
	k	Incentive costs per peak kW reduced	$0	$0
	l	Incentive costs per annual therm reduced	$0.70	$0.10
		Primary intervention for Direct Process Heating		
	m	Additional costs above variable costs for intervention (annual)	$40,000	$5,000
	n	Market management and field staff (% of variable costs)	15%	5%
	o	Incentive costs per annual kWh saved	$0.04	$0.01
	p	Incentive costs per peak kW reduced	$125	$25
	q	Incentive costs per annual therm reduced	$0.70	$0.10

4	**Measure life (years)**	12	2
5	**Proportion of program costs allocated to electric impacts**	15%	2%

1. Impacts

The size of the process cooling, boiler and steam, and direct process heating markets in Wisconsin was estimated as a percentage portion of the overall natural gas (therms) and electric energy usage (GWh and MW) in manufacturing statewide. The approach started with statewide gas and electricity forecasts, segmented overall sales by 22 industry types, and then broke down the sales within each industry type by primary industrial end uses. This "top down" approach to estimating market size was taken due to inadequate data on equipment sales and operating parameters required for a "bottom up" estimate of full achievable potential.

The statewide electricity forecast for industrial electric energy sales (GWh), peak load (MW), and growth rate from 2005 through 2015 was derived using data from the Public Service Commission of Wisconsin (PSC, 2004 and Kliebenstein, 2005). Overall electric sales were segmented into the industry types shown in Table 13.01.3, based on utility sales data for 2004 where available, or other sources as a default (WCDSR, 1994). Industry types were classified following the U.S Census Bureau's Standard Industrial Classification (SIC) system, or the more recent North American Industrial Classification System (NAICS). Natural gas sales and growth rate were derived from 2004 Wisconsin Energy Statistics (DOA, 2004). Segmentation of sales by industry type relied upon national data (EIA, 2005).

TABLE 13.01.3. INDUSTRY TYPE SEGMENTATION AND ENERGY USE (ELECTRIC AND GAS)

SIC CODE	INDUSTRY TYPE	GWH	THERMS
10-14	Mining	0.3%	0.0%
20	Food & Kindred	11.1%	14.8%
21	Tobacco (included in SIC 20)	0.0%	0.0%
22	Textiles	0.2%	0.2%
23	Apparel	0.1%	0.1%
24	Lumber & Wood Products	1.9%	1.0%
25	Furniture	0.5%	0.2%
26	Paper & Allied	30.4%	38.2%
27	Printing	2.3%	1.0%
28	Chemicals & Allied	5.9%	10.5%
29	Petroleum	0.0%	0.2%
30	Rubber & Plastics	5.4%	1.9%
31	Leather	0.3%	0.2%
32	Stone, Clay & Glass	3.6%	6.1%
33	Primary Metals	8.4%	9.5%
34	Fabricated Metals	9.6%	6.8%
35	Machinery	9.4%	5.0%
36	Electrical Equipment	3.4%	1.7%

SIC CODE	INDUSTRY TYPE	GWH	THERMS
37	Transportation Equip	3.6%	2.0%
38	Instruments	0.6%	0.1%
39	Miscellaneous	1.2%	0.6%
46	Pipelines	1.8%	0.0%

A break out into ten electric end-uses and four gas end-uses (Table 13.01.4), based on the characteristics of each industry type, was applied to the electric sales segmented by industry type. The end use break outs by industry type were derived using data available from the United States Energy Information Administration (EIA), "1998 Manufacturing Energy Consumption Survey" (2005). The sales data for each end use was summed across each industry type to provide the estimated electricity and gas used by that end use. The end-use fractions in Table 13.01.4 provide results averaged across all Wisconsin industry included in the market. To account for uncertainty between end-use shares while keeping the analysis within the overall industrial forecast, we estimated the size for each market at 95 percent (+/-5%) of the estimated end-use share.

TABLE 13.01.4. INDUSTRY ELECTRIC AND NATURAL GAS END USE BREAK OUTS

ELECTRIC END USES	FRACTION (ALL INDUSTRY)	NATURAL GAS END USES	FRACTION (ALL INDUSTRY)
Fan Systems & Motors	9.4%	Boilers	46%
Pump Systems & Motors	15.3%	Direct Process Heat	36%
Compressed Air Systems & Motors	7.6%	Facility HVAC	9%
Process Cooling Systems & Motors	5.8%	Other	9%
Other Process Motors	26.8%		
Process Heat	10.6%		
Other Process	2.2%		
Facility Lighting	7.7%		
Facility HVAC	9.2%		
Other Facility	5.5%		

Following the approach outlined above, the energy usage for process cooling was estimated to be 1,435 GWh for 2005. Natural gas usage for boilers and steam systems was estimated to be 62.7 trillion Btus, plus 169 GWh. Direct process heating, electric and gas, was estimated to be 2,614 GWh and 49.0 trillion Btus. The summer coincident peak MW load of process cooling and heating load was taken as equal to the average industrial load factor used by the Public Service Commission (PSC, 2004) of 83.3 percent. This assumption should be revised in future analyses.

To calculate the potential for energy savings in these markets, it is necessary to establish the baseline forecast conditions against which to measure the savings potential. This requires an estimate of the efficiency level of existing systems, and the future energy efficiency improvements that would occur absent all program interventions. The natural, annual rate of process change, absent any program, was estimated to be 8.3 percent of the market (on an energy usage basis), the inverse of the process measure life. Absent specific data on naturally occurring energy efficiency improvements, we have estimated the naturally occurring improvement at 0.3 percent per year, or 3 percent over 10 years, similar to the estimate made for the motor systems markets.

Process cooling savings are taken from work done by the Northwest Energy Efficiency Alliance (NEEA, 2004) that estimated achievable refrigeration savings in the food processing industry could save 4 percent of total energy use in that industry. When adapted to Wisconsin, the savings from NEEA are 14.3 percent of our refrigeration electric usage.

The energy savings for boilers and steam systems were adapted from a U.S. Department of Energy steam system opportunity assessment in specific industries, including papermaking (Resource Dynamics, 2002). The study estimated boiler and steam system savings in steam intensive industries using a panel of experts to provide data on 30 efficiency measures. The study grouped 19 measures into a "General Measures" category that were applicable across all industries studied (for example, "install continuous blowdown heat recovery"). Four additional measures were included as special opportunities for facility-wide improvements, and we have applied the savings in these measures to all industries in this study.

Three categories of measures in the study were unique to the pulp and paper industry. These are shown in Table 13.01.5 below. In Wisconsin, papermaking accounts for 58.9 percent of natural gas usage for boilers, and savings for these unique measures are additive to the 19 general and 4 facility-wide measures mentioned above. These savings estimates are derived from research and experience of the Focus on Energy program (Focus on Energy, 2005).

The total energy savings estimated for boilers and steam systems is provided in Table 6, and equals 15.3 percent of boiler energy usage. An uncertainty of 25 percent was estimated by visual scan of the uncertainty values given measure by measure in the Steam System Assessment (Resource Dynamics, 2002), which ranged from 15 percent to 35 percent, and clustered in the twenties.

TABLE 13.01.5. BOILER ENERGY SAVINGS FROM MEASURES UNIQUE TO THE PAPERMAKING INDUSTRY

PAPERMAKING INDUSTRY UNIQUE MEASURES	INDUSTRY FUEL SAVINGS (%)
Optimize Steam Use in Pulp and Paper Drying Applications	5.0
Optimize Steam Use in Pulp and Paper Air Heating Applications	1.1
Optimize Steam Use in Pulp and Paper Water Heating Applications	1.2
Paper Industry Subtotal	7.3

TABLE 13.01.6. BOILER AND STEAM SYSTEM ENERGY SAVINGS FROM ALL MEASURES IDENTIFIED

BOILER AND STEAM SYSTEM OPPORTUNITY	TYPICAL FUEL SAVINGS (%)	PERCENT OF FACILITIES (%)	INDUSTRY FUEL SAVINGS (%)
Add/Restore Boiler Refractory	0.6	3.7	0.02
Clean Boiler Heat Transfer Surfaces	1.4	6.4	0.09
Establish the Correct Vent Rate for the Deaerator	0.6	8.6	0.05
Improve Blowdown Practices	0.8	14.0	0.11
Improve Boiler Operating Practices	1.5	11.2	0.17
Improve Quality of Delivered Steam	1.0	9.7	0.10
Improve System Balance	1.4	7.2	0.11
Install Combustion Air Preheaters	1.7	3.4	0.08
Install Continuous Blowdown Heat Recovery	0.8	12.0	0.10
Install Feedwater Economizers	2.7	13.0	0.36
Isolate Steam from Unused Lines	0.9	7.8	0.07
Minimize Boiler Combustion Loss by Optimizing Excess Air	2.2	29.4	0.64
Minimize Vented Steam	2.9	6.5	0.20
Optimize Condensate Recovery	2.1	24.2	0.48
Reduce Steam System Generating Pressure	1.3	8.9	0.11
Repair or Replace Burner Parts	1.5	9.8	0.15
Repair Steam Leaks	1.4	15.7	0.22
Use High-Pressure Condensate to Make Low-Pressure Steam	1.5	8.2	0.11
Correct Problems from Improper Water Treatment Good=>Excellent	1.6	30.8	0.50
Correct Problems from Improper Water Treatment Inadequate=>Excellent	2.9	14.9	0.70
Implement an Effective Steam Trap Mgt Program: Informal=>Effective	3.0	40.1	1.30
Implement an Effective Steam Trap Mgt Program: None=>Effective	7.2	25.5	1.70
Steam Piping, Valves, Fittings, and Vessels Insulated: Inadequate=>Excellent	2.5	38.9	1.10
Improve Plantwide Testing & Maintenance Practices: Good=>Excellent	2.2	36.5	0.80
Improve Plantwide Testing & Maintenance Practices: Inadequate=>Excellent	5.3	34.4	1.70
Pulp and Paper Unique Measures	7.3	58.9	4.30
		Total	15.3%

The energy savings for direct process heating for electric and natural gas fueled systems were adapted from the U.S. Department of Energy report *Improving Process Heating, A Sourcebook for Industry* (LBNL, 2004). This sourcebook provides a range of savings for measures that may be used in electric and gas equipment, however, it does not give applicability factors but says that many measures are widely applicable. We averaged all the energy saving measures to develop a savings value to apply across all systems. This effectively assumes that every system could apply one of the measures. We averaged the low range estimates, the high range estimates, took the midpoint as the savings, and retained the low-high uncertainty. Details are provided in Table 13.01.7 and Table 13.01.8.

TABLE 13.01.7. DIRECT PROCESS HEATING EFFICIENCY MEASURES FOR NATURAL GAS FUELED SYSTEMS

NATURAL GAS ENERGY EFFICIENCY MEASURE	TYPICAL FUEL SAVINGS (%)		
	LOW	MID	HIGH
Heat Generation			
Control Air-to-Fuel Ratio	5%	15.0%	25%
Preheat Combustion Air	15%	22.5%	30%
Use Oxygen Enriched Combustion Air	5%	15.0%	25%
Heat Transfer			
Improve Heat Transfer with Advanced Burners and Controls	5%	7.5%	10%
Improving Heat Transfer within a Furnace	5%	7.5%	10%
Heat Containment			
Reduce wall heat losses	2%	3.5%	5%
Furnace Pressure Control	5%	7.5%	10%
Maintain door and tube seals	0%	2.5%	5%
Reduce cooling of internal parts	0%	2.5%	5%
Reduce radiation heat losses	0%	2.5%	5%
Heat Recovery			
Fluid or load preheating	5%	12.5%	20%
Heat cascading	5%	12.5%	20%
Fluid heating or steam generation	5%	12.5%	20%
Absorption cooling	5%	12.5%	20%
Sensors and Process Control			
Install high turndown combustion systems	5%	7.5%	10%
Programmed heating temperature setting for part load operation	5%	7.5%	10%
Monitoring & control of exhaust gas oxygen and unburned HC and CO	2%	8.5%	15%
Correct location of sensors	5%	7.5%	10%
Average of Measure Savings	4%	9.3%	14%
		Uncertainty Range	4.9%

TABLE 13.01.8. DIRECT PROCESS HEATING EFFICIENCY MEASURES FOR ELECTRIC SYSTEMS

ELECTRIC ENERGY EFFICIENCY MEASURE	TYPICAL ELECTRIC SAVINGS (%)		
	LOW	MID	HIGH
Heat Generation			
None identified	0%	0.0%	0%
Heat Transfer			
Improving heat transfer within a furnace	5%	7.5%	10%
Heat Containment			
Reduce wall heat losses	2%	3.5%	5%
Furnace pressure control	5%	7.5%	10%
Maintain door and tube seals	0%	2.5%	5%
Reduce cooling of internal parts	0%	2.5%	5%
Reduce radiation heat losses	0%	2.5%	5%
Heat Recovery			
Fluid or load preheating	5%	12.5%	20%
Heat cascading	5%	12.5%	20%
Fluid heating or steam generation	5%	12.5%	20%
Absorption cooling	5%	12.5%	20%
Sensors and Process Control			
Programmed heating temperature setting for part load operation	5%	7.5%	10%
Correct location of sensors	5%	7.5%	10%
Average of Measure Savings	2%	5.1%	8%
		Uncertainty Range	2.7%

We did not quantify measures for heating reduction through process cooling, electricity reduction in boiler and steam systems (except where fans and motors are addressed their own markets), nor any electric demand savings for electric process heating, due to lack of data to support an estimate.

2. Program Participation

We have modeled the interventions to achieve program participation for system improvements beginning at 2.0 percent (+/- 1.0%) of the total stock in year one and ramping up to peak participation of 4.0 percent (+/-1.0%) by year 5 (+/- one year). On this participation schedule, 34 percent of the market will participate in this intervention after 10 years. In support of this assumption, National Grid reports that 55 percent of eligible electric customers have participated in their Energy Initiative Custom retrofit program over a ten year time frame (York and Kushler, 2003). The Energy Initiative program targets similar customer types that our intervention targets for improvements. A net to gross program value of 0.80 (+/- 0.10) was used, reported by National Grid for their Energy Initiative Program (Quantum, 2004b)

3. Program Costs

Program costs reflect approximations we made following the review of costs for mature programs with similar approaches and customer targets (Quantum, 2004b). Incentive costs are 81 percent of total program costs, while non-incentive costs are 19 percent. Start up costs of $125,000 over three years

($15,000 per year) are allocated to achieve a statewide effort, filling gaps in areas such as market research, information and outreach, demonstration projects, tools, and case studies. A general administrative cost of 4 percent of all intervention costs provides funding for management of the overall market effort, program specific tracking and reporting, planning meetings, and other expenses.

Costs for each intervention in the market are broken into three categories:

- incentives for participants, designers, suppliers, and other program allies;
- a market manager to handle day-to-day responsibilities and field staff to work with participants on specific projects; and
- annual fixed costs for activities such as training, product and service development (tools, manuals, guides, software, etc.).

Incentives are paid for therm, electric energy, and demand savings. The overall incentive pool may be provided as participant rebates, supplier rebates, feasibility studies, or other project specific costs to influence participation. The incentive costs for this intervention were intended to cover approximately 50 percent of total installed measure costs. In practice, incentives would be adjusted as needed to maintain cost-effectiveness and include appropriate limitations, while maintaining this guideline.

4. Measure Life

We assume an average lifespan of 12 years for system performance measures included in our analysis, with an uncertainty of 2 years. This reflects literature that places the life of process equipment in industrial environments at between 10 and 15 years. While individual components can last for decades, one expert interviewed estimated that optimization usually lasts five years, after which the system may need to be tuned-up again (ECW, 2003b).

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MARKET 14 — MUNICIPAL WATER AND WASTEWATER

Market Scope

This market comprises energy efficiency upgrades of water supply and wastewater facility systems, including variable frequency drives for water pump motors, chemical supply pump motors, and flocculation motors, proper sizing of high efficiency motors to replace existing motors, aeration system upgrades, lighting upgrades, and off-peak operation of wastewater facilities.

Market Characteristics

As of June 21, 2004, there were 580 annual reports filed with the Public Service Commission by water utilities and sanitary districts for the year 2003. The total of 580 includes 84 Class AB utilities (the largest), 146 Class C utilities (mid-sized), and 350 Class D utilities (smallest). We estimated the total annual energy consumption for the water and wastewater market in Wisconsin to be just over 803 GWh with a peak demand of 201 MW. Pumping constitutes the major end use at water supply facilities, followed by treatments such as flocculation, and disinfection by means of micro-filtration, ultra-violet radiation, or application of ozone (ECW, 2002 and 2003). Wastewater treatment, including aeration, is the predominant end use at wastewater facilities, followed by pumping.

Beginning with extraction from a groundwater or surface source, utilities pump raw water, treat it, and perhaps store it before distributing it to customers. Water sources vary considerably. Groundwater aquifers are present in limestone, sandstone, shale, and other porous or cracked rock, and occur at varying depths. Utilities also pump surface water from Lake Michigan, and other lakes. Every source requires its own type of treatment to remove whatever unwanted organic and inorganic compounds, minerals, radionuclides, and biological contaminants that may be present. As a water table is drawn down, pumping demand increases, and new treatments may be required to reduce increased concentrations of minerals and radionuclides.

Wisconsin utilities lose between 9.6 percent and 12.6 percent of the water they distribute through unaccounted losses—such as leaks and fire department use. These unaccounted losses can represent energy waste if they are from leaks. Improvements to reduce energy use through proper equipment sizing, pressure reduction, and operations and maintenance procedures can reduce unaccounted losses.

Used water, along with sewage material, returns to a wastewater treatment facility. These facilities screen influent to remove solid debris and then apply processes to eliminate phosphorous, nitrogen, biological oxygen demand (BOD), biological pathogens, and other contaminants. The utility then delivers cleaned wastewater to the environment, or in rare cases where there is infrastructure to do it, cleaned wastewater (“graywater”) is reused for tasks such as cleaning. Recovered sludge and other solid waste may be converted to usable byproducts or stored in a way that protects the environment and human health.

The municipal water and wastewater industry faces significant challenges stemming from changing regulations, pressures to reduce costs, global competition, new and unfamiliar technologies, and the growing drive for sustainability. For an individual utility, these challenges could prove insurmountable. In these situations industries often develop joint action plans to tackle the problems they share, resulting in a calculated, concerted response that can be enormously effective (ECW, 2002)

Water utilities consider energy use to be high in their facilities, but managing energy costs are given low priority in overall operations. Although operators are aware of overall energy use, many are not aware of energy efficient options or how to take advantage of electric rate structures (ECW, 2002). New regulations to meet health, safety, and environmental requirements will force utilities to look at new technology options. Utilities may choose from ultrafiltration, ultraviolet (UV) disinfection, ozonation, and using new chemicals. Each technology carries a capital cost and energy charge that will affect life-cycle costs and decisions (ECW, 2002).

Utilities need more information about energy costs and guidance in selecting the best technologies for specific situations. Utilities may also choose from an array of new designs as they expand to meet demand or replace outmoded facilities with new ones. Design considerations include: water source; levels of various chemical, biological, and radiological contaminants; effluent and biosolid byproduct requirements; space availability; and capital and operating costs. In order to give full treatment to the life cycle costs of options, the costs of energy and other operating costs must be included with capital cost (ECW, 2002).

Water utilities vary in their capability to evaluate and adopt energy efficiency measures. The largest utilities have staff experts that have overseen implementation of many efficiency measures, while many smaller utilities lack such expertise. Mid to larger-sized utilities are an attractive program target that combine moderate staff expertise with significant energy saving opportunities.

Providing wastewater utilities with the ability to perform self benchmarking for each well or site — depending on the type of facility— would give operators a measurable method for tracking performance and visually seeing changes over time. Monthly data on kW, head, flow/time and other variables could be recorded and graphed to note trends for well performance. Operators would likely need training on the benchmarking concepts, use of the data, and interpreting the data (Olsen, 2005).

Program Approaches

Our analysis of this market considered two program efforts:

- Increase installation of high efficiency retrofits in existing facilities through delivery strategies appropriate to their size and operations.
- Promote installation of high efficiency options at new plants or plants that are being renovated

PROGRAM AREA 14.01 — INCENTIVES FOR RETROFITS TO WATER AND WASTEWATER FACILITIES

Our analysis of the achievable potential for this program area is projected from an extrapolation of experience from the current Wisconsin demand-side management programs.

TABLE 14.01.1. ESTIMATED VALUES FOR PROGRAM AREA 14.01, INCENTIVES FOR WATER PLANT EFFICIENCY UPGRADES

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		\$513 to \$767	\$631 to \$955
	Incremental Impacts	peak kW	696 to 1,118	891 to 1,434
		annual kWh (000s)	2,779 to 4,449	3,552 to 5,692
		annual therms (000s)	0 to 0	0 to 0
	Levelized resource cost	per peak kW	\$61 to \$101	\$59 to \$98
		per kWh	1.6¢ to 2.5¢	1.5¢ to 2.4¢
		per therm	NA to NA	NA to NA
Scaling factors[a]		program costs	1.0 to 2.0	1.0 to 2.0
		impacts	1.0 to 1.4	1.0 to 1.4

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Below, we document the technical assumptions made for energy savings in the water and wastewater sector.

Program Area 14.01 — Incentives for Water and Wastewater Plant Improvements

Inputs for this program model are summarized in the table below, and described on the following pages.

TABLE 14.01.2. MODEL INPUTS FOR INCENTIVES FOR WATER AND WASTEWATER PLANT IMPROVEMENTS

Model Inputs (14.01)			Value	±
1		**Impacts**		
	a	2005 market size (GWh)	803	40
	b	2005 market size (peak MW)	201	10
	c	Annual electric market growth rate (2006-2015)	1.8%	0.2%
	Efficiency improvement within 2006 inventory w/o program intervention			
	d	Annual market undergoing improvements (2006-2015)	6.7%	1.4%
	e	Electric energy % saved within failed systems	4.6%	0.9%
	f	Electric peak demand % saved within failed systems	4.6%	0.9%
	Identified savings potential for primary intervention within inventory as of 1/1/2006			
	g	Annual market for intervention (2006-2015)	10.0%	1.0%
	h	Electric energy % savings (normal replacements)	14.0%	2.8%
	i	Electric peak demand % savings (normal replacements)	14.0%	2.8%
	j	Electric energy % savings (accelerated replacements)	14.0%	2.8%
	k	Electric peak demand % savings (accelerated replacements)	14.0%	2.8%
	Identified savings potential in new usage with primary intervention			
	l	Electric energy % savings	14.0%	2.8%
	m	Electric peak demand % savings	14.0%	2.8%
2		**Program Participation**		
	Primary intervention for 2006 existing			
	a	Participation in Year 1 (% of 2006 replaced inventory)	20%	5%
	b	Ultimate annual participation rate (% of replaced inventory)	50%	10%
	c	Year ultimate participation reached	5	1
	d	Net-to-gross ratio for primary intervention	0.80	0.10
	Primary intervention for new usage			
	e	Participation in Year 1 (% of annual new usage)	20%	5%
	f	Ultimate annual participation rate (% of annual new usage)	50%	10%
	g	Year ultimate participation reached	5	1
	h	Net-to-gross ratio for primary intervention	0.80	0.10

3		**Program costs**		
	a	Administration start up cost premium (total over years 1 - 3)	$75,000	$15,000
	b	Base administrative costs (% of all intervention costs)	4%	1%
	Primary intervention for 2006 existing			
	c	Additional costs above variable costs for intervention (annual)	$20,000	$5,000
	d	Market management and field staff (% of variable costs)	15%	5%
	e	Incentive costs per annual kWh saved	$0.07	$0.01
	f	Incentive costs per peak kW reduced	$175	$25
	Primary intervention for new usage			
	g	Additional costs above variable costs for intervention (annual)	$20,000	$5,000
	h	Market management and field staff (% of variable costs)	15%	5%
	i	Incentive costs per annual kWh saved	$0.05	$0.01
	j	Incentive costs per peak kW reduced	$125	$25
4		**Measure life (years)**	15	3

1. Per Unit Impacts

The size of the water and wastewater market in Wisconsin was estimated by determining the number of water supply facilities of each class type in the state, calculating an annual water flow, and determining annual kWh consumption based on a weighted average of kWh/kgal of water (ECW, 2002). Annual consumption for wastewater facilities was estimated by subtracting a weighted average of supply waste percentages for all classes of facilities (approximately 12 percent) and further subtracting a percentage of water used for irrigation or lawn watering that is not sent to wastewater facilities (assumed to be 15 percent). The result is that flow from supply facilities is estimated at 250.5 BGY and the flow through wastewater facilities is estimated at 182.4 BGY. Market growth of 1.8 percent (the growth rate assumed for the industrial market (PSC, 2004) was assumed for the water and wastewater market.

To estimate savings potential, we first estimated the consumption percentages for major end uses at water and wastewater plants as shown in Table 14.01.3 and Table 14.01.4, and then applied relevant measure savings percentages to each of the end uses. Savings estimates were determined by assuming a base case saturation for all measures, and identifying saturation for the corresponding replacement scenario.

Variable frequency drives for water pumps and other motors were estimated to provide 30 percent savings over constant speed motors. Applying variable frequency drives in estimated feasible applications results in an overall savings of 16.7 percent. Applying variable frequency drives to flocculation and chemical feed pumps results in an estimated 18.9 percent savings. Replacing less efficient motors with premium efficiency motors and properly sizing motors results in motor savings of 6.6 percent. Lighting savings are based on upgrading 15 percent of lighting load from incandescent to compact fluorescent, using saturations reported by KEMA (2005), for savings of 13 percent. Aeration system improvements were assumed to provide 30 percent savings over standard systems (ECW, 2002).

TABLE 14.01.3. WATER SUPPLY FACILITY ELECTRIC END USE BREAK OUTS AND SAVINGS FRACTIONS

ELECTRIC END USES	END USE SHARE	ENERGY AND DEMAND SAVINGS
Pumping (general)	50%	3.2%(motors)+2.7% (VFD) Naturally Occurring 6.6% (motors)+16.7% (VFD) Intervention
Pumping (filtration)	15%	None included
Treatment	10%	None included
Aeration	0%	None included
Flocculation	15%	2.6% Naturally Occurring 18.9% Intervention
Lighting	5%	23.8% Naturally Occurring 13.0% Intervention
Miscellaneous	5%	None included

TABLE 14.01.4. WASTEWATER FACILITY ELECTRIC END USE BREAK OUTS AND SAVINGS FRACTIONS

ELECTRIC END USES	END USE SHARE	ENERGY AND DEMAND SAVINGS
Pumping (general)	20%	3.2%(motors)+2.7% (VFD) Naturally Occurring 6.6% (motors)+16.7% (VFD) Intervention
Pumping (filtration)	0%	None included
Treatment	35%	None included
Aeration	35%	6.4% Naturally Occurring 20.5% Intervention
Flocculation	0%	
Lighting	5%	23.8% Naturally Occurring 13.0% Intervention
Miscellaneous	5%	None included

Annual replacement rates were estimated by using the inverse of the average life of the measure. Measures for water treatment facilities are assumed to have a 15 year life; therefore the annual replacement rate is estimated at 1/15, or 6.7 percent. The intervention is intended to induce accelerated replacements and retrofits that allow for higher activity levels than a 6.7 percent replacement rate. We have set the annual program *target* market at 10 percent of facilities. Only a portion of the target market would participate, as described below.

2. Program Participation

We have modeled the interventions to achieve program participation for water measures beginning at 20 percent (+/- 5%) in year one and ramping up to peak participation of 50 percent (+/-10%) by year 5 (+/- one year). The lower range of participation estimate is intended to extrapolate from current activity in

Wisconsin. Under the most optimistic scenario (4 year ramp up, 60 percent maximum annual participation), this participation schedule allows the program to match the results of National Grid's Energy Initiative Custom Program, an "exemplary program" that achieved 55 percent participation over 11 years (York and Kushler, 2003). This optimistic scenario translates to 22 percent cumulative participation within 5 years, and 52 percent participation over 10 years. The mid-point scenario achieves 17 percent cumulative participation within 5 years, and 42 percent after 10 years. The least optimistic scenario achieves 12 percent within 5 years, and 32 percent after 10 years.

We used National Grid's Energy Initiative Custom Program as an upper benchmark of performance because it is a comprehensive incentive and technical assistance program offered across the nonresidential market, including water facilities, using an incentive structure and delivery strategy that is analogous to our proposed intervention. We did not locate data for programs that identified participation levels broken out separately for the water facilities market.

Net to gross program values of 0.80 were used, based on data from comprehensive incentive programs reported in the National Energy Efficiency Best Practices Study (Quantum, 2004b).

3. Program Costs

Program costs reflect approximations we made following a review of costs for mature programs with similar approaches and customer targets (Quantum, 2004b). Incentive costs are 78 percent of total program costs, while non-incentive costs are 22 percent. Start up costs of $75,000 over three years ($25,000 per year) are allocated to achieve a statewide effort, filling gaps in areas such as market research, information and outreach, demonstration projects, tools, and case studies. A general administrative cost of 4 percent of all intervention costs provides funding for management of the overall market effort, program specific tracking and reporting, planning meetings, and other expenses.

Costs for each intervention in the market are broken into three categories:

- Incentives for participants, designers, suppliers, and other program allies;
- A market manager to handle day-to-day responsibilities and field staff to work with participants on specific projects; and
- Annual fixed costs for activities such as training, product and service development (tools, manuals, guides, software, etc.).

Incentives are paid for electric energy and demand savings. The overall incentive pool may be provided as participant rebates, supplier rebates, feasibility studies, or other project specific costs to influence participation. The incentive costs for this intervention were intended to cover approximately 50 percent of total measure costs. In practice, incentives would be adjusted as needed to maintain cost-effectiveness and include appropriate limitations, while maintaining this guideline.

4. Measure Life

A measure life of 15 years was used in the water and wastewater input model, based on the type of measures included within the program intervention.

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MARKET 15 — AGRICULTURE ENERGY EFFICIENCY

Market Scope

This market comprises energy efficiency upgrades on dairy farms, other farms, and in grain drying facilities in Wisconsin. These upgrades include measures such as milk cooling plate coolers, variable speed drives for vacuum pumps, compressor heat recovery for water heating, lighting upgrades, variable frequency drive pumping applications, and grain drying improvements including burner retrofits.

Market Characteristics

Hasselman and Hackner (2005) estimate that dairy operations are responsible for 70 percent of Wisconsin's agriculture energy consumption. The major end uses in dairy farms include water heating for sterilization, vacuum pump, milk cooling, and barn ventilation, followed by lighting and other end uses (Brown and Elliot, 2005; Sanford, 2003). Key end uses in other (non-dairy) agricultural facilities include material transport, drying, and ventilation. Total annual energy consumption for the agricultural market in Wisconsin is estimated to be 2,015 GWh with an estimated peak demand of 577 MW (DOA, 2004). Market growth of 1.0 percent was estimated for this market (DOA, 2004).

Wisconsin continued to lose about 100 milking operations each month between 1993 and 2001. In 2004, the number of dairy farms lost each month was close to 50, or half those previous losses (WASS, 2004). Some dairy producers have exited the business for personal reasons such as health issues, retirement age, more time for the family, or other interests. Many Wisconsin dairy producers have experienced the stress of high debt loads, pressure from urban sprawl, and other challenges.

Even so, Wisconsin has an excellent dairy infrastructure to assist those who choose to continue to milk cows. Annual milk production has remained steady. Increasing milk per cow and cows per herd have offset the decline in number of dairy herds. There is a strong in-state interest to help Wisconsin modernize dairy operations (Hasselman and Hackner, 2005), including better planning (Commerce Department Dairy 2020 program), investment (Commerce Department "Milk Money" and "Grow Wisconsin" from DATCP, et al), re-wire, dairy siting regulations, and education.

On most dairy farms, 70 percent of the electricity is used for milk harvesting, with bulk tanks, vacuum pumps and water heaters using the lion's share. According to University of Wisconsin-Extension, dairy farms in Wisconsin typically spend an average of $57 to $91 per cow per year on energy, which includes electricity, natural gas, LP gas and heating oil. It's estimated that electricity accounts for 2 to 5 percent of a dairy farm's cost of production. This translates to annual electricity use of 700-900 kilowatt-hours (kWh) per cow or 3.5 to 4.5 kWh per hundredweight (cwt) of milk produced.

Between 2000 and 2004, the largest percentage of investments on dairy farms was for dairy cow housing on all size farms. Between 2005 and 2009, the three middle size groups (30-49, 50-99, and 100-199 head) are planning to increase their percentage of investments in housing. Almost all of the size groups are planning to increase their percentage of investments in manure handling and storage. In the next five years, many milk producers plan to add parlors. About two thirds of the increase is expected to occur in two herd size groups– 50 to 99 and 100 to 199 head (WASS, 2004). Larger operations with higher levels of automation mean longer and more continuous energy-intensive operations. Increasing adoption of "long day" (18 hours of lighting) will also increase energy usage in this market.

Program Approaches

Our analysis of this market considered two main program efforts:

- Increase installation of high efficiency measures on dairy farms, other farms, and grain drying facilities through the use of financial incentives and education
- Promote energy efficient design and construction of new agricultural facilities

PROGRAM AREA 15.01 — INCENTIVES FOR AGRICULTURE

Our analysis of the achievable potential for this program area is projected from an extrapolation of experience from the current Focus on Energy program.

TABLE 15.01.1. ESTIMATED VALUES FOR PROGRAM AREA 15.01, INCENTIVES FOR AGRICULTURE EFFICIENCY UPGRADES

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$1,320 to $2,574	$1,560 to $3,098
	Incremental Impacts	peak kW	1,215 to 2,540	1,459 to 3,077
		annual kWh (000s)	5,494 to 11,843	6,599 to 14,327
		annual therms (000s)	29 to 65	35 to 78
	Levelized resource cost	per peak kW	$110 to $211	$109 to $208
		per kWh	2.4¢ to 4.5¢	2.4¢ to 4.4¢
		per therm	17.8¢ to 36.8¢	17.6¢ to 36.4¢
Scaling factors[a]		program costs	0.6 to 1.5	0.6 to 1.5
		impacts	0.7 to 1.2	0.7 to 1.2

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Below, we document the technical assumptions we made for energy savings in the agricultural sector.

Program Area 15.01 — Incentives for Agriculture Efficiency Upgrades

Inputs for this program model are summarized in the table below and described on the following pages.

TABLE 15.01.2. MODEL INPUTS FOR INCENTIVES FOR AGRICULTURE EFFICIENCY UPGRADES

Model Inputs (15.01)			**Value**	**±**
1		**Impacts**		
	a	2005 market size (GWh)	2,015	101
	b	2005 market size (peak MW)	577	29
	c	2005 market size (10^12 Btu)	2.7	0.1
	d	Annual electric market growth rate (2006-2015)	1.0%	0.1%
	e	Annual gas market growth rate (2006-2015)	1.0%	0.1%
	Efficiency improvement within 2006 inventory w/o program intervention			
	f	Annual market undergoing improvements (2006-2015)	10.0%	3.3%
	g	Electric energy % saved within failed systems	12.2%	2.4%
	h	Electric peak demand % saved within failed systems	11.5%	2.3%
	i	Natural gas energy % saved within failed systems	3.6%	0.7%
	Identified savings potential for primary intervention within inventory as of 1/1/2006			
	j	Annual market for intervention (2006-2015)	10.0%	3.3%
	k	Electric energy % savings (normal replacements)	15.9%	3.2%
	l	Electric peak demand % savings (normal replacements)	11.3%	2.3%
	m	Natural gas energy % savings (normal replacements)	6.9%	1.4%
	Identified savings potential in new usage with primary intervention			
	n	Electric energy % savings	15.9%	3.2%
	o	Electric peak demand % savings	15.9%	3.2%
	p	Natural gas energy % savings	6.9%	1.4%
2		**Program Participation**		
	Primary intervention for 2006 existing			
	a	Participation in Year 1 (% of 2006 replaced inventory)	25%	5%
	b	Ultimate annual participation rate (% of replaced inventory)	50%	10%
	c	Year ultimate participation reached	5	1
	d	Net-to-gross ratio for primary intervention	0.60	0.10
	Primary intervention for new usage			
	e	Participation in Year 1 (% of annual new usage)	25%	5%
	f	Ultimate annual participation rate (% of annual new usage)	50%	10%
	g	Year ultimate participation reached	5	1

	h	Net-to-gross ratio for primary intervention	0.60	0.10
3		**Program costs**		
	a	Administration start up cost premium (total over years 1 - 3)	$75,000	$15,000
	b	Base administrative costs (% of all intervention costs)	4%	1%
	Primary intervention for 2006 existing			
	c	Additional costs above variable costs for intervention (annual)	$40,000	$10,000
	d	Market management and field staff (% of variable costs)	15%	5%
	e	Incentive costs per annual kWh saved	$0.07	$0.01
	f	Incentive costs per peak kW reduced	$175	$25
	g	Incentive costs per annual therm reduced	$0.80	$0.10
	Primary intervention for new usage			
	h	Additional costs above variable costs for intervention (annual)	$20,000	$10,000
	i	Market management and field staff (% of variable costs)	15%	5%
	j	Incentive costs per annual kWh saved	$0.06	$0.01
	k	Incentive costs per peak kW reduced	$150	$25
	l	Incentive costs per annual therm reduced	$0.80	$0.10
4		**Measure life (years)**	10	3
5		**Proportion of program costs allocated to electric impacts**	96%	1%

1. Per Unit Impacts

As described under market characteristics, the estimated energy consumption for agricultural facilities in Wisconsin in 2005 is 2,015 GWh and 2.71 trillion Btus. To estimate savings potential for agriculture, we first estimated the consumption percentages for major end uses at agricultural facilities as shown in Table 15.01.3 and Table 15.01.4, and then applied relevant measure savings percentages to each of the end uses (Brown and Elliot, 2005; Sanford, 2003). Savings estimates were determined by assuming a base case saturation for all measures, and identifying saturation for the corresponding replacement scenario.

TABLE 15.01.3. DAIRY ELECTRIC AND NATURAL GAS END USE BREAK OUTS

ELECTRIC END USES		NATURAL GAS END USES	
Water Heating	18%	Water Heat	80%
Vacuum Pump	17%	Space Heat	20%
Milk Cooling	25%	Miscellaneous	0%
Lighting	15%		
Ventilation	19%		
Irrigation	0%		
Space Heat	1%		
Miscellaneous	5%		

TABLE 15.01.4. OTHER AGRICULTURE ELECTRIC AND NATURAL GAS END USE BREAK OUTS

ELECTRIC END USES		NATURAL GAS END USES	
Water Heating	2%	Water Heat	5%
Vacuum Pump	0%	Space Heat	10%
Milk Cooling	0%	Miscellaneous	85%
Lighting	10%		
Ventilation	25%		
Irrigation	30%		
Space Heat	1%		
Miscellaneous	32%		

Milk plate coolers were estimated to save 14.5 percent (NYSERDA, 2003). Variable frequency drives for vacuum pumps and other motors were estimated to provide 30 percent savings over constant speed motors (NYSERDA, 2003). Milk cooling compressor heat recovery for water heating was estimated to provide 13.4 percent savings (NYSERDA, 2003). High-volume low-speed fans for barn ventilation were estimated to provide 80 percent savings over standard ventilation systems due to the fact that several blowers are often eliminated (Hasselman and Hackner, 2005).

Lighting savings are based on conversion from incandescent to compact fluorescent, using saturations reported by KEMA (2005). The existing in-place inventory was estimated to be approximately 50 percent compact fluorescent, while natural replacements are 85 percent compact fluorescent. The program would aim to convert all incandescent to compact fluorescent, which if fully achieved would save 27.8 percent. Grain drying improvements were estimated to provide 25 percent savings (Hasselman and Hackner, 2005), with a 50 percent naturally occurring saturation, resulting in a savings of 14.3 percent relative to standard replacement practices.

Measures for agricultural facilities are assumed to have a 10 year life due to extreme conditions in agricultural environments; therefore the annual replacement rate is estimated at 1/10, or 10 percent.

2. Program Participation

We have modeled the interventions to achieve program participation for agricultural measures beginning at 25 percent (+/- 5%) in year one and ramping up to peak participation of 50 percent (+/-10%) by year 5 (+/- one year). The lower range of participation estimate is intended to extrapolate from current activity in Wisconsin, while support for the upper participation levels include results reported by Brown, Elliot, and Nadel (2005) for high-participation programs. Efficiency Vermont reports 35 percent of dairy farms in the state have participated after 4 years of operating a farm program, while participation levels for farm programs in other states are reported as high as 53 percent to 88 percent (Brown, Elliot, and Nadel (2005).

Net to gross program values of 0.60 (+/- 0.10) were used, based on the average of 0.80 from National Grid’s comprehensive incentive program reported in the National Energy Efficiency Best Practices Study (Quantum, 2004b), and 0.40 from recent results from the Agriculture program in Focus on Energy (PA Government Services, 2005). We set the uncertainty at half the difference between these two values.

3. Program Costs

Program costs reflect approximations we made following the review of costs for mature programs with similar approaches and customer targets (Brown, Elliot, and Nadel, 2005, and Quantum, 2004b). Incentive costs are 81 percent of total program costs, while non-incentive costs are 19 percent. Start up costs of $75,000 over three years ($25,000 per year) are allocated to achieve a statewide effort, filling gaps in areas such as market research, information and outreach, demonstration projects, tools, and case studies. A general administrative cost of 4 percent of all intervention costs provides funding for management of the overall market effort, program specific tracking and reporting, planning meetings, and other expenses.

Costs for each intervention in the market are broken into three categories:

- Incentives for participants, designers, suppliers, and other program allies;
- A market manager to handle day-to-day responsibilities and field staff to work with participants on specific projects; and
- Annual fixed costs for activities such as training, product and service development (tools, manuals, guides, software, etc.).

Incentives are paid for therm, electric energy, and demand savings. The overall incentive pool may be provided as participant rebates, supplier rebates, feasibility studies, or other project specific costs to influence participation. The incentive costs for this intervention were intended to pay 2 years worth of savings to buy-down the cost of installed measures. In practice, incentives would be adjusted as needed to maintain cost-effectiveness and include appropriate limitations, while maintaining this guideline.

4. Measure Life

A measure life of 10 years was used in the input model. Measures for agricultural facilities are assumed to have a 10 year life due to extreme conditions in agricultural environments, even though individual components, such as pumps and heat exchangers, might otherwise experience longer lives in other environments.

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MARKET 16 — ELECTRONIC APPLIANCES MARKET

Market Scope

This market comprises purchases of electronic products for residential use, including video, audio, telephony, and computer equipment, and set-top boxes.

Market Characteristics

The consumer electronic appliance market comprises a variety of loosely related products that use little energy per unit. Their combined energy consumption is substantial, however, because of the large number of consumer electronic devices in use, the number of hours during which they are in active use, and their stand-by power usage.

Consumer electronics account for approximately 10 percent of residential electricity consumption – over 60 percent of which is consumed when the devices are in standby mode (Rosen and Meier).

Opportunities to save energy consumed by electronic appliances rest in:

- Purchases of energy-efficient models; and
- Behavioral changes by consumers.

Energy-efficient consumer electronic appliances differ from their conventional counterparts primarily in the power requirements of their power supplies. Because power supplies use electricity even when the appliance is switched off, consumer electronics use a substantial share of their electricity passively. As a result, the national ENERGY STAR® program focuses its standards for consumer electronics on the draw of devices' power supplies. Table 16.01.1 shows the ENERGY STAR standby specifications for selected consumer electronics (2004 ENERGY STAR® Home Electronics Holiday Campaign).

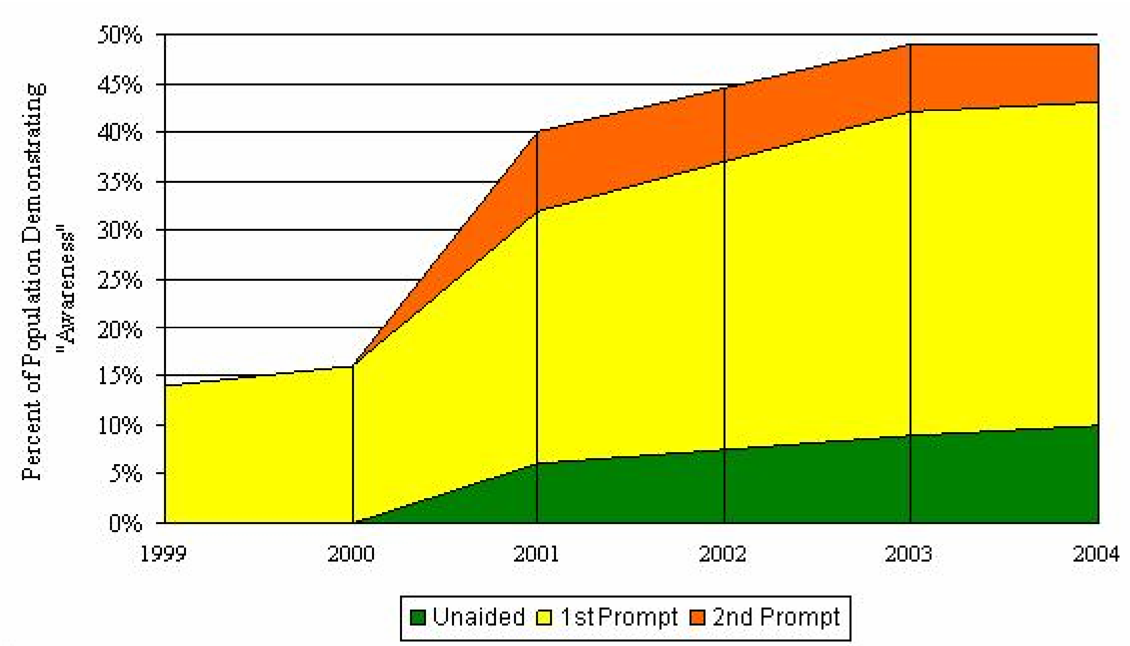
TABLE16.01.1. 2004 ENERGY STAR STANDBY SPECIFICATIONS FOR CONSUMER ELECTRONICS

Product Category	ENERGY STAR Standby Specification	Percentage Energy Saved Compared to Standard
TV	< 1 watt (analog)	25%
TV/DVD and other Combo Units	< 4 watts	30%
DVD Player	< 1 watt	70%
Home Theater System	< 1 watt	70%
Digital Video Recorder (DVR)	< 15 watts	50%

The ENERGY STAR label on consumer electronics with comparatively low standby usage provides an opportunity to promote energy-efficiency by encouraging the stocking and purchase of ENERGY STAR-qualified models.

Consumer awareness of the ENERGY STAR label is increasing in Wisconsin and nationally. Figure 16.01.1 shows the growth of awareness among Wisconsin residents since 1999, a year before any wide-scale mass media marketing of the label in Wisconsin (Winch, 2005). Although states without local marketing have experienced growth in awareness of the label as well, high publicity areas like Wisconsin have seen faster growth in awareness. Compared to Iowa, for example, Wisconsin holds a 10 percentage point edge in awareness and a 7 percentage point lead in understanding (a more demanding standard that requires residents to be able to identify the meaning of the label). Among those shopping for home or office electronics, the awareness gap was only 4 percent, however (Winch, 2005).

FIGURE16.01.1. ENERGY STAR AWARENESS IN WISCONSIN SINCE 1999 (BASED ON TELEPHONE SURVEYS)



It is not clear to what extent the label has influenced consumer behavior generally or for purchases of consumer electronics specifically. At least two barriers stand in the way of the label to influence consumer choices:

- The ENERGY STAR label competes with many other factors consumers are likely to consider in their purchase decisions, including brand, features, instant availability, and price.
- Energy costs of individual consumer electronics are modest, thereby giving shoppers little incentive to make an energy-efficient choice for a single unit. For example, a television set that uses 50 watts while operating for four hours per day and one watt while on standby costs less than $10 per year to operate.

Behavioral changes among consumers could reduce the “on-time” of consumer electronics while they are not being used and eliminate the standby losses for some appliances, but there are substantial barriers. Reducing “on-time” would require consumers to be more diligent about turning equipment off when not in use; reducing standby losses requires disconnecting devices from a power source – either by unplugging the device or turning off a power strip into which it is plugged in. However, changing people’s everyday habits is difficult, and the incremental cost of using an electronic device tends to be less than one cent per hour of active use or one cent per day of standby use.

In addition to normal replacements and new acquisitions of consumer electronics, households are likely to make a one-time purchase of new electronic devices when digital-only broadcasts of television signals replace analog broadcasts in 2007 (Amann, 2004). Consumers with analog television sets who rely on through-the-air transmission of television signals will need to purchase a new television set or a set-top converter box.

The California Energy Commission has established appliance standards that will limit the stand-by wattage of audio and video equipment and some power supplies sold in that state (CEC 2004). Because of the size of California's market, these regulations, which are slated to take effect in 2005, are likely to affect the energy-efficiency of consumer electronics that would be offered in Wisconsin even without a program.

Program Approaches

Our analysis of this market considered two program efforts:

- Increase consumer awareness of the ENERGY STAR label; and
- Promote stocking of ENERGY STAR models by Wisconsin retailers.

We modeled these program approaches as being mutually exclusive. As a result, our model will accept only the lower-cost approach for any one simulation, but not both approaches. We recognize that both approaches could co-exist, but each one would diminish the effectiveness of the other. For lack of any data on the extent to which the approaches would cannibalize each other – and to keep the model from becoming even more complex with little gain in precision – we chose to make the simplifying assumption that the approaches cannot be implemented cost-effectively at the same time.

We also considered a program to promote the use of the power-saving mode for newly purchased computers and monitors. However, our background research revealed that approximately 98 percent of computers available in the marketplace carry the ENERGY STAR label, which means they are delivered with the power-saving mode enabled (Forging Ahead..., 2004). At that rate, we chose not to model a program that targets the remaining two percent of computer purchases.

PROGRAM AREA 16.01 — ENERGY STAR MARKETING

Wisconsin has been promoting the ENERGY STAR label through mass media advertising and in-store promotions since approximately 2000. These local efforts have resulted in higher consumer awareness of the label in Wisconsin than in states that rely solely on national marketing efforts, but there is room for higher awareness. We assume that a consumer electronics program would continue to market the label and promote the benefits of choosing qualifying products. The marketing would be primarily aimed at increasing general recognition of the label, but may occasionally include targeted efforts to feature the benefits of ENERGY STAR consumer electronics.

TABLE 16.01.2. ESTIMATED VALUES FOR PROGRAM AREA 16.01, ENERGY STAR MARKETING

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$77 to $122	$77 to $122
	Incremental Impacts	peak kW	0 to 38	0 to 42
		annual kWh (000s)	5 to 417	5 to 453
		annual therms (000s)	0 to 0	0 to 0
	Levelized resource cost	per peak kW	$679 to $66,737	$611 to $65,814
		per kWh	6.0¢ to 575.1¢	5.6¢ to 577.9¢
		per therm	NA to NA	NA to NA
Scaling factors[a]		program costs	0.1 to 3.2	0.3 to 3.1
		impacts	0.1 to 2.5	0.3 to 2.4

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

PROGRAM AREA 16.02 — RETAILER PROMOTION OF ENERGY STAR CONSUMER ELECTRONICS

We also assume continuation of existing efforts to work through Wisconsin's retailers to promote favorable stocking practices. For consumer electronics, this effort would include modest stocking spiffs. In addition, we assume expansion of the retailer-based program to include all parts of the state and all major retailers. We have built in a reduction in eligible products after a few years of program activity, as we assume that regulatory changes in California will make promotion of energy-efficient models of some consumer electronics unnecessary in Wisconsin.

TABLE 16.02.1. ESTIMATED VALUES FOR PROGRAM AREA 16.02, RETAILER PROMOTION OF ENERGY STAR CONSUMER ELECTRONICS

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$2,556 to $28,148	$2,308 to $25,738
	Incremental Impacts	peak kW	136 to 2,898	127 to 2,641
		annual kWh (000s)	1,515 to 31,371	1,465 to 29,022
		annual therms (000s)	0 to 0	0 to 0
	Levelized resource cost	per peak kW	$1,230 to $12,262	$1,234 to $12,270
		per kWh	11.5¢ to 108.6¢	11.5¢ to 108.6¢
		per therm	NA to NA	NA to NA
Scaling factors[a]		program costs	0.1 to 2.6	0.1 to 2.6
		impacts	0.1 to 1.6	0.1 to 1.6

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Following are the technical assumptions we made for stand-alone programs to market ENERGY STAR as a way to increase sales of energy-efficient consumer electronics. The model inputs assume that each program is implemented independently of the other and do not account for the effects that the programs might have on each other We will account for the effects each program approach has on the other in our aggregation of all programs' potential.

Program Area 16.01 — ENERGY STAR Marketing

We estimate the energy potential for consumer electronics from an ENERGY STAR marketing program based on the following sequence:

Marketing → Increased ENERGY STAR Awareness → Greater Rate of ENERGY STAR Purchases → Reduced Standby Energy Consumption

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 16.01.3. MODEL INPUTS FOR ENERGY STAR MARKETING

Model Inputs (16.01)			Value	±
1		**Program Effect on ENERGY STAR Awareness**		
	a	Households in Wisconsin	2,300,000	500,000
	b	Current ENERGY STAR awareness	50%	5%
	c	Maximum attainable ENERGY STAR awareness	75%	10%
	d	Share of unattained awareness reached per year with program	20%	5%
	e	Share of unattained awareness reached per year without program	10%	4%
2		**Program Effect on Rate of ENERGY STAR Purchases**		
	a	Number of consumer electronic devices per household	9	3
	b	Annual increase in number of consumer electronic devices per household	5%	5%
	c	One time increase in number of consumer electronic devices per household due to digital television conversion (assumed for 2007)	225,000	75,000
	d	Lifespan of consumer electronic devices	5	2
	e	ENERGY STAR market share among electronic devices bought by unaware consumers	50%	15%
	f	Share of non-ENERGY STAR devices converted to ENERGY STAR by new awareness of the label	10%	10%
3		**Per-Unit Impact (unit = consumer electronic device)**		
	a	Average difference in standby power consumption (Watts) between ENERGY STAR and non-ENERGY	3	1

		STAR consumer electronic devices		
	b	Average hours of standby usage for consumer electronic devices	20	3
4		**California-driven market transformation effects**		
	a	years of program activity before California-driven market transformation effects	2	2
	b	share of units affected by California-driven market transformation effects	70%	30%
5		**Program costs**	$100,000	$25,000
6	a	**Measure life (years)** *(same as 2d)*	5	2
7	a	**Diversified Demand Factor**	0.8	0.2

1. Program Effect on ENERGY STAR Awareness

Our analysis is based on Wisconsin households. According to the 2000 Census, there are 2,084,544 housing units in the state (Census 2000). To reflect an assumed 1.5 percent annual growth since 2000, we used a figure of 2,300,000 households.

ENERGY STAR awareness in Wisconsin was nearly 50 percent and on a flattened trajectory in 2004 (Winch, 2005). Hence, we used 50 percent (+/- 5 percentage points) as the starting point for a new marketing program. We assume that there is a maximum awareness level that can be attained through marketing, but there is no empirical evidence of what that level might be. We assume that a clear majority of households can be informed about ENERGY STAR, but a significant minority will be difficult to reach. For this reason, we used 75 percent (+/- 10) as the maximum attainable awareness level.

These numbers provide a gap of 35 percent between current and attainable awareness. Marketing of the label will cause awareness among the easier-to-reach households first, leading to ever more difficult efforts to increase awareness. We assume that program marketing can reach 20 percent (+/- 5) of the gap between current and attainable awareness in any given year. At current levels of awareness, that amounts to an increase of six percentage points, which is consistent with past increases in awareness of nearly five percentage points annually from 2001 to 2003 (Winch, 2005).

ENERGY STAR awareness is likely to increase due to national efforts, even in the absence of a Wisconsin program. We used a non-program growth rate of 14 percent (+/- 5). This rate is based on the "awareness gap" between Wisconsin and Iowa and the awareness growth rate in Iowa, which is a comparison state with low levels of program activity (Winch, 2005). Between 2000 and 2004, Iowa's awareness rate increased about 70 percent as much as Wisconsin's awareness with both rates beginning at similar levels in 2000.

2. Program Effect on Rate of ENERGY STAR Purchases

The program effect on the purchase rate of ENERGY STAR consumer electronics is a function of the number of these devices being purchased and the difference between the percentage of these purchases that are ENERGY STAR-compliant among consumers who are ENERGY STAR aware and those who are not.

We address the purchase rate of electronic devices by combining replacements of existing units and the accumulation of additional devices. Data on numbers of consumer electronics in households is incomplete. Energy Information Administration data show that households in the East North Central Census division have an average of 2.4 color television sets and 1.6 video players (VCRs and DVD players) (2001 Residential Energy Consumption Survey). In addition, three-fourths of households possess stereo equipment and another third have a large screen television set. However, these data exclude computers, monitors, printers, and some other consumer electronics. Based on these incomplete data, we assume that the average household possesses 9 consumer electronic devices (+/- 3). Further, we assume an average lifespan of five years (+/- 2), leading to an annual replacement rate of two devices.

We acknowledge that households appear to be accumulating electronic devices, but do not know at what rate. For our analysis, we assumed a growth rate in number of devices of 5 percent (+/- 5) per year. In addition, the switch to digital-only television broadcast signals will trigger a one-time purchase of new digital television sets or conversion devices by many of the households that rely on through-the-air analog broadcasts. An article published by Silicon Valley.Com suggests that 15 percent of Americans might be affected by this switch, which would be about 300,000 households (Landers, 2005). We assume that 75 percent, or 225,000 (+/- 75,000), of these households will add an electronic device that they would not have bought otherwise when analog broadcasts cease. The switch to digital-only broadcasts is currently proposed for December 31, 2006, but delays are possible. We assume that the temporary increase in purchases of electronic devices would occur in 2007.

The effect of increased awareness of ENERGY STAR on purchase rates of consumer electronics that qualify for the label will build on current purchase rates by unaware purchasers who are already selecting ENERGY STAR models unintentionally. We assume that purchase rates by unaware consumers are purely a function of stocking practices. ENERGY STAR program data suggests a range of market penetrations nationally for consumer electronic devices, but the average in this category is near 50 percent (ENERGY STAR 2003). Therefore, we assume that about 50 percent (+/- 15 percent) of electronic devices purchased by consumers who are not aware of ENERGY STAR qualify for the label. That leaves up to 50 percent of non-ENERGY STAR purchases that could be converted to ENERGY STAR purchases by an aware consumer who seeks out products with the label. Because we expect energy considerations to be only a small part of aware consumers' considerations when choosing a single electronic device, we assume that about 10 percent (+/- 10) of these non-ENERGY STAR purchases would be converted to ENERGY STAR models.

3. Per-Unit Impact

The average difference in standby usage between ENERGY STAR and non-ENERGY STAR models appears to be 3 watts (+/- 1). This number is based on the program's specifications table that lists maximum standby usage and percentage saved in comparison to standard products for selected product types (2004 ENERGY STAR® Home Electronics Holiday Campaign). We assume standby usage for the typical consumer electronic device of 20 hours (+/- 3) per day to compute a total energy effect for each consumer electronic device converted to ENERGY STAR.

4. California-driven Market Transformation Effects

New regulations for appliances, audio and video equipment, and power supplies are scheduled to go into effect in California in 2005 (CEC 2004). Because of the size of California's market, these regulations have the potential to affect manufacturers' specifications of these devices for the entire United States market, thereby bringing energy-efficient consumer electronics to Wisconsin even without a program. We acknowledge this possibility by including in our model a date by which the program's effect would be reduced because the market would introduce efficient equipment on its own (2 years after program start +/- 2 years) and the share of units affected (70 percent +/- 30 percent).

5. Program Costs

Marketing the ENERGY STAR label is a cross-cutting function that provides benefits to multiple markets. Its costs need to be included in our analysis, but not applied fully to any single market. The base annual cost of ENERGY STAR marketing is accounted for separately in our analysis when the individual programs are aggregated. We did assign a marginal cost of $100,000 annually for adding consumer electronics to the overall ENERGY STAR marketing campaign. We assume no change in these cross-cutting program costs even after the California-driven market transformation effects take hold.

6. Measure Life

As stated in #2 above, we assume an average lifespan of 5 years for the family of consumer electronic devices included in our analysis.

7. Diversified Demand Factor

For computation of demand savings, we assume standby usage for consumer electronic devices affected by the program are somewhat less likely to occur during system peak hours than during the rest of the day. We applied a diversified demand factor of 0.8 to account for this phenomenon.

Program Area 16.02 — Retailer Promotion of ENERGY STAR Consumer Electronics

Model inputs for this program area are summarized in the table below, and described on the following pages. These inputs draw somewhat from the inputs for program area 16.01 above.

TABLE 16.02.2. MODEL INPUTS FOR RETAILER PROMOTION OF ENERGY STAR CONSUMER ELECTRONICS

Model Inputs (16.02)			Value	±
1		**Consumer Electronic Devices Purchased**		
	a	Households in Wisconsin	2,300,000	500,000
	a	Number of consumer electronic devices per household	9	3
	b	Annual increase in number of consumer electronic devices per household	5%	5%
	c	One time increase in number of consumer electronic devices per household due to digital television conversion (assumed for 2007)	225,000	75,000
	d	Lifespan of consumer electronic devices	5	2

2		**Program-Induced Change in Stocking Practices**		
	a	Share of stocked models that are ENERGY STAR – pre-program	50%	15%
	b	Share of stocked models in participating stores that are ENERGY STAR – with program influence	80%	15%
	c	Market share of participating stores	75%	15%
3		**Per-Unit Impact (unit = consumer electronic device)**		
	a	Average difference in standby power consumption (Watts) between ENERGY STAR and non-ENERGY STAR consumer electronic devices	3	1
	b	Average hours of standby usage for consumer electronic devices	20	3
4		**California-driven market transformation effects**		
	a	years of program activity before California-driven market transformation effects	2	2
	b	share of units affected by California-driven market transformation effects	70%	30%
5		**Program costs**		
	a	Fixed costs	$150,000	$25,000
	b	Variable costs (per ENERGY STAR device sold)	$10.00	$2.50
	c	share of program time that spiffs are offered	50%	20%
6	a	**Measure life (years)** *(same as 1d)*	5	2
7	a	**Diversified Demand Factor**	0.8	0.2

1. Consumer Electronic Devices Purchased

Several of our inputs allow for an estimate of the number of consumer electronic devices to be purchased by Wisconsin households in each of the next ten years. These inputs are taken from variables used for program approach 16.01, and the sources of our numbers are explained further in the technical documentation for that program approach. These variables are:

- Wisconsin households;
- Number of consumer electronic devices per household;
- Annual increase in number of consumer electronic devices per household;
- One-time increase in number of devices due to digital television conversion; and
- Lifespan of consumer electronic devices.

2. Program-Induced Change in Stocking Practices

The program-induced change in stocking practices by participating retailers is the difference between:

- The future share of consumer electronics models stocked on the shelves of participating retail stores that are ENERGY STAR qualified; and
- The current share of consumer electronics models stocked on the shelves of retail stores that will/would participate in this program.

We assume a current ENERGY STAR share of 50 percent (+/- 15 percent) for consumer electronics based on national program data (ENERGY STAR 2003). (See also market 16.01.)

We assume a future ENERGY STAR share of 80 percent (+/- 15 percent), which is based on an aggressive spiff, as described above. Our research could not identify any programs that have targeted the promotion of ENERGY STAR consumer electronics through spiffs, so we were not able to base this number on actual experience or research.

Because Wisconsin consumers will purchase some electronic devices from non-participating stores (out-of-state retailers or in-state stores that choose not to participate), we developed an estimate of the share of consumer electronic devices purchased in participating stores. We used 75% percent (+/-15) as the market share of participating stores. This number is intended to account for out-of-state purchases and for a small number of non-participating stores in-state.

3. Per-Unit Impact

We used the same per-unit impact as in program approach 16.01.

4. California-driven Market Transformation Effects

We used the same assumptions as in program approach 16.01. The California-driven market transformation effects reduce the program's effect and variable costs once they take hold in Wisconsin.

5. Program Costs

The program would need a network in place to promote and administer the SPIFF program. Focus on Energy staff have estimated the cost of this network at $150,000. We used this cost estimate with an uncertainty of +/- $25,000.

The variable costs associated with a spiff would occur for each ENERGY STAR model sold by a retailer participating in the program. We assumed a $10 spiff per device – a figure that is on the high end of probable spiffs discussed in a stakeholder meeting. We chose the higher amount because (1) we also assumed that this program would make a substantial difference in increasing shares of ENERGY STAR models stocked by all participating retailers and (2) some consumer electronics are expensive with presumably higher profit margins (computers, digital-ready television sets, entertainment centers, etc.) and would probably require a high spiff to motivate retailers. We assume that the program's approach would be to offer a variety of spiff amounts for different product types (based on the energy savings and profit margins of each), but rather than model a complicated matrix of spiffs by product types, we opted for a single average amount.

To enhance cost-effectiveness, we assume an intermittent spiff that is offered about 50 percent of the time that the program is active. We assume that this approach would still achieve the effects we described above, but at lower cost, because retailers who react to the spiff when it is offered would maintain their revised stocking practices in the "no spiff" times.

The number of units eligible for a spiff would decrease once the California-driven market transformation effects take hold in Wisconsin. We assume that entire types of consumer electronic devices would be affected, so complete categories of spiffs could be eliminated.

The number of models that need to be spiffed are: number of models purchased by Wisconsin households (computed using the inputs in #1 above) times the share of stocked models in participating stores (described in #2 above) times the market share of participating stores (described in #2 above).

6. Measure Life

We used the same measure life assumptions as in program approach 16.01.

7. Diversified Demand Factor

For computation of demand savings, we assume standby usage for consumer electronic devices affected by the program are somewhat less likely to occur during system peak hours than during the rest of the day. We applied the same diversified demand factor as for program approach 16.01.

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MARKET 17 — HOMEOWNER/RENTER RETAIL LIGHTING PURCHASE MARKET

Market Scope

This market involves homeowners or renters purchasing light bulbs for existing fixtures in homes and apartments. Potential estimates will be based on programmatic approaches to increasing the market share of CFLs. This market does not include lighting fixtures for new homes or those purchased for remodeling projects. Analysis of lighting fixtures for new homes and those purchased for remodeling projects are addressed in Markets 24 and 25, respectively.

Market Characteristics

CFLs have been promoted since the early 1990's by government and utility energy efficiency programs. Despite these efforts, Wisconsin and national market share of CFLs in 2000 was less than one percent (Itron, 2004).

CFLs were incorporated into Focus on Energy from its inception in 2001. Focus on Energy program efforts have concentrated on both the demand side, through customer rewards, and the supply side, through retailer efforts. The market share of CFLs has grown substantially in Wisconsin between 2000 and 2002, from less than one percent to about seven percent (Winch, 2003). This growth exceeds national trends as well as trends in California where there is a high level of CFL program activity (Itron, 2004). The market potential for CFLs is large. Roughly 20 million medium screw-based lamps (MSBLs) are sold in Wisconsin annually and studies have shown that three-quarters of Wisconsin households could cost-effectively retrofit one or more incandescent lamps with CFLs (Itron, 2004). Although the potential is large, high first cost and satisfaction with light quality are still predominant barriers to CFL use.

CFLs use one-fourth to one-third the electricity of incandescent light bulbs and last about six times longer.

Program Approaches

Our analysis of this market focuses on increasing the market share of CFLs through program efforts that lower the cost of CFLs to the end-user, either through direct customer incentives (processed and paid instantly at the register versus paid weeks after the sale via mail-in rebate processing) or through retailer/manufacturer buy-downs. We discuss the achievable potential from these program efforts below.

PROGRAM AREA 17.01 — INCENTIVES FOR CFLS

Our analysis of the achievable potential for this program area is projected from the current Focus on Energy incentive program for CFLs. The analysis is based on the Focus on Energy evaluation, which quantified the impact of the program on the overall market share for CFLs in Wisconsin (Focus on Energy Statewide Evaluation, 2003; Winch, 2003; Talerico and Winch, 2005; and Winch and Talerico, 2005). We have assumed continued growth in this market, resulting in both an increase in the number of direct participants in the program as well as broader market effects beyond immediate participants.

Please refer to the technical documentation of this report for a detailed description of the inputs and outputs of the model for this program area.

TABLE 17.01.1. ESTIMATED VALUES FOR PROGRAM AREA 17.01, INCENTIVES FOR CFLS

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		\$3,371 to \$7,021	\$4,994 to \$9,772
	Incremental Impacts	peak kW	3,026 to 9,027	4,380 to 12,430
		annual kWh (000s)	50,498 to 117,230	75,032 to 161,464
		annual therms (000s)	0	0
	Levelized resource cost	per peak kW	\$136 to \$340	\$137 to \$344
		per kWh	1.1¢ to 1.9¢	1.1¢ to 1.9¢
		per therm	NA	NA
Scaling factors[a]		program costs	1.1 to 2.1	1.1 to 2.1
		impacts	1.0 to 1.5	1.0 to 1.5

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

Program Area 17.01 — Incentives for CFLs

Model inputs are summarized in the table below and described on the following pages.

TABLE 17.01.2. MODEL INPUTS FOR INCENTIVES FOR CFLS

Model Inputs (17.01)			Value	±
1		**Per-Unit Impacts (Unit = CFL)**		
	a	Annual Electricity Savings (kWh)	35.8	6
	b	Coincident Summer Peak Demand Savings (Watts)	2.5	1
2		**Size of Annual CFL-Compatible MSBL Market w/o CFLs Installed**		
	a	CFL-Compatible MSBLs in Market w/o CFLs Installed (Technical Potential) (000's)	67,000	10,000
	b	Annual Compound Growth Rate of Market	1%	1%
	c	Percent of Market Replaced Annually	30%	10%
3		**Market Share of CFL**		
	a	Wisconsin Market Share	12%	3%
	b	Annual Percentage Point Increase in Wisconsin Market Share	1.5%	0.5%
	c	Baseline Market Share	2%	1%
	d	Annual Percentage Point Increase in Baseline Market Share	0.25%	0.25%
4		**Program Participation**		
	a	Percent of CFLs Sold Annually Incented through Program	95%	5%
5		**Program Costs**		
	a	Fixed Administrative Cost	$50,000	$25,000
	b	Incremental Retailer Network Costs	$150,000	$25,000
	c	Variable Administrative Cost Per Incented CFL	$0.35	$0.15
	d	Incentive Per CFL	$1.50	$0.25
6		**Measure Life (years)**	6	1

1. Per Unit Impacts

We derive annual electricity savings using the formula below.

kWh Savings = (Watts Saved /1,000) x (Daily Hours of Operation x 365 Days) x Installation Rate

We use Focus on Energy's estimate of 51.9 W for Watts saved (Wisconsin Energy Conservation Corporation, 2002; Focus on Energy Statewide Evaluation, 2002). This estimate is based on program participant data.

Focus on Energy has used an estimate of 3.5 hours for daily hours of operation. This estimate was selected not because it is rooted in current research but rather because it is has been historically used in Wisconsin. The Focus on Energy evaluation team is currently in the process of adjusting this estimate to 2.7 hours based on a review of recently conducted metering studies (Winch and Talerico, 2005). Therefore, we use 2.7 hours rather than the 3.5 historical-based estimate for the model.

Focus on Energy CFL installation rate evaluation research shows that participants who purchased CFLs install 67-75 percent of them (Focus on Energy Statewide Evaluation, 2003). Based on this information, we use 70 percent as our installation rate estimate.

Applying these estimates to the formula above yields an annual electricity savings estimate of 35.8 kWh [(51.9/1,000) x (2.7 x 365) x 0.70)] ***(Input 1a)***. We assign this estimate an uncertainty of +/- 6 kWh.

We derive coincident summer peak demand savings (in Watts) using the formula below.

Peak Demand Savings = Watts Saved x Summer Peak Coincidence Factor x Installation Rate

We use 51.9 W and 70 percent for Watts saved and the installation rate, respectively (see discussion above for rationale).

The Focus on Energy evaluation team is also currently in the process of adjusting the summer peak coincidence factor to 7 percent (Winch and Talerico, 2005). We use this estimate as the summer peak coincidence factor for the model.

Applying these estimates to the formula above yields a coincident summer peak demand savings estimate of 2.5 W (51.9 x 0.07 x 0.70)] ***(Input 1b)***. We assign this estimate an uncertainty of +/- 1 W.

2. Size of Annual CFL-Compatible MSBL Market

The analysis presented in this section is based on the Focus on Energy evaluation, which quantified the impact of the program on CFL market share in Wisconsin (Winch, 2003), and findings from a study of CFL program efforts in Massachusetts (Bonanno, 2004).

We first estimate the number of CFL-compatible medium screw-based lamps (MSBL) in Wisconsin households that do not have CFLs installed (i.e., technical potential). Based on the MA study, the typical household has 52 lighting sockets. Applying this estimate to the 2 million Wisconsin households yields 108 million lighting sockets in Wisconsin. Based on the MA study, 70 percent of lighting sockets are CFL-compatible. Applying this estimate to the 108 million lighting sockets yields 76 million lighting sockets that are CFL-compatible in Wisconsin. We then estimate the number of these sockets that already have CFLs installed. According to research conducted by the Energy Center of Wisconsin, 5 percent of all lighting sockets have a CFL installed (Pigg and Nevius, 2000). Applying this estimate to the 108 million lighting sockets in Wisconsin yields 5.4 million CFLs installed. This estimate, however, was as of 1999. Since then, Focus on Energy has rewarded 3.5 million CFLs, which when added to the 5.4 million CFLs as of 1999 yields about 9 million CFLs installed. Subtracting this estimate from the 76 million lighting sockets that are CFL-compatible yields 67 million CFL-compatible lighting sockets without CFLs installed ***(Input 2a)***. We use this as our estimate for technical potential and assign this estimate an uncertainty of +/- 10 million.

The next step is to estimate the rate of growth in this technical potential over time and the percent of this potential that is replaced annually. Table 17.01.2 shows annual sales of MSBLs in Wisconsin and nationally during 2000-2002 (Itron, 2004). About 20 million MSBLs were sold in Wisconsin annually during 2000-2002. MSBL sales in Wisconsin grew minimally during this period (small negative growth from 2000 to 2001 and small positive growth from 2001 to 2002) while growth in national MSBL sales was negative.

TABLE 17.01.2. TRENDS IN MEDIUM SCREW-BASED LAMP (MSBL) SALES

Year	Wisconsin		National		Wisconsin Share of National
	MSBLs (000's)	Growth Rate	MSBLs (000's)	Growth Rate	
2000	19,660	--	1,368,312	--	1.4%
2001	19,367	-1.5%	1,331,605	-2.7%	1.5%
2002	19,689	1.7%	1,310,803	-1.6%	1.5%

Source: Itron (2004)

Although the data in Table 17.01.2 indicates no growth, we use an estimate of 1 percent with an uncertainty of +/- 1 percent for the growth rate in technical potential over time ***(Input 2b)***. The 20 million MSBLs sold annually represents about 30 percent of the 67 million lighting sockets without CFLs installed that are CFL-compatible. We use this estimate with an uncertainty of +/- 10 percent as the percent of the market that is replaced annually ***(Input 2c)***.

3. Market Share of CFLs (Share of Overall Market)

The analysis presented in this section is based on the Focus on Energy evaluation, which quantified the impact of the program on CFL market share in Wisconsin (Winch, 2003), and a review of other CFL programs (Samiullah, 2004; Bonanno, 2004; and Northwest Energy Efficiency Alliance, 2004).

To project CFL market share during Years 1-10 of program implementation, we looked at CFL market share trends in Wisconsin during 2000-2002 (Itron, 2004). These trends are presented in Table 17.01.3.

TABLE 17.01.3. TRENDS IN WISCONSIN CFL MARKET SHARE

Year	Wisconsin CFL Market Share
2000	0.6%
2001	1.7%
2002[1]	6.7%

[1] First full year of Focus on Energy CFL program implementation efforts
Source: Itron (2004)

The first full year of Focus on Energy CFL program implementation efforts was in 2002. Prior to Focus on Energy, CFL market share in Wisconsin was in the 1-2 percent range (0.6 percent in 2000 and 1.7

percent 2001). Subsequent to Focus on Energy, CFL market share was about 7 percent. It is important to note, however, that the Focus on Energy program does not cover all of the potential MSBL market. In fact, it is only involved with two of the five major retail channels in which CFLs are sold. Specifically, the program is involved with the home improvement and hardware retail channels, but not involved with the food, drug, and mass merchandiser retail channels. Given that the home improvement and hardware retail channels comprise about 45 percent of the MSBL market, we would expect the market share to have been closer to 15 percent rather than about 7 percent if it were involved in all retail channels (15 percent = 6.7 percent ÷ 45 percent). Although we assume that future program efforts will focus on gaining access to these retail channels, we do not assume that these relationships will be developed instantaneously, regardless of increases in funding available to the program. We looked at the performance of other CFL programs for indications on what is achievable in Wisconsin. As shown in Table 17.01.4, current Focus on Energy CFL efforts surpassed program efforts in California and Massachusetts on a CFL per household basis (0.603 CFLs per household vs. 0.304 and 0.397 CFLs per household for CA and MA), but did not reach the level achieved by program efforts in the Northwest (1.128 CFLs per household). We assume that the program efforts in Wisconsin can achieve the levels in the Northwest. Applying the 2004 Northwest results to Wisconsin yields a market share of 11.7 percent. Based on this result, we use 12 (+/- 3) percent as our estimate of CFL market share in Year 1 ***(Input 3a)***. We also estimate the annual percentage point increase in CFL market share based on program efforts in the Northwest. The goal for program efforts in the Northwest is to achieve CFL sales of 9 million by 2010 (Table 17.01.4). Applying this estimate to Wisconsin yields a market share of 21 percent. Therefore, CFL market share in the Northwest, when adjusted for Wisconsin, is projected to grow from 12 percent in 2004 to 21 percent in 2010. This represents a nine percentage point increase over a period of six years, which amounts to an average annual percentage point increase of 1.5. Based on this result, we use 1.5 (+/- 0.5) percent as our estimate for annual percentage point increase of CFL market share ***(Input 3b)***.

TABLE 17.01.4. PERFORMANCE OF CFL PROGRAMS

Program/State/Region	Period/Scenario	CFLs	Households (Based on 2000 Census)	CFLs Per Household
Focus on Energy	2003/04 Program Year	1,255,990	2,084,544	0.603
CA[1]	2002	3,500,000	11,502,870	0.304
MA[2]	2003	969,928	2,443,580	0.397
Northwest[3]	2004	5,000,000	4,433,433	1.128
WI	11.7% Market Share on 20M MSBLs (Comparable to Northwest 2004)	2,350,937	2,084,544	1.128
Northwest	2010 Goal	9,000,000	4,433,433	2.030
WI	21.1% Market Share on 20M MSBLs (Comparable to Northwest 2010 Goal)	4,231,686	2,084,544	2.030

[1] Source: Samiullah (2004)
[2] Source: Bonanno (2004)
[3] Source: Northwest Energy Efficiency Alliance (2004)

To project baseline market share (i.e., market share in the absence of program activity), we looked at CFL market share nationally, excluding Wisconsin and California, two states with high levels of CFL energy efficiency program activity (Itron, 2004). These trends are presented in Table 17.01.5.

TABLE 17.01.5. TRENDS IN WISCONSIN CFL MARKET SHARE

Year	National (Excluding WI and CA)
2000	0.4%
2001	1.3%
2002	1.8%

Source: Itron (2004)

CFL market share nationally (excluding Wisconsin and California) was comparable to Wisconsin in 2000 (0.4 vs. 0.6 percent) and 2001 (1.3 vs. 1.6 percent). In 2002, market share nationally (excluding Wisconsin and California) was around 2 percent, which was substantially lower than market share in Wisconsin. Based on these estimates, we use 2 percent with an uncertainty of +/- 1 percent as our best projection of baseline CFL market share during Years 1-10 of program implementation ***(Input 3c)***. We assume an annual percentage point increase of 0.25 (+/- 0.25) in baseline market share ***(Input 3d)***. Our reasoning for this low growth rate is that CFL market share in Wisconsin and nationally in 2000 was extremely low despite the fact that CFLs have been available and promoted by government and utility energy efficiency programs since the early 1990's. Given this prior trend, we would not expect a significant percentage point increase in baseline CFL market share from Year 1 to Year 10.

4. Program Participation

Finally, our analysis needs to account for the percent of CFLs sold in the market that are incented through the program. Given our assumptions for program delivery, the program will achieve broad market coverage through availability in all five retail market channels and the fact that the incentives for CFLs will be paid instantly at the cash register to customers or directly to retailer and manufacturer through buydowns. Therefore, we assume that the program will capture 95 percent of the CFLs sold in the market ***(Input 4a)***. We assign this estimate an uncertainty of +/- 5 percent.

5. Program Costs

We estimate program costs based on input from the Focus on Energy program manager (Van de Grift, 2005). We estimate the annual administrative cost of the program to be about $50,000 +/- $25,000 ***(Input 5a)***. The model assumes retailer network costs of $150,000 +/- $25,000 ***(Input 5b)*** for adding this program to an existing retailer network with circuit riders like the one currently operated by Focus on Energy. We estimate the administrative cost per incented CFL at $0.35 +/- $0.15 ***(Input 5c)***. We estimate the incentive per CFL at $1.50 +/- $0.25 ***(Input 5d)***.

6. Measure Life

We estimate the measure life as 6 years +/- 1 year ***(Input 6)***. This estimate is based on assumptions in the Lighting Buyers Guide that is on the Energy Star Website (2005).

7. Model Outputs

Table 17.01.6 shows the key outputs from our model. We provide a brief overview of the outputs below. Please refer back to Sections 1 thru 6 for derivations.

Column A shows the number of CFL-compatible sockets / bulbs in Wisconsin. We assume an annual compound growth rate of 1 percent Years 2-10. Column B shows the CFLs installed at the beginning of each year. The Year 2 estimate is equal to the Year 1 estimate (9,000) plus the number of new CFLs installed (Column G). The same pattern holds for Years 3-10. Remaining CFL technical potential is illustrated in Column C, which is equal to Column A minus Column B. CFL saturation (Column D) is equal to Column B divided by Column A. Column E shows MSBL sales, excluding CFL sales to replace previous year CFLs—which comes into play in Year 7 (see Column H). This is equal to 30 percent of Column C. The share of annual MSBL sales that are CFLs is presented in Column F. This share grows by 1.5 percentage point annually in Years 2-10. Column G shows new CFL sales in the market, which is the product of Columns E and F. CFLs sales in the market to replace CFLs purchased in previous years are presented in Column H. Because CFLs last six times longer than incandescent light bulbs (6 years vs. 1 year), a CFL purchased in Year 1 will not need to be replaced until Year 7. Accordingly, the estimates for Years 7-10 are identical to the estimates for Years 1-4 in Column G. Column I shows the total CFL sales in the market, which is equal to the sum of Columns G and H. Cumulative previous year new CFL sales in the market (Column J) is a running total of Column G. CFL sales incented through the program are shown in Column K. This is equal to 95 percent of Column I. Column L contains the projection of the baseline number of CFLs in the market. The Year 2 estimate is equal to the Year 1 estimate (9,000) plus the number of new baseline CFLs in the market (Column O). The same pattern holds for Years 3-10. Column M illustrates the remaining baseline CFL technical potential, which is equal to Column A minus Column L. Column N shows baseline MSBL sales, excluding CFL sales to replace previous year baseline CFLs—which comes into play in Year 7 (see Column P). This is equal to 30 percent of Column M. Column O contains new baseline CFL sales in the market. This is equal to baseline market share, which is 2 percent in Year 1 and increases by 0.25 percent each subsequent year, multiplied by Column N. Baseline CFLs sales in the market to replace baseline CFLs purchased in previous years are presented in Column P. Because CFLs last six times longer than incandescent light bulbs (6 years vs. 1 year), a CFL purchased in Year 1 will not need to be replaced until Year 7. Accordingly, the estimates for Years 7-10 are identical to the estimates for Years 1-4 in Column O. The number of CFLs that were program induced is shown in Column Q. This is equal to Column I minus the sum of Columns O and P. Finally, the net-to-gross ratio is presented in Column R. This is equal to the ratio of Column Q to Column K.

The estimates from Table 17.01.6 are used to derive estimates of program costs and impacts, which are presented in Table 17.01.1.

TABLE 17.01.6 MIDPOINT ESTIMATES OF PROJECTIONS FOR PROGRAM AREA 17.01, INCENTIVES FOR CFLS

	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)	(Q)	(R)
Yr	CFL-Compatible Sockets / Bulbs	CFL-Compatible Sockets / Bulbs with CFLs Installed at Beginning of Year	Remaining CFL Technical Potential	CFL Saturation	MSBL Sales (Excluding CFL Sales to Replace Previous Year CFLs)	CFL Market Share	CFL Sales in Market (New)	CFL Sales in Market (Replace Previous Year CFLs)	Total CFL Sales in Market	Cumulative Previous Year New CFL Sales in Market	Program CFL Sales	CFLs in Market (Baseline)	Technical Potential (Baseline)	MSBL Sales (Baseline)	Baseline CFL Sales (New)	Baseline CFL Sales (Previous Years)	Program-Induced Sales	Net-to-Gross Ratio
1	76,000	9,000	67,000	11.8%	20,100	12.0%	2,412	0	2,412	0	2,291	9,000	67,000	20,100	402	0	2,010	88%
2	76,760	11,412	65,348	14.9%	19,604	13.5%	2,647	0	2,647	2,412	2,514	9,402	67,358	20,207	455	0	2,192	87%
3	77,528	14,059	62,701	18.1%	18,810	15.0%	2,822	0	2,822	5,059	2,680	9,857	67,671	20,301	508	0	2,314	86%
4	78,303	16,880	59,880	21.6%	17,964	16.5%	2,964	0	2,964	7,880	2,816	10,364	67,939	20,382	560	0	2,404	85%
5	79,086	19,844	56,916	25.1%	17,075	18.0%	3,073	0	3,073	10,844	2,920	10,925	68,161	20,448	613	0	2,460	84%
6	79,877	22,918	53,842	28.7%	16,153	19.5%	3,150	0	3,150	13,918	2,992	11,538	68,339	20,502	666	0	2,483	83%
7	80,676	26,067	50,693	32.3%	15,208	21.0%	3,194	2,412	5,606	17,067	5,325	12,204	68,471	20,541	719	402	4,485	84%
8	81,482	29,261	47,499	35.9%	14,250	22.5%	3,206	2,647	5,853	20,261	5,560	12,923	68,559	20,568	771	455	4,627	83%
9	82,297	32,467	44,293	39.5%	13,288	24.0%	3,189	2,822	6,011	23,467	5,710	13,695	68,602	20,581	823	508	4,680	82%
10	83,120	35,656	41,104	42.9%	12,331	25.5%	3,144	2,964	6,108	26,656	5,803	14,518	68,602	20,581	875	560	4,673	81%

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MARKET 18 — MULTI-FAMILY COMMON AREA LIGHTING MARKET

Market Scope

This market focuses on multifamily building operators who purchase lighting products for common-areas in existing buildings. It includes renovation projects, but not lighting purchased for new buildings.

Market Characteristics

The multi-family market comprises rental housing that ranges from duplexes to large apartment complexes. Excluding rented single-family homes, there are approximately 106,600 rental buildings in the state encompassing 486,800 housing units. Small buildings with fewer than five units account for approximately 90 percent of the buildings and more than 50 percent of the units (Pigg and Price, 2005).

This market has been a challenging one for energy efficiency programs. Barriers to addressing this market in Wisconsin include:

- A split incentive, whereby those who select and pay for energy-using equipment (owners) often do not benefit from the savings that an energy-efficient choice would generate because they do not pay the energy bill;
- Distribution of a large share of rental units among small buildings;
- A large number of small-scale owners who control just a few units or buildings;
- A lack of strong and active apartment associations through which an energy program could offer its services; and
- A lack of demand for energy-efficiency from tenants.

These barriers help to shape the nature of the multi-family programs we include in our model. The common area lighting market, for instance, is not subject to a split incentive because owners make decisions regarding lighting equipment and pay the energy bills that result from their choices. To mitigate the high cost of identifying and marketing such a service to the applicable decision-makers, we chose to focus this (and other) multi-family program(s) on buildings of a sufficient size to warrant the effort. For this reason, we are limiting this program to buildings with five or more units. We assume that those with fewer units would be served through promotional programs that encourage energy-efficient purchases at the retail level.

Common area lighting encompasses three distinct types:

- Interior lighting, such as hallways, lobbies, and special areas (laundry rooms, storage rooms, etc.);
- Exit lights; and
- Outdoor lighting for entrances, walkways, and parking lots.

Efficiency levels for lights in these areas vary greatly. Incandescent lighting accounts for a substantial share of interior and exterior lighting even though compact fluorescent light bulbs offer the same amount of light at a third the energy consumption and cost. For high-use lights, such as those in multi-family common areas, replacing incandescent bulbs with compact fluorescent ones offers very short paybacks of less than 6 months. Nevertheless, many multi-family facilities continue to use incandescent bulbs.

Even among fluorescent lights, there are efficiency opportunities. Older, T-12 fluorescent bulbs often burn 40 watts while newer, more efficient T-8 fluorescent bulbs use 32 or 34 watts. However, a switch from T-12 bulbs to T-8 bulbs also requires the replacement of the ballast, which "starts" the bulb. This complication extends the payback period for high-use lights to several years, but they are still cost-effective.

Exit lights offer very efficient alternatives that are used by only a minority of multi-family buildings: light-emitting diode (LED) lights that can operate with as little as 2 watts. Because exit lights need to operate 24 hours per day, the LED lights offer substantial energy savings over their incandescent and fluorescent cousins with paybacks between one and four years for conversion kits.

Wisconsin's Focus on Energy program has offered direct install lighting replacements for multi-family buildings since 2001. The program has targeted the three types of replacements discussed above. Program staff provide multi-family building owners or operators with a choice of several lighting options, replace existing lights with the selected models, and cover a substantial share of the cost of the replacement. Depending on the estimated operating hours of the lights being replaced, the program will cover between 65 and 85 percent of the cost, while the multi-family building owner or operator pays the rest.

Focus on Energy also promotes the replacement of inefficient common area lighting in its market-based whole building program. This program conducts facility evaluations and provides recommended changes and performance-based incentives for multi-family building owners and operators to make energy improvements. Unlike the direct install program, however, the actual work is performed by contractors rather than program representatives.

Program Approaches

To estimate achievable potential through the upgrading of common area lighting in multi-family buildings, we modeled an aggressive direct install program. Similar results might be possible through a market-based approach or a combination of both. Like the current Focus on Energy program, we assume replacements of incandescent and inefficient fluorescent lights with compact fluorescents and efficient fluorescents, respectively, as well as the replacement of conventional exit signs with LED exit signs. Unlike the current program, however, we assumed no budget constraints that would limit the share of the willing market that could be reached.

PROGRAM AREA 18.01 — COMMON AREA LIGHTING - DIRECT INSTALL

TABLE18.01.1. ESTIMATED VALUES FOR PROGRAM AREA 18.01, COMMON AREA LIGHTING - DIRECT INSTALL

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		\$62 to \$1,184	\$277 to \$873
	Incremental Impacts	peak kW	20 to 396	95 to 295
		annual kWh (000s)	250 to 4,744	1,192 to 3,439
		annual therms (000s)	0 to 0	0 to 0
	Levelized resource cost	per peak kW	\$470 to \$1,047	\$454 to \$1,004
		per kWh	4.0¢ to 8.2¢	3.9¢ to 7.9¢
		per therm	NA to NA	NA to NA
Scaling factors[a]		program costs	0.2 to 1.0	0.2 to 1.0
		impacts	0.3 to 1.0	0.3 to 1.0

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

Program Area 18.01 — Common Area Lighting - Direct Install

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 18.01.2. MODEL INPUTS FOR COMMON AREA LIGHTING – DIRECT INSTALL

Model Inputs (18.01)			Value	±
1		**Buildings Served**		
	a	rental buildings in Wisconsin (bldgs > 4 units)	20,800	3,120
	b	rental buildings that can be reached by the program	15,000	3,000
	c	market barriers coefficient for buildings reached	107	81
	d	curve shape coefficient for buildings reached	1.35	0.65
	e	share of assessed buildings with common area lighting review	90%	10%
	f	share of bldgs with 4+ units that have 20+ units	15%	3%
2		**Installations per Building (5-19 units)**		
	a	replace indoor incandescent (excl. exit lights)	7.5	0.75
	b	replace indoor fluorescent (excl. exit lights)	1.8	0.18
	c	replace incandescent exit lights	0.6	0.06
	d	replace fluorescent exit lights	0.6	0.06
	e	replace outdoor incandescent	4.4	0.44
	f	replace outdoor fluorescent	0.2	0.02
3		**Installations per Building (20+ units)**		
	a	replace indoor incandescent (excl. exit lights)	12.1	1.21
	b	replace indoor fluorescent (excl. exit lights)	10.6	1.06
	c	replace incandescent exit lights	1	0.1
	d	replace fluorescent exit lights	3.7	0.37
	e	replace outdoor incandescent	4.7	0.47
	f	replace outdoor fluorescent	1.2	0.12
4		**Per-Item Impact (kWh) (5-19 units)**		
	a	replace indoor incandescent (excl. exit lights)	166	16.6
	b	replace indoor fluorescent (excl. exit lights)	31	3.1
	c	replace incandescent exit lights	333	33.3
	d	replace fluorescent exit lights	79	7.9
	e	replace outdoor incandescent	95	9.5
	f	replace outdoor fluorescent	15	1.5
5		**Per-Item Impact (kWh) (20+ units)**		
	a	replace indoor incandescent (excl. exit lights)	131	13.1
	b	replace indoor fluorescent (excl. exit lights)	31	3.1
	c	replace incandescent exit lights	333	33.3
	d	replace fluorescent exit lights	79	7.9

Model Inputs (18.01)		Value	±
e	replace outdoor incandescent	181	18.1
f	replace outdoor fluorescent	26	2.6
6	**Program costs (variable costs expressed per building)**		
a	Program management costs – per building assessed	$20	$10
b	Marketing costs – per building assessed – 1st year	$300	$200
c	Marketing costs – per building assessed – decrease per year	50%	25%
d	Assessment costs – per building assessed	$300	$100
e	electric rates (5-19 units)	$0.10	$0.01
f	electric rates (20+ units)	$0.07	$0.01
g	average payback period expected for multi-family building owners (years)	0.5	0
h	replace indoor incandescent (excl. exit lights) (5-19 units)	$0.00	$0.00
i	replace indoor fluorescent (excl. exit lights) (5-19 units)	$56	$5.60
j	replace incandescent exit lights (5-19 units)	$17	$1.70
k	replace fluorescent exit lights (5-19 units)	$25	$2.50
l	replace outdoor incandescent (5-19 units)	$14	$1.40
m	replace outdoor fluorescent (5-19 units)	$6	$0.60
n	replace indoor incandescent (excl. exit lights) (20+ units)	$41	$4.10
o	replace indoor fluorescent (excl. exit lights) (20+ units)	$333	$33.30
p	replace incandescent exit lights (20+ units)	$33	$3.30
q	replace fluorescent exit lights (20+ units)	$156	$15.60
r	replace outdoor incandescent (20+ units)	$8	$0.80
s	replace outdoor fluorescent (20+ units)	$38	$3.80
7	**Measure life (years)**		
a	replace indoor incandescent (excl. exit lights)	6	2
b	replace indoor fluorescent (excl. exit lights)	12	6
c	replace incandescent exit lights	20	10
d	replace fluorescent exit lights	20	10
e	replace outdoor incandescent	6	2
f	replace outdoor fluorescent	12	6
8 a	**Demand Savings (W per kWh saved)**	0.0821	0.0164

1. Buildings Served

Most Wisconsin rental buildings have between one and four units – too few for a cost-effective direct install program. However, there are 20,800 buildings with 5 or more units; approximately 15 percent of these have 20 or more units (Pigg and Price, 2005). These buildings are the target for the multi-family common area direct install program.

A single market-based whole-building effort would serve this and most other multi-family program approaches we are modeling for this study. Similar to Focus on Energy's current market-based approach for multi-family buildings, this program would offer whole-building assessments and make recommendations that span multiple "markets" included in this study, including lighting, HVAC upgrades, and fuel switching. The program would market its offerings both directly to multi-family building owners and operators and to contractors who serve that market. According to this program's theory, contractors and owners/operators who participate in the program are likely to come back to the program when future opportunities arise on other buildings (such as when bidding or working on another heating or lighting system), thereby producing a "snowball" of program participation without additional marketing. This snowball would cause exponential growth in program participation until the most responsive part of the multi-family market is saturated. After that, the program would likely see a drop-off of growth rates and even participation due to diminishing marginal returns.

We used the little empirical information that exists about the effectiveness of this market-based approach for multi-family programs in order to estimate a range of participation growth curves for our model. These curves are s-shaped curves that show participation over time up to an asymptotic limit. We developed separate curves for the optimistic and pessimistic scenarios and then built a midline estimate based on these scenarios. These curves take the form of:

$$y = 2 * (1 + m * e ^ (-t/r)) / (1 + (2m * 1) * e ^ (-t/r)) – 1) * a$$

where y = number of buildings assessed by the program (cumulative)

m = market barriers coefficient, which defines how far the upward movement in the curve is shifted laterally

t = the program year

r = curve shape coefficient, which defines the "s-ness" of the curve

a = asymptote, which defines the total number of buildings that can be reached by the program

For the optimistic scenario, we assumed that the program would eventually reach and conduct assessments on 90 percent of the multi-family buildings in the state, or about 18,000 buildings. Annual participation rates are modeled after years 1 and 2 of the market-based multi-family program run by Focus on Energy, which resulted in 165 and about 500 participants, respectively (Brody, 2005). Together, these points define a curve that follows:

$$y = 2 * (1 + 188 * e ^ (-t/0.7)) / (1 + 377 * e ^ (-t/0.7)) – 1) * 18,000$$

For the pessimistic scenario, we assumed that the program would eventually reach and conduct assessments on 60 percent of the multi-family buildings in the state, or about 12,000 buildings. Annual participation rates are modeled after years 1 and 4 of the market-based multi-family program run by Focus on Energy, which resulted in 165 and about 600 participants, respectively (Brody, 2005). Together, these points define a curve that follows:

$$y = 2 * (1 + 26 * e ^ (-t/2)) / (1 + 53 * e ^ (-t/2)) – 1) * 12,000$$

By averaging the market barrier coefficient and the curve shape coefficient, we obtained midpoint values for the model of:

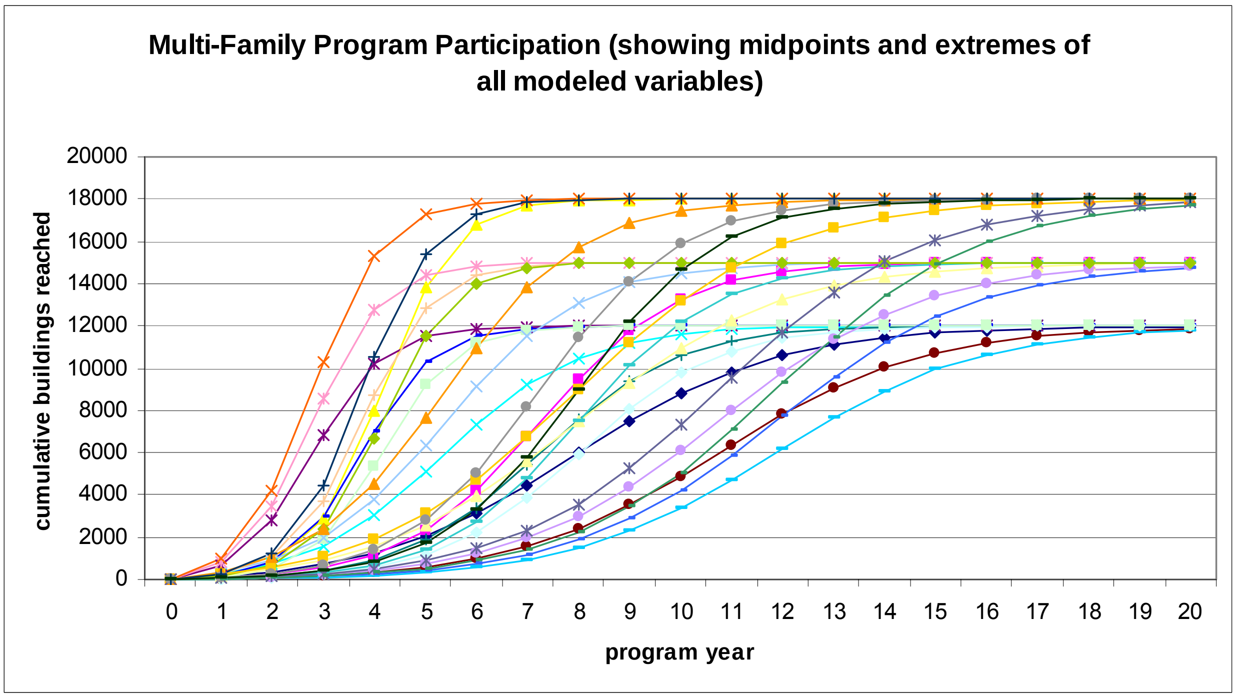
m = 107 +/- 81

r = 1.35 +/- 0.65

a = 15,000 +/- 3,000

The uncertainties range from the midpoint to each extreme – the optimistic and pessimistic scenario – thereby providing a large range of possible participation rates, as shown in the graph below. This wide range of uncertainty is justified by the range of opinion about the promise of multi-family programs. Stakeholders argued strongly for large potential for snowball effects, while the literature on multi-family programs suggests large barriers that cause multi-family buildings to be a difficult-to-reach market sector.

FIGURE 18.01.1. MULTI-FAMILY PROGRAM PARTICIPATION



The curve defined by the mid-point values serves as the starting point for each market-based multi-family program. Each market's model makes adjustments from that point.

For the common area lighting model, we assumed that 90 percent of the assessed buildings include a review of common area lighting, which could lead to recommended change-out of lighting equipment.

Installation rates, energy impacts, and costs are modeled separately for buildings with 5-19 units and those with 20+ units. We assumed the same distribution of buildings in these size categories as observed by the Energy and Rental Housing Study, which suggested that 15 percent of multi-family buildings are in the larger of these categories (Pigg and Price, 2005).

2&3. Installations per Building Served

We modeled different installation rates for smaller buildings with 5-19 units and larger buildings with 20 or more units. Installation rates are based on the prevalence of replaceable lighting in existing rental buildings in these two size categories. Table 18.01.2 shows the basis of our estimates of replaceable lighting. All numbers shown in the table are based on data collected for the Energy Center's Energy and Rental Housing Study (Pigg and Price, 2005).

TABLE 18.01.2. INSTALLATIONS PER BUILDING SERVED – BASIS FOR MODEL INPUTS

Bldg Size	Basis for Model Inputs[a]
Indoor Incandescent Lamps	
5 – 19 units	97% of buildings have common area lighting * 76% of these buildings have indoor incandescent * 10 indoor incandescent bulbs per building
20+ units	100% of buildings have common area lighting * 63% of these buildings have indoor incandescent * 19 indoor incandescent bulbs per building
Indoor Fluorescent Lamps	
5 – 19 units	97% of buildings have common area lighting * 18% of these buildings have fluorescent * 19 fixtures per building * 20% of these fluorescent are identifiable as T-12 * 3 lamps per fixture * 90% assumed share of common area fluorescent that are indoors
20+ units	100% of buildings have common area lighting * 27% of these buildings have fluorescent * 70 fixtures per building * 48% of these fluorescent are identifiable as T-12 * 1.3 lamps per fixture * 90% assumed share of common area fluorescent that are indoors
Incandescent Exit Lights	
5 – 19 units	3 exit signs per building * 33% of bldgs have incandescent exit lights
20+ units	16 exit signs per building * 10% of buildings have incandescent exit lights
Fluorescent Exit Lights	
5 – 19 units	3 exit signs per building * 34% of bldgs have fluorescent exit lights
20+ units	16 exit signs per building * 37% of bldgs have fluorescent exit lights
Outdoor Incandescent Lamps	
5 – 19 units	97% of buildings have common area lighting * 65% of these buildings have outdoor incandescent * 7 outdoor incandescent bulbs per building
20+ units	100% of buildings have common area lighting * 26% of these buildings have outdoor incandescent * 18 outdoor incandescent bulbs per building
Outdoor Fluorescent Lamps	
5 – 19 units	97% of buildings have common area lighting * 18% of these buildings have fluorescent * 19 fixtures per building * 20% of these fluorescent are identifiable as T-12 * 3 lamps per fixture * 10% assumed share of common area fluorescent that are outdoors
20+ units	100% of buildings have common area lighting * 27% of these buildings have fluorescent * 70 fixtures per building * 48% of these fluorescent are identifiable as T-12 * 1.3 lamps per fixture * 10% assumed share of common area fluorescent that are outdoors

[a] Actual model inputs may differ slightly from the results of the computations shown due to rounding.

4&5. Per-Item Impact

Per-item impact is a function of wattage of the lamps replaced, wattage of the lamps installed, and operating hours. Table 18.01.3 and Table 18.01.4 show the numbers we used for each of these inputs and the sources from which we derived these numbers.

TABLE 18.01.3. EXISTING WATTAGE – BASIS FOR MODEL INPUTS

Lighting Type	Assumed Existing Wattage (5-19 units / 20+ units)	Source
Indoor Incandescent	56 / 45	unpublished data from Rental Characterization Study
Indoor Fluorescent	40 / 40	assumed that 40 Watt T-12 lighting is the primary target light to be replaced – based on stakeholder meeting input
Incandescent Exit Sign	40 / 40	Alliant Energy Web-based informational sheet (Alliant, 2005)
Fluorescent Exit Sign	11 / 11	Alliant Energy Web-based informational sheet (Alliant, 2005)
Outdoor Incandescent	66 / 74	unpublished data from Rental Characterization Study
Outdoor Fluorescent	40 / 40	used same as for indoor fluorescent

TABLE 18.01.4. NEWLY INSTALLED WATTAGE – BASIS FOR MODEL INPUTS

Lighting Type	New Wattage (5-19 units / 20+ units)	Source
Indoor Incandescent *(replaced with compact fluorescent bulbs)*	18 / 15	using 1/3 of the wattage of currently installed incandescent bulbs – based on stakeholder meeting input
Indoor Fluorescent *(replaced with T-8 fluorescent lighting)*	33 / 33	based on a mixture of 32 watt and 34 watt T-8 bulbs with electronic ballasts – T-8 bulbs were identified as the current target by program staff during stakeholder meetings
Incandescent Exit Sign *(replaced with LED exit lights)*	2 / 2	Alliant Energy Web-based informational sheet (Alliant, 2005)
Fluorescent Exit Sign *(replaced with LED exit lights)*	2 / 2	Alliant Energy Web-based informational sheet (Alliant, 2005)
Outdoor Incandescent *(replaced with compact fluorescent bulbs)*	22 / 25	using 1/3 of the wattage of currently installed incandescent bulbs – based on stakeholder meeting input
Outdoor Fluorescent (replaced with T-8 fluorescent lighting or equivalent)	33 / 33	used same as for indoor fluorescent

TABLE 18.01.5. OPERATING HOURS – BASIS FOR MODEL INPUTS

Lighting Type	Operating Hours per Day (5-19 units / 20+ units)	Source
Indoor Incandescent *(replaced with compact fluorescent bulbs)*	12 / 12	assumed average usage for interior lighting that is probably dominated by hallway lighting that is on at least 12 hours per day and some special use lighting that is on intermittently
Indoor Fluorescent *(replaced with T-8 fluorescent lighting)*	12 / 12	same as indoor incandescent
Incandescent Exit Sign *(replaced with LED exit lights)*	24 / 24	legal requirements
Fluorescent Exit Sign *(replaced with LED exit lights)*	24 / 24	legal requirements
Outdoor Incandescent *(replaced with compact fluorescent bulbs)*	5.9 / 10.1	based on Energy and Rental Housing data on controls for outdoor incandescent lights and California data on operating hours by type of control – see below
Outdoor Fluorescent (replaced with T-8 fluorescent lighting or equivalent)	5.9 / 10.1	used same as for outdoor fluorescent

For our estimates of outdoor lighting operating hours, we combined Energy and Rental Housing data on lighting controls (Pigg and Price, 2005) and California data on operating hours for outdoor lighting by type of controls (ADM Associates, 2002). The underlying data that led to the inputs shown in Table 18.01.5 are:

- 5-19 units: Outdoor incandescent lights are controlled by a switch (63%), timer (22%), or photocell (15%). The annual (and daily) operating hours for these controls are 725 (2.0), 4,279 (11.7), and 4,887 (13.4), respectively.
- 20+ units: Outdoor incandescent lights are controlled by a photocell (42%), timer (34%), or switch (24%). The annual (and daily) operating hours for these controls are the same as shown above.

We used weighted averages of these numbers to derive the operating hours for outdoor lighting.

6. Program Costs

We included four different types of cost for this program in our model. The first is a cross-cutting program management cost. We assume this market's share of that cost would total about $20 per assessed building. This cost includes program management, coordination, and logistical support for the installation teams.

The second is program marketing. Marketing would be most intensive early in the program life with an assumed cost of $300 per building assessed attributed to this program. Thereafter, the per building marketing cost would decrease by 50 percent per year as the number of buildings assessed grows and the need for marketing is decreased by the snowball effect described earlier. The actual marketing costs per building is higher than shown here, but we assume that two to three multi-family programs share the marketing costs for the building assessments.

The third is the cost of the assessments. We assume an average cost of $300 per building, which is based on Focus on Energy program staff experience, which shows that building assessments require about a day to complete (Brody, 2005). Those hours translate to a greater cost than $300 per building, but we assume that two to three multi-family programs share the marketing costs for the building assessments.

The fourth is the cost of the installations themselves. We assume that this cost would be borne jointly by multi-family building owners/operators and the program. For purposes of our analysis, we assumed that building owners/operators would be willing to commit an investment that, on average, provides a payback within six months. This assumption forms the basis for our cost share between owners/operators and the program.

Per device costs of installation are based on experiences of the existing Focus on Energy multi-family common area direct install program. Costs vary from month to month, but recent experiences suggest average costs (rewards plus owner-paid) of $8 for the installation of a compact fluorescent bulb to replace an incandescent, $65 for the installation of a two-lamp fluorescent fixture (or $32.50 per bulb), and $45 for the installation of a light emitting diode (LED) exit lamp (Jenkins, 2005b).

The computation of six-month paybacks also depends on electric rates. We based a statewide average rate on Madison rates and lowered these slightly. For these rates, we assumed that buildings with fewer than 20 units would pay the same rates as residential customers – approximately 10 cents per kilowatt-hour – but that buildings with 20 or more units would pay a lower average commercial rate of 7 cents per kilowatt-hour (Faultersack, 2005)

7. Measure Life

Measure life is a function of the rated life of the newly installed lamps and the rate at which remodel efforts would replace these lights. Based on stakeholder input, we are assuming minimal natural replacements of existing lighting types would occur in the absence of the program or after participation in the direct install program. Furthermore, we assume that the lighting types installed by the program would be replaced, in most cases, with comparable lighting upon failure of the bulbs.

With these factors in mind, we estimated measure life to be:

- 6 years for compact fluorescent bulbs (10,000 hours rated life, or 2 years, until replacement followed by 2 generations of owner-initiated replacements);
- 12 years for T-8 fluorescent bulbs (20,000 hours rated life, or 4 years, until replacement followed by 2 generations of owner-initiated replacements); and
- 20 years for LED exit lights (10 years rated life (Alliant, 2005) followed by one generation of owner-initiated replacement).

8. Demand Savings Factor

This program's primary goal is to reduce energy consumption. Peak load reductions are an incidental benefit that will occur at more modest levels than the program-induced energy savings. As a result, we estimated demand savings in a simplified way that is based on estimated energy savings and a conversion factor. Our conversion factor is 0.0821 watts of demand reduction for every kilowatt-hour saved by the program. This factor is based on a ratio of the evaluated kilowatt and kilowatt-hour savings by Focus on Energy's present direct install program for multi-family common areas (Focus on Energy Public Benefits Evaluation Quarterly Report, 2004).

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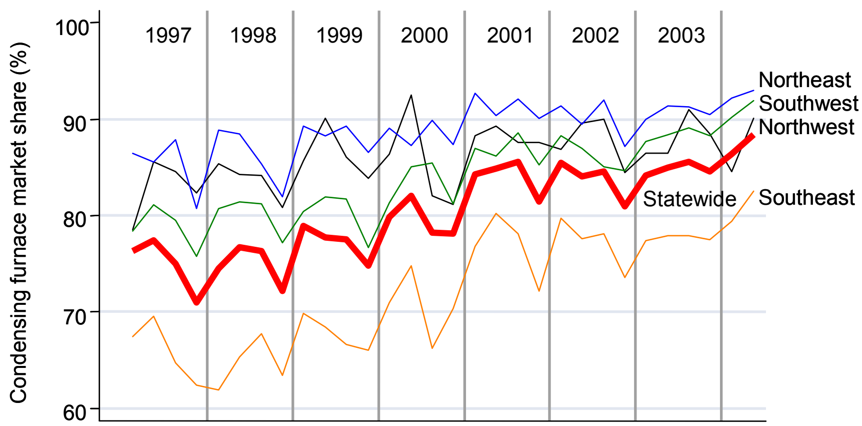
Market Scope

This market comprises purchases of residential-sized natural gas fired furnaces, both as replacements for existing units and furnaces installed in new homes.

Market Characteristics

More than three out of every four Wisconsin homes are heated with a forced air furnace, and the vast majority of new homes use this technology. Various sources point toward 80,000 to 100,000 furnaces sold in Wisconsin each year, with replacement furnaces comprising two-thirds to three-quarters of the market.

FIGURE 19.01.1. WISCONSIN MARKET SHARE FOR HIGH EFFICIENCY FURNACES, 1997-2004.



Source: ECW FACTS project

Most new furnaces sold in Wisconsin are high-efficiency, condensing models with an annual fuel utilization efficiency (AFUE) of 90 percent or higher. In fact, according to data released by the Gas Appliance Manufacturers Association (GAMA), Wisconsin led the nation in market share for condensing furnaces over the period from 1995 to 2000, with a market share significantly above that of most neighboring states. Separate data collected under the Energy Center's Furnace and AC Tracking System (FACTS) project suggests a somewhat higher market share for condensing furnaces, and reveals some regional differences within the state (Figure 19.01.1).

Furnaces can also consume a considerable amount of electricity, particularly in households that operate the furnace fan continuously for air circulation and filtering. Furnaces with more efficient electronically commutated motors (ECMs) have started to attract more attention from consumers, manufacturers and energy efficiency policymakers because they are quieter, more efficient and can deliver a wider range of airflows. Most manufacturers now offer furnaces with ECMs, which are typically bundled with multi-stage firing and other features in premium product lines.

ECM furnaces have been eligible for Focus on Energy rewards of $100 to $150 since 2001 to help offset what we estimate to be an average $500 upgrade cost for these premium products. These rewards have helped push the market share for ECM furnaces to about 20 percent of all furnace sales according to FACTS data for 2003 through early 2005. The number of rebated furnaces under the program has increased from about 1,100 in 2001/02 to 8,100 in the most recent program year (2003/04). National interest in this technology has also led to GAMA adding a separate designator for electrically efficient furnaces in its directory of energy efficiency ratings for furnaces, making it easier to identify such furnaces. Moreover, the Federal Energy Policy Act of 2005 provides for a tax credit of up to $50 for electrically efficient furnaces with "advanced main air circulating fans" such as ECMs. Both the FACTS market tracking data and Focus reward data indicate that after substantial growth through 2003, sales of ECM furnaces have leveled off—and perhaps even declined somewhat.

The changing federal standard for central air conditioners is a wild card for the ECM furnace market as well, because air conditioners have higher SEER ratings when paired with ECM furnaces. This might lead to a natural increase in ECM furnace sales.

A 2003 Energy Center field study of electricity consumption in new furnaces showed significant savings potential from the technology, particularly when the furnace fan is operated continuously. However, a 2004 survey on fan operation practices conducted by Glacier Consulting showed that many purchasers of ECM furnaces switch to continuous-fan operation on the advice of their contractor. This reduces the aggregate electricity savings from the technology, since these consumers end up running their furnace fan many more hours than they would have had they purchased a conventional furnace.

Furnace installation practices also come into play for homes with central air conditioners, as the furnace fan also serves as the air conditioner's air handling system. Air conditioner performance is adversely affected if airflow is significantly lower or higher than specified by the manufacturer for optimum air conditioner performance.

Program Approaches

Since Wisconsin already leads the nation in the market share for furnaces with high gas efficiency there would seem to be little remaining achievable potential for gas savings (except perhaps for low to moderate income households, which budget constraints prevented us from addressing.)

The discussion here therefore concentrates on achievable potential from encouraging the installation of electrically efficient furnaces, which we discuss below.

PROGRAM AREA 19.01 — INCENTIVES FOR ELECTRICALLY EFFICIENT FURNACES

Our analysis of the achievable potential for this program area is projected from the current Focus on Energy incentive program for ECM furnaces. The analysis is based on a recent evaluation of the program, which sought to quantify the impact of the program on the overall market share for ECM furnaces in the state. We have assumed continued growth in this market, resulting in both an increase in the number of direct participants in the program as well as broader market effects beyond immediate participants. Given that past utility incentives for high efficiency furnaces are at least partly responsible for their current high market share in Wisconsin, it is conceivable that incentives for electrically efficient furnaces could result in a similar transformation toward electrically efficient furnaces.

The promotion of electrically efficient furnaces results in a small increase in gas consumption (represented here as negative gas savings) to make up for reduced motor waste heat.

TABLE 19.01.1. ESTIMATED VALUES FOR PROGRAM AREA 19.01, INCENTIVES FOR ELECTRICALLY EFFICIENT FURNACES

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$1,619 to $2,841	$1,738 to $3,963
	Incremental Impacts	peak kW	771 to 2,024	879 to 2,784
		annual kWh (000s)	7,580 to 15,242	8,417 to 21,474
		annual therms (000s)	-317 to 167	-416 to 217
	Levelized resource cost	per peak kW	$106 to $287	$103 to $280
		per kWh	1.4¢ to 2.9¢	1.4¢ to 2.9¢
		per therm	NA to 896.5¢	NA to 870.2¢
Scaling factors[a]		program costs	0.9 to 2.1	0.9 to 2.1
		impacts	0.9 to 1.4	0.9 to 1.4

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Data from the Energy Center's 2003 Appliance Sales Tracking Survey indicate that 3.4 percent of owners of existing older homes purchase a new furnace each year (sampling error is +/- 0.6 percentage points at 90 percent confidence level). This figure already incorporates the fact that not all homes are heated with a forced-air furnace. This proportion extrapolates to 48,000 (+/- 8,000) statewide annual furnace purchases for existing homes across the approximately 1.4 million Wisconsin owner-occupied households. Given approximately 25,000 new homes built in the state each year (see Market 24) of which about 90 percent are heated with furnaces (Pigg and Nevius, 2000), we estimate the overall number of furnaces sold to single-family homeowners in the state to be approximately 70,000 (+/- 10,000) units. (This estimate is somewhat lower than data from the Gas Appliance Manufacturers Association (GAMA) showing that annual furnace sales to Wisconsin between 1995 and 2000 ranged from 86,000 to 106,000, with an average of 95,000 units (Kendall, 2002), but the former does not include sales for rental housing while the latter presumably does.) It is also noteworthy that approximately 7,000 furnaces are installed annually under low-income weatherization and energy assistance programs, for which program guidelines preclude the installation of ECM models (Bair, 2005).

Program Area 19.01 — Incentives for ECM furnaces

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 19.01.2. MODEL INPUTS FOR INCENTIVES FOR ECM FURNACES

Model Inputs (19.01)			Value	±
1		**Per-Unit Impacts (unit = furnace)**		
	a	Annual electricity savings (kWh)	850	100
	b	Peak demand savings (Watts)	150	50
	c	% of homes w/ central AC	90%	5%
	d	Summer peak coincidence factor	0.75	0.10
	e	Annual gas impacts in (therms)	-5	20
	f	ann. increase in savings from fan-switch mitigation (%)	0.75%	0.75%
2		**Program Participation**		
	a	Participants in Year 1	11,000	2,000
	b	Annual increase in participation	7.5%	7.5%
	c	Gross-to-net ratio	1.00	0.25
3		**Program costs**		
	a	Variable costs per-participant (incentives + admin.)	$170	$30
4	a	**Measure life (years)**	23	4

1. Per Unit Impacts

Savings per furnace are based on an impact assessment study of ECM furnaces conducted by Talerico and Winch (2004b). That study combined findings from an Energy Center field study of electricity use in new furnaces (Pigg 2003) and interviews with homeowners regarding fan operation practices. Savings from an ECM furnace depend on fan operation practices and whether central air conditioning is also present in the home: the study estimated a weighted average annual savings of 774 kWh for ECM furnaces installed in existing homes, and average savings of 1,126 kWh for new homes. These figures include adjustments for take-back in the form of increased fan use. Although, the available data suggest that about a third of furnace sales are toward new homes, we have assumed a somewhat lower penetration of ECM furnaces in that market, and thus weighted the above savings at 80 percent existing home replacements and 20 percent new homes—for a weighted average of approximately 850 kWh ***(Input 1a)***. We assigned an uncertainty of +/- 100 kWh to this value.

Peak demand savings are estimated at 150 +/- 50 Watts ***(Input 1b)***, based on the average measured difference in air handler power for an ECM furnace compared to a standard new furnace from the field study (Pigg, 2003) for a 2.5 ton system. Based on Talerico and Winch (2004b), we applied a saturation of 90% +/- 5% for the saturation of central air conditioning among households that purchase an ECM furnace ***(Input 1c)***. We also used a 0.75 (+/- 0.10) ***(Input 1d)*** peak coincidence factor applied across markets with central air conditioning impacts to account for the fact that not all air conditioning systems are in use at system peak.

Gas impacts were not directly addressed by the Energy Center field study or the subsequent Focus impact evaluation. The reduced electricity consumption by the air handler increases gas consumption as less waste motor heat is introduced into the airstream, particularly under continuous fan operation (see Gusdorf et al., 2004). From Talerico and Winch (2004b), we estimate the weighted average heating season electricity savings for an ECM furnace at about 540 kWh (500 kWh for existing homes and 700 kWh for new homes). This translates into an additional 20 therms of gas that must be provided by the furnace. On the other hand, ECM furnaces often have AFUE ratings that are one or two percentage points higher than standard furnaces. Assuming an average 650 therm heating load for a typical Wisconsin home, the difference between an ECM furnace with a 94% AFUE and a standard condensing furnace with a 92% AFUE would translate into savings of about 15 therms over the course of a heating season. We therefore estimated -5 therms as the net impact of ECM furnaces on gas consumption ***(Input 1e)***. Given the somewhat speculative nature of this estimate, we assigned it an uncertainty of +/- 20 therms.

We also assume that program efforts will be made to mitigate the practice of contractors advising homeowners to operate their furnace fans continuously. Calculations using the fan operation proportions from Talerico and Winch (2004b) suggest that each percentage point decrease in the proportion of homeowners who change from auto-fan to continuous-fan operation increases the average electricity savings by about 6 kWh. We assumed that program efforts to change this behavior might result in somewhere between a zero and two percentage point change in this proportion each year, which we translate into roughly a 0.75% +/- 0.75% increase in savings each year ***(Input 1f).***

2. Program Participation

The table below shows ECM furnace rewards by Contract Year. After initial growth, the number of annual rewards appears to have leveled off at about 8,000 units. Approximately 85 percent of Wisconsin households are eligible for this program. Extrapolating to full statewide program coverage, we estimate participation in the first year of the analysis at 11,000 +/- 2,000 participants ***(Input 2a)***. Estimating future trends in participation is difficult; after initial growth, program growth appears to be leveling off, though the changing federal standard for central air conditioners could help push up the market for ECM furnaces (since pairing an ECM furnace with an air conditioner boosts the system SEER), and the comfort benefits of these units could continue to drive the market beyond what may be a temporary recent lull—especially if retail prices decline with increasing market share. In light of this uncertainty, we assumed a (compound) annual increase in program participation of 7.5 (+/- 7.5) percent per year ***(Input 2b).*** This range embraces the full range of possibilities, from continued stagnation to a substantial increase in the ECM market share.

TABLE 19.01.2. ECM FURNACE REWARDS BY FOCUS ON ENERGY PROGRAM AND CONTRACT YEAR.

Contract Year	Home Performance with Energy Star	Wisconsin Energy Star Homes	Total
2001/02	1,123	0	1,123
2002/03	5,382	82	5,464
2003/04	7,264	882	8,146
2004/05*	7,854	1,098	8,952

*Extrapolated by multiplying mid-year figures by 2.

An important consideration in assessing the net impacts of the program is the gross-to-net ratio to account for program free riders as well as potential program-induced purchases outside the program (spillover). Talerico and Winch (2004b) assessed the gross-to-net ratio for the program using data from the Gas Appliance Manufacturers Association (Kendall 2002) on total Wisconsin furnace sales, as well as 2003 data from the Energy Center's Furnace and AC Tracking System (FACTS) on the overall market share for ECM furnaces, and an estimate of the pre-program market share for ECM furnaces based on interviews with furnace distributors. Unfortunately there is uncertainty in all of these factors. Talerico and Winch examined three scenarios that yielded gross-to-net ratios of 1.14, 0.89 and 0.64, depending on what one assumed about the size of the market and the degree to which FACTS can be considered to be representative of the overall market in terms of ECM market share. They discounted the last value as being unlikely, but concluded that the other two values were plausible. Going forward, if the changing federal standard for central air conditioners does create a natural increase in the market for ECM furnaces, then one could expect a higher free ridership rate for incentive programs.

In this light, we adopted a gross-to-net ratio of 1.00 +/- 0.25 for the assessment of achievable potential from the program (***Input 2c)***. This estimate implies that the net impacts from the program could be somewhat larger than indicated by the number of participants (program spillover exceeds free ridership), or could be somewhat less if free ridership exceeds spillover.

3. Program Costs

We estimate the variable cost for the program at $170 +/- $30 ***(Input 3a)***: this reflects a rebate level of about $150 with an additional $20 administrative and other costs per unit. These values are reasonably consistent with the current Focus on Energy Efficient Heating and Cooling Initiative, which has an administrative budget of about $500, 000 on an operating budget of $3.7 million for both ECM furnace and central air conditioner incentives (Newmann, 2005).

4. Measure Life

Estimated measure life is derived as follows: 77 (+/- 4) percent of Wisconsin single-family, owner-occupied homes are heated primarily with a forced-air furnace (Pigg and Nevius, 2000). Data from the Energy Center's 2003 Appliance Sales Tracking Survey indicate that 3.4 percent of owners of existing older homes purchase a new furnace each year (sampling error is +/- 0.6 percentage points at 90 percent confidence level). This figure already incorporates the fact that not all homes are heated with a forced-air furnace. Together, these figures imply that the average furnace life is about 23 years ***(Input 4a)***. The combined uncertainty for this figure is about +/- 4 years.

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MARKET 20 — HOMEOWNER CENTRAL AIR CONDITIONER PURCHASE AND TUNEUP

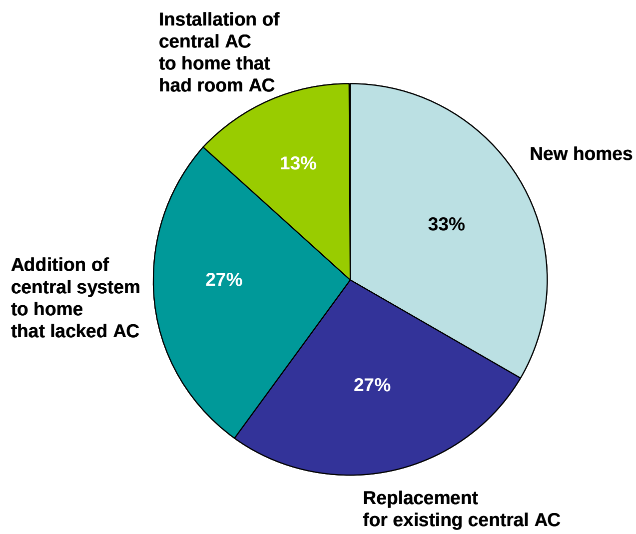
Market Scope

This market comprises purchases of new central air conditioners by residential homeowners as well as tune-ups of existing systems. The market includes replacement purchases, households adding central air conditioning to an existing home, purchases for new homes, and refrigerant charge and airflow adjustments for existing units.

Market Characteristics

Well over half of Wisconsin homes have central air conditioning— a figure that grows each year as central air is added to existing homes, and new homes (nearly all of which have central air conditioning) are built (Figure 20.01.1). All told, we estimate that between 70,000 and 80,000 central air conditioners are installed in Wisconsin single-family homes each year. Data from the Energy Center's biennial Appliance Sales Tracking surveys suggest that about half of central air conditioner sales are also associated with the purchase of a new furnace.

FIGURE 20.01.1. THE WISCONSIN CENTRAL AIR CONDITIONER MARKET.



Source: ECW Appliance Sales Tracking Survey

With respect to efficiency levels, the most important news is that starting in 2006 (Year 1 of our analysis), new federal standards will require all new units manufactured to have a minimum SEER rating of 13—up three points from the current standard of SEER 10. Since only about 10 percent of the Wisconsin market currently meets or exceeds the new standard, this will significantly increase the efficiency of central air conditioners installed in the state.

With the most efficient air conditioner models now at SEER 20, there is still room to stimulate markets for more efficient units. However, for Wisconsin's relatively short cooling season, the payback for upgrading beyond SEER 13 is not particularly attractive. For example, the electricity savings on a typical 2.5 ton unit that is operated 400 hours per year amounts to only about $12 per year for upgrading from SEER 13 to SEER 15, an upgrade that would likely cost at least several hundred dollars.

As part of the rule-making process that led to the SEER-13 standard, the federal government considered a number of possible scenarios for what the distribution of efficiency levels would look like (at a national level) after implementation of a new standard. On the optimistic side, the distribution of efficiency levels in the market could simply shift to a higher baseline, resulting in a significant increase in sales of higher efficiency equipment. On the pessimistic side, sales of current equipment below the new standard could simply "roll-up" to the new standard with no effect on higher efficiency unit sales. The most pessimistic scenario considered was a “collapse” scenario in which the new standard actually draws down sales of higher efficiency units.

For the SEER-13 standard that was eventually implemented, the analysis concluded that on the basis of consumer paybacks and likely changes in prices, even a “roll-up” scenario would be optimistic for current technology, implying a real possibility that sales of higher efficiency equipment will decline in the future as competition reduces prices at the SEER-13 level. Though noting that the pace of technological development in the air conditioning market has declined since the 1990s, the analysis did leave open the possibility, however, that emerging technology could reduce the cost increment between SEER-13 and higher efficiency equipment, creating upgrade cost effectiveness comparable to the market under the current SEER-10 standard.

All of the preceding analysis is premised on the notion that consumers are primarily motivated by payback (or at least absolute energy cost savings) in their choice of efficiency level. Yet it is not implausible that at least some consumers are less motivated by payback and simply want high end equipment. Moreover, two-stage air conditioners have begun to make limited headway in the Wisconsin market; these are marketed as providing comfort features that consumers may find attractive regardless of the energy economics. These aspects of the market also create the possibility of at least a niche for equipment sales beyond the new standard.

Some argue that installation practices have as much—or more—influence on actual field performance of central air conditioners than the rated efficiency level. To operate at peak efficiency, units must have the correct refrigerant charge and airflow (RCA) over the indoor evaporator coil. Too much or too little of either leads to reduced operating efficiency. Research in other parts of the country (and limited data from Wisconsin) suggests that optimal installations are more the exception than the rule, with typical savings on the order of 10 to 20 percent from correcting installation defects. At the same time, central air conditioners that use a device called a thermostatic expansion valve (TXV) are less susceptible to performance problems related to refrigerant charge and airflow—and the use of TXVs may become more prevalent under the new efficiency standards.

Lack of awareness on the part of homeowners regarding the prevalence of sub-performing systems—as well as the relatively minor impact on energy bills from correcting these defects—may limit the potential for this market, especially among the large population of homes with existing systems, where an if-it-ain’t-broke-don’t-fix-it attitude may prevail. At the same time, the recently enacted Energy Policy Act of 2005 authorizes a federal program to “carry out a program to educate homeowners and small business owners concerning the energy savings from properly conducted maintenance of air conditioning, heating, and ventilating systems.” It is too soon to know the nature and extent of this program, however.

Programs in California have achieved success in dealing with central air conditioning RCA issues by providing telephone and computer support for field technicians. One of these programs—CheckMe®, developed by Proctor Engineering—has been cited as an exemplary program design by the American Council for an Energy Efficient Economy. In Wisconsin, Focus on Energy has initiated efforts to promote these practices in a slightly different manner, by providing paper worksheets for technicians to diagnose and correct RCA problems. Regardless of the specific approach, third-party verification of sampled units is important.

Programs to promote air conditioner installation practices may receive a boost in 2007, when the EPA is considering separating the rated efficiency and the installation quality in its ENERGY STAR qualification criteria. Under this approach, units would receive a separate ENERGY STAR label for installation.

Program Approaches

We consider here both an incentive program to promote systems with rated efficiencies higher than the upcoming SEER-13 standard (as well as proper installation practices for these units), and a program to address refrigerant charge and airflow tuning both for minimum-SEER new units and existing systems.

PROGRAM AREA 20.01 — INCENTIVES FOR HIGH EFFICIENCY CENTRAL AIR CONDITIONERS

This program area is oriented toward encouraging central air conditioner upgrades beyond SEER 13, which would probably be in the range of SEER 14 or SEER 15. Since the market has not yet transitioned to the new federal standard, it is difficult to predict what the market response would be to such a program offering; we have therefore modeled substantial uncertainty for this program. Note that this program incorporates proper installation practices for the high-efficiency units that it addresses.

TABLE 20.01.1. ESTIMATED VALUES FOR PROGRAM AREA 20.01 — INCENTIVES FOR HIGH EFFICIENCY CENTRAL AIR CONDITIONERS.

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		\$101 to \$421	\$115 to \$606
	Incremental Impacts	peak kW	139 to 904	160 to 1,275
		annual kWh (000s)	56 to 387	65 to 544
		annual therms (000s)	0	0
	Levelized resource cost	per peak kW	\$33 to \$134	\$33 to \$134
		per kWh	7.6¢ to 32.6¢	7.6¢ to 32.6¢
		per therm	NA	NA
Scaling factors[a]		program costs	0.4 to 2.8	0.4 to 2.8
		impacts	0.4 to 2.3	0.4 to 2.3

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

PROGRAM AREA 20.02 — CENTRAL AC TUNE-UP AND INSTALLATION PRACTICES

This program would seek to encourage contractors who install new SEER-13 systems to properly adjust refrigerant charge and airflow for peak performance. It would also provide incentives for owners of existing systems to have their systems tuned in this regard. The model used here to estimate achievable potential has assumptions about the savings that would typically derive from these tune-ups, as well as a projection of the scale of program participation. The model looks separately at savings and participation for new and existing systems.

TABLE 20.02.1. ESTIMATED VALUES FOR PROGRAM AREA 20.02 — HVAC INSTALLATION PRACTICES

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$293 to $3,663	$1,046 to $8,252
	Incremental Impacts	peak kW	249 to 8,533	882 to 20,564
		annual kWh (000s)	199 to 4,559	711 to 10,691
		annual therms (000s)	0 to 0	0 to 0
	Levelized resource cost	per peak kW	$35 to $429	$36 to $440
		per kWh	7.0¢ to 49.6¢	7.2¢ to 51.0¢
		per therm	0.0¢ to 0.0¢	0.0¢ to 0.0¢
Scaling factors[a]		program costs	0.1 to 2.3	0.1 to 2.3
		impacts	0.1 to 2.0	0.1 to 2.0

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

Program Area 20.01 — Incentives for central air conditioner efficiency upgrade

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 20.01.2. MODEL INPUTS FOR INCENTIVES FOR CENTRAL AIR CONDITIONER EFFICIENCY UPGRADE

Model Inputs (20.01)			**Value**	**±**
1		**Per-Unit Impacts (unit = one central air conditioner)**		
	a	std. unit SEER	13.0	0.0
	b	upgrade unit SEER	14.5	0.5
	c	field performance factor	1.0	0.15
	d	Mean cooling capacity of unit (tons)	2.5	0.25
	e	Mean annual hours of operation	400	100
	f	estimated SEER - EER difference	1.5	0.25
	g	Diversified demand factor	0.75	0.10
2		**Program Participation**		
	a	Participants in Year 1	1,000	500
	b	compounded annual growth in participation (Years 2-5)	30%	25%
	c	net-to-gross ratio	1.0	0.5
3		**Program costs**		
	a	Variable costs per-participant (incentive, and admin.)	$125	$30
4		**Measure life (years)**		
	b	Measure life (years)	20	4

1. Per Unit Impacts

We assume that the typical upgrade under the program would be from the federal standard SEER 13 ***(Input 1a)*** to either SEER 14 or SEER 15 ***(Input 1b)***, which results in a mid-point estimate of about a 10 percent efficiency improvement. There is some uncertainty as to the extent to which the SEER rating procedure captures the average field efficiency of a central air conditioner installed in Wisconsin (James J. Hirsch and Associates, 2004). We therefore built in a +/- 15 percent performance uncertainty factor into the estimates as well ***(Input 1c)***. This factor essentially allows for the actual field SEER for both the standard and upgrade systems to differ by up to two SEER points on either side of the mid-point estimate (e.g. SEER 11 or SEER 15 instead of SEER 13).

We assume that the typical central system has a cooling capacity of about 2.5 tons (30,000 Btu per hour), as reflected in the data from the Energy Center's 1999 Energy and Housing study (Pigg and Nevius, 2000) ***(Input 1d)***.

We found little public data on the hours of operation for central air conditioners in Wisconsin. Maps of cooling load hours for the United States available from several public sources (Iowa Association for Energy Efficiency, n.d.; Louisiana Energy & Environmental Resource & Information Center (n.d.); and USGPO, n.d.) suggest between 400 and 600 hours of operation for a typical Madison-area central air conditioner (Madison is close to the population-weighted average weather for the state). However, data from 26 southern Wisconsin homes monitored as part of the Energy Center's field study of electricity use in new furnaces (Pigg, 2003) showed a range in weather normalized annual hours of operation from about 100 to 800 hours per year, with an average of about 350 hours per year. For the purposes here, we have taken 400 +/- 100 hours as the typical operating hours for a Wisconsin central air conditioner ***(Input 1e)***.

Estimating peak demand impacts requires assumptions about the efficiency of the systems under peak conditions (since air conditioner efficiency is strongly related to outdoor temperature) as well as estimating the degree to which the population of central air conditioners is in use at the time of system peak.

The energy efficiency ratio (EER) is the standard measure of system efficiency at the high outdoor temperatures that typify summer peak utility system demand. EER is similar to SEER in terms of measuring the ratio of Btu/hr of cooling capacity to input electrical energy. But EER is based on a 95^{o}F outdoor temperature, while SEER is based on 82^{o}F outdoor conditions. The technical analysis conducted as part of the rulemaking for the SEER-13 standard provided data showing that the EER of SEER-13 split air conditioners mostly ranged between 11.0 and 12.0, with a median of 11.6 (USDOE, 2002). We have therefore assumed (for both standard and high efficiency units) that on average EER is 1.5 +/- 0.25 lower than SEER ***(Input 1f)***.

In terms of system operation at time of utility peak, we assume a diversified peak demand factor of 0.75 +/- 0.10, representing the average fraction of full system output at system peak ***(Input 1g)***. This factor reflects both the likelihood that not all air conditioners will be operating during system peak as well as the duty cycle of those that are operating. We have derived this estimate from unpublished data from the Energy Center's 2003 Appliance Sales Tracking survey that asked respondents about how they had operated their air conditioner in the previous 24 hours. These data suggest that about 70 to 80 percent of households will be operating their air conditioner on a hot weekday afternoon with the temperature above 90^{o}F.

2. Program Participation

Participation in this program is difficult to predict given the uncertainties in the market from the new federal standard. On the one hand, what is now considered to be an unusually efficient air conditioner will become the norm, seemingly leaving little incentive for households to upgrade to higher efficiency levels—especially if the upgrade cost is considerable, as suggested by the technical analysis conducted as part of the rulemaking for the SEER-13 standard (USDOE, 2002). On the other hand, it is not implausible that some consumers would continue to be receptive to marketing on the basis of higher efficiency relative to the new baseline, and that two-stage equipment will have attractions that go beyond the operating cost economics.

Focus on Energy provided incentives for about 1,000 SEER 14+ air conditioners in the last two quarters of 2004, which typically account for 40-50 percent of annual sales, according to tracking data from the Energy Center's Furnace and AC Tracking System (FACTS), though at a much higher rebate level than could be justified for the smaller incremental efficiency gain after the standard takes effect. We have therefore assumed 1,000 +/- 500 participants in Year 1 of the analysis ***(Input 2a)***. We also assume a compounded annual growth rate in the number of participants of 30 +/- 25 percent per year between Years 2 and 5 of the analysis ***(Input 2b)***. The combination of these two inputs results in a mid-point estimate of about 3,000 participants per year in Year 5, but with a (90% confidence band) that spans from about 1,500 to 5,000 participants, reflecting the considerable uncertainty in the market response to the program.

The program net-to-gross ratio (reflecting the combined impact of free riders and program spillover to non participants) is also fairly uncertain. On the one hand, it is plausible that a significant proportion of program participants might be households that would have purchased a high efficiency unit regardless of the incentives. On the other hand, it is also possible that incentives might stimulate the market for two-stage units that have additional comfort benefits. We assume a net-to-gross ratio of 1.0 +/- 0.5 to attempt to bridge these possibilities ***(Input 2c)***.

3. Program Costs

We have assumed an upgrade incentive of approximately $100—large enough to attract attention, but considerably less than the current incentive. We also include $25 per unit for program administration, marketing and other costs ***(Input 3a)***.

4. Measure Life

We assume a central air conditioner life of approximately 20 +/- 4 years ***(Input 4a)***. This figure is reasonably consistent with values used in the technical analysis conducted for the rulemaking process that led to the SEER-13 standard (USDOE, 2002).

Program Area 20.02 — Central AC Tune-Up And Installation Practices

Model inputs are shown below, and described in more detail on the following pages.

TABLE 20.02.1. MODEL INPUTS FOR CENTRAL AC TUNE UP AND INSTALLATION PRACTICES

Model Inputs (20.02)			**Value**	**±**
1		**Per-Unit Impacts (unit = one central air conditioner)**		
	a	avg. nominal SEER (new system)	13.0	0.0
	b	avg. nominal SEER (Year 1, older system)	9.5	0.5
	c	SEER field performance factor	1.0	0.15
	d	annual increase in avg. SEER of existing units	0.1	0.05
	e	annual increase in avg. SEER of new units	0.05	0.025
	f	efficiency derating factor for installation defects (existing)	0.85	0.05
	g	efficiency derating factor for installation defects (new)	0.90	0.075
	h	mean cooling capacity of unit (tons)	2.5	0.25

	i	mean annual hours of operation	400	100
	j	estimated SEER - EER difference	1.5	0.25
	k	diversified demand factor	0.75	0.10
2		**Program Participation**		
	a	maximum annual number of new systems	50,000	15,000
	b	maximum annual number of existing systems	40,000	30,000
	c	logistic parameter *a*	100	50
	d	logistic parameter b	0.75	0.40
	e	program net-to-gross ratio	0.75	0.50
3		**Program costs**		
	b	variable costs per-participant (incentive, and admin.) --- existing units	$135	$40
	c	variable costs per-participant (incentive, and admin.) --- new units	$95	$25
4		**Measure life (years)**		
	a	measure life (new systems)	20	5
	b	measure life (existing systems)	10	5

1. Per Unit Impacts

We first assume that a typical new central AC system will have a nominal SEER rating of 13 ***(Input 1a)***, and that the average older system will have a nominal SEER rating of 9.5 +/- 0.5 ***(Input 1b)***. The latter is based on data collected from the Energy Center's 1999 Energy and Housing study (Pigg and Nevius, 2000), and increased slightly for the seven years that have elapsed since the study was conducted. We further introduce a "SEER field performance" factor of 1.0 +/- 0.15 to account for uncertainty related to how well the federal test procedure that measures SEER reflects seasonal performance for Wisconsin systems ***(Input 1c)***. This factor essentially allows for the actual field SEER to differ by up to two SEER points on either side of the mid-point estimate (e.g. SEER 11 or SEER 15 instead of SEER 13). Finally, we also postulate an increase over time in the average rated SEER for existing systems of 0.1 +/- 0.05 per year ***(Iinput 1d)***, and an increase of 0.05 +/- 0.025 for new systems ***(Input 1e)***.

We next estimate the average amount by which RCA (and condenser fouling) defects reduce the rated performance of the system, which we model as a de-rating factor on the nominal SEER. Based on Mowris et al. (2004) and Neme et al. (1999), we assume a range of 0.85 +/- 0.05 for this factor, implying between 10 and 20 percent savings from correcting RCA problems with existing air conditioners ***(Input 1f)***.

We used a slightly higher (but more uncertain) factor of 0.90 +/- 0.075 for new air conditioners ***(Input 1g)***. This has to do with an assumption that many new systems will be equipped with thermostatic expansion valves (TXVs) after the new SEER-13 standard comes into play in 2006. Bench-testing of systems with and without TXVs under different charging conditions suggests that systems with TXVs are less susceptible to performance degradation from improper RCA (Farzad and O'Neal, 1993). On the other hand, Mowris (2004) found that in California, systems with TXVs had as much performance improvement as non-TXV systems. However, these improvements may not fully translate to Wisconsin, since the Mowris study found that the poorer-than-expected performance of TXV systems had to do with failure to properly mount and insulate the refrigerant line sensing bulb in systems installed in hot attics, which are uncommon in Wisconsin.

We also duplicate here assumptions from Market 20 about average system size, operating hours, difference between SEER and EER and diversified demand ***(Inputs 1h through 1k)***. These are documented under Program Area 20.01.

Together, these inputs work out to the midpoint estimates of energy and peak demand savings shown below.

TABLE 20.02.2. MIDPOINT ESTIMATES OF YEAR 1 PER-UNIT ENERGY AND DEMAND SAVINGS FROM CORRECTING REFRIGERANT CHARGE AND AIRFLOW PROBLEMS WITH CENTRAL AIR CONDITIONERS.

	Annual kWh savings	Peak kW savings
New system	103	0.217
Existing system	223	0.312

2. Program Participation

Potential program participants can be divided into those who install a new central air conditioner in a given year (this may be a replacement system, addition of central air to an existing home that lacked central AC, or construction of a new home), and those who have an existing central air conditioner that could be tuned up.

Survey data from the Energy Center's 2003 Appliance Sales Tracking Survey (Bensch and Weitner, 2004) suggest that about 60,000 +/- 11,000 Wisconsin single-family households in older homes purchase a new central air conditioner in a given year.[1] Moreover, about 25,000 new homes are built in Wisconsin each year, the vast majority of which have central air conditioning. Together, these statistics suggest that about 85,000 new air conditioners are installed in Wisconsin single-family homes annually.

We estimate that a long-running, mature program promoting installation practices could ultimately affect perhaps 50 to 75 percent of systems installed in older homes and 25 to 50 percent of systems installed in new homes. We therefore take 50,000 +/- 15,000 as an estimate of the maximum annual participation from new air conditioner installations ***(Input 2a)***.

For existing air conditioners, the Energy Center's 1999 Energy and Housing study found that about half of older single-family homes had central air conditioning. Survey data from the Energy Center's 2003 Appliance Sales Tracking Survey further suggest that about 2.5 percent of households add central air conditioning each year, implying a statewide 2006 saturation of about 67 percent. This works out to roughly one million central systems in existing Wisconsin homes in 2006.

[1] This is based on a self-reported purchase rate of 4 percent among owners of single-family homes built prior to 2000, and Census data showing about 1.4 million such households in the state.

Data from Energy Center's 2003 Appliance Sales Tracking Survey suggest that about 40 percent of furnace purchases are not associated with a simultaneous AC purchase. However, the proportion of these households that have central AC is unknown. On the conservative side, one could assume that nearly all central AC systems are replaced at the same time as the furnace. On the more optimistic side, one could assume that central AC saturation among furnace replacers is about the same as the general population. These two extremes suggest somewhere between zero and 12,000 furnace installations per year in homes with existing central AC systems.[2] Tracking data from the Energy Center's Furnace and AC Tracking System indicate that about half of furnace sales occur during the first and fourth quarters of the year, when assessing AC refrigerant charge is difficult or impossible. This implies somewhere between zero and 6,000 furnace installations per year occur where central AC system RCA improvements could be made concurrently.

This still leaves roughly 970,000 Wisconsin households with existing air conditioners. Many—if not most—of these homeowners will likely have little motivation to address refrigerant charge or airflow if the system is functioning and providing acceptable comfort. On the other hand, a program that offers a clean-and-tune at little or no cost to the homeowner could stimulate a significant response. For the purposes here, we have estimated the maximum annual participation for these households at 2.5 +/- 2.0 percent annually, or about 35,000 +/- 30,000 households per year. Together, these two estimates add up to a maximum annual potential of somewhere between 10,000 and 70,000 existing central AC systems per year ***(Input 2b)***.

This potential could not be immediately achieved, since the program would need to gradually pull contractors and consumers within its orbit. We assume an S-shaped logistic growth function toward both of these maxima, of the form

$$P(t) = L/(1+ae^{-bt})$$

Where

P(t) = annual participants in Year *t;*

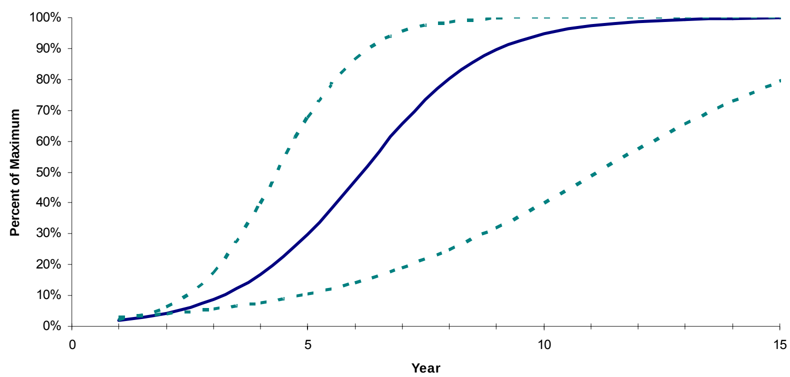
L = estimated maximum number of participants per year; and,

a, b are parameters that help determine the shape of the S-curve.

We use 100 +/- 50 for the value of *a* ***(Input 2c)***, and 0.75 +/- 0.25 for the value of *b* ***(Input 2d)***. These parameter estimates give rise to the (normalized) S-curve of the form shown below, indicating that at the mid-point (solid line) about a third of the maximum annual achievable potential could be realized within five years, and nearly all can be achieved within 10 years. The assigned uncertainties result in a wide range of possible trajectories, however, as indicated by the curves defined by the extremes (dashed lines).

[2] The latter figure is calculated as 1.4 million households * 3.4% furnace replacement rate * 40% of furnace replacements not associated with central AC replacement * 67% central AC saturation among single-family homes.

FIGURE 20.02.1. ESTIMATED GROWTH IN NORMALIZED PROGRAM PARTICIPATION.



The combined uncertainty in maximum annual participation and the S-curve parameters results in an overall uncertainty in Year 5 participation of between 5,000 and 30,000 households that install new central AC systems, and between 3,000 and 30,000 households with existing air conditioners that participate.[3] (The uncertainty in Year 10 participation is 30,000 to 60,000 and 10,000 to 65,000 participants for the two groups, respectively.)

The mid-point program trajectory is reasonably consistent with reported participation for California's CheckMe! program (York and Kushler, 2003). That statewide program had about 53,000 participants in 2002, four years after start-up. According to the 2001 Residential Energy Consumption Survey (EIA, 2004), California has about four million central air conditioners, or about four times as many as we estimate for Wisconsin.[4] A comparable program in Wisconsin would thus scale to about 13,000 participants in Year 4, not far different than the 15,000 obtained from our midpoint estimate based on the logistic projection.

Finally, we estimate program net-to-gross ratios to account for the fact that some contractors may already be practicing RCA tuning and some owners of existing systems may already be inclined to have their system tuned up. In terms of contractor practices, recent interviews with 30 participating contractors by Focus on Energy evaluators showed that two-thirds to three-quarters were already practicing some form of RCA testing prior to participation in the program (Talerico, 2004).

For consumer practices in maintaining existing central air conditioners, the Energy Center's 1999 Energy and Housing study asked homeowners about the frequency with which they typically maintained their central air conditioner; nearly 40 percent of respondents reported having their system checked-up at least once a year, about one in four reported having a refrigerant check at least once a year, and about half report checking refrigerant at least every six years.

Taken at face value, the above statistics would imply that the majority of new systems are properly adjusted and the majority of existing systems are regularly maintained and tuned. However, the former

[3] These are 90 percent confidence intervals.
[4] Table HC4-7a.

study notes that the contractors who were interviewed could be early-adopter contractors, and this proportion could drop under wider program implementation. And socially desirable responding is likely a significant factor in the homeowner self-reports from the Energy Center study. Moreover, the relatively rosy picture of central AC installation and maintenance practices painted by these studies is contradicted by the limited field data available on Wisconsin systems (Deforest, 2005a).

In the face of this uncertainty, we adopt program net-to-gross ratio of 0.75 +/- 0.50 for both new and existing systems ***(Input 2e)***. This range accommodates both scenarios where most impacts under the program would have occurred anyway, to a scenario in which the net impacts from the program are actually somewhat greater than that for participants alone. The latter could occur if the program results in increased general adoption of RCA evaluation outside the context of the program.

3. Program Costs

The market cost of performing standard central AC clean and tune has been estimated at about $90, though with additional programmatic reporting requirements, this becomes more on the order of $125 (Deforest, 2005b). The latter figure would be a reasonable estimate of the variable program cost if it is assumed that the program would subsidize the entire cost of the work. Separate data for the statewide California CheckMe! Program indicates an overall program cost of about $84 per diagnostic run for 2002 (York and Kushler, 2003).

Based on these figures and adding an additional $10 per unit for overall program administration and other costs, we estimate the variable cost of the program at $135 +/- $40 for existing units where a separate visit is needed to conduct the work ***(Input 3a)***, and $95 +/- $25 for new installations where the work can be performed as part of the installation itself ***(Input 3b)***.

4. Measure Life

The effective life of savings from correcting refrigerant charge and airflow are somewhat uncertain. In the absence of system refrigerant leaks or changes to the air furnace, the savings should accrue over the remaining life of the unit. (Airflow may drop over time due to coil fouling unrelated to the tune-up, but this would occur regardless of participation in the program). We take 20 +/- 5 years as the effective savings life for a new system ***(Input 4a)***, and 10 +/- 5 years as the effective savings life for an existing system ***(Input 4b)***.

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MARKET 21 — RENTAL HEATING SYSTEM REPLACEMENT

Market Scope

This market is defined as rental building operators who are seeking to replace existing boilers or furnaces, as well as those engaging in renovation projects that offer heating system opportunities. Potential estimates will be based on program options to encourage high efficiency replacements, modular installations, and controls to maximize system performance. This market does not include systems purchased for new buildings.

Market Characteristics

The multi-family market comprises rental housing that ranges from duplexes to large apartment complexes. There are approximately 106,600 multi-family rental buildings in the state encompassing 486,800 housing units. Small buildings with fewer than five units account for approximately 90 percent of the buildings and somewhat more than 50 percent of the units (Pigg and Price, 2005).

This market has been a challenging one for energy efficiency programs. Barriers to addressing this market in Wisconsin include:

- A split incentive, whereby those who select and pay for energy-using equipment (owners) often do not benefit from the savings that an energy-efficient choice would generate because they do not pay the energy bill;
- Distribution of a large share of rental units among small buildings;
- A large number of small-scale owners who control just a few units or buildings;
- A lack of strong and active apartment associations through which an energy program could offer its services; and
- A lack of demand for energy-efficiency from tenants.

The market for rental building heating systems is complicated further by the variety of heating systems in use.

Forced Air Furnaces – As shown by the Energy Center's Energy and Rental Housing study, heating among smaller buildings (with one to four units) is dominated by forced air furnaces (Pigg and Price, 2005). These furnaces are essentially identical to those installed in most owner-occupied single family homes in the state, except that those in rental units are predominately only of standard efficiency. In contrast to owner-occupied housing, only fourteen percent of the furnaces in rental units are high efficiency condensing furnaces. These high-efficiency furnaces, which have become the standard for owner-occupied housing in Wisconsin, feature efficiency levels of 90 percent or better, compared with efficiencies in the 80 percent range for standard-efficiency furnaces. The main barriers for high efficiency furnaces in rental units are:

- Higher costs of $500 per unit – a significant price differential at the $2,000 cost of many furnaces; and
- A split incentive, whereby landlords incur the costs of furnaces, while their renters almost always incur the cost (or reap the savings) dictated by the efficiency level of the furnace.

Currently, there is no comprehensive program to address this part of the Wisconsin rental market, but we modeled one for this study.

Magic Paks – A share of mid-sized buildings heat and cool multiple units with a system known as a "Magic Pak." However, these systems are built into the shell of the building, thereby making replacement with anything other than another Magic Pak difficult and costly. As a result, the efficiency level of replacements is limited to the efficiency levels available among new Magic Paks. No current energy efficiency program in Wisconsin addresses Magic Pak replacements, and we did not model one for this study.

Heating Systems for Midsized and Larger Buildings – Most mid-sized and larger buildings (i.e., buildings with five or more units) use central boilers that heat and circulate water (or steam). Some buildings use in-unit electric resistance heaters, which we address in a separate market on multi-family fuel switching. Because boilers are central units that serve multiple units, landlords pay for the equipment as well as their operating costs, thereby eliminating the split incentive barrier.

Boilers are large systems built of replaceable parts that can be operated for many decades and are replaced only infrequently. Efficiency levels of boilers range from 60 percent for some older systems to more than 90 percent for newer, modular condensing systems. The energy savings of these systems can be substantial. In addition, boiler-based heating systems can be retrofitted with controls that reduce the temperature of the heated water during shoulder seasons, thereby reducing standby losses.

The current Wisconsin Focus on Energy multi-family energy efficiency program addresses central heating systems as part of a whole-building approach that comprises a building assessment and a range of recommendations to the client. This program is market-based, meaning that it tends to work through contractors who serve multi-family buildings. The program offers a performance-based incentive that offers cash rewards based on the estimated amount of energy saved by each recommended measure that the multi-family building decision-maker chooses to implement.

Program Approaches

Our analysis of this market considered two program efforts:

- A whole-building approach to improve the energy efficiency of multi-family buildings with 5 or more units; and
- A rebate program for owners of rental buildings with 4 or fewer units that are heated by forced air furnaces with standard efficiency levels.

PROGRAM AREA 21.01 — MULTI-FAMILY HEATING SYSTEM REPLACEMENT – MEDIUM AND LARGER BUILDINGS

The program we modeled for buildings with 5 or more units is based on Wisconsin Focus on Energy's current market-based whole-building program for the multi-family sector (described above). A program team and participating contractors would promote program-sponsored building assessments. Multi-family building decision-makers would qualify for a performance-based incentive if they implement recommended measures. We assume a more extensive marketing effort than is currently in place, resulting in a greater number of building assessments, more recommendations, and more implementations. We used generally the same incentive levels as the current program.

TABLE 20.01.1. ESTIMATED VALUES FOR PROGRAM AREA 21.01, MULTI-FAMILY HEATING SYSTEM REPLACEMENT – MEDIUM AND LARGER BUILDINGS

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$47 to $895	$193 to $655
	Incremental Impacts	peak kW	0	0
		annual kWh (000s)	0	0
		annual therms (000s)	13 to 262	61 to 203
	Levelized resource cost	per peak kW	NA	NA
		per kWh	NA	NA
		per therm	16.9¢ to 39.7¢	15.7¢ to 36.2¢
Scaling factors[a]		program costs	1.5 to 5.1	1.5 to 5.1
		impacts	1.2 to 3.2	1.2 to 3.2

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

PROGRAM AREA 21.02 — MULTI-FAMILY HEATING SYSTEM REPLACEMENT – SMALL BUILDINGS

We modeled a rebate program to encourage owners of small rental buildings (< 5 units) to replace standard efficiency furnaces with high-efficiency, condensing furnaces upon failure. Rebates cover a high proportion of the incremental cost to overcome the barriers posed by the split incentive whereby tenants almost always pay the heating costs.

TABLE 21.02.1. ESTIMATED VALUES FOR PROGRAM AREA 21.02, MULTI-FAMILY HEATING SYSTEM REPLACEMENT – SMALL BUILDINGS

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$303 to $2,599	$1,142 to $3,660
	Incremental Impacts	peak kW	0	0
		annual kWh (000s)	0	0
		annual therms (000s)	43 to 571	215 to 824
	Levelized resource cost	per peak kW	NA	NA
		per kWh	NA	NA
		per therm	29.7¢ to 80.9¢	28.2¢ to 72.1¢
Scaling factors[a]		program costs	1.0 to 4.0	0.9 to 4.0
		impacts	1.0 to 2.9	0.9 to 2.9

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Following are the technical assumptions we made for programs to promote efficient heating system replacements in rental buildings.

Program Area 21.01 — Multi-Family Heating System Replacement – medium and large buildings

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 21.01.2. MODEL INPUTS FOR MULTI-FAMILY HEATING SYSTEM REPLACEMENT – MEDIUM AND LARGE BUILDINGS

Model Inputs (21.01)			Value	±
1		**Buildings Served**		
	a	rental buildings in Wisconsin (bldgs > 4 units)	20,800	3,120
	b	rental buildings that can be reached by the program	15,000	3,000
	c	market barriers coefficient for buildings reached	107	81
	d	curve shape coefficient for buildings reached	1.35	0.65
	e	share of assessed buildings with heating system review	80%	10%
	f	share of bldgs with 4+ units that have 20+ units	15%	3%
2		**Recommended Measures – 5-19 units (% of assessed buildings)**		
	a	boiler replacement	4%	1%
	b	boiler upgrade on failure	6%	1%
	c	boiler controls	27%	5%
	d	boiler pipe insulation	13%	3%
3		**Recommended Measures – 20+ units (% of assessed buildings**		
	a	boiler replacement	9%	2%
	b	boiler upgrade on failure	10%	2%
	c	boiler controls	8%	2%
	d	boiler pipe insulation	13%	3%
4		**Implementation Rate of Recommended Measures – 5-19 units (% of recommendations)**		
	a	boiler replacement	25%	20%
	b	boiler upgrade on failure	50%	20%
	c	boiler controls	70%	20%
	d	boiler pipe insulation	90%	10%
5		**Implementation Rate of Recommended Measures – 20+ units (% of recommendations**		
	a	boiler replacement	25%	20%
	b	boiler upgrade on failure	25%	20%

	c	boiler controls	70%	20%
	d	boiler pipe insulation	90%	10%
6		**Energy Savings (therms per implemented measure) – 5-19 units**		
	a	boiler replacement	486	100
	b	boiler upgrade on failure	1,017	200
	c	boiler controls	351	70
	d	boiler pipe insulation	45	9
7		**Energy Savings (therms per implemented measure) – 20+ units**		
	a	boiler replacement	3,280	600
	b	boiler upgrade on failure	4,320	800
	c	boiler controls	1,480	300
	d	boiler pipe insulation	200	40
8		**Program Costs**		
	a	Program management costs – per building assessed	$20	$10
	b	Marketing costs – per building assessed – 1st year	$300	$200
	c	Marketing costs – per building assessed – decrease per year	50%	25%
	d	Assessment costs – per building assessed	$300	$100
	e	variable costs – incentives per 1st year therm saved	$0.60	$0.10
	f	variable costs – incentives processing per 1st year therm saved	$0.03	$0.01
9	a	**Measure Life (years)**	30	10

1. Buildings Served

A single market-based whole-building effort would serve this and most other multi-family program approaches we are modeling for this study. Similar to Focus on Energy's current market-based approach for multi-family buildings, this program would offer whole-building assessments and make recommendations that span multiple "markets" included in this study, including lighting, HVAC upgrades, and fuel switching. Please see Market 18 for an explanation of the model inputs we used for this cross-cutting effort to estimate the total number of buildings assessed.

For the rental heating system replacement model, we assumed that 80 percent of the assessed buildings include a review of the heating systems, which could lead to recommended change-out of heating equipment.

Installation rates, energy impacts, and costs are modeled separately for buildings with 5-19 units and those with 20+ units. We assumed the same distribution of buildings in these size categories as observed by the Energy and Rental Housing Study, which suggested that 15 percent of multi-family buildings are in the larger of these categories (Pigg and Price, 2005).

2 & 3. Recommended Measures

We modeled four different categories of measures that were studied in detail in the Energy and Rental Housing study: boiler replacement, boiler upgrade on failure, boiler controls, and boiler insulation. These categories match well with the current program's emphasis for heating systems, except that they exclude water heating considerations, which may under-represent the achievable potential somewhat. For each of the four categories of measures, we assumed that the assessment would recommend the measure in the same proportion with which the Energy and Rental Housing study found these measures to provide a 10-year payback without incentives. We assumed that boiler upgrades on failure would be treated as immediate replacements, which may over-represent the achievable potential somewhat.

Therefore, for buildings with 5-19 units, we modeled assessment results that recommend boiler replacements 4 percent of the time (+/- 1 percent), boiler upgrades on failure 6 percent of the time (+/- 1 percent), boiler controls 27 percent of the time (+/- 5 percent), and boiler pipe insulation 13 percent of the time (+/- 3 percent). For buildings with 20+ units, we modeled assessment results that recommend boiler replacements 9 percent of the time (+/- 2 percent), boiler upgrades on failure 10 percent of the time (+/- 2 percent), boiler controls 8 percent of the time (+/- 2 percent), and boiler pipe insulation 13 percent of the time (+/- 3 percent) (Pigg and Price, 2005).

4 & 5. Implementation Rate of Recommended Measures

Program history shows that multi-family building decision-makers will implement only a share of the recommended measures. We assume that decision-makers will be more likely to implement projects with short payback periods, so we used the proportion of recommended measures that have two-year paybacks as a general guide in assigning implementation rates. Table 21.01.3. shows the percentage of recommended measures with paybacks of two years or less and the implementation rates we assumed. We assume the same implementation rates for buildings with 5-19 units as those with 20+ units unless noted otherwise.

TABLE 21.01.3. IMPLEMENTATION RATES

Measure	Percentage of Recommendations with Paybacks of Two Years or Less[a]	Assumed Implementation Rate	Assigned Uncertainty
boiler replacement	0%	25%	+/- 20%
boiler upgrade on failure	50% for 5-19 units 10% for 20+ units	50% for 5-19 units 25% for 20+ units	+/- 20%
boiler controls	70 for 5-19 units 63% for 20+ units	70%	+/- 20%
boiler pipe insulation	100%	90%	+/- 10%

[a] source: Pigg and Price, 2005

6 & 7. Energy Savings (therms per implemented measure)

The Energy and Rental Housing study computed energy savings for each measure included in that study. That study expressed these savings in terms of dollars saved per housing unit. We transformed these estimates into therms per building by multiplying the financial savings by the average number of units per building (9 for buildings with 5-19 units and 40 for buildings with 20+ units) and dividing by $1/therm (Pigg and Price, 2005). That computation suggested energy savings of:

- boiler replacement – 486 therms for buildings with 5-19 units, 3,280 therms for 20+ units;
- boiler upgrade on failure – 1,017 and 4,320 therms;
- boiler controls – 351 and 1,480 therms; and
- boiler pipe insulation – 45 and 200 therms.

We turned all of the savings into therms because the vast majority of the heating systems replaced and installed by this program would operate on natural gas. We assigned uncertainties of about 20 percent of the savings values.

8. Program Costs

There are four main components to our assumed program costs. Three of these components are cross-cutting costs already defined in market 18. They are:

- program management costs;
- program marketing costs; and
- assessment costs.

These are shared costs that we assume to span two or three multi-family programs. We modeled the share of these costs attributable to the rental heating system replacement program to be identical as the costs attributed to the common area lighting market (#18).

The fourth cost category – incentives – is independent of the other multi-family programs. Incentives would follow the model established by the current market-based Focus on Energy program for the multi-family market, which offers performance-based incentives that range from $0.40 to $0.80 per 1st-year therm saved by a project (Focus on Energy). We assumed an average incentive rate of $0.60 per therm saved (+/- $0.10).

9. Measure Life

We assumed a measure life of 30 years (+/- 10 years). We acknowledge stakeholder input that newly installed boilers – which account for a substantial share of the energy savings potential in this market – may last longer than 30 years. However, a measure life of 30 years accounts for the fact that some of these replacements might have happened on their own in fewer than 30 years, thereby reducing the period of time influenced by the program.

Program Area 21.02 — Multi-Family Heating System Replacement – small buildings

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 21.02.2. MODEL INPUTS FOR MULTI-FAMILY HEATING SYSTEM REPLACEMENT – SMALL BUILDINGS

Model Inputs (21.02)			Value	±
1		**Number of Furnaces**		
	a	Existing forced air furnaces in rental buildings (1-4 units)	309,000	31,000
	b	Replacement rate	5%	1%
	c	Share of furnaces with standard efficiency level	86%	5%
	d	Share of furnaces with landlord-paid heat	3%	2%
	e	Share of furnaces with tenant-paid heat	97%	2%
2		**Share of Furnaces Upgraded – landlord-paid heat**		
	a	1st year	10%	10%
	b	growth per year	100%	50%
	c	maximum	85%	15%
3		**Share of Furnaces Upgraded – tenant-paid heat**		
	a	1st year	5%	5%
	b	growth per year	100%	50%
	c	maximum	60%	20%
4		**Energy Savings per Unit**		
	a	average heating energy per unit (therms) – standard efficiency	850	100
	b	% reduction in average heating energy per unit – high efficiency (compared to standard efficiency)	13%	4%
	c	peak demand reduction per unit (kW)	0	0
	d	net-to-gross ratio	0.85	0.15
5	a	**Measure Life (years)**	20	4
6		**Program Costs**		
	a	fixed costs – program administration & management	$25,000	$15,000
	b	fixed costs – marketing & contractor outreach	$75,000	$25,000
	c	variable costs – incentive per unit	$400	$100
	d	variable costs – incentive processing per unit	$10	$5

1. Number of Furnaces

According to the Energy Center's Energy and Rental Housing study, forced air furnaces heat 362,000 rental units in Wisconsin. Of these, 309,000 units are in smaller buildings with one to four units. We counted these units (with an uncertainty of +/- 31,000 units) as the potentially replaceable furnaces under this program approach. We excluded furnaces in larger buildings because a substantial share of them may be "magic packs," which can be retrofitted with high-efficiency furnaces only with extensive effort.

We assume a replacement rate of five percent annually (+/- one percent), which suggests a furnace lifespan of 20 years.

Only 14 percent of existing forced air furnaces in Wisconsin rental buildings are high-efficiency condensing furnaces with AFUE ratings exceeding 90 percent, suggesting that 86 percent of furnaces in rental units are standard efficiency (with AFUE ratings below 90 percent). We assigned an uncertainty level of 5 percentage points.

Tenants pay the heating energy costs in a vast majority of the rental units with forced air furnaces. According to data collected for the Energy and Rental Housing study, landlords pay the heat for only three percent of the furnaces. We assigned an uncertainty of +/- two percentage points. Therefore, tenants pay the heating costs for 97 percent of units with furnaces.

2 & 3. Share of Furnaces Upgraded – landlord-paid heat and tenant-paid heat

We assume a program approach in which program staff reaches out to heating contractors to encourage them to promote high-efficiency furnaces to landlords of small buildings and advertise the program's substantial incentive for upgrades. Because landlords who pay the heating cost have a greater incentive to install high-efficiency equipment, we modeled units with landlord-paid and tenant-paid heat separately. For landlord-paid heat, we assume an initial upgrade rate for eligible furnaces of 10 percent (+/- 10 percent) with a doubling (+/- 50 percent) of that rate every year until it reaches 85 percent (+/- 15 percent). For tenant-paid heat, we assume an initial upgrade rate of five percent (+/- 5 percent) with a doubling (+/- 50 percent) every year until it reaches 60 percent (+/- 20 percent).

4. Energy Savings per Unit (unit = furnace)

We computed energy savings based on the average space heating energy used in Wisconsin rental buildings that are heated by furnaces. According to data collected for the Energy and Rental Housing study, rented single-family homes with a standard-efficiency furnace use an average of about 1,000 therms per year; units in 2-4 unit buildings use an average of about 700 therms per year. We used an average of 850 therms (+/- 100). Further, we assume that high-efficiency furnaces use 13 percent less energy than the standard-efficiency furnaces (+/- four percent). This savings rate is based on 90 percent efficiency levels for efficient furnaces and 80 percent efficiency levels for standard efficiency furnaces (90/80=1.13).

Because the savings are limited to winter-use of natural gas, there are no electricity consumption or demand savings.

We applied a net-to-gross ratio of 0.85 (+/- 0.15) to these energy savings to account for the possibility of free-ridership by rental unit owners who might be planning to upgrade furnace efficiency upon replacement.

5. Measure Life

We assume a measure life equal to the equipment life of forced air furnaces, which is about 20 years (+/- 4).

6. Program Costs

We assume fixed costs of $25,000 (+/- $15,000) for program administration and management and another $75,000 for personnel and direct costs to market this program to heating contractors. Variable costs for the program consist of an incentive per unit of $400 (+/- $100) and a processing cost per incentive of $10 (+/- $5). We used a $400 incentive with the intention of covering the majority of the approximate $500 incremental cost of upgrading from a standard-efficiency furnace to a high-efficiency furnace.

References

Pigg, Scott and Andrew Price. (2005). *Energy and Rental Housing: A Wisconsin Characterization Study*. Energy Center of Wisconsin Report 232-1, Madison, WI.

American Council for an Energy Efficient Economy (ACEEE). (2003). Exemplary Natural Gas Energy Efficiency Program, Apartment & Condo Efficiency Services Focus on Energy. Retrieved May 31, 2005 from http://aceee.org/utility/ngbestprac/foe.pdf.

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MARKET 22 — ROOM AIR CONDITIONER PURCHASE MARKET

Market Scope

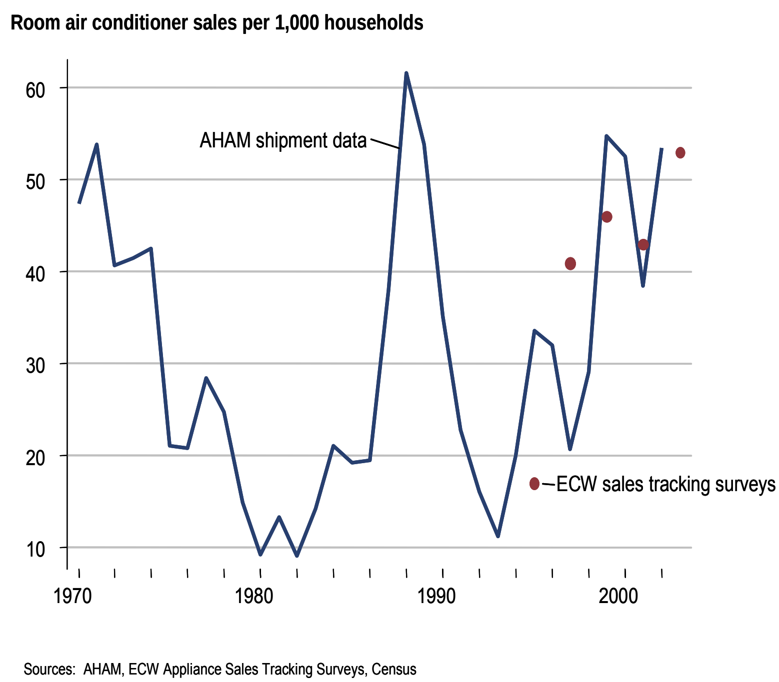
This market comprises purchases—and early retirement—of room air conditioners by residential homeowners, renters and landlords.

Market Characteristics

About one in five single-family Wisconsin homes has at least one room air conditioner, and more than one in four renters owns their own room AC unit. These add up to an estimated 700,000 homeowner- or tenant-owned room air conditioners in the state

Survey data and manufacturers' shipment data both suggest that currently about 50 air conditioners are sold for every thousand Wisconsin households, or about 110,000 annual units. However, annual sales can vary substantially from year to year based on summer weather conditions, as can be seen in the large spike in sales associated with very hot summers in the late 1980s (Figure 22.01.1).

FIGURE 22.01.1. WISCONSIN ROOM AIR CONDITIONER SALES.



By virtue of federal standards for energy efficiency, new room air conditioners are considerably more efficient than older existing models. A new standard room air conditioner with an EER rating of 9.8 will use nearly 25 percent less electricity than a 20-year old model with an EER of 7.5.[5] Among new air conditioners, the difference in energy efficiency is less dramatic—on the order of 10 percent savings for an ENERGY STAR® labeled unit with an EER rating of 10.8 compared to a unit with a federal standard minimum EER of 9.8.

Several sources of regional and national data peg the market for ENERGY STAR labeled room air conditioners at about one quarter to a third of sales (though one estimate places the California market share at more than 60 percent). The incremental cost for an ENERGY STAR labeled room air conditioner is estimated to be in the range of $25 to $30, and the number of ENERGY STAR labeled models has increased significantly over the last five years.

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[5] EER stands for "energy efficiency ratio" and expresses the ratio of cooling capacity to electricity consumption.

Most room air conditioner sales occur in the spring and summer, for which retailers typically place orders in the preceding fall. Most consumers simply purchase what is available on store shelves, so retailer stocking practices are an important aspect of the market.

Program Approaches

The low incremental savings associated with upgrading to an ENERGY STAR labeled room air conditioner has led most program planners away from offering direct consumer incentives at the time of purchase. The literature and discussions with stakeholders revealed two principal program approaches to increasing the efficiency of room air conditioners:

1. Bounty programs to encourage early retirement of older inefficient air conditioners; and,
2. Retailer spiffs to encourage stocking of ENERGY STAR labeled units.

These are discussed in turn below.

PROGRAM AREA 22.01 — BOUNTY FOR EARLY RETIREMENT OF ROOM AIR CONDITIONERS

Bounty programs seek to induce people to replace an older room air conditioner before the end of its life with a new efficient model. By offering a cash incentive—as well as reduced hassle in disposing of the old appliance—such a program can capture energy savings from the difference in efficiency between the old unit and the new unit. These savings accrue over the period between when the unit is actually replaced due to the program and when it would otherwise have been replaced, which we call the "early-retirement period." Most estimates place this period at 3 to 5 years. If the turn-in bounty is paired with a requirement of proof of purchase of a new ENERGY STAR labeled model, there will be savings after this period as well if a standard efficiency unit would otherwise have been purchased. We call this period the "upgrade period."

A bounty program operated in New York state resulted in nearly 270,000 units being turned in between 2001 and 2003 (nearly two-thirds of these occurred in 2002). Adjusted for the smaller stock of room air conditioners in Wisconsin, a similar response in Wisconsin would translate into roughly 40,000 air conditioners being turned in during a three-year period. However, limited efforts in Wisconsin by Focus on Energy (in 2001) and in Minnesota (2004) to promote early turn-in of room air conditioners did not result in widespread participation. Our estimates of achievable potential strike a balance between these extremes, with an uncertainty band that embraces both (though with an adjustment for the learning curve associated with the earlier Wisconsin effort).

TABLE 22.01.1. ESTIMATED VALUES FOR PROGRAM AREA 22.01 — ROOM AC TURN-IN PROGRAM

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$132 to $424	$146 to $484
	Incremental Impacts	peak kW	212 to 883	199 to 892
		annual kWh (000s)	119 to 634	112 to 630
		annual therms (000s)	0	0
	Levelized resource cost	per peak kW	$94 to $320	$106 to $387
		per kWh	12.8¢ to 59.8¢	14.4¢ to 71.3¢
		per therm	NA	NA
Scaling factors[a]		program costs	0.1 to 0.8	0.1 to 0.9
		impacts	0.1 to 0.8	0.1 to 0.9

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

PROGRAM AREA 22.02 — RETAILER INCENTIVES FOR ROOM AIR CONDITIONERS

In contrast to consumer incentives, retailer incentives for increased stocking of room air conditioners may make an attractive program offering, because a modest $5 to $10 per-unit stocking spiff can significantly increase retailer profits on units sold. We assumed a program modeled after Focus on Energy's current retailer program, which uses established relationships with retailers throughout the state, circuit riders, point-of-purchase materials, and spiffs.

Our analysis assumes that the market for ENERGY STAR labeled room air conditioners is naturally increasing year by year, but that stocking spiffs could substantially increase stocking practices among participating retailers. We further assume that the spiffs would gradually be reduced as the market share for efficient unit climbs.

TABLE 22.02.1. ESTIMATED VALUES FOR PROGRAM AREA 22.02, RETAILER INCENTIVES FOR ROOM AIR CONDITIONERS

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$360 to $829	$334 to $834
	Incremental Impacts	peak kW	300 to 1,326	274 to 1,162
		annual kWh (000s)	183 to 948	164 to 820
		annual therms (000s)	0	0
	Levelized resource cost	per peak kW	$52 to $241	$56 to $272
		per kWh	7.5¢ to 40.9¢	7.9¢ to 46.2¢
		per therm	NA	NA
Scaling factors[a]		program costs	0.1 to 1.9	0.2 to 2.0
		impacts	0.1 to 1.7	0.2 to 1.8

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Based on the two Energy Center energy and housing studies (Pigg and Nevius, 2000, and Pigg and Price, 2005), we estimate that there are slightly fewer than one million room air conditioners in Wisconsin housing (Table 22.01.2), of which about a quarter are owned by landlords and used in rental properties.

TABLE 22.01.2. ESTIMATED SATURATION OF ROOM AIR CONDITIONERS IN WISCONSIN

		Renter-Occupied[b]	
	Owner-Occupied[a]	**Tenant-provided**	**Landlord-provided**
Households w/ room AC (000s)	300	180	240
# of room air conditioners per household			
1	64%	66%	94%
2	27%	31%	5%
3	7%	1%	0.6%
4	2%	2%	0.4%
Average per household	1.47	1.39	1.08
Total units (000s)	440	250	260

[a]From Pigg and Nevius (2000); does not include owner-occupied multifamily housing

[b]From Pigg and Price (2005).

Wisconsin shipment data on room air conditioners from the Association of Home Appliance Manufacturers (AHAM), shows that room air conditioner sales can be substantially affected by the weather: the large spike in sales in 1988 and 1989 correspond to particularly hot summers (Table 22.01.3). The trend for higher room air conditioner sales in recent years in the AHAM data is not associated with the weather, but corresponds reasonably well with trends in sales based on biennial consumer telephone surveys conducted by the Energy Center.

TABLE 22.01.3. HISTORICAL WISCONSIN ROOM AC SALES.

Year	Total WI room AC sales[a]	Sales per 1,000 households[b]	Households per 1,000 reporting purchasing a room AC unit in previous 12 months[c]	Days exceeding 90°F (Madison)
1970	62,715	47		11
1971	73,088	54		19
1972	56,642	41		11
1973	58,855	41		13
1974	61,785	42		12
1975	31,297	21		23
1976	31,594	21		31
1977	44,128	28		17
1978	39,170	25		15
1979	24,010	15		1
1980	15,290	9		18
1981	22,060	13		5
1982	15,242	9		3
1983	23,992	14		20
1984	35,900	21		3
1985	33,100	19		4
1986	33,900	19		8
1987	67,000	38		19
1988	109,700	62		35
1989	97,200	54		12
1990	64,100	35		8
1991	42,000	23		19
1992	30,000	16		4
1993	21,200	11		3
1994	38,400	20		8
1995	65,400	34	17	27
1996	63,100	32		2
1997	41,300	21	41	3
1998	58,900	29		0
1999	112,300	55	46	13
2000	109,600	53		2
2001	81,200	38	43	11
2002	114,800	54		12
2003			53	9

[a]Source: AHAM

[b]AHAM sales adjusted based on interpolated Census data on number of Wisconsin households

[c]Source: ECW Appliance Sales Tracking Surveys

Three sources of regional and national data (EPA, 2004; Dethman, 2004; and NYSERDA, 2004) peg the market for ENERGY STAR labeled room air conditioners at about one quarter to a third of sales, though one estimate places the California market share at more than 60 percent (Itron, 2004). Most of these estimates show the ENERGY STAR market share increasing from about ten percent in about 2000.

Program Area 22.01 — Bounty program for room air conditioners

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 22.01.4. MODEL INPUT FOR BOUNTY PROGRAM FOR ROOM AIR CONDITIONERS

Model Inputs (22.01)			**Value**	**±**
1		**Per-Unit Impacts (unit = one room air conditioner)**		
	a	Mean EER of existing unit	8.25	0.5
	b	annual increase in EER of turned in existing unit	0.1	0.05
	c	EER of Energy star replacement unit	10.7	0.1
	d	EER of standard replacement unit	9.8	0.1
	e	Mean cooling capacity of unit (BTUh)	8,400	500
	f	Mean annual hours of operation	400	200
	g	Diversified demand factor	0.6	0.15
2		**Program Participation**		
	a	Turn-in events in Year 1	8	2
	b	Compounded annual increase in events (Years 2-3)	75%	25%
	c	Average number of units turned in per event	200	100
	d	Current Energy Star Market Share	35%	5%
	e	Maximum Energy Star Market Share	85%	10%
	f	% of unattained market added each year w/ program 22.02	40%	15%
3		**Program costs**		
	a	Fixed cost per event	$25,000	$5,000
	b	Variable costs per turn-in (Year 1)	$60	$15
4		**Measure life (years)**		
	a	Years until existing unit would have been replaced	3	2
	b	Life of air conditioner	15	5

1. Per Unit Impacts

The early-replacement savings for a room air conditioner depend on the efficiency (EER) of the existing replacement units, the cooling capacity of the air conditioner, and the hours of operation, and are calculated as:

Energy savings = hours of use * cooling capacity * ($1/(EER_{existing}) - 1/(EER_{replacement})$)

Savings after the early-replacement period are calculated similarly, but are based on the EER of the alternative new unit that would have been purchased instead of the EER of the existing unit.

EER

Using data on the age distribution of room air conditioners from the Energy Center's Energy and Housing study (Pigg and Nevius, 2000), combined with AHAM data on the shipment-weighted average EER by year of manufacture, we estimate the distribution of existing Wisconsin room air conditioners to be as shown in Table 22.01.5 below.

TABLE 22.01.5. ESTIMATED DISTRIBUTION OF WISCONSIN ROOM AIR CONDITIONER AGE AND EER.

Percentile	Age (years)	Year of manufacture	Rated EER
10	2	2004	10.05
20	3	2003	9.96
30	5	2001	9.77
40	7	1999	8.99
50	9	1997	9.09
60	10	1996	9.08
70	11	1995	9.03
80	17	1989	8.48
90	22	1984	7.48

Assuming that turned in air conditioners come from the older half of the stock, we assumed an EER of 8.25 for the average EER of an existing unit that is turned in ***(Input 1a)***. The average EER of the oldest half of the distribution is actually about 8.6, but we assumed some performance degradation over time. Further, the average EER of a turned-in unit can be expected to increase with each year that goes by: we estimated this increase at 0.1 EER per year ***(Input 1b)***.

The average EER of a new ENERGY STAR labeled unit is taken to be 10.7, per the current ENERGY STAR standards ***(Input 1c)***, and the EER of a new standard unit is taken to be 9.8, per the current federal energy efficiency standards ***(Input 1d)***.

Cooling Capacity

We estimate the average room air conditioner to have a cooling capacity of about 8,400 Btu per hour ***(Input 1e)***. This figure is based on a weighted average of data from the two Energy Center energy and housing studies (Pigg and Nevius, 2000; Pigg and Price, 2005).

Hours of Use

There is little data on the actual hours of operation for room air conditioners in Wisconsin. Summer billing data combined with room AC data from the Energy Center's Energy and Housing Study (Pigg and Nevius, 2000) suggests 325 to 375 hours of operation per year. On the other hand, the Energy Star savings calculator for room air conditioners uses 487 hours per year for Madison.[6] An intermediate value of 400 hours per year is used here ***(Input 1f)***.

Demand savings also require the estimation of the diversified demand at time of system peak (ie. the fraction of room air conditioners that will be in use during system peak). Based on (NEEP 2001), we have estimated this at 0.6 +/- 0.15 ***(Input 1g)***.

2. Program Participation

Data on the New York state Cool Choice program indicate that a total of 267,000 bounties were paid between 2001 and 2003 (with 175,000 of these occurring in 2002) (NYSERDA, 2004). The New York program offered a bounty of $75 per unit for the first two years; this was reduced to $35 in the third year, and the bounty has been eliminated in Year four.

Data from the federal Energy Information Administration's 2001 Residential Energy Consumption Survey (EIA 2004) suggests that there are about 6 to 7 million room air conditioners in New York State, compared to our estimate of about one million Wisconsin units.[7] Thus, if the New York results could be achieved in Wisconsin, one might expect about 40,000 turn-ins over a similar period.

At the same time, a turn-in program offering a $20 bounty by Focus on Energy in 2002 (in conjunction with consumer rebates for room air conditioners) resulted in only about 400 turn-ins (WECC, 2005). Part of the discrepancy between the two programs might be due to the difference in bounty levels, but the large urban concentration of the New York metropolitan area might also play a role.

The program approach may also be important. The earlier Focus on Energy program was more of a general retailer-driven effort. Program staff at Wisconsin Energy Conservation Corporation have since adopted an event-driven model in which specific retailers and communities are targeted for weekend turn-in events in the spring and early summer (Van de Grift, 2005a). Data from operating these types of events in Minnesota suggest that a typical weekend event targeting both room air conditioners and dehumidifiers might yield 150 to 200 room air conditioners (and 300 to 350 dehumidifiers), of which about two-thirds are associated with the purchase of a new unit. (homeowners may drop off older units without purchasing a new qualifying unit, but receive no incentive, and must pay the recycling fee). Program staff believe that they could achieve larger turn-ins for future events (Van De Grift, 2005b).

For this study, we assume that a Wisconsin statewide program would sponsor 6 to 10 turn-in events in the first year of operation ***(Input 2a)***, but that the number of events per year could be increased by 50 to 100 percent per year over the next two years before leveling off at about 25 events per year thereafter ***(Input 2b)***.

We further assume that an average turn-in event would yield about 200 +/- 100 room air conditioners ***(Input 2c)***, resulting in a mid-point estimate of about 5,000 turn-ins per year after the ramp-up period. These estimates exclude units that are not associated with the purchase of a new unit.

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[6] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_RAC_Sav_Calc.xls
[7] Table HC4-7a.

Finally, we also assigned a factor to account for the likelihood that some households that turn in an older room air conditioner for a new ENERGY STAR labeled unit would have eventually bought an ENERGY STAR labeled unit anyway. In fact, given the rising market share for ENERGY STAR labeled products—and the possibility of a parallel program area promoting these products at the retailer level (Program Area 22.02)—it is likely that many turn-in participants would eventually do so in the absence of a turn-in program. We used the assumptions for current and future ENERGY STAR market share for Program Area 22.02 here as well to model this proportion, which varies over time as the ENERGY STAR market share increases ***(Inputs 2e, 2f)***. These are described in more detail under Program Area 22.02. These assumptions result in midpoint estimates that between 75 and 85 percent of turn-in participants (depending on the year of participation) would have purchased an ENERGY STAR labeled unit anyway. Since these figures presume the existence of Program Area 22.02, they are somewhat conservative.

3. Program Costs

Since, it is likely that room air conditioners and dehumidifiers would both be targeted for turn-in events, fixed costs are shared across the similar Program Area 26.01 for dehumidifier turn-ins. We assumed an annual fixed program cost of $50,000 ***(Input 3a)***. Based on estimates from Van de Grift (2005a), the cost of staging a weekend turn-in event with about 500 appliance turn-ins is about $30,000, or about $60 per appliance ***(Input 3b).***

4. Measure Life

We assumed 3 +/- 2 years as the average remaining life of the units turned in (***Input 4a)*** This mid-point estimate is consistent with the current NYSERDA assumption of 2.7 years (Hammer, 2004), and the high end of the range embraces a citation of an estimated 5 years of remaining life provided by Reeder and Calwell (2001). The low end of the range would represent a scenario in which most turn-in units have little or no remaining life.

The AHAM shipment data combined with the estimated saturation of room air conditioners suggests that about one in ten room units turns over each year, for an average equipment life of 10 years. This figure concurs reasonably with some estimates in the literature (EPA, 2004; NEEP, 2001), but is less than the 15-20 years assumed by others (Reeder and Calwell, 2001; Hammer 2004). We used 13 +/- 4 years in an attempt to bridge this dichotomy ***(Input 4b)***.

PROGRAM AREA 22.02 — RETAILER INCENTIVES FOR ROOM AIR CONDITIONERS

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 22.02.2. INPUT MODEL FOR RETAILER INCENTIVES FOR ROOM AIR CONDITIONERS

Model Inputs (22.02)			Value	±
1		**Per-Unit Impacts (unit = one room air conditioner)**		
	a	EER of Energy star replacement unit	10.7	0.1
	b	EER of standard replacement unit	9.8	0.1
	c	Mean cooling capacity of unit (BTUh)	8,400	500
	d	Mean annual hours of operation	400	200
	e	Diversified demand factor	0.6	0.2
2		**Program Participation**		
	a	annual market size	100,000	20,000
	b	current market share	35%	5%
	c	maximum market share	85%	10%
	d	% of unattained market added each year w/ program	40%	15%
	e	% of unattained market added each year w/o program	15%	5%
3		**Program costs**		
	a	Variable costs per-participant (Year 1)	$9	$3
	b	Decline in variable costs (Years 2+), compounded % per year	5%	5%
4		**Measure life (years)**		
	a	Life of new unit	15	5

1. Per-Unit Impacts

See Program area 22.01.

2. Program Participation

The model used here is based on stocking incentives increasing the market share for ENERGY STAR labeled room air conditioners beyond what would naturally occur. The size of the market is estimated at about 100,000 units per year ***(Input 2a)***, based on the AHAM data described earlier.

Three sources of regional and national data (EPA, 2004; Dethman, 2004; and NYSERDA, 2004) peg the market for ENERGY STAR labeled room air conditioners at about one quarter to a third of sales, though one estimate places the California market share at more than 60 percent (Itron, 2004). Most of these estimates show the ENERGY STAR market share increasing from about ten percent in about 2000. We assumed 35 +/- 5 percent for the starting market share ***(Input 2b)***.

We estimate that the maximum achievable market share for ENERGY STAR labeled room air conditioners is about 85 percent ***(Input 2c)***, and that each year of program operation can reduce the gap between the current and maximum market share by 40 +/- 15 percent ***(Input 2d)***, compared to a naturally occurring closing rate of 15 +/- 5 percent ***(Input 2e)***. There is little empirical basis for these estimates, though the maximum market share is comparable to what has been achieved for condensing furnaces, and the trend in naturally occurring market share is reasonably consistent with the national trend since 2000.

The mid-point values for these inputs results in a program-induced market share gain of 18 to 20 percentage points during most years of the analysis, though the gain is on the order of 10 to 12 percentage points for the early and late years.

3. Program Costs

The variable costs associated with a spiff would occur for each ENERGY STAR model sold by a retailer participating in the program. We assumed a variable cost of between $8 and $12 per unit ***(Input 3a).*** This range is consistent with spiff levels of $5 to $10 mentioned in the stakeholder meeting, plus $2 to $3 per unit for administrative costs, marketing, and a portion of the cost of maintaining a general retailer network.

We also modeled a decline in variable costs over time of 5% +/- 5% compounded percent per year ***(Input 3b)***. This decline in costs would be consistent with the notion that as the market share rises, the incentive per unit could be decreased.

The combined effect of increasing market share and decreasing incentives is a relatively stable program cost of about $500,000 to $600,000 per year.

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MARKET 23 — HOMEOWNER WATER HEATER PURCHASES

Market Scope

This market is defined as homeowners who are in the market to replace an existing water heater. This market does not include systems purchased for new homes.

Market Characteristics

Approximately 84,000 water heaters are installed for existing homes in Wisconsin annually (Bensch and Tannenbaum, 2002 and 2004). About 24,000 of these water heaters are fueled by electricity, with 13,000 of these electric water heaters in homes that use natural gas or propane for other end-uses (Pigg and Nevius, 2000). These 13,000 water heaters represent the technical potential for a program that promotes water heater fuel conversions from electric to gas/propane.

Two barriers to fuel conversions are the high cost of converting a water heater from electricity to gas/propane and lack of homeowner awareness of the benefits of converting (Global Energy Options, 2001). Compounding this is that municipal utilities have a history of promoting the use of electric water heaters in an effort to build load (Global Energy Options, 2001).

High cost is also the primary barrier to the installation of on-demand water heaters (Hoeschele and Springer, 2005). The high cost is due to higher equipment costs and higher installation costs, which are in part due to the possibility that an on-demand water heater may require a larger diameter gas pipe because of their higher gas input rating. At the same time, the Energy Policy Act of 2005 contains a provision for tax incentives of 10 percent of the cost (up to $300) for water heaters with an Energy Factor of 0.80 or more, which many on-demand water heaters currently achieve. Coupled with rising steel prices that hit conventional water heater prices the hardest, the price gap between on-demand and conventional water heaters could narrow substantially in near future.

Another barrier to program efforts is that about half of purchasers of replacement water heaters report that they needed to replace the old water heater right away—within 48 hours (Bensch and Tannenbaum, 2002). Related to this are the barriers of installation contractors not taking the time to sell water heaters to homeowners, lack of contractor interest in promoting water heater conversions, and concerns that some installation contractors have with power-vented and on-demand water heaters (Global Energy Options, 2001).

Due to this set of barriers, a segment of end-users and installation contractors may not be as receptive to considering and proposing fuel conversions, or upgrades to power venting or on-demand options. Therefore, program efforts not only need to provide incentives to increase market acceptance but also incorporate education, training, and marketing efforts targeted to end-users, installation contractors, and retailers to increase awareness of the benefits to water heater fuel conversions and upgrades to power venting or on-demand options.

Furthermore, about a third of purchasers report installing the new water heater themselves (Bensch and Tannenbaum, 2002). This finding is consistent with research conducted by Global Energy Options (2001). Therefore, program efforts that target building supply retailers are needed to address this segment of the market.

Program Approaches

We model achievable potential estimates for program options to encourage (1) water heater fuel conversions from electric to gas/propane, (2) the installation of power-vented water heaters, and (3) the installation of on-demand water heaters. We do not include program options to encourage upgrades in the energy factor of replacement water heaters because of the Department of Energy's (DOE) recent decision not to establish ENERGY STAR criteria for domestic water heaters (Department of Energy, 2004). DOE's decision was based on the fact that there would be only small differences between the best-performing products and those just meeting the minimum Federal standard, which increased in January 2004, making an ENERGY STAR designation less meaningful. Further, although DOE, the Gas Technology Institute and two water heater manufacturers are working on a design for a high-recovery capacity condensing water heater for the residential market (Gas Technology Institute, 2003), there are no products currently available, and no data to indicate the incremental price beyond a standard water heater. We have therefore not included this technology in our achievable potential estimates, though we believe that this market bears watching.

Please refer to the technical documentation of this report for a detailed description of the inputs and outputs of the model for each of these three program areas.

PROGRAM AREA 23.01 – INCENTIVES FOR WATER HEATER PURCHASES – FUEL CONVERSIONS

This program area provides incentives to end-users and installation contractors to increase fuel conversions of water heaters from electric to gas/propane. This program area also incorporates education, training, and marketing efforts targeted to end-users, installation contractors, and retailers to increase awareness of the benefits to water heater fuel conversions. This type of integrated program approach is consistent with recommendations made as part of research conducted by Global Energy Options (2001).

TABLE 23.01.1. ESTIMATED VALUES FOR PROGRAM AREA 23.01—INCENTIVES FOR WATER HEATER PURCHASES—FUEL CONVERSIONS

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$301 to $1,106	$373 to $1,480
	Incremental Impacts	peak kW	206 to 781	262 to 1,075
		annual kWh (000s)	2,574 to 9,313	3,250 to 12,804
		annual therms (000s)	-210 to -52	-283 to -66
	Levelized resource cost	per peak kW	$67 to $161	$65 to $158
		per kWh	0.6¢ to 1.3¢	0.5¢ to 1.3¢
		per therm	NA to NA	NA to NA
Scaling factors[a]		program costs	1.5 to 5.4	1.5 to 5.4
		impacts	1.2 to 3.2	1.2 to 3.2

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

PROGRAM AREA 23.02 – INCENTIVES FOR WATER HEATER PURCHASES – POWER VENT/CLOSE THE HOLE

This program area provides incentives to end-users and installation contractors to increase the installation of power-vented water heaters. This program area also incorporates education, training, and marketing efforts targeted to end-users, installation contractors, and retailers to increase awareness of the benefits of power-vented water heaters. This type of integrated program approach is consistent with recommendations made as part of research conducted by Global Energy Options (2001).

TABLE 23.02.1. ESTIMATED VALUES FOR PROGRAM AREA 23.02— INCENTIVES FOR WATER HEATER PURCHASES—POWER VENT/CLOSE THE HOLE

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$311 to $1,072	$436 to $1,661
	Incremental Impacts	peak kW	-23 to -4	-36 to -5
		annual kWh (000s)	-212 to -46	-328 to -67
		annual therms (000s)	46 to 271	68 to 416
	Levelized resource cost	per peak kW	NA	NA
		per kWh	NA	NA
		per therm	19.8¢ to 80.6¢	19.1¢ to 78.3¢
Scaling factors[a]		program costs	1.1 to 5.5	1.0 to 5.5
		impacts	1.1 to 4.1	1.0 to 4.1

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

PROGRAM AREA 23.03 – INCENTIVES FOR WATER HEATER PURCHASES – ON-DEMAND/CLOSE THE HOLE

This program area provides incentives to end-users and installation contractors to increase the installation of on-demand water heaters. This program area also incorporates education, training, and marketing efforts targeted to end-users, installation contractors, and retailers to increase awareness of the benefits of on-demand water heaters and effect some degree of market transformation to overcome non-financial barriers to increased penetration of this technology. This type of integrated program approach is consistent with recommendations made as part of research conducted by Global Energy Options (2001).

TABLE 23.03.1. ESTIMATED VALUES FOR PROGRAM AREA 23.03— INCENTIVES FOR WATER HEATER PURCHASES—ON DEMAND/CLOSE THE HOLE

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		\$1,203 to \$3,857	\$2,074 to \$9,105
	Incremental Impacts	peak kW	-55 to -10	-127 to -18
		annual kWh (000s)	-502 to -125	-1,166 to -226
		annual therms (000s)	244 to 1,073	439 to 2,520
	Levelized resource cost	per peak kW	NA	NA
		per kWh	NA	NA
		per therm	17.0¢ to 59.3¢	16.8¢ to 58.6¢
Scaling factors[a]		program costs	0.8 to 2.3	0.8 to 2.3
		impacts	0.9 to 1.5	0.9 to 1.5

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Program Area 23.01 — Incentives for Water Heater Purchases—Fuel Conversions

Model inputs are summarized in the table below and described on the following pages.

TABLE 23.01.2. MODEL INPUTS FOR INCENTIVE FOR WATER HEATER PURCHASES – FUEL CONVERSIONS

Model Inputs (23.01)			**Value**	**±**
1		**Per-Unit Impacts**		
	a	Annual Electricity Savings (kWh)	3,680	400
	b	Demand Savings (Watts)	300	50
	c	Annual Gas Savings (Therms)	-78	10
2		**Program Participation**		
	a	Participants in Year 1	1,500	900
	b	Annual Increase in Participation	10%	5%
	c	Net-to-Gross Ratio	85%	15%
3		**Program costs**		
	a	Fixed Program Costs	$50,000	$35,000
	b	Variable Costs	$330	$110
4		**Measure life (years)**	30	5

1. Per Unit Impacts

Focus on Energy currently assigns electricity savings of 3,680 kWh ***(Input 1a)***, demand savings of 300 W ***(Input 1b)***, and gas savings of -194 therms to water heater fuel conversions from electricity to gas (Wisconsin Energy Conservation Corporation, 2002). The Focus on Energy values are reasonably consistent with electricity use and demand forecasts for electric water heaters prepared for the Advance Plan 7 process by the major utilities (Public Service Commission of Wisconsin, 1994).

For this analysis, we adjust the -194 therms estimate by 40 percent to account for the prevalence of conversions from electricity to propane (Bensch and Tannenbaum, 2002). This adjustment yields an estimate of -78 therms ***(Input 1c)***. We assign the electricity savings estimate an uncertainty of +/- 400 kWh, the demand savings estimate an uncertainty of +/- 50 W, and the gas savings estimate an uncertainty of +/- 20 therms.

2. Program Participation

In the 2003-04 program year, Focus on Energy paid incentives to 303 homeowners for converting their electric water heater to gas/propane (Focus on Energy Statewide Evaluation, 2005). Based on input from stakeholders, budget constraints limited program activity. Our analysis assumes about a fivefold increase in participation given increased levels of program funding and the inclusion of education, training, and marketing efforts targeted to end-users, retailers, and installation contractors to complement incentive offers targeted to end-users and installation contractors. This assumption yields 1,500 (+/- 900) participants ***(Input 2a)***. We also assume an annual (compound) increase in participation of 10 (+/- 5) percent per year ***(Input 2b)*****.** Because the incentives cover the majority of the incremental costs, it would be unlikely that there would be nonparticipant spillover/free driver effects. Therefore, we model the net-to-gross ratio so that it cannot exceed 100% (85 +/- 15 percent) (***Input 2c)***.

3. Program Costs

We assume the program in total, across the three program areas, has a total administrative cost of $150,000. This covers program manager and staff time as well as the education, training, and marketing efforts targeted to end-users, installation contractors, and retailers. We allocate these costs equally to each of the three program areas, which yield an annual administrative cost of $50,000 +/- $35,000 ***(Input 3a)*** for each program area.

According to research conducted by Global Energy Options (2001), the incremental cost to replace an electric water heater with a gas water heater, assuming no power venting, as opposed to another electric water heater is in the $300-$400 range. Given the barriers of high cost from the end-user perspective and lack of installation contractor interest in promoting water heater conversions identified by Global Energy Options (2001), we assume that incentives will need to cover most of the incremental cost in order to move this market. Therefore, we estimate the variable cost for the program at $330 +/- $110 ***(Input 3b)***: This reflects incentive levels of $300 with an additional $10 administrative cost per unit. The $300 incentive includes $200 to the end-user (which is equal to the incentive level offered by Focus on Energy during the 2003-04 program year) and an additional $100 to the installation contractor.

4. Measure Life

We assume a measure life of 30 (+/- 5) years commensurate with the remaining life of the house ***(Input 4)***. The logic is that once the effort is made to convert to natural gas/propane, it is extremely likely that all future water heaters installed will continue to use natural gas/propane

5. Model Outputs

Table 23.01.03 shows the key outputs from our model for this program area (Columns A-B) and compares these outputs to the size of the market (Columns D-E).

TABLE 23.01.3. MIDPOINT ESTIMATES OF PROJECTIONS FOR PROGRAM AREA 23.01—INCENTIVES FOR WATER HEATER PURCHASES—FUEL CONVERSIONS

Year	(A) Program Participants	(B) Program Induced	(C) Overall Market Size[1]	(D) Potential Fuel Conversions[2]	(E) Percent of Potential Accounted for by Program
1	1,500	1,275	84,000	13,440	11.2%
2	1,650	1,403	85,680	13,709	12.0%
3	1,815	1,543	87,394	13,983	13.0%
4	1,997	1,697	89,141	14,263	14.0%
5	2,196	1,867	90,924	14,548	15.1%
6	2,416	2,053	92,743	14,839	16.3%
7	2,657	2,259	94,598	15,136	17.6%
8	2,923	2,485	96,490	15,438	18.9%
9	3,215	2,733	98,419	15,747	20.4%
10	3,537	3,006	100,388	16,062	22.0%

[1] Based on 84,000 water heaters sold for existing homes during Year 1 and a 2 percent annual growth in sales
[2] Based on 16 percent of households have an electric water heater but also have natural gas or propane service for other end uses

The first output is a projection of the number of participants in each year (Column A). This is based on an assumption of 1,500 participants in Year 1 and a 10 percent compound annual growth in participation in subsequent years. We then estimate the number of participants that were program induced. This is equal to the number of participants multiplied by the net-to-gross ratio, which we assume at 85 percent. We then compare program participation to overall market activity. We estimate 84,000 water heaters installed for existing homes during Year 1 (Column C). This is based on approximately 7.5 percent of single-family homeowners purchasing a water heater each year, with about 80 percent of these for existing homes (Bensch and Tannenbaum, 2002 and 2004). Applying these estimates to the 1.4 million owner-occupied households in Wisconsin yields 84,000 water heaters sold annually to existing owner-occupied households in the Wisconsin market. We assume a two percent compound annual growth in installations in subsequent years. We then project the potential number of fuel conversions in the market (Column D) based on about 16 percent of households having an electric water heater but also having natural gas or propane service for other end uses (Pigg and Nevius, 2000). Finally, we estimate the percent of this potential that is accounted for by the program (Column E), which is the ratio of Column A to Column D. As the table shows, the program captures 11 percent of the potential in Year 1 and almost 22 percent in Year 10.

The estimates from Table 23.01.3 were used to derive estimates of program costs and impacts, which are presented in Table 23.01.1.

Program Area 23.02 — Incentives for Water Heater Purchases—Power Vent/Close the Hole

Model inputs are summarized in the table below and described on the following pages.

TABLE 23.02.2. MODEL INPUTS FOR INCENTIVES FOR WATER HEATER PURCHASES – POWER VENT/CLOSE THE HOLE

Model Inputs (23.02)			Value	±
1		**Per-Unit Impacts**		
	a	Annual Electricity Savings (kWh)	-50	20
	b	Demand Savings (Watts)	-5	3
	c	Annual Gas Savings (Therms)	60	35
2		**Program Participation**		
	a	Participants in Year 1	2,000	1,200
	b	Annual Increase in Participation	15%	5%
	c	Net-to-Gross Ratio	85%	15%
3		**Program costs**		
	a	Fixed Program Costs	$50,000	$35,000
	b	Variable Costs	$225	$60
4		**Measure life (years)**	30	5

1. Per Unit Impacts

We include some small negative electricity and demand impacts due to the vent motor of the power-vented water heater. We use impacts of -50 (+/- 20) kWh and -5 (+/- 3) W, respectively, for electricity and demand savings ***(Inputs 1a and 1b)***. This is based on Energy Center power draw tests on a limited number of water heaters and an estimated 5 percent annual duty cycle for a typical water heater (Pigg, 2005a).

Focus on Energy currently assigns 94 therms of space heating savings due to reducing water heater stack infiltration when switching to a power-vented water heater. These calculations are derived from engineering estimates based on assumptions about the size of the water heater flue, the height of the chimney, and the temperature difference between the bottom and the top of the chimney (Wisconsin Energy Conservation Corporation, 2002).

This estimate seems high to us, since it would represent more than 10 percent of total space heating energy consumption in a typical Wisconsin home that uses about 880 therms of natural gas annually for space heating (Pigg and Nevius, 2000). We therefore conducted our own assessment of these savings. Our approach was to use measured data on water heater flue draft during firing to estimate firing-cycle air flow through the flue, and then extrapolate this downward to off-cycle air flow when the temperature differential between the flue and outdoors is much less.

We started with measured water heater flue drafts for about 150 atmospheric water heaters tested as part of the Energy Center's energy and housing study (Pigg and Nevius, 2000). These data suggest a typical heating-season draft for a firing water heater of about 9 Pascals (0.037 inches of water column), suggesting about 40 cfm of airflow through a typical four-inch flue pipe (using standard sharp-edge orifice calculations). We estimate that during firing under typical winter conditions, there might be a 320

F° temperature difference between the flue gasses at the entrance to the stack and outdoor air at the top, compared to a 60 F° difference during the offcycle. Since stack-effect airflow is related to the square root of the temperature difference across the stack, this suggests off-cycle air flow of about $(60/320)^{1/2}$ that of a firing water heater, or about 17 cfm. Further calculations suggest a range of off-cycle airflow from about 12 to 24 cfm depending on outdoor temperature.

Further, we estimate that air that is drawn up the water heater flue is not fully conditioned in most cases, since it likely enters the home at the top of the foundation and moves across the (the relatively cold) basement floor. We assigned a range of 50 to 60 °F for the temperature of the air that enters the bottom of the water heater, depending on outdoor temperature. Combining the above flow rates and air temperatures in a bin analysis of Madison heating season outdoor air temperatures, results in about 25 therms of annual space heating energy.

Ultimately, we use a savings estimate of 60 therms and assigned this estimate an uncertainty of +/-- 35 therms so that it encompasses the above estimate of 25 therms on the low end and the Focus on Energy estimate of 94 therms on the high end ***(Input 1c)***.

2. Program Participation

In the 2003-04 program year, Focus on Energy paid incentives to 422 homeowners for installing power venting water heaters and closing the hole (Focus on Energy Statewide Evaluation, 2005). Based on input from stakeholders, budget constraints limited program activity. Our analysis assumes about a fivefold increase in participation given increased levels of program funding and the inclusion of education, training, and marketing efforts targeted to end-users, retailers, and installation contractors to complement incentive offers targeted to end-users and installation contractors. This assumption yields 2,000 (+/- 1,200) participants ***(Input 2a)***. We also assumed an annual (compound) increase in participation of 15 (+/- 5) percent per year ***(Input 2b)***. This growth rate is 5 percentage points higher than that for fuel conversions because power venting water heaters have not been promoted for as long as fuel conversions, and therefore have more potential for growth. Because the incentives cover the majority of the incremental costs, it would be unlikely that there would be nonparticipant spillover/free driver effects. Therefore, we model the net-to-gross ratio so that it cannot exceed 100% (85 +/- 15 percent) (***Input 2c)***.

3. Program Costs

We assume the program in total, across the three program areas, has a total administrative cost of $150,000. This covers program manager and staff time as well as the education, training, and marketing efforts targeted to end-users, retailers, and installation contractors. We allocate these costs equally to each of the three program areas, which yield an annual administrative cost of $50,000 +/- $35,000 ***(Input 3a)*** for each program area.

We estimate the variable cost for the program at $225 +/- $60 ***(Input 3b)***: This reflects a rebate level of about $200 with an additional $10 administrative cost per unit. The $200 incentive includes $150 to the end-user (which is equal to the incentive level offered by Focus on Energy during the 2003-04 program year) and an additional $50 to the installation contractor.

4. Measure Life

We assume a measure life of 30 (+/- 5) years commensurate with the remaining life of the house ***(Input 4)***. The logic is that closing the flue is a permanent change to the house.

5. Model Outputs

Table 23.02.3 shows the key outputs from our model for this program area (Columns A-B) and compares these outputs to the size of the market (Columns C-D).

TABLE 23.02.3. MIDPOINT ESTIMATES OF PROJECTIONS FOR PROGRAM AREA 23.02—INCENTIVES FOR WATER HEATER PURCHASES—POWER VENT/CLOSE THE HOLE

Year	(A) Program Participants	(B) Program Induced	(C) Overall Market Size[1]	(D) Percent of Market Accounted for by Program
1	2,000	1,700	84,000	2.4%
2	2,300	1,955	85,680	2.7%
3	2,645	2,248	87,394	3.0%
4	3,042	2,585	89,141	3.4%
5	3,498	2,973	90,924	3.8%
6	4,023	3,419	92,743	4.3%
7	4,626	3,932	94,598	4.9%
8	5,320	4,522	96,490	5.5%
9	6,118	5,200	98,419	6.2%
10	7,036	5,980	100,388	7.0%

[1] Based on 84,000 water heaters sold for existing homes during Year 1 and a 2 percent annual growth in sales

The first output is a projection of the number of participants in each year (Column A). This is based on an assumption of 2,000 participants in Year 1 and a 15 percent compound annual growth in participation in subsequent years. We then estimate the number of participants that were program induced. This is equal to the number of participants multiplied by the net-to-gross ratio, which we assume at 85 percent. We then compare program participation to overall market activity. We estimate 84,000 water heaters installed for existing homes during Year 1 (Column C). This is based on approximately 7.5 percent of single-family homeowners purchasing a water heater each year, with about 80 percent of these for existing homes (Bensch and Tannenbaum, 2002 and 2004). Applying these estimates to the 1.4 million owner-occupied households in Wisconsin yields 84,000 water heaters sold annually to existing owner occupied households in the Wisconsin market. We assume a two percent compound annual growth in installations in subsequent years. Finally, we estimate the percent of this potential that is accounted for by the program (Column D), which is the ratio of Column A to Column C. As the table shows, the program captures over 2 percent of the potential in Year 1 and 7 percent in Year 10.

The estimates from Table 23.02.3 were used to derive estimates of program costs and impacts, which are presented in Table 3.02.1.

Program Area 23.03 — Incentives for Water Heater Purchases—On-Demand/Close the Hole

Model inputs are summarized in the table below and described on the following pages.

TABLE 23.03.2. INCENTIVES FOR WATER HEATER PURCHASES – ON DEMAND/CLOSE THE HOLE

Model Inputs (23.03)			**Value**	**±**
1		**Per-Unit Impacts**		
	a	Annual Electricity Savings (kWh)	-50	20
	b	Demand Savings (Watts)	-5	3
	c	Annual Gas Savings (Therms)	105	50
2		**Program Participation**		
	a	Participants in Year 1	4,000	2,000
	b	Annual Increase in Participation	25%	10%
	c	Net-to-Gross Ratio	85%	15%
3		**Program costs**		
	a	Fixed Program Costs	$100,000	$25,000
	b	Variable Costs	$350	$100
4		**Measure life (years)**	30	5

1. Per Unit Impacts

We include some small negative electricity and demand impacts due to the vent motor of the on-demand water heater. We use impacts of -50 (+/- 20) kWh and -5 (+/- 3) W, respectively, for electricity and demand savings ***(Inputs 1a and 1b)***. This is based on Energy Center power draw tests on a limited number of water heaters and an estimated 5 percent annual duty cycle for a typical water heater (Pigg, 2005a).

The 105 therms savings estimate ***(Input 1c)*** includes 60 therms of savings from closing the hole (see Program Area 23.02 — Incentives for Water Heater Purchases—Power Vent/Close the Hole) and 45 therms of savings due to the elimination of standby losses from the installation of an on-demand water heater (Pigg, 2005b).

2. Program Participation

The future of the on-demand water heater market is difficult to predict. On the one hand, most consumers and plumbers are unfamiliar with the technology, which—although widely employed in other countries—is still rare in the U.S. On the other hand, the current high cost differential between on-demand and conventional water heaters (several hundred to a thousand dollars) will likely narrow substantially due to both the provision of a 10% tax credit (up to $300) in the Energy Policy Act of 2005, currently high steel prices that affect conventional water heaters more strongly than on-demand units, and reduced mark-ups as the technology becomes more prevalent. In addition, on-demand water heaters offer the promise of never running out of hot water, although these units do have quirks, such as a minimum flow rate below which the unit will not fire.

We have therefore assumed a relatively low program penetration at the outset with a higher (but uncertain) annual growth in participation over time. We anchor our starting point for this program area to program participation for the installation of power venting water heaters, a more mature technology relative to on-demand water heaters. We assume that the number of participants installing on-demand water heaters is half the number installing power venting water heaters. This assumption results in 4,000 (+/- 2,000) participants ***(Input 2a)***. We assume an annual (compound) increase in participation of 25 (+/- 10) percent per year ***(Input 2b).*** This growth rate is 10 percentage points higher than that for power venting water heaters. Because the incentives cover the majority of the incremental costs, it would be unlikely that there would be nonparticipant spillover/free driver effects. Therefore, we model the net-to-gross ratio so that it cannot exceed 100% (85 +/- 15 percent) (***Input 2c)***.

3. Program Costs

We assume the program in total, across the three program areas, has a total administrative cost of $150,000. This covers program manager and staff time as well as the education, training, and marketing efforts targeted to end-users, retailers, and installation contractors. We allocate these costs equally to each of the three program areas, which yields an annual administrative cost of $50,000 +/- $35,000 ***(Input 3a)*** for each program area.

We estimate the variable cost for the program at $350 +/- $100 ***(Input 3b)***: This reflects a rebate level of about $250 with an additional $10 administrative cost per unit. The $250 incentive includes $150 to the end-user (on top of the federal tax incentive available in 2006 and 2007) and an additional $100 to the installation contractor to help overcome the reluctance of many plumbers to adopt new technology.

4. Measure Life

We assume a measure life of 30 (+/- 5) years commensurate with the remaining life of the house ***(Input 4)***. The logic is that closing the flue is a permanent change to the house.

5. Model Outputs

Table 23.03.3 shows the key outputs from our model for this program area (Columns A-B) and compares these outputs to the size of the market (Columns C-D).

TABLE 23.03.3. MIDPOINT ESTIMATES OF PROJECTIONS FOR PROGRAM AREA 23.03—INCENTIVES FOR WATER HEATER PURCHASES—ON-DEMAND/CLOSE THE HOLE

Year	(A) Program Participants	(B) Program Induced	(C) Overall Market Size[1]	Market Penetration
1	1,000	850	84,000	1.2%
2	1,350	1,148	85,680	1.6%
3	1,823	1,549	87,394	2.1%
4	2,460	2,091	89,141	2.8%
5	3,322	2,823	90,924	3.7%
6	4,484	3,811	92,743	4.8%
7	6,053	5,145	94,598	6.4%
8	8,172	6,946	96,490	8.5%
9	11,032	9,378	98,419	11.2%
10	14,894	12,660	100,388	14.8%

[1] Based on 84,000 water heaters sold for existing homes during Year 1 and a 2 percent annual growth in sales

The first output is a mid-point projection of the number of participants in each year (Column A). This is based on an assumption of 1,000 participants in Year 1 and a 35 percent compound annual growth in participation in subsequent years. We then estimate the number of participants that were program induced. This is equal to the number of participants multiplied by the net-to-gross ratio, which we assume at 85 percent. We then compare program participation to overall market activity. We estimate 84,000 water heaters installed for existing homes during Year 1 (Column C). This is based on approximately 7.5 percent of single-family homeowners purchasing a water heater each year, with about 80 percent of these for existing homes (Bensch and Tannenbaum, 2002 and 2004). Applying these estimates to the 1.4 million owner-occupied households in Wisconsin yields 84,000 water heaters sold annually to existing owner occupied households in the Wisconsin market. We assume a two percent compound annual growth in installations in subsequent years. Finally, we estimate the market penetration for the technology (Column D), which is the ratio of Column A to Column C. As the table shows, the program captures a little more than 1 percent of the potential in Year 1 and over 7 percent in Year 10. The uncertainty built into these estimates are such that in Year 5, the market penetration ranges from 1.2% to 8.4% (90% probability range).

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MARKET 24 — NEW HOME CONSTRUCTION

Market Scope

This market focuses on the construction of single-family, owner-occupied housing. Potential estimates will be based on program options to encourage more efficient building shells and efficiency upgrades for hard-wired lighting fixtures.

Market Characteristics

About 25,000 new homes are typically constructed in Wisconsin each year. Though detailed statistics are difficult to come by, compared to some other states, Wisconsin appears to have relatively more homes built by small-volume builders and fewer homes built by large production builders. Information shared at the stakeholder discussions indicated that less than a dozen builders build more than 100 homes per year and that the majority of Wisconsin builders are custom builders who build 2-24 homes annually.

Focus on Energy has encouraged the construction of new homes with more efficient building shells since its inception in 1999 through the Wisconsin ENERGY STAR Homes (WESH) program. WESH works with homeowners, builders, and the building industry to construct homes that are more energy efficient than homes built to Wisconsin's Uniform Dwelling Code. The program is driven by independent consultants and regional coordinators who work directly with builders and their subcontractors to pay greater attention to construction details. Every home in the WESH program goes through a series of performance tests and must meet specific program standards before being certified.

In the 2003-04 Focus on Energy program year, about 250 builders completed about 1,500 homes that were WESH-certified (Talerico and Winch, 2005). Overall, about half of WESH builders certify only one home in a given year. For the upcoming 2005-06 program year, WESH will provide a subsidy of up to $260 toward defraying the cost of certification by the independent consultants under the program. The consultants set their own fees, which typically range between about $650 and $1,000.

An Energy Center study of differences in gas and electricity use in new Wisconsin homes suggested that the WESH homes use about 100 therms less natural gas than comparable non-program homes (Pigg, 2002). The study showed no statistically significant difference in electricity use at that time. In addition to natural gas savings, the adoption of WESH building practices results in potential non-energy benefits that accrue to both the homeowner and the builder. These include potential improvements to the home's comfort, safety, and durability, as well as possible reductions in costs to the builder due to decreased callbacks and/or more efficient construction practices.

Finally, discussions at the stakeholder meetings suggested that builders are not the most effective market channel for programs to target in order to increase the installation of energy efficient appliances, central air conditioners (CACs), and furnaces in new homes. Rather, retailers are the most effective market channel to target for appliances because the purchase decision is made by the homeowner; and HVAC contractors are the most effective market channel to target for CACs and furnaces because HVAC contractors influence the builder's decision on the types of HVAC equipment to install. Given this view of the market, the new home construction market analysis focuses solely on more efficient building shells and efficiency upgrades for hard-wired lighting fixtures. Analysis of appliances, central air conditioners, and furnaces installed in new homes are addressed in their respective markets (Market 29 for clothes washers, Market 20 for CACs, and Market 19 for furnaces).

Program Approaches

Our analysis of this market focuses on program efforts to increase the market share of new homes that have more efficient building shells and efficiency upgrades for hard-wired lighting fixtures. The program efforts are modeled closely after the 2005-06 WESH program (discussed in the Market Characteristics section above). The approach not only relies on incentives paid to builders to subsidize the extra cost of working with WESH consultants but also provides builders education and training opportunities and cooperative advertising.

Based on information provided by the WESH program manager, potentially effective program efforts include promoting ENERGY STAR Designated Advanced Lighting Packages to larger scale builders who typically purchase lighting via contract sales and developing relationships with lighting manufacturers, distributors and retailers who are better positioned to influence the majority of lighting decisions being made on the showroom floor (Nahn, 2005). Accordingly, the analysis models a program approach based on these program efforts.

PROGRAM AREA 24.01 — INCENTIVES FOR NEW HOMES

Our analysis of the achievable potential is based on Focus on Energy evaluation results, which quantified the impact of WESH on the new construction market (Talerico and Winch, 2005). We have assumed continued growth in this market, resulting in both an increase in the number of direct participants in the program as well as broader market effects beyond immediate participants. Please refer to the technical documentation of this report for a detailed description of the inputs and outputs of the model for this program area.

TABLE 24.01.1. ESTIMATED VALUES FOR PROGRAM AREA 24.01, INCENTIVES FOR NEW HOMES

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$1,210 to $3,055	$1,710 to $4,762
	Incremental Impacts	peak kW	7 to 54	13 to 101
		annual kWh (000s)	103 to 732	186 to 1,386
		annual therms (000s)	78 to 684	147 to 1,126
	Levelized resource cost	per peak kW	$2,353 to $17,102	$1,954 to $13,203
		per kWh	17.5¢ to 112.4¢	14.5¢ to 89.2¢
		per therm	18.5¢ to 136.7¢	17.3¢ to 107.2¢
Scaling factors[a]		program costs	0.5 to 2.2	0.4 to 2.2
		impacts	0.6 to 1.5	0.5 to 1.5

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

Program Area 24.01 — Incentives for New Homes

Model inputs are summarized in the table below and described on the following pages.

TABLE 24.02.2. MODEL INPUTS FOR INCENTIVES FOR NEW HOMES

Model Inputs (24.01)			Value	±
1		**Per-Unit Impacts**		
	a	Annual Gas Savings Per EE New Home (Therms)	100	68
	b	Annual Electricity Savings Per EE Lighting Fixture (kWh)	82.8	10
	c	Coincident Summer Peak Demand Savings Per EE Lighting Fixture (Watts)	5.9	2
2		**Annual # of New Homes Constructed in WI (Size of Overall Market)**		
	a	Year 1 (000's)	25,000	5,000
	b	Annual Compound Growth Rate in New Home Construction	3%	1%
3		**Market Share of EE Homes (Share of Overall Market)**		
	a	EE Market Share	12%	5%
	b	Annual Percentage Point Increase in EE Market Share	3%	2%
	c	Baseline EE Market Share	5%	5%
	d	Annual Percentage Point Increase in Baseline Market Share	0.5%	0.5%
4		***Program Participation***		
	a	Percent of EE Homes Incented through Program	90%	5%
	b	Annual Percentage Point Decrease in Percent of EE Homes Incented through Program	1%	1%
	c	Percent of EE Homes Installing EE Lighting Fixtures	15%	10%
	d	Annual Percentage Point Increase in EE Homes Installing EE Lighting Fixtures	1%	1%
	e	Number of EE Fixtures Installed in EE Homes Installing EE Lighting Fixtures	5	3
5		**Program costs**		
	a	Incentive Per EE Home	$445	$120
	b	Incentive Per EE Lighting Fixture	$25	$10
	c	Other Program Costs (000s)	$50,000	$25,000
6		**Measure life (years)**		
	a	**Homes**	50	10
	b	**Lighting Fixtures**	25	5

1. Per Unit Impacts

We use Focus on Energy's estimate of 100 therms for natural gas savings resulting from the adoption of building practices that lead to a more energy efficient (EE) building shell ***(Input 1a)***. This estimate is based on an Energy Center study of differences in gas and electricity use in new Wisconsin homes. (Pigg, 2002). We assign this estimate an uncertainty of +/- 68 therms based on the 90 percent confidence interval from the study.

We derive annual electricity savings from the installation of EE lighting fixtures using the formula below.

kWh Savings = (Watts Saved /1,000) x (Daily Hours of Operation x 365 Days) x Installation Rate

We use Focus on Energy's estimate of 84 W for Watts saved (Focus on Energy Statewide Evaluation, 2002). This estimate assumes a fixture that contains two 18 W CFLs as opposed to two 60 W incandescent light bulbs.

Focus on Energy has used an estimate of 3.4 hours for daily hours of operation. This estimate was selected not because it is rooted in current research but rather because it is has been historically used in Wisconsin. The Focus on Energy evaluation team is currently in the process of adjusting this estimate to 2.7 hours based on a review of recently conducted metering studies (Winch and Talerico, 2005). Therefore, we use 2.7 hours rather than the 3.4 historical-based estimate for the model.

Because the fixtures are hard-wired and can only accept CFLs, we use 100 percent as our installation rate estimate.

Applying these estimates to the formula above yields an annual electricity savings estimate of 82.8 kWh [(84/1,000) x (2.7 x 365) x 1.00)] ***(Input 1b)***. We assign this estimate an uncertainty of +/- 10 kWh.

We derive coincident summer peak demand savings (in Watts) using the formula below.

Peak Demand Savings = Watts Saved x Summer Peak Coincidence Factor x Installation Rate

We use 84 W and 100 percent for Watts saved and the installation rate, respectively (see discussion above for rationale).

The Focus on Energy evaluation team is also currently in the process of adjusting the summer peak coincidence factor to 7 percent (Winch and Talerico, 2005). We use this estimate as the summer peak coincidence factor for the model.

Applying these estimates to the formula above yields a coincident summer peak demand savings estimate of 5.9 W (84 x 0.07 x 1.00)] ***(Input 1c)***. We assign this estimate an uncertainty of +/- 2 W.

2. Annual Number of New Homes Constructed in WI (Size of Overall Market)

We use an estimate for overall market size of 25,000 (+/- 5,000) new homes constructed in Year 1 ***(Input 2a)***. We assume an annual compound growth rate of 3 (+/-1) percent ***(Input 2b)***. (DOC, 2003.)

3. Market Share of EE New Homes (Share of Overall Market)

Our analysis of the achievable potential is based on Focus on Energy evaluation results, which quantified the impact of WESH on the new construction market (Talerico and Winch, 2005).

Table shows annual WESH program activity. The number of WESH-certified homes has grown from 321 in program year 2000-01 to a projection of 3,000 in 2005-06. The projection of 3,000 homes for 2005-06 represents 12 percent of the 25,000 housing starts estimated in Year 1 (2006). Based on this, we estimate that energy efficient new homes will comprise 12 (+/-5) percent of housing starts in Year 1 ***(Input 3a).*** We also assume that this market share will increase by 3 (+/-2) percentage points annually ***(Input 3b)***.

TABLE 24.01.3. TRENDS IN WISCONSIN ENERGY STAR HOMES AND ANNUAL HOUSING STARTS

Program Year	Number of Homes Certified through WESH
2000-01	321
2001-02	678
2002-03	824
2003-04	1,490
2004-05	1,901
2005-06	3,000[1]

[1] Projections based on discussions with program manager (Nahn, 2005)

Our analysis also needs to account for the baseline market share of energy efficient homes (i.e., market share in the absence of program activity). Unfortunately, we have no quantitative information available on which to base this estimate. The Frequently Asked Questions (FAQ) section of the program website, however, states that "Most builders are already doing a majority of the building practices that are required by the Wisconsin ENERGY STAR Homes program. Usually, builders only need to address minor changes to their practices" (Focus on Energy Website, 2005). Weighing this perspective in light of no quantitative information available, we use 5 (+/- 5) percent as our estimate of baseline market share ***(Input 3c)***. We assume that the baseline market share will increase by 0.5 (+/- 0.5) percentage points annually ***(Input 3d).***

4. Program Participation

Finally, our analysis needs to account for the percent of energy efficient homes that are incented through the program. Again, we have no quantitative information available on which to base this estimate. We use 90 percent as our estimate ***(Input 4a)*** and assign this estimate an uncertainty of +/- 5 percent. Broader market effects outside the program are accounted for in the remaining 10 percent of energy efficient homes. This covers (1) former participating builders who no longer certify their homes but have continued implementing practices learned from the program and (2) builders who have never certified a home through WESH but have improved their practices as a result of WESH-related education and training. The analysis also accounts for growth in broader market effects over time due to the market transformation-related aspects of the program. This is modeled by decreasing the percent of energy efficient homes that are incented through the program by 1 (+/- 1) percentage point per year (i.e., the percent outside the program increases by 1 percentage point each year) ***(Input 4b)***.

Now that we have accounted for the number of energy efficient homes built in the market and through the program, we need to address the installation of energy efficient lighting fixtures in these homes.

Based on information provided by the WESH program manager, potentially effective program efforts include promoting ENERGY STAR Designated Advanced Lighting Packages to larger scale builders who typically purchase lighting via contract sales and developing relationships with lighting manufacturers, distributors and retailers who are better positioned to influence the majority of lighting decisions being made on the showroom floor (Nahn, 2005). Accordingly, the analysis models a program approach based on these program efforts.

During the 2003-2004 program year, six builders built 30 or more homes. We use the activity of these builders to represent program activity that is comprised by larger-scale builders. In all, these six builders accounted for half of the homes built through the program during the year (759 out of 1,490). We use this as an upper bound on the potential percent of energy efficient homes that will have energy efficient lighting fixtures installed. Of course, the program is not likely to induce all of these homes from the onset. Assuming a starting point of roughly 30 percent of the potential targeted homes having energy efficient lighting fixtures installed in Year 1, we would expect 15 percent (30 percent installed x 50 percent potential) of all energy efficient homes built in Year 1 to have energy efficient lighting fixtures installed ***(Input 4c).*** We assign this estimate an uncertainty of +/- 10 percent. With regard to growth in this share over time, we assume an annual percentage point increase of 1 percent +/- 1 percent ***(Input 4d).*** Finally, we assume that 5 energy efficient lighting fixtures will be installed in the homes in which energy efficient lighting fixtures are installed ***(Input 4e).*** We assign this estimate an uncertainty of +/- 3 fixtures.

5. Program Costs

We estimate program costs based on input from the Focus on Energy program manager (Nahn, 2005). For the upcoming 2005-06 program year, WESH will provide a subsidy of up to $260 toward defraying the cost of certification by the independent consultants under the program. We use this—with an additional $185 in variable program costs—as the energy efficient home incentive amount for our analysis ***(Input 5a)***. We assign this estimate an uncertainty of +/- $40. In the past, WESH has provided an incentive of $10 per energy efficient lighting fixture. Because research conducted by Faesy et al. (2004) indicates that builders have been reluctant to install ENERGY STAR Designated Advanced Lighting Packages because of incremental costs and the desire to ensure consumer choice and minimize callbacks (i.e., the fixtures can only accommodate a CFL so if a customer is dissatisfied, it takes an electrician and a replacement fixture to resolve), we use a higher incentive amount of $25 per fixture for the analysis ***(Input 5b)***. We assign this estimate an uncertainty of +/- $10. We also assumed an additional $50,000 +/- $25,000 for other fixed program costs ***(Input 5c)***.

6. Measure Life

For both energy efficient new homes and lighting fixtures, we assume long measure lives and use an estimate of 50 years +/- 10 years for new homes ***(Input 6a)*** and 25 years +/- 5 years for lighting fixtures.

7. Model Outputs

Table 24.01.4 shows the key outputs from our model. We provide a brief overview of the outputs in the paragraph following the table.

TABLE 24.01.4 MIDPOINT ESTIMATES OF PROJECTIONS FOR PROGRAM AREA 24.01, INCENTIVES FOR EE HOMES

Year	(A) Market Size	(B) EE Homes	(C) Baseline	(D) Program Induced	(E) Program Incented	(F) Spillover (Broader Market Effects)	(G) Net-to-Gross Ratio	(H) EE Fixtures
1	25,000	3,000	1,250	1,750	2,700	300	65%	2,250
2	25,750	3,863	1,416	2,446	3,438	425	71%	3,090
3	26,523	4,774	1,591	3,183	4,201	573	76%	4,058
4	27,318	5,737	1,776	3,961	4,991	746	79%	5,163
5	28,138	6,753	1,970	4,783	5,808	945	82%	6,415
6	28,982	7,825	2,174	5,651	6,651	1,174	85%	7,825
7	29,851	8,955	2,388	6,567	7,523	1,433	87%	9,403
8	30,747	10,146	2,613	7,533	8,422	1,725	89%	11,161
9	31,669	11,401	2,850	8,551	9,349	2,052	91%	13,111
10	32,619	12,722	3,099	9,623	10,304	2,417	93%	15,266

The first output is a projection of the overall size of the Wisconsin home construction market in each year (Column A). We then project the market share of EE homes in Wisconsin and apply this share to the overall size of the Wisconsin market (Column A) to estimate the number of EE homes built in the Wisconsin market (Column B). We also project the baseline market share of EE homes in Wisconsin and apply this share to the overall size of the Wisconsin market (Column A) to estimate the number of EE homes built in Wisconsin in the absence of the program (Column C). Next, we estimate the number of EE homes that were program induced (Column D). This is equal to Column B minus Column C. We then project the percent of EE homes built in Wisconsin that are incented through the program and apply this share to the number of EE homes built in Wisconsin (Column B) to generate the number of EE homes incented through the program (Column E). Spillover (Column F), which accounts for broader market effects, is equal to the number of EE homes in the market (Column B) minus the number incented by the program (Column E). We then estimate the net-to-gross ratio (Column G), which is equal to the ratio of Column D to Column E. Finally, we estimate the percent of EE homes that have EE lighting fixtures installed and the average number of fixtures installed to project the number of EE lighting fixtures installed (Column H).

The estimates from Table 24.01.4 were used to derive estimates of program costs and impacts presented in Table 24.01.1.

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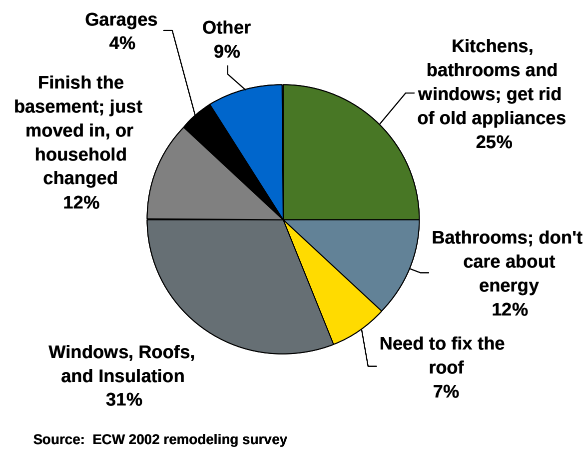
Market Scope

This market encompasses homeowners undertaking a remodeling project. Energy efficiency potential considered here is limited to building shell improvements, such as adding insulation and air sealing. Replacement of mechanical systems and appliances are considered in other markets in this study.

Market Characteristics

Home remodeling is big business in Wisconsin. Survey data suggest that at any point in time, about 10 percent of Wisconsin homes are undergoing some sort of remodeling project costing $5,000 or more. That translates into more than 117,000 single-family homes being remodeled in a given year. Over a ten-year period, nearly three-quarters of Wisconsin homes are remodeled—with some undergoing multiple projects.

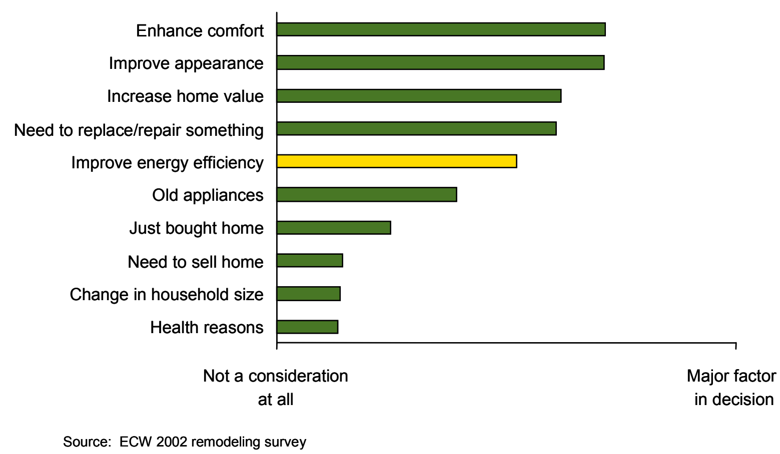
FIGURE 25.01.1. SEGMENTATION OF REMODELING ACTIVITIES AND MOTIVATORS.



The term 'remodeling' comprises a wide variety of home improvements and repairs—with a range of energy efficiency opportunities. And often more than one area of the home is addressed within the same project. Figure 25.01.1 shows one segmentation of the remodeling market in terms of activities undertaken and motivators for those activities.

An Energy Center survey of homeowners engaging in remodeling projects found, on average, energy efficiency to be less important than improving comfort and home resale value when it comes to remodeling (Figure 25.01.2) (Pigg, 2002). But average rankings disguise the fact that energy efficiency is a major motivator for about a quarter of those surveyed (and not at all a motivator for another quarter).

FIGURE 25.01.2. MOTIVATORS FOR REMODELING.



Window replacement is a key activity among those motivated to save energy when remodeling (driven, some would say, by advertisements with misleading savings predictions). However, the window market is already dominated by energy efficient products, so there is little remaining potential from promoting efficient windows.

On the other hand, research has shown that homeowners are often not aware of—or are misinformed about—significant insulation and air sealing opportunities in their homes. In the Energy Center's energy and housing study of single-family homes, more than half of homeowners whose homes were judged to be inadequately insulated by auditors conducting on-site inspections stated on a survey that their home was adequately- or well-insulated (Pigg and Nevius, 2000).

Nearly half of remodeling projects in Wisconsin homes do not involve using contractors of any kind, though this varies depending on the nature of the project: contractors are least likely to be used for decks and basement remodels, and most likely to be used when siding or mechanical system replacement is involved. A recent survey of home remodeling in California estimated that the do-it-yourself segment constituted 30 percent of the remodeling market (Primen, 2001).

The program approach taken by Focus on Energy in the last three years—through the Home Performance with ENERGY STAR® program—has been to link independent private-sector energy efficiency consultants with remodeling contractors and trade allies to establish networks in which contractors routinely include energy assessments as part of their work. This arrangement is intended to reduce callbacks and liability for contractors, as well as provide them with a marketing edge. The program currently has 36 consultants (many of whom also work on ENERGY STAR certification of new homes). Focus on Energy subsidizes the cost of the assessment, and provides rebates to homeowners for implementing measures under the program. In the most recent program year (2003/04), energy efficiency assessments were done on about 2,500 homes. Of these, about 60 percent resulted in at least one shell efficiency improvement being made. Assessments are linked to program incentives for implementing various shell measures. Attic insulation, sidewall insulation and air sealing led the list of implemented measures, accounting for more than 80 percent of estimated savings from the program.

Finally, the Federal Energy Policy Act of 2005 contains provisions for tax credit incentives up to $500 for undertaking insulation and other envelope improvements in existing homes. This could serve as a stimulus for homeowners to undertake such improvements, and well as providing for a larger income base for consultants who operate in the field, given the certification standards that are yet to be worked out in detail.

Program Approaches

PROGRAM AREA 25.01 — INTEGRATED ENERGY ASSESSMENTS IN REMODELING

This program area extends the current Focus on Energy approach of building networks of private energy efficiency consultants and contractors with the intent of making energy efficiency improvements a routine practice in home remodeling. We have assumed a significant—but realistic—expansion in the number of energy efficiency consultants around the state, with a concomitant increase in the number remodeling projects affected by the program. By our assessment, such efforts could lead to shell improvements on 10,000 to 20,000 homes per year by the end of our ten-year analysis period.

TABLE 25.01.1. ESTIMATED VALUES FOR PROGRAM AREA 25.01 – INTEGRATED ENERGY ASSESSMENTS IN REMODELING

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		\$2,480 to \$3,724	\$4,439 to \$6,678
	Incremental Impacts	peak kW	776 to 1,552	1,422 to 2,827
		annual kWh (000s)	929 to 1,852	1,710 to 3,392
		annual therms (000s)	782 to 1,542	1,433 to 2,818
	Levelized resource cost	per peak kW	\$175 to \$431	\$171 to \$421
		per kWh	14.5¢ to 36.2¢	14.1¢ to 35.4¢
		per therm	17.5¢ to 43.1¢	17.1¢ to 42.2¢
Scaling factors[a]		program costs	1.0 to 2.4	1.0 to 2.4
		impacts	1.0 to 1.5	1.0 to 1.5

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

Program Area 25.01 — Integrated Energy Assessments in Remodeling

TABLE 25.01.2 MODEL INPUTS FOR INTEGRATED ENERGY ASSESSMENTS IN REMODELING

Model Inputs (25.01)			Value	±
1		**Per-Unit Impacts (unit = one home)**		
	a	Gas savings per participant (Year 1), therms/year	250	50
	b	Electricity savings per participant (Year 1), kWh/year	300	60
	c	Demand savings per participant (Year 1), peak Watts	250	50
2		**Program Participation**		
	a	Participants in Year 1	1500	500
	b	Annual increase in participation	1500	250
	c	net-to-gross ratio	1.00	0.25
3		**Program costs**		
	a	annual training costs	$150,000	$30,000
	b	variable program costs	$650	$100
4		**Measure life (years)**		
	a	Measure life (years)	25	10

1. Per Unit Impacts

Deemed savings from the Focus on Energy Home Performance with ENERGY STAR program are currently estimated at about 400 therms and 1,000 kWh per participating household implementing at least one shell measure (Newman, 2005). Program tracking data indicate that three measures account for more than 80 percent of the program aggregate impacts as shown in Table 25.01.3 below.

TABLE 25.01.3. IMPLEMENTATION RATE AND CONTRIBUTION TO TOTAL DEEMED SAVINGS FOR TOP THREE MEASURES UNDER HOME PERFORMANCE WITH ENERGY STAR.

	Approximate implementation rate	% of program deemed savings
Sidewall insulation	40%	45%
Attic insulation	80%	25%
Air sealing	80%	15%

These program deemed savings estimates—which are based on engineering heat loss calculations for individual measures and are blended averages across heating fuels and air conditioning types—have not been verified in the field. Our review of the measure-level savings estimates suggests that at least some of the savings estimates could be on the optimistic side. In particular, Home Performance with ENERGY STAR is credited with savings of 433 therms for sidewall insulation in homes with natural gas heat (Global Energy Options, 2003). This estimate is considerably higher than the range of 150-200 therms that has been estimated from analysis of pre- and post-weatherization utility billing data for several low-income weatherization programs (Blasnik, 1999; Dalhoff and Associates, 2003; Pigg and Hasselman, 2002), and is also higher than the average of 250 therms per home estimated as part of the Energy Center's energy and housing study (Pigg and Nevius, 2000). Differences in home size do not fully explain this discrepancy, as the average insulated area of about 1,300 square feet per home for Home Performance with ENERGY STAR participants is about the same as that for participants in the Wisconsin weatherization program.

For the purposes here, we have assumed that attic insulation saves an average of 100 +/- 40 therms in the 80 percent of homes where this measure is implemented, and that wall insulation saves an average of 225 +/- 50 therms in the 50 percent of participant homes where it is installed. In addition, about 80 percent of homes that implement at least one measure are credited with air sealing savings, with a blower-door measured leakage reduction of about 800 cfm @ 50 Pascals. We assume that these homes have an additional savings of about 70 +/- 30 therms. Together, these three measures yield a blended average of about 250 +/- 50 therms per home ***(Input 1a)***.

In addition, the current deemed savings estimates assume that on average 95 percent of participant homes have gas heat and 5 percent have electric heat, based on proportions in the general housing stock. However, the high cost of electric heat—as well as more stringent code requirements—means that most electrically heated homes are already well insulated and therefore unlikely to be participants in Home Performance with ENERGY STAR. This assertion is borne out by the 10 or so electrically heated homes in the Energy Center's energy and housing study, none of which were judged to have opportunities for additional wall or ceiling insulation. Data on heating fuel for the relatively few homes in the program that receive full home energy ratings also suggest that insulation upgrades in electrically heated homes are at best rare (Newman, 2005).

While the assumption of 95 percent gas heat and 5 percent electric heat has only a minor effect on the estimated average gas savings from the program, by introducing a small percentage of homes with large electricity impacts it roughly doubles the average electricity impacts compared to an assumption that electricity savings are restricted to furnace fan and air conditioning impacts in gas-heated homes. For example, the assumption of 5 percent electric heat reduces the deemed average gas savings for wall insulation from 433 to 411 annual therms per participant, but it increases the deemed electricity savings from 593 to 1,113 kWh per year.

For electricity impacts from the program used here, we have assumed that a negligible proportion of participants have electric heat, which roughly halves the deemed electricity savings. We also prorated these remaining electricity savings—which arise from reduced air conditioner use and furnace electricity consumption—according to the difference between our estimates of therm savings and the program deemed savings (225/400). These adjustments result in roughly 300 kWh per year for average electricity impacts, to which we have assigned an uncertainty of +/- 60 kWh ***(Input 1b)***.

We extended the analysis to summer peak demand savings by multiplying our estimate of kWh savings by 0.85, which is the ratio of peak demand impacts to annual kWh impacts for wall insulation from the program deemed savings calculations (after removing the five percent electric space heat assumption). This yields an estimate of about 250 Watts per home, to which we assigned an uncertainty of +/- 50 Watts ***(Input 1c)***.

We have not incorporated savings potential from window replacement in our assessments. While windows are a key energy efficiency item in the eyes of many homeowners, in fact the payback is relatively long in strict energy savings terms. Moreover, one industry expert's assessment is that most if not all products currently on the market in Wisconsin are efficient, double-pane products with low-e coatings (DePaola, 2005). There does not therefore appear to be significant potential at this time in terms of either increasing the proportion of homeowners who replace windows or upgrading the efficiency of replacements that occur.

2. Program Participation

We estimate the maximum achievable annual program participation for this approach to be in the range of about 10,000 to 20,000 households per year. We derive this figure starting with Wisconsin's roughly 1.3 million single-family homes and an estimate that 10 percent are remodeled each year, based on a telephone survey conducted by the Energy Center on behalf of Focus on Energy in 2002 (Pigg 2002). The same survey further suggests that about half of remodeling projects involve a contractor of some kind, resulting in an estimated 65,000 homes remodeled with the assistance of an outside contractor each year.

We then further estimate that the program might be able to build relationships with contractors working in perhaps half of these homes, and that between a quarter and a half of these homes might have shell measure opportunities and homeowners amenable to implementing them. Rounded, these estimates work out to about 10,000 to 20,000 participants per year. Note that even at this rate it would take many years to address all of the estimated one-third of older single-family homes that the Energy Center's energy and housing study suggest have opportunities for air sealing or wall or ceiling insulation.

Achieving this level of participation would require a significant increase in the pool of energy efficiency consultants operating in the state, and this may be the factor that most limits the achievable potential. In the most recent complete program year (2003/04), 36 energy efficiency consultants working with about 50 contractors and other trade allies resulted in about 1,600 home assessments, of which about 1,000 resulted in implementation of at least one shell measure. We assume about 1,500 participants for Year 1 of our analysis ***(Input 2a)***.

We have assumed training of an additional 60 consultants per year, of which 40 become established and begin to build a network of contractor relationships (the latter assumption presumes that efforts can be made to decrease somewhat the percentage of training graduates who do not become active consultants—a figure that is currently about 50 percent). Some of these consultants would establish networks in parts of the state that are un-served or under-served by the current pool of consultants, and others would join forces with established consultants to expand their capacity.

We also assume a gradual increase in the proportion of homes that implement recommendations, from the current 60 percent to 75 percent after five years. This might be effected through methods such as increased use of infrared imaging, which has been shown to increase the likelihood that homeowners will implement shell measures (Derome et al., 2004).

Overall, these trends suggest an annual increase of about 1,500 +/- 250 program participants per year throughout our 10-year analysis period ***(Input 2b)***—about double the current rate of program expansion. This rate of program expansion would result in about 55,000 to 90,000 total participants over the 10-year period, with 12,000 to 17,000 annual participants by Year 10.

We also assigned a net-to-gross ratio of 1.0 +/- 0.25 to the program ***(Input 2c)***. It is likely that some insulation improvements implemented under the program would have been done anyway, but it is also plausible that as more contractors participate in the program, it may precipitate additional shell improvement activity beyond that tracked by the program.

3. Program Costs

Program costs can be divided into training costs, fixed administrative and marketing costs, and variable participant costs.

Training
Consultants under the program are required to complete an 8-day training course. Based on the $30,000 budget in the most recent program year to train two classes of 15 consultants each, we estimate the annual cost to train 60 new consultants a year to be approximately $60,000 per year. There are also program costs related to mentoring new consultants in the field, which we estimate at $1,000 to $2,000 per consultant. We have therefore estimated the total annual cost of training and mentoring new consultants at $150,000 +/- $30,000 per year ***(Input 3a)***.

Variable program costs
Based on current incentive levels and measure installation rates, we estimate the average variable program cost per participant to be on the order of $650 +/- $100 ***(Input 3b).***

4. Measure Life

There is no inherent limit on the life of insulation or air sealing measures. However, it is reasonable to assume that these measures would be undertaken at some point even in the absence of the program. We therefore set the life of the impacts due to the program at 25 +/- 10 years.

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MARKET 26 — RESIDENTIAL DEHUMIDIFIER PURCHASE MARKET

Market Scope

This market comprises purchases—and early retirement—of dehumidifiers by residential homeowners and renters.

Market Characteristics

Wisconsin's humid summers and preponderence of basements means that Wisconsin has a relatively high saturation of dehumidifiers. While nationally less than 20 percent of households have a dehumidifier, the proportion is closer to two-thirds for Wisconsin homeowners (and nearly one in five among renters), adding up to about one million dehumidifiers in Wisconsin homes. The majority of these units are reported by survey respondents to be used all summer long.

A federal ENERGY STAR® labeling program for dehumidifiers was initiated in 2001, and appears to have quickly taken hold of the market: nationally, the ENERGY STAR market share is estimated at more than 80 percent (a separate estimate puts the 2003 market share for the upper Midwest at between 53 and 77 percent). There is also reported to be little or no price difference between a conventional dehumidifier and an ENERGY STAR labeled unit. Moreover, the recently enacted Federal Energy Policy Act of 2005 establishes a minimum efficiency standard for dehumidifiers equivalent to the current ENERGY STAR qualifying level starting in October 2007.

Current estimates suggest that a new ENERGY STAR labeled dehumidifier will use 15 to 20 percent less electricity than a comparable conventional new unit to remove the same amount of moisture. Although models with much higher efficiencies exist—including one model for which Focus on Energy rebates are available—these are high capacity (and high cost) units that likely represent a very small share of the market (as reflected in the small number of units rebated by Focus on Energy).

The market for dehumidifiers is similar to that of room air conditioners in many respects: products are mostly ordered by retailers in the fall and purchased by consumers during the summer. The main purchase criteria are moisture removal capacity, price and availability.

It has been noted that, while dehumidifiers contribute to summer electrical system peak demand, there is no inherent reason that they need to be operating during peak hours. Strategies to shift dehumidifier load to off-peak hours could thus reduce system peak demand.

Program Approaches

From the standpoint of state-level efforts, it appears that the market is naturally evolving to the higher efficiency level represented by the current ENERGY STAR standard, and that no higher ENERGY STAR benchmark will be established in the near future. We have therefore estimated achievable potential on the basis of programs to accelerate the retirement of older units and mitigate the impact of dehumidifiers on peak load.

PROGRAM AREA 26.01 — BOUNTY FOR EARLY RETIREMENT OF DEHUMIDIFIERS

This program approach is comparable to that proposed for room air conditioners—homeowners (and renters) would receive cash incentives for turning in older operable dehumidifiers with proof of purchase of a new ENERGY STAR labeled unit. For increased cost effectiveness, we envision this program being paired with a room air conditioner bounty program that would also take advantage of a retailer network that addresses retail lighting, clothes washers and other appliances.

We have assumed participation levels (and program costs) that are comparable to those assumed for the room air conditioner bounty program (Program Area 22.01), since the estimated number of older dehumidifiers in the state is comparable to that for room air conditioners. In contrast to early retirement of room air conditioners, we have assumed savings from dehumidifiers only during the early-replacement period. Given the high market share for efficient units, in all likelihood, participants who turn in an older dehumidifier would eventually purchase an ENERGY STAR labeled unit without program intervention.

TABLE 26.01.1. ESTIMATED VALUES FOR PROGRAM AREA 26.01 — DEHUMIDIFIER TURN-IN PROGRAM.

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		\$297 to \$735	\$332 to \$844
	Incremental Impacts	peak kW	213 to 1,307	242 to 1,496
		annual kWh (000s)	527 to 2,019	597 to 2,325
		annual therms (000s)	0	0
	Levelized resource cost	per peak kW	\$161 to \$1,376	\$160 to \$1,368
		per kWh	10.6¢ to 63.4¢	10.5¢ to 62.9¢
		per therm	NA	NA
Scaling factors[a]		program costs	0.1 to 0.9	0.1 to 0.9
		impacts	0.1 to 0.9	0.1 to 0.9

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

PROGRAM AREA 26.02 — NON-DISPATCHABLE LOAD CONTROL OF DEHUMIDIFIERS

The concept for this program area is that a timer (or some other non-dispatchable device) is permanently attached to a dehumidifier to prevent it from operating during system peak hours. Since dehumidifiers themselves are plug-in appliances, the installation of these devices would likely require skilled labor. The program approach considered here assumes tapping into HVAC contractor visits to homes for installation and maintenance of air conditioners and furnaces.

TABLE 26.02.1. ESTIMATED VALUES FOR PROGRAM AREA 26.02 — NON-DISPATCHABLE LOAD CONTROL OF DEHUMIDIFIERS.

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$89 to $632	$91 to $1,048
	Incremental Impacts	peak kW	113 to 1,598	137 to 2,667
		annual kWh (000s)	0	0
		annual therms (000s)	0	0
	Levelized resource cost	per peak kW	$74 to $511	$70 to $475
		per kWh	NA	NA
		per therm	NA	NA
Scaling factors[a]		program costs	0.3 to 1.7	0.1 to 1.6
		impacts	0.4 to 1.6	0.1 to 1.5

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

The two Energy Center characterization studies (Pigg and Nevius, 2000; Pigg and Price, 2005) provide a basis for estimates for the statewide saturation of portable dehumidifiers among homeowners and renters (Table 26.01.2). These estimates are in reasonable agreement with saturations reported by the major utilities in the Advance Plan – 7 (AP-7) process (PSCW, 1994), which range from about 44 percent to 71 percent for single-family homes and 14 to 30 percent for households in multifamily buildings.

When combined with Census 2000 data, the total saturations for Wisconsin are about 870,000 dehumidifiers in single-family owner-occupied homes, and 82,000 tenant-owned units in rental households.

TABLE 26.01.2. SURVEY DATA ON SATURATION, OWNERSHIP AND USE OF DEHUMIDIFIERS IN WISCONSIN.

		Single-family Homeowners	Renters
Households with a dehumidifier		64%	18%
Who provided it?	Tenant		69%
	Landlord		31%
How much is it used?	Rarely	11%	12%
	Part of the summer	24%	40%
	All summer long	65%	48%

Sources: (Pigg and Nevius, 2000; Pigg and Price, 2005)

Program Area 26.01 — Bounty program for dehumidifiers

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 26.01.3. MODEL INPUTS FOR BOUNTY PROGRAM FOR DEHUMIDIFIERS

Model Inputs (26.01)			Value	±
1		**Per-Unit Impacts (unit = one dehumidifier)**		
	a	savings over an existing unit	20%	5%
	b	annual energy consumption of an existing unit (kWh)	600	300
	c	diversified peak demand for an existing unit (kW)	0.35	0.25

2		**Program Participation**		
	a	Turn-in events in Year 1	8	2
	b	Compounded annual increase in events (Years 2-3)	75%	25%
	c	Average number of units turned in per event	400	100
3		**Program costs**		
	a	Fixed program costs Year 1	$25,000	$3,000
	b	Cost per turn-in	$60	$15
4		**Measure life (years)**		
	a	Years until existing unit would have been replaced	3	2

1. Per Unit Impacts

ENERGY STAR labeled dehumidifiers in the typical capacity range used in Wisconsin homes (about 20 to 40 pints/day) are required to have a moisture removal efficiency of 1.2 to 1.3 liters per kWh or more (EPA, 2005a). The average efficiency of currently-listed models in this size range is 1.36 liters per kWh (EPA 2005b). The current energy savings calculator on the ENERGY STAR web site lists the moisture removal efficiency of a conventional 20-pint dehumidifier as 1.10 liters per kWh and that of a 40-pint model as 1.1817 liters/kWh (EPA 2005c). Comparing the average of these figures to the average of ENERGY STAR qualified models produces an estimate of about 16 percent savings for an ENERGY STAR labeled unit. These savings can also be expressed in terms of the reduction in the amount of electricity used per pint of moisture removed: approximately 0.06 kWh/pint.

The savings above are relative to a new conventional unit. However, because there are no standards for dehumidifier energy efficiency, we take these estimates to also be representative of replacing an older dehumidifier in good working order. At the same time, it has been noted that older units may be more subject to freeze-up problems (in which the dehumidifier operates continuously but no moisture removal occurs) (Deforest, 2004). We therefore increased the average estimated savings to 25 percent with an uncertainty of +/- 5 percentage points ***(Input 1a)***.

Annual electricity savings in kWh terms are a function of how much the average dehumidifier operates. In this regard, there is no lack of estimates, but little in the way of empirical data for this highly variable end use. Zogg and Alberino (1998) compiled estimates of annual dehumidifier energy consumption from around the nation: these ranged from under 200 kWh per year to nearly 3,000 kWh per year. Only one of these sources (a cited Central Maine Power Company study) appears to have involved actual metering. That study showed dehumidifier consumption of 324 kWh per month, which Zogg and Alberino extrapolated to 1,620 kWh per year assuming three months of summer-season cooling at the full CMP value, and three additional months at half this amount. However, in a recent docket, CMP testified that 638 kWh/year was a reasonable estimate of annual dehumidifier energy use (Maine Public Utilities Commission, 2003).

The Association of Home Appliance Manufacturers (AHAM) also publishes a dehumidification selection guide (AHAM, nd.) for moisture removal capacity. For a typical Wisconsin basement (1,000 square feet), the guide estimates 17 pints of moisture removal per day under "very damp" conditions. Using the 1.1817 liters/kWh figure from above, this works out to about 350 kWh per month, a figure that is reasonably consistent with the monthly CMP value above. For three months of operation, this would work out to slightly more than 1,000 kWh of annual consumption, a range that is reasonably consistent with estimates for a 20-pint conventional unit from the energy savings calculator on the ENERGY STAR web site (944 kWh/year)—though the calculator assumes six months of operation at a duty cycle of 67 percent. This number is also consistent with an estimate published by the Department of Energy (DOE, 2005).

On the other hand, utility estimates of annual dehumidifier energy consumption in single-family homes filed under AP-6 and AP-7 ranged from 300 to more than 700 kWh (PSCW, 1991 and 1994), considerably less than the above figures. It may be that the former are predicated on full seasonal use, while the latter incorporate the fact that not all dehumidifiers are used all summer long (see Table 26.01.2).

In the absence of better information, we estimate the annual energy use of a conventional dehumidifier to be 600 +/- 300 kWh per year ***(Input 1b)***.

The power draw for a typical home dehumidifier has been estimated at about 600 Watts (USDOE, 2005). Estimates by the major Wisconsin utilities (for AP-6 and AP-7) of the average peak demand of a dehumidifier ranged from less than 100 to more than 600 Watts (PSCW, 1991 and 1994), implying a diversified demand factor of anywhere between 15 and 100 percent. We assume 350 +/- 250 Watts for diversified demand of an existing dehumidifier to span the range of these estimates ***(Input 1c)***. Peak demand savings from turn-in are then calculated by applying the percentage savings figure above by this diversified demand.

2. Program Participation

A dehumidifier turn-in program would likely be bundled with a room air conditioner turn-in program (see Program Area 22.01). We therefore use the same assumptions as used in the latter program, which is modeled on conducting weekend turn-in events coupled with the purchase of a new unit during the spring and early summer.

We assume that a Wisconsin statewide program would sponsor 6 to 10 turn-in events in the first year of operation ***(Input 2a)***, but that the number of events per year could be increased by 50 to 100 percent per year over the next two years before leveling off at about 25 events per year thereafter ***(Input 2b)***.

We further assume that an average turn-in event would yield about 400 +/- 100 dehumidifiers ***(Input 2c)***, resulting in a mid-point estimate of about 10,000 turn-ins per year after the ramp-up period. These estimates exclude units that are not associated with the purchase of a new unit.

3. Program Costs

Since, it is likely that room air conditioners and dehumidifiers would both be targeted for turn-in events, fixed costs are shared across the similar Program Area 22.01 for room AC turn-ins. We assumed an annual fixed program cost of $25,000 +/- $3,000 ***(Input 3a)***. Based on estimates from Van de Grift

(2005), the cost of a weekend turn-in event with about 500 appliance turn-ins is about $30,000, a figure that translates to about $60 per turned-in appliance ***(Input 3b)***.

4. Measure Life

The EPA estimates the lifetime of a dehumidifier at 11 years ***(***EPA, 2004), comparable to that assumed for room air conditioners. We thus assume a 3-year period of early-replacement savings ***(Input 4a)***, comparable to that used for room air conditioners. We assume no savings beyond the early replacement period, as the high market share for Energy Star qualified units indicates that most consumers would have purchased an Energy Star labeled unit anyway. Moreover, the recently enacted Federal Energy Policy Act of 2005 establishes a minimum efficiency level for dehumidifiers that is equivalent to the current Energy Star standard starting in October 2007.

Program Area 26.02 — Non-dispatchable load control for dehumidifiers

The concept for this program area is that a timer (or some other non-dispatchable device) is permanently attached to a dehumidifier to prevent it from operating during system peak hours. Since dehumidifiers themselves are plug-in appliances, the device would need to have battery back-up to maintain the correct time of day.

Model inputs for this program area are summarized in the table below, and are described on the following pages.

TABLE 26.02.2. MODEL INPUTS FOR NON-DISPATCHABLE LOAD CONTROL FOR DEHUMIDIFIERS

Model Inputs (26.02)			**Value**	**±**
1		**Per-Unit Impacts (unit = one dehumidifier)**		
	a	diversified peak demand for an existing unit (kW)	0.35	0.25
2		**Program Participation**		
	a	Year 1 participants	600	400
	b	Compounded annual increase in participation (Years 2-5)	100%	75%
3		**Program costs**		
	a	Program startup costs	$100,000	$50,000
	b	variable costs	$150	$25
4		**Measure life (years)**		
	a	assumed life (years)	5	3

1. Per-Unit Impacts

We assume 350 +/- 250 Watts for the diversified demand of an existing dehumidifier, as discussed under Market 26.01 ***(Input 1a)***. This is the assumed load that is avoided by shifting dehumidifier operation to off-peak hours. We assume here that there are no electrical energy savings from this program effort.

2. Program Participation

Stakeholder discussion related to this program area centered on two possible approaches: getting manufacturers or retailers to attach some sort of timer or other load-shift device to dehumidifiers before selling the unit, or having HVAC contractors install a device on dehumidifiers that are already in homes. We consider the latter route to be the more viable of the two.

The number of annual participants is thus limited to the number of homes visited by HVAC contractors in a given year, which we conservatively estimate to be about six percent of single-family owner-occupied households, or about 80,000 households. If half of the HVAC contractors in the state could be enrolled to participate in the program, and if two-thirds of the households they visit have dehumidifiers, and if about one in three of these homeowners could be convinced to participate in the program, the annual number of participants would be on the order of about 10,000 for a mature program. We assume a relatively modest starting point of 600 +/- 400 participants in Year 1 ***(Input 2a)***, with a 100 +/- 75 percent compounded increase for Years 2-5 ***(Input 2b)***, leading to a mid-point estimate of 9,600 participants per year by Year 5.

Our analysis assumes that none of these customers would otherwise implement this measure on their own, and that no program-induced activity would occur other than that of the program participants. These assumptions might be violated among the small number of customers on time-of-day rates, but we consider the associated errors to be much smaller than other uncertainties in the analysis.

3. Program Costs

While off-the-shelf technology appears to be available for the actual timed control of the devices (Deforest 2005), we assume program startup costs of about $100,000 +/- $50,000 would be required to determine a tamper-proof method to attach the devices to a dehumidifier, and to set up the program ***(Input 3a)***.

The variable costs of the program include the material and labor cost of the load control devices, incentives to induce contractor and homeowner participation, and variable program administrative costs. We estimate these to be $150 +/- $25 per participant ***(Input 3b)***.

4. Measure life

We estimate the life of the measure to be a relatively modest 5 +/- 3 years ***(Input 4a)***, both due to the short life of dehumidifiers in general and to the fact that it can be expected that some proportion of consumers will disable or remove the devices prior to the end of the unit's life.

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MARKET 27 — RESIDENTIAL DIRECT INSTALL MARKET (FORMERLY HOT WATER SAVERS)

Market Scope

This market comprises the direct installation of energy-saving equipment in single-family homes and rental units. Equipment to be installed may include low-flow showerheads, faucet aerators, compact fluorescent light bulbs, and pipe insulation. This market also includes consumer information initiatives to urge consumers to turn down hot water thermostats.

Market Characteristics

The direct install market is not a market in an economic sense, but a collection of low-cost measures that energy efficiency programs have commonly promoted by replacing inefficient equipment with more efficient alternatives in people's homes. These programs have been implemented throughout the country at various times – many of them by utilities as part of demand side management efforts. These programs generally offer several measures free of charge to home owners and/or renters, but the programs have varied somewhat in the measures they offer, the target audience, and program approaches.

The most commonly installed measures in direct install programs are compact fluorescent light bulbs (CFLs) and measures that reduce the energy required for water heating. CFLs use approximately one-third the electrical energy of incandescent light bulbs, and last much longer before they need to be replaced. Nevertheless, they constitute a minority of the light bulbs in use in Wisconsin households. In 2000, CFLs represented about five percent of the light bulbs in use in single-family homes in the state (Pigg and Nevius, 2000). In the past, some consumers have expressed dissatisfaction with the quality of the light emitted by CFLs, and some lighting fixtures do not leave enough space for these light bulbs. However, recent rebate programs have resulted in the sale of large numbers of CFLs in Wisconsin and some other states.

Depending on the fuel used by the water heater, water-related measures can save either natural gas, electricity, or a different fuel. These measures include:

- Low-flow showerheads;
- Low-flow faucet aerators;
- Pipe wrap insulation;
- Water heater insulation; and
- Water heater temperature reductions.

Low-flow showerheads and faucet aerators both reduce the amount of hot water used and, thereby, the amount of energy required to heat that water. Federal standards have reduced the flow rate of new showerheads to 2.5 gallons per minute (gpm), but previously installed showerheads can allow a greater flow rate. In owner-occupied homes in Wisconsin, for example, the Energy Center's Energy and Housing Study found that a quarter of showerheads exceeded a flow rate of 2.5 gpm (Pigg and Nevius, 2000). Stakeholders have indicated that showerheads exist with flow rates as low as 1.5 gpm, but suggest that a program should use models with flow rates of 2.0 gpm because they still offer acceptable performance.

Faucet aerators reduce the amount of running water drawn from kitchen or bathroom faucets by reducing the flow rate of those faucets. Approximately 73 percent of water drawn from these faucets is hot water that was previously heated. A study in Seattle found that low flow faucet aerators installed into homes reduced the hot water usage from 8.6 to 7.7 gallons per person per day (Mayer, 2000).

Pipe wrap and water heater insulation both reduce the loss of thermal energy by water that has been heated by a water heater. Pipe wrap reduces heat loss through hot water pipes, both while hot water is flowing through the pipes and while the water heater is storing hot water for future use. Most pipes in homes are not insulated.

Water heater insulation reduces heat loss from hot water stored in the heater's tank. Past direct install programs have wrapped a blanket of insulation around the water heater tank, but increased internal insulation in new water heaters have made this measure less imperative. Stakeholders recommended against including water heater insulation in our modeling of a direct install program.

Excessive temperature settings in a water heater's thermostat also increase the heat losses from the water heater while storing hot water. From the perspective of home occupants, however, safety is a primary reason for turning temperatures down to the generally recommended temperature setting of 120 degrees Fahrenheit. Temperatures that are substantially higher pose a scalding risk for household occupants, especially children and the elderly. However, the Energy and Housing Study found that 23 percent of owner-occupied single-family homes in Wisconsin had their hot water heater set at 135 degrees or more (Pigg and Nevius, 2000). Some direct install programs adjust this temperature, although an accurate adjustment may require a second visit to measure the newly established temperature.

Target audiences for direct install programs have often been lower-income households. Opportunities to save energy through these measures are slightly higher in the housing typically occupied by lower income households (Pigg and Nevius, 2000), but the savings opportunities also exist in households in general.

Direct install programs can be implemented in either owner-occupied houses or rental units in multi-family buildings, but program approaches need to address the varying implementation issues posed by these housing types. Owner-occupied, single-family homes offer a wide range of potential measures, but require the permission of each individual home's owner to conduct the direct installations. Multi-family units offer economies of scale because a single property manager can provide access to multiple units, but some measures (e.g., pipe wrap insulation) may not apply in some kinds of buildings.

Programs for owner-occupied and rental housing, therefore, need to be structured differently. Past program approaches for owner-occupied housing have tended to follow one of two models: broad-based marketing with a dispatch of installers or mobile teams that market locally and canvass neighborhoods. Programs for multi-family housing need to approach apartment managers, operators, or owners. These programs can be administered alongside other programs for multi-family housing.

Program Approaches

Our analysis of this market includes three different program efforts – two for owner-occupied and one for rental housing. All three program efforts are based on direct installation of energy-saving devices, but the entree into owner-occupied and rental homes differ.

PROGRAM AREA 27.01 — DIRECT INSTALL THROUGH PARTNERS / OWNER-OCCUPIED HOUSING

As suggested by participants in our stakeholder meeting for this market, we modeled a program approach based on one or more partnerships with social service or similar agencies that already make home visits. In exchange for an incentive, these agencies would add direct installations of selected items when they visit homes. Because these agencies are most likely to visit lower-income households and those with elderly residents, these groups are also the most likely ones for this program to reach. The measures that are installed would depend on the arrangements with the participating social service agencies. We presume that CFL installations and screening for water heaters that are set too high would occur in nearly all homes. The other measures might not be performed by all partnering agencies or be feasible in all homes. Table 27.01.1 shows the measures by assumed frequency.

TABLE 27.01.1. DIRECT INSTALL MEASURES BY ASSUMED FREQUENCY OF INSTALLATION

Nearly All Households	**Majority of Households**	**Minority of Households**
Install 2 CFLs in high-usage fixtures	Replace showerhead(s)	Install pipe wrap insulation
Measure water temperature setting and provide information on how to adjust	Install aerator in kitchen faucet	

TABLE 27.01.2. ESTIMATED VALUES FOR PROGRAM AREA 27.01, DIRECT INSTALL THROUGH PARTNERS / OWNER-OCCUPIED HOUSING

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$203 to $354	$190 to $300
	Incremental Impacts	peak kW	51 to 136	45 to 107
		annual kWh (000s)	566 to 1,341	500 to 1,050
		annual therms (000s)	45 to 107	39 to 83
	Levelized resource cost	per peak kW	$222 to $573	$242 to $620
		per kWh	2.3¢ to 5.1¢	2.5¢ to 5.5¢
		per therm	20.4¢ to 48.8¢	22.0¢ to 51.6¢
Scaling factors[a]		program costs	0.6 to 3.2	0.7 to 3.3
		impacts	0.7 to 2.6	0.7 to 2.6

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

PROGRAM AREA 27.02 — DIRECT INSTALL BY PROGRAM STAFF / OWNER-OCCUPIED HOUSING

To complement a partner-based program, we also modeled a traditional direct install program run by an energy-efficiency program. In most respects this program is similar to the partner-based program, but it uses program staff who go door-to-door in rotating geographic areas. As a result, the costs will be higher and the success rate at gaining access to a home may be lower. However, the potential number of homes available to this program is much higher than to the sister program that relies on partnerships.

TABLE 27.02.1. ESTIMATED VALUES FOR PROGRAM AREA 27.02, DIRECT INSTALL BY PROGRAM STAFF / OWNER-OCCUPIED HOUSING

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$976 to $3,293	$1,170 to $4,089
	Incremental Impacts	peak kW	103 to 423	126 to 526
		annual kWh (000s)	1,122 to 4,313	1,379 to 5,344
		annual therms (000s)	74 to 277	91 to 344
	Levelized resource cost	per peak kW	$642 to $1,575	$635 to $1,560
		per kWh	6.5¢ to 14.0¢	6.4¢ to 13.8¢
		per therm	66.6¢ to 146.7¢	65.8¢ to 145.6¢
Scaling factors[a]		program costs	0.6 to 3.3	0.6 to 3.3
		impacts	0.7 to 3.1	0.7 to 3.1

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

PROGRAM AREA 27.03 — DIRECT INSTALL / RENTAL HOUSING

For the rental market, we assume a program that offers direct installations to owners and operators of buildings with five or more units. Traveling teams of program staff would identify multi-family building owners from property tax records, contact owners and operators to offer the program, and conduct installations. If requested, program staff would also visit the multi-family building owner or operator to display and demonstrate the equipment they would be installing. The teams would cover a region at a time to keep travel time and expenses to a minimum.

TABLE 27.03.1. ESTIMATED VALUES FOR PROGRAM AREA 27.03, DIRECT INSTALL / RENTAL HOUSING

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$393 to $894	$254 to $767
	Incremental Impacts	peak kW	414 to 818	258 to 705
		annual kWh (000s)	5,152 to 8,059	3,054 to 7,116
		annual therms (000s)	149 to 246	90 to 216
	Levelized resource cost	per peak kW	$78 to $230	$78 to $230
		per kWh	0.7¢ to 2.0¢	0.7¢ to 2.0¢
		per therm	16.1¢ to 45.5¢	16.1¢ to 45.5¢
Scaling factors[a]		program costs	1.2 to 2.6	1.2 to 2.6
		impacts	1.1 to 1.5	1.1 to 1.5

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

Program Area 27.01 — Direct Install through Partners / Owner-Occupied Housing

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 27.01.3. MODEL INPUTS FOR DIRECT INSTALL THROUGH PARTNERS / OWNER-OCCUPIED HOUSING

Model Inputs (27.01)			Value	±
1		**Homes Visited**		
	a	number of program partners	3	2
	b	unique homes per partner program – initial	25,000	10,000
	c	unique homes added per partner program per year	3,725	1,500
	d	partnership search (years)	2	1
	e	program ramp-up period – existing customers (years)	4	1
2		**Installations per Visit**		
	a	showerhead	0.7	0.2
	b	faucet aerator	0.7	0.2
	c	CFL	3.6	0.2
	d	pipe wrap	0.25	0.2
	e	water heater – share needing temperature reduction	0.23	0.05
	f	water heater – share of needed changes implemented	0.4	0.2
3		**Per-Item Impact (natural gas – therms)**		
	a	share of homes using natural gas for water heating	62%	7%
	b	showerhead	14	2
	c	faucet	3.4	0.5
	d	CFL	0	0
	e	pipe wrap	5	0.5
	f	water heater temperature	15	1.5
4		**Per-Item Impact (electricity – kWh)**		
	a	share of homes using electricity for water heating	28%	5%
	b	showerhead	250	25
	c	faucet	76	20
	d	CFL	44	6
	e	pipe wrap	98	10
	f	water heater temperature	270	27
5		**Program costs**		
	a	fixed costs	$100,000	$25,000
	b	variable costs (per home visited)	$25	$5
6		**Measure life (years)**		
	a	showerhead	10	3

	b	faucet aerator	3	2
	c	CFLs	5	2
	d	pipe wrap	10	3
	e	water heater temperature setting	5	1
7	a	**Demand Conversion Ratio ($W_{summer\ peak}/kWh_{annual}$)**		
	a	CFLs	0.0885	0.0328
	b	water-saving measures	0.1	0.03
8		**Proportion of program costs**	55%	10%

1. Homes Visited

The number of homes visited depends on the number of partnerships formed with organizations that regularly visit homes, the number of customers they serve when the partnership is formed, and the stream of homes that are newly served by the partner program.

Finding feasible partnerships may be a challenge. In our search for potential partnerships, we found a small number of organizations that make regular home visits to a large number of the households they serve. The vast majority of these organizations have missions that are far removed from energy, which presents a bit of a hurdle, and many are decentralized, which makes coordination and effective partnerships difficult. Some, like Meals on Wheels, use large numbers of volunteers that each conduct a small number of visits and even instruct their volunteers (in at least some administrative jurisdictions) not to enter people's homes out of liability concerns. Organizations or programs cited by stakeholders or identified through our search include:

- Meals on Wheels;
- Home health visits;
- The Volunteer Senior Home Repair Program
- Foster care visits;
- Adoption services; and
- The Community Options Program.

Obtaining counts of unique homes visited by any of these programs is difficult. We found an indication that the federal Food & Nutrition Service provided 5,539,610 meals in Wisconsin in fiscal year 2001 (USDA). At one meal per day, that would amount to about 150,000 people served if every customer stayed in the program for the entire year. However, that number includes meals served in congregate settings at senior centers and other institutional facilities as well as meals provided to single family homes through Meals on Wheels. However, liability concerns may preclude some or even many of these homes from being reached through a partnership with the program.

One other potential program, the Community Options Program, served 25,197 unique clients in 2002 with a case closure rate of 15 percent (Department of Health & Family Services, 2002). We assume (but did not verify) constant caseloads, which would mean a rate of new cases that equals 15 percent of the total caseload. Using this program as a model, we assume that a partnership could result in instant access to about 25,000 homes with a stream of 3,725 new homes per year.

Because the search of a potential partner will encounter the challenges described above and the need to train large numbers of providers, we assume that substantial program activity would not begin for two years. Once it does, we assume it will take four years to visit existing clients. New clients would be visited immediately.

2. Installations per Visit

Under our assumed program approach, partnering program staff would attempt to install one showerhead, one kitchen faucet aerator, an average of four compact fluorescent bulbs, and pipe wrap insulation in each new home visited. In addition, they would check the hot water temperature. For those homes where the water temperature is set at 135 degrees Fahrenheit or above, program staff would leave information that would seek to inform, enable, and cause the homeowner to reduce the water temperature to 120 degrees.

The rate at which the visits will result in actual installation by the program staff and temperature reductions by homeowners will fall short of these goals because:

- Not every program staff will take the time on every visit to attempt energy-related installations that are secondary to the primary purpose of the in-home visit;
- Installations will not always be feasible or sufficiently easy for minimally trained staff of non-energy programs; and
- Some homeowners will not want some measures to be installed.

Table 27.01.4 shows the installation rates per visit that we assume and the barriers we think will reduce implementation rates from their theoretical maximum.

TABLE 27.01.4. INSTALLATION RATES PER VISIT AND BARRIERS TO INSTALLATION

Measure	**Assumed Installations per Visit**	**Barriers**
showerhead	0.7	*ease of access to shower; motivation by program staff to enter homeowner's bathroom; reluctance by homeowner to have program staff work in bathroom; inability to easily remove existing showerhead; program staff who choose not to participate or do not have time on a particular visit*
faucet aerator	0.7	*reluctance by homeowner to alter the flow rate of the kitchen faucet; inability by program staff to install quickly; program staff who choose not to participate or do not have time on a particular visit*
CFLs	3.6	*reluctance of homeowner to have CFLs installed; lack of accessible fixtures; program staff who choose not to participate or do not have time on a particular visit*
pipe wrap	0.25	*lack of easy access to hot water pipes; reluctance of program staff or homeowner to have staff working in basement or near location of water heater; program staff who choose not to participate or do not have time on a particular visit*
water heater temperature	0.23 (identification) 0.4 (implementation)	*Identification rate based on the Energy and Housing Study findings; implementation rate reduced by time and follow-through of homeowner.*

We did not model testing of showerheads before replacement to ensure that only showerheads with sufficiently high flows are replaced. A program may incorporate such testing into its process. Modeling this step would complicate our computations, but we believe it would have relatively small effects on our results of our analysis because the lower number of showerhead replacements generally would be offset by larger savings per unit replaced. The biggest effect would be on program costs, which would decrease by the cost of showerheads that would not need to be installed. However, those costs are relatively minor. (See program costs assumptions below.)

3 & 4. Per-Item Impact

The Energy Center's Energy and Housing Study provides most of the input and assumptions for the per-unit impact of the installed measures (Pigg and Nevius, 2000). These include the following inputs and those in Table 27.01.5:

- Water heating fuel (natural gas - 62 percent, electricity – 28 percent, other - remainder);
- Natural gas savings from a 1 gallon-per-minute flow rate decrease from 3.5 to 2.5 in showerheads (30 therms);
- Electric savings from a 1 gallon-per minute flow rate decrease from 3.5 to 2.5 in showerheads (550 kWh);
- Distribution of showerhead flow rates (see Table 27.01.5);
- Natural gas savings from a water heater temperature reduction to 125 degrees Fahrenheit (1 therm per year per degree);
- Electricity savings from a water heater temperature reduction to 125 degrees Fahrenheit (18 kWh per year per degree).

TABLE 27.01.5. DISTRIBUTION OF SHOWERHEAD FLOW RATES

% of showerheads	deviation from 2 gpm	weighted deviation from 2 gpm
2%	-1.0	-0.02
2%	-0.5	-0.01
2%	-0.25	-0.005
23%	0	0
5%	0.25	0.0125
45%	0.5	0.225
3%	0.75	0.0225
18%	1.0	0.18
3%	1.75	0.0525
	avg deviation from 2 gpm	0.4575

<u>Showerhead Impact Calculations:</u>

Showerhead impact (for each natural gas showerhead): 30 therms (for flow rate decrease of 1 gpm from 3.5 to 2.5) * 0.4575 (avg decrease in flow rate) = 14 therms per showerhead replaced

Showerhead impact (for each electric showerhead): 550 kWh (for flow rate decrease of 1 gpm from 3.5 to 2.5) * 0.4575 (avg decrease in flow rate) = 250 kWh

Faucet Aerator Impact Calculations:

In a study in Seattle (Mayer, 2000), the installation of faucet aerators resulted in a statistically insignificant decrease in hot water usage from 8.6 gallons per capita per day (gcd) to 7.7 gcd. Using 2.67 people per household (Census 2000) and kitchen faucet usage to account for half of total hot water faucet usage, these numbers translate to a savings from 11.48 gallons per day (gpd) to 10.28 gpd, or 1.2 gpd. This amounts to approximately 440 gallons per year, although with a high uncertainty, as indicated by the statistical insignificance of the underlying study.

The amount of energy required to heat 440 gallons of water equals:

440 gal * 1 cal/mL-K * 3800 ml/gal * 3.97 Btu/1000 cal * 1 K/1.8 F * 70 F = 258,138 Btu

For a natural gas water heater with a recovery efficiency of 0.78, this amounts to 3.4 therms (258,138 Btu * 1 therm/100,000 Btu / 0.78). For an electric water heater, this amounts to 76 kilowatt-hours (258,138 Btu * 1 kWh/3,412 Btu).

CFL Impact Calculations:

Our estimate of the impact of CFL installations is based on the estimate described in market 17 – retail lighting – with one adjustment. We excluded the installation rate portion of the calculation shown in the market 17 documentation because our installations per visit account for the number of CFLs actually installed. This amounts to 44 kWh per year for each installed CFL.

Pipe Wrap Insulation Impact Estimate:

Our estimate of the impact of pipe wrap insulation is based on an evaluation of Iowa's low-income weatherization program, which estimated effects of 5 therms or 98 kilowatt-hours per year (Dalhoff, 2003).

Water Heater Thermostat Turn-Down Impact Calculations:

Thermostat turn-down impact (for each natural gas water heater): 15 degrees (avg temp reduction) * 1 therm/degree/year = 15 therms/year

Thermostat turn-down impact (for each electric water heater): 15 degrees (avg temp reduction) * 18 kWh/degree/year = 270 kWh/year

5. Program Costs

Fixed Costs: Because of the highly decentralized nature of many potential partner programs and their possible reluctance to divert in-home time to energy installations, we anticipate a high degree of effort required to establish viable partnerships. For this reason, we assume an initial need for a full-time program staff person to build the relationships. Thereafter, the program would need a half-time person to maintain the relationships and manage the program and another half-time person to conduct local training throughout the state. We assume fully loaded costs of $100,000 per full-time staff.

Variable Costs: The variable costs associated with the program depend on the number of homes visited. For each home, the program will need to pay an incentive to the partner program and fund the cost of the materials used. We are assuming a $15 incentive and $10 materials cost per home visited. Materials costs are based on the experience of the Focus on Energy multi-family program (based on $2 per CFL, $2.25 per showerhead, and $0.50 per faucet aerator) (Jenkins, 2005).

6. Measure Life

For this program approach measure life is a function of the technical longevity of the installed measure and how long homeowners are willing to keep it. Table 27.01.6 lists the measure life we assume and the basis of these assumptions.

TABLE 27.01.6 MEASURE LIFE ASSUMPTIONS

Measure	**Assumed Measure Life**	**Rationale**
showerhead	10 years	Showerheads last many years; most likely cause of replacement is a remodeling project or dissatisfaction with the performance of the existing showerhead.
faucet aerator	3 years	Faucet aerators are unlikely to fail, but satisfaction surveys have shown high degrees of dissatisfaction with low flow faucet aerators (Aquacraft, 2000). A share of homeowners will replace the faucet aerator soon after installation.
CFLs	*5 years*	Rated life of CFLs are generally 5,000-8,000 hours, which would imply about 5-8 years at average usage. However, satisfaction surveys show some dissatisfaction with the quality of the light produced. We assume that a share of homeowners will replace the light bulb soon after installation, so we are using the bottom end of the 5-8 year range.
Pipe wrap	*10 years*	Pipe wrap will eventually disintegrate, but should last for many years. Some pipe wrap will be removed and not replaced when a plumber or the homeowner installs a new water heater.
Water heater temperature setting	5 years	We assume that the new water heater temperature setting will continue as long as the same water heaters serves the house, but will not transfer to the next water heater. With an average water heater lifespan of roughly 10 years, we assume that the average remaining lifespan of water heaters at the time of the temperature adjustment is 5 years.

7. Demand Conversion Ratio

For computation of demand savings, we applied an adjustment to the estimated kilowatt-hour savings to take into account the likelihood that the installed measures are “in use” during summer peak periods. (A ratio of 0.114 would mean that a given measure is as likely to be in use during the peak period as any another time of the day or year.) For CFLs, we applied a factor of 0.0885 W/kWh, which is the ratio of 2.7 Watts of peak reduction per CFL and 30.5 kilowatt-hours per CFL. Both of these savings estimates are documented in the write-up for market 17. The water saving factor of 0.1 W/kWh is based on utility forecasts for electric water heater consumption and peak demand contribution from Advance Plans 6 and 7 (PSCW, 1994).

8. Allocation of Program Costs

For calculating levelized resource costs, we allocated approximately 55 percent +/- 10 percent of the program costs to electric savings, and the remainder to gas savings, in proportion to the savings provided by the measures.

Program Area 27.02 — Direct Install through Program Staff / Owner-Occupied Housing

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 27.02.2. MODEL INPUTS FOR DIRECT INSTALL THROUGH PROGRAM STAFF / OWNER-OCCUPIED HOUSING

Model Inputs (27.02)			Value	±
1		**Homes Visited**		
	a	owner-occupied households in Wisconsin	1,300,000	65,000
	b	share of households in sufficiently dense areas (i.e., urban)	68%	2%
	c	participation rate among homes offered the direct installation	25%	15%
	d	program capacity – initial (# of homes of attempted)	16,000	3,200
	e	program capacity – growth rate per year	100%	10%
	f	program capacity – maximum (# of homes attempted)	80,000	16,000
2		**Installations per Visit**		
	a	showerhead	0.8	0.2
	b	faucet aerator	0.8	0.2
	c	CFL	9	3
	d	pipe wrap	0.5	0.2
	e	water heater – share needing temperature reduction	0.23	0.05
	f	water heater – share of needed changes implemented	0.4	0.2
3		**Per-Unit Impact (natural gas – therms)**		
	a	share of homes using natural gas for domestic water	62%	7%
	b	showerhead	14	2
	c	faucet	3.4	0.5
	d	CFL	0	0
	e	pipe wrap	5	0.5
	f	water heater temperature	15	1.5
4		**Per-Unit Impact (electricity – kWh)**		
	a	share of homes using electricity for water heating	28%	5%

	b	showerhead	250	25
	c	faucet	76	20
	d	CFL	33	4.5
	e	pipe wrap	98	10
	f	water heater temperature	270	27
5		**Program costs**		
	a	fixed costs	$100,000	$25,000
	b	variable costs (per home visited)	$144	$25
6		**Measure life (years)**		
	a	showerhead	10	3
	b	faucet aerator	3	2
	c	CFLs	5	2
	d	pipe wrap	10	3
	e	water heater temperature setting	5	1
7	a	**Demand Conversion Ratio ($W_{summer\ peak}/kWh_{annual}$)**		
	a	CFLs	0.0885	0.0328
	b	water-saving measures	0.1	0.03
8		**Proportion of program costs**	55%	10%

1. Homes Visited

We define homes visited as the share of homes into which the program is invited to install at least some measures. This number is a function of the targeted homes, the rate at which targeted homeowners agree to have measures installed, and the capacity of the program to contact targeted homes.

We assume the program would target primarily homes in areas with moderate to high densities (i.e., urban areas) that appear to be owner-occupied (i.e., mostly single-family homes). Our estimate of the number of applicable owner-occupied homes is based on the number of owner-occupied single-family housing units in Wisconsin (1,291,025) and the share of the Wisconsin population in urban areas (68 percent) (Census 2000).

The participation rate among the homes contacted is somewhat speculative. We examined five past direct install programs, of which three provided similar services and approaches as our model. Goals for penetration rates were as high as 75 percent, but with comparatively small target audiences and high costs per participant. Actual participation rates at the time of evaluation were closer to 25 percent. While not a directly transferable metric, this number provides one indication of the participation rate of the program approach we are modeling. Eventual penetration rates for these programs were probably higher, but we used 25 percent in our model because we assumed a lower-cost approach in which the direct install team moves on after a brief attempt to canvass a targeted neighborhood with no additional follow-up. As a result, the costs we model are also lower than those of the comparison programs (Results Center, 1992a; Results Center, 1992b; Results Center, 1994).

2. Installations per Visit

Please see the technical documentation for market approach 27.01. We used many of the same assumptions and inputs as shown for that approach, with the following exceptions and adjustments:

- We assume an attempt at 10 CFL installations per visit with a success rate of 90 percent, leading to an average of 9 installations.
- We adjusted the pipe wrap installation rate upward by 100 percent to account for the lack of partner barriers, such as lack of time on a particular visit, reluctance to perform work in a client's basement, etc.
- We adjusted all other installation rates upward by 10 percent to account for the lack of partner barriers, such as lack of time on a particular visit, reluctance to perform work in a client's bathroom, etc.

3. Per-Unit Impact (natural gas – therms)

Please see the technical documentation for market approach 27.01. We used the same assumptions and inputs as shown for that approach.

4. Per-Unit Impact (electricity – kWh)

Please see the technical documentation for market approach 27.01. We used the same assumptions and inputs as shown for that approach, except for CFLs. We reduced the savings per CFL by 25 percent to acknowledge that 10 installations may not operate as much, on average, as a lower number of CFLs installed in a home's high-use fixtures.

5. Program Costs

Please see the technical documentation for market approach 27.01. We used the same assumptions and inputs as shown for that approach for fixed costs. The variable costs of this direct install program are based on past programs (The Results Center, 1992a and The Results Center, 1992b), which were $101 and $157 per participant. We used the lower of these numbers with an inflation adjustment to 2006 of 43 percent -- 38.8 percent through March 2005 (Department of Labor, 2005) and another 3 percent to 2006. That calculation resulted in a variable cost of $144 per participant.

6. Measure Life (years)

Please see the technical documentation for market approach 27.01. We used the same assumptions and inputs as shown for that approach.

7. Demand Conversion Ratio

Please see the technical documentation for market approach 27.01. We used the same assumptions and inputs as shown for that approach.

8. Allocation of Program Costs

For calculating levelized resource costs, we allocated approximately 55 percent +/- 10 percent of the program costs to electric savings, and the remainder to gas savings, in proportion to the savings provided by the measures.

Program Area 27.03 — Direct Install / Rental Units

Model inputs for this program area are summarized in the table below, and described on the following pages. These inputs draw somewhat from the inputs for program area 27.01 above.

TABLE 27.03.2. MODEL INPUTS FOR DIRECT INSTALL / RENTAL UNITS

Model Inputs (27.03)			Value	±
1		**Units Reached**		
	a	rental units in Wisconsin (buildings greater than 4 units)	329,000	49,350
	b	share of units with sufficient geographic density	85%	10%
	c	share of units for which decision-makers can be identified and reached	80%	20%
	d	acceptance rate	65%	20%
	e	program installation capacity – initial (units completed per year)	8,000	2,000
	f	program installation capacity – growth rate per year (units completed per year)	100%	10%
	g	program installation capacity – maximum (units completed per year)	24,000	6,000
2		**Installations per Visit**		
	a	showerhead – installation rate per unit reached	0.9	0.1
	b	faucet aerator – installation rate per unit reached	1.8	0.2
	c	CFL – installation rate per unit reached	5.4	0.5
	d	water heater – share flagged as needing temperature reduction	0.27	0.05
	e	water heater – share of flagged water heaters leading to owner/operator temperature reduction	0.25	0.1
3		**Per-Item Impact (natural gas – therms)**		
	a	share of homes using natural gas for domestic hot water	65%	5%
	b	showerhead	11	2
	c	faucet aerator	2.7	0.5
	d	CFL	0	0
	e	water heater temperature	15	1.5
4		**Per-Unit Impact (electricity – kWh)**		
	a	share of homes using electricity for domestic hot water	35%	5%
	b	showerhead	200	25
	c	faucet aerator	61	20

	d	CFL	44	6
	e	water heater temperature	270	27
5		**Program costs**		
	a	Program management (per unit visited)	$4	$1
	b	Marketing (identifying decision-makers and sales calls – per unit visited)	$2	$1
	c	Labor (per unit visited)	$22.50	$12.50
	d	Equipment costs – CFL (per item)	$2.00	$0.50
	e	Equipment costs – showerheads (per item)	$2.25	$0.20
	f	Equipment costs – faucet aerators (per item)	$0.50	$0.05
6		**Measure life (years)**		
	a	showerhead	10	3
	b	faucet aerator	3	2
	c	CFLs	5	2
	d	water heater temperature setting	5	1
7	a	**Demand Conversion Ratio ($W_{summer\ peak}/kWh_{annual}$)**		
	a	CFLs	0.0885	0.0328
	b	water-saving measures	0.1	0.03
8		**Proportion of program costs**	55%	10%

1. Units Reached

The number of units the program enters is a function of:

- The number of multi-family building owners and operators to whom the program is marketed and the number of units these decision-makers represent;
- The conversion (or acceptance) rate of these decision-makers; and
- The program's installation capacity.

We assumed that the traveling teams would reach as many of the rental units in buildings with more than 4 units as practical. There are 329,000 units in these buildings (Pigg and Price, 2005).

Some of these units will be in locations with sparse concentrations of rental buildings and, therefore, impractical to reach. We assume that 85 percent of the 329,000 units are located in areas with sufficient concentrations for the program to schedule a presence. This percentage is based roughly on the share of rental units located in southeastern, south-central, and northeast Wisconsin, although we do not intend to imply that the program would cover every corner of this part of the state or not include the northern and western portions. We assume the program would cover those areas in which rental buildings exist in reasonable concentrations – wherever they are.

The share of decision-makers who can be reached depends on how many of them can be identified via property tax records and what share of these the program can reach. We assume this number to be 80 percent of the units not already excluded due to geography.

Only a share of multi-family building decision makers presented with this program offering will choose to participate. Decision-makers who have used Focus on Energy program services in the past will accept the offer at a higher rate than those who do not have experience with the program. Based on past experiences of Focus on Energy's multi-family program, we use a blended acceptance rate of 65 percent.

Finally, the rate at which installations can be completed is subject to the program's staffing limitations. We assumed an initial capacity of 8,000 units per year, which could be doubled each year until it reaches 24,000 units.

2. Installations per Visit

The Focus on Energy multi-family program has conducted a direct install program in which they installed up to six CFLs (at installer's discretion) in high-use sockets, two faucet aerators, and one showerhead (Jenkins, 2005). We assumed that the six CFL limit would result in an actual average of six CFLs attempted per unit for the program we are modeling. Further, we assumed that the actual implementation rate in units would be 90 percent of these numbers to account for units that the installers cannot access in participating buildings, instances in which the devices being installed do not fit the infrastructure, and instances in which a renter is present and asks that a particular device not be installed.

For water heater temperature reductions, we assumed that program staff would provide informational material for the building decision-makers or maintenance staff whenever the measured hot water temperature exceeds 135 degrees Fahrenheit. We estimate that 27 percent of water heaters would be flagged as exceeding this temperature (based on Pigg and Price, 2005), but that multi-family building owners and operators would reduce the temperature in only about a quarter of these cases. At stakeholder meetings, current program staff indicated that the water temperature can drop substantially by the time it reaches the return line, so multi-family building operators are reluctant to reduce water heater settings that might cause some units to receive colder-than-desired water temperatures. In addition, we took into account the fact that measures recommended to multi-family building operators will be implemented at a reduced rate than measures installed by program staff.

3&4. Per-Item Impact

We based our assumptions of the per-item energy impact on our calculations for program approach 27.01, but made the following adjustments:

- Among rental units, the weighted average distribution of water heater fuels is 65 percent for natural gas and 35 percent for electricity (based on Pigg and Price, 2005).
- Per-unit occupancy is lower among rented housing units (2.12 in Wisconsin) than owner-occupied housing units (2.67) (Census 2000). Accordingly, we adjusted the per-item impacts we calculated for owner-occupied housing by a factor of 2.12/2.67, or 0.79. This adjustment reduced the per-item impact of showerheads to 11 therms or 200 kilowatt-hours and the impact of faucet aerators to 2.7 therms or 61 kilowatt-hours.

5. Program Costs

The two primary activities for this program are marketing and direct installations. We expressed all costs on a "per unit" basis to account for the high degree of scalability of the program's size and cost.

Costs for direct installations themselves comprise labor and materials. These can be expressed on a per-unit basis. For each housing unit visited, we assume $22.50 in labor costs (based on Jenkins, 2005), and the following costs for materials (also based on Jenkins, 2005): $2.00/CFL, $2.25/showerhead, and $0.50/faucet aerator.

Costs for marketing and project management are $2 and $4 per unit, respectively. Marketing costs cover the effort required to obtain property tax records, identify multi-family building decision-makers, and present the program offerings to them. Project management entails supervision of the installation team and overall oversight of the program efforts. At our assumed costs, the program would need a half-time marketing professional and a full-time team supervisor and project manager at full staffing of about six installers.

6. Measure Life

We used the same measure life assumptions as in program approach 27.01.

7. Demand Conversion Ratio

We used the same demand conversion ratio as for program approach 27.01.

8. Allocation of Program Costs

For calculating levelized resource costs, we allocated approximately 55 percent +/- 10 percent of the program costs to electric savings, and the remainder to gas savings, in proportion to the savings provided by the measures.

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MARKET 28 — RESIDENTIAL BUILDING SHELL IMPROVEMENTS

Market Scope

This market focuses on single-family homeowners with building shell improvement opportunities such as wall insulation and ceiling insulation or air sealing. Achievable potential considered here does not include homes that are being remodeled, as these are included in Market 25. Rather, the program strategy considered for this market is aimed at increasing the number of households that undertake shell improvements and participate in a program such as the one discussed in Market 25. This program strategy may also result in improvements by landlords to rental properties, though these are not a specific focus of the program.

Market Characteristics

The Energy Center's energy and housing study of single-family owner occupied homes (Pigg and Nevius, 2000) showed that fully a third of single-family owner-occupied homes have uninsulated areas such as walls or ceilings or have excessive air leakage (Table 28.01.1).

TABLE 28.01.1. MAJOR INSULATION AND AIR SEALING OPPORTUNITIES IN WISCONSIN HOMES.

	Percent of older homes with significant opportunity[a]	Approximate statewide number of homes
Wall insulation	15%	140,000
Ceiling insulation	21%	190,000
Air Sealing	17%	155,000
Any of Above	33%	300,000

Source: ECW Residential Characterization Study

[a]Excludes households at or below 150 percent of federal poverty guideline

Moreover, a survey conducted as part of that study suggests that most homeowners are unaware of these opportunities. Among homes judged to be inadequately insulated by on-site auditors, more than half of survey respondents reported that their home was "adequately" or "well" insulated, and about one in five said they did not know how well insulated their homes were, leaving only a quarter of respondents who agreed with the on-site auditor about the need for additional insulation.

The programmatic challenge is thus how to build awareness and motivation to address these opportunities—which, after all, are out of sight in wall cavities and attics. In addition, this market is explicitly defined to exclude homeowners who are already undertaking renovation work on their homes (the latter homes are considered under Market 25 — homeowner remodeling), which makes this by definition a "non-market" where the goal is to stimulate activity.

The program approach described below is designed to stimulate awareness and motivation to address shell energy efficiency improvements in this segment of the population. The concept is to provide homeowners with information about how their heating use compares to similar homes in the vicinity. The program would be targeted to high-use gas customers in older homes; these are much more likely to have insulation or air sealing opportunities (Pigg and Nevius, 2000).

The recently enacted Federal Energy Policy Act of 2005 may have some impact on this market, as it provides for up to $500 in tax credit incentives to homeowners who undertake building envelope improvements.

Program Approaches

PROGRAM AREA 28.01 — HEATING ENERGY USE BENCHMARKING AND MARKETING

The goal of this program approach is to provide homeowners with the means to see how their energy use compares with their neighbors—or at least with similar Wisconsin homes. This approach is based on the notion that when people can see that their consumption is higher than their peers, they will be motivated to take action.

Several different angles for this general program concept have been tried in the past. The EPA attempted to create an ENERGY STAR® billing program in the late 1990s that would have provided utility customers with graphical comparisons on their bills (Bengston, 1997). Only a few utilities across the nation participated in this effort, however.

More recently, third-party vendors have begun to provide utilities with web portal services for customers to view consumption histories and assess how their energy consumption compares to a typical home. In Wisconsin, Alliant Energy, Xcel Energy, and Wisconsin Public Service corporation all use the services of one such vendor. In addition, two Wisconsin utilities (Wisconsin Electric and Madison Gas and Electric) have in-house, web-based tools that allow customers to compare their energy use to that of homes of similar age and size. For stimulating shell improvements, this approach has the drawback that it requires active interest on the part of the homeowner.

The program approach proposed here is a hybrid concept that would involve direct mailings to customers with a customized representation of how their energy use compares to other homes in their community or county, together with a web-based tool allowing for more detailed comparison based on home size and age. The mailings would steer homeowners to the web-based tool, and both would be linked to an assessment program such as Home Performance with ENERGY STAR.

Response to a program such as this is highly uncertain. We have assumed for this program that the response rate to the mailings would be somewhere between 1 and 15 percent, and that between 5 and 35 percent of these would result in an insulation or air sealing improvement that would not otherwise have been undertaken. The program, which would be targeted to gas customers of the major utilities, would cover the state regionally over a five-year period.

TABLE 28.01.2. ESTIMATED VALUES FOR PROGRAM AREA 28.01 — HEATING ENERGY USE BENCHMARKING AND MARKETING.

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$283 to $2,433	$160 to $1,239
	Incremental Impacts	peak kW	7 to 351	4 to 179
		annual kWh (000s)	8 to 410	5 to 207
		annual therms (000s)	7 to 355	4 to 181
	Levelized resource cost	per peak kW	$431 to $4,357	$428 to $4,085
		per kWh	38.7¢ to 379.8¢	38.4¢ to 351.7¢
		per therm	43.9¢ to 445.9¢	43.8¢ to 413.8¢
Scaling factors[a]		program costs	0.8 to 4.2	0.8 to 4.2
		impacts	0.8 to 3.6	0.8 to 3.6

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

Program Area 28.01 — Heating energy use benchmarking and marketing

This program approach entails using utility billing histories to target older, high usage homes for a direct mailing showing homeowners how their gas usage compares to other homes in their area. The program would involve the following steps for each utility service territory or geographic region:

1. Use utility billing records to determine the distribution of gas usage for all customers. Flag high-usage customers, and use service address in-service dates (or other means) to identify older homes.
2. Conduct a survey of home size and age for a statistical sample of customers in the area. Use to develop quantiles of gas usage per square foot for various home vintages. Develop a web-based tool to allow homeowners to compare gas use to other homes of the same age and size.
3. Send a customized mailing to account holders of high-use, older homes showing how they compare to other homes in the area. The mailing would direct homeowners to the web-based tool that provides more detail and links to an energy assessment and improvement program, such as Home Performance with ENERGY STAR.

Inputs for this program area are shown in the table below, and discussed in more detail on the pages that follow.

TABLE 28.01.3. MODEL INPUTS FOR HEATING ENERGY USE BENCHMARKING AND MARKETING

Model Inputs (28.01)			Value	±
1		**Per-Unit Impacts (unit = one home)**		
	a	Gas savings per participant (Year 1), therms/year	350	100
	b	Electricity savings per participant (Year 1), kWh/year	400	100
	c	Demand savings per participant (Year 1), peak Watts	350	100
	d	Annual increase in savings (Years 2-5), %	2.5%	1%
2		**Program Participation**		
	a	Annual customer mailings (Years 1-5)	80000	20000
	b	Response to mailings	8%	7%
	c	Net percent of respondents who implement measures	20%	15%
	d	Participants per year beyond Year 5	50	50
3		**Program costs**		
	a	Annual fixed costs (Years 1-5)	$150,000	$30,000
	b	variable participant costs	$700	$200
4		**Measure life (years)**		
	a	Measure life (years)	25	10

1. Per Unit Impacts

See Program Area 25.01 for a more detailed discussion of per-unit savings from insulation and air sealing. For this program area, we have assumed somewhat higher per-home savings of 350 therms along with higher uncertainty of +/- 100 therms (we have also assumed commensurately higher electricity impacts as well). Our logic is that the program is more likely to pull in homeowners with larger homes and homes with more significant opportunities, since the initial point of comparison for homeowners would be on total gas use, rather than gas use per square foot.

2. Program Participation

There are about 1.5 million residential natural gas customers in Wisconsin, of which we assume about one million are single-family homeowners. We assume direct mailing to about 80,000 households per year over a five-year period representing the upper two quintiles of natural gas usage ***(Input 1a)***. The ability of these mailings to stimulate investment in insulation and air sealing activity is uncertain: we have assumed that the response rate to the mailings would be somewhere between 1 and 15 percent ***(Input 1b)***, and that between 5 and 35 percent of these households would eventually install insulation or implement air sealing that would not otherwise have been undertaken ***(Input 1c)***. These estimates work out to a mid-point estimate of about 1,300 participants per year, but with an estimated uncertainty of between about 300 and 3,000 participants per year.

We further assume that beyond Year 5, up to 100 households per year might opt to implement measures based on using the web-based usage tool.

3. Program Costs

We estimate the annual fixed cost for the program effort at about $175,000 +/- $50,000 ***(Input 2a)***. This would include processing utility billing histories, conducting a survey of a sample of customers, implementing a web-based tool for assessing usage, and implementing a targeted mailing to high-use customers in older homes.

We estimate the variable (incentive) costs per participant at about $700 +/- $200 per participant. This is somewhat higher than the assumption used in Program Area 25.01, and reflects our assumption that these households will implement more measures on average.

4. Measure Life

As with Market 25, we assigned a measure life of 25 +/- 10 years to this program.

References

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MARKET 29 — HOMEOWNER WASHER PURCHASE MARKET

Market Scope

This market is defined as homeowners who purchase a new washing machine.

Market Characteristics

Clothes washers have been included in the ENERGY STAR® program since 1997. ENERGY STAR qualified clothes washers not only offer energy savings potential, but offer other benefits such as water savings, larger tub capacity which allows more laundry per load, less wear and tear on clothes, and less detergent use. Because of these benefits, ENERGY STAR qualified clothes washers are typically marketed as high performance washers. According to the ENERGY STAR website (2005), the average cost of an ENERGY STAR qualified clothes washer is $750, compared to $450 for a conventional washer.

ENERGY STAR qualified clothes washers were incorporated into Focus on Energy from its inception in 2001. Focus on Energy program efforts have concentrated on both the demand side, through customer rewards, and the supply side, through salesperson spiffs (incentives) and retailer efforts. The market share of ENERGY STAR qualified clothes washers has grown substantially in Wisconsin between 2000 and 2004, from 14 percent to about 44 percent (Winch, 2004). Over 140,000 clothes washers were shipped to Wisconsin in 2003. The growth in Wisconsin shipments has been steadily increasing since 1997 (ranging from 1 to 7 percent) and has consistently comprised about two percent of national shipments.

On January 1, 2007, the Federal standard for all clothes washers will increase. In response to the upcoming changes in Federal standards, ENERGY STAR standards will also be changing effective January 1, 2007. The new criteria will also address water use.

Program Approaches

Our analysis of this market focuses on increasing the market share for ENERGY STAR qualified clothes washers through program efforts that offer a combination of customer rebates and salesperson spiffs.

A key issue with regard to achievable potential is that changes in Federal and ENERGY STAR standards take effect during Year 2 (2007). On January 1, 2007, the Federal standard for all clothes washers will increase from a Modified Energy Factor (MEF) of 1.04 (which took effect January 1, 2004) to 1.26 (which was the ENERGY STAR minimum standard prior to 2004). The MEF is the energy performance metric for all clothes washers. A higher MEF signifies a more energy efficient clothes washer. The current ENERGY STAR standard for clothes washers is an MEF of 1.42 (which took effect January 1, 2004). In response to the upcoming changes in Federal standards, ENERGY STAR standards will also be changing effective January 1, 2007. The required MEF will increase from 1.42 to 1.72. In addition, the new criteria also address water use, requiring a water factor of 8.0 or less. A lower water factor signifies less water use. The implication for the program is that the type of equipment the program can offer and the baseline from which savings are calculated will change beginning in Year 2.

PROGRAM AREA 29.01 — INCENTIVES FOR ENERGY STAR QUALIFIED CLOTHES WASHERS

Our analysis of the achievable potential for this program area is projected from the current Focus on Energy incentive program for ENERGY STAR qualified clothes washers. The analysis is based on the Focus on Energy evaluation, which quantified the impact of the program on the overall market share for ENERGY STAR qualified clothes washers in Wisconsin. We have assumed continued growth in this market, resulting in both an increase in the number of direct participants in the program as well as broader market effects beyond immediate participants.

Please refer to the technical documentation of this report for a detailed description of the inputs and outputs of the model for this program area.

TABLE 29.01.1. ESTIMATED VALUES FOR PROGRAM AREA 29.01, INCENTIVES FOR ENERGY STAR QUALIFIED CLOTHES WASHERS

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		\$558 to \$959	\$759 to \$1,472
	Incremental Impacts	peak kW	0	0
		annual kWh (000s)	1,051 to 4,172	1,139 to 4,601
		annual therms (000s)	35 to 140	37 to 155
	Levelized resource cost	per peak kW	NA	NA
		per kWh	0.7¢ to 3.6¢	0.9¢ to 5.0¢
		per therm	37.4¢ to 178.6¢	48.0¢ to 242.4¢
Scaling factors[a]		program costs	0.5 to 2.4	0.6 to 2.4
		impacts	0.7 to 1.5	0.7 to 1.5

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

Program Area 29.01 — Incentives for ENERGY STAR Qualified Clothes Washers

Model inputs are summarized in the table below and described on the following pages. Please note that in cases where the changes in ENERGY STAR and Federal standards affect the model inputs, we derive separate estimates for Year 1 vs. Years 2-10.

TABLE 29.01.2. MODEL INPUTS FOR INCENTIVES FOR ENERGY STAR QUALIFIED CLOTHES WASHERS

Model Inputs (29.01)			Value	±
1		**Per-Unit Impacts (Unit = Clothes Washer)**		
	a	Annual Electricity Savings (kWh)		
		Year 1	244	30
		Years 2-10	180	22
	b	Peak Demand Savings (Watts)		
		Year 1	0	0
		Years 2-10	0	0
	c	Annual Gas Savings (Therms)		
		Year 1	8	2
		Years 2-10	6	1
2		**Annual # of CWs Sold in WI (Size of Overall Market)**		
	a	Year 1	161,500	11,500
	b	Annual Compound Growth Rate in CW Sales	4.5%	2.5%
3		**Market Share of ES Qualified CWs (Share of Overall Market)**		
	a	Wisconsin Market Share		
		Year 1	56.3%	5%
		Year 2	13.3%	5%
	b	Annual Percentage Point Increase		
		Years 3-10	6.4%	2%
	c	Percentage Point Increase Over Baseline	7.6%	5%
4		**Program Participation**		
	a	Percent of ES Qualified CWs Incented through Focus (via Rebate or Spiff)		
		Years 1-10	23%	5%
5		**Program costs**		
	a	Fixed Program Costs	$50,000	$25,000
	b	Variable Admin Cost Per Incented CW	$18	$9
	c	Incremental Retailer Network Costs	$150,000	25,000
	d	Customer Rebate Amount	$37.50	$12.50
	e	Percent of Incented CWs Incented via Rebates	50%	10%
	f	Salesperson Spiff Amount	$17.50	$7.50
	g	Percent of Incented CWs Incented via Spiffs	50%	10%
	h	Percent of Program Costs Attributable to Gas Savings	62%	11%
6		**Measure life (years)**	12	2

1. Per Unit Impacts

We apply the methodology used by Focus on Energy to estimate clothes washer impacts (Wisconsin Energy Conservation Corporation, 2002; Focus on Energy Statewide Evaluation, 2002).

The derivation of impacts for Year 1 are based on the 2004 ENERGY STAR and Federal standards. The derivation of impacts for Years 2-10 are based on the 2007 ENERGY STAR and Federal standards.

YEAR 1

We derived the energy use for an ENERGY STAR qualified clothes washer purchased in the typical Wisconsin household using the formula below.

kWh Use = Tub Volume x Wash Cycles / MEF

The average tub volume of clothes washers rewarded through Focus on Energy during 2004 is 2.95 cubic feet while the average MEF is 1.74. Although no information is collected on the number of wash cycles, Focus on Energy assumes 392 cycles per year based on DOE test procedures. Please note that the 392 cycles per year estimate is consistent with findings from the Energy Center's energy and housing study (Pigg and Nevius, 2000). These three estimates yield 665 kWh of energy use.

The MEF accounts for the three ways in which energy is used to wash clothes. The first is machine energy, which is the electrical energy to operate the clothes washer itself. The second is hot water energy, which is the energy used to heat the water and depends on the fuel type of the water heater. The third is dryer energy, which is the amount of dryer energy used to remove the remaining moisture content in washed items and depends on the fuel type of the dryer.

The 665 kWh energy use estimate is based on use of an electric water heater and electric dryer. Therefore, we need to adjust the estimate to account for the water heater and dryer fuel mix among households in Wisconsin.

The first step for this adjustment is to apportion the 665 kWh to machine kWh, hot water kWh, and dryer kWh. Original Focus on Energy estimates, which were derived prior to the development of the MEF, assumed a ratio of 1:9 for machine energy to hot water energy, but did not provide any assumptions on the relationship to dryer energy. Our calculations assume that dryer energy accounts for 50 percent of total energy. We then apportion the remaining 50 percent to machine and hot water energy using the 1:9 ratio, which yields 5 percent for machine energy and 45 percent for hot water energy. Applying these percentages to the 665 kWh energy use estimate yields 33 kWh of machine energy use, 299 kWh of hot water energy use, and 332 kWh of dryer energy use.

The next step is to convert the hot water and dryer kWh energy use to therm energy use for cases where the water heater and/or dryer fuel types are not electric-fueled. We use a factor of 0.03413 therms/kWh for the conversion. Further, we incorporate an adjustment for hot water use to reflect an 80 percent recovery efficiency for gas water heaters. This yields an estimate of 13 therms for water heater use (299 kWh x 0.03413 therms/kWh ÷ 80%) and 11 therms for dryer use (332 kWh x 0.03413 therms/kWh).

Next we derive energy use estimates for the four combinations of water heater and dryer fuel types. ENERGY STAR qualified clothes washers in households with gas water heaters and electric dryers use

365 kWh (33 kWh + 332 kWh) and 13 therms. ENERGY STAR qualified clothes washers in households with gas water heaters and gas dryers use 33 kWh and 24 therms (13 therms + 11 therms). ENERGY STAR qualified clothes washers in households with electric water heaters and electric dryers use 665 kWh (33 kWh + 299 kWh + 332 kWh). ENERGY STAR qualified clothes washers in households with electric water heaters and gas dryers use 332 kWh (33 kWh + 299 kWh) and 11 therms.

Finally, we derive an overall energy use estimate by weighting the energy use estimates for the four combinations of water heater and dryer fuel types by the frequency with which they occur in Wisconsin households. Based on the Energy Center's energy and housing study, 48 percent of homes have a gas water heater and electric dryer, 25 percent have a gas water heater and gas dryer, 26 percent have an electric water heater and electric dryer, and 1 percent have an electric water heater and a gas dryer (Pigg and Nevius, 2000). Applying these estimates yields overall energy use of 362 kWh and 12 therms for an ENERGY STAR qualified clothes washer in the typical Wisconsin household.

We then estimate baseline energy use against which to calculate impacts. Focus on Energy uses the Federal minimum standard MEF to estimate baseline energy use. For Year 1, this is equal to the 2004 standard, which is an MEF of 1.04. Using the same tub volume (2.95) and number of washer cycles (392) as above with an MEF of 1.04, we estimate 1,112 kWh of baseline energy use (2.95 x 392 / 1,112). The baseline use of 1,112 kWh is apportioned and adjusted in the same manner as the 665 kWh energy use estimate for the ENERGY STAR qualified clothes washer (described above). This end result is overall energy use of 606 kWh and 20 therms for a baseline clothes washer in the typical Wisconsin household.

The impact estimate is the difference between the baseline and ENERGY STAR qualified clothes washer estimates. This yields 244 kWh (606 kWh – 362 kWh) ***(Input 1a–Year 1)*** and 8 therms (20 therms – 12 therms) ***(Input 1c–Year 1)***. We set peak demand savings equal to 0 because Focus on Energy assumes no peak demand impacts ***(Input 1b–Year 1)***.

We derived the +/- range for kWh and therms by estimating impacts assuming that dryer energy accounts for 33 percent of total energy (+) and assuming that dryer energy accounts for 67 percent of total energy (-).

YEARS 2-10

We derive the impact estimates for Years 2-10 following the same technique as Year 1, with two exceptions, each related to the change in Federal and ENERGY STAR standards in 2007.

First, rather than using all clothes washers rewarded through Focus on Energy during 2004 to derive the average tub volume and MEF of ENERGY STAR qualified clothes washers, we limited the analysis to clothes washers rewarded through Focus on Energy during 2004 that would have met the new ENERGY STAR standard (MEF of 1.72 and a water factor of 8.0). The average tub volume of these clothes washers is 3.06 cubic feet while the average MEF is 1.93. The end result is overall energy use of 339 kWh and 11 therms for an ENERGY STAR qualified clothes washer in the typical Wisconsin household.

Second, we use the 2007 Federal minimum standard MEF (1.26) to estimate baseline energy use. The end result is overall energy use of 519 kWh and 17 therms for a baseline clothes washer in the typical Wisconsin household.

The impact estimate is the difference between the baseline and ENERGY STAR qualified clothes washer estimates. This yields 180 kWh (519 kWh – 339 kWh) ***(Input 1a–Years 2-10)*** and 6 therms (17 therms – 11 therms) ***(Input 1c–Years 2-10)***. Again, we set peak demand savings equal to 0 because Focus on Energy assumes no peak demand impacts ***(Input 1b–Years 2-10)***.

Similarly, we derived the +/- range for kWh and therms by estimating impacts assuming that dryer energy accounts for 33 percent of total energy (+) and assuming that dryer energy accounts for 67 percent of total energy (-).

2. Annual Number of Clothes Washers Sold in WI (Size of Overall Market)

The analysis presented in this section is based on the Focus on Energy evaluation, which quantified the impact of the program on the overall market share for ENERGY STAR qualified clothes washers in Wisconsin (Winch, 2004; Talerico and Winch, 2005).

According to the Association of Home Appliance Manufacturers (AHAM), over 141,500 clothes washers were shipped to Wisconsin in 2003 (2004 Wisconsin data were not available). The growth in Wisconsin shipments has been increasing since 1997. The average annual growth rate between 1997 and 2003 was 4.5 percent and ranged from 1.3 to 6.9 percent. Table 2 shows trends in Wisconsin and national clothes washer shipments.

TABLE 29.01.3. TRENDS CLOTHES WASHER SHIPMENTS

Year	AHAM Wisconsin		AHAM National		Wisconsin Share of National
	Shipments	Increase	Shipments	Growth Rate	
1997	108,400	--	6,345,400	--	1.7%
1998	115,800	6.8%	6,834,400	7.7%	1.7%
1999	123,800	6.9%	7,313,200	7.0%	1.7%
2000	125,400	1.3%	7,495,300	2.5%	1.7%
2001	128,100	2.2%	7,362,200	-1.8%	1.7%
2002	135,400	5.7%	7,744,900	5.2%	1.7%
2003	141,500	4.5%	8,145,900	5.2%	1.7%
2004	--	--	8,825,000	8.3%	--

Source: AHAM

To project the size of the market in Year 1 (2006), we apply the 4.5 percent annual growth rate to the 2003 estimate of market size (141,500). This yields an estimate of 161,500 clothes washers (141,500 x $(1.045)^3$) ***(Input 2a)***. To project the market size for Years 2-10, we apply the average annual growth rate from 1997-2003 of 4.5 percent ***(Input 2b)*** to the 161,500 clothes washers in Year 1. We derived the +/- 2.5 percent range (2 to 7 percent) for the annual growth rate such that it covered most of the range in annual growth rates between 1997-2003 (1.3 to 6.9 percent). We derived the +/- 11,500 range for Year 1 market size by applying the lower and upper end of the growth rate range (2 and 7 percent, respectively) to the 2003 estimate of market size (141,500 x $(1.02)^3$ and 141,500 x $(1.07)^3$, respectively).

3. Market Share of ENERGY STAR Qualified Clothes Washers (Share of Overall Market)

The analysis presented in this section is also based on the Focus on Energy evaluation, which quantified the impact of the program on the overall market share for ENERGY STAR qualified clothes washers in Wisconsin (Winch, 2004; Talerico and Winch, 2005).

We have two sources for data on market share of ENERGY STAR qualified clothes washers in Wisconsin. The first is data from D&R International. While this source adequately covers national retailers, it under-represents independent retailers. To supplement D&R International, Wisconsin Energy Conservation Corporation collects market share data among a sample of independent retailers in Wisconsin. To derive an overall market share estimate, we weight each source by 50 percent. Table 29.01.4 presents market share trends in Wisconsin during Focus on Energy program efforts (2001-2004) based on these two sources.

TABLE 29.01.4. TRENDS IN WISCONSIN ENERGY STAR QUALIFIED MARKET SHARE

Year	D&R International Estimate (National Retailers)	WECC Estimate (Local Independent Retailers)	Overall Estimate[1]
2001	15.2%	20.7%	17.9%
2002	25.6%	26.6%	26.1%
2003	42.0%	37.2%	39.6%
2004	40.6%	46.4%	43.5%

[1] Weighted average of D&R International (50%) and WECC (50%) estimates.

Between 2001 and 2004, market share increased from 17.9 percent to 43.5 percent. This represents a 25.6 percentage point increase, which over the four year period is an average increase of 6.4 percentage points per year. To project market share in Year 1 (2006), we take the market share in 2004 (43.5 percent) and add 12.8 percentage points (6.4 percentage point increase per year times two years). This yields an estimate of 56.3 percent ***(Input 3a-Year 1)***. We assign this estimate an uncertainty of +/- 5 percent.

Given that the change in ENERGY STAR standards in 2007 (Year 2) are more restrictive (an increase in MEF from 1.42 to 1.72 and the additional requirement of a water factor), we expect market share of ENERGY STAR qualified clothes washers to be much lower than in Year 1. To estimate what this market share might be, we looked at the percent of clothes washers rewarded through Focus on Energy during 2004 that would have met the new ENERGY STAR standards. We found that 23.7 percent of these units would have qualified. Applying this percentage to the 56.3 percent share in Year 1 yields a share of 13.3 percent for Year 2 ***(Input 3a-Year 2)***. We assign this estimate an uncertainty of +/- 5 percent.

To project market share in Years 3-10, we take the market share in Year 2 (13.3 percent) and add 6.4 percentage points each year. We assign the 6.4 percent percentage point increase estimate an uncertainty of +/- 2 percent ***(Input 3b)***. As an example, we project market share in Year 10 at 64.5 percent. This is 13.3 percent in Year 2 plus 51.2 percent points (6.4 percentage points multiplied by 8 years). During the stakeholder meetings, attendees proposed 60-70 percent as a reasonable range for ENERGY STAR qualified market share at which a program should exit the market. The Year 10 projection falls within this range.

To project baseline market share (i.e., market share in the absence of program activity), we looked at market share in Michigan, a non-program state in the Midwest that has comparable demographics to Wisconsin with respect to percent of population having a BA degree or higher and median household income. Table 29.01.5 presents market share trends in Michigan during 2000-2004.

TABLE 29.01.5 TRENDS IN MICHIGAN ENERGY STAR QUALIFIED MARKET SHARE

Year	National Retailers[1]	Local Independent Retailers[2]	Overall Estimate[3]
2000	9.4%	13.9%	11.6%
2001	10.8%	14.7%	12.7%
2002	18.2%	18.9%	18.6%
2003	26.0%	23.1%	24.5%
2004	29.1%	33.2%	31.2%

[1] Based on D&R International.

[2] Equal to National Retailer estimate times the ratio of Local to National in Wisconsin (from Table 3). For 2004, this equals 29.1% x (46.4% / 40.6%), which equals 33.2%.

[3] Weighted average of National Retailer (50%) and Local Independent Retailer (50%) estimates.

Next, we compare Michigan and Wisconsin market share in 2000, the year prior to the start of Focus programs, to account for any difference in starting points. We found that market share in Wisconsin was 14 percent in 2000, which is 2.4 percentage points higher than Michigan's market share. Therefore, to derive a baseline with a comparable starting point as Wisconsin, we adjust Michigan market share estimates upward by 2.4 percentage points each (e.g., 2001 baseline market share increases from 12.7% to 15.1%, 2002 increases from 18.6% to 21.0%, and so on). Then, to project what the increase in market share is as a result of the program, we take the difference between Wisconsin and the adjusted baseline market share. As shown in Table 5, the increase in market share as a result of the program ranges from a low of 2.8 percentage points in 2001 to a high of 12.7 percentage points in 2003. For modeling purposes, we use an increase of 7.6 percentage points (the average of the four years) and assign this estimate an uncertainty of +/- 5 percent to cover the range of values during the four years ***(Input 3c)***.

TABLE 29.01.6 COMPARISON OF TRENDS IN WISCONSIN AND BASELINE ENERGY STAR QUALIFIED MARKET SHARE

Year	Wisconsin Market Share	Baseline Market Share	Percentage Point Increase in Market Share Over Baseline
2001	17.9%	15.1%	2.8%
2002	26.1%	21.0%	5.1%
2003	39.6%	26.9%	12.7%
2004	43.5%	33.6%	9.9%

4. Program Participation

Table 29.01.7 compares the total number of ENERGY STAR qualified clothes washers sold in Wisconsin (equal to Wisconsin AHAM shipments multiplied by Wisconsin ENERGY STAR market share) to the total number of ENERGY STAR clothes washers rewarded through Focus on Energy. The percent of ENERGY STAR qualified clothes washers rewarded through the program was much higher in 2003 and 2004 (27.1 and 18.7 percent) than in the first two years of the program (2.9 and 9.3 percent). We hypothesize that this is because it took the program two years to establish itself in the marketplace. Given that the program approach being modeled follows the paradigm of the current Focus program that is already established in the marketplace, we think that the estimates in 2003 and 2004 will be more reflective of future program efforts. Accordingly, we use 23 percent (the average of 2003 and 2004) as the estimate for the percent of ENERGY STAR qualified clothes washers in Wisconsin that are incented through Focus and assign this estimate an uncertainty of +/- 5 percent to cover the range of values during 2003 and 2004 ***(Input 4a)***.

TABLE 29.01.7 OVERALL ENERGY STAR QUALIFIED CLOTHES WASHERS IN MARKET COMPARED TO ENERGY STAR QUALIFIED CLOTHES WASHERS REWARDED BY FOCUS ON ENERGY

Year	AHAM Shipments	Wisconsin ENERGY STAR Market Share	Number of ENERGY STAR Clothes Washers in Wisconsin	Number of ENERGY STAR Qualified Clothes Washers Rewarded by Focus on Energy	Percent of ENERGY STAR Clothes Washers in Wisconsin Rewarded by Focus on Energy
2001	128,100	17.9%	22,988	677	2.9%
2002	135,400	26.1%	35,353	3,279	9.3%
2003	141,500	39.6%	56,041	15,190	27.1%
2004	147,868[1]	43.5%	64,293	12,009	18.7%

[1] Projected based on 4.5% growth rate applied to 141,500

5. Program Costs

We estimate program costs based on input from the Focus on Energy program manager (Van de Grift, 2005). We estimate the annual administrative cost of the program to be about $50,000 +/- $25,000 ***(Input 5a)*** and the variable administrative cost for the program at $18 +/- $9 ***(Input 5b)***. We also included retailer network costs of $150,000 +/- $25,000 ***(Input 5c)*** in the model.

The ENERGY STAR qualified clothes washers purchased through the program will be incented using two mutually exclusive mechanisms. The first is customer rebates in the range of $25-50. We project that 40-60 percent of the program-incented ENERGY STAR qualified clothes washers will be incented via customer rebates. For modeling purposes, we use $37.50 +/- $12.50 ***(Input 5d)*** for the customer rebate amount and 50 percent +/- 10 percent ***(Input 5e)*** for the percent of clothes washers that are incented via customer rebates. The second is salesperson spiffs in the range of $10-25. We project that 40-60 percent of the program-incented ENERGY STAR qualified clothes washers will be incented via salesperson spiffs. For modeling purposes, we use $17.50 +/- $7.50 ***(Input 5f)*** for the salesperson spiff amount and 50 percent +/- 10 percent ***(Input 5g)*** for the percent of clothes washers incented via salesperson spiffs. Finally, the model attributes 62 percent +/- 11 percent ***(Input 5h)*** of program costs to gas savings. Savings depend on both water heater and dryer fuel type. According to the Energy Center's energy and housing study, 73 percent of homes have a gas water heater and 51 percent have a gas dryer (Pigg and Nevius, 2000). The estimate of 62 percent +/- 11 percent covers this range.

6. Measure Life

We estimate the measure life as 12 years +/- 2 years ***(Input 6)***. This estimate is based on assumptions in the clothes washer savings worksheet that is on the ENERGY STAR Website (2005).

7. Model Outputs

Table 29.01.8 shows the key outputs from our model. We provide a brief overview of the outputs in the paragraph following the table.

TABLE 29.01.8. MIDPOINT ESTIMATES OF PROJECTIONS FOR PROGRAM AREA 29.01, INCENTIVES FOR ENERGY STAR QUALIFIED CLOTHES WASHERS

Program Year	(A) Market Size	(B) ENERGY STAR Qualified	(C) Baseline	(D) Program Induced	(E) Program Incented	(F) Net-to-Gross Ratio
1	161,500	90,925	78,651	12,274	20,913	59%
2*	168,768	22,446	9,620	12,826	5,163	248%
3	176,362	34,743	21,340	13,404	7,991	168%
4	184,298	48,102	34,095	14,007	11,063	127%
5	192,592	62,592	47,955	14,637	14,396	102%
6	201,258	78,290	62,994	15,296	18,007	85%
7	210,315	95,273	79,289	15,984	21,913	73%
8	219,779	113,626	96,923	16,703	26,134	64%
9	229,669	133,438	115,983	17,455	30,691	57%
10	240,004	154,803	136,562	18,240	35,605	51%

* New Federal and ENERGY STAR standards take effect.

The first output is a projection of the overall size of the Wisconsin clothes washer market in each year (Column A). We then project the market share of ENERGY STAR qualified clothes washers in Wisconsin and apply this share to the overall size of the Wisconsin market (Column A) to estimate the number of ENERGY STAR qualified clothes washers in the Wisconsin market (Column B). We also project the baseline market share of ENERGY STAR qualified clothes washers in Wisconsin and apply this share to the overall size of the Wisconsin market (Column A) to estimate the number of ENERGY STAR qualified clothes washers sold in Wisconsin in the absence of the program (Column C). Next, we estimate the number of ENERGY STAR qualified clothes washers that were program induced (Column D). This is equal to Column B minus Column C. We then project the percent of ENERGY STAR qualified clothes washers in Wisconsin that are incented through the program and apply this share to the number of ENERGY STAR qualified clothes washers in Wisconsin (Column B) to generate the number of ENERGY STAR qualified clothes washers incented through the program (Column E). Finally, we estimate the net-to-gross ratio (Column F), which is equal to the ratio of Column D to Column E.

The estimates from Table 29.01.8 are used to derive estimates of program costs and impacts, which are presented in Table 29.01.1.

References

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MARKET 30 — RENTAL FUEL SWITCHING

Market Scope

This market embraces programs that encourage the conversion of electric space heating or water heating systems to gas-fired systems in rental housing. This includes opportunities associated with renovation.

Market Characteristics

Natural-gas fired heating (of either space or water) is more efficient and less costly to operate than electrical heating. Electrical resistance heating elements are, in themselves, very efficient, turning practically all of the electrical energy they use into useable heat. However, electric generation and transmission losses make electrical heating inherently inefficient, reducing the overall efficiency of electrical space or water heating to about 30 percent. Newer natural gas-fired systems, on the other hand, achieve efficiency levels of 80 to 95 percent for space heating and water heating.

Nevertheless, as shown in Table 30.01.1, a significant minority of multifamily buildings use electric systems for space and water heating. Electrical systems might have been installed in these buildings because the buildings were built during a moratorium on natural gas systems in the 1970's or natural gas was not available at the buildings' location, to shift the respective energy cost to the tenant, or because electric systems have a lower first cost.

TABLE 30.01.1 PERCENTAGE OF RENTAL BUILDINGS IN WISCONSIN WITH ELECTRICAL SPACE OR WATER HEATING

Type of Heating	Units in Building			
	1	2-4	5-19	20+
water heating	33%	16%	31%	40%
space heating	<10%	6%	27%	38%

Pigg & Price: Energy and Rental Housing study

In most cases, electrical space and water heating systems are installed directly in individual housing units and the cost of running these systems is included on the tenants' electric bills. As a result, landlords have limited incentive to convert electrical systems to more efficient natural gas systems. In order to benefit from such a conversion, landlords would need to be able to increase rents sufficiently to cover the cost of the conversion.

Furthermore, conversions can be expensive if they require more than just the replacement of electrically fueled equipment with natural gas-fueled equipment. Depending on the building's location and design, a fuel conversion project can entail cost for:

- The laying of a natural gas line to the building;
- Distribution of natural gas within the building – either to a basement or utility room or to individual housing units to serve decentralized heating equipment;

- The installation of ductwork (applicable for space heating conversion).

From a societal perspective, however, these conversions often do make sense because of the lower cost of natural gas heating, lower BTU requirements, and reduced demand on the electricity generation and transmission system. Hence, utility programs and, more recently, Focus on Energy's Apartment and Condominium Services program have provided incentives to encourage fuel switching.

The scale and scope of the current Focus on Energy effort have been limited by funding and the nature of Wisconsin's rental market. Our analysis is not constrained by current funding limitations, but we have taken into account the nature of Wisconsin's markets and their effect on potential program designs.

One of the most important limiting factors is the widely dispersed nature of smaller rental buildings and the inherent difficulty in finding and reaching their owners. Excluding rented single-family homes, there are approximately 106,600 rental buildings in the state encompassing 486,800 housing units. Small buildings with fewer than five units account for approximately 90 percent of the buildings and more than 50 percent of the units (Pigg and Price, 2005). These small buildings are controlled by a large number of decision-makers, many of whom operate one or a few buildings as a secondary income source or investment. They tend not to belong to well-organized apartment associations or other trade groups, thereby making it difficult and costly to market and provide services to this population.

The current Wisconsin multi-family energy efficiency program provides incentives for fuel switching for buildings with four or more units. It provides performance-based incentives that offer rewards based on the estimated amount of energy saved by each recommended measure that the multi-family building decision-maker chooses to implement. These recommendations arise out of building assessments performed through the program that are marketed via contractors who serve multi-family buildings (e.g., dealers and installers of heating systems) or directly to the decision-makers.

Program Approaches

Our analysis of this market considered a single program effort based on the current Focus on Energy program's general approach with one main deviation. As suggested by market stakeholders, we assume the program would need to pay a large percentage of the conversion costs to motivate building owners to undertake the projects.

(Also, in contrast to the Focus on Energy program, we based our estimates on buildings with five or more units – instead of four or more for Focus on Energy. We made this choice not for any programmatic decisions, but because the best available data is organized that way.)

TABLE 30.01.2. ESTIMATED VALUES FOR PROGRAM AREA 30.01, MULTI-FAMILY FUEL SWITCHING

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$82 to $1,957	$317 to $1,721
	Incremental Impacts	peak kW	1 to 77	3 to 84
		annual kWh (000s)	92 to 2,909	350 to 2,829
		annual therms (000s)	-132 to -4	-125 to -17
	Levelized resource cost	per peak kW	$691 to $17,702	$654 to $16,921
		per kWh	3.0¢ to 11.7¢	2.8¢ to 10.9¢
		per therm	NA to NA	NA to NA
Scaling factors[a]		program costs	0.3 to 1.7	0.3 to 1.7
		impacts	0.4 to 1.7	0.4 to 1.6

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Following are the technical assumptions we made for programs to promote fuel switching in rental buildings.

Program Area 30.01 — Multi-Family Fuel Switching

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 30.01.3. MODEL INPUTS FOR MULTI-FAMILY SWITCHING

Model Inputs (30.01)			**Value**	**±**
1		**Buildings Served**		
	a	rental buildings in Wisconsin (bldgs > 4 units)	20,800	3,120
	b	rental buildings that can be reached by the program	15,000	3,000
	c	market barriers coefficient for buildings reached	107	81
	d	curve shape coefficient for buildings reached	1.35	0.65
	e	share of assessed buildings with fuel switch review	90%	10%
	f	share of bldgs with 4+ units that have 20+ units	15%	3%
2		**Recommended Measures – 5-19 units (% of assessed buildings)**		
	a	space heating fuel switch (electricity to natural gas)	20%	15%
	b	water heating fuel switch (electricity to natural gas)	2%	2%
3		**Recommended Measures – 20+ units (% of assessed buildings**		
	a	space heating fuel switch (electricity to natural gas)	24%	15%
	b	water heating fuel switch (electricity to natural gas)	9%	9%
4		**Implementation Rate of Recommended Measures – 5-19 units (% of recommendations)**		
	a	space heating fuel switch (electricity to natural gas)	4%	4%
	b	water heating fuel switch (electricity to natural gas)	25%	15%
5		**Implementation Rate of Recommended Measures – 20+ units (% of recommendations**		
	a	space heating fuel switch (electricity to natural gas)	4%	4%
	b	water heating fuel switch (electricity to natural gas)	25%	15%
6		**Energy Savings – 5-19 units**		
	a	space heating fuel switch (electricity to natural gas) – kWh saved	60,000	18,000
	b	space heating fuel switch (electricity to natural gas) – therms added	2,400	720
	c	water heating fuel switch (electricity to natural gas) – kWh saved	30,000	12,000
	d	water heating fuel switch (electricity to natural gas) –	1,500	600

		therms added		
7		**Energy Savings – 20+ units**		
	a	space heating fuel switch (electricity to natural gas) – kWh saved	230,000	69,000
	b	space heating fuel switch (electricity to natural gas) – therms added	9,300	2,800
	c	water heating fuel switch (electricity to natural gas) – kWh saved	100,000	40,000
	d	water heating fuel switch (electricity to natural gas) – therms added	5,600	2,000
8		**Program Costs**		
	a	Program management costs – per building assessed	$20	$10
	b	Marketing costs – per building assessed – 1st year	$300	$200
	c	Marketing costs – per building assessed – decrease per year	50%	25%
	d	Assessment costs – per building assessed	$300	$100
	e	variable costs – 90% of heating system conversion costs – 5-19 units	$32,000	$10,000
	f	variable costs – 90% of heating system conversion costs – 20+ units	$144,000	$43,000
	g	variable costs – 90% of water heating system conversion costs – 5-19 units	$5,000	$1,500
	h	variable costs – 90% of water heating system conversion costs – 20+ units	$20,000	$6,000
9	a	**Demand Savings (W per kWh saved)**	0.06	0.03
10	a	**Measure Life (years)**	30	10

1. Buildings Assessed

A single market-based whole-building effort would serve this and most other multi-family program approaches we are modeling for this study. Similar to Focus on Energy’s current market-based approach for multi-family buildings, this program would offer whole-building assessments and make recommendations that span multiple “markets” included in this study, including lighting, HVAC upgrades, and fuel switching. Please see market 18 for an explanation of the model inputs we used for this cross-cutting effort to estimate the total number of buildings assessed.

For the rental fuel switching model, we assumed that 90 percent of the assessed buildings include a review of the heating fuels, which could lead to recommendations that the owner or operator switch to natural gas heating.

Installation rates, energy impacts, and costs are modeled separately for buildings with 5-19 units and those with 20+ units. We assumed the same distribution of buildings in these size categories as observed by the Energy and Rental Housing Study, which suggested that 15 percent of multi-family buildings are in the larger of these categories (Pigg and Price, 2005).

2 & 3. Recommended Measures

We assume that 80 percent of assessed buildings that have electric resistance space heating or central electric water heating would be candidates for fuel switching and lead to a recommendation by the program. Data collected for the Energy and Rental Housing study shows that 25 percent of 5-19 unit buildings and 30 percent of 20+ unit buildings have electric resistance space heating. In addition, 2 percent of 5-19 unit buildings and 11 percent of 20+ unit buildings have central electric water heating (Pigg and Price, 2005). The uncertainties for these numbers are high, so we assigned high uncertainties to our inputs as well. Eighty percent of these values (and our assigned uncertainties) are:

<u>space heating recommendations</u>

- 20% (+/- 15%) of buildings with 5-19 units
- 24% (+/- 15%) of buildings with 20+ units

<u>water heating recommendations</u>

- 2% (+/- 2%) of buildings with 5-19 units
- 9% (+/- 9%) of buildings with 20+ units

We excluded in-unit electric water heating because the costs of installing natural gas distribution to individual units outweighs the scale of benefits offered by a single unit's water consumption.

4 & 5. Implementation Rate of Recommended Measures

As noted in the market characteristics write-up for this market, landlords have relatively little incentive to convert electrical space or water heating to natural gas unless they pay the energy costs. At our stakeholder meeting for this market, participants agreed that fuel conversions would be a difficult "sell" and stated their belief that it would be easier to convert water heaters than space heating equipment. Our estimated implementation rates of 4 percent (+/- 4 percent) of buildings for which conversion was recommended for space heating. Landlords have a greater incentive to switch fuels for water heaters when recommended because we assumed that building assessments would suggest fuel switching only for central water heaters (for which landlords generally pay the energy bills). We used an implementation rate of 25 percent (+/- 15 percent) for water heating to balance this greater incentive for landlords with the fact that only a share of water heaters will be near the end of their lifespan at the time of the assessment, the probable reluctance of many landlords to replace new equipment, and the difficulty programs have encountered with efforts to secure future replacements. We used the same estimates for buildings with 5-19 units and those with 20+ units.

6 & 7. Energy Savings (therms per implemented measure)

Fuel switching results in a drastic reduction in electricity usage and a substantial increase in natural gas usage. Multi-family buildings with electrical space heating average 3.0 Btu/ft^2/HDD of heating energy intensity for buildings with 5-19 units and 2.7 Btu/ft^2/HDD for buildings with 20+ units. These intensities compute to approximately 60,000 and 230,000 kilowatt-hours, respectively, assuming 7,499 heating degree days, 9,000 ft^2 and 39,100 ft^2 average building sizes, and 3,412 Btu per kilowatt-hour (Pigg and

Price, 2005, and DOA, 2005). We assigned uncertainties of about 30 percent of these computed electric heating consumptions.

Applying the same heating energy intensities, we computed an increase in natural gas usage of 2,400 therms for buildings with 5-19 units and 9,300 therms for buildings with 20+ units. These estimates are based on the same factors described above, plus an assumed efficiency level of natural gas heating systems of 85 percent and a conversion factor of 100,000 Btu per therm. We assigned uncertainties of about 30 percent of these computed natural gas heating consumptions.

We estimate average water heating usage of 30,000 kilowatt-hours for buildings with electric water heating in the 5-19 size category and 100,000 kilowatt-hours for those in the 20+ size category. These estimates are based on non-space heating usage of natural gas (which we presume to be water heating) in buildings in these size categories that use natural gas water heating (170 therms/unit for 5-19 units and 140/unit for 20+ units), average numbers of units per building (9 and 40, respectively), a therms to kilowatt-hour conversion of 29.3 kilowatt-hours per therm, and an end-use energy efficiency advantage for electric water heaters of 1.54 (based on average energy factors of 0.55 for natural gas water heaters and 0.85 for electric ones) (Pigg and Price, 2005). These levels of electric usage could be replaced by 1,530 (170 therms/unit * 9 units) and 5,600 therms (140 therms/unit * 40 units), respectively.

To account for uncertainties associated with our estimate of the proportion of space heating energy used for water heating, we increased the 30 percent uncertainty rate used for space heating to 40 percent for the energy implications of a water heating conversion.

8. Program Costs

There are four main components to our assumed program costs. Three of these components are cross-cutting costs already defined in market 18. They are:

- program management costs;
- program marketing costs; and
- assessment costs.

These are shared costs that we assume to span two or three multi-family programs. We modeled the share of these costs attributable to the rental heating system replacement program to be identical as the costs attributed to the common area lighting market (#18).

The fourth cost category – incentives – would pay the majority of the costs of electric-to-gas conversions. We assume that incentives would be structured to pay 80 to 100 percent of the conversion cost, so we computed incentives per building as 90 percent of the conversion cost. Conversion costs are shown in the Energy and Rental Housing study as follows:

- $4,000 per unit for space heating fuel conversion; and
- $569 per unit for water heating fuel conversion (Pigg and Price, 2005).

We adjusted these costs to a “per building” basis by multiplying each value by 9 units per building in the 5-19 unit category and by 40 units per building in the 20+ unit category. Then, we took 90 percent of that product for a 90 percent incentive. Hence, our model inputs for incentives became:

space heating conversions

- $32,000 per building in the 5-19 unit category;
- $144,000 per building in the 20+ unit category;

water heating conversions

- $5,000 per building in the 5-19 unit category;
- $20,000 per building in the 20+ unit category.

We assigned uncertainties equal to about 20 percent of these values to account for imprecision in these cost estimates and in the percentage of conversion costs the program will need to actually offer to motivate multi-family building decision-makers.

9. Demand Savings

Because electric system peaks tend to occur in the summer, we did not assign any demand savings to space heating system conversions. Water heating does occur during the summer, and a share of water heating systems actively heat the water in their tanks during the typical afternoon system peaks. We assigned demand savings of 0.6 watts per kilowatt-hour saved (+/- 0.3) based on data collected on central water heater demand curves for the Wisconsin Demand-Side Options Database (Synergic Resources Corp. 1990).

10. Measure Life

We assumed a measure life of 30 years (+/- 10 years). For this market, the measure life is not a function of the equipment life, but an acknowledgement that the natural gas-fired equipment installed during a fuel conversion is likely to be replaced with another natural gas-fired unit upon failure, thereby creating very long measure lives. However, fluctuations in market conditions, energy prices, future regulations, or other factors may cause some multi-family building decision-makers to convert their electric equipment to natural gas in the future even without a program, thereby reducing the measure life for those buildings. We chose the measure life of 30 years as a compromise between these factors.

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MARKET 31 — RESOURCE CHARACTERIZATION: SOLAR ENERGY

Three of the markets addressed by this study are for solar technologies: commercial photovoltaics (solar PV), commercial/institutional solar thermal (water heating) and residential solar thermal. All three employ panels known as flat plate technologies. These panels, both for electrical generation (solar PV) and water heating (solar thermal), use the sun's ambient light and heat, and do not employ mirrors or other optical elements to concentrate the sun's energy. Therefore, they function well in both direct and diffuse sunlight, unlike solar concentrator technologies which require high concentrations of direct sunlight to function reliably. Solar concentrator technologies work best in locations like the desert of the Southwest which has few cloudy days. Flat plate technologies perform well in many climates with varying degrees of cloud cover such as the Upper Midwest.

The National Renewable Energy Laboratory (NREL, 2004) characterizes the solar resource for flat plate systems in Wisconsin as "good," ranging from 4.0 to 5.0 kWh per square meter per day. Generally speaking, the potential is slightly higher in the western half of the state. Wisconsin's potential compares in range to the photovoltaic solar resource in Indiana, Ohio and Michigan, but is less than Minnesota and Illinois, and states farther west and south.

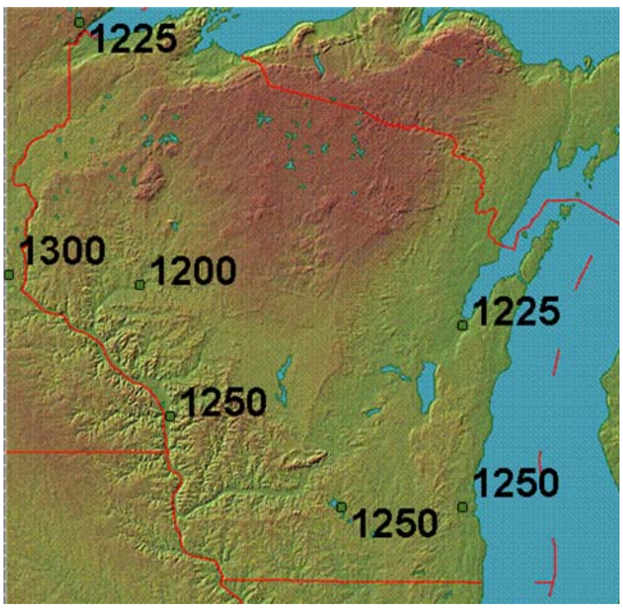

FIGURE 31.01.1. PV SYSTEM PRODUCTION DATA PV system production data show optimum yield in kWh per year, per kW of solar PV installed in five cities in Wisconsin and two in Minnesota. These numbers represent PVWatts data less 20 percent to account for typical system losses. (NREL, 2004)

Solar technologies are particularly appropriate in urbanized settings. Both electric and thermal solar systems can be installed on existing buildings, are quiet to operate and require little maintenance. Furthermore, both solar PV and solar thermal applications offset the use of fossil fuels. Photovoltaic systems can replace coal and natural gas used for electric generation while solar thermal applications replace or augment the use of natural gas, propane or oil used for heat.

Market Scope

This market consists primarily of retrofitted installations of site-dedicated solar PV systems on commercial buildings and facilities, and secondarily, of building integrated photovoltaic (BIPV) systems installed in the form of roofing, glazing and other building materials as part of new commercial construction.

Market Characteristics

Volatile fossil fuel markets, growing public pressure to increase regulatory controls on greenhouse gasses, and new concerns about energy security are beginning to drive interest in distributed generation (DG) strategies among commercial and institutional power customers. Solar PV shows particular potential as a DG strategy because it can be retrofitted easily, even in urban settings, and requires little maintenance. New financing options, state and federal incentives, and easier access to grid interconnection also play an important role in the growth of this market. Further economic considerations include federal tax advantages, accelerated depreciation, and time-of-use utility rates.

In recent years there has been notable growth in grid connected solar PV both nationally and internationally. A Solarbuzz report (May 2004) states that "37 Megawatts of grid-connected solar photovoltaics were installed in the United States in 2003. This represents growth of 32 percent over 2002 installations of 28 megawatts." While the residential market is currently growing the fastest, the potential for customer sited commercial PV installations is huge, as distributed generation (DG) strategies become more appealing to both businesses and utilities. Businesses with high quality power needs have created a leading edge in this market through integration of battery bank solar PV systems with uninterrupted power supply (UPS) systems.

Commercial Solar PV in Wisconsin

In a recent Energy Foundation study of PV market potential, Chaudhari, Frantzis and Hoff (2004) estimate that in 2010 there will be 1,323 million square feet of roof area in Wisconsin offering unimpeded solar access. Forty-seven percent of this roof area, or 602 million square feet, will be on commercial structures. As a hypothetical example, if we estimate 70 percent of this roof space to be dedicated to solar PV applications (reserving 30 percent for thermal installations), there would be 421.4 million square feet of roof area potentially dedicated to solar PV for Wisconsin businesses. This represents a technical potential of approximately 3.5 to 4.3 gigawatt hours of electricity per year produced by commercial solar PV installations in the state (based on 90-110 kWh per square meter). If only 10 percent of this roof area were developed in solar PV, it would mean a total of 27.2MW to 34.4MW installed. The Energy Foundation study projects that demand for commercial solar PV in Wisconsin in 2010 will be approximately 6MW (at $4.24-$4.65/watt installed), or 17 percent-22 percent of this hypothetical ten percent.

While Wisconsin's geographic potential for solar energy is described as good, the effective load carrying capacity (ELCC) for photovoltaic applications in the state is excellent. According to NREL, which used utility load shape characteristics to map the ELCC for photovoltaics across the nation (NREL, 1996), "The intensity of the solar resource is obviously critical to PV power generation. But in determining PV's value to a utility, the magnitude of the sun's intensity is less important than its relationship to load requirements." Three characteristics of areas with a high ELCC are occurrence of intense summer heat waves, high daytime commercial power demand, and low demand for electric heat. Wisconsin fits this description well and was mapped into the two highest categories (60 percent -- 100 percent), where the state's power demand curve is matched with the power production curve of solar electricity.

Commercial solar PV has made little progress to date in Wisconsin. In addition to the high costs, there is evidence that the Wisconsin public does not identify with solar PV as a source of electricity for the state. In a report prepared for the Garfield Foundation, Action Media describes results of its Midwestern focus groups for studying public perceptions of electric energy production (Action Media, 2005). They found that Wisconsin residents identify wind and biomass as sources of clean electricity for the future, but solar PV was not mentioned during the focus group discussion. Clearly, raising the general awareness level is an important program challenge.

In the future, some building owners will undertake installation of PV systems on their own, but as economic advantages and public policy support accrue, development of this market might be accomplished to some extent by third party solar electric utilities. They will either install site-dedicated systems and sell the power to the building owner, or lease roof or land space as independent power producers.

While stakeholders see great potential for solar PV installations in the commercial sector in Wisconsin, they feel this market is still in an "early adopter" stage where potential system owners are interested in the environmental benefits rather than the economic return. They are willing to take on greater than average risk as a result. Stakeholders have concluded that mainstream adoption of solar PV in the commercial sector is quite possible but somewhere down the road.

Stakeholders agree that three things will be required to establish an effective market infrastructure for driving future development of the commercial solar PV market:

a. Favorable public policy and consistently supported incentive programs
b. Reduction in economic barriers for installation of equipment
c. Promotion of the environmental value of solar energy

Stakeholders further agree that expansion of the commercial solar PV market, even among early adopters, will primarily require strategies that reduce economic barriers. These barriers include the expense of the equipment and the lack of market recognition for the economic value of an energy source without emissions or pollutants. Stakeholders suggested that raising the net metering maximum above 20kW will not necessarily increase the number of installed systems in and of itself, but it could have a significant impact. Net metering credits surplus kilowatt hours produced by the customer's system at the retail rate. The average size of net-metered systems in Wisconsin is currently around 2kW, but most are residential installations.

Program Approaches

Further suggestions for lowering existing barriers included a production tax credit (like that in existence for wind energy), a renewable portfolio standard set-aside, higher buy-back rates for renewable energy, building code changes, first-cost incentives, and education, facilitation and marketing efforts. Of these, only incentives and outreach efforts are within the purview of a public benefits program, and could be considered program approaches. It is clear that program effectiveness will require equally aggressive emphasis on both these areas.

Wisconsin has a head start with its public benefits program already in place. At present, installations of commercial solar PV are almost exclusively tied to Focus on Energy Program incentives and facilitation. As financial incentives require promotion and education efforts to be effective, and facilitation of individual system development can be key to completing installations, these approaches are addressed here as an interdependent package.. This point of view is shared by findings in the *Commercial Solar Energy Market Potential Study* (Grover, 2004):

> In sum, it is clear that both environmental concerns and economic factors are perceived as very important among commercial facilities that have installed solar, while interest in demonstrating the technology and gaining recognition are significant, but less important. These findings suggest that the market will continue to require significant incentives to encourage adoption for the foreseeable future, and that the availability of incentives should be used in tandem with marketing efforts that emphasize the environmental and other benefits of solar power for the commercial sector.

PROGRAM AREA 31.01 – INCENTIVES FOR CUSTOMER-SITED, GRID-CONNECTED COMMERCIAL SOLAR PHOTOVOLTAICS (PV)

TABLE 31.01.6. ESTIMATED VALUES FOR PROGRAM AREA 31.01, INCENTIVES AND OUTREACH FOR COMMERCIAL SOLAR PV:

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$675 to $838	$1,346 to $1,797
	Incremental Impacts	peak kW	82 to 129	279 to 438
		annual kWh (000s)	164 to 263	554 to 891
		annual therms (000s)	0	0
	Levelized resource cost	per peak kW	$455 to $746	$281 to $452
		per kWh	22.5¢ to 37.8¢	13.9¢ to 22.8¢
		per therm	NA	NA
Scaling factors[a]		program costs	NA	NA
		impacts	NA	NA

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Program Area 31.01 — incentives and Outreach for Commercial solar PV:

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 31.01.2. MODEL INPUTS FOR INCENTIVES AND OUTREACH FOR COMMERCIAL SOLAR PV

Model Inputs (31.01)			**Value**	**±**
1		**Per-Unit Impacts (unit = 1 kW PV installed)**		
	a	Summer peak coincidence factor (%)	0.625	0.075
	b	Capacity factor	0.143	0.020
2		**Program Participation**		
	a	Kilowatts installed by end of year one	74	15
	b	% Compound annual increase in installed kW	42%	10%
3		**Program costs**		
	a	Fixed program costs -- Year 1	$300,000	$30,000
	b	Annual increase in fixed costs	7%	5%
	c	Variable costs per-unit Year 1	$3,050	$305
	d	Annual reduction in incentives per unit	4.7%	0.7%
4		**Measure life (years)**		
	a	Program life of system	25	5

1. Per Unit Impacts

We estimate the summer peak coincidence factor ***(Input 1a)*** for commercial solar PV from an annual peak on a summer afternoon between the hours of 1:00 PM and 5:00 PM. Panel capacity is based on the DC rating. Losses incurred when the power is converted to AC average about 20 percent, and high temperatures experienced on summer peak days reduce PV panel efficiency by about 10 percent more. Allowing an additional 5 percent for possible further losses from clouds or shadows, the resulting summer peak coincidence factor for stationary panels is about 55-60 percent (Wolter, 2005, and Perez, Schlemmer, Bailey & Elsholtz, 2000).

To determine the capacity factor ***(Input 1b)***, we examined data from the Focus on Energy Renewable Energy Program. These data indicate that the installed capacity of commercial PV systems was 3.84 kW (5,946 kWh) in FY2002, 5.84 kW (7,601 kWh) in FY2003, 14.73 kW (22,001 kWh) in FY2004, and an estimated 52.13 kW (67,710 kWh) in FY2005. The 76.55 kW total installed capacity produced an estimated 103,258 kWh. The PV systems installed had rated capacities of 0.48 kW to 11.52 kW – both fixed and tracking systems. The average annual capacity factor for all systems was 0.154, or 1,349 kWh/year, per installed kW. However, because the factors presented a broad range in capacity, we incorporate this range by using an uncertainty factor of plus or minus 200 kWh/year (per installed kW), or a capacity factor uncertainty range of 0.04.

2. Program Participation

The commercial solar PV market in the U.S. has been constrained primarily by the high up-front cost of installation that prevents it from competing successfully with coal and other fossil fuels. However, utilities and other energy investors are beginning to recognize the economic value of solar PV as a clean source of energy. National trends have shown greater than 30 percent growth in PV installations per year over the last five years (NREL, SNL & BNL, 2004) and annual growth at this level is expected through the next ten years as the technology matures in the marketplace. While growth has been greatest in the West and Southwest, a number of states in the Northeast have developed aggressive public benefits programs supporting development of solar PV (Luce, 2004), illustrating that the solar resource in colder, cloudier northern climates offers significant possibilities.

Conditions in Wisconsin have yet to reflect this optimism, but the state shows some potential for catching up with national trends. According to the Energy Foundation study (Chaudhari, Frantzis & Hoff , 2004), in 2010 the potential annual demand for grid-connected commercial PV in Wisconsin will be six MWp, if the price per watt is $4.25 to $4.64. In *Our Solar Power Future: The U.S. Photovoltaics Industry Roadmap Through 2030 and Beyond* (NREL, SNL & BNL, 2004), the base case projected per watt price in 2010 is $4.87, which drops to $4.24 by 2015. Even by assuming this conservative base-case scenario (the report's "roadmap" scenario predicts $4.65/W in 2010 and $3.68/W in 2015 if their aggressive program is followed), Wisconsin could potentially be generating at least six MWp of solar electricity by 2015 at the latest, if current economics and regulatory processes continue. PV industry stakeholders in Wisconsin agree that economic and regulatory barriers are beginning to fall, and some of those mentioned are along the lines recommended as actions for market expansion in *Our Solar Power Future* (NREL, SNL & BNL, 2004). These include investment tax credits, uniform net metering, and building public-private partnerships like public benefits programs to support renewable energy development.

By looking ahead at existing program co-funded PV resource site assessments, feasibility studies and the funding application queue, we project 74kW of PV installed in Year 1 ***(Input 2a)***. This incorporates the marked increase in project applications received in the last two months of the most recent program year, which have almost doubled previous projections. The uncertainty factor takes into account both the possibility that more proposals will be received, and that all project proposals may not result in installations.

In determining a potential growth rate for commercial solar PV in Wisconsin over the next ten years, we are employing the projections in *Our Solar Power Future* (NREL, SNL & BNL, 2004) and the Energy Foundation study (Chaudhari, Frantzis & Hoff , 2004) to assume that Wisconsin can join other northern states in keeping pace with national trends. The Energy Foundation study projects that Wisconsin will have 6MWp installed if the price drops to $4.25 to $4.64 by 2010. The Industry Roadmap estimates its conservative base case scenario price as $4.24/W installed in 2015, the 9th year of the study. Based on these numbers (and our Year 1 kW projection), to install 6MWp total by year ten, the average compound increase in installations in Wisconsin would need to be 52 percent per year. This rate of growth would require the most optimal development of economic conditions and the industry infrastructure in the state, so we assume this percentage to be our maximum estimate. ***Input 2b*** is our estimate that the compound annual increase would be 42 percent plus or minus 10 percent. This range would keep Wisconsin's minimum growth close to the international growth rate in 2003, which was 32 percent (NREL, SNL & BNL, 2004). An aggressive program, however, will be essential to achieving this rate of growth.

3. Program Costs

Fixed program costs ***(Input 3a)*** include such activities as sponsorship and participation in general renewable energy events, cross-cutting marketing and PR functions, and a variety of administrative program costs. Fixed costs also include project facilitation and administration of incentives for this particular market. Rather than break down these costs in detail (which would require a specific program design, we have estimated an aggregated FTE total to include the time required for all the tasks listed above, regardless of the number of projects ultimately receiving funding. This estimate is based on Focus on Energy program administrator and contractor experience.

We estimate personnel requirements for the commercial solar PV program for Years 1 through 3 be 3.0 FTE to cover the variety of activities involved in production and distribution of publications, individual project facilitation, grant and incentive administration, and event participation on behalf of the market. While the program will encourage development of promotional capabilities by market providers (and therefore reduce program staff time for these activities), we anticipate the program will need to increase staff for facilitation of the growing number of individual projects. We estimate this growth will be approximately seven percent per year starting in Year 4, bringing total staffing to about 3.5 in Year 10. Once again, this projection is based on program contractor experience. Personnel costs are assumed to be $100,000 for 1 professional-level FTE, fully loaded. The uncertainty factor for total fixed program costs is estimated to be plus or minus 10 percent.

Variable costs for the commercial solar PV market ***(Input 3b)*** are those incentive costs that can be attributed per unit. A 50 percent incentive for commercial solar PV equates with the aggressive levels offered by a number of utilities in California (DSIRE, 2005). A marketing vice president at Powerlight states, "As far as the economics, the market still needs significant incentives; it really takes a 50 percent incentive level to have the numbers work. Even at 50 percent a lot of projects are right on the fence."(Grover, 2005). California has built periodic reductions into its incentive levels to ease its programs out of the marketplace. Because Wisconsin's market is not as mature as California's, we maintain the 50 percent incentive level throughout the ten years. The total incentives paid, however, will fall with the price of equipment.

According to targets and projections presented in *Our Solar Power Future* (NREL, SNL & BNL, 2004), the 2004 system installation price per watt for commercial PV was $6.10, and the report projects this will fall to $4.24 by 2015 as the base case if market conditions remain the same, and to $3.68 if the aggressive development roadmap is followed. We are adopting the projections in the Roadmap Report as the basis for our incentive. We therefore use 50 percent or $3.05 per watt as the incentive in year 1. As the installed cost per watt decreases, we assume the total incentive amount will also fall at a rate of about 4.6 percent per year to reach $3.96 per watt, the approximate midpoint between the two Roadmap scenarios.

4. Measure Life

The program measure life ***(Input 4a)*** refers to the number of years that can be credited to the influence of this program approach on the adoption of the technology. In other words, it considers the likelihood that the technology would be adopted anyway given a certain amount of time, but that the program can be considered the reason it was installed sooner, and can therefore be credited with saving fossil fuel energy during that period. The payback period for commercial PV systems continues to shrink due to stabilizing equipment and installation quality, the potential for green energy pricing and the development of new business models. However, this remains the most expensive renewable energy option, and therefore this is a market where program incentives and education will remain necessary if Wisconsin is to realize its potential.

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MARKET 32 — COMMERCIAL SOLAR THERMAL HOT WATER

Market Scope

This market focuses on businesses and institutions that use large volumes of hot water. These include car washes, hotels, health clubs, recreational facilities, industrial laundries and restaurants. Public institutions could include public and private schools, hospitals, nursing homes, college athletic facilities, public pools and transportation maintenance facilities.

We do not include industrial applications in this market, even though the technology is similar, because specific applications are widely varied and program efforts would require distinctly different approaches to maximize effectiveness. Nor do we include multi-family housing with central water heating systems because their total volume of hot water use is not generally as high per site as the commercial applications listed above.

Market Characteristics

Like solar PV, solar water heating systems use flat plate, or non-concentrating solar collectors. Therefore the solar resource for water heating in Wisconsin is "good," ranging from 4.0 to 5.0 kWh per square meter per day. In Wisconsin's cold weather climate, this resource is sufficient to economically provide 40 percent to 50 percent of the energy required to heat water used in commercial businesses and institutions. Where water use is high, the savings are potentially significant.

In a recent study of PV market potential, Chaudhari, Frantzis and Hoff estimate that in 2010 there will be 1,323 million square feet of roof area in Wisconsin offering unimpeded solar access. Forty-seven percent of this roof area, or 602 million square feet, will be on commercial structures. While this roof space would necessarily be shared between solar PV and thermal installations, estimating just 10 percent for thermal applications yields 60.2 million square feet of roof area potentially dedicated to solar hot water heating for Wisconsin businesses. This represents a technical potential of approximately 156.5 million therms produced by commercial solar water heater installations in the state.

The most common source of energy for commercial water heating in Wisconsin is natural gas. The commercial solar thermal market has been almost completely unexplored until recently primarily because natural gas has been both cheap and available. However, the natural gas supply is now seen as less reliable and solar water heating is beginning to attract serious attention from the commercial and institutional sectors. While beyond the scope of this present study, there is a significant need to identify the market potential for commercial solar thermal energy among the broad variety of Wisconsin businesses and institutions that require large volumes of hot water.

Over the years, the cost of fossil fuel has risen at a greater rate than the price of solar thermal equipment or the costs of installation. Program projects are currently showing a payback of around twelve years. "The systems, especially for non-profits, can not realize a positive cash flow in the first year until the price per therm is $1.20 to $1.40" (Wichert, 2005). However, the industry hopes to see payback calculations of ten years or less for installation of solar thermal technologies soon, making this a potential source of reliable savings for the commercial sector. Stakeholders in the commercial solar thermal market agree that both businesses and institutions will need to consider the economics first, but that with present

Focus on Energy incentives and the economy of scale for larger systems, some systems can realize a positive cash flow immediately (Ramlow, 2005).

Stakeholders further agree that the commercial solar thermal market can be divided into two segments: short term investors who require a quick payback (laundromats, car washes and restaurants which are high-turnover, bottom-line oriented businesses) and long-term investors who can tolerate a moderate to long payback (academic institutions and businesses interested in future growth and developments such as health facilities, hotels and commercial laundries). These two groups will need slightly different approaches to develop the potential for using solar thermal technologies.

One business model for delivering solar hot water is a third-party solar hot water utility. Wisconsin has an operating third-party solar hot water utility, Solar Mining, Inc. of Green Bay, which was founded in 2003. Under their solar utility program, this company owns the solar water heating systems it installs, and sells its customers the hot water that those systems produce. There has been considerable interest on the part of potential customers for this service, but this business model has been slow to attract investment capital. Stakeholders identified the shortage of investment capital to be a significant barrier to the development of solar thermal (as well as other renewable energy) utilities in Wisconsin.

The shortage of investment capital can be attributed somewhat to misconceptions about the reliability of solar thermal technologies. These misconceptions about solar hot water systems are a remnant from the tax credit days of the 70's when many systems were poorly installed and later abandoned. Also, businesses are generally unaware of the potential energy savings available from using solar heated water, and of the existence of the third-party solar utility business model that would eliminate operation and maintenance responsibilities.

Program Approaches

According to the 2005 technology roadmap developed by representatives of the water heater industry and facilitated by U.S. DOE, U.S. use of solar thermal technologies for water heating "is woefully inadequate considering their potential." (Representatives of the Water Heater Industry, 2005). The report indicates that the solar thermal industry has the potential to make a major contribution to clean energy goals, but that it has received a secondary level of attention in state programs when compared to solar PV. At the present time, Wisconsin is quite possibly the only state that specifically includes the commercial solar thermal market in its program (Wichert, June 2005).

Stakeholders agree that the potential for installation of commercial solar water heating in Wisconsin is tremendous, and the most effective program approach would be a combination of incentives and targeted customer education. For example, a primary target in this market would be swimming pool heating for both indoor and seasonal facilities. Promotion of pool heaters would attract interest from schools, municipalities, health clubs and hotels or resorts with swimming facilities. While incentives will play a less important role than they do for commercial solar PV, they still will be needed to boost the customer interest and involvement generated by the education efforts.

We consider financial incentives and education efforts to be an interactive program approach. Financial incentives could be tailored to the length of payback tolerance of short-term and long-term customer priorities. Long-term business thinkers are considered to be the most likely adopters in the first five years and the short-term business thinkers would follow their example during the subsequent five years.

Education programs include one-on-one "sales"/facilitation, and program presence at professional trade shows and on web sites. The program could organize district demonstrations projects, working with a number of businesses in the same neighborhood or area.

TABLE 32.01.1 ESTIMATED VALUES FOR PROGRAM AREA 32.01 – INCENTIVES AND OUTREACH FOR COMMERCIAL SOLAR THERMAL (HOT WATER)

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		\$908 to \$1,181	\$929 to \$1,270
	Incremental Impacts	peak kW	0	0
		annual kWh (000s)	0	0
		annual therms (000s)	132 to 212	182 to 304
	Levelized resource cost	per peak kW	NA	NA
		per kWh	NA	NA
		per therm	43.1¢ to 74.3¢	32.0¢ to 55.9¢
Scaling factors[a]		program costs	0.7 to 1.8	0.7 to 1.8
		impacts	0.8 to 1.4	0.8 to 1.4

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

Program Area 32.01 — Incentives and Outreach for Commercial Solar Thermal (Hot Water)

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 32.01.2 MODEL INPUTS FOR INCENTIVES AND OUTREACH FOR COMMERCIAL SOLAR THERMAL (HOT WATER)

Model Inputs (32.01)			Value	±
1		**Per-Unit Impacts (unit = one sq ft of panel installed)**		
	a	Annual per-unit natural gas savings (therms)	3.3	0.5
2		**Program Participation**		
		Sq ft of panels installed to displace natural gas per year:		
	a	Systems installed under 1,000 therms, in units, year 1	10,000	2,500
		Compound annual % increase in installed units (a)	15%	5%
	b	Systems installed 1,000-5,000 therms, in units, year 1	18,000	4,500
		Compound annual % increase in installed units (b)	15%	5%
	c	Systems installed over 5,000 therms, in units, year 1	12,000	6,000
		Compound annual % increase in installed units (c)	10%	5%
3		**Program costs**		
	a	Fixed program costs in Years 1-3	$300,000	$30,000
		annual reduction in fixed costs years 4-10	5%	2%
		Variable costs per-unit (incentives) each year		
	b	Systems under 1,000 therms, per unit, years 1-5	$20.80	$2.08
		Compound annual decrease in incentive level, years 6-10	10%	5%
	c	Systems between 1,000-5,000 therms, per unit, years 1-5	$13.00	$1.30
		Compound annual decrease in incentive level, years 6-10	15%	7%
	d	Systems over 5,000 therms, per unit, years 1-5	$11.25	$1.13
		Compound annual decrease in incentive level, years 6-10	15%	5%
4		**Measure life (years)**		
	a	Program life of system	20	5

1. Per Unit Impacts

We estimate that one square foot of solar thermal panel produces between 650 and 750 Btu's per square foot per day, or 237,000 to 274,000 Btu's per year. This range is based on accurately metered energy output of commercial solar thermal systems installed and maintained by Solar Mining Co. of Green Bay. Refined monitoring data from this source is only available from winter, 2005 and therefore reflects the low sun resource of the winter months. The Solar Mining Company findings are that their flat plate collectors are producing between 237,412 to 273,937 Btu/sq. ft. per year, depending on the system and application. Again, with this data reflecting the low-sun time of year, higher averages are anticipated when full-year figures are available (Ramlow, 2005). To support their analysis, results from sample RETscreen computer simulations (RETScreen, 2004) for Focus on Energy solar thermal projects were very similar at 275,000 Btu per square foot of flat plate. RETscreen is an accepted industry standard for simulating system performance. For purposes of this study, we are using the midpoint of 700 Btu's per square foot per day (or approximately 260,000 Btu's per year per square foot).

Natural gas savings per unit *(Input 1a)*: Gas-fired boilers are currently available in two efficiency ranges. Information from Alliant Energy indicates that conventional boilers are 80 percent efficient on average, and high efficiency boilers (condensing units) boost efficiency into the nineties (www.alliantenergy.com/stellent/groups/public/documents/pub/012379.pdf). However, many older, less efficient boilers operate in the 60 percent -- 70 percent efficiency range (www.alliantenergy.com/stellent/groups/public/documents/pub/sb_wi_ee_hc_blaze_000548.hcsp#P50_5860). We are therefore calculating our thermal displacement range from this efficiency range, using 80 percent efficiency plus or minus 15 percent of therms displaced at 80 percent. The number of therms of natural gas required to produce a level of Btu's equivalent to one square foot of solar thermal panel from an 80 percent efficient gas-fired water heater is 325,000 Btu's, or about 3.3 therms, based on 1 therm = 100,000 Btu 's, plus or minus .49 therms.

2. Program Participation

At the present time, the most economical solar-heated water for the commercial/institutional sector is available from Solar Mining Company of Green Bay. Acting as a solar utility, they manufacture and install their own panels, and sell hot water to their customers for an average price of $45 per square foot installed. The Citizens Energy Cooperative, another new organization, is beginning to buy up systems installed by the Solar Mining Company. This third party model derives considerable benefit from the presence of the public benefits program, and they work well together to get systems installed. The Solar Mining Company is particularly interested in systems over 1,000 therms in size (Ramlow, June 2005).

Solar Mining Company estimates that there are 5,000 swimming pools in Wisconsin owned by schools, municipalities or hotels and resorts. Swimming pool systems are highly efficient because these facilities are usually used seven days a week, whether they are indoor or seasonal. While there are many other potential opportunities for commercial solar water heating, program personnel predict that swimming pool systems will dominate the installations for at least five years (Ramlow, June, 2005).

There are three sizes of commercial solar thermal systems currently designated in the program, with different incentive levels assigned. We are maintaining these categories because they reflect different segments of the market. The swimming pool market straddles the small and medium size categories for solar water heating. Systems under 1,000 therms ***(Input 3a)***, ranging up to about 400 square feet in size, will see the most growth over the next few years because this group includes the majority of swimming pool systems (Ramlow, June 2005). This size category also serves domestic hot water needs for small businesses including small car washes or laundromats. While systems in this size range are eligible for the largest incentives, they are also the most expensive to install per square foot ($65). They are currently the least cost efficient both from the economy-of-scale perspective, and because these systems are not in the range offered by Solar Mining Company. They might, however, eventually be served by the Citizen's Energy Cooperative or another third party energy company. At present, these systems are primarily customer-owned and financed. Based on Focus on Energy program applications and experience, we estimate installations will number 25 systems per year in the first year, with a 15 percent rate of growth per year after that. We estimate the uncertainty factor for installations in this size range to be plus or minus 25 percent (7,500 to 12,500 therms) to account for the volatility of natural gas prices and potential development of third-party energy providers for this segment, particularly during the first five years. This means as few as 18 systems or as many as 31 could be installed in year 1.

For the next size range, 1,000 to 5,000 therms ***(Input 3b)***, we estimate that about 6-9 systems, mostly swimming pool systems, will be installed in the first year . Installation of systems in this size range is then estimated to increase by 15 percent in each of the following years. The uncertainty factor for this range is estimated at plus or minus 25 percent.

Systems sized over 5,000 therms ***(Input 3c)*** will be fewer in number but will contribute greatly to the total number of therms installed. One market as yet untapped in Wisconsin is correctional facilities which need a very predictable and constant supply of hot water. Growth in this size category will likely depend on adoption of solar thermal technology for such state facilities. Solar Mining Company is already selling panels to installers in other states who are tapping this market. We estimate 1-2 system installations in this category for the first year, and a 10 percent per year increase after that. This largest market is firmly centered in the third-party utility scenario. We estimate the uncertainty factor for this segment to be plus or minus 50 percent (6,000-18,000 therms), due to the number of unknown factors. Only one system may be installed in year one if third-party capitalization remains a problem. However, as many as three to four may be possible if capital is made available and the utility attracts new customers such as Wisconsin correctional facilities.

Stakeholders and program professionals agree there is considerable untapped potential for application of solar thermal technology in Wisconsin, but that realizing this potential will require an assertive and targeted program effort, with primary emphasis on customer education and facilitation, and the support of attractive incentives. We have increased the estimates for numbers of systems installed beyond present program data in all three categories based on the expansion of program commitment as reflected in the fixed cost estimate below.

3. Program Costs

Fixed costs ***(Input 3a)*** include such program activities as sponsorship and participation in general renewable energy events, cross-cutting marketing and PR functions. Fixed costs also include project facilitation and administration of incentives for this particular market. Rather than break down these costs in detail (which would require a specific program design), we have estimated an aggregated FTE total to include the time required for all the tasks listed above, regardless of the number of projects ultimately receiving funding. This estimate is based on Focus on Energy program administrator and contractor experience.

Based on industry input that recommends assertive promotion of solar thermal technology in Wisconsin, personnel requirements for a commercial solar thermal program are estimated at 3.0 FTE for the first three years, to cover production and distribution of publications, individual project facilitation, grant and incentive administration, and event participation on behalf of the market. This is more than twice the present level of allocated program resources, and would include development of proactive educational efforts and assistance with industry infrastructure development. After year three, depending on market development, we project that efficient use of personnel to transfer primary project facilitation and public information responsibilities to market providers will reduce program personnel requirements approximately five percent per year, bringing total personnel requirements to about 2.5 in Year 10. Once again, this projection is based on program contractor experience. Personnel costs are assumed to be $100,000 for one professional-level FTE, fully loaded. The uncertainty factor for total fixed program costs is estimated to be plus or minus 10 percent.

Variable costs for the commercial solar thermal market are those incentive costs that can be attributed per unit. This includes cash-back rewards and implementation grants. The Focus on Energy incentive levels for commercial solar hot water projects compare favorably with solar thermal incentives available in other states (Luce, 2004), where percentages vary from 15 percent to 50 percent, and maximum incentives from $12,500 to $250,000. In states where a flat incentive rate is offered, they average between $500 and $1,000 per system. In most other states, incentives are offered for displacing electric water heaters only, whereas Wisconsin's present program offers incentives to displace natural gas as well.

Solar Mining Company estimates that energy rates will have to reach $1.40 per therm before they will be able to guarantee that a system would produce enough energy to equal the customer's lease payment. They project this could happen within six years (Ramlow & Solar Mining Company, June 2005). We are therefore projecting fully funded incentives for the first five years, which will begin decreasing in year six at slightly differing rates. For projects of less than 1,000 therms ***(Input 3b)***, the incentive level is $8.00 per therm or $20.80 per square foot (based on 2.6 therms per square foot) which will begin decreasing at 10 percent per year in year six. Projects in the 1,000-5,000-therm range ***(Input 3c)*** are presently more economical than smaller systems and will remain so into the future. We estimate accelerated growth in this range will allow reduction of incentives ($5.00 per therm or $13.00 per square foot) at a rate of 15 percent per year. We estimate the largest systems ***(Input 3d)*** (over 5,000 therms) will become economical enough in year six to allow reduction of incentives by 15 percent per year as well.

Stakeholders favor leaving Wisconsin incentive rates as they are presently set up, using rates established for the 2006 fiscal year. However, they also feel that larger projects should receive more encouraging incentives than are presently available to attract a broader customer base. To encourage aggressive development of the larger systems, we are increasing the incentive levels for installations over 5000 therms from about 17 percent of project cost (up to $35,000) to 25 percent of project cost (no upper limit). The incentive level remains competitive with other state solar thermal programs (which are almost exclusively small, residential systems) and assures that the infrastructure for larger systems is developed. As illustrated in random examples of present incentive levels in the table below, only projects over approximately 10,000 therms would receive a notably greater incentive than is presently available. System size is based on 2.6 therms per square foot.

TABLE 32.01.3

System Size	Est Max Sq Ft	Install $/sq ft	Incentive $/sq ft	System $ total	Incentive $ total	% of Sys cost
Less than 1000 therms (999)	384	$65	$20.80	$24,960	$7,987	32%
1000 -5000 therms (5000)	1,923	$45	$13.00	$86,535	$24,999	29%
Over 5000 therms (Example: 10,000 therms)	3,846	$45	$11.25	$173,070	$43,268	25%
Example: 12,000 therms	4,615	$45	$11.25	$207,675	$51,919	25%
Example: 20,000 therms	7,692	$45	$11.25	$346,140	$86,535	25%

4. Program Measure Life

The program measure life ***(Input 4a)*** is an estimate of the number of years that the influence of this program approach has accelerated the adoption of commercial solar thermal systems. In other words, it considers the likelihood that the technology would be adopted anyway given a certain amount of time, but that the program can be considered the reason it was installed sooner, and can therefore be credited with saving fossil fuel energy during that period. The payback period for commercial hot water systems continues to shrink due to stabilizing equipment and installation quality, rising gas prices, and the development of new business models. However, public perceptions of the technology continue to lag. This is a market where program incentives and education will remain necessary for at least ten more years if Wisconsin is to realize its potential to create an established market infrastructure for commercial solar water heaters.

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MARKET 33 — RESIDENTIAL SOLAR THERMAL (HOT WATER)

Market Scope

This market includes installations of solar thermal water heaters on new and existing single family homes. Multi-family housing is not included in this market because of the differences in system scale and ownership.

Market Characteristics

The National Renewable Energy Laboratory (NREL) characterizes Wisconsin's solar resource for water heating, a flat plate technology, as "good," ranging from 4.0 to 5.0 kWh per square meter per day (NREL, 2004). In a recent study of PV market potential, Chaudhari, Frantzis and Hoff estimate that in 2010 there will be 1,323 million square feet of roof area in Wisconsin offering unimpeded solar access. Fifty-three percent of this number, or 704 million square feet, will be on residential structures (Chaudhari, Frantzis & Hoff, 2004). This roof space would be shared between solar PV and thermal installations but estimating just 50 percent for thermal applications would yield 353 million square feet of roof area that potentially could be dedicated to solar hot water heating for Wisconsin homes. At 60 to 80 square feet per typical residential system, this represents a technical potential of 4.4 to 5.8 million solar water heater installations in the state, or approximately 902 million therms.

According to typical industry rules of thumb as laid out in Home Power Magazine (Olsen, 2001), panel area requirements for a solar water heating system on a home in the Midwest are one square foot of panel per gallon of tank capacity. An 80-gallon residential hot water tank would therefore need 80 square feet of solar thermal panels. This size system is intended to provide 100 percent of hot water in the summer and about 40 percent in the winter (as a general estimate). However, each individual site must be analyzed based on incoming water temperature, hot water temperature setpoint, actual usage and intensity of solar resource on site. Water conservation measures can improve the savings (and payback) potential of a solar hot water system. In general, solar hot water systems are installed to augment the existing water heater.

Target homeowner demographics might describe custom home buyers who want to incorporate clean and green energy measures and may find that the net monthly mortgage cost of their solar water heater is lower than what they would pay per month for electric or even gas-heated water. Owners of existing homes (with sufficient solar access) might be feeling the pinch of rising natural gas prices and wish to save on energy for the long-term.

Another target group for solar hot water systems would be homeowners who have already adopted energy-efficient appliances and other energy saving home improvements. According to a characterization study prepared for the Energy Trust of Oregon, people who installed a solar water heating system were likely to have also purchased other energy efficient products (Kunkle, Kivlen & Dethman, 2004).

In U.S. households, heating water is a major energy expense. According to Pigg and Nevius (2000), 28 percent of residential water heaters in Wisconsin are electric, 61.9 percent are fueled by natural gas, 8.7 percent by propane and 04 percent by oil. With rising prices for natural gas and other fossil fuels, the initial capital cost of a solar water heating system begins to make economic sense. As a hedge against rising fuel costs, solar thermal offers the advantage of purchasing future heating energy in advance, and can offset a significant portion of utility costs for heating water for a household in Wisconsin. At present, only 1 percent of water heaters in the state are solar powered (Pigg & Nevius, 2000).

Installation of a residential solar water heater system in Wisconsin is still most cost effective on new homes where solar access is usually more predictable due to the absence of mature trees. Good solar access for existing homes is much less likely. Home builders who are already developing energy efficient housing may move toward the "Zero Energy Home" concept by offering a solar hot water system as an option in their appliance package. The next step would be combining solar hot water with a grid connected solar PV option.

Fluctuating fuel and electricity costs may soon make installation on existing homes very cost effective, but this alone will not move the market. According to an industry report, "Solar water heaters are stuck in the 'chasm' between early adopters and adoption by mainstream users…Transitioning into the mainstream will require marketing specific applications to discrete market segments and locations with favorable conditions to help get the most from limited resources…" (Representatives of the Water Heater Industry, 2005).

The 1997 report, *Wisconsin Solar Domestic Water Heater Market Research*, identifies first cost as a primary barrier to solar water heater adoption, but also found potential customers uncertain about system reliability and maintenance (Peters, Robison & Winch, 1997). This report goes on to suggest the most effective strategy for overcoming first cost, maintenance and system credibility issues would be the development of a third-party solar hot water utility that would install and own the systems, and sell the hot water to homeowners. Now, just eight years later, the Citizens Energy Cooperative has been established to provide this service, and demand is strong. The growth of this company follows the successful establishment of Solar Mining, Inc. of Green Bay, a third-party solar water utility for commercial systems.

Public concern about climate change and shrinking fossil fuel supplies have increased since 1997, which has only broadened general interest in energy alternatives. However, Peters, Robison and Winch (1997) also concluded that public awareness of solar water heating technology was very low and that a general education campaign would be essential to increasing the number of systems installed. This conclusion was confirmed in a program evaluation completed three years later (Opinion Dynamics Corporation, 2000). The report summary states "Home builders and new home buyers need evidence that solar water heating is a cost-effective, viable option for new homes." Builders indicated "they have very little knowledge about solar water heating and, in addition to the cost-effectiveness concerns, they are concerned about the warranty, durability, roof integrity, reliability, appearance, resale value, water temperature regulation, unproven technology, lack of sun in Wisconsin and extra basement space required." Currently, industry professionals agree that the public's continuing lack of knowledge about solar hot water systems is a major barrier. Consumers lack faith because of outdated perceptions of the solar hot water industry. This is a residual barrier left over from the tax credit days of the 70's when many systems were poorly installed and later abandoned.

Program Approaches

It is clear that updating the public's perceptions of solar thermal technology will be key to realizing the potential for this market in Wisconsin. The solar water heating industry needs the support of an aggressive promotional and educational effort to "jump-start" market growth. Such a program should also be coupled with continued financial incentives to attract potential adopters who find the technology too capital-intensive.

Because natural gas prices have generally been low, most state programs promoting solar hot water to the residential sector have focused on using it to replace electric water heaters. This is still true for many states outside Wisconsin. Recent trends in gas pricing, plus gathering concern over combustion of fossil fuels in general have lead to new interest in solar hot water as a replacement for natural gas water heaters as well. Development of this local renewable energy sector would support priorities at the national level as well, where strategies for reduction of natural gas demand are now being addressed. A recent report for the U.S. Department of Energy titled *Easing the Natural Gas Crisis* states “Renewable energy and energy efficiency can reduce demand for natural gas and thus indirectly place downward pressure on gas prices” (Wiser, Bolinger & St. Clair, 2005).

Wisconsin does offer solar thermal incentives to homeowners with natural gas water heaters, but incentive levels and educational efforts have been low key. According to stakeholders, an assertive combination of incentives and facilitation, including a strong educational component, is the primary program approach to effectively address the potential in this market. An effective program approach would address both the negative image of solar water heating left over from the 70’s, and raise public awareness of the new realities of energy economics and climate change. Financial incentives can serve to attract potential adopters at the beginning of this program period and can be reduced as the technology becomes known and trusted. Program facilitation will assist in the completion of systems once interest has been raised. A bullet-proof warranty and quality system commissioning is needed to complete the package.

According to Kunkle, Kivlen and Dethman (2004), “Creating demand for solar water heating requires both marketing efforts to raise awareness about available programs and educational efforts that give people the opportunities to experience solar water heating and how it works.” Promotional and educational efforts, directed at both new and existing home owners, should emphasize current system reliability, equipment and installer certification programs, information on how saving natural gas costs influences cash flow, and the importance of clean energy for the future.

Further educational activities would address the professional sector. Education and training of plumbing professionals for installation of solar thermal systems might include mentoring, curriculum development or training grants. Special emphasis should be made to target new home builders about integrating solar water heating with energy efficiency strategies to make up an economical “green” package for prospective home owners.

PROGRAM AREA 33.01 – INCENTIVES, EDUCATION AND FACILITATION FOR RESIDENTIAL SOLAR THERMAL (HOT WATER)

TABLE 33.01.1. ESTIMATED VALUES FOR PROGRAM AREA 33.01, INCENTIVES, EDUCATION AND FACILITATION FOR RESIDENTIAL SOLAR THERMAL (HOT WATER)

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$497 to $642	$490 to $728
	Incremental Impacts	peak kW	10 to 21	13 to 29
		annual kWh (000s)	197 to 333	240 to 472
		annual therms (000s)	12 to 26	18 to 55
	Levelized resource cost	per peak kW	$802 to $1,928	$601 to $1,639
		per kWh	4.9¢ to 10.2¢	3.7¢ to 8.7¢
		per therm	131.1¢ to 274.8¢	71.1¢ to 183.2¢
Scaling factors[a]		program costs	0.3 to 1.1	0.1 to 1.0
		impacts	0.4 to 1.0	0.2 to 1.0

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

Program Area 33.01 — Incentives for Residential Solar Thermal (Hot Water)

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 33.01.2. MODEL INPUTS FOR INCENTIVES FOR RESIDENTIAL SOLAR THERMAL (HOT WATER)

Model Inputs (33.01)			Value	±
1		**Per-Unit Impacts (unit = one sq ft of panel installed)**		
	a	Annual per-unit natural gas savings (therms)	3.4	0.5
	b	Annual per-unit electric savings (kWh)	76.2	11.4
	c	Annual per-unit peak demand savings (kW)	0.0044	0.0013
2		**Program Participation**		
	a	Sq ft of panels installed to displace natural gas in year 1	3,600	1,080
		Compound annual increase to displace natural gas	20%	10%
	b	Sq ft of panels installed to displace electricity, year 1	2,800	560
		Compound annual increase to displace electricity	10%	5%
3		**Program costs**		
	a	Fixed program costs, gas replacement-- Years 1-5	$207,000	$20,700
	b	Fixed program costs, electricity replacement -- years 1-5	$93,000	$9,300
		Annual reduction in fixed costs years 6-10 (gas)	$6,900	$690
		Annual reduction in fixed costs years 6-10 (electricity)	$3,100	$310
	b	Variable costs per-unit (incentives) years 1-5	$30	$5
		Compound annual decrease in incentive level, years 6-10	15%	5%
4		**Measure life (years)**		
	a	Program life of system	20	5
5		**Proportion of program costs**	35%	5%

1. Per Unit Impacts

We estimate that one square foot of solar thermal panel produces between 650 and 750 Btu's per square foot per day, or 237,000 to 274,000 Btu's per year. This range is based on accurately metered energy output of commercial solar thermal systems installed and maintained by Solar Mining Co. of Green bay. Refined monitoring data from this source is only available from winter, 2005 and therefore reflects the low sun resource of the winter months. The Solar Mining Company findings are that their flat plate collectors are producing between 237,412 to 273,937 Btu/sq. ft. per year, depending on the system and application. Again, with this data reflecting the low-sun time of year, higher averages are anticipated when full-year figures are available (Ramlow, 2005). To support their analysis, results from sample

RETscreen computer simulations (RETScreen, 2004) for Focus on Energy solar thermal projects were very similar at 275,000 Btu per square foot of flat plate. RETscreen is an accepted industry standard for simulating system performance.

Natural gas savings per unit *(Input 1a)*: Taking the midpoint of 700 Btu's per square foot per day (or approximately 260,000 Btu's per year per square foot) produced by the solar thermal panel, and the combustion efficiency of 76 percent for the average residential gas water heater in Wisconsin (OCS, 1998), we calculate that 3.4 therms of natural gas would be required to produce the same quantity of hot water per year, per unit.

Of all water heaters in Wisconsin that are powered by either natural gas or electricity, approximately 69 percent are gas fired (Pigg & Nevius, 2000). This study is not addressing the displacement of propane, oil or other energy sources with solar power for residential water heating.

Electric savings per unit *(Input 1b)*: We estimate the thermal efficiency of electric water heaters in Wisconsin to be 100 percent, as all heat delivered by the element is absorbed by the water in the tank. This means that using the midpoint of 260,000 Btu's per year per square foot, and based on 3,412 Btu's per kWh, 76.2 kWh of electricity would be required to produce an equivalent number of Btu's. Approximately 31 percent of all water heaters in Wisconsin that are powered by either natural gas or electricity are electric water heaters (Pigg & Nevius, 2000)

The annual per-unit peak demand savings ***(Input 1c)*** is derived from utility AP-6 and AP-7 forecasts (PSCW, 1991 & 1994). These forecasts estimate peak demand for a home water heater at 350 watts plus or minus 100 watts. This is consistent with load shapes used in the Energy Center's Demand-side Options Database from the 1990's. The per-unit savings is calculated using the average of 80 square feet per single home system.

2. Program Participation

The appeal of solar water heating will be primarily influenced by the rise in natural gas prices, but the number of systems actually installed will depend on how many homeowners are aware of the efficacy of the solar alternative. Therefore, we have based our installation estimates on the assumption that an aggressive and targeted promotion campaign accompanies the incentives to attract new adoptions.

Natural gas prices are now in a period of rapid increase, and future prices are extremely unpredictable. While many people have taken measures to contain or reduce their natural gas consumption for space heating, their gas bills continue to rise. Solar water heating is beginning to attract owners of gas-fired water heaters who are looking for a way to reduce their utility bills. Gas prices are already making the installation of a solar water heater cash-flow neutral when added to a new mortgage (Kinyon, 2005). This would mean that anyone purchasing either a new or existing home, or refinancing their present home might wish to take the opportunity to replace either their gas or electric water heater with a solar one.

Total square footage equals a slight increase over present program levels for installation for year one, at about 80 systems averaging 80 square feet each. We estimate about 55 percent for gas water heater replacement ***(Input 2a)*** and 45 percent for electric water heater replacement ***(Input 2b)***, based on growing public concern about gas prices, and the expectation that replacement of electric systems will remain steady. Because of the volatility of gas prices, we have chosen an uncertainty factor of plus or minus 30 percent for square footage of systems replacing gas units, and a factor of plus or minus 20 percent for electric unit replacement.

3. Program Costs

Fixed costs ***(Inputs 3a and b)*** include such activities as sponsorship and participation in general renewable energy events, cross-cutting marketing and PR functions, and a variety of administrative program costs. Fixed costs also include project facilitation and administration of incentives for this particular market. Rather than break down these costs in detail (which would require a specific program design), we have estimated an aggregated FTE total to include the time required for all the tasks listed above, regardless of the number of projects ultimately receiving funding. This estimate is based on Focus on Energy program administrator and contractor experience.

Based on existing studies that show the need to "jump start" efforts to raise public awareness about the efficacy of solar thermal technology in Wisconsin, personnel requirements for a residential solar thermal program are estimated at 3.0 FTE for the first three years, to cover production and distribution of publications, individual project facilitation, grant and incentive administration, and event participation on behalf of the market. This is more than twice the present level of allocated program resources, and would include development of proactive educational efforts and assistance with industry infrastructure development. After year three, we project that efficient use of personnel to transfer primary project facilitation and public information responsibilities to market providers will reduce program personnel requirements approximately five percent per year, reducing personnel requirements to about 2.7 at the end of ten years. Once again, this projection is based on program contractor experience. Personnel costs are assumed to be $100,000 for 1 professional-level FTE, fully loaded. The uncertainty factor for total fixed program costs is estimated to be plus or minus 10 percent.

Variable costs ***(Input 3c)*** for the residential solar thermal market are those incentive costs that can be attributed per unit. We are estimating incentive costs based on the current program incentive for residential solar water heaters, for years one through five. Wisconsin currently offers an attractive incentive for residential solar water systems when compared to other states (Luce, 2004). Most states will only pay incentives to replace electric water heaters with a solar system, but Wisconsin offers incentives for natural gas displacement as well. Furthermore residential incentives frequently consist of a flat rate in the $500-$750 range, or a maximum of no more than $1,000. Hawaii boasts one of the most successful programs, which has installed over 20,000 systems since 1996. The Hawaiian utility program "Energy $olutions Solar Water Heater Rebate" offers incentives in the $750-$1,000 range, and the state offers an additional 35 percent tax credit to customers. The program was also heavily promoted in the media and directly to utility customers (Luce, 2004).

The present Wisconsin incentive of $30/square foot of panel installed is approximately 30 percent-42 percent of system cost depending on current system installation cost which ranges from $70-$100 per square foot for a residential system (see table below). However, there is currently a maximum of 30 percent or $3,000. Removing these maximum levels would raise the Wisconsin incentives without raising percentage levels dramatically. Indeed, the typical residential system is about 80 square feet in size, and if installed at a mid-range price of $85 per square foot, the system cost total would be $6,800, making the $2,400 incentive (@ $30/square foot) comparable to the Hawaiian tax credit at 35 percent of the system cost. The following table illustrates incentive levels compared to the current range of system costs.

Size in Sq Ft	Total Incentive	Min system cost @ $70/SF	Max system cost @ $100/SF	Incentive % of system
40	$1,200	$2,800	$4,000	43%/30%
80	$2,400	$5,600	$8,000	43%/30%
120	$3,600	$8,400	$12,000	43%/30%

To account for greater acceptance and familiarity with the technology and a stronger market after the first five years of the program, we are calculating the incentives as decreasing by 15 percent per year in the second five years. We allow for a plus or minus 5 percent uncertainty factor on the strength of the market at the end of five years.

4. Program Measure Life

The program measure life ***(Input 4a)*** is an estimate of the number of years that the influence of this program approach has accelerated the adoption of residential solar thermal systems. In other words, it considers the likelihood that the technology would be adopted anyway given a certain amount of time, but that the program can be considered the reason it was installed sooner, and can therefore be credited with saving fossil fuel energy during that period. The payback period for residential hot water systems continues to shrink due to stabilizing equipment and installation quality, rising gas prices, and the growing encouragement of government incentives and development of new business models. However, public perceptions of the technology continue to lag. This is a market where program incentives and education will remain necessary for at least ten more years if Wisconsin is to realize its potential to create an established market infrastructure for residential solar water heaters.

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MARKET 34 — WOOD RESIDUE FOR COMMERCIAL/INSTITUTIONAL HEAT

Market Scope

This market comprises all non-residential applications for wood waste heating, including commercial and institutional facility heating, and industrial process heating. This would include businesses that generate wood waste as part of their process, or businesses or institutions within an economical distance of a source of wood waste. Applicable systems for this market are defined as those with automatic-feed boilers that use a combustion fan and that meet Environmental Protection Agency and Wisconsin Department of Natural Resources emissions standards.

Market Characteristics

The primary sources of wood residue in Wisconsin include forest management and logging (forest) residue. The United States Department of Agriculture estimates this resource to be 147 million cubic feet per year in Wisconsin (Reading & Whipple, 1999). Secondary sources include wood products manufacturing, shipping waste (pallets and other wooden shipping materials), urban tree trimming and removal, construction waste and demolition waste.

Mill residue from the timber industry is another significant source. However, mill residue is used primarily within the industry. According to a USDA Forest Service report on Wisconsin's timber industry (Reading and Whipple, 1999), industry use of residue from Wisconsin production of solid wood products includes fiber products (including paper pulp) (44 percent), on-site industrial fuel (24 percent), industrial fuel sold (7 percent), domestic fuel (5 percent), and miscellaneous uses (17 percent). Only about 2 percent of the residue was not used.

The use of wood residue as fuel requires a reliable, local supply that is of consistent quality. Secondary residue sources provide the most fuel wood; primarily municipal solid waste (MSW) or construction and demolition waste (C&D). The wood component in MSW includes discarded wood products, containers and packaging, trees and woody yard waste, and production waste from wood products manufacturing. According to the most recent *Wisconsin Wood Residue Study* (Everson et al., 1993), the manufacturing sector in Wisconsin disposes of at least 500,000 tons of wood residue each year, or about one quarter of the residue it produces, costing businesses about $7,000,000 annually. For example, two major sources are wood milling companies and others that make things from tree parts (non-pallet residue), and businesses that receive wood as shipping materials for other products and materials (pallet residue). Unutilized residue (both pallet and non-pallet) is primarily generated in southeastern Wisconsin although there are sources distributed around the state.

Solid wood waste (not including yard trimmings) totaled about 6 percent of all MSW in 2002 and Falk and McKeever (2004) estimate that 10 percent of this wood was recycled for other uses, and about 22 percent was combusted, primarily for producing energy. Programs for recycling wood from municipal tree removal and brush collection have focused primarily on chipping and composting methods, although this is a potential source of fuel. Current practice and policy, based on the state recycling law, favors composting of wood residue over energy recovery. This has been reflected in the availability of subsidies for equipment.

Construction and demolition waste provides further residue resources. Wood waste from residential wood-frame construction is considered to be highly recoverable. Out of an estimated 3.7 million metric tons of U.S. residential construction wood waste generated in 2002, 3.3 million metric tons, or about 89 percent, was recoverable (Falk and McKeever, 2004). Demolition waste is more problematic because wood from demolition sites is frequently contaminated by paint or hazardous chemicals, or is in other ways more costly to recover. Falk and McKeever estimate only a 30 percent recovery rate for demolition wood waste.

There is a broad range of potential customers for waste wood heat in Wisconsin. Businesses or institutions in rural areas whose heating bills exceed $100,000 per year might save energy dollars by converting to a waste wood boiler system (Wichert, 2005). In addition to the volatile and rising costs of natural gas, there are other reasons commercial enterprises and institutions in Wisconsin might choose to use waste wood combustion as a source of heat. For those businesses producing wood residue on site, both waste disposal and energy costs can be greatly reduced if the residue is used for fuel. Also, pallet manufacturers are now required by certain of their customers to heat the pallets to a minimum temperature to kill resident nematodes. This raises energy inputs and costs.

Industry stakeholders agree that one of the greatest challenges to developing the maximum potential of wood residue for heating applications in Wisconsin is finding efficient ways to connect wood waste sources with potential customers. Currently there is no consistently efficient and reliable infrastructure for recovering and transporting this material to customers. This is principally due to the diversity of stakeholders which includes logging companies, manufacturers of wood products, utilities (tree trimming and removal operations), construction/demolition contractors, and municipal solid waste departments (tree recycling). Businesses or institutions within range of an economically transportable wood residue source must first become aware of their proximity to a useable source before exploring its possible use. Potential customers must also explore sources of wood burning boilers and equipment, and, possibly, third party energy developers and operators.

Recovering wood residue from a variety of sources is a challenge, and a grinding process is required before residue becomes useable fuel. There are transportation limitations as well, based on distance and geographic distribution of wood waste resources. Other barriers to development of this market include on-site technological challenges. For example, the complexity of the technology requires a higher level skill for operation and maintenance. There are space constraints on large units because of fuel storage requirements. Closed storage of either dry or wet wood can deplete oxygen or cause spontaneous combustion. Also, the overall quality and energy content of wood waste varies from source to source. Ash management and disposal issues present their own challenges. Moisture content of wood waste can affect transport costs and efficiency in burning, and emissions are higher with greater levels of moisture.

The Wisconsin Department of Natural Resources requires an air permit for systems that generate 5 million Btu's per hour or more. Additional potential air quality standards and other environmental approvals include those for control of plume opacity, particulate emissions, greenhouse gasses, and carcinogens.

Program Approaches

The most notable contributions to the success of the current Focus on Energy renewable energy program are its project support through facilitation and technical assistance, and its public information strategies.

Participants who took advantage of these program services report that they helped in their decision to adopt the renewable energy technology (Tannenbaum & Barry, 2004). Steady growth has been achieved across renewable energy markets despite constraints on incentive levels, particularly in markets where capital investment is highest. Increasing the program investment in these areas will be essential for addressing the future potential of the wood waste market.

The primary program approach recommended by stakeholders and industry professionals is to continue providing appropriate financial incentives, in tandem with targeted marketing to specific types of businesses and institutions. There are still many commercial operations that generate wood waste and are not making use of its energy potential, as well as schools and other institutions within transport distance of waste wood resources. Tapping this potential will require dedicating more program resources to information, facilitation and technical assistance. Maintaining project incentive levels but eliminating maximum grant amounts would continue to attract potential projects, but would not exceed 15 percent of project cost and would therefore be unlikely to create an artificial market for the technology. Incentives could take the form of demonstration grants for both individual and district heating systems. Project facilitation might include assistance with resource coordination and development of strategies in this area, and guidance on demonstrating new business models.

PROGRAM AREA 34.01 – INCENTIVES FOR WOOD RESIDUE FOR COMMERCIAL/INSTITUTIONAL HEAT

TABLE 34.01.7. ESTIMATED VALUES FOR PROGRAM AREA 34.01, INCENTIVES AND OUTREACH FOR WOOD RESIDUE FOR COMMERCIAL/INSTITUTIONAL HEAT

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$568 to $692	$645 to $880
	Incremental Impacts	peak kW	0 to 0	0 to 0
		annual kWh (000s)	0 to 0	0 to 0
		annual therms (000s)	484 to 724	616 to 974
	Levelized resource cost	per peak kW	NA to NA	NA to NA
		per kWh	NA to NA	NA to NA
		per therm	8.8¢ to 15.8¢	8.2¢ to 14.3¢
Scaling factors[a]		program costs	1.7 to 3.3	1.7 to 3.3
		impacts	1.2 to 1.6	1.2 to 1.6

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

Program Area 34.01 — Incentives for Wood Residue for Commercial/Institutional Heat

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 34.01.2. MODEL INPUTS FOR WOOD RESIDUE FOR COMMERCIAL/INSTITUTIONAL HEAT

Model Inputs (34.01)			**Value**	**±**
1		**Per-Unit Impacts (unit = 1 therm capacity installed)**		
	a	Annual per-unit natural gas savings (therms)	1.00	0.0
2		**Program Participation**		
		Units installed to displace natural gas:		
	a	Installations less than 10,000 therms (total units in year 1)	75,000	7,500
	b	Installations between 10,000-50,000 therms (total units in year 1)	187,500	18,750
		compound annual % increase in installed units for a & b	15%	5%
	c	Installations over 50,000 therms (total units each year)	250,000	125,000
3		**Program costs**		
	a	Fixed program costs -- Years 1-3	$250,000	$25,000
		Annual reduction in fixed costs years 4-10	$10,000	$1,000
	b	Variable costs per-unit (incentives) every year:		
		per therm rate for installations less than 10,000 therm	$1.07	$0.11
		per therm rate for installations between 100,000-50,000 therms	$0.71	$0.07
		per therm rate for installations over 50,000	$0.39	$0.04
4		**Life of system (years)**		
	a	Program life of system	15	5

1. Per Unit Impacts

In most instances, commercial-scale wood-fired boilers replace natural gas-fired boilers and are sized to replace the therms produced by natural gas. We assume the annual per-unit natural gas savings ***(Input 1a)*** to be wood residue output equal to that produced by one therm of natural gas**.**

2. Program Participation

According to previous Focus on Energy program experience; there are distinct size categories of wood waste boilers that make up typical installation patterns (Katers & Stebor, 2005). Systems producing 10,000 therms/year or less ***(Input 2a)*** average 5,000 therms of output, and systems producing 10,000-50,000 therms ***(Input 2b)*** generally average 25,000 therms of output. Installation of systems under these first two categories has been steady despite limited program resources. With accelerated efforts to promote waste wood boilers to specific businesses in these categories, program personnel feel that installation of small and medium-sized boiler systems would rapidly increase. The program has already identified over 1600 businesses in Wisconsin engaged in producing various wood products, under appropriate SIC and NAIC codes. The estimates shown for Inputs 2a and 2b are based on projections by program personnel for businesses in these categories and for small to medium institutional applications (primarily schools).

Systems producing more than 50,000 therms ***(Input 2c)*** average 125,000 therms of output. Opportunities for installations of this size are fewer, primarily due to factors such as resource proximity, timeliness of boiler replacement and up-front capital investment. Program personnel estimate that opportunities in this segment of the market are not likely to expand, but will remain steady from year to year for the next ten years.

3. Program Costs

Fixed costs ***(Input 3a)*** refer to program costs related to this market only, and include such activities as sponsorship and participation in general renewable energy events, cross-cutting marketing and PR functions, and a variety of administrative program costs. Fixed costs also include project facilitation and technical assistance, and administration of incentives for this particular market. Rather than break down these costs in detail (which would require a specific program design), we have estimated an aggregated FTE total to include the time required for all the tasks listed above, regardless of the number of projects ultimately receiving funding. This estimate is based on Focus on Energy program administrator and contractor experience.

Based on projections for realizing the untapped potential already identified by the existing Focus on Energy program (Katers, 2005) and requiring accelerated investment in information and facilitation services, personnel requirements for a commercial heat from wood residue program are estimated at 2.5 FTE for each of the first three years, to cover production and distribution of publications, individual project facilitation, grant and incentive administration, and event participation on behalf of the market. This would include development of resource coordination strategies and new business models. After three years of aggressive program market development, we project that efficient use of personnel to transfer primary project facilitation and public information responsibilities to market providers will reduce program personnel requirements approximately 0.1 FTE per year. Once again, this projection is based on program contractor experience. Personnel costs are assumed to be $100,000 for 1 professional-level FTE, fully loaded. The uncertainty factor for total fixed program costs is estimated to be plus or minus 10 percent.

Variable costs ***(Input 3b)*** for the commercial heat from wood residue market are those incentive costs that can be attributed per unit. Using the present Focus on Energy program implementation grant formula ($25 x (therms utilized per year)$^{0.63}$) we calculated the per therm incentive for the market segment averages stated above: $1.07 per therm for 5,000-therm system; $0.71 per therm for a 25,000 system and $0.39 per therm for a 125,000-therm system. No upper limit is placed on the incentives at these rates. Using the program calculation for a 250,000-therm system, the incentive would be $0.30 per therm or $75,479. This would represent approximately 15 percent of the $500,000 cost to install system. At the recommendation of program personnel, we assume the necessity of continuing present incentive levels through the ten-year projected period.

4. Measure Life

The program measure life ***(Input 4a)*** is an estimate of the number of years that the influence of this program approach has accelerated the adoption of waste wood heating systems. In other words, it considers the likelihood that the technology would be adopted anyway given a certain amount of time, but that the program can be considered the reason it was installed sooner, and can therefore be credited with saving fossil fuel energy during that period. Rising gas prices and the development of new business models for using clean energy technologies make wood residue an attractive resource.

However, it will be necessary for the industry to refine resource distribution and coordination, and other infrastructure issues, made difficult by the wide variety of businesses and stakeholders involved. This is a market where program incentives, education and facilitation will remain necessary for at least ten years if Wisconsin is to realize its potential from wood residue for commercial and institutional heating. Given levels of program investment appropriate to accomplish reduction of these barriers over the next few years, the economic potential of the technology will emerge and begin driving the market.

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MARKET 35 — CUSTOMER SITED, COMMERCIAL WIND ENERGY

Market Scope

This market comprises wind turbines installed by commercial utility customers who are farmers, rural business persons or land owners, or educational institutions in rural settings. The turbines in this market are grid connected, and considered to be in a mid-size range. Turbines for this market are sized from 35kW – 225kW and are available as both newly manufactured and remanufactured equipment.

This market also includes a larger category of customer-sited turbines normally considered utility scale such as 660kW or 1.5 MW up to approx 2 MW. Turbines of this size would be used for projects referred to variously as community wind, local wind, or investment venture wind projects. While turbines in this market are often installed as investments in energy production, they differ from the typical wind farm model in that they are customer sited by either individuals or cooperatives, and are usually comprised of only one to three turbines.

Market Characteristics

Customer-sited mid-sized turbines are a recent phenomenon, driven by the availability of remanufactured utility turbines in the 35-225 kW range. These are primarily Vestas turbines from Denmark which were originally installed in California on the first utility-scale wind farms developed over twenty years ago. Since that time, technology for large turbines has advanced, and the older sites are being retrofitted with the new standard 1.5 to 2.2 MW utility-scale turbines. The remanufactured Vestas turbines are very reliable and cost less than new machines. They are therefore gaining attention from farmers and other rural land owners who want to benefit directly from investment in the wind power industry. Evidence of this trend is reported by installers and Focus on Energy program staff but it remains anecdotal as no formal study has been undertaken to explore the technical potential of this market in Wisconsin. Stakeholders estimate the customer potential in this market as being considerable because it represents a broad cross section of rural business and institutional interests, and, as noted below, there is a potentially large wind resource available in the state for turbines in this size range.

Life expectancy of wind turbines varies greatly from manufacturer to manufacturer and is also highly influenced by site conditions and level of maintenance. The remanufactured turbines in this market are primarily 35kW, 65kW and 90kW models manufactured by Vestas Wind Systems in Randers, Denmark and remanufactured after eighteen to twenty years of service. Experience has shown that these particular turbines are of very robust construction and can be reliably predicted to perform another 20 or so years after remanufacturing. Furthermore, remanufacturing requirements for these turbines are minimal, making the recycling of these turbines highly economical (Sagrillo, 2005).

The U.S. Department of Energy estimates that 0.4 percent of the land area of Wisconsin (or about 140,000 acres) has the minimum required wind resource (16+ mph at 60-100 meters high) to be appropriate for utility-scale wind farm development. They calculate that this area, developed as wind farms with turbines 1.5MW and larger, could produce about 12 percent of Wisconsin's electricity consumption (assuming a 56,483,750 MWh total consumption) (EERE, 2005).

However, smaller turbines in the 35kW to 225kW range, mounted on 30-40-meter towers, are well-suited to harvest wind energy from the 10-12 mph wind resource that is potentially available on 85.2 percent of the land area of Wisconsin, or approximately 46,000 square miles (Focus on Energy, 2003). Even if only ten percent of this area were hypothetically appropriate for siting turbines and just one turbine were sited within each square mile, the potential would be 4,600 turbines. Depending on the size installed, the total capacity would range from 161 to 1,035 megawatts as follows:

turbine size kW	1 per sq mile	mW installed
35	4,600	161
65	4,600	299
90	4,600	414
225	4,600	1,035

Data for the Focus on Energy maps were gathered from over a dozen wind monitoring locations, including several in adjoining states, which measured wind speeds at 30, 60 and 100-meter heights. However, these maps are insufficient for identifying specific wind turbine locations. Each potential site must be analyzed individually because topography, buildings and other factors can greatly influence the local wind energy potential and appropriateness of siting a turbine. In addition, sites not located in "good" wind resource areas indicated on the map may still have the potential to produce wind energy economically.

Wind turbines in Wisconsin generated 103.8 million kWh of electricity in 2003 (Wisconsin Energy Statistics, 2004). This includes power from utility wind farms and small systems owned by individuals. While wind power currently provides only a tiny portion of the state's power needs, wind installations increased 122 percent since 2000. A number of new utility projects currently being planned will further expand the capacity. Until recently, wind energy development in Wisconsin has focused on these utility-scale wind farms and on small systems sized under 20kW, usually installed in rural residential settings and eligible for net metering. Utilities are beginning to propose increases in the 20kW net metering maximum established in 1983. Stakeholders foresee a potential increase to 100kW in the foreseeable future. This will have a great influence on the mid-size turbine market.

Wind energy stakeholders regard customer profile as the primary factor defining this market. Stakeholders agree that the market for customer-sited commercial wind turbines is dominated by two general customer profiles. One customer group invests in or owns a wind turbine to save on energy costs for its own operations, and the other group invests to sell the energy back to the grid. Both groups have similar motivations for investing in wind energy and face similar barriers. The primary difference is that the investor group relies entirely on economic motivations and therefore is more influenced by changes in rate structures, potential availability of green tags, and other economic incentives to own renewable energy generation. At present, customers who install site-dedicated turbines in order to stabilize and reduce energy costs in their own facilities and to achieve energy independence reap the greatest advantages by installing turbines sized as close as possible to their actual load in order to avoid uneconomical buyback rates on excess generation.

Due to a new incentive in the Focus on Energy Program, an additional segment of this market is developing projects initiated as demonstrations by schools. The program is currently experiencing a large number of incentive applications from school districts for installations of 35kW and 90kW turbines. These applications combine educational opportunities in demonstrating clean energy technology with notable energy cost savings for the schools.

Stakeholders agree that this new, customer sited wind generation market currently depends on the continued availability of remanufactured utility turbines, and it might be hampered in the near future if this source dries up. New turbines in the 35-225 kW range are available from a number of manufacturers, but are more expensive than the remanufactured units. Wisconsin wind turbine installers report that towers for the remanufactured turbines are difficult to obtain as well. Taller towers are generally required in Wisconsin than those used with the turbines in their original California locations. Stakeholders agree, however, that equipment availability should improve as the market develops, including the possibility that new turbines of this size range may become more readily available and therefore more economical.

Federal-level interest in wind generation development currently offers two key financial incentives to this particular market. First, for the wind energy investor, the federal production tax credit can be a key factor in determining the success of a project. While this incentive has yet to be adopted in the long term, it continues to gain significant legislative support as wind power potential is developed nationwide. Second, the U.S. Department of Agriculture is currently supporting rural renewable energy projects through its grant program that offers twenty-five percent of project cost up to $500,000 for wind, anaerobic digestion and solar projects.

Program Approaches

Customer-sited commercial wind is a very promising market that could see significant growth in the next ten years with assistance from an aggressive program approach. Indeed, all existing customer sited commercial wind turbines in Wisconsin have been supported by Focus on Energy. The ideal program approach would include a combination of increased financial incentives for installing turbines, project facilitation services and community education efforts. We are incorporating these three components into a single program package.

The program model provides higher incentive grants for larger turbines to encourage creation of demonstration systems. We include facilitation services to support projects that develop new business models including those that reduce economic risk for farms, businesses, and community wind projects. The accompanying education efforts for commercial wind would focus on raising awareness about wind energy systems among zoning officials, and local community leaders, and the general public.

TABLE 35.01.8. ESTIMATED VALUES FOR PROGRAM AREA 35.01, INCENTIVES FOR COMMERCIAL WIND ENERGY

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		$1,275 to $1,803	$1,636 to $2,291
	Incremental Impacts	peak kW	276 to 437	533 to 842
		annual kWh (000s)	5,652 to 7,914	10,559 to 14,782
		annual therms (000s)	0	0
	Levelized resource cost	per peak kW	$325 to $722	$216 to $476
		per kWh	1.8¢ to 3.6¢	1.3¢ to 2.4¢
		per therm	NA	NA
Scaling factors[a]		program costs	1.0 to 2.2	1.0 to 2.2
		impacts	1.0 to 1.5	1.0 to 1.5

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Program Area 35.01 — Incentives for Customer Sited, Commercial Wind Energy

Model inputs for this program area are summarized in the table below, and described on the following pages.

TABLE 35.01.2. MODEL INPUTS FOR CUSTOMER SITED, COMMERCIAL WIND ENERGY

Model Inputs (35.01)			**Value**	**±**
1		**Per-Unit Impacts (unit = 1 kW Installed)**		
	a	Summer peak coincidence factor	0.100	0.025
	b	Capacity factor under 225 kW	0.149	0.050
	c	Capacity factor 225kW and over	0.240	0.050
2		**Program Participation**		
	a	Units installed in first year (up to 225kW)	494	99
		% Compound annual increase in installed kW	25%	10%
	b	Units installed in first year (225 kW and over)	1,800	360
3		% Compound annual increase in installed kW	15%	10%
		Program costs		
	b	Fixed program costs -- Years 1-5	$300,000	$15,000
		Annual reduction in fixed costs, years 6-10	5.0%	0.5%
4		Variable costs per-unit (up to 225 kW) in Years 1-5	$624	$125
	a	% Compound annual decrease, years 6-10	15%	5%
	b	Variable costs per-unit (over 225 kW) in Years 1-5	$326	$33
		% Compound annual decrease, years 6-10	15%	5%
		Measure life (years)		
		Program life of system	15	5

1. Per Unit Impacts

For the summer peak coincidence factor ***(Input 1a)*** we have chosen to use the default capacity credit of 10 percent stated in the MidAmerica Interconnected Network Guide 3B (MAIN, 2005) for unconventional resources. The Guide allows the use of this default when there is no historical data available on an installation, and we use it in the general sense to represent wind turbine generation as a source. We assume an uncertainty range of 5 percent.

We derived the estimated average capacity factor for turbines under 225kW ***(Input 1b)*** based on the estimated performance of wind turbine projects installed over three years by the Focus on Energy Renewable Energy Program. The 460 kW rated total installed capacity produced an estimated 599,045 kWh which resulted in an average annual capacity factor of 0.149. KWh estimates for individual projects were made as part of the required professional site assessments that determine the total incentive to be paid.

For turbines over 225kW ***(Input 1c)***, we use the capacity factor of 0.24, which is an average derived from two sources. According to Focus on Energy, "Most of the commercial turbines have capacity factor ranges of 0.20 - 0.27 for Wisconsin." (Slaymaker, 2005). Second, 0.23 – 0.28 was given as the capacity factor range for Wisconsin in *Windpower: An Essential Part of a Healthy Energy Diet*, in a RENEW Wisconsin presentation (Vickerman, 2005).

2. Program Participation

Customer-sited commercial-scale wind turbines have only recently begun to appear in the Wisconsin landscape, prompted primarily by the availability of remanufactured 35, 65 and 90 kW machines. Initial customer-sited installations in this size range have led to project proposals for even larger turbines, up to 1.8 MW in size. Because this market is still experimental in nature, projections of its potential for growth can be based only on anecdotal data. While stakeholders agree there is tremendous interest among farmers and other rural business people, a number of factors, both positive and negative, may influence the direction this market will take. Factors such as availability of equipment, establishment of more favorable buy-back rates, or settlement of contentious zoning questions will shape both direction and speed with which customer-sited commercial wind will grow.

Data from the Focus on Energy Renewable Energy Program indicates the installed kilowatts of mid-size wind turbines (over 20 kW rated capacity) was 65 kW in FY 2003, 0 kW in FY 2004 and 395 kW in FY2005. The turbines installed had rated capacities of 35 kW, 65 kW or 90 kW – all in the mid-size range. All of the installed turbines to date are rebuilt turbines coming out of California wind farms. In addition to continued interest in this size range, the Focus on Energy program has received an application for at least one large (1.8 MW) customer-sited turbine for FY06. This would indicate the possibility that additional larger projects will be proposed, depending on wind resources, financing prospects, and tariff negotiations.

We are splitting the market into two size categories: 35-225 kW, and greater than 225 kW. Program experience so far indicates that the smaller turbines are likely to be installed by farms and businesses that will use the power themselves as a cost-saving measure, whereas the larger turbines will be of greater interest to energy investors. We project that hese two segments will grow at different rates with different levels of uncertainty.

Discussions with wind contractors indicate that annual installations of mid-size turbines appear to be increasing steadily, perhaps by 20 percent to 25 percent per year. By looking ahead at Focus on Energy Program co-funded wind resource site assessments, feasibility studies and the funding application queue, a projection was made of mid-size turbines to be installed in the next two years. This projection confirmed the wind contractor's estimate of annual capacity installations. The estimate of 494kW in Year 1 is 25 percent more than was installed in the last full project year. We have chosen to use the higher 25 percent growth estimate because of Wisconsin stakeholder confidence that growth will be at least 20 percent per year. We have incorporated an uncertainty factor of plus or minus 5 percent.

Comparatively fewer customer-sited utility-scale turbines over 225kW are expected, unless buy-back rates, equipment availability, and community acceptance all improve, and the federal production tax credit for wind energy is reliably extended. This segment of the market will rely on being attractive as investment potential as well as on availability of superior wind resources. A limited number of projects are under development, with only one 1800kW turbine anticipated in the next program year. We assume this project to represent a baseline, and estimate a 15 percent per year growth rate, plus or minus 10 percent.

3. Program Costs

Fixed costs ***(Input 3a)*** include such program activities as sponsorship and participation in general renewable energy events, cross-cutting marketing and PR functions. Fixed costs also include project facilitation and administration of incentives for this particular market. Rather than break down these costs in detail (which would require a specific program design), we have estimated an aggregated FTE total to include the time required for all the tasks listed above, regardless of the number of projects ultimately receiving funding. This estimate is based on Focus on Energy program administrator and contractor experience. Purely administrative costs for the overall program that do not relate directly to market programs will be added over and above the costs shown here.

Personnel requirements for a commercial wind program are estimated at 3.0 FTE for the first five years to support an aggressive program approach. This covers production and distribution of publications, individual project facilitation, grant and incentive administration, and participation at appropriate events. As the program matures, we project that public awareness will be sufficiently raised by the end of year five that efficient use of personnel to transfer primary project facilitation and public information responsibilities to market providers will reduce program personnel requirements by approximately five percent per year. Once again, we base this projection on program contractor experience. We assume personnel costs to be $100,000 for one professional-level FTE, fully loaded. We estimate the uncertainty factor for total fixed program costs to be plus or minus 10 percent.

Variable costs for the commercial wind market are incentive costs per kW installed. Based on federal grants currently available, it appears the impact of program incentives on the level of turbine installations can be significantly increased without reducing cost effectiveness. At present, program incentives offer a maximum of 35 percent of a project up to $45,000. For the large turbine segment, project costs can easily reach $2 million per turbine, which would mean the maximum incentive would contribute just over two percent of the cost. Grants for wind turbine projects awarded by the federal government under Farm Bill 9006 have been in the range of 25 percent, even for the largest turbines and other major renewable energy projects.

We are therefore modeling our incentive costs using a reward factor similar to the existing federal program for the largest turbines, but allowing a 35 percent maximum for projects up to (and including) 225kW. The following table illustrates proposed incentives in this model based on selected turbine sizes and a typical budget for current program projects. The current program incentive is categorized as a reward factor and is awarded based on an estimate of the amount of electricity the turbine will produce in an average year. We also include the average per kW costs for a site assessment for each size. Site assessment incentives average $250 -- $300. The reward factor per kW installed for turbines 35kW – 225kW ***(Input 3b)*** is the average derived from rewards for this range shown in the table, or $624. The reward factor per unit for larger turbines ***(Input 3c)*** is based on the 1500kW turbine.

Size in kW	Typ Installed cost	Reward per kWh	kWh	incentive	Percentage of project cost	$/kW installed
35	$100,000	$0.77	45,683	$20,557.53	35.20%	$587
65	$100,000	$0.41	84,841	$29,694.21	34.80%	$457
90	$140,000	$0.42	117,472	$35,241.48	35.20%	$392
225	$250,000	$0.30	293,679	$73,419.75	35.20%	$326
1,500	$2,000,000	$0.25	1,957,860	$489,465.00	24.50%	$326

4. Measure Life

The program measure life ***(Input 4a)*** is an estimate of the number of years that the influence of this program approach has accelerated the adoption of mid-range, customer-sited wind turbines. In other words, it considers the likelihood that the technology would be adopted anyway given a certain amount of time, but that the program can be considered the reason it was installed sooner, and can therefore be credited with saving fossil fuel energy during that period. The payback period for commercial wind systems continues to shrink due to the potential for green energy pricing and the development of new business models. Utility-scale wind energy is already attracting mainstream attention as an economical source of green energy. However, because there is still significant investment necessary to install a turbine in this class, this is a market where program incentives and education efforts will remain necessary, potentially beyond this ten-year study, if Wisconsin is to realize its potential.

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MARKET 36 — AGRICULTURAL ANAEROBIC DIGESTION

Market Scope

This market comprises dairy or livestock farms where anaerobic digestion could be cost-effectively employed to produce electric energy from animal manure.

Market Characteristics

Anaerobic digestion is a process that breaks down animal manure or other organic feedstocks into useable components, including methane. This gas can be used to generate electricity or for heating or cooling processes. It is also possible to store methane in order to use anaerobic digesters as peaking plants, or to clean up the gas so it can be injected into the natural gas pipeline. The energy potential of animal manure is currently of great interest among farmers, utilities and third-party energy companies.

There are close to one and a quarter million cows on Wisconsin dairy farms, comprising 15,400 dairy herds. About 42 percent of these herds fall in the 50-99-head size category. At present, there are 200 dairy farms (about 1.2 percent) in Wisconsin with herds of at least 500 head (WASS Statistics, 2004), the number needed to economically and efficiently use manure as a source of methane to produce electricity and/or heat. Alliant Energy released a study in January 2005 that estimates a statewide potential for anaerobic digestion of 39 megawatts from dairy operations in Wisconsin (Alliant Energy, 2005). This could be viewed as the current technical potential in Wisconsin for economical generation of electricity from manure. Even though manure from other types of livestock operations can be used for anaerobic digestion as well, the Alliant Energy report points out that "dairy herds are the greatest percentage of all animal operations in Wisconsin."

Much of the growth in the agricultural anaerobic digestion market may be driven by the non-energy benefits this technology provides. Farm anaerobic digesters are a means of turning the liability of animal waste into an asset while significantly reducing odors. The Livestock Facility Siting Law (s. 93.90, Stats., created by 2003 Wis. Act 235) was designed to facilitate the siting of new and expanded livestock facilities in Wisconsin. The law establishes a general statewide framework for local approval of new or expanded livestock facilities. The Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) proposed rule "ATCP 51" in response to this law (DATCP, 2005). If approved, the rule will apply to new or expanded facilities that will have 500 or more "animal units." This rule would affect dairy farm operations with approximately 357 or more dairy cows. The rule mandates that livestock facilities have a positive "odor index." DATCP estimates that this rule will apply to approximately 50-70 local siting applications each year. While operations with less than 500 cows might employ anaerobic digestion for manure management only, larger operations will be more likely to incorporate generation of electricity into their systems as it approaches cost-effectiveness at 500 cows.

Federal-level regulations are already affecting large-scale farming operations. Farms designated as concentrated animal feeding operations (CAFOs) are similarly good candidates for anaerobic digesters, as they are required to have a manure management program in place to safeguard water quality and public health. A farm that confines 1,000 or more animal units meets the regulatory definition of a CAFO. As of April 2005, the Wisconsin Department of Natural Resources has issued permits for a total of 138 CAFOs in the state for beef (3), dairy (116), poultry (12) and swine (7), with four dairy permits pending (WDNR Statistics, 2005).

Anaerobic digesters are of primary interest to CAFO operators because they help these operations conform to regulatory standards. Installation of a digester relieves manure disposal problems and costs. The process reduces weed seeds and pathogens, decreases pest control costs and assists with nutrient management (phosphorus). Furthermore, an anaerobic digestion system serves as the farm's primary odor reduction strategy. The solids can be used for animal bedding or as a soil amendment, and may have other value-added uses in the future. While these non-energy benefits contribute significantly to farm operations, we do not account for them in our analysis of this market.

There are currently eight anaerobic digesters in operation in Wisconsin, and between eight and 14 more systems in process. They represent only about 7 percent of the potential from Wisconsin operations large enough to derive energy benefits from an anaerobic digestion system.

Large dairy farms and CAFOs currently are the most likely market for this technology, but cooperative business models can make anaerobic digesters a viable technology for smaller farms. The Port of Tillamook Bay in Oregon operates a centralized anaerobic digestion system that currently serves nine dairy farms with a total of 2,000 cows (Port of Tillimook Bay, 2005). A variety of other business models could include utility partnerships and third-party owners and operators. At present, anaerobic digester projects are eligible for grant funding from the US Department of Agriculture, and tax and investment credits are also available.

A primary barrier to meeting the full potential of electrical generation from anaerobic digestion on farms in Wisconsin continues to be the minimum size of operation for which this technology is presently cost-effective. For operations large enough to benefit, the up-front costs of installing a system are high, and many farmers are reluctant to take on the operation and maintenance responsibilities for such a complex system. Other barriers include low buy-back rates for electricity, lack of thermal infrastructure on-site to use the heat generated, an uncertain solids market and hesitation about a developing technology.

The electric generator incorporated into an anaerobic digestion system produces a quantity of heat energy that can be used in a variety of farming operations, and can therefore make the overall system more economical. A typical farm is able to utilize about 10,000 therms per year for space heating, concrete slab heating in barns, and water heating. Utilized thermal energy is the amount actually used for a heating application, not the energy required to operate the system (parasitic power) or dissipated in a radiator. Except in rare cases, the energy displaced by the thermal energy from anaerobic digestion in agricultural systems is liquid propane gas, not natural gas as most farms are located away from access to natural gas pipelines. Because we have been asked to account for natural gas displacement only, the therms produced by agricultural anaerobic digestion systems are not included in our potential study calculations.

Program Approaches

Even though the nutrient management capability of anaerobic digestion may be the primary driver of its installation by many large farming operations, the energy potential is also significant, and program strategies will be vital to increasing the use of agricultural methane for production of electricity. The most notable contributions to the success of the current Focus on Energy renewable energy program are its project support through facilitation and technical assistance, and its public information strategies. Participants who took advantage of these program services report that they helped in their decision to adopt the renewable energy technology (Tannenbaum & Barry, 2004). For agricultural anaerobic digestion, facilitation and technical assistance play the most important program role for achieving the potential that exists in the large dairies and livestock operations in the state. Stakeholders agree that a coordinated and customized technical assistance program that helps farmers tap such resources as the USDA grants, state-level incentives, and the developing green credits market is absolutely essential to assuring the installation of these systems. Potential adopters continue to need assistance with obtaining financing and evaluating emerging technologies, and in creating and demonstrating new cooperative and third-party partnership business models.

Financial incentives will continue to play an important role as well in persuading farmers to incorporate anaerobic digestion systems into their operations. Currently, however, financial incentives total about 2 percent -- 5 percent of overall project cost, and consequently serve more as a motivator and leveraging tool than as providing significant capital for the project. While this level of incentive has attracted a certain number of projects to the program, the USDA grants awarded to projects in Wisconsin in 2004 offered up to 25 percent of the project cost, which has proven to be very effective in raising the adoption rate. Therefore, to encourage a faster rate of system adoption, it will be particularly vital that higher incentives be made available, partnered with the ongoing aggressive facilitation effort.

Raising public awareness about the technology requires educating environmental organizations about the value of this technology. These organizations tend to view agricultural anaerobic digestion as a technology that encourages factory farming.

PROGRAM AREA 36.01A – INCENTIVES FOR AGRICULTURAL ANAEROBIC DIGESTION

TABLE 36.01.9. ESTIMATED VALUES FOR PROGRAM AREA 36.01, INCENTIVES FOR AGRICULTURAL ANAEROBIC DIGESTION

			5-year (average annual)	10-year (average annual)
Base model	Program cost (000s)		\$1,827 to \$2,131	\$2,887 to \$3,406
	Incremental Impacts	peak kW	1,380 to 1,525	2,517 to 2,782
		annual kWh (000s)	10,038 to 12,583	18,309 to 22,951
		annual therms (000s)	0 to 0	0 to 0
	Levelized resource cost	per peak kW	\$100 to \$157	\$87 to \$137
		per kWh	1.2¢ to 2.1¢	1.1¢ to 1.8¢
		per therm	NA to NA	NA to NA
Scaling factors[a]		program costs	1.2 to 2.4	1.2 to 2.4
		impacts	1.1 to 1.5	1.1 to 1.5

[a]For combined analysis. Reported scaling factors are for iterations where estimated program resource cost was at or below avoided cost target.

TECHNICAL DOCUMENTATION

Below, we document the technical assumptions we made for the energy savings in the commercial refrigeration market.

Program Area 36.01 — Incentives for Agricultural Anaerobic Digestion

Model inputs for this program area are summarized in the table below, and described on the following pages.

Table 36.01.2. Model Inputs for Incentives for Agriculture and Anaerobic Digestion

Model Inputs (36.01)			Value	±
1		**Per-Unit Impacts (unit = 1 kW installed)**		
	a	Summer peak coincidence factor (%)	0.90	0.05
	b	Capacity factor	0.80	0.10
2		**Program Participation**		
	a	Units installed in year one	1,053	200
	b	Compound annual % increase in installed units	21.5%	7%
3		**Program costs**		
	a	Fixed program costs -- Years 1-3	$300,000	$30,000
	b	Annual % reduction in fixed costs years 4-10	5%	3%
	c	Variable costs per-unit (incentives) years 1-5	$1,046	$105
	d	Compound annual reduction -- years 6-10	10%	5%
4		**Measure life (years)**		
	a	Program life of system	20	5

1. Per Unit Impacts

Climate conditions in Wisconsin do not prevent anaerobic digesters from running at their full capacity during summer peak periods. Dairy farm peak load revolves around milking time, which can occur during system peak periods, making it practical to make sure the gen-set is operating at these times. We assume that planned digester maintenance can be scheduled for off-peak times of year as it is for coal and other baseload fuel plants. We therefore choose a summer peak coincidence factor ***(Input 1a)*** of .90 plus or minus .05 to represent peak load power availability from anaerobic digestion.

Only a few anaerobic digester projects have been closely monitored for electricity production over a meaningful period of time. Furthermore, monitoring was usually done early in the life of the system when technical problems were still being eliminated, and methods and priorities for the studies have varied. Therefore, identifying a capacity factor ***(Input 1b)*** applicable to the average system requires a broad uncertainty range. This is illustrated by the following system examples: Gordondale Farms of Nelsonville, WI (before tuning: Kramer, 2004; after tuning: Martin, 2005), Top Deck Dairy, Inc. of Westgate, IA (Iowa DNR, 2005), and Bell Farms of Creston, IA (Iowa DNR, 2002).

Farm	kW installed	kWh/year	Capacity factor
Bell Farms (SWIne USA project)	80	435,848	.62
Top Deck Dairy, Inc	130	864,000	.76
Gordondale Farms (before tuning)	140	876,051	.71
Gordondale Farms (after tuning)	140	1,056,675	.86

To approximate the range of this limited sampling of capacity factor data, we have selected a capacity factor of .80 plus or minus .10. The lowest data (.62) was gathered in 1999-2000, and the system experienced considerable technical difficulties during monitoring (Iowa DNR, 2002). We assume that engineering progress in the industry since that time would make this capacity level less likely. We feel that the dramatic improvement in the Gordondale system from .71 to .86 after the replacement of the spark plugs indicates a move toward higher capacity factor levels as the technology matures.

2. Program Participation

Not all farmers with a sufficient manure resource will choose to install a digester or a digester/gen set combination. Some will wish to continue use of the traditional sand bedding for their cows which would interfere with proper functioning of the digester. This would also eliminate the cost effectiveness of using digester solids for bedding. Also, some farms do not employ a scraping system for manure collection, which is the most economical method of moving manure to the digester. There are also farmers who are unwilling or unable to assume the financial risk of such a large-scale project, particularly when the gen-set is included in the budget, and new technologies, such as manure incineration, are offering other choices for nutrient management. Program experience so far has indicated that approximately 25 percent of farms in this size classification will probably not install a digester for one or more of these reasons.

For our Year 1 projection, ***(Input 2a)*** we estimate that about 1,053 kW of anaerobic digestion generation will be installed. This is based on known projects anticipated by the Focus on Energy program for the new program year. We anticipate a growth rate of approximately 21 percent per year over the next ten years which will result in a total of almost 30MW installed in the state. This estimate is in line with generation potentials developed by Alliant Energy in their report on anaerobic digestion potential (Alliant Energy, 2005). They estimate there is potential for about 39MW of biogas production in Wisconsin. We have taken 75 percent of that number as a total achievable potential over the next ten years based on the program experience outlined above. While it is unlikely that the development curve will be a steady 21 percent increase each year, the uncertainty factor will allow for a 14.5 percent -- 28.5 percent range of expansion in any given year.

3. Program Costs

Fixed costs ***(Input 3a)*** include program activities such as sponsorship and participation in general renewable energy events, cross-cutting marketing and PR functions. Fixed costs also include project facilitation and administration of incentives for this particular market. Rather than break down these costs in detail (which would require a specific program design), we have estimated an aggregated FTE total to include the time required for all the tasks listed above, regardless of the number of projects ultimately receiving funding. This estimate is based on Focus on Energy program administrator and contractor experience. Purely administrative costs for the overall program that do not relate directly to incentive and outreach program activities will be added over and above the costs shown here.

Personnel requirements for an agricultural anaerobic digestion program are estimated at 3.0 FTE for the first three years to cover production and distribution of publications, individual project facilitation, grant and incentive administration, and event participation on behalf of the market. Then in Year 4, depending on development of the market, we project that efficient use of personnel to transfer primary project facilitation and public information responsibilities to market providers will reduce program personnel requirements approximately 5 percent per year. Once again, this projection is based on program contractor experience. Personnel costs are assumed to be $100,000 for one professional-level FTE, fully loaded. The uncertainty factor for total fixed program costs is estimated to be plus or minus 10 percent.

Variable costs ***(Input 3b)*** for the agricultural anaerobic digestion market are those incentive costs that can be attributed per unit. Present program incentive levels serve as a motivating and leveraging tool rather than as a notable contribution to project financing. In order to provide effective support for increasing adoption of this technology, higher incentive levels will be necessary. We propose an incentive level of 25 percent of system cost, which is in line with the highly effective federal incentives offered through the USDA Farm Bill. We have calculated program costs assuming this level is to be maintained for the first five years of the program, with a 10 percent per year decrease each year in years 6 – 10. The decrease is based on the assumption that market barriers will gradually be reduced and incentives will no longer be as necessary to make projects economically viable.

4. Program Measure Life

The program measure life ***(Input 4a)*** is an estimate of the number of years that the influence of this program approach has accelerated the adoption of agricultural anaerobic digestion systems. In other words, it considers the likelihood that the technology would be adopted anyway given a certain amount of time, but that the program can be considered the reason it was installed sooner, and can therefore be credited with saving fossil fuel energy during that period. The payback period for agricultural anaerobic digestion systems continues to shrink due to stabilizing equipment and installation quality, the potential for green energy pricing and the development of new business models. However, program incentives and education will remain necessary if Wisconsin is to realize its potential.

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