

the power of working together

learn how simple, energy-saving actions add up to help our environment



your community energy company

Taking simple steps to save energy

Most of us think about electricity and natural gas use on an individual basis. How much is my bill this month? But there are bigger questions that involve all of us. How does our energy use impact the environment? Are there simple steps we can take to reduce the impact?

MGE's advertising messages include broad statements about the energy we can save by working together. Individual actions to add a compact fluorescent or to turn down the thermostat a degree seem like they have a small effect. But when many customers take these steps, the savings and environmental effects really add up.

To help quantify the power of working together, we asked the Energy Center of Wisconsin to estimate and provide documentation for the environmental savings from specific actions. The fact sheets they developed also explain the challenges involved in making these estimates. Use them to learn more about how appliance choices, thermostat settings and building practices can change our world for the better.

It's your energy. We can help you understand how to use it more efficiently and reduce environmental impacts. When we all take the right steps, we can make a difference. That's the power of working together.

Actions you can take to save energy and help the environment	Per-home savings						If we all take this step, how much we can save? (system-wide savings in millions)						The system wide savings meets the annual energy use of this many homes.	
	kWh	therms	co2	nox	sox	coal	kWh	therms	co2	nox	sox	coal	Electricity	Natural Gas
			(lbs)	(lbs)	(lbs)	(lbs)			(lbs)	(lbs)	(lbs)	(lbs)		
Purchase Energy Star rated appliances														
Air conditioner														
High SEER central air conditioner savings	477		1,057	2.72	5.82	358	32.9		73.0	0.188	0.402	24.71	4,850	
High EER room air conditioner savings	93		207	0.53	1.14	70	6.5		14.3	0.037	0.079	4.84	950	
Clothes washer														
Energy Star savings	371	40	1,291	2.12	4.53	279	42.6	4.6	147.9	0.243	0.519	31.92	6,260	5,910
Bonus dryer savings	173	2	488	1.17	2.51	130	19.8	0.3	55.9	0.134	0.288	14.86	2,910	340
Dehumidifier														
Energy Star savings	156		346	0.89	1.90	117	10.1		22.3	0.057	0.123	7.54	1,480	
Dishwasher														
Energy Star savings	68	4	199	0.39	0.84	51	4.3	0.3	12.6	0.025	0.053	3.25	640	330
Furnace														
Energy Star savings	78		920	0.00	0.00	0	2.5	29.2	0.000	0.000	0.00		3,220	
Furnace/Central air conditioner combination														
Energy Star savings if 1 in 10 buy	489	78	2,003	2.79	5.96	367	7.7	1.2	31.5	0.044	0.094	5.75	1,130	1,590
Refrigerator														
Energy Star savings	516		1,143	2.94	6.29	387	60.2		133.5	0.343	0.735	45.18	8,860	
Change thermostat settings														
1° F overnight setback														
Heating Season Savings	16	5	95	0.09	0.20	12	1.1	0.3	6.4	0.006	0.013	0.81	160	440
1° F 24 hour per day setback														
Heating season savings	48	15	285	0.27	0.59	36	7.5	2.4	44.8	0.043	0.092	5.65	1,110	3,100
3° F overnight setback														
Heating season savings	48	15	285	0.27	0.59	36	3.2	1.0	19.3	0.018	0.040	2.43	480	1,330
5° F overnight setback														
Heating season savings	80	25	475	0.46	0.98	60	5.4	1.7	32.1	0.031	0.066	4.05	790	2,220
Reduce air conditioner use by 10%														
Cooling season savings	120		266	0.68	1.46	90	16.0		35.4	0.091	0.195	11.99	2,350	
Use compact fluorescent bulbs														
Savings from replacing one incandescent bulb	76		168	0.43	0.92	57	11.9		26.4	0.068	0.145	8.92	1,750	
Savings from replacing five most used incandescent bulbs	379		840	2.16	4.62	284	59.5		131.8	0.339	0.726	44.61	8,750	
Use appliances efficiently														
Savings from washing clothes in cold water	159	45	880	0.91	1.94	120	22.3	6.3	123.0	0.127	0.272	16.70	3,280	8,120
Savings from washing full dishwasher loads	60	7	218	0.34	0.73	45	5.2	0.6	19.0	0.030	0.064	3.92	770	820
Savings from heat recovery ventilation	0	20	240	0.00	0.00	0								
Build with energy savings in mind														
Savings from building/buying an Energy Star new home	389	118	2,248	2.22	4.75	292	1.1	0.3	6.1	0.006	0.013	0.79	150	410
Change from electric to natural gas appliances														
Gas dryer savings	865	-34	1,806	5.87	12.56	649	80.6	-3.2	189.3	0.615	1.316	60.49	11,870	-4,110
Gas range/oven savings	518	-28	815	2.95	6.32	389	35.5	-1.9	55.8	0.202	0.433	26.63	5,220	-2,520
Gas water heater savings	4150	-200	6,844	23.66	50.63	3113	48.5	-2.3	79.9	0.276	0.591	36.36	7,130	-3,030

Savings from Purchasing a New High-SEER Central Air Conditioner

Summary

Higher SEER air conditioners use less electricity for the same amount of cooling. The savings estimates are based on the estimated operating hours for a typical-sized central air conditioner. System-wide savings are based on estimates of the number central air conditioners in owner-occupied homes in MGE's service territory, plus the savings potential for upgrading the efficiency of units installed in new homes and households that add central air conditioning to their home each year.

Note: As of January 2006 federal efficiency standards will require that all central air conditioners meet what is currently considered a high-SEER unit (SEER 13).

Annual Savings

	Electricity (kWh)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household					
Replace older unit	489	1,083	2.79	5.96	367
Upgrade efficiency of New AC	277	614	1.58	3.38	208
MGE system-wide (millions)	32.9	73.0	0.188	0.402	24.7
Equivalent to electric use of	4,800	homes			

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

A typical Wisconsin central air conditioner has a cooling capacity of about 2.5 tons (30,000 Btu/hr) and a nominal SEER of about 9.3 (Pigg and Nevius, 2000), though these often perform at less than their rated efficiency. SEER 8.5 is taken as the average efficiency of an existing central air conditioner. SEER 13 would be considered typical for a new high efficiency unit, though the majority of the Wisconsin market for new air conditioners continues to be at the current federal minimum of SEER 10. The efficiency difference is thus taken to be SEER 8.5 to SEER 13 for replacement air conditioner, and SEER 10 to SEER 13 for air conditioners for new homes and those for homes that are adding central air conditioning.

There is little data on the actual hours of operation for central air conditioners in Wisconsin. However, maps of cooling load hours for the United States available from several public sources suggest about 400 to 450 hours of operation for a typical Madison-area central air conditioner.¹ The former figure is used here.

Based on the estimates above, the savings from replacing an older air conditioner are estimated as:

$$(30,000)*(400)*(1/8.5 - 1/13)/1000 = 489 \text{ kWh per year}$$

The savings from upgrading from a SEER 10 to SEER 13 is similarly estimated as:

$$(30,000)*(400)*(1/10 - 1/13)/1000 = 277 \text{ kWh per year}$$

The 2003 Load Research Survey conducted by the Energy Center for MGE suggests that about 62 percent of MGE residential customers are home owners. The 2003 MGE Home Energy Survey data also indicate that two-thirds of homeowners have central air conditioning. The number of air conditioners that could be replaced with a new high efficiency unit is therefore approximately 65,200.

Data from the Center's Appliance Sales Tracking survey for 2003 (Bensch and Weitner, 2004) suggests that about 4 percent of single-family homeowners purchase a new air conditioner each year (excluding purchases for new homes) and about 30 percent of these are for adding air conditioning to a home that previously lacked it. The estimated number of homes in MGE's service territory that add air conditioning each year is thus estimated as $111,500 * .04 * 0.3 = 1,300$.

The number of new single-family homes built in MGE's service territory is estimated to be 2,700 (see "Savings from Building an ENERGY STAR® Home"). Although the Center's Residential Characterization Study indicated that 70 percent of homes built between 1994 and 1999 had central air conditioners, the 2003 MGE Home Energy Survey shows nearly complete saturation of central AC in new homes in MGE's service territory.

Overall, the above suggests that there are about 65,200 MGE homes that could replace an older air conditioner with a new high efficiency unit and about 3,800 homes either built new or that add air conditioning that could be upgraded to a high efficiency model.

¹ See http://www.iowaenergy.org/professionals/stuff/cooling_load_hrs.htm, <http://www.leeric.lsu.edu/bgbb/7/ecep/hvac/a/a.htm> and <http://www.access.gpo.gov/ecfr/graphics/pdfs/ec04oc91.053.pdf>

Issues

- The number of hours of operation for a typical air conditioner is somewhat uncertain.
- The actual average SEER of an existing unit is uncertain.

References

Bensch, Ingo and Sean Weitner. 2004. *Appliance Sales Tracking Study 2003*. State of Wisconsin Department of Administration, Division of Energy—Residential Programs: Market Assessment, July 2004. Available from www.ecw.org as Report 232-1.

Pigg, Scott and Monica Nevius. 2000. *Energy and Housing in Wisconsin: A Study of Single-family Owner-Occupied Homes*. Energy Center of Wisconsin, Reports 199-1 (report and appendices) and 199-2 (databook), November 2000. Available from www.ecw.org

Revision History

Draft: February 28, 2005

March 25, 2005

1. Removed 10-year old age restriction for replacement of existing systems, with consequence that existing EER is now estimated at 8.5 instead of 8.0, and pool of potential replacements is increased to 65,200.
2. Changed the fraction of new homes with central air conditioning from 90% to 100% per the 2003 Home Energy Survey.
3. Added avoided pounds of coal to summary table.

Savings from Purchasing a New High-EER Room Air Conditioner

Summary

Higher EER air conditioners use less electricity for the same amount of cooling. The savings estimates are based on the estimated operating hours for a typical-sized room air conditioner. System-wide savings are based on an estimate of the total number of room air conditioners among MGE customers.

Annual Savings

	Electricity (kWh)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household	93	207	0.533	1.140	70
MGE system-wide (millions)	6.46	14.31	0.037	0.079	4.84
Equivalent to electric use of	950	homes			

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

Data from the Center's 199 Residential Characterization Study (Pigg and Nevius, 2000) suggest that a typical Wisconsin room air conditioner has a cooling capacity of about 8,200 Btu/hr and a nominal EER of about 8.2.

MGE's 2003 Home Energy Survey indicates that 67 percent of MGE customers have no room air conditioners, 25 percent have one unit, 5 percent have two units, and 3 percent have three or more units.¹ This works out to an average of 0.44 air conditioners per customer. Applied across the approximately 157,000 MGE residential customers, there are thus approximately 69,000 room air conditioners that could be replaced with a new ENERGY STAR® unit with an EER of 10.7.

¹ The data from the survey were weighted to reflect the proportion of gas-only, electric-only and combined gas and electric customers from MGE customer counts in December 2003.

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 Center's Residential Characterization Study 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.² An intermediate value of 400 hours per year is used.

Based on the estimates above, the savings from replacing an older room air conditioner are estimated as:

$$(8,200) \cdot (400) \cdot (1/8.2 - 1/10.7) / 1000 = 93 \text{ kWh per year}$$

Issues

Hours of operation for room air conditioners are uncertain.

References

Pigg, Scott and Monica Nevius. 2000. *Energy and Housing in Wisconsin: A Study of Single-family Owner-Occupied Homes*. Energy Center of Wisconsin, Reports 199-1 (report and appendices) and 199-2 (databook), November 2000. Available from www.ecw.org

Revision History

Draft: February 28, 2005

March 25, 2005

1. Removed ten-year old age restriction for replacement, with consequence that average EER of an existing unit increases from 8.0 to 8.2, and population of potential replacements increases from 34,540 to 69,080.
2. Revised average capacity from 8,000 kBtu/hr to 8,200 kBtu/hr.
3. Added avoided pounds of coal to summary table.

² http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_RAC_Sav_Calc.xls

Savings from Purchasing an ENERGY STAR® Labeled Clothes Washer

Summary

Purchasing a new ENERGY STAR labeled clothes washer saves energy mainly by reducing the amount of hot water needed for a wash cycle. There are also savings in the electricity needed to operate the washing machine, as well as reduced clothes dryer energy, because high efficiency washers remove more moisture from the wash load.

The savings figures below are for the various combinations of water heater and dryer fuel, along with a weighted average across the population. Total system-wide potential is based on an estimate of the number of MGE residential customers who own a standard clothes washer.

Annual Savings

		Electricity (kWh)	Gas (therms)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household							
Water heater	Dryer						
Gas	Electric	296	48.1	1,221	1.69	3.61	222
Gas	Gas	65	57.1	816	0.37	0.80	49
Electric	Electric	902	0.0	1,998	5.14	11.00	676
Electric	Gas	671	9.0	1,594	3.83	8.19	504
Blended average		371	39.8	1,291	2.12	4.53	279
MGE system-wide (millions)		42.6	4.56	147.9	0.243	0.519	31.9
Equivalent to electric use of		6,300	homes				
Equivalent to gas use of		5,900	homes				

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

A number of field studies of the savings from efficient washers have been conducted by Battelle and Oak Ridge National Laboratory (Durfee and Tomlinson, 2001; FEMP 2000; Sullivan et al., 2000, 2001 and 2004; Tomlinson and Rzy, 1998). Though these studies varied widely in the residential setting—two were single family detached housing, one was condominium in-unit laundry, and three were multifamily common-area laundry—

they generally show substantial water savings from efficient washers, as well as lower washer operating energy (though the latter represents only a small fraction of total washer energy consumption). In addition, the studies have generally documented that efficient washers remove more moisture from clothing at the end of the cycle, and this reduces dryer energy consumption as well.

The EPA ENERGY STAR Web site also has an MS Excel-based calculator for estimating savings from energy efficient washers.¹ Default assumptions for this calculator are reasonably comparable to the results from the above field studies, and suggest that a typical ENERGY STAR washer uses somewhere in the range of 2 to 5 gallons of hot water per cycle, compared to 7 to 12 gallons for a new standard washer. Key assumptions (from the ENERGY STAR calculator) are shown in the table below.

Energy use per cycle	Standard Top Loader (new)	ENERGY STAR
Hot water		
Gas water heater (therms)	0.087	0.046
Electric water heater (kWh)	1.41	0.58
Motor/controls (kWh)	0.16	0.07

The ENERGY STAR calculator savings are based on the difference between a new standard washer and an ENERGY STAR labeled unit. To translate this into savings relative to the existing stock of clothes washers, an age-weighted average usage is calculated as shown in the table below. For this table, annual energy consumption values are derived from data provided in *2004 Wisconsin Energy Statistics* (DOA, 2004), and the estimated age distribution is based on data reported in Tomlinson and Rizy (1998).

Clothes washer age	Clothes washer annual electricity (kWh) (electric water heat)	Estimated proportion of population
<5 years	832	30%
5-9 years	866	30%
10-14 years	959	15%
15-19 years	1,029	15%
20+ years	1,187	10%
Weighted average	926	

¹http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Clothes_Washer_Sav_Calc.xls (11/22/04 update version)

The age-weighted average of 926 kWh per year is separated into electricity for hot water consumption (90%) and machine energy (10%), then the former is converted to therms of gas for gas water heat using the ratio of gas therms per cycle to electric kWh per cycle in the ENERGY STAR calculator (0.0793).

Calculations of annual energy use and savings are based on 392 laundry loads per year, the specified average value for use in the federal test procedure, which also assumes that 84 percent of wash loads are dried in the dryer.² The former value works out to 7.5 loads per week, which is comparable to the value of 7.2 obtained from a survey of 299 Wisconsin homeowners in the Energy Center’s Residential Characterization Study (Pigg and Nevius, 2000).

In addition, two of the studies cited above document that high efficiency washers save clothes drying energy because they remove more moisture in the spin cycle (Durfee and Tomlinson, 2001; Sullivan et al., 2001). Both studies showed 20 to 25 percent dryer energy savings. The figures from the latter study—which reported an electric dryer consumption decline from 3.2 kWh/cycle to 2.5 kWh/cycle following washer retrofit—are used here.³

The table below shows the estimated annual energy savings by water heater and dryer fuel type, along with a weighted average based on data from the 2003 Home Energy Survey.

Water heater fuel	Dryer fuel	Percent of customers ^a	Annual energy savings	
			Electricity (kWh/year)	Natural gas (therms/year)
Gas ^b	Electric	55%	296	48.1
Gas	Gas	23%	65	57.1
Electric	Electric	20%	902	0.0
Electric	Gas	2%	671	9.0
Weighted average			371	39.8

^aFrom MGE 2003 Home Energy Survey

^bAlso includes a small number of reported propane and oil water heaters.

² 10 CFR 430, Subpart B, Appendix J1.

³ For gas dryers, these figures are converted to therms per cycle, with an assumption that gas dryers use 15% more thermal energy than electric dryers (E Source, 2001)

System-wide potential is based on an estimate of the number of MGE residential customers with a standard clothes washer, and is derived as follows:

1. There are approximately 157,000 active MGE residential accounts.
2. Of the 1,036 Home Energy Survey (2003) respondents who answered the question (B3) about washing machines, 89 percent responded that they have a washer.⁴
3. At the time of the survey, 12 percent of respondents with clothes washers said they had a front-loading machine.
4. The most recent Appliance Sales Tracking Survey (Bensch and Weitner, 2004) shows that about 8 percent of Wisconsin households purchase a clothes washer each year, and of these about 38 percent purchase a “resource-efficient” unit. This implies that between 2003 and 2005 an additional 6 percent of MGE customers would have purchased an energy efficient unit, for an estimated saturation in 2005 of 18 percent for high efficiency clothes washers.
5. The estimated number of MGE residential customers with a standard washer is therefore $157,000 * 0.89 * 0.82 = 114,600$

References

- Bensch, Ingo and Sean Weitner. 2004. *Appliance Sales Tracking Study 2003*. State of Wisconsin Department of Administration, Division of Energy—Residential Programs: Market Assessment, July 2004. Available from www.ecw.org as Report 232-1.
- Durfee, David J. and John J. Tomlinson. 2001. *Boston Washer Study*. Oak Ridge National Laboratory, ORNL-TM-2001/21-4, December, 2001. Available at: http://www.ornl.gov/sci/btc/pdfs/TM2001_214.pdf.
- E Source. 2001. *Technology Atlas Series; Volume V — Residential Appliances*. McGraw Hill.
- Erickson, Jeff, Carmen Best, David Sumi, Bryan Ward, Bryan Zent and Karl Hausker. 2004. *Estimating Seasonal and Peak Environmental Emissions Factors—Final Report*. State of Wisconsin Department of Administration, Division of Energy: Focus on Energy Public Benefits Evaluation, May 21, 2004.
- FEMP (Federal Energy Management Program). 2000. *Assessment of High-Performance, Family-Sized Commercial Clothes Washers*, DOE/EE-0218. Available at: <http://www.eere.energy.gov/femp/pdfs/clotheswashers.pdf>

⁴ Responses were weighted to represent the proportion of MGE customers with electric-only service (25.9%), gas-only service (24.7%) and combined gas and electric service (49.4%).

Pigg, Scott and Monica Nevius. 2000. *Energy and Housing in Wisconsin: A Study of Single-family Owner-Occupied Homes*. Energy Center of Wisconsin, Reports 199-1 (report and appendices) and 199-2 (databook), November 2000. Available from www.ecw.org

Sullivan, G. P., J. W. Currie, T. C. Hillman, and G. B. Parker, 2000. *Southern California Edison High-Performance Clothes Washer Demonstration at Leisure World Laguna Woods* final report submitted to Southern California Edison Company by Battelle Pacific Northwest Laboratory, December 2000.

Sullivan, G. P., D. B. Elliot, T. C. Hillman and A. R. Hadley, 2001. *The Save Water and Energy Education Program: SWEEP — Water and Energy Savings Evaluation*. Pacific Northwest National Laboratory, PNNL-13538, May 2001. Available at: http://www.eere.energy.gov/buildings/emergingtech/pdfs/sweep_report.pdf

Sullivan, G. P., G. B. Parker, and J. W. Currie, 2004. *Wisconsin Focus on Energy Resource Efficient Laundry (REL) Room Demonstration*, Wisconsin Focus on Energy PNWD-3445, June 2004.

Tomlinson, J. J., and D. T. Rizey. 1998. *Bern Clothes Washer Study Final Report*. Oak Ridge National Laboratory, ORNL/M-6382. March 1998 Available at: http://www.energystar.gov/ia/partners/manuf_res/bernstudy.pdf

Wisconsin Department of Administration (DOA). 2004. *2004 Wisconsin Energy Statistics*.

Revision History

Draft: January 13, 2005

Revisions:

February 28, 2005

1. Revised water heater and dryer fuel proportions based on applying weights to 2003 Home Energy Survey to correctly account for the proportion of electric-only, gas-only and combined gas and electric customers
2. Incorporated federal test procedure assumption that 84% of wash loads are dried in the dryer.
3. Revised the total number of MGE residential customers to 157,000.

March 25, 2005

1. Revised the estimated energy use of a standard washer to reflect an age-weighted average, per *2004 Wisconsin Energy Statistics*.
2. Added avoided pounds of coal to summary table.

Dryer Savings from Purchasing an ENERGY STAR® Clothes Washer

Summary

ENERGY STAR clothes washers extract more water from the wash load; less water in the laundry that comes out of the washer translates into energy required for drying the load. Estimated dryer savings for ENERGY STAR clothes washers are summarized below for gas and electric dryers, along with a weighted average of the two. Total system-wide potential takes into account the estimated number of MGE residential customers that currently have ENERGY STAR labeled clothes washer.

(Note that the dryer savings reported here are included in the separately-documented estimates of overall savings from purchasing an ENERGY STAR Clothes Washer.)

Annual Savings

	Electricity (kWh)	Gas (therms)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household						
Electric dryer	230	0.000	608	1.56	3.35	173
Gas dryer	0	9.047	127	0.00	0.00	0
Blended average	173	2.262	488	1.17	2.51	130
MGE system-wide (millions)						
Equivalent to electric use of	2,900	homes				
Equivalent to gas use of	340	homes				

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

See “Savings from Purchasing an ENERGY STAR Labeled Clothes Washer” for a general description of the literature regarding energy savings for upgrading to a new ENERGY STAR labeled clothes washer. Two studies document that high efficiency washers save clothes drying energy because they remove more moisture in the spin cycle (Durfee and Tomlinson, 2001; Sullivan et al., 2001). Both studies showed 20 to 25 percent dryer energy savings. The figures from the latter study—which reported an

electric dryer consumption decline from 3.2 kWh/cycle to 2.5 kWh/cycle following washer retrofit—are used here.¹

Calculations of annual energy use and savings are based on the 392 laundry loads per year assumed for the federal test procedure for clothes washers.² The federal test procedure also assumes that 84 percent of wash loads are dried in a dryer.

The table below shows the estimated annual energy savings by dryer fuel type, along with a weighted average based on the proportion of households with electric versus gas dryers (MGE 2003 Home Energy Survey):

Dryer fuel	Percent of customers	Annual energy savings	
		Electricity (kWh/year)	Natural gas (therms/year)
Electric	75%	230	0.00
Gas	25%	0	9.04
Weighted average		173	2.26

System-wide potential is based on 157,000 active MGE residential accounts, of which 89 percent have a clothes washer (2003 Home Energy Survey), and an estimated 18 percent already have an ENERGY STAR clothes washer (See “Savings from Purchasing an ENERGY STAR Labeled Clothes Washer”).

References

- Durfee, David J. and John J. Tomlinson. 2001. *Boston Washer Study*. Oak Ridge National Laboratory, ORNL-TM-2001/21-4, December, 2001. Available at: http://www.ornl.gov/sci/btc/pdfs/TM2001_214.pdf.
- E Source. 2001. *Technology Atlas Series; Volume V — Residential Appliances*. McGraw Hill.
- Sullivan, G. P., D. B. Elliot, T. C. Hillman and A. R. Hadley, 2001. *The Save Water and Energy Education Program: SWEEP — Water and Energy Savings Evaluation*. Pacific Northwest National Laboratory, PNNL-13538, May 2001. Available at: http://www.eere.energy.gov/buildings/emergingtech/pdfs/sweep_report.pdf

¹ For gas dryers, these figures are converted to therms per cycle, with an assumption that gas dryers use 15% more energy for drying (E Source, 2001)

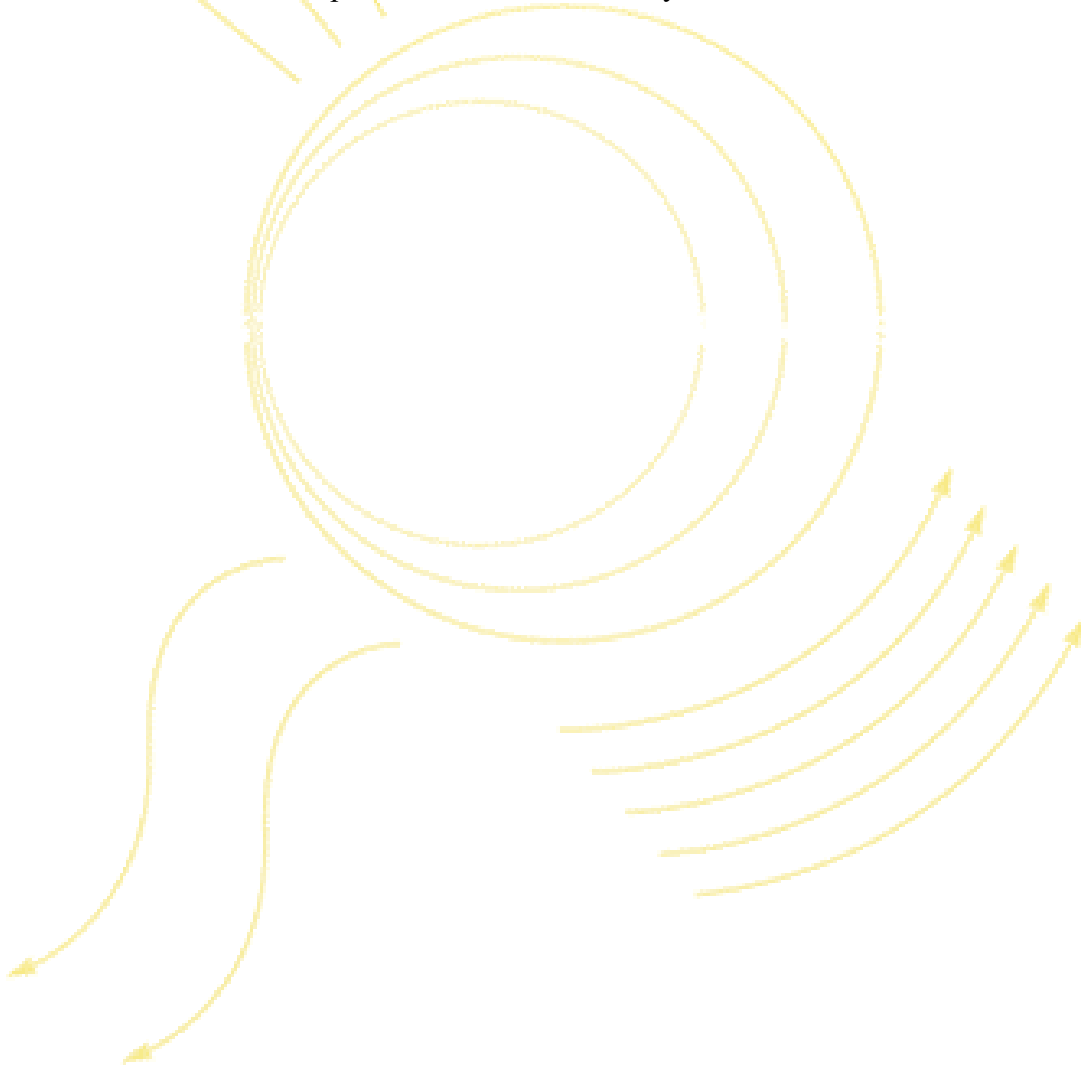
² 10 CFR 430, Subpart B, Appendix J1.

Revision History

Draft: February 28, 2005

March 25, 2005

1. Added per-household electric dryer and gas dryer savings to summary table.
2. Added avoided pounds of coal to summary table.



Savings from Purchasing an ENERGY STAR® Labeled Dehumidifier

Summary

ENERGY STAR labeled dehumidifiers use about 10 to 20 percent less electricity to remove the same amount of moisture as a standard dehumidifier. The per-household savings below assume three months of dehumidifier operation. System-wide savings are based on the number of MGE customers with dehumidifiers, and an estimate of diversified usage of dehumidifiers.

Annual Savings

	Electricity (kWh)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household	156	346	0.889	1.903	117
MGE system-wide (millions)	10.05	22.28	0.057	0.123	7.54
Equivalent to electric use of	1,480	homes			

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

In terms of efficiency, 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.¹ The average efficiency of currently-listed models in this size range is 1.36 liters per kWh.² The current energy savings calculator on the ENERGY STAR Web site lists the moisture removal efficiency of a 20-pint conventional dehumidifier as 1.10 liters per kWh and that of a 40-pint model as 1.1817 liters/kWh. Comparing the average of these figures to the average ENERGY STAR qualified models, yields 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.

¹ See http://www.energystar.gov/index.cfm?c=dehumid.pr_dehumidifiers

² See http://www.energystar.gov/ia/products/prod_lists/dehumid_prod_list.xls

Annual electricity savings 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.³

The Association of Home Appliance Manufacturers (AHAM) also publishes a dehumidification selection guide (see figure below) for moisture removal capacity.⁴ 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.

AHAM DEHUMIDIFICATION SELECTION GUIDE					
Values in table indicate dehumidification required in Pints per 24 Hours, based on the area of the space to be dehumidified and the conditions that would exist in that space when a dehumidifier is not in use.					
CONDITION WITHOUT DEHUMIDIFICATION	AREA -- SQ. FT.				
	500	1000	1500	2000	2500
During warm and humid outdoor conditions.					
Moderately damp -- Space feels damp and has musty odor only in humid weather.	10	14	18	22	26
Very damp -- Space always feels damp and has musty odor. Damp spots show on walls and floor.	12	17	22	27	32
Wet -- Space feels and smells wet. Walls or floor sweat, or seepage is present.	14	20	26	32	38
Extremely wet -- Laundry drying, wet floor, high load conditions.	16	23	30	37	44

Dehumidification variables also include such other factors as climate, laundry equipment, number of family members, number of doors and windows, and degree and intensity of area activity.

³ <http://www.energymaine.com/orders-documents/2002-162%20EE%20Pot%20Sum%20V5%202.pdf>

⁴ see <http://www.aham.org/consumer/getstartdehum.cfm>

In the absence of better data, the CMP value of 324 kWh/month for a conventional dehumidifier is used here, with an assumption of three full months of operation, or 972 kWh per year. This 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.

Savings for an ENERGY STAR labeled unit are taken as 16% of 972 = 156 kWh per year.

For system-wide savings, the 2003 Home Energy Survey shows 53 percent saturation of dehumidifiers among MGE customers. This figure is applied to the approximately 157,000 MGE customers, assuming that the number of existing units that are ENERGY STAR qualified is negligible. A diversified usage factor of 0.77 is also applied to account for the fact that not all homes with dehumidifiers use them for the entire summer. The usage factor is derived from survey data from the Center's 1999 Residential Characterization Study (Pigg and Nevius, 2000) as follows:

"How is [your dehumidifier] used?"	Percent of respondents	Assumed usage factor
It is rarely used	10.5%	0
It is used for a part of the summer	24.1%	0.5
It is used all summer long	65.4%	1.0
Weighted average		0.77

Issues

- There is little data on how much energy dehumidifiers actually use in homes.

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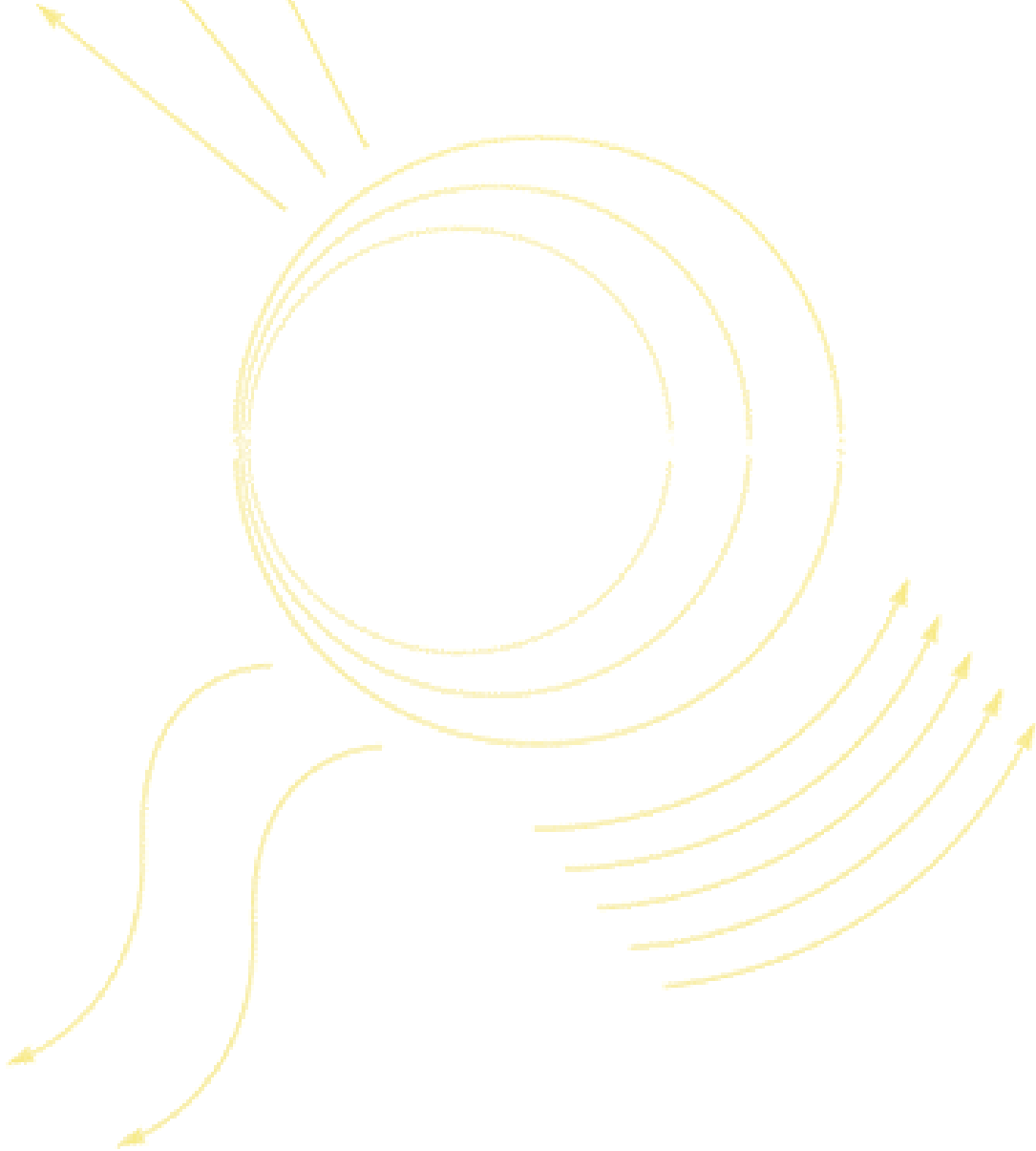
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Revision History

Draft: March 25, 2005

Revisions:



Savings from Purchasing an ENERGY STAR® Labeled Dishwasher

Summary

ENERGY STAR labeled dishwashers are required to use at least 25 percent less energy than a conventional new dishwasher. The savings figures below represent the average savings for a new ENERGY STAR labeled dishwasher compared to an older unit, for homes with electric and gas water heaters. System-wide savings are based on the estimated number of MGE homeowners with an automatic dishwasher.

Annual Savings

	Electricity (kWh)	Gas (therms)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household						
Electric water heater	122	0.0	269	0.693	1.483	91
Gas water heater	53	5.2	179	0.305	0.653	40
Blended average	68	4.0	199	0.390	0.835	51
MGE system-wide (millions)	4.33	0.26	12.6	0.025	0.053	3.25
Equivalent to electric use of	640	homes				
Equivalent to gas use of	330	homes				

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

The dishwasher savings calculator on the ENERGY STAR Web site assumes per cycle energy consumption values shown in the table below for ENERGY STAR labeled and conventional new dishwashers. Based on 215 loads per year used in the federal standard rating procedure, this works out to 336 kWh/year for an ENERGY STAR labeled unit in a home with electric water heat compared to 439 kWh for a conventional new dishwasher.¹

¹ The 215 loads per year used in the federal test procedure is reasonable consistent with the number of loads reported by respondents to the Center's Residential Characterization Study (4.3 loads/week, or 224 loads/year).

	ENERGY STAR		Conventional new	
	Electricity kWh/cycle	Natural Gas Therms/cycle	Electricity kWh/cycle	Natural Gas Therms/cycle
Electric water heat	1.5625	0	2.04	0
Gas Water heat	0.6875	0.038	0.90	0.058

Of course, most existing dishwashers are older and use more energy than the conventional new unit used in the ENERGY STAR calculator. The 2004 Wisconsin Energy Statistics book (DOA, 2004) provides a table of shipment-weighted energy consumption for appliances back to 1972. The table shows dishwasher energy consumption declining from about 900 kWh/year in 1972 to about 400 kWh/year in 2003 (the tables assume electric water heat). The table below combines these data with an approximate distribution of dishwasher age to derive an age-weighted average dishwasher energy consumption.² This average usage corresponds to what a typical dishwasher purchased between 1990 and 1995 would consume.

Dishwasher age	Dishwasher annual electricity (kWh) (electric water heat)	Estimated proportion of population
<5 years	416	40%
5-9 years	440	40%
10-14 years	512	10%
15-19 years	583	5%
20+ years	700	5%
Weighted average	458	

To convert the above figure to energy consumption in homes with gas water heat, the ratio of electricity consumption for gas water heat to electricity consumption for electric water heat from the ENERGY STAR calculator (0.44) is first used to derive the electricity consumed by the dishwasher itself (201 kWh/year). The remaining 257 kWh/year then represents the energy in the hot water used by the dishwasher, which is converted to the number of therms used by a gas water heater (13.3) taking into account the respective energy factors of electric water heaters (0.87 assumed) and gas water heaters (0.57 assumed).

The table below shows the estimated annual consumption for ENERGY STAR labeled and age-weighted older dishwashers along with the savings from an ENERGY STAR labeled model, assuming 215 loads per year.

² This age distribution is derived from the (largely self-reported) distribution of dishwasher ages from the Center's Residential Characterization Study (Pigg and Nevius, 2000)

	Gas water heat		Electric water heat
	Electricity kWh/year	Natural Gas Therms/year	Electricity kWh/year
Older	201	13.3	458
ENERGY STAR	148	8.2	336
Savings	53	5.2	122

These savings are blended at 22 percent saturation of electric water heat in MGE's service territory (from the 2003 Home Energy Survey), for an overall average savings per household of 68 kWh per year of electricity and 4.0 therms per year of natural gas.

System-wide savings are based on the number of MGE homeowners with an automatic dishwasher. Data on dishwashers were not gathered as part of the 2003 Home Energy Survey, so statewide data from the Center Residential Characterization Study (Pigg and Nevius, 2000) are used. That study indicated a statewide dishwasher saturation of 65 percent among homeowners. This saturation is applied to MGE's 157,000 residential customers, with an assumption that 62 percent of MGE customers are homeowners (this figure is derived from survey data from the 2003 load research survey conducted by the Center for MGE). The total estimated number of automatic dishwashers in owner-occupied homes in MGE's service territory is estimated at about 63,300.

The distribution of dishwasher age implies a 10 to 15-year life for the average dishwasher. Assuming an average 12 year life would imply that about 8 percent of dishwashers are replaced each year, or about 5,300 per year in MGE's service territory. About 2,700 new homes are also built in MGE's service territory almost all of which have an automatic dishwasher. The total number of dishwashers purchased is thus on the order of 8,000 per year.

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Revision History

Draft: March 25, 2005

Revisions:

April 7, 2004

1. Added a note on the estimated number of dishwashers purchased in MGE's service territory per year.



Savings from Purchasing an ENERGY STAR® Labeled Furnace

Summary

ENERGY STAR labeled Furnaces are required to have an AFUE (Annual Fuel Utilization Efficiency) of 90 percent or better. The savings estimates below are based on replacing a typical older non-condensing furnace with a new ENERGY STAR labeled condensing unit.

System-wide savings are based on the estimated number of homes in MGE's service territory with noncondensing furnaces that could be replaced with a high efficiency model, along with the number of new homes built each year for which furnace efficiency is a purchase choice.

[Note: Center tracking of furnace sales in the Madison area indicates that nine out of ten purchasers already choose a high efficiency furnace.]

Annual Savings

	Gas (therms)	CO ₂ (lbs.)
Per household	78	920
MGE system-wide (millions)	2.48	29.2
Equivalent to gas use of	3,200	homes

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

ENERGY STAR labeled Furnaces are required to have an AFUE (Annual Fuel Utilization Efficiency) of 90 percent or better. In practice, this means using a furnace that condenses water vapor from the flue gas. Although these units range up to more than 96 percent efficient, 92 percent efficiency is assumed here as typical of a condensing furnace. While very old furnaces can be considerably less efficient, a typical non-condensing furnace has an AFUE rating of about 80 percent.

The savings from replacing an 80 percent efficient furnace with a 92 percent efficient model are calculated as:

$$\text{Heating load (therms/year)} \times (1 - 80/92)$$

Data from the Center's Residential Characterization Study (Pigg and Nevius, 2000) indicates that the average Wisconsin home has an annual heating load of about 5.5 Btu/ft² per heating degree day (square footage excludes basement area). For an average home in the Madison area with 1,500 above-grade square feet of floor space, this works out to an annual heating load of about 600 therms. Estimated average heating savings are thus:

$$600 \times (1 - 80/92) = 78 \text{ therms.}$$

In terms of system-wide potential, the 2003 load forecasting survey conducted by the Center for MGE suggests that about 62 percent of MGE customers are homeowners, and 94 percent of these customers have forced air furnaces. Across MGE's estimated 157,000 residential customers, this would translate into about 92,500 owner-occupied homes with a furnace.

Many of these furnaces are likely to already be high efficiency models, however. The 1999 Center Residential Characterization Study showed that statewide about half of furnaces in single-family homes were condensing models (Pigg and Nevius, 2000). Assuming a typical furnace replacement rate of about 3.4 percent per year (Bensch and Weitner, 2004) over the six years since the characterization study—of which about 90 percent are typically high efficiency purchases (based on the Center's Furnace and AC Tracking System project)—this would translate into about 68 percent saturation of high efficiency furnaces in MGE's service territory in 2005. This works out to an estimated 29,300 older non-condensing furnaces remaining in MGE's service territory.

Approximately 2,700 new homes are also built in MGE's service area each year (see "Savings from Building an ENERGY STAR Home"), of which an estimated 90 percent (2,400) are heated with a forced air furnace. Added to the estimated pool of older furnaces above, the total number of furnaces with potential to convert to high efficiency is taken as approximately 31,700.

Issues

- The saturation of condensing furnaces in MGE's service territory is somewhat uncertain.

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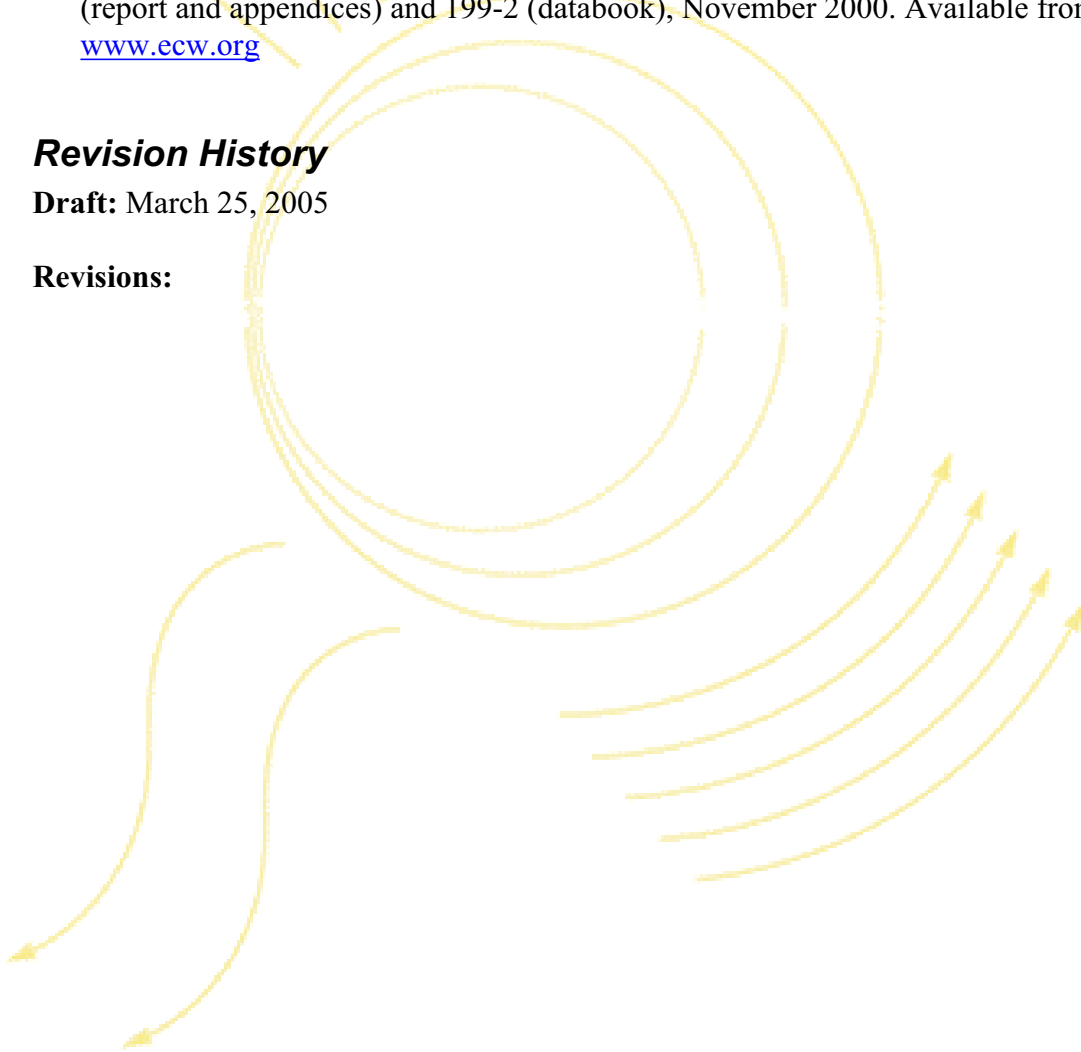
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Revision History

Draft: March 25, 2005

Revisions:



Savings from One in Ten Households Buying ENERGY STAR® Heating and Cooling Equipment

Summary

MGE has about 157,000 residential customers. The table below shows the energy savings and avoided emissions from one in ten MGE households (15,700) buying an ENERGY STAR labeled furnace and central air conditioner to replace existing units.

Annual Savings

	Electricity (kWh)	Gas (therms)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household						
Furnace	0	78	920	0.00	0.00	0
Central AC	577	0.0	1,278	3.29	7.04	433
MGE system-wide (millions)	9.06	1.23	34.52	0.05	0.11	6.79
Equivalent to electric use of	1,330	homes				
Equivalent to gas use of	1,590	homes				

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

See “Savings from Purchasing an ENERGY STAR Labeled Furnace” and “Savings from Purchasing a New High-SEER Central Air Conditioner” for derivation of per-household savings for buying ENERGY STAR labeled furnace and central air conditioner. These are estimated to save 78 therms and 577 kWh, respectively.

To estimate the system-wide impacts if one household in ten were to replace existing units, these estimates are multiplied by one tenth of MGE’s residential customer base (15,700 households).

Revision History

Draft: March 25, 2005

Revisions:

Savings from Purchasing a New ENERGY STAR® Refrigerator

Summary

New refrigerators use much less electricity than older models, and ENERGY STAR qualified models are more efficient still. The savings below are based on replacing an average refrigerator in an owner occupied home in MGE's service territory with an ENERGY STAR labeled model.

Annual Savings

	Electricity (kWh)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per refrigerator	516	1,140	2.94	6.29	387
MGE system-wide (millions)	60.2	134	0.343	0.735	45.2
Equivalent to electric use of	8,900	homes			

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

Older refrigerators use substantially more electricity than models built since the mid 1990s, and ENERGY STAR qualified models are required to be at least 15 percent more efficient than current federal efficiency standards.

Analysis of 280 refrigerators with short-term metered consumption data from the Center's Residential Characterization Study indicate that the typical Wisconsin refrigerator uses about 1,000 kWh per year (Pigg and Nevius, 2000).

How much a new ENERGY STAR qualified refrigerator will consume depends on the type and size of the unit. The Center's 2001 Appliance Sales Tracking Survey asked Wisconsin purchasers of new refrigerators about the type and features of the refrigerator they purchased. The data showed that about two-thirds of respondents purchased a top-freezer model, a quarter purchased a side-by-side model, and a small percentage purchased a bottom-freezer model. The vast majority of side-by-side refrigerators had through-the-door water ice, while the vast majority of other models do not have these features. The table below combines these proportions with the estimated consumption of typical new ENERGY STAR qualified models based on the EPA's Consumer Refrigerator

Savings Calculator.¹ The analysis suggests that a typical new ENERGY STAR qualified refrigerator will use about 480 kWh per year.

Type	% of market ^a	Average adjusted volume of new refrigerator ^b	Typical annual energy use (kWh) for ENERGY STAR qualified model ^c
Top-freezer	65%	20.75	479
Side-by-side ^d	27%	22.60	497
Bottom-freezer	8%	20.75	479
Weighted average			484

^aSource: ECW 2001 Appliance Sales Tracking Survey

^bSource: AHAM "Energy Consumption and Efficiency Trends" data for 2001. Data obtained from Jim Mapp, WI Division of Energy. (Adjusted volume is calculated as volume of fresh food compartment + 1.63*volume of freezer compartment)

^cCalculated by refrigerator type as 85% of federal efficiency standard based on type and size (equations from EPA Energy Star Consumer Refrigerator Savings Calculator)

^dWith through-the-door ice and water

The savings per refrigerator are thus estimated to be about $1,000 - 484 = 516$ kWh per year.

The calculation of system-wide savings potential is based on the following:

1. There are approximately 157,000 MGE residential customers.
2. The 2003 Load Research survey conducted by the Center for MGE suggests that about 62 percent of MGE customers are homeowners.
3. The Center's Residential Characterization Study suggests that there are about 1.2 refrigerators per single-family home.

Combining the items above yields an estimated 116,800 refrigerators in owner-occupied housing.

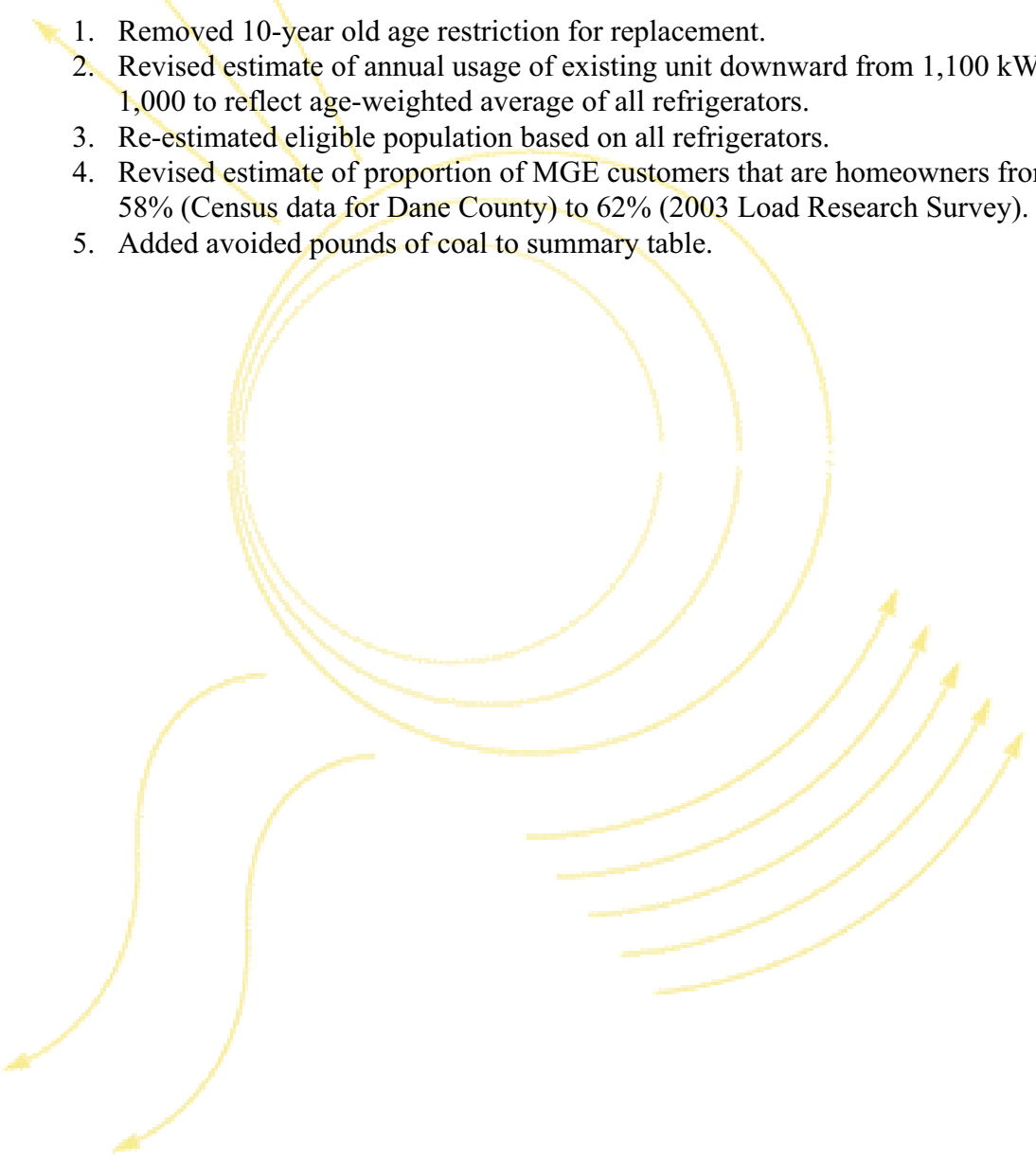
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Revision History

Draft: February 28, 2005

March 25, 2005

1. Removed 10-year old age restriction for replacement.
 2. Revised estimate of annual usage of existing unit downward from 1,100 kWh to 1,000 to reflect age-weighted average of all refrigerators.
 3. Re-estimated eligible population based on all refrigerators.
 4. Revised estimate of proportion of MGE customers that are homeowners from 58% (Census data for Dane County) to 62% (2003 Load Research Survey).
 5. Added avoided pounds of coal to summary table.
- 

Savings from Setting Back the Thermostat

Summary

Setting back the thermostat saves heating energy, because it reduces the temperature difference between indoors and outdoors slightly. The savings estimates below are for several levels of overnight setbacks during the heating season and are a weighted average of single-family and multifamily savings for homes with gas or electric heat. System-wide savings take into account that more than half of Wisconsin households already set back the thermostat at night. The final table is based on all residential customers turning their heat down by 1F° for 24 hours/day during the heating season.

Annual Savings (1F° overnight setback)

	Electricity (kWh)	Gas (therms)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household						
Gas heat	0	6.85	80.6	0	0	0
Electric heat	80	0	177	0.456	0.976	60
MGE system-wide (millions)	1.08	0.342	6.42	0.006	0.013	0.810
Equivalent to electric use of	160	homes				
Equivalent to gas use of	440	homes				

Annual Savings (3F° overnight setback)

	Electricity (kWh)	Gas (therms)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household						
Gas heat	0.00	20.6	242	0.00	0.00	0
Electric heat	240	0	5312	1.37	2.93	180
MGE system-wide (millions)	3.24	1.03	19.3	0.018	0.040	2.43
Equivalent to electric use of	480	homes				
Equivalent to gas use of	1,300	homes				

Annual Savings (5F° overnight setback)

	Electricity (kWh)	Gas (therms)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household						
Gas heat	0	34.3	403	0.00	0.00	0
Electric heat	400	0	886.4	2.28	4.88	300
MGE system-wide (millions)	5.40	1.71	32.1	0.031	0.066	4.05
Equivalent to electric use of	800	homes				
Equivalent to gas use of	2,200	homes				

Annual Savings (1F° 24-hour setback)

	Electricity (kWh)	Gas (therms)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household						
Gas heat	0.00	20.6	242	0.00	0.00	0
Electric heat	240	0	532	1.37	2.93	180
MGE system-wide (millions)	7.54	2.39	44.8	0.043	0.092	5.65
Equivalent to electric use of	1,100	homes				
Equivalent to gas use of	3,100	homes				

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

Setting back the thermostat saves energy because it reduces one of the main components of heating energy consumption: the indoor/outdoor temperature difference that drives heat through the building shell by conduction. A rule of thumb that has been used since the late 1970s is that each 1 F° of regular setback for an eight-hour period translates into 1 percent heating energy savings. This rule of thumb appears to have been derived from modeling work and limited monitoring done at the onset of energy crisis (e.g., Nelson, 1973; Pilati, 1975; Quentzel, 1976). Little or no research has been done on the issue since then.

While some subscribe to the notion that the savings from setting back the thermostat are completely offset by the recovery period the next morning, in fact, so long as the average long-term indoor temperature (including both setback and non-setback periods) is less than it would be if there was no setback, savings will be realized. In this sense, savings from newer homes are probably less than savings in older homes, since the latter are more poorly insulated and drop to the setback temperature more quickly. Nonetheless, for the purposes here, the simple rule-of-thumb approach is applied universally. Also, to simplify the analysis, we considered only night setback during the heating season.

Savings from setback during the cooling season is considerably more complicated.

For thermostat turn-down (i.e., 24 hour/day setback), we estimated 3 percent savings per F° reduction in the setpoint.

The 2003 MGE Home Energy Survey indicates that about 74 percent of MGE residential customers have gas heat, 20 percent have electric heat, and 6 percent heat with another fuel. Most of the customers with electric heat are in multifamily buildings. We used billing system data on more than 32,000 single family customers compiled recently for other purposes to estimate the average heating use for a single-family home with gas heat as 740 therms. We used values for 5-19 unit buildings from the Center's Rental

Characterization Study as the basis for estimating that a multifamily apartment with gas heat will use about 450 therms per year and one with electric heat will use about 5,000 kWh per year. We took 20,000 kWh per year as a reasonable estimate for the amount of electricity used for space heating for the small proportion of single-family homes that have electric space heat. The table below summarizes values used for the analysis.

	Gas heat		Electric heat	
	% of all customers ^a	Avg. annual heating use (therms)	% of all customers ^a	Avg. annual heating use (kWh)
Single-family	60%	740 ^b	4%	20,000 ^c
Multifamily	14%	450 ^d	16%	5,000 ^d
Weighted average		685		8,000

^aFrom 2003 Home Energy Survey (weighted)
^bBased on data for ~32,000 accounts provided in March 2004
^cEstimate
^dEstimate from ECW Rental Characterization Study

Survey data from the Center’s Residential and Rental Characterization studies (Pigg and Nevius, 2000; Pigg and Price, 2005) indicate that similar proportions of single-family homeowners and multifamily renters currently set back the thermostat at night: about 57%. The pool of customers who could save by setting back is thus taken as 43%.

Per household and system-wide savings are derived by applying the savings rule of thumb to the usage estimates above, and then weighting by the population proportions. System-wide savings potential for turning the thermostat down by 1F^o is based on all MGE residential customers.

Issues

While supported by heat loss theory, there is little recent empirical validation of claimed setback savings.

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Revision History

Draft: February 28, 2005

Revisions

March 25, 2005

1. Added avoided pounds of coal to summary table.

April 7, 2005

2. Added 1F° 24hour/day setback scenario.

Savings from Reducing Air Conditioner Use by 10 Percent

Summary

Air-conditioning represents a significant portion of electricity consumption on the summer days that most strain the electrical system. Per household savings below are for homes that have—and use—their central or room air conditioning. System-wide savings are based on the estimated number of MGE customers that have air conditioning, and takes into account that some households that have air conditioning do not use it.

Annual Savings

	Electricity (kWh)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household					
Central AC	141	313	0.80	1.72	106
Room AC	60	133	0.34	0.73	45
MGE system-wide (millions)	16.0	35.4	0.091	0.195	12.0
Equivalent to electric use of	2,400	homes			

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

The typical central air conditioner in Wisconsin is a 2.5-ton unit with a SEER rating of 8.5 that operates for about 400 hours per year (see “Savings from Purchasing a New High-SEER Central Air Conditioner”). These values imply annual electricity consumption of about 1,400 kWh per year, and 140 kWh of savings if usage is reduced by 10 percent.

Similarly, the average room air conditioner has an output capacity of about 8,200 Btu/hour and an EER rating of 8.2 (“Savings from Purchasing a New High-EER Room Air Conditioner”). Again assuming 400 hours of annual operation, this implies annual electricity consumption per unit of about 400 kWh, and 40 kWh of savings if usage is reduced by 10 percent. MGE survey data suggest that on average there are 1.5 room air conditioners per household, so the average savings per household is thus about 60 kWh per year.

The above figures assume that all air conditioners are used. The Center's 1999 Residential Characterization Study of single-family homes showed that about 15 percent of central air conditioners were not used. This adjustment is applied to both central and room air conditioning systems here.

Developing system-wide savings estimates requires information about the number of MGE customers that have air conditioning. Two separate surveys of MGE customers in 2003 asked about the existence of central and room air conditioning. While the surveys show reasonably close agreement on the saturation of central air conditioning (69 percent and 73 percent respectively), the figures for room air conditioning differ somewhat (19 percent and 33 percent). For the purposes here, 70 percent saturation is used for central air conditioning and 25 percent is used for room air conditioning. These figures are applied to the total 157,000 MGE residential customers to estimate system-wide savings.

Issues

- Hours of operation for air conditioners are uncertain.
- The proportion of room air conditioners that are not used is based on data on central air conditioners.
- Two separate surveys of MGE customers disagree somewhat on the saturation of room air conditioners.

References

Pigg, Scott and Monica Nevius. 2000. *Energy and Housing in Wisconsin: A Study of Single-family Owner-Occupied Homes*. Energy Center of Wisconsin, Reports 199-1 (report and appendices) and 199-2 (databook), November 2000. Available from www.ecw.org

Revision History

Draft: April 7, 2005

Savings from Installing a Compact Fluorescent Lightbulb

Summary

Compact fluorescent lightbulbs use one-third to one-fourth the electricity of a regular incandescent lightbulb. The savings estimates below are based on MGE's 157,000 residential customers replacing a single high-use incandescent lightbulb with a CFL.

Annual Savings

	Electricity (kWh)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household	75.8	168	0.432	0.924	57
MGE system-wide (millions)	11.9	26.4	0.068	0.145	8.92
Equivalent to electric use of	1,800	homes			

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

The energy savings from replacing an incandescent lightbulb with a compact fluorescent depends on two factors: the difference in wattage between the two bulbs, and the number of hours the light is used. These two parameters are discussed separately below.

Wattage Difference

The packaging for CFLs typically claim that a given CFL produces the equivalent light output (measured in lumens) of an incandescent bulb that uses four times as much electricity: thus a 15-Watt CFL might be advertised as the replacement for a 60-Watt incandescent.

On the other hand, differences in the spectral distribution of CFL light and the direction that some CFLs throw the light means that in practice, CFLs are sometimes perceived by consumers as dimmer than their lumen ratings would suggest. Perhaps in recognition of this, the ENERGY STAR web site for CFLs states that "ENERGY STAR qualified CFLs use 66% less energy than a standard incandescent bulb..." implying a three-to-one ratio of power draw between incandescents and CFLs.

Focus on Energy uses 51.9 Watts as the average difference between a CFL and an incandescent bulb for residential applications, based on an analysis of the database of CFLs that have received incentives (WECC 2002).

As a cross-check of the Focus estimate, we analyzed on-site data collected on high-use (2 hours per day or more) incandescent bulb wattages in 299 Wisconsin homes from the Center's Residential Characterization Study (Pigg and Nevius, 2000). For bulbs in the 40-150 Watt range likely to be replaced by a CFL, a four-to-one assumed ratio between incandescent and CFL power draw yields an average wattage difference of 54.5 Watts, while a three-to-one ratio results in an estimate of 48.5 Watts. These two figures bracket the Focus estimate of 51.9, and---if averaged---are nearly identical to the Focus estimate.

Given this convergence, the Focus estimate of an average of 51.9 Watt reduction in power draw is used here.

Hours of Use

A recent California study provides the most comprehensive assessment of hours of use for residential CFLs to date (KEMA, 2005). That study shows that the average CFL in a home is used for about 2.3 hours per day. For the purposes of estimating the replacement of an average high-use bulb, 4 hours per day is used here. The estimated savings per home for replacing a single incandescent with a CFL is therefore:

$$(51.9 \text{ Watts}) / (1000 \text{ Watts/Kilowatt}) * (4 \text{ hours/day}) * (365 \text{ days/year}) = 75.8 \text{ kWh/year}$$

For system-wide savings, this figure is aggregated across the approximately 157,000 MGE residential customers.

References

KEMA. 2005. *CFL Metering Study*, Final Report prepared for Pacific Gas and Electric Company, San Diego Gas and Electric Company, and Southern California Edison Company, February 25, 2005. (Available from www.calmac.org.)

Pigg, Scott and Monica Nevius. 2000. *Energy and Housing in Wisconsin: A Study of Single-family Owner-Occupied Homes*. Energy Center of Wisconsin, Reports 199-1 (report and appendices) and 199-2 (databook), November 2000. Available from www.ecw.org

(WECC) Wisconsin Energy Conservation Corporation. 2002. *Residential Default Savings for Wisconsin Focus on Energy*. April 2002.

Revision History

Draft: February 18, 2005

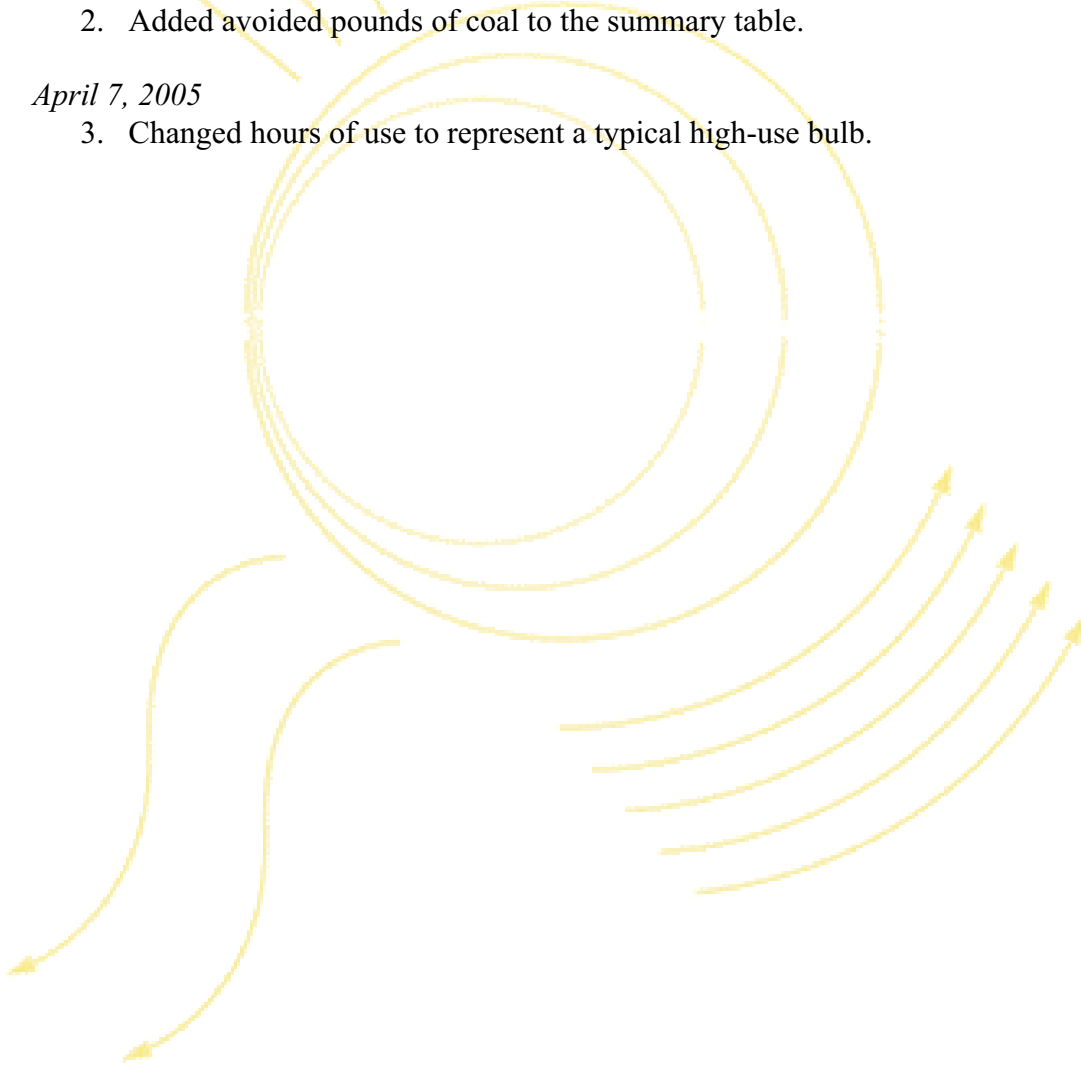
Revisions

March 25, 2005

1. Modified hours of use estimate to 2.3, based on new California study (KEMA 2005).
2. Added avoided pounds of coal to the summary table.

April 7, 2005

3. Changed hours of use to represent a typical high-use bulb.



Savings from Replacing the Five Most Frequently Used Bulbs with Compact Fluorescents

Summary

Compact fluorescent lightbulbs use one-third to one-fourth the electricity of a regular incandescent lightbulb, and a small proportion of bulbs account for most of the lighting energy in a typical home. Savings estimates below assume replacement with CFLs of five bulbs in the most-used location in the home.

Annual Savings

	Electricity (kWh)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household	379	840	2.16	4.62	284
MGE system-wide (millions)	59.5	131.8	0.339	0.726	44.61
Equivalent to electric use of	8,800	homes			

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

The energy savings from replacing an incandescent lightbulb with a compact fluorescent depends on two factors: the difference in wattage between the two bulbs, and the number of hours the light is used. A reduction in wattage between incandescent and CFLs of 51.9 Watts is used here (see the discussion in the write-up for “Savings from one Compact Fluorescent”).

The recent California study of hours of use of CFLs (KEMA, 2005) provides estimates of average hours of use for CFLs installed in various locations in the home, as shown in the table below.

Location	Hours of use (w/ 90% conf. interval)
Bedroom	1.6 ± 0.4
Bathroom	1.5 ± 0.4
Family room	2.5 ± 1.3
Garage	2.5 ± 6.0
Halls/entry	1.6 ± 0.9
Kitchen	3.5 ± 2.1
Living room	3.3 ± 1.5
Laundry room	1.2 ± 0.8
Other room	1.9 ± 1.7
Outdoor	3.1 (not metering based)
Overall	2.3 ± 0.4

Source: KEMA, 2005.

These data suggest that on average, there are locations within most homes that average at least 3 hours per day of burn time.

At the same time, the one comprehensive field study of all lighting use in homes (Tribwell and Lerman, 1996) provides data suggesting that many homes have four to five bulbs that operate in excess of four hours per day. The study indicates that between 57 and 82 percent of homes (depending on the season in which monitoring occurred) had lamps that were used for 4 or more hours per day, with an average of 3.6 to 4.7 lamps per home.

Also in this vein, the 2001 Residential Energy Consumption Survey (RECS) (EIA, 2001) provides self-reported figures on the number of indoor lights turned on in categories of 1-4 hours per day, 4-12 hours per day, and more than 12 hours per day. A rough analysis with these data for the East North Central Census division suggest that the top five *indoor* lights could average somewhere between 3 and 9 hours of burn time per day per light. However, the data are self-reported and do not add up to anywhere near the full inventory of lighting in the typical home (for the ENC Census division, the data imply that an average of only 4 lights per home are reported in the data). The RECS also asked householders whether they left an outdoor light burning all night: 22 percent of households in the East North Central Census division responded that they do so. Moreover, the aforementioned California study found that self-reported hours of use average about a third higher than metered use.

In the absence of more precise information, the assumption used here is that the top five bulbs in the average home are used for an average of 4 hours per day. The savings are thus calculated as:

$$5 * (51.9 \text{ Watts}) / (1000 \text{ Watts/Kilowatt}) * (4 \text{ hours/day}) * (365 \text{ days/year}) = 379 \text{ kWh/year}$$

For system-wide savings, this figure is aggregated across the approximately 157,000 MGE residential customers.

Issues

There is significant uncertainty in the average hours of use for the top five bulbs used in the average home.

References

(EIA) Energy Information Agency. 2001. *Residential Energy Consumption Survey*.
www.eia.doe.gov/emeu/recs/contents.html.

KEMA. 2005. *CFL Metering Study*, Final Report prepared for Pacific Gas and Electric Company, San Diego Gas and Electric Company, and Southern California Edison Company, February 25, 2005. (Available from www.calmac.org.)

Tribwell, Lyle S. and David I. Lerman. 1996. *Baseline Residential Lighting Energy Use Study*. Final Report, May 29, 1996.

Revision History

Draft: February 18, 2005

Revisions

March 25, 2005

1. Added avoided pounds of coal to summary table.
2. Added discussion of new California study (KEMA, 2005) to Discussion section.

Savings from Washing Clothes in Cold Water

Summary

Most of the energy for washing clothes goes into heating the water used by the washing machine. Using cold water for washing eliminates this energy use. Estimated savings from cold water washing are summarized below for the combinations of water heater fuel and washer type, along with a weighted average of savings across all homes. Total system-wide potential is based on the estimated number of MGE residential customers with individual clothes washers.

Annual Savings

		Electricity (kWh)	Gas (therms)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household							
Water heater	Washer						
Gas	Standard	0	66.1	777	0.00	0.00	0
Gas	Energy Star	0	18.0	212	0.00	0.00	0
Electric	Standard	834	0.0	1,847	4.75	10.17	625
Electric	Energy Star	227	0.0	504	1.30	2.77	171
Blended average		159	44.8	880	0.91	1.94	120
MGE system-wide (millions)		22.27	6.26	122.99	0.127	0.272	16.7
Equivalent to electric use of		3,300	homes				
Equivalent to gas use of		8,100	homes				

Discussion

See the description of energy savings for upgrading to a new ENERGY STAR labeled clothes washer for background information on field studies and other estimates of energy consumption by washing machines. The table below shows the estimated average energy used for hot water used in the age-weighted average of existing stock and ENERGY STAR labeled clothes washers. These figures represent average hot water use per cycle: all of this energy would be saved by using all cold wash cycles.

Energy use per cycle		Existing (Age-weighted average)	ENERGY STAR
Hot water			
	Gas water heater (therms)	0.169	0.046
	Electric water heater (kWh)	2.13	0.58

Calculations of annual energy use and savings are based on 392 laundry loads per year, as documented in “Savings from Purchasing an ENERGY STAR Labeled Clothes Washer.”

The table below shows the estimated annual energy savings by water heater fuel type and washer type, along with weighted average proportions based on data from the 2003 Home Energy Survey and an estimated 18 percent penetration of ENERGY STAR labeled clothes washers in MGE’s service territory (as documented “Savings from Purchasing an ENERGY STAR Labeled Clothes Washer.”).

Water heater fuel	Washer Type	Percent of customers^a	Annual energy savings	
			Electricity (kWh/year)	Natural gas (therms/year)
Gas ^b	Standard	64%	0	66.1
Gas ^b	ENERGY STAR	14%	0	18.0
Electric	Standard	18%	834	0.0
Electric	ENERGY STAR	4%	227	0.0
Weighted average			159	44.8

^aFrom MGE 2003 Home Energy Survey with an overall estimated 18 percent saturation of Energy Star washers.

^bAlso includes a small number of reported propane and oil water heaters.

System-wide potential is based on an estimate of the number of MGE residential customers with a clothes washer, and is based on 157,000 active MGE residential accounts, of which 89 percent have a clothes washer (2003 Home Energy Survey).

Revision History

Draft: February 28, 2005

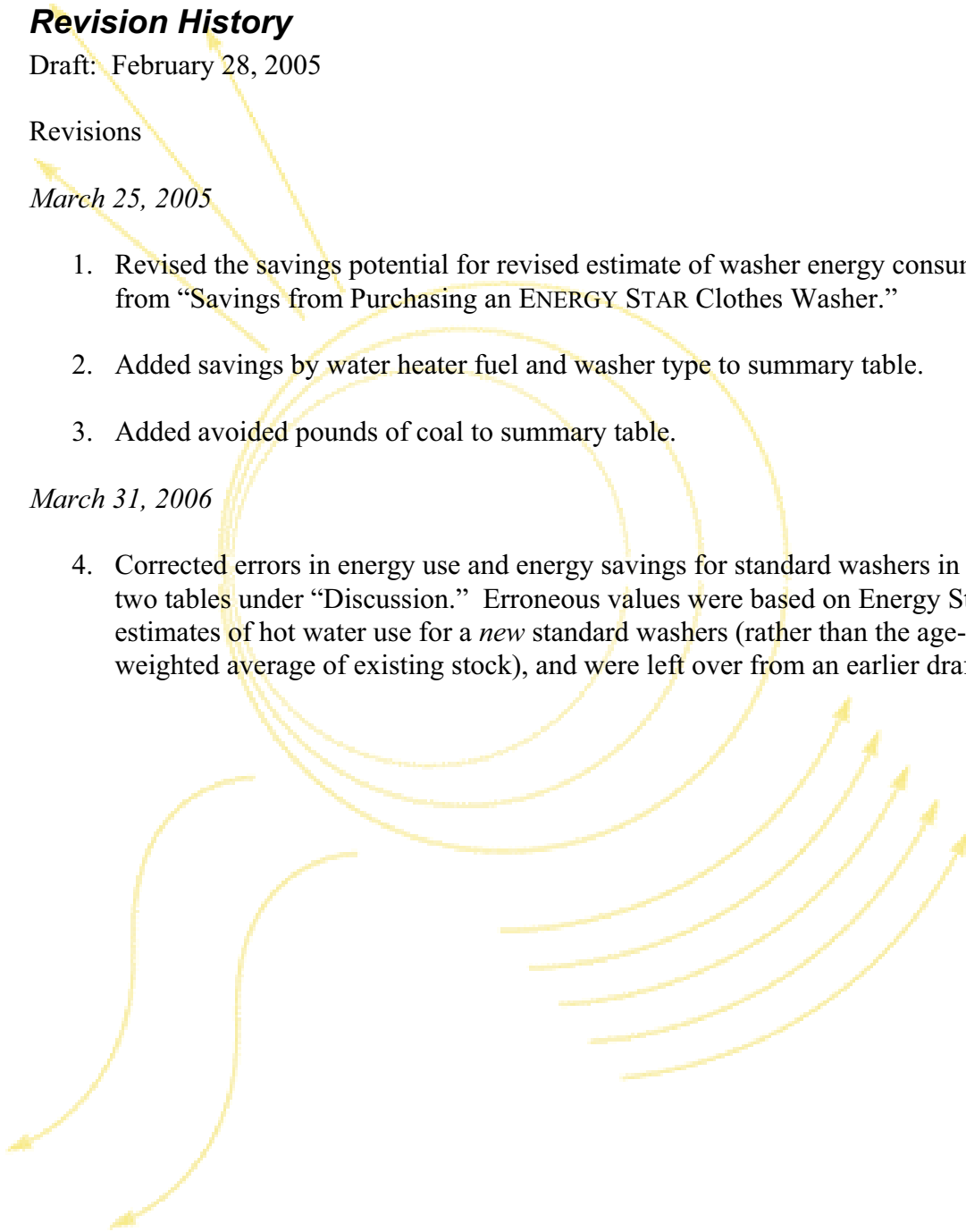
Revisions

March 25, 2005

1. Revised the savings potential for revised estimate of washer energy consumption from “Savings from Purchasing an ENERGY STAR Clothes Washer.”
2. Added savings by water heater fuel and washer type to summary table.
3. Added avoided pounds of coal to summary table.

March 31, 2006

4. Corrected errors in energy use and energy savings for standard washers in the first two tables under “Discussion.” Erroneous values were based on Energy Star estimates of hot water use for a *new* standard washers (rather than the age-weighted average of existing stock), and were left over from an earlier draft.



Savings from Washing a Full Load of Dishes in the Dishwasher

Summary

Most dishwashers use the same amount of energy regardless of the size of the load. The per-household savings below are based on survey data suggesting that the average household washes about 50 partial dishwasher loads per year. Savings are based on the assumption that half of these could be eliminated by running only full loads.

System-wide savings are based on the estimated number of automatic dishwashers among MGE customers.

Annual Savings

	Electricity (kWh)	Gas (therms)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household						
Electric water heater	106	0.0	236	0.606	1.298	80
Gas water heater	47	9.3	213	0.267	0.571	35
Blended average	60	7.3	218	0.342	0.731	45
MGE system-wide (millions)	5.32	0.64	19.4	0.030	0.065	3.99
Equivalent to electric use of	780	homes				
Equivalent to gas use of	840	homes				

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

Although some newer dishwashers have sensors that adjust the amount of water used based on the amount of soil in the load, older dishwashers use the same amount of energy regardless of the size of the load. The Center's two residential characterization studies provide self-reported data on the number of dishwasher loads washed per week as well as the frequency of washing full loads. The latter question was posed as "How often do you take the following sorts of actions," followed a list of actions including "run the dishwasher only when it is full. Response categories are shown below, along with the assumptions used here for the estimated fraction of loads that are partial loads corresponding to each response category.

"How often do you...run the dishwasher only when it is full?"	
Response category	Assumed partial loads as a proportion of all loads
Rarely or never	100%
Some of the time	75%
Most of the time	25%
Always	0%

When combined with the self-reported number of loads washed per week (and weighted across homeowners and renters), the data suggest an average of about 50 partial loads washed per year. Assuming that these are half-full loads on average, this would imply that 25 loads per year could be eliminated by running only full loads.

These additional 25 loads per year are multiplied by the age-weighted average dishwasher energy use per cycle (2.128 kWh for electric water heat, and 0.936 kWh and 0.062 therms for gas water heat—see “Savings from Purchasing an ENERGY STAR® Labeled Dishwasher”) to obtain an estimate of the per-household savings.

System-wide savings are calculated based on the estimated number of automatic dishwashers in MGE’s service territory. The number of automatic dishwashers among homeowners is estimated at 63,300 (see “Savings from Purchasing an ENERGY STAR® Labeled Dishwasher”). For renters, the Center’s Rental Characterization Study (Pigg and Price, 2005) suggests about 40 percent dishwasher saturation among rental households. Applied across the estimated 38 percent of MGE customers that are rental households (based on the 2003 load research survey conducted by the Center for MGE), this works out to approximately 23,900 automatic dishwashers in rental households.

Issues

- The approach used to estimate the average number of partial dishwasher loads per year is approximate, and based on self-reported behavior.

References

Pigg, Scott, and Andrew Price 2005. *Energy and Rental Housing: A Wisconsin Characterization Study*. Energy Center of Wisconsin, forthcoming.

Revision History

Draft: March 25, 2005

Revisions:

Savings from Heat-Recovery Ventilation

Summary

Heat recovery ventilators transfer heat from the exhaust airstream to pre-warm incoming ventilation air. The savings figures below are for using a heat recovery ventilator versus exhaust-only ventilation in a typical new home with gas heat that averages 60 cfm of ventilation over the course of the heating season.

Because the prevalence of mechanical exhaust-only ventilation in MGE's service territory is not known, system-wide savings are not calculated here.

Annual Savings

	Gas (therms)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household	20	240	0	0	0

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

The recently adopted ASHRAE Standard 62.2, "Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings," provides a basis for estimating mechanical ventilation in homes (ASHRAE, 2003). The standard calls for 7.5 cfm of ventilation per occupant (with bedrooms plus one as a proxy if occupancy is unknown), plus 1 cfm per 100 square feet of floor space. For a typical new Wisconsin home, the standard would call for about 60 cfm of continuous ventilation (Pigg, 2003).¹

The savings for using a heat recovery ventilator versus exhaust-only ventilation accrue from recovering some of the heat in the exhaust air to temper the amount of heat required to warm incoming replacement air to the thermostat setpoint (taken as 70F here).

However, it has been noted that exhaust-only ventilation draws air in through the same leakage paths as natural infiltration. One rule of thumb based on field measurements holds that if the amount of exhaust ventilation is less than two times the estimated natural infiltration, only half of the exhaust ventilation is actually added to the air exchange rate

¹ Since it is much more common for mechanical ventilation to be applied to new homes than existing homes, this analysis presumes the former.

of the home.² Field data from Wisconsin (Pigg, 2003) suggest that the average new home with a conditioned volume of about 26,000 cubic feet will have a natural air exchange rate between about 0.1 and 0.2 air changes per hour, which translates into roughly 40 to 90 cfm. Since the target mechanical ventilation rate (60 cfm) is well below twice these values, the assumption that exhaust-only ventilation adds about 30 cfm to the existing natural ventilation rate is used here.

Heat recovery ventilators on the other hand provided balanced supply and exhaust air, and the full airflow is added to the heating load of the home. At the same time, these units recover a significant portion of the heat in the exhaust airflow. The amount of heat recovered varies with outdoor temperature and by model (HVI, 2005), but a reasonable average of 70 percent can be used.

The heating savings from heat recovery ventilation versus mechanical exhaust-only ventilation are thus the difference in the heating requirement for 60 cfm with 70 percent recovery versus 30 cfm with no recovery. For new homes in the Madison area, this heating requirement is based on 5,900 heating degree days at a base temperature of 60F, which has been shown to be typical of new Wisconsin homes (Pigg 2002). The calculations for annual savings are as follows:

Exhaust-only ventilation:

$(30 \text{ cfm}) * (1,440 \text{ minutes/day}) * (5,900 \text{ HDDs}) * (0.018 \text{ Btu/ft}^3\text{F for air}) / (90\% \text{ heating system efficiency}) / (1 \times 10^5 \text{ Btu/therm}) = 51 \text{ therms}$

Heat recovery ventilator:

$(60 \text{ cfm}) * (1,440 \text{ minutes/day}) * (5,900 \text{ HDDs}) * (0.018 \text{ Btu/ft}^3\text{F for air}) * (30\% \text{ heat not recovered}) / (90\% \text{ heating system efficiency}) / (1 \times 10^5 \text{ Btu/therm}) = 31 \text{ therms}$

Savings:

51 therms – 31 therms = 20 therms

The above calculations assumed that the electricity consumption required to provide the ventilation is approximately equivalent between the two systems.

Because the prevalence of mechanical exhaust-only ventilation in MGE's service territory is not known, system-wide savings are not calculated here.

² See <http://oikos.com/esb/50/ventilation.html>.

Issues

- The prevalence of exhaust-only ventilation among MGE customers is not known, preventing calculation of system-wide savings
- The savings calculations used here are approximate; the interaction between natural and mechanical ventilation can be complex.

References

Home Ventilating Institute (HVI). 2005. *Certified Home Ventilating Products Directory*, March 2005. (available from www.hvi.org)

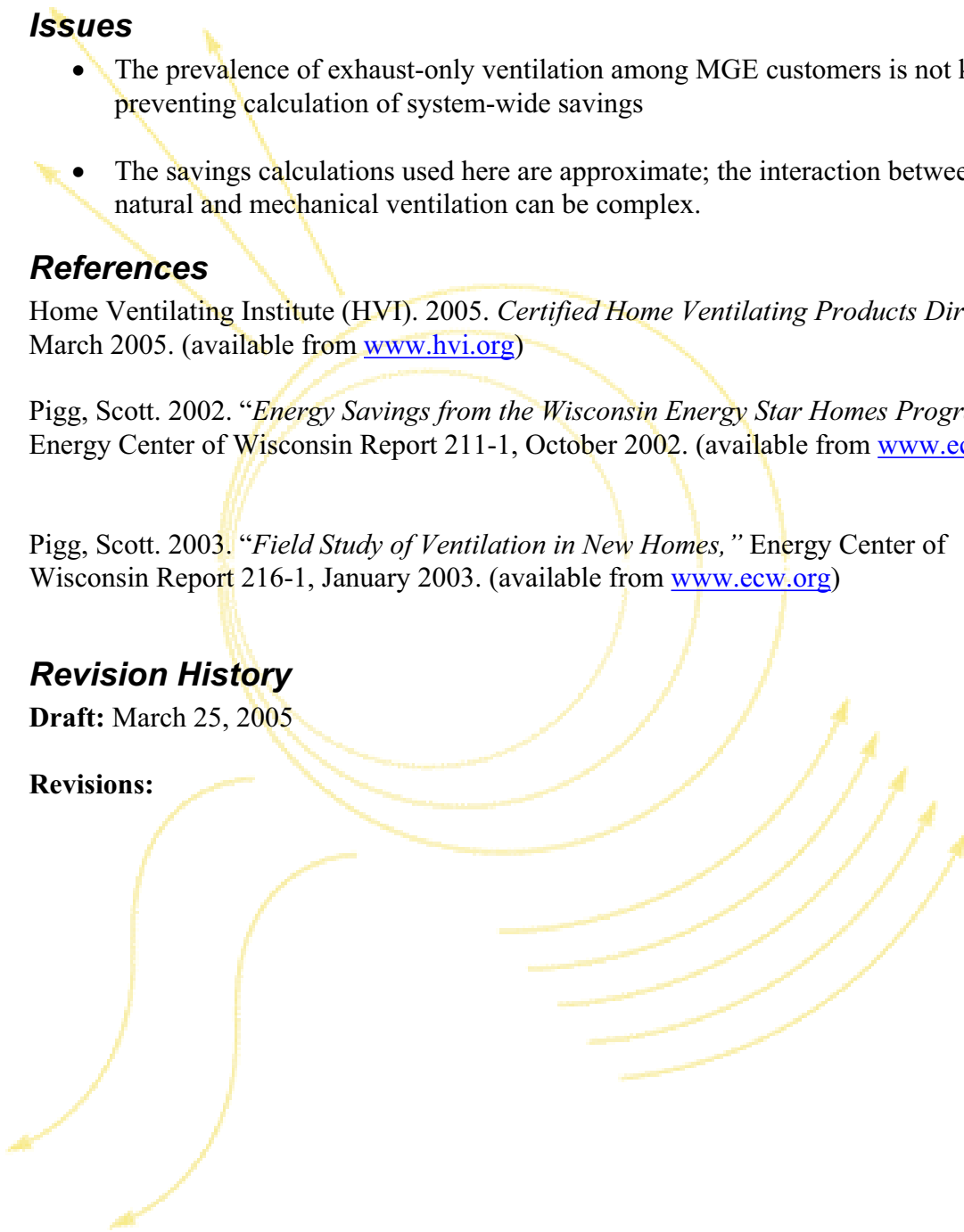
Pigg, Scott. 2002. "Energy Savings from the Wisconsin Energy Star Homes Program," Energy Center of Wisconsin Report 211-1, October 2002. (available from www.ecw.org)

Pigg, Scott. 2003. "Field Study of Ventilation in New Homes," Energy Center of Wisconsin Report 216-1, January 2003. (available from www.ecw.org)

Revision History

Draft: March 25, 2005

Revisions:



Savings from Building an ENERGY STAR® Home

Summary

Homes built under the Wisconsin ENERGY STAR homes program have been documented to use about 100 therms less gas energy for heating than typical new homes. The savings below are based on an estimated 2,700 new homes constructed in MGE's service territory each year, and include the assumption that the major home appliances (refrigerator, dishwasher, clothes washer and central air conditioner) are all upgraded to ENERGY STAR labeled units.

System-wide savings are based on 2,700 new homes built in MGE's service territory each year, and are relative to a baseline of all new homes being non- ENERGY STAR without ENERGY STAR labeled appliances.

Annual Savings

	Electricity (kWh)	Gas (therms)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household	389	118	2,248	2.22	4.75	292
MGE system-wide (millions)	1.05	0.318	6.07	0.006	0.013	0.788
Equivalent to electric use of	160	homes				
Equivalent to gas use of	410	homes				

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Electric savings above are a weighted average for various appliances and water heater fuels. The per-household savings for these are shown below. These are all based on the difference in energy use between a standard new appliance and an ENERGY STAR labeled unit.

Appliance	(water heater fuel)	Electricity (kWh)	Gas (therms)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Refrigerator		80	0	177	0.46	0.98	60
Dishwasher	(electric)	103	0	228	0.59	1.26	77
	(gas)	46	4	149	0.26	0.56	35
Clothes washer	(electric)	360	0	798	2.05	4.39	270
	(gas)	36	16	268	0.21	0.44	27
Central air conditioner		277	0	614	1.58	3.38	208

Discussion

The Wisconsin ENERGY STAR homes program requires insulation levels and equipment efficiency to achieve a Home Performance Rating Score of 86 or higher to be certified as an ENERGY STAR home. In addition, the program has maximum air leakage standards that are validated by blower door tests.

While program materials claim that Wisconsin ENERGY STAR homes average 25 percent lower energy consumption than homes built to code minimums, in practice many builders outside the program go beyond code minimums. A 2002 comparison of utility usage data for a sample program participants and non-participant new homes (Pigg, 2002) showed that program homes used 96 ± 68 therms less gas than comparable non-participant homes. No statistically significant difference in electricity consumption was found. These results are consistent with the notion that program homes are more tightly sealed than non-participant homes, but are comparable in most other respects related to energy consumption. For the purposes here, 100 therms per home is taken as the typical heating energy savings for an ENERGY STAR new home.

Savings for upgrading major appliances from conventional efficiency levels to ENERGY STAR levels are shown below. These are largely based on the savings calculators available on the ENERGY STAR web site (www.energystar.gov). Savings for central air conditioners are based on calculations documented in "Savings from Purchasing a New High-SEER Central Air Conditioner."

Appliance	Annual Savings	
	Electricity kWh	Natural Gas therms
refrigerator	80	0
dishwasher (electric water heat)	103	0
dishwasher (gas water heat)	46	4
clothes washer (electric water heat)	360	0
clothes washer (gas water heat)	36	16
central air conditioner	277	0

From the 2003 Home Energy Survey, it appears that about 7 percent of new homes have electric water heat, and 89 percent have gas water heat. The survey also reveals that virtually all new homes have central air conditioning. These values were used to create a weighted average savings per home.

Data provided by MGE in 2003 indicate an average of about 2,700 new single-family service addresses added per year. This figure is consistent with reported new home starts in Dane county of 2,600 homes in between mid-2003 and mid-2004 (Balousek, 2004). The former figure is used to estimate the system-wide potential savings if all new homes were built to program standards.

Issues

The current market share for ENERGY STAR appliances in Madison area new homes is unknown. The analysis is references against a baseline of all appliances being non-ENERGY STAR.

References

Balousek, Marv. 2004. "Madison, Sun Prairie Lead Home Building," Wisconsin State Journal, June 20, 2004.

Pigg, Scott. 2002. *Energy Savings from the Wisconsin Energy Star Homes Program*. Research report 211-1. (Available from www.ecw.org)

Revision History

Draft: February 28, 2005

March 25, 2005

1. Added savings estimates for various home appliances.
2. Added avoided pounds of coal to summary table.

April 7, 2005

3. Added table with per-household appliance savings to summary.

Savings from Changing to a Gas Dryer

Summary

The operating cost of a gas dryer is about one-third that of an electric dryer. Gas dryers also result in fewer emissions. The savings estimates below are based on converting the estimated 67 percent of MGE customers with electric dryers to gas.

Annual Savings

	Electricity (kWh)	Gas (therms)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household	865	-33.9	1,806	5.87	12.56	649
MGE system-wide (millions)	80.6	-3.17	189	0.615	1.32	60.5
Equivalent to electric use of	11,900	homes				
Equivalent to gas use of	-4,100	homes				

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

See “Dryer Savings from Purchasing an ENERGY STAR Labeled Clothes Washer” for a general description of the literature regarding dryer energy savings for upgrading to a new ENERGY STAR labeled clothes washer. Two studies document dryer energy use--- and the difference in dryer energy use associated with high efficiency washers that remove more moisture from the wash load. (Durfee and Tomlinson, 2001; Sullivan et al., 2001). The figures from the latter study—which reported an electric dryer consumption of 3.2 kWh/cycle and 2.5 kWh/cycle for standard and high efficiency washers, respectively—are used here. For gas dryers, these figures are converted to therms per cycle, with an assumption that gas dryers use 15% more energy for drying (E Source, 2001).

Calculations of annual energy use are based on the 392 wash loads per year used in the federal test procedure for clothes washers, which is also based on an assumption that 84 percent of wash loads are dried in the dryer.¹

¹ 10 CFR 430, Subpart B, Appendix J1

The table below shows the estimated annual energy impacts by washer type, along with a weighted average based on the estimated 18 percent saturation of high efficiency washers in MGE's service territory (See "Savings from Purchasing an ENERGY STAR Labeled Clothes Washer").

Washer Type	Percent of customers	Annual energy savings	
		Electricity (kWh/year)	Natural gas (therms/year)
Standard	82%	1,054	-41.4
High Efficiency	18%	823	-32.3
Weighted average		865	-33.9

System-wide potential is based on 157,000 active MGE residential accounts, of which 89 percent have a clothes washer and 75 percent of these have an electric dryer (2003 Home Energy Survey), for an overall electric dryer saturation of 67 percent. Survey data also indicate that 89 percent of households with an electric dryer have natural gas service.

References

- Durfee, David J. and John J. Tomlinson. 2001. *Boston Washer Study*. Oak Ridge National Laboratory, ORNL-TM-2001/21-4, December, 2001. Available at: http://www.ornl.gov/sci/btc/pdfs/TM2001_214.pdf.
- E Source. 2001. *Technology Atlas Series; Volume V — Residential Appliances*. McGraw Hill.
- Sullivan, G. P., D. B. Elliot, T. C. Hillman and A. R. Hadley, 2001. *The Save Water and Energy Education Program: SWEEP — Water and Energy Savings Evaluation*. Pacific Northwest National Laboratory, PNNL-13538, May 2001. Available at: http://www.eere.energy.gov/buildings/emergingtech/pdfs/sweep_report.pdf

Revision History

Draft: February 28, 2005

March 25, 2005

1. Added avoided pounds of coal to summary table.

April 7, 2005

2. Added an adjustment to account for proportion of households with electric dryers that have natural gas service.

Savings from Changing to a Gas Range/Oven

Summary

Gas ranges and ovens cost less to operate than electric models. Gas cooking also results in fewer emissions. The savings figures below are estimates of the average savings from replacing an electric range/oven with an electric-ignition gas model. Per household estimates are a weighted average of homes with electric range/oven combinations and a small proportion of households with an existing gas range and an electric oven. System-wide savings are based on estimates of the total number of electric range/ovens in MGE's service territory, including those owned by tenants in rental buildings. These estimates also take into account the proportion of households with electric cooking equipment that also have gas service.

Annual Savings

	Electricity (kWh)	Gas (therms)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household	518	-28	815	2.95	6.32	389
MGE system-wide (millions)	35.5	-1.94	55.8	0.202	0.433	26.6
Equivalent to electric use of	5,200	homes				
Equivalent to gas use of	-2,500	homes				

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

The table below shows Department of Energy estimates of energy use for various range and oven types. The figures shown here for ovens are an average of estimated energy use for standard and self-cleaning units.

	Gas (therms/year)		Electric
	Pilot	No pilot	(kWh/year)
Oven	30	16	295
Range	34	13	235
Total	64	29	530

Source: E Source, 2001.

Consumers who replace an electric range and oven with a gas model will save 530 kWh per year and increase their gas consumption by about 29 therms per year. Some homes have electric ovens, but have gas ranges; the figures above suggest that these homes will save 295 kWh per year and increase gas use by 16 therms by replacing the electric oven with a gas model.

For calculating system-wide impacts, an estimate of the total number of electric ranges and ovens in MGE’s service territory is required. The table below shows the saturation of range and oven fuel by fuel type from the 2003 Home Energy Survey, split out by homeowners versus renters:

	Range Fuel	Oven Fuel	
		Electric	Gas
Homeowners (62%)	Electric	71%	0%
	Gas	4%	25%
Renters (38%)	Electric	91%	0%
	Gas	1%	8%

Most tenants do not supply their own range/oven. Tenant survey data from The Center’s Rental Characterization Study (Pigg and Price, 2005) indicate that about a third of tenants in 1-4 unit rental properties supply their own range and oven, but that virtually no tenants in larger properties do so. According Census 2000 data, 39 percent of renters in Dane County reside in 1-4 unit buildings. This works out to an estimated 13 percent of renters who supply their own range/oven.

In addition, not all households with electric cooking equipment have natural gas service. The 2003 Home Energy Survey data indicate that about 90 percent of homeowners and 70 percent of renters (in small buildings that are most likely to supply their own cooking equipment) with electric cooking have gas service.

When applied across the 157,000 MGE residential customers, the figures above indicate that 65,500 electric range/ovens could be converted to gas in MGE’s service territory, along with 3,400 electric ovens in homes with gas ranges.

References

E Source. 2001. *Technology Atlas Series; Volume V — Residential Appliances*. McGraw Hill.

Pigg, Scott, and Andrew Price 2005. *Energy and Rental Housing: A Wisconsin Characterization Study*. Energy Center of Wisconsin, forthcoming.

Revision History

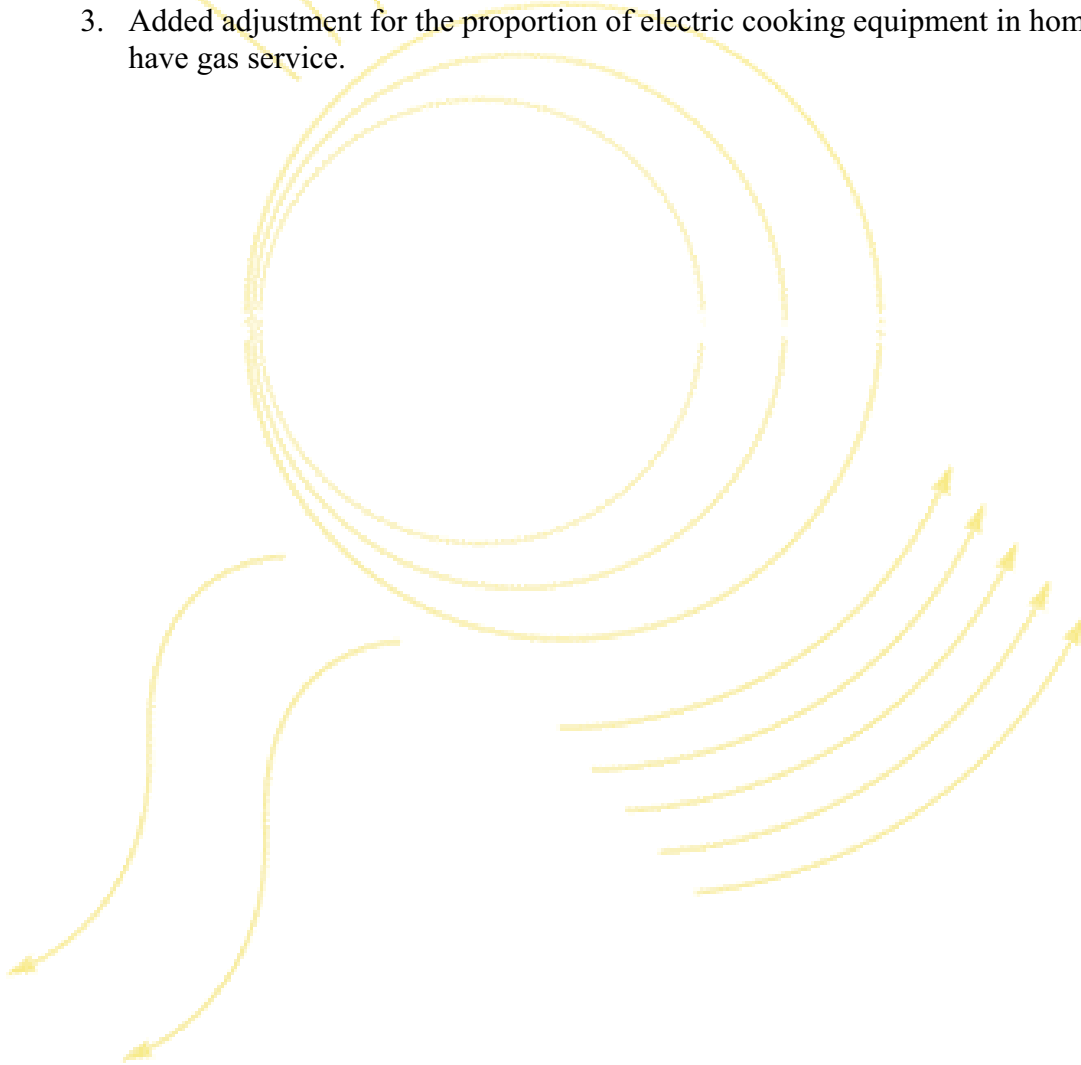
Draft: February 28, 2005

March 25, 2005

1. Added avoided pounds of coal to summary table.

April 7, 2005

2. Changed homeowner/renter proportion to 62/38 percent to be consistent with other write-ups.
3. Added adjustment for the proportion of electric cooking equipment in homes that have gas service.



Savings from Changing to a Gas Water Heater

Summary

The operating cost of a gas water heater is about one-half that of an electric water heater. Gas water heaters also result in fewer emissions. The savings estimates below are based on a typical household using about 50 gallons of hot water per day. System-wide savings are based on converting the estimated 12 percent of MGE customers who are homeowners with electric water heaters in homes that also have gas service.

Annual Savings

	Electricity (kWh)	Gas (therms)	CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Per household	4,150	-200	6,840	23.7	50.6	3,110
MGE system-wide (millions)	48.5	-2.34	79.9	0.276	0.591	36.4
Equivalent to electric use of	7,130	homes				
Equivalent to gas use of	-3,030	homes				

Note: **Per household** savings estimate the environmental impact of the average household taking this action. The **MGE system-wide** section combines the individual savings to estimate the affect throughout the MGE system. The number of homes powered annually by the savings is estimated to illustrate the power of working together.

Discussion

The amount of energy required for water heating is a strong function of household size. The 2003 Load Research survey suggests that the average number of occupants in an owner-occupied MGE home is about 2.5. For this household size, estimates of hot water use vary:

- 38 gallons per day based on a model of hot water use developed by Lawrence Berkeley Laboratory¹;
- 63 gallons per day based on monitored data for 10 homes in Seattle (Mayer et al., 2000);
- 53 gallons per day based on monitored data for 10 homes in California (Mayer et al., 2003).

For the purposes here, the middle value of 53 gallons per day is used. Using the LBL method referenced above, this level of hot water use translates into about 4,200 kWh per year for a typical electric water heater with an energy factor of 0.87. Similarly, a high efficiency (EF = 0.63) power-vented gas water heater can be expected to consume about

¹ see <http://hes.lbl.gov/hes/aboutwhm.html>

200 therms of gas per year (along with about 50 kWh of electricity). These estimates form the basis of the per-household savings.

System-wide potential is based on (weighted) data from the 2003 MGE Home Energy and Load Research Surveys, which show:

- About 62 percent of MGE customers are homeowners
- 17 percent of MGE homeowners have an electric water heater
- 71 percent of homeowners with electric water heaters report having a gas-fired heating system, clothes dryer, range or oven, and thus represent households that could relatively easily convert to gas water heat

When the above fractions are applied to the approximately 157,000 MGE residential customers, an estimate of 11,700 homes that could convert from electric to natural gas is obtained. [Note that the survey data also indicate that there are about 900 owner-occupied homes that could convert from electric to propane water heat: these were not included in the analysis.]

References

Mayer, Peter W., William B. DeOreo, and David M. Lewis. 2000. "Seattle Home Water Conservation Study — The Impacts of High Efficiency Plumbing Fixture Retrofits in Single-Family Homes," report presented to Seattle Public Utilities and the US EPA, December 2000. (available from: <http://www.cuwcc.org/Uploads/product/Seattle-Final-Report.pdf>)

Mayer, Peter W., William B. DeOreo, Erin Towler and David M. Lewis. 2003. "Residential Indoor Water Conservation Study — The Evaluation of High-Efficiency Indoor Plumbing Fixture Retrofits in Single-Family Homes in The East Bay Municipal Utility District Service Area," report presented to the East Bay Municipal Utility District and the US EPA, July 2003. (available from: <http://www.cuwcc.org/Uploads/product/EBMUD-Final-Report.pdf>)

Revision History

Draft: April 7, 2005

What Percent of Home Energy Use is for Space Heating and Cooling?

Summary

Statewide, approximately 45 percent of (primary) energy used in Wisconsin single-family homes goes toward space heating and cooling.

Discussion

The analysis below is confined to single-family, owner-occupied Wisconsin homes, and is based on data collected for the Center's 1999 Residential Characterization Study (Pigg and Nevius, 2000). The data collected for that study suggest that the average Wisconsin home uses about 219 million Btu of primary energy per year.¹

Fuel	% of homes using fuel	Average annual use when present	Average annual use across all homes (MMBtu) ^a
Electricity	100	10,630 kWh	115.1
Natural gas	70	1,025 therms	71.8
Propane	17	994 gallons	16.3
Fuel oil	10	706 gallons	10.0
Wood	6	88.0 MMBtu	5.7
Total:			218.9

^aElectricity is converted to primary energy assuming 35% power plant efficiency and 10% distribution losses. Conversion to Btu as follows: electricity, 3,413 Btu/kWh; natural gas, 100,000 Btu/therm; propane, 95,000 Btu/gallon; fuel oil, 135,000 Btu/gallon.

The characterization study also provides estimates of annual space heating and cooling energy consumption. Annual space heating consumption in homes averages 87.9 million Btu per household across all fuels. When the small amount of electric space heat is converted to primary energy, this figure becomes 92.6 million Btu per household. Air conditioning electricity use averages 663 kWh per year across all households (including those that do not have—or do not use—air conditioning). Converted to primary energy consumption, this figure becomes 7.2 million Btu. Altogether, space heating and cooling thus represent $92.6 + 7.2 = 99.8$ million Btu out of 218.9, or 45 percent.

¹ Primary or “source” energy takes into account the energy required to generate and transmit electricity.

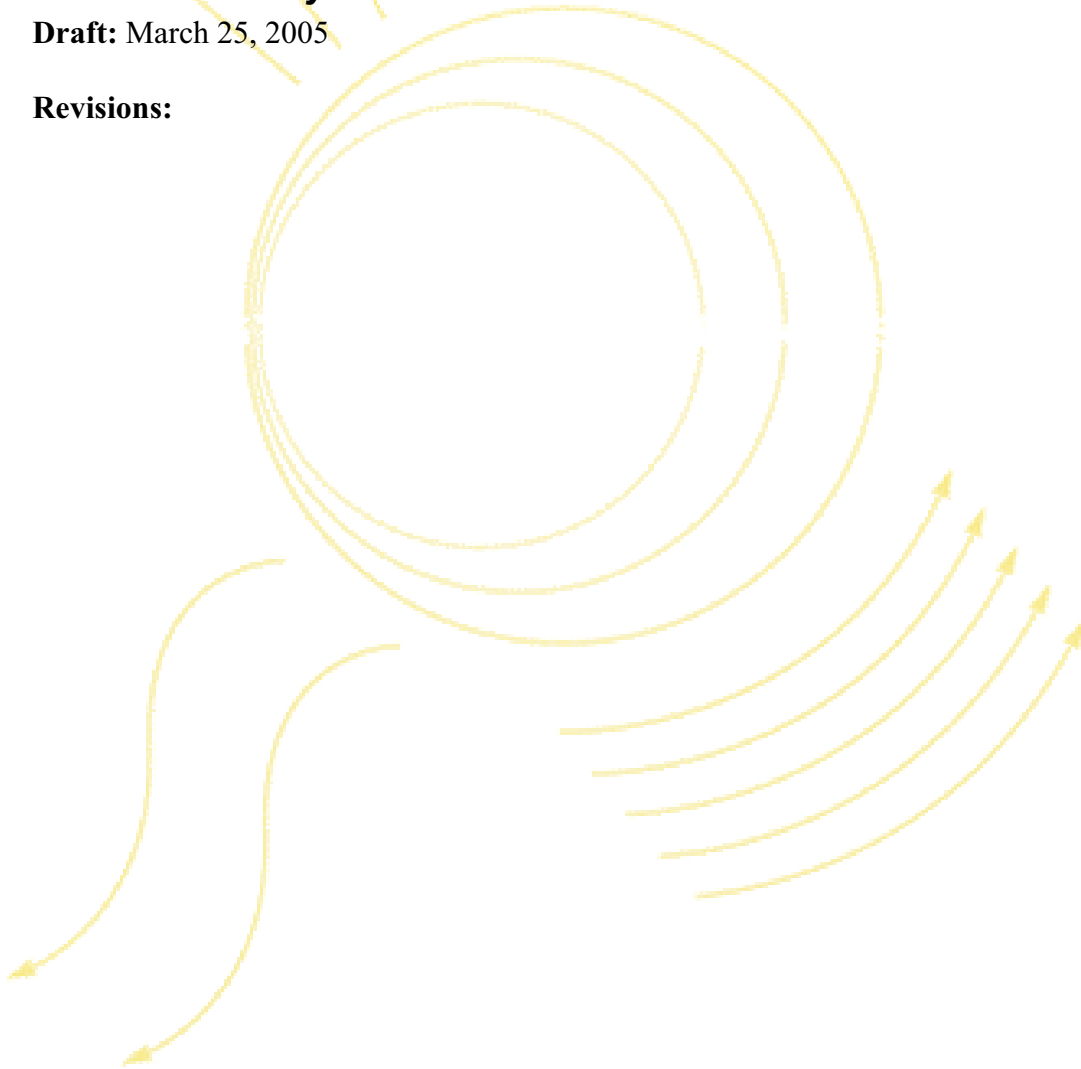
References

Pigg, Scott and Monica Nevius. 2000. *Energy and Housing in Wisconsin: A Study of Single-family Owner-Occupied Homes*. Energy Center of Wisconsin, Reports 199-1 (report and appendices) and 199-2 (databook), November 2000. Available from www.ecw.org

Revision History

Draft: March 25, 2005

Revisions:



Amount ENERGY STAR® Choices Can Save

Summary

ENERGY STAR products use less energy than their conventional counterparts. The ENERGY STAR products analyzed for this project can save up to more than \$300, or about 25 percent of the average residential customer bill.

Discussion

The table below summarizes savings for replacing various appliances and products analyzed for this project with ENERGY STAR labeled units.

Annual savings

			CO ₂ (lbs.)	NO _x (lbs.)	SO _x (lbs.)	Coal (lbs.)
Clothes washer (electric water heat, electric dryer)	902	kWh	2,000	5.14	11.00	676
5 most used lights	379	kWh	840	2.16	4.62	284
Refrigerator	516	kWh	1,140	2.94	6.29	387
Dishwasher (electric water heat)	122	kWh	269	0.69	1.48	91
Dehumidifier	156	kWh	346	0.89	1.90	117
Central AC	489	kWh	1,080	2.79	5.96	367
Furnace	78	therms	920	0.00	0.00	0

A homeowner who replaced all of the above with new ENERGY STAR labeled versions could expect to save more than 2,500 kWh of electricity and about 80 therms of natural gas per year. At 10 cents/kWh and 80 cents/therm, these savings are worth about \$320 per year in energy costs—or about 25 percent of the \$1,300 energy bill for the average MGE customer.

Issues

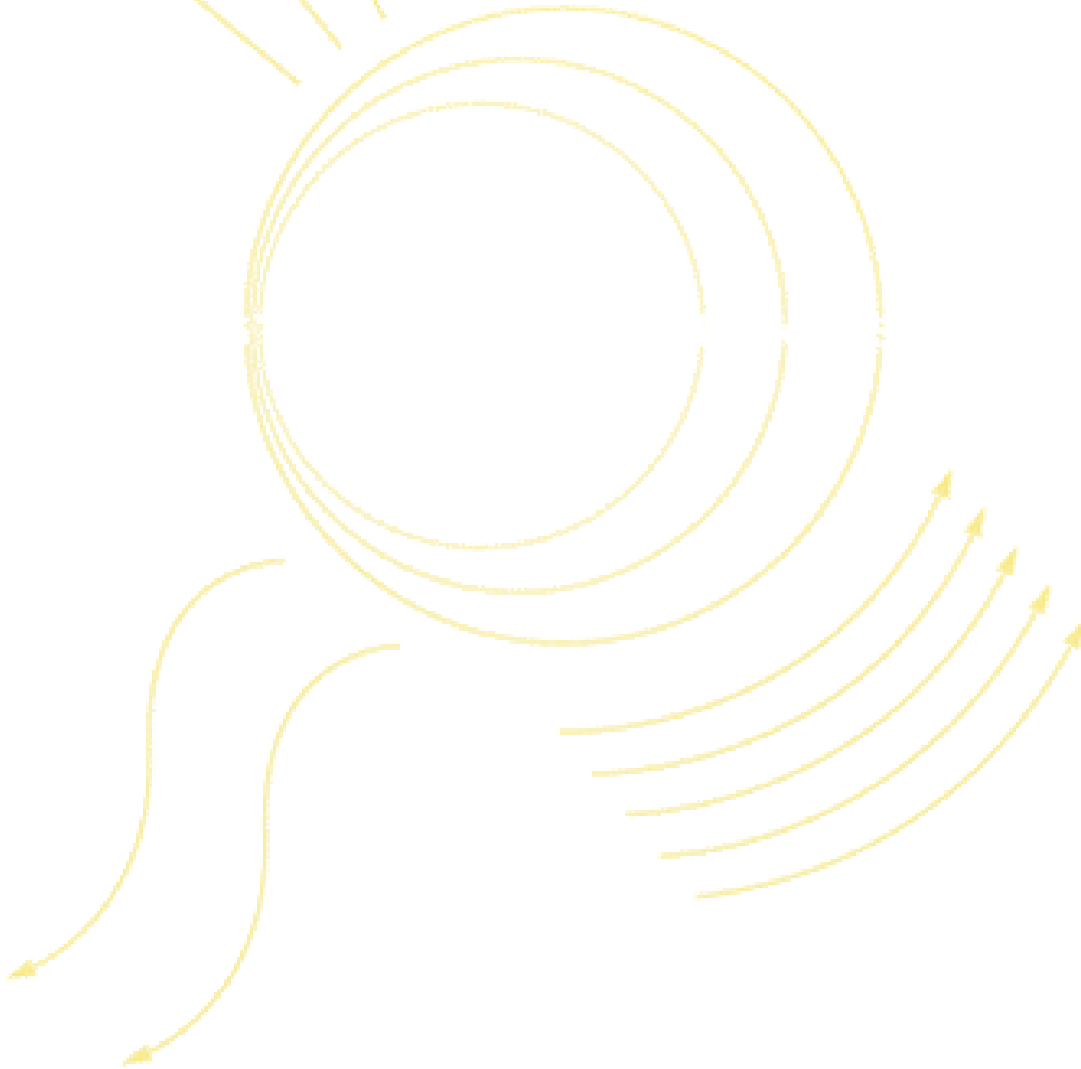
1. Average MGE customer bill based on system-wide average electricity use (6,791 kWh/year) and gas use (771 therms/year). This may differ from the average bill.

Revision History

Draft: March 25, 2005

April 7, 2005

1. Added avoided emissions and coal to table of appliance savings.



Global Assumptions for Consumer Energy Savings Calculations

Emissions Factors

The following emissions factors are used throughout the calculations to estimate the avoided emissions associated with energy savings for the various measures. These are taken from Focus on Energy statewide estimates (Erickson et al., 2004).

Electricity	CO ₂	2,216 lbs/MWh = 2.216 lbs/kWh
	NO _x	5.7 lbs/MWh = 0.0057 lbs/kWh
	SO _x	12.2 lbs/MWh = 0.0122 lbs/kWh
Natural gas	CO ₂	11.76 lbs/therm

Avoided Coal Consumption

The heat value of coal varies between about 8,000 and 13,000 Btu per pound. Taking an average value of 10,500 Btu per pound, a power plant efficiency of about 35 percent and 10 percent transmission and distribution losses, an estimated 1.03 pounds of coal is consumed per kWh of delivered coal-generated electricity. About 72 percent of Wisconsin-generated electricity is derived from coal-fired power plants (DOA, 2004), so the average amount of coal saved for each avoided kWh of electricity is taken to be 0.75 pounds.

Residential Customers and Typical Use

The number of MGE residential customers is approximated at 157,000 throughout the savings calculations. This figure is derived from figures provided on the number of residential electric customers and gas customers for 2004 (115,875 and 118,233, respectively), along with the proportion of customers that have both electric and gas service from MGE (49.4%) based on MGE data from December 2003. When the latter percentage is applied to the above customer accounts for residential electric and gas service, this works out to about 77,000 customers with combined service: we used 77,108 as a reasonable approximation that results in an even estimate of 157,000 total residential customers.

Note that throughout the calculations, the assumption is made to count electricity or gas savings even if those savings do not occur on MGE's system. Thus electricity savings for a customer with gas-only MGE service would still be counted in system-wide savings. The rationale behind this approach is that the objective is to calculate how much energy MGE customers can save with various actions, regardless of whether those savings occur on MGE's system.

Typical use for electric and gas customers are calculated as follows based on 2004 data provided in February 2005:

Electric use: $787,580,625 \text{ kWh} / 115,875 \text{ customers} = 6,797 \text{ kWh per customer}$

Gas use: $91,157,164 \text{ therms} / 118,233 \text{ customers} = 771 \text{ therms per customer}$

References

Erickson, Jeff, Carmen Best, David Sumi, Bryan Ward, Bryan Zent and Karl Hausker. 2004. *Estimating Seasonal and Peak Environmental Emissions Factors—Final Report*. State of Wisconsin Department of Administration, Division of Energy: Focus on Energy Public Benefits Evaluation, May 21, 2004.

Wisconsin Department of Administration (DOA). 2004. *2004 Wisconsin Energy Statistics*.

Revision History

Draft: February 28, 2005

March 25, 2005

Added pounds per kWh to emissions factors for electricity.

Added calculation for pounds of coal avoided per kWh.

Role of the Energy Center of Wisconsin

MGE worked with the Energy Center of Wisconsin to estimate and document energy savings and environmental impacts of specific consumer actions related to household energy use.

The Energy Center of Wisconsin (ECW) is a private, non-profit organization that provides objective research, information, and education on energy issues to businesses, professionals, policymakers, and the public. Their work helps consumers and businesses to make informed decisions about energy. Learn more about them at www.ecw.org.

MGE asked ECW energy analysts to:

- Estimate and document energy savings for various consumer actions
- Provide estimates in terms of individual and aggregate MGE service territory terms
- Provide estimates in terms of energy as well as avoided CO₂, NO_x and SO_x emissions
- Provide documentation on the source of estimates