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Report

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Energy Savings from the Wisconsin ENERGY STAR® Homes Program

October 2002

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Research Report

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Energy Savings from the Wisconsin ENERGY STAR® Homes Program

October 2002

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Contents

Summary

This report examines differences in energy use between participants in the Wisconsin Energy Star Homes program in 1999 and 2000 and similar non-participants who built new homes during the same period. It is based on utility billing histories and a homeowner survey for approximately 100 program participants and 170 randomly recruited non-participating homeowners.

The two groups were reasonably well-matched in terms of square footage and (self-reported) thermostat settings, and were weighted to be geographically balanced. Notable differences between the two groups are: (1) fewer participant households have children, and are slightly more likely to be senior households; and, (2) survey respondents in the non-participant group scored higher on an index of perceived ability to save energy than did the participating households.

Findings:

1. **On average, Wisconsin Energy Star Homes program participants' use 9 (± 6) percent less natural gas compared to the typical new Wisconsin home.** Though the average difference in gas use is somewhat uncertain, the available data strongly indicate that Wisconsin Energy Star Homes do use less natural gas than comparable non-participating homes.

2. **The gas savings from the program are roughly in line with what might be expected from reduced air leakage in the program homes.** Measured air leakage in the program homes is about half what was measured for a separate study of new Wisconsin homes (non-participant homes in this study were not tested). Moreover, there is a statistically significant correlation between measured air leakage and heating energy intensity for the participant homes: homes with higher measured air leakage use more heating energy per square foot per heating degree-day.

3. **Wisconsin Energy Star homes use somewhere between 3 percent more and 11 percent less electricity than non-participant homes.** The observed difference in electricity use between the study groups is not statistically significant. This means we cannot conclude with a high degree of certainty that Wisconsin Energy Star homes do in fact use less electricity than comparable non-participants. The electricity analysis is also complicated by the fact that participating households differ somewhat demographically, and score lower on an index of perceived ability to save energy. Both of these external factors are correlated with electricity use. The data at hand point toward electricity savings of about 4 percent (400 kWh).

4. **Among program homes, the rating software prediction of heating energy use tracks reasonably well with actual heating consumption, but over-predicts heating use slightly on average.** The over-prediction is probably a consequence of a quirk of the rating process that results in an overestimate of duct leakage. Because the program standards control insulation levels efficiency and infiltration levels, there is not much variation in heating usage per square foot, and differences in heating usage are mainly driven by size differences among the homes.

Background

The Wisconsin Energy Star® Homes Program was instituted in 1999. Using a combination of utility and state funding, the voluntary program is designed to promote the widespread adoption of building practices that yield safe, durable, comfortable, and energy efficient new homes. As of May 2001, more than 400 Wisconsin homes had been certified by Wisconsin Energy Conservation Corporation, which developed and implements the program.

In addition to meeting the national ENERGY STAR Homes program requirements, the Wisconsin program has additional certification requirements that include air tightness, combustion safety, and mechanical ventilation standards. Energy consultants associated with the program conduct three site visits to each house at various stages of construction to verify that the homes meet the program standards. The consultants also conduct the home energy rating that qualifies the home for the national program (rating score of 86 or higher).

The air leakage standards are of particular importance for this study: the program standard requires that certified homes have measured air leakage (cubic feet per minute at 50 Pascals pressure difference) of no more than one-fourth the total shell area of the building. This generally implies a limit on natural air leakage of between 0.15 and 0.20 air changes per hour. This standard was actually a guideline until May 2001. Nonetheless most (89%) of the homes in the participant group for this study meet the standard, and the average program home exceeds the standard by about 30 percent.

Objectives

The primary objective of this project was to assess the actual energy savings due to the program. Though energy savings per home had been predicted by the program administrator and the program evaluation team, these were largely estimates based on simulations and self-reported data from builders and others regarding construction practices.

A secondary objective was to assess the reliability with which the home energy rating system (HERS) software used in the program (REM/Rate) predicts energy use.

Method

The approach used in this project was to compare energy use in program homes with a comparable sample of non-participating new homes. We limited the participant sample to homes with natural gas heating (though some homes with propane heat were included the electricity analysis) that were certified before February 2001. Non-participating homes in the study came from a purchased sample of 500 homes drawn from construction permits (Appendix A).

We recruited homeowners for the study using a mailing that included a promise that participants in the study would receive a report comparing their energy use to other new homes. The mailing included a questionnaire to be completed by the homeowner, and a release form to allow us to obtain monthly utility billing records directly from their gas and electricity suppliers (Appendix D). Fifty six percent of program participants, and 39 percent of the non-participant sample responded to the mailing.

We obtained monthly utility data for natural gas and electricity use for respondents to the mailing, and analyzed usage during a roughly one-year period from August 2000 to September 2001. The analysis involved statistically disaggregating total use into heating, cooling and non weather-dependent usage, as well as correcting weather-dependent use to typical Wisconsin heating and cooling degree days (Appendix B). About 100 homes were in the final participant study, and 175 in the non-participant group (the numbers vary somewhat between natural gas and electricity).

The analysis was mostly based on simple differences in means between the two groups. We also conducted linear regression analysis to explore the effect of various external factors on the results. The data were weighted to correct for geographic differences between the two groups.

Results

Gas and Electricity Savings

We begin with the bottom-line: the estimated savings in natural gas and electricity due to the program. The data indicate that participants in the Wisconsin Energy Star Homes program use about 9 percent less natural gas than non-participants (Table 1). In terms of actual energy use, this translates into about 100 therms saved per home. The sampling uncertainty of these savings is about ± 6 percentage points.[1]

Program participants may use less electricity than non-participants, but the results obtained here are not statistically distinguishable from zero. This means that there is a non-trivial probability that the electricity savings are actually zero even though we observed positive savings for these study groups. It does not mean that we have strong evidence that there are no electricity savings from the program. Regardless, we can reasonably conclude that the electricity savings from the program, if any, are less than roughly 10 percent.

Table 1, Natural gas and electricity use, by group, and difference between groups.

	Participants	Non-Participants	Difference	Percent Difference
Natural Gas				
Total use[a] (therms/year)	928	1024	-96 ± 68[b]	-9.4% ± 5.7
Heating Energy Intensity[c] (BTU/ft^2/HDD)	2.51	2.83	-0.32 ± 0.20	-11.3% ± 5.4
Electricity (kWh/year)[d]				
unadjusted	9,495	10,068	-573 ± 813	-5.7% ± 7.6
adjusted for difference in household size[e]			-396 ± 680	-3.9% ± 6.8

results weighted by county/county-group
[a]based on screening level 3; part. n=87, non-part. n=157 (see Table C8, Appendix C); square footage includes basements; heating degree days to base 65F
[b]90% confidence interval
[c] based on screening level 5; part. n=47, non-part. n=98 (see Table C8, Appendix C)
[d]based on screening level 4; part. n=86, non-part. n=148 (see Table C8, Appendix C)
[e]based on Model 5a (see Appendix C)

As we will discuss later, the electricity results are also affected by differences in household demographics—and perhaps attitudes—between the two groups. Table 1 shows estimates of the electricity savings from the program with and without adjustment for differences in household size. The adjusted estimates are based on regression analysis that controls for differences in household size (see Appendix C).

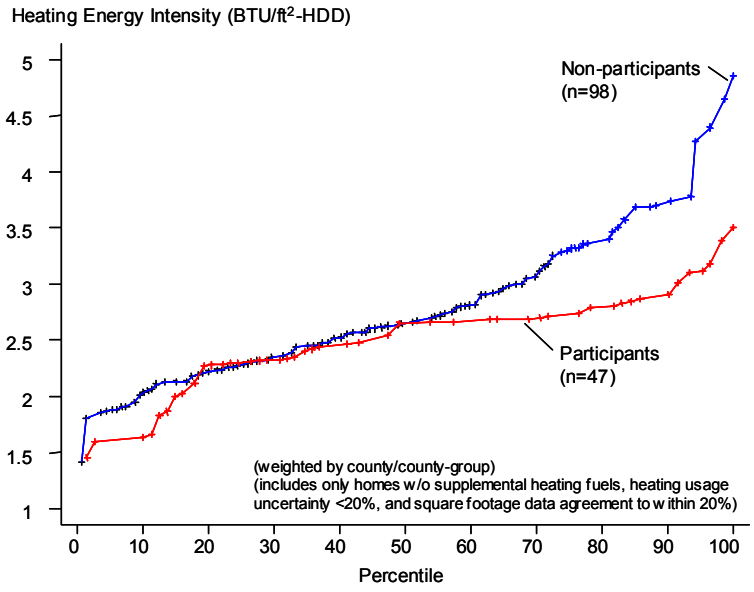
[1] Sampling error arises from using a sample of homes to infer how two larger populations might differ: we would expect to get somewhat different results each time if we repeated the study multiple times with different homes in the samples. Though these will tend to cluster around the true value for the population, it is possible to get a sample that just through the (bad) luck of the draw happens to differ from the true difference between the two populations by a substantial amount. This uncertainty can be quantified based on the number of homes in the analysis and the variability in gas (or electricity) use among homes. The error bands reported here are 90 percent confidence intervals. This means that we can be 90 percent confident that the true population value lies somewhere within the confidence interval.

We found that for both natural gas and electricity use, the estimates of the difference in energy use are somewhat sensitive to how the data were screened and weighted for geographic differences. We obtained point estimates that ranged over most of the above sampling uncertainty range. Appendix C details how the differences vary depending on how the data are screened or weighted; we show here what we believe to be the most likely point estimates for the two groups.

In terms of heating energy intensity, both participating homes and non-participating homes are about 40 to 50 percent more efficient than the overall stock of Wisconsin single-family homes, which has an average heating intensity of 4.4 BTU/ft^2-HDD (Pigg and Nevius, 2000).[2] However, they are also about the same percentage larger (3,570 ft^2 compared to 2,640 ft^2). The end result is that the homes studied here are close to the statewide average gas (and electricity) use for single-family homes.

A closer look at the distribution of heating energy intensity for the two groups (Figure 1) suggests that while some of the difference in gas use may be due to program participants with homes that are unusually efficient to heat, much of the difference seems to arise at the upper end of the distribution. The majority of program homes use between 2 and 3 Btu/ft^2-HDD, while a significant proportion of non-participant homes use more than 3 Btu/ft^2-HDD. This difference in the distribution of heating energy intensity is consistent with a notion that quality control mechanisms in the program help avoid occasional construction flaws that result in high heating energy use.

Figure 1, Distribution of heating energy intensity, by group.



Comparability of the two groups

In comparing energy use between participating and non-participating homes, there is an implicit assumption that the only factors affecting energy use that differs between the two groups are those related to the program. In fact, the greatest threat to validity for an observational study such as this is that there are other influences on energy use that differ for the two groups. What if, for example, the participant homes are smaller on average than the non-participant homes, or if participants keep their thermostats set lower than non-participants?

[2] The heating energy intensity reported here for Wisconsin housing stock (4.4 Btu/ft^2-HDD) is lower than that reported in Residential Characterization Study report (7.5 Btu/ft^2-HDD), because the latter figure excludes basements, which are more appropriately included in the new homes studied here.

We therefore spent considerable effort gathering and analyzing data to help assess the equivalence of the two study groups. We considered a number of variables that might affect energy use and might conceivably be different between Wisconsin Energy Star Homes participants and non-participants. These include:

- geographic distribution of the homes
- use of auxiliary fuels for heating
- square footage of the home
- occupancy
- thermostat settings
- energy-related attitudes that might drive energy-using behavior

With two important exceptions that affect electricity use (occupancy and energy-related attitudes), the data mostly suggest that the two groups are fairly closely matched, and that if anything, biases from the above tend to slightly underestimate the savings due to the program. We summarize these analyses here; additional details can be found in Appendix C. In all cases, the estimated bias due to these differences is considerably less than the sampling uncertainty.

Geographic Distribution

The final participant and non-participant samples differed somewhat from the distribution of homes in the program population. We developed two different weighting schemes to correct for these differences. The gas savings varied from about 50 therms to 115 therms depending on how (or whether) we weighted the data geographically. The electricity results were less strongly influenced by this weighting. The results above are based on truing up the samples to the population distribution by county for counties that represent a significant proportion of the participant population, and regional corrections for counties that have fewer participants.

Use of Supplementary Fuels

We found only a few homes in either group that reported heavy use of wood stoves (three homes) or supplementary electric heat (nine homes). Though we removed these homes from the analysis, they do not substantially alter the results.

Square Footage

Square footage analysis turned out to be tricky. Square footage information from the home energy rating is available for program homes. For non-participating homes, we had only data from our survey and construction permit data on square footage. Although both groups appear to be fairly well matched in the overall distribution of square footage (which ranged from under 2000 square feet to more than 7000 square feet), how closely the average square footage of the two groups agree depends on what source of square footage data we used, and how the homes are screened and weighted. On balance, the data suggest that if there is a bias, it is toward the participant homes being slightly larger. This would cause the program savings to be underestimated by a few percentage points when examining total energy use.

Occupancy

Program households have slightly fewer occupants that non-participating households, averaging 3.0 members, compared to 3.3 for non-participating households. This mainly stems from fewer participant households having children (51%, compared to 63% of non-participants). This does not have a large impact on gas usage, but electricity use is correlated with the number of occupants. The data suggest that a difference in household size of this magnitude would create a difference in electricity use of 2.5 to 3 percent, which is a substantial fraction of the observed difference between the two groups. We therefore obtained adjusted estimates of the difference in electricity use by relying on a regression model that accounts for household size. The effect of this adjustment is a downward revision of the estimated electricity savings.

Thermostat Settings

We combined a number of items on thermostat settings and length of occupancy from the questionnaire into a single estimate of the average heating season thermostat setting in each home. These average about 68 ^{o}F, but ranged from 58 ^{o}F to 76^{o}F for individual homes. Though participants were considerably less likely to report using the programmable features of their thermostats, the two groups were within a few tenths of a degree in the average thermostat setpoint. We found that the reported thermostat setpoint is correlated with actual gas use, but the difference between the two groups suggests a one percent bias or less.

Energy Attitudes

We presented a series of statements on the questionnaire, and asked respondents to tell us how much they agreed or disagreed with them. The statements—such as "my energy bills are about as low as they can get"—were intended to measure the extend to which respondents were interested in saving energy, which we call conservation-mindedness, as well as their perceptions about how much savings they could achieve in their homes.

We found that program participants scored no differently than non-participants in terms of conservation mindedness, but that participants scored significantly lower than non-participants in their perceived ability to save energy. Moreover, our index of perceived ability to save energy is correlated with actual electricity and gas use: people who perceive more opportunities to reduce their energy use have higher energy use, and vice versa.

Some of the difference between the two groups is due to demographic differences (senior households generally score lower and households with children score higher in their perceived ability to save energy), but there also appears to be an innate difference between the groups. This finding can be interpreted in two ways that have very different implications for assessing savings from the program:

1) Program participants are generally more frugal in their energy use, and therefore perceive fewer opportunities to save energy in their home; or,

2) Participants perceive fewer savings opportunities as a result of knowing that they live in a Wisconsin Energy Star Home, which they perceive to be inherently more efficient than a typical new home.

The former interpretation implies that the difference in attitude between participants and non-participants is an external factor that should be accounted for in assessing the savings from the program. Electricity savings estimates in particular are lower when this difference is accounted for (in the range of about negative electricity savings to savings of about 100 kWh/year).

On the other hand, the latter interpretation implies that the difference in perception is actually caused by participation in the program, and therefore should not be controlled for. Since participants and non-participants do not differ in their conservation-mindedness or their thermostat setting behavior, we tend to favor this interpretation, and therefore did not adjust the electricity savings estimates for this difference.

Do the observed savings match expectations?

One might also ask whether the observed difference in gas use is in line with what we would expect based on what we know about how the program affects home construction. Previous evaluation of the program (Winch and Cole, 2001) involved interviews with participating builders and subcontractors, participating and non-participating homebuyers, and program energy consultants. The results indicate that:

- Builders and insulation contractors do not perceive Wisconsin Energy Star Homes as having a substantial impact on insulation levels. The program does foster greater attention to insulation details, and a few participating builders report increasing the amount of insulation they install in new homes.

- The program does foster increased attention toward air leakage and mechanical ventilation. Blower door tests are new to most of the participating builders, and many report paying greater attention to sealing shell penetrations that are sources of air leakage.

- The program does not substantially affect efficiency levels of furnaces and air conditioners. Most participating builders were already installing high efficiency gas furnaces in their homes prior to the program, and the program standards do not require high SEER air conditioners.

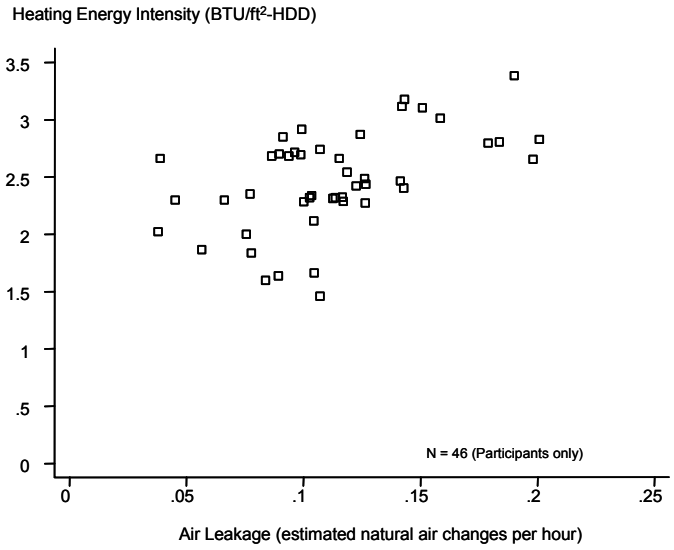
- Some participating builders promote Energy Star lighting and appliances to their home buyers, but the current program has little control over what the buyers choose to install. Participants in the program have a higher awareness of the Energy Star label, and are more likely to report purchasing Energy-Star qualified lighting or appliances, however.

Based on this information and savings projections from program staff, program evaluators had separately estimated that the gas savings per home average about 160 therms per year, and electricity savings average about 250 kWh/year.

The predicted electricity savings of 250 kWh/year is reasonably consistent with our best point estimate from the billing data analysis, though the wide confidence interval for this estimate allows for the possibility of savings that are up to four times higher.

On the other hand, average gas savings of 160 therms per home is higher than this study would indicate. This level of savings is close to the upper 90% confidence limit for our best point estimate of the program savings. This means that, from a sampling standpoint, there is about a 5 percent chance that the program gas savings are actually 160 therms and we happened to get a sample that yielded only about 100 therms. It is therefore not likely that the actual savings are this high.

Figure 2, Heating energy intensity versus air leakage for participants.



The observed gas savings are reasonably consistent with what one would expect from reduced air leakage in participant homes. Though we did not measure air leakage for the non-participant homes in this study, a previous study that included 44 new Wisconsin homes showed a median estimated natural air leakage of 0.2 air changes per hour based on blower-door tests (Pigg and Nevius, 2000).[3] The Wisconsin Energy Star homes in our sample averaged about half that value, or 0.1 air changes per hour. For the typical participant home, this works out to about 90 therms less natural gas needed for heating.[4]

Moreover, we found a statistically significant relationship between the blower-door based air leakage measurement and gas use for heating among participant homes (Figure 2, see also Models 3, 4 and 6E in Appendix C). This provides further evidence that air leakage—and differences in air leakage between participant and non-participant homes—is an important factor in saving energy for the program.

We also quantified the potential savings from high efficiency furnaces in participant homes. Virtually all Wisconsin Energy Star homes are heated with high efficiency furnaces. From a separate project that tracks furnace sales in Wisconsin, we know that most—but not all—furnaces sold in the state each year are high efficiency models. If the market share for high efficiency furnaces in new homes is comparable to that of the overall market, then it means that some proportion of new non-program homes are equipped with lower efficiency furnaces. This would then translate into an average difference in gas use for heating between the two groups.

The question then becomes what is our best estimate of the proportion of non-participant homes that receive a lower efficiency furnace? We used the furnace tracking data for 1999 and 2000 to estimate this proportion for the three regions of the state where the program was active over the time period for this study. When weighted according to program participation, the data suggest that about 17 percent of non-participant new homes did not receive a high efficiency furnace (Table 2). Given the typical difference in efficiency between a standard efficiency furnace (80%) and the high efficiency units installed in the participant homes (92%), this translates into about a 2 percent (20 therm) aggregate difference in gas use between participant and non-participant homes.

Of course the furnace sales tracking data cover both new homes and replacements of existing furnaces (as well as sales for some small commercial applications), and the market for new homes

[3] We converted air changes per hour at the blower-door induced pressure difference (50 Pascals) to an estimate of air changes under natural conditions by dividing by 20.

[4] (0.1 air changes per hour)*(31,400 avg. ft^3/home)*(0.018 BTU/ft^3-F^o)*(6100 heating degree days at base 60)*(24 hours/day)/(1x10^5 BTU/therm)/(0.92 avg. heating system efficiency) = 90 therms

could be different.[5] In particular, builders may have extra incentive to install high efficiency furnaces in new homes, because these are typically side-vented, and can thus eliminate the need for a chimney. If so, our calculated 2 percent difference due to furnace efficiency could be on the high side.

Table 2, Market share of high efficiency furnaces, by region, and weighted by program population.

Region	Forced Air Furnace Sales Marketing Areas	1999-2000 High Efficiency[1] Market Share	Percent of Program Population
Northeast	8, 9, 10, 11, 16	88.4%	60%
South Central	1, 2, 3	80.7%	27%
Southeast	4, 5, 6	65.8%	13%
Overall		83.4%	

Source: Energy Center of Wisconsin Furnace and CAC Sales Tracking Project.
[1]High efficiency defined as 90% AFUE or higher.

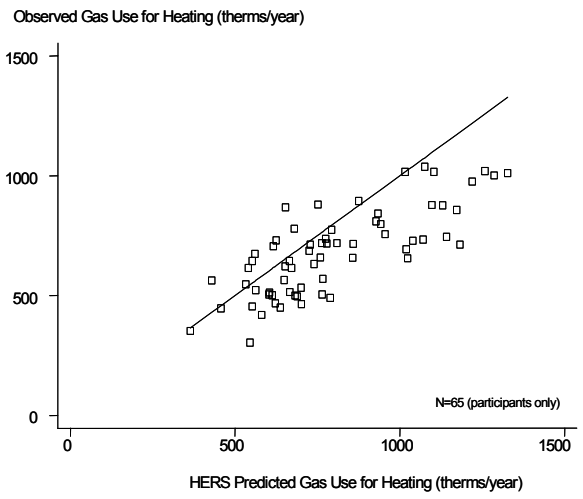
Accuracy of Predicted Heating Use

We compared our estimates of gas use for heating energy use with that predicted by the HERS software used to certify the program homes (REM/Rate, version 9.12). The analysis was restricted to 84 participant homes that did not use supplementary heating fuels, and had reasonably well-determined heating use.

The results indicate that actual heating energy use tracks fairly well with the predicted value (Figure 3). However, most of the variation in heating use is due to differences in the size of the homes. Differences in the square footage of the homes explain 50 percent of the house-to-house variation in heating use (regression models 6a-6e, Appendix C). The HERS prediction of heating use—which includes copious data about insulation levels, air leakage, heating system efficiency, and window and door characteristics—explains 52 percent.

That simply knowing the square footage allows one to make about as good a prediction of heating energy use as the full HERS analysis is probably a reflection of the fact that program standards ensure that the homes are fairly tightly controlled in terms of air leakage, insulation levels, and heating system efficiency. This in turn keeps heating energy use per square foot within a fairly tight range.

Figure 3, Observed versus predicted heating energy use.



[5] We believe that about a third of the furnace sales tracked by the project are installed in new homes. For example, the tracking system—which covers about 85 percent of the total market—records a total of 52,468 furnace sales in 1999, a year in which 23,000 new homes were built in Wisconsin.

On average, heating use is over-predicted by the rating software by about 10 to 13 percent (Table 3). This discrepancy may well be attributable to a quirk of the rating process: because the rating process does not include duct leakage testing, national standards require that the rating be based on duct leakage assumptions that result in about a 15 percent increase in estimated heating use. In fact, most Wisconsin homes have all of their ductwork inside the conditioned living space, and have little direct leakage to the outside.

Table 3, HERS heating prediction error, percent (n=84)

Error range	-53% — +49%
Mean error	+10%
Median error	+13%
Mean absolute error	19%
Median absolute error	18%
% of houses with error less than or equal to…	
± 5%	17%
± 10%	25%
± 20%	56%
± 50%	99%
% of houses where…	
HERS > observed	76%
HERS < observed	24%
HERS within 90% confidence interval for observed	48%

Error defined as [(HERS– observed)/observed]*100

Conclusions

The available data provide good evidence that the program results in natural gas savings for participating homeowners, though the savings appear to be somewhat lower than prior expectations. The evidence points toward the bulk of these savings being derived from reduced air leakage in participant homes.

The data are more equivocal regarding electricity savings. The observed difference is reasonably consistent with prior expectations, but wide confidence intervals preclude a solid conclusion about whether there are electricity savings from the program. The electricity analysis is also complicated by demographic and attitudinal differences between the participant and non-participant study groups.

The HERS software used in the program does a reasonably good job of predicting space heating use, but no better than simply predicting heating use on the basis of square footage. This is because participant homes are relatively uniform in terms of insulation levels, air leakage and furnace efficiency.

Finally, though not a stated objective of the project, there are hints that program participants are somewhat more complacent about their energy using habits than non-participants. Participants perceive fewer opportunities to save energy in their home, are less likely to program their setback thermostats, and keep their homes slightly warmer on average (though only the first is statistically significant). This is by no means solid evidence of significant program "take-back" of energy savings, but it may be enough to consider adding some educational elements to the program that emphasize how much effect lifestyle can have on energy use.

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Appendix A — Sampling

Sampling for the study started with a list of 427 program-certified homes as of July 13, 2001. We trimmed this list to 274 homes that were certified before February 1, 2001, deeming homes certified after this date to have insufficient utility history for analysis. We also eliminated 37 of the remaining homes (13.5%) because their heating fuel was propane. This left a sample of 237 gas-heated homes for the study.

The 237 homes were grouped into four geographic areas, and then further divided into four quartiles of square footage (based on the total conditioned square footage listed in the program tracking database, which includes basement areas), as shown in Table A1.

Table A1, Regions, counties, and square footage quartiles.

			Square Footage (incl. basement)		
Region	Counties	n	25th percentile	50th percentile	75th percentile
Northeast	Brown, Calumet, Fond du Lac, Green Lake, Kewaunee, Manitowoc, Outagamie, Sheboygan, Winnebago	114	3230	3780	4137
South Central	Columbia, Dane, Dodge, Green, Iowa, Jefferson, Rock, Sauk	62	2821	3424	4126
Southeast	Kenosha, Milwaukee, Ozaukee, Walworth, Washington, Waukesha	38	2392	2990	4285
Other	Clark, Crawford, Lincoln, Marathon, Marinette, Portage	23	2728	3293	3943

To draw the non-participant sample, we started with a random sample of about 1100 homes drawn from a proprietary database (Amerifax Corp.) of residential new construction permits issued by the State of Wisconsin. This sample was originally drawn to be representative of the WESH program participants based on county, and was restricted to homes listed as being built for permanent occupancy and having natural gas service. The sample was drawn from homes that were permitted between June 1, 1999 and May 31, 2000. We dropped a few cases with incomplete information, and also six homes that were program participants.

From this larger sample of non-participant homes, we drew a smaller sample of 500 homes stratified by region and quartile of square footage as defined for the program population above. The sample size for each stratum was calculated to be proportional to the program population. The square footage for non-participant homes was based on the sum of finished living area and unfinished basement square footage as listed in the permit database.

There were two cells for which there were not enough homes in the non-WESH sample to meet the target sample size:

1. in the Northeast region, third quartile, there were only 51 cases, which fell 9 short of a target sample size of 60
2. in the Southeast region, first quartile, there were only 8 cases, which fell 12 cases short of a target sample size of 20.

In both these cases, we filled in the remaining cases from the South Central region.

The resulting starting samples matched well in terms of the distribution of square footage and the counties represented (Tables A2 and A3).

Table A2, square footage percentiles, by group, for initial sample.

Square Footage	**WESH (n=237)**	**non-WESH (n=500)**
5th percentile	2134	2048
25th percentile	2904	2952
50th percentile	3546	3564
75th percentile	4130	4138
95th percentile	5406	5364

Table A3, counties by group for initial sample.

	n		Percent	
County	Part.	Non-Part.	Part.	Non-Part.
Dane	49	125	20.7	25.0
Brown	43	75	18.1	15.0
Outagamie	28	51	11.8	10.2
Waukesha	25	31	10.5	6.2
Fond Du Lac	12	38	5.1	7.6
Portage	12	32	5.1	6.4
Winnebago	10	28	4.2	5.6
Manitowoc	8	22	3.4	4.4
Marathon	6	16	2.5	3.2
Sheboygan	6	7	2.5	1.4
Rock	5	15	2.1	3.0
Kenosha	4	0	1.7	0.0
Washington	4	8	1.7	1.6
Sauk	3	0	1.3	0.0
Calumet	3	0	1.3	0.0
Green Lake	2	5	0.8	1.0
Walworth	2	15	0.8	3.0
Kewaunee	2	5	0.8	1.0
Milwaukee	2	14	0.8	2.8
Marinette	2	0	0.8	0.0
Iowa	1	0	0.4	0.0
Dodge	1	0	0.4	0.0
Columbia	1	0	0.4	0.0
Crawford	1	0	0.4	0.0
Ozaukee	1	0	0.4	0.0
Clark	1	0	0.4	0.0
Green	1	0	0.4	0.0
Lincoln	1	0	0.4	0.0
Jefferson	1	13	0.4	2.6
Total	**237**	**500**	**100.0**	**100.0**

A mailing was then sent to each of the sampled participant and non-participant households. The mailing included a cover letter, a questionnaire, and a utility data release form (see Appendix D). The cover letter promised that respondents would receive a report that compared their energy use to other new homeowners in Wisconsin. The mailing for most of the sample was sent out on August 1 and 2, 2001. A small percentage was mailed later in August.

Table A4 shows the disposition of the mailing. Some respondents returned the utility release form but not the questionnaire and vice versa. We considered a missing questionnaire to be a valid respondent, but a missing utility release form was cause for dropping the respondent. Overall, 56 percent of the Wisconsin Energy Star Program participants and 39 percent of the non-participants responded to the mailing.

Table A4, Mailing and utility data request attrition.

	Participants		Non-Participants	
	Attrition	Remaining	Attrition	Remaining
Mailing				
Starting sample		*205*		*500*
Not returned	78	127	268	232
Undeliverable	7	120	15	217
No utility release form	5	115	24	193
Utility Data				
Starting sample (mailing + field study)		*133*		*199*
Gas				
No gas heat	8	125	0	199
No gas data received from utility	12	113	22	177
Insufficient data for analysis	13	100	6	171
Electric				
Did not request data (muni or co-op customer or utility unknown)	20	113	17	182
No electric data received	1	112	6	176
Insufficient data for analysis	2	110	1	175

To this pool we added 18 program participants and six non-participants who had been previously recruited both for a related field study of ventilation in new homes and the utility data study. We then requested gas and electric data for all customers of Wisconsin's Class A utilities. Due to budget and time constraints, we did not request electricity data from customers of small municipal or co-op utilities.

Not all accounts were matched by the utilities, and we obtained information for only one fuel for some participants. In additional some accounts had insufficient histories to analyze (Table A4).

Appendix B: Weather Normalization

Utility billing histories were in the form of monthly data that included meter read date, amount used, and meter read codes to designate whether the meter read was an actual or estimated read. We removed the estimated readings (which made up about 10 percent of the data) by consolidating down to consumption periods between actual meter readings.

We also trimmed the data to the later of the month and year the occupant moved into their home or August 1, 2000. The billing histories generally extended to August or September, 2001. Finally, we screened the data by hand to flag (and remove) egregious outliers. This screening affected about one percent of the data

Models for Weather Normalization

The weather has a significant impact on space heating and air conditioning in homes, and temperatures the last few years have been particularly anomalous. We used the Princeton Scorekeeping Method (PRISM) to perform two important functions: (1) separate weather-sensitive space heating and air conditioning use from the overall gas or electricity use; and, (2) adjust these uses to typical weather conditions.

Given a monthly usage history and a database of daily outdoor temperatures, the PRISM software that we used (Advanced Version 1.0) can statistically fit any of three models to the data:

1. heating-only model— Use per day = $\alpha + \beta_h h_h(\tau_h)$

2. cooling-only model— Use per day = $\alpha + \beta_c h_c(\tau_c)$

3. heating and cooling model — Use per day = $\alpha + \beta_h h_h(\tau_h) + h_c(\beta_c \tau_c)$

where,

α = non-weather sensitive (or base) use per day

$\beta_{h,c}$ = use per heating or cooling degree day

$h_{h,c}$ = heating or cooling degree days per day from base temperature τ, which are calculated from daily average outdoor temperatures (T_{avg}) as:

$H_h = \max(\tau_h - T_{avg}, 0)$

$H_c = \max(T_{avg} - \tau_c, 0)$

and then averaged over the consumption period

$\tau_{h,c}$ = base temperature for calculating heating or cooling degree days

Model 1 (heating only) is appropriate for analyzing gas usage for houses with gas space heat. Model 2 (cooling only) would be appropriate for analyzing electricity usage for houses with air conditioning, but no electric space heat. And Model 3 is appropriate for analyzing houses with electric space heat and air conditioning. The α, β, and τ coefficients are fit individually to each house using a modified least-squares approach that allows the non-linear τ to be optimized.

In some cases, the τ parameter is poorly determined from the data, usually because there are too few data points. In these cases, we substituted fixed-τ models, with the τ's fixed at the median values (60F for heating, and 73F for cooling) based on houses that were run successfully under the standard PRISM models. Only 18 (6.6%) of 271 homes with natural gas data needed to be run using the fixed-τ heating model, but 53 (28%) of 189 homes with electricity data and air conditioning were run using the fixed-τ cooling (or heating and cooling) model.

There were also cases where the heating and cooling coefficients ($\beta_{h,c}$) or the estimated non-weather dependent usage (α) were negative. These generally represented cases where the model was inappropriately specified (e.g., a heating and cooling model for a household that did not use their air conditioning). In these cases, we switched to a different model.

Once the appropriate model is fit to the data, Weather normalized annual use for each component can be calculated as:

normalized annual base consumption (Base) = $365.25*\alpha$

normalized annual heating consumption (NAHC) = $\beta_h H_{oh}(\tau_h)$

normalized annual cooling consumption (NACC) = $\beta_c H_{oc}(\tau_c)$

and

normalized annual consumption (NAC) = Base + NAHC + NACC

where

$H_{oh,c}(\tau_{h,c})$ represent long-term average annual heating or cooling degree days to base temperature τ.

For houses without heating or cooling loads, we simply annualized the data as 365.25 times average use over the billing history, but only for homes with at least 180 days of utility history. This did not apply to any of the natural gas homes, but applied to about a third of the electricity homes; though nearly all homes in the study had central air conditioning, many apparently use it so little that it was not detectable in the electricity histories.

Table B1 shows the model assignments for each fuel for the two groups, and the typical fit of the data to the model. The natural gas data for each home were generally highly linear in heating degree days. Electricity data were not nearly as linear in cooling degree days. Both of these results are typical of energy use in Wisconsin homes.

Table B1, Weather correction model (and median model r^2) by fuel and study group.

		Participants	Non-Participants	Model fit (r^2)
Natural Gas				
	Heating-only	94	159	0.991
	Heating-only (fixed-τ)	6	12	0.971
Electricity				
	Annualize (no weather correction)	42	54	NA
	Cooling-only	49	83	0.762
	Cooling-only (fixed-τ)	16	36	0.488
	Heating and cooling	1	0	0.586
	Heating and cooling (fixed-τ)	2	2	0.740

Weather Data

The homes in the study were located in 26 counties (though concentrated in about 8 counties). We assigned each county to one of four weather stations, and obtained daily average temperature data for the stations. Long-term normals were based on the 20-year period from 1980 through 1999. Table B2 shows the assignment of counties to the weather stations, along with the 20-year average heating and cooling degree days (base 65).

Table B2, Weather stations applicable to each county

Weather Station	Annual Heating Degree Days (1980-1999)	Annual Cooling Degree Days (1980-1999)	Counties
Green Bay	7762	479	Brown, Calumet, Kewaunee, Manitowoc, Marinette, Outagamie, Winnebago
Hancock	7621	569	Clark, Lincoln, Marathon, Portage
Madison	7313	612	Dane, Dodge, Fond Du Lac, Green, Green Lake, Jefferson, Rock, Sauk
Milwaukee	6861	680	Kenosha, Milwaukee, Ozaukee, Sheboygan, Walworth, Washington, Waukesha

Appendix C — Analysis Details

Geographic Representativeness

Despite an attempt to get a non-participant sample that matched the geographic distribution of the participant sample, the final non-participant sample differed from the participant sample somewhat geographically. The participant sample also differed somewhat from the geographic distribution of the program population. We therefore developed post-hoc weights to true both groups up to the participant population.

We explored two weighting schemes. The first simply ensured that the participant and non-participant groups were regionally matched without regard to differences at the county level. We clustered counties into three specific regions (northeast, southeast, south-central), and added an "other" stratum for the few homes in counties outside these regions.

In the second weighting scheme, we made sure that the two groups matched in terms of the proportion of participant and non-participant homes in each of the top seven counties, and then weighted regionally for smaller counties (it is not possible to base the weighting completely at the county level, because some homes in each group were located in counties that were not represented in the other group).

Table C1 shows how the natural gas and electricity samples compare to the program population at the county level, and how the counties are assigned to regions or county groups for the two weighting schemes. Table C2 shows how the samples compare to the program population for the strata defined by the two weighting schemes. And Table C3 shows the relative weights assigned to cases for the two weighting schemes to true them up to the program population proportions. These are based on using all available cases; for analyses where we screened out some homes, we recalculated the weights to account for the missing cases.

The choice of weighting affects the results somewhat, as we demonstrate later in this appendix.

Table C1, Participant population and gas and electricity analysis samples by county (unweighted)

County	Region Group	County Group	Number of Homes					Percent of Homes				
				Gas		Electricity			Gas		Electricity	
			Pop.	Part.	Non.	Part.	Non.	Pop.	Part.	Non.	Part.	Non.
Brown	NE	Brown	75	25	29	25	29	17.6	25.0	17.0	22.7	16.6
Outagamie	NE	Outagamie	49	10	19	12	15	11.5	10.0	11.1	10.9	8.6
Winnebago	NE	Winnebago	22	5	11	6	13	5.2	5.0	6.4	5.5	7.4
Portage	NE	Portage	22	4	13	5	13	5.2	4.0	7.6	4.5	7.4
Fond Du Lac	NE	Fond Du Lac	21	6	13	7	13	4.9	6.0	7.6	6.4	7.4
Manitowoc	NE	Other (NE)	19	2	1	1	2	4.4	2.0	0.6	0.9	1.1
Sheboygan	NE	Other (NE)	11	3	3	2	3	2.6	3.0	1.8	1.8	1.7
Oconto	NE	Other (NE)	6	0	0	0	0	1.4	0.0	0.0	0.0	0.0
Calumet	NE	Other (NE)	5	1	0	1	0	1.2	1.0	0.0	0.9	0.0
Kewaunee	NE	Other (NE)	4	0	1	0	1	0.9	0.0	0.6	0.0	0.6
Green Lake	NE	Other (NE)	3	1	1	1	1	0.7	1.0	0.6	0.9	0.6
Shawano	NE	Other (NE)	3	0	0	0	0	0.7	0.0	0.0	0.0	0.0
Marinette	NE	Other (NE)	3	1	0	2	0	0.7	1.0	0.0	1.8	0.0
Dane	SC	Dane	83	19	53	14	47	19.4	19.0	31.0	12.7	26.9
Rock	SC	Other (SC)	8	2	2	1	2	1.9	2.0	1.2	0.9	1.1
Green	SC	Other (SC)	5	0	0	1	0	1.2	0.0	0.0	0.9	0.0
Columbia	SC	Other (SC)	4	0	0	0	0	0.9	0.0	0.0	0.0	0.0
Jefferson	SC	Other (SC)	3	1	5	0	3	0.7	1.0	2.9	0.0	1.7
Sauk	SC	Other (SC)	3	1	0	2	0	0.7	1.0	0.0	1.8	0.0
Iowa	SC	Other (SC)	2	0	0	0	0	0.5	0.0	0.0	0.0	0.0
Dodge	SC	Other (SC)	2	1	0	1	0	0.5	1.0	0.0	0.9	0.0
Waukesha	SE	Waukesha	26	12	9	15	10	6.1	12.0	5.3	13.6	5.7
Kenosha	SE	Other (SC)	8	3	0	3	0	1.9	3.0	0.0	2.7	0.0
Washington	SE	Other (SC)	7	1	1	1	1	1.6	1.0	0.6	0.9	0.6
Walworth	SE	Other (SC)	4	1	4	1	5	0.9	1.0	2.3	0.9	2.9
Racine	SE	Other (SC)	4	0	0	0	0	0.9	0.0	0.0	0.0	0.0
Milwaukee	SE	Other (SC)	3	1	6	1	6	0.7	1.0	3.5	0.9	3.4
Ozaukee	SE	Other (SC)	2	0	0	1	0	0.5	0.0	0.0	0.9	0.0
Marathon	Other	Other	6	0	0	5	11	1.4	0.0	0.0	4.5	6.3
Vernon	Other	Other	2	0	0	0	0	0.5	0.0	0.0	0.0	0.0
Grant	Other	Other	2	0	0	0	0	0.5	0.0	0.0	0.0	0.0
Oneida	Other	Other	2	0	0	0	0	0.5	0.0	0.0	0.0	0.0
Clark	Other	Other	1	0	0	1	0	0.2	0.0	0.0	0.9	0.0
Dunn	Other	Other	1	0	0	0	0	0.2	0.0	0.0	0.0	0.0
Crawford	Other	Other	1	0	0	0	0	0.2	0.0	0.0	0.0	0.0
Wood	Other	Other	1	0	0	0	0	0.2	0.0	0.0	0.0	0.0
Vilas	Other	Other	1	0	0	0	0	0.2	0.0	0.0	0.0	0.0
Lincoln	Other	Other	1	0	0	1	0	0.2	0.0	0.0	0.9	0.0
St Croix	Other	Other	1	0	0	0	0	0.2	0.0	0.0	0.0	0.0
Pierce	Other	Other	1	0	0	0	0	0.2	0.0	0.0	0.0	0.0
		TOTAL	427	100	171	110	175	100.0	100.0	100.0	100.0	100.0

Table C2, Participant population and analysis samples by region and county/county group.

Weighting Scheme	Number of Homes					Percent of Homes				
		Gas		Electricity			Gas		Electricity	
	Pop.	Part.	Non.	Part.	Non.	Pop.	Part.	Non.	Part.	Non.
Region										
Northeast	245	58	91	62	90	57.4	58.0	53.2	56.4	51.4
South Central	110	24	60	19	52	25.8	24.0	35.1	17.3	29.7
Southeast	54	18	20	22	22	12.6	18.0	11.7	20.0	12.6
Other	18	0	0	7	11	4.2	0.0	0.0	6.4	6.3
Total	427	100	171	110	175	100.0	100.0	100.0	100.0	100.0
County and County Group										
Dane	83	19	53	14	47	19.4	19.0	31.0	12.7	26.9
Brown	75	25	29	25	29	17.6	25.0	17.0	22.7	16.6
Other (Northeast)	54	8	6	7	7	12.6	8.0	3.5	6.4	4.0
Outagamie	49	10	19	12	15	11.5	10.0	11.1	10.9	8.6
Other (Southeast)	28	6	11	7	12	6.6	6.0	6.4	6.4	6.9
Ohter (South Central)	27	5	7	5	5	6.3	5.0	4.1	4.5	2.9
Waukesha	26	12	9	15	10	6.1	12.0	5.3	13.6	5.7
Portage	22	4	13	5	13	5.2	4.0	7.6	4.5	7.4
Winnebago	22	5	11	6	13	5.2	5.0	6.4	5.5	7.4
Fond Du Lac	21	6	13	7	13	4.9	6.0	7.6	6.4	7.4
Other	20	0	0	7	11	4.7	0.0	0.0	6.4	6.3
Total	427	100	171	110	175	100.0	100.0	100.0	100.0	100.0

Table C3, Relative weights for region and county/county-group weighting.

Weighting Scheme	Relative Weight			
	Gas		Electricity	
	Participant	Non-Participant	Participant	Non-Participant
Region				
Northeast	0.9666	1.0535	0.9947	1.0901
South Central	1.0488	0.7174	1.4573	0.8471
Southeast	0.6865	1.0565	0.6178	0.9829
Other	NA	NA	0.6473	0.6553
County and County Group				
Dane	1.0230	0.6271	1.5273	0.7238
Brown	0.7026	1.0357	0.7728	1.0599
Other (Northeast)	1.5808	3.6042	1.2781	1.5105
Outagamie	1.1475	1.0328	1.0519	1.3388
Other (Southeast)	1.0929	1.0194	1.2781	1.5105
Other (South Central)	1.2646	1.5447	1.2781	1.5105
Waukesha	0.5074	1.1569	0.4465	1.0656
Portage	1.2881	0.6777	1.1335	0.6936
Winnebago	1.0304	0.8009	0.9446	0.6936
Fond Du Lac	0.8197	0.6469	0.7728	0.6620
Other	NA	NA	1.2781	1.5105

Square Footage

Determining the square footage of the homes in the sample is an important part of the analysis. This figure is needed to verify that the two groups are comparable in terms of the size of the homes, and to calculate heating energy intensity.

We relied on three sources of square footage information:

- Program tracking database
- Permit data
- Homeowner survey

Program tracking data

The program tracking database contains the total square footage of the home based on measurements made for the home energy rating on each home. These values include basement areas. We consider this to be the most accurate source for square footage, since it is measured independently by the energy rater and double-checked by program staff. But it is only available for participants in the program, not for the non-participating homes that we sampled.

Permit data

The permit data purchased from Amerifax includes fields that capture the total finished and unfinished square footage of the home (garage square footage is included in a separate field). These fields have non-zero entries in more than 95 percent of cases. Hence, almost all of the non-participants had square footage data from the permit records. However, we were not able to match about a third of the participant homes into the Amerifax database, so a significant proportion of participant homes do not have permit-based square footage data.

Homeowner Survey

We also asked about square footage on the questionnaire that program participants and non-participants completed for the study. The questions were designed to mimic the way the information is captured in the permit data, and appeared as follows:

> What is the approximate total square footage of the following parts of your home?
> *(Fill in the blanks)*
>
> **<u>Finished</u> living areas (including finished basement area) _____ square feet**
>
> **<u>Unfinished</u> basement area _____ square feet**

The respondents provided this information in about 80 percent of cases.

In many cases we had two or three sources of square footage data for the same house. We analyzed the degree to which these sources of square footage information agreed with one another (Table C4, Figure C1). In most cases, the various estimates of square footage agree nicely; the

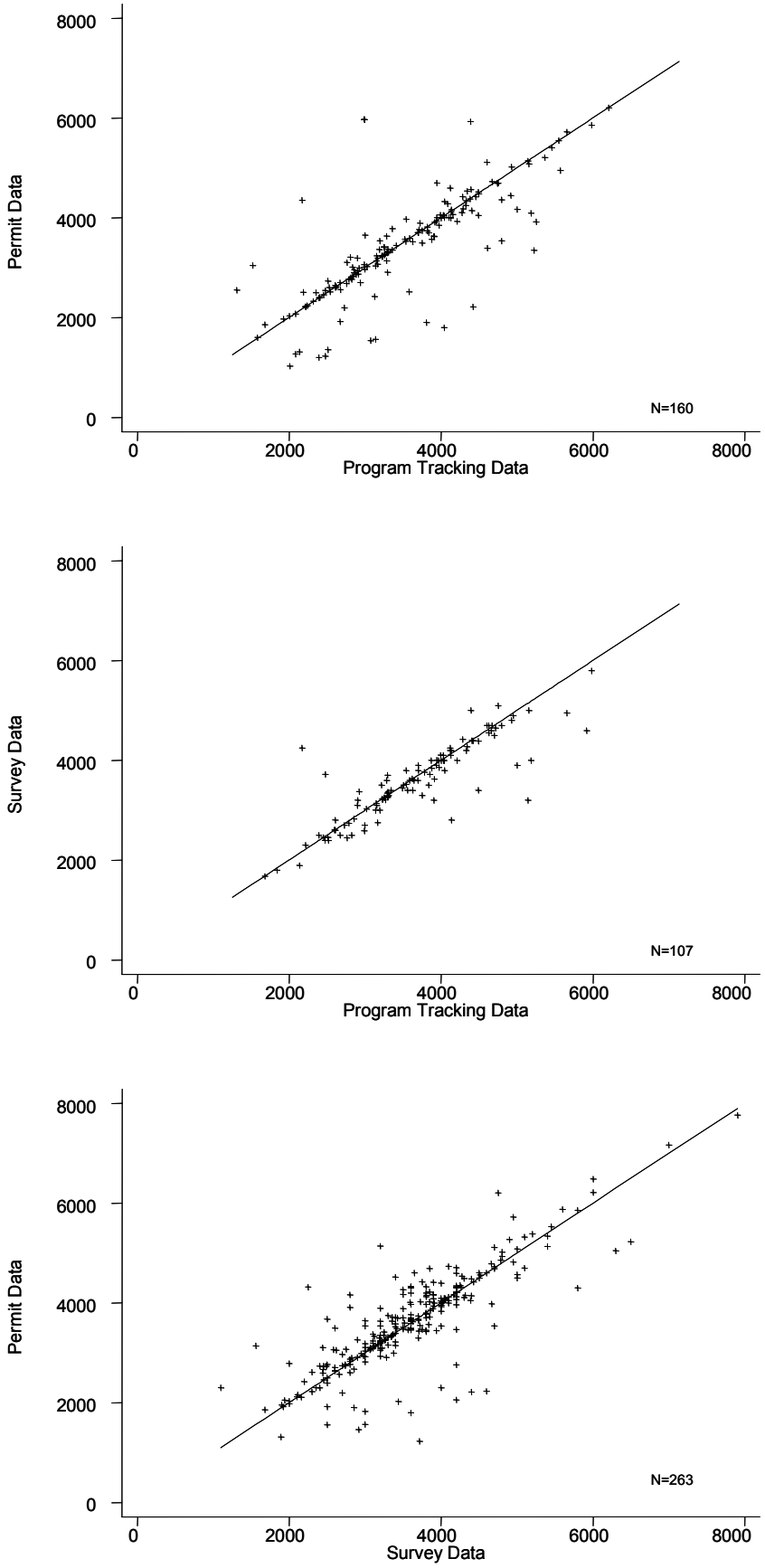
majority are comparable to within 10 percent. This is an important result, in that it shows that the homeowner survey and the permit data are not dominated by erroneous data.

Table C4, Comparison of three sources of square footage data.

	Permit data to Tracking data	Survey data to Tracking data	Permit data to Survey data
n	160	107	263
Mean square footage			
Tracking data	3,523	3,669	—
Permit data	3,443	—	3,622
Survey data	—	3,596	3,600
difference	-80	-73	+22
% difference	2.3%	2.0%	0.6%
Median absolute % difference	2.5%	2.6%	4.3%
Percent of cases that agree to within			
±1%	34%	24%	21%
±5%	64%	68%	55%
±10%	74%	81%	72%
±25%	86%	96%	89%

At the same time, the program tracking system data yields an average square footage that is about 2.5 percent larger than that obtained from the other sources for the same houses. This seems like a small difference, but it is not a trivial one given the size of the energy use differences between the two groups. Since the tracking system data is only available for participants, using this information for the participants alone could lead to a 2.5 percent bias in the difference in heating energy intensity between the two groups. On the other hand, the tracking system data are least likely to have large outliers that might also affect the results erroneously. We generally used the tracking system square footage data for participants, but factored this probable bias into our interpretation of the data. We also looked at how some key results were affected by using the survey and permit data for participants (based on the protocol for non-participants described below).

Figure C1, three measures of square footage plotted against one another.



For the non-participants (and the alternative square footage measurement for participants), we used the following protocol to select between the survey data and the permit data for square footage:

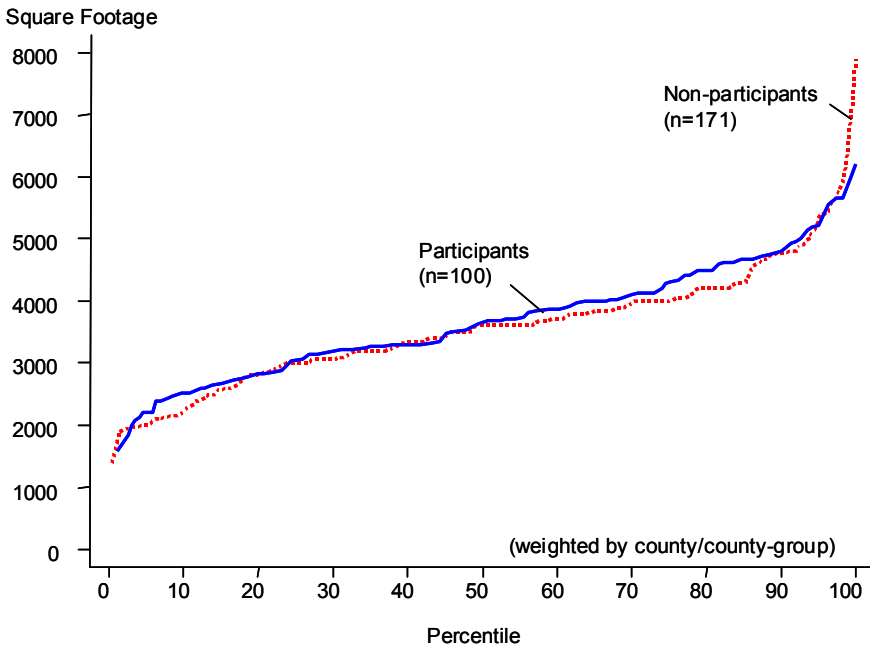
1. Use homeowner survey as the primary source of square footage (147 cases initially assigned).

2. If the survey data are missing for the non-participants, use the permit data (23 cases initially assigned).

3. Given the chosen square footage estimate from 1-2 above, calculate the heating energy intensity of the home. If the calculated heating energy intensity is outside the range of 1.6 to 3.6 Btu/ft^2/HDD (which roughly corresponds to the 5th and 95th percentile of heating energy intensity), and the heating energy intensity calculated from the alternative square footage estimate is within the 1.6-3.6 range, use the alternative estimate. (7 cases switched from survey estimate to permit estimate).

Analysis of the resulting square footage data between the two groups shows that they are reasonably well-matched, both in terms of the average square footage and the distribution of square footage. The participant group has a few homes that are smaller than the smallest non-participant home, and the non-participant group has a few homes that are larger than the largest participant home, but the bulk of the distribution is quite similar (Figure C2). The average (gas) participant square footage of 3,688 ft^2 is about 2.4 percent more than the average non-participant square footage of 3,598 ft^2, which is about the amount of bias observed between the tracking system data and the other sources. If the three non-participant homes that are larger than the largest participant home are excluded, the difference between the two groups becomes 4.5 percent.

Figure C2, Distribution of square footage, by study group.



Occupancy

Though the distribution of the number of household occupants is reasonably comparable between the two groups, the program participant group averages about 0.3 fewer occupants than the non-participant group. This difference is mostly attributable to fewer households with children in the participant group (Table C5). As we show later, As we show later, this mainly affects the analysis of electricity use, which is more strongly correlated with occupancy. A difference of 0.3 household members on average could be expected to create about a 300 kWh/year difference in electricity use—or about half of the observed difference in electricity use between the two groups.

Table C5, number of occupants, by group.

	Participants (n=110)	Non-Participants (n=173)	Difference	p-value*
Number of occupants				
1	6%	5%	+1%	
2	39%	31%	+9%	
3	15%	17%	-2%	
4	28%	32%	-4%	
5	9%	8%	+1%	
6	3%	4%	-1%	
7	0%	3%	-3%	
Total	100%	100%		0.505
Households with children	51%	63%	-12%	0.053
Senior households	8%	6%	+2%	0.668
Average occupants per household				
Age <18	1.07	1.31	-0.24	0.121
Age 18-64	1.85	1.86	-0.01	0.814
Age 65+	0.12	0.09	-0.03	0.550
Total	3.04	3.30	-0.26*	0.112

weighted by county/county-group using electricity analysis sample
*p-values are chi-square tests for proportions and t-tests for difference of means for average occupants per household

Data Screens

We looked at several data screens that attempt to weed out erroneous or misleading information that might influence the results. The screens for the gas analysis are shown in Table C6. The first three screens remove only a small number of homes from the analysis. The final two screens, however, eliminate are significant fraction of the data for both groups. These screens mainly apply to the estimation of heating energy intensity.

Table C6, Data screens for gas analysis.

			Homes Eliminated (in addition to prior screens)	
Screen #	Screen	Criteria	Participants (n=100)	Non-Participants (n=171)
0	none			
1	Supplementary heating fuel use	(see below)	5	6
2	square footage larger than largest participant home	square footage > 6205	0	3
3	poorly determined gas use	confidence interval of NAC>20% of NAC estimate	8	5
4	poorly determined heating use	confidence interval of NAHC>25% of NAHC estimate	21	34
5	Single source of square footage or multiple sources that disagree	single source of square footage, or two sources that disagree by more than 20%	19	25

criteria for screening out homes with supplemental heating:

1. responded "yes" to survey question 7 "Are any of the rooms in your home heated only with electricity
2. responded "yes" to survey question 10 "Do you have any other heating sources besides your main furnace or boiler?" AND indicated an electric heater of some type AND selected "just about every day" in response to follow-up question about how often it is used.
3. responded "yes" to survey question 9 "Do you have any wood-burning fireplaces?" or question 10 "Do you have any wood-burning stoves?" AND selected "just about every day" in response to follow-up question about how often it is used.

Tables C7-C9 show how these screens—and the effect of weighting the data for geographic differences— affect the estimates of gas usage and differences between participants and non-participants.

Table C7, Gas results by screen, unweighted for geographic differences.

	Screen	Mean Value: *Participants*	Mean Value: Non-Participants	Difference	90% conf. interval	% Difference	90% conf. interval
Total Gas Use (therms/year)	0	950	1035	-84	70	-8.1	6.4
	1	959	1049	-90	71	-8.6	6.5
	2	959	1032	-73	70	-7.1	6.5
	3	952	999	-46	60	-4.6	5.9
	4	954	1003	-48	65	-4.8	6.4
	5	945	998	-53	74	-5.3	7.4
Gas use for Heating (therms/year)	0	684	742	-58	54	-7.8	7.0
	1	694	754	-60	55	-7.9	7.0
	2	694	740	-46	54	-6.3	7.0
	3	686	722	-36	48	-5.0	6.5
	4	688	728	-39	51	-5.4	7.0
	5	679	722	-44	57	-6.0	7.8
Non-Heating gas use (therms/year)	0	266	292	-27	41	-9.1	13.2
	1	264	295	-30	42	-10.3	13.5
	2	264	291	-27	42	-9.2	13.8
	3	266	277	-11	31	-3.8	11.1
	4	266	275	-9	34	-3.4	12.5
	5	266	275	-9	42	-3.4	15.1
Heating energy intensity (BTU/sf-HDD) *using tracking system square footage*	0	2.55	2.83	-0.27	0.17	-9.6	5.6
	1	2.58	2.86	-0.29	0.17	-10.0	5.6
	2	2.58	2.87	-0.29	0.17	-10.1	5.6
	3	2.58	2.82	-0.24	0.16	-8.4	5.4
	4	2.43	2.85	-0.43	0.16	-15.0	5.0
	5	2.49	2.73	-0.24	0.15	-8.8	5.4
Heating energy intensity (BTU/sf-HDD) *excluding tracking system square footage*	0	2.72	2.83	-0.11	0.20	-3.7	7.2
	1	2.75	2.86	-0.11	0.21	-3.8	7.2
	2	2.75	2.87	-0.11	0.21	-3.9	7.2
	3	2.77	2.82	-0.04	0.21	-1.6	7.4
	4	2.62	2.85	-0.24	0.20	-8.3	6.7
	5	2.53	2.73	-0.20	0.16	-7.2	5.7
Square Footage *using tracking system data*	0	3688	3589	99	201	2.8	5.7
	1	3710	3597	113	206	3.2	5.8
	2	3710	3532	179	197	5.1	5.7
	3	3653	3509	145	199	4.1	5.8
	4	3792	3507	285	224	8.1	6.6
	5	3628	3586	42	226	1.2	6.4
Square Footage *excluding tracking system data*	0	3567	3589	-22	205	-0.6	5.7
	1	3581	3597	-16	210	-0.5	5.9
	2	3581	3532	49	202	1.4	5.8
	3	3514	3509	5	204	0.2	5.9
	4	3604	3507	98	227	2.8	6.6
	5	3581	3586	-5	229	-0.1	6.5

Table C8, Gas results by screen, weighted by county/county-group.

	Screen	Mean Value Participants	Mean Value Non-Participants	Difference	90% conf. interval	% Difference	90% conf. interval
Total Gas Use (therms/year)	0	941	1057	-117	75	-11.0	6.2
	1	950	1067	-118	76	-11.0	6.3
	2	950	1053	-103	76	-9.8	6.3
	3	928	1024	-96	68	-9.4	5.7
	4	914	1032	-118	77	-11.5	5.9
	5	911	1025	-114	87	-11.1	6.8
Gas use for Heating (therms/year)	0	676	762	-86	60	-11.3	6.7
	1	690	771	-82	59	-10.6	6.6
	2	690	758	-69	58	-9.1	6.7
	3	673	746	-73	56	-9.7	6.3
	4	673	755	-82	64	-10.9	6.7
	5	673	749	-76	67	-10.2	7.3
Non-Heating gas use (therms/year)	0	264	295	-31	44	-10.4	13.2
	1	260	296	-36	45	-12.1	13.4
	2	260	294	-34	46	-11.5	13.7
	3	255	278	-24	33	-8.5	10.8
	4	240	276	-36	35	-13.0	11.1
	5	238	276	-38	44	-13.6	13.7
Heating energy intensity (BTU/sf-HDD) *using tracking system square footage*	0	2.51	2.93	-0.41	0.19	-14.1	5.2
	1	2.54	2.96	-0.42	0.19	-14.2	5.1
	2	2.54	2.96	-0.42	0.19	-14.2	5.2
	3	2.55	2.93	-0.38	0.19	-12.9	5.1
	4	2.43	2.96	-0.53	0.21	-17.9	4.9
	5	2.51	2.83	-0.32	0.20	-11.3	5.4
Heating energy intensity (BTU/sf-HDD) *excluding tracking system square footage*	0	2.67	2.93	-0.26	0.22	-8.9	6.6
	1	2.72	2.96	-0.24	0.23	-8.2	6.7
	2	2.72	2.96	-0.24	0.23	-8.2	6.7
	3	2.74	2.93	-0.19	0.23	-6.4	6.9
	4	2.72	2.96	-0.24	0.30	-8.1	7.4
	5	2.54	2.83	-0.28	0.21	-10.1	5.6
Square Footage *using tracking system data*	0	3680	3573	107	217	3.0	5.7
	1	3716	3573	144	226	4.0	5.9
	2	3716	3512	204	218	5.8	5.8
	3	3621	3500	121	224	3.5	5.8
	4	3763	3524	239	266	6.8	6.6
	5	3631	3608	22	267	0.6	6.3
Square Footage *excluding tracking system data*	0	3557	3573	-16	220	-0.4	5.7
	1	3572	3573	0	230	0.0	5.9
	2	3572	3512	60	221	1.7	5.8
	3	3468	3500	-32	223	-0.9	5.8
	4	3508	3524	-15	295	-0.4	6.8
	5	3589	3608	-19	264	-0.5	6.3

Table C9, Gas results by screen, weighted by region.

	Screen	Mean Value: *Participants*	Mean Value: Non-Participants	Difference	90% conf. interval	% Difference	90% conf. interval
Total Gas Use (therms/year)	0	955	1036	-82	70	-7.9	6.4
	1	964	1049	-85	71	-8.1	6.5
	2	964	1032	-68	70	-6.6	6.5
	3	953	999	-46	60	-4.6	5.9
	4	932	1006	-74	70	-7.4	6.3
	5	908	1004	-96	98	-9.5	7.5
Gas use for Heating (therms/year)	0	689	740	-51	53	-6.9	6.9
	1	699	752	-52	53	-7.0	6.9
	2	699	738	-39	52	-5.2	6.9
	3	687	721	-34	47	-4.7	6.5
	4	672	732	-60	56	-8.3	6.9
	5	659	730	-72	67	-9.8	7.6
Non-Heating gas use (therms/year)	0	266	296	-30	43	-10.2	13.2
	1	265	298	-33	44	-11.0	13.5
	2	265	294	-29	44	-9.9	13.9
	3	266	278	-12	31	-4.2	11.1
	4	260	274	-14	35	-5.1	12.3
	5	249	274	-24	49	-8.9	15.1
Heating energy intensity (BTU/sf-HDD) *using tracking system square footage*	0	2.54	2.81	-0.27	0.16	-9.6	5.5
	1	2.56	2.85	-0.30	0.16	-10.4	5.4
	2	2.56	2.86	-0.30	0.16	-10.4	5.5
	3	2.57	2.82	-0.24	0.16	-8.6	5.4
	4	2.38	2.88	-0.49	0.17	-17.1	4.9
	5	2.39	2.75	-0.35	0.23	-12.9	5.7
Heating energy intensity (BTU/sf-HDD) *excluding tracking system square footage*	0	2.69	2.81	-0.12	0.19	-4.1	6.9
	1	2.72	2.85	-0.13	0.19	-4.7	6.9
	2	2.72	2.86	-0.13	0.20	-4.7	6.9
	3	2.76	2.82	-0.06	0.20	-2.1	7.2
	4	2.62	2.88	-0.25	0.24	-8.7	6.9
	5	2.43	2.75	-0.31	0.23	-11.4	6.0
Square Footage *using tracking system data*	0	3706	3600	105	202	2.9	5.7
	1	3739	3603	136	206	3.8	5.8
	2	3739	3538	201	197	5.7	5.7
	3	3660	3510	150	200	4.3	5.8
	4	3790	3514	276	246	7.9	6.7
	5	3724	3607	117	278	3.3	6.6
Square Footage *excluding tracking system data*	0	3584	3600	-16	203	-0.4	5.7
	1	3608	3603	5	208	0.1	5.8
	2	3608	3538	70	199	2.0	5.7
	3	3522	3510	12	203	0.3	5.8
	4	3577	3514	63	285	1.8	6.9
	5	3671	3607	64	274	1.8	6.6

For the electric analysis, we retained the first three screens from the gas analysis, but dropped the screen related to heating energy use (which largely does not apply to electricity use) and the screen related the accuracy of square footage data. We added a screen to eliminate a few homes with electric water heaters that occurred in the non-participant group but not the participant group. Table C10 shows the electric screens and the attrition attributable to them. Tables C11-C13 show how the screens and the choice of geographic weighting affect the results.

Table C10, Data screens for electric analysis.

Screen #	Screen	Criteria	Homes Eliminated (in addition to prior screens)	
			Participants (n=110)	Non-Participants (n=175)
0	none			
1	supplementary heating fuel use	(see below)	5	5
2	square footage larger than largest participant home	square footage > 6205	0	5
3	poorly determined electric use	confidence interval of NAC>20% of NAC estimate	19	13
4	electric water heater	drop if electric water heater	0	4

criteria for screening out homes with supplemental heating:

1. responded "yes" to survey question 7 "Are any of the rooms in your home heated only with electricity
2. responded "yes" to survey question 10 "Do you have any other heating sources besides your main furnace or boiler?" AND indicated an electric heater of some type AND selected "just about every day" in response to follow-up question about how often it is used.
3. responded "yes" to survey question 9 "Do you have any wood-burning fireplaces?" or question 10 "Do you have any wood-burning stoves?" AND selected "just about every day" in response to follow-up question about how often it is used.

Table C11, Electric results by screen, unweighted for geographic differences.

	Screen	Mean Value *Participants*	Non-Participants	Difference	90% conf. interval	% Difference	90% conf. Interval
Total Electricity Use (kWh/year)	0	9556	10204	-647	782	-6.3	7.4
	1	9498	10246	-748	803	-7.3	7.6
	2	9498	10097	-599	790	-5.9	7.6
	3	9654	10232	-578	824	-5.7	7.9
	4	9654	10121	-467	822	-4.6	8.0
Electricity use for air conditioning (kWh/year)	0	761	763	-2	207	-0.2	27.3
	1	736	780	-44	208	-5.6	26.2
	2	736	757	-21	209	-2.8	27.5
	3	749	691	58	180	8.3	26.9
	4	749	692	57	181	8.3	27.1
Non air-conditioning electricity use (kWh/year)	0	8877	9372	-495	769	-5.3	8.0
	1	8876	9424	-548	793	-5.8	8.2
	2	8876	9291	-415	785	-4.5	8.3
	3	9100	9494	-394	823	-4.2	8.6
	4	9100	9376	-276	821	-2.9	8.7
Square Footage *using tracking system data*	0	3675	3622	53	190	1.5	5.3
	1	3705	3626	79	193	2.2	5.4
	2	3705	3546	159	183	4.5	5.3
	3	3733	3534	199	194	5.6	5.7
	4	3733	3532	201	196	5.7	5.7
Number of occupants	0	3.16	3.29	-0.14	0.26	-4.1	7.9
	1	3.12	3.30	-0.18	0.27	-5.6	7.9
	2	3.12	3.29	-0.18	0.27	-5.3	8.0
	3	3.15	3.35	-0.21	0.29	-6.2	8.4
	4	3.15	3.34	-0.20	0.29	-5.9	8.4

Table C12, Electric results by screen, weighted by county/county-group

	Screen	Mean Value: *Participants*	Mean Value: Non-Participants	Difference	90% conf. interval	% Difference	90% conf. interval
Total Electricity Use (kWh/year)	0	9406	10116	-710	786	-7.0	7.3
	1	9335	10128	-794	799	-7.8	7.4
	2	9335	9998	-663	786	-6.6	7.5
	3	9495	10157	-662	812	-6.5	7.5
	4	9495	10068	-573	813	-5.7	7.6
Electricity use for air conditioning (kWh/year)	0	679	690	-11	184	-1.6	27.2
	1	657	702	-44	187	-6.3	26.6
	2	657	685	-28	188	-4.1	27.6
	3	738	644	94	183	14.6	28.7
	4	738	649	89	184	13.7	28.6
Non air-conditioning electricity use (kWh/year)	0	8760	9332	-572	765	-6.1	7.8
	1	8737	9363	-626	782	-6.7	8.0
	2	8737	9248	-511	773	-5.5	8.0
	3	8898	9446	-549	794	-5.8	8.0
	4	8898	9346	-448	796	-4.8	8.2
Square Footage *using tracking system data*	0	3658	3594	64	190	1.8	5.2
	1	3682	3594	88	192	2.4	5.3
	2	3682	3522	160	181	4.5	5.1
	3	3601	3506	95	202	2.7	5.5
	4	3601	3505	96	204	2.7	5.6
Number of occupants	0	3.04	3.30	-0.27	0.27	-8.0	7.6
	1	3.02	3.31	-0.29	0.28	-8.7	7.7
	2	3.02	3.31	-0.28	0.28	-8.5	7.8
	3	3.03	3.37	-0.34	0.29	-9.9	8.0
	4	3.03	3.37	-0.34	0.29	-10.0	8.0

Table C13, Electric results by screen, weighted by region

	Screen	Mean Value: *Participants*	Mean Value: Non-Participants	Difference	90% conf. interval	% Difference	90% conf. interval
Total Electricity Use (kWh/year)	0	9535	10242	-706	800	-6.9	7.4
	1	9500	10264	-764	816	-7.4	7.6
	2	9500	10113	-612	802	-6.1	7.6
	3	9618	10261	-643	844	-6.3	7.9
	4	9618	10157	-539	843	-5.3	8.0
Electricity use for air conditioning (kWh/year)	0	761	764	-3	204	-0.5	26.5
	1	740	780	-40	205	-5.1	25.7
	2	740	758	-18	206	-2.4	26.9
	3	786	698	87	191	12.5	27.5
	4	786	697	89	192	12.7	27.8
Non air-conditioning electricity use (kWh/year)	0	8864	9413	-549	782	-5.8	8.0
	1	8878	9445	-567	802	-6.0	8.2
	2	8878	9307	-429	792	-4.6	8.3
	3	9026	9516	-490	841	-5.2	8.5
	4	9026	9409	-383	839	-4.1	8.7
Square Footage *using tracking system data*	0	3684	3638	46	189	1.3	5.2
	1	3715	3639	76	191	2.1	5.3
	2	3715	3560	155	180	4.4	5.1
	3	3730	3543	187	195	5.3	5.6
	4	3730	3539	191	196	5.4	5.7
Number of occupants	0	3.08	3.29	-0.21	0.26	-6.3	7.7
	1	3.04	3.29	-0.25	0.26	-7.6	7.8
	2	3.04	3.28	-0.24	0.27	-7.4	7.8
	3	3.07	3.35	-0.28	0.28	-8.3	8.1
	4	3.07	3.34	-0.27	0.28	-7.9	8.2

Thermostat Settings

The homeowner questionnaire asked about type of thermostat and thermostat settings when people were awake at home, during sleeping hours, and when no one was home. In addition, we asked how many hours someone was home during weekdays between 8 am and 5 pm, and how many hours someone was home during those hours on weekends. We also combined this information into a single estimate of the average thermostat setting for each home.

As Table C14 shows, although program participants with programmable thermostats were less likely to use the programmable features, in all other respects the two groups appear to be comparable.

Table C14, thermostat-related data.

	Participants (n=100)	Non-Participants (n=168)	p-value
Programmable thermostat (Q1)?			
Yes	75%	73%	
No	25%	27%	0.742
Use programmable features, if programmable (Q2)			
Yes	64%	83%	
No	36%	17%	0.008
Mean thermostat setpoint (^{o}F)…			
…when someone was awake at home (Q3a)	69.6	69.6	0.962
…during sleeping hours (Q3b)	66.3	65.6	0.272
…when no one was home (Q3c)	65.2	64.7	0.455
Mean hours at home between 8 am and 5pm…			
…weekdays (Q4)	4.84	4.26	0.270
…weekends (Q5)	7.57	7.40	0.525
Mean value of calculated average thermostat setting* (^{o}F)	67.9	67.7	0.505

based on gas analysis samples using county/county-group weights
*average thermostat setting for each house calculated as:
(7*8*Q3b+5*(7+Q4)*Q3a+5*(9-Q4)*Q3c+2*(7+Q5)*Q3a+2*(9-Q5)*Q3c)/168

Attitude Indices

The study participant questionnaire included a battery of attitude-related questions in the form of statements with which respondents could agree or disagree on a four-point scale (see Appendix D). The statements were replicated from a questionnaire administered to 299 homeowners in the ECW Residential Characterization Project (Pigg and Nevius, 2000). The majority of the selected statements were ones that were found in the Residential Characterization Project to represent two statistically significant attitude constructs that we call "conservation mindedness" and "perceived ability to save energy."

These constructs are represented by indices created by summing (and re-scaling) the responses that each respondent gave to the following statements:

Conservation Mindedness

- "I am not interested in making energy-saving improvements to my home."
- "It's just not worth putting on more clothing in the winter to try to save a little energy."
- "I would only conserve energy if I could not afford to pay for it."
- "I am not interested in making my home more efficient"

Perceived Ability to Save Energy

- "My energy bills are about as low as they can get."
- "I only use electricity when it's really needed; there's no way I could cut down."
- "There's nothing more I can do to cut back on my home's energy use."

Scores for the conservation mindedness index had a possible range from zero to 10, with zero representing low interest in saving energy, and 10 representing high interest. The scores for the index of perceived ability to save energy could range from zero to nine, with zero representing low perceived ability to save energy, and nine representing a high perceived ability.

As Table C15 shows, participants and non-participants were roughly equivalent in terms of conservation mindedness, but program participants scored significantly lower than non-participants in terms of perceived ability to save energy.

We break this out further demographically in Table C16. In general, households with seniors tend to score lower in terms of both indices, but these households make up only 8 percent and 6 percent of the participant and non-participant groups, respectively. Households with children score the highest in terms of perceived ability to save energy, and this is also the group for which there is the greatest demographic difference between program participants and non-participants (51% of participants, compared to 64% of non-participants). Thus, the overall difference between the two groups in perceived ability to save energy is partly driven by demographic differences between the two groups.

However, even within the three household types (no children, children, and senior) non-senior participant households score lower than non-participant households in terms of their perceived ability to save energy (though the difference is statistically significant only for households without children).

There are two possible ways to interpret this finding. First, it is possible that people who participate in the Wisconsin Energy Star Homes program are generally more frugal in their energy using habits, and therefore feel they have less ability to further reduce their energy use. In this case, energy use in the program homes might be lower because the people who live in them are more conserving in their day-to-day activities.

But if that is true, then why do the two groups show no difference in terms of their conservation-mindedness, which is based on statements such as "It's just not worth putting on more clothing in the winter to try to save a little energy?" Similarly, why do program participants report slightly *higher* thermostat settings than non-participants?

An alternative explanation is that it is largely the fact that participants live in Wisconsin Energy Star Homes that explains why these householders perceive less ability to save energy. Program householders may feel that they went the extra mile to get an efficient Wisconsin Energy Star home, and therefore they are more likely to agree with statements such as "My energy bills are about as low as they can get."

Though we favor the latter interpretation, it is not possible to know which interpretation is more correct with certainty based on the data at hand. This creates at least the possibility that program savings are less than the observed difference in energy use between the two groups. When we attempted to control for the difference in perceived ability to save energy (with regression model), the gas and electricity savings attributed to the program are substantially lower, and are not statistically significant.

Table C15, Indices of conservation mindedness, and perceived ability to save energy.

		Participants (n=167)	**Non-Participants** (n=92)
Index of conservation mindedness			
(low interest in saving energy)	0	1%	<1%
	1	2%	<1%
	2	3%	<1%
	3	3%	3%
	4	8%	6%
	5	7%	13%
	6	9%	12%
	7	19%	14%
	8	20%	19%
	9	20%	16%
(high interest in saving energy)	10	8%	16%
	mean score	6.90	7.21
	Difference		-0.31**
Index of perceived ability to save energy			
(low perceived ability)	0	0%	1%
	1	2%	2%
	2	3%	1%
	3	15%	8%
	4	18%	8%
	5	33%	26%
	6	22%	24%
	7	2%	19%
	8	4%	8%
(high perceived ability)	9	3%	4%
	Mean score	4.86	5.60
	Difference		-0.74*

Based on electricity study groups (gas results are similar)
Weighted analysis based on county/county-group
*p=0.001
**p=0.310

Table C16, Mean scores for conservation mindedness and perceived ability to save energy, by household type and study group.

	Participants	Non-Participants	Overall	p-value (Part./Non-Part.)
Conservation-Mindedness				
No children in household (n_{part}= 34,$n_{non\text{-}part}$ = 53)	7.4	7.0	7.2	0.413
Children in household (n_{part}= 48,$n_{non\text{-}part}$ = 106)	6.9	7.5	7.2	0.132
Senior household (n_{part}= 8,$n_{non\text{-}part}$ = 8)	5.1	5.6	5.3[a]	0.739
Perceived ability to save energy				
No children in household (n_{part}= 34,$n_{non\text{-}part}$ = 52)	4.5	5.5	5.0	0.002
Children in household (n_{part}= 47,$n_{non\text{-}part}$ = 105)	5.4	5.8	5.6	0.160
Senior household (n_{part}= 8,$n_{non\text{-}part}$ = 7)	3.9	3.3	3.6[b]	0.593

[a] $p<0.02$ for senior households compared to non-senior households
[b] p $p<0.001$ for senior households compared to non-senior households
weighted by county/county-group using electricity analysis data

Regression Analyses

In addition to calculating simple averages and differences of averages for electricity and gas use, we also conducted some linear regression analysis. The purpose of this analysis was to simultaneously control for external factors—such as square footage and number of occupants—that might affect the results. We also conducted some regression analysis to examine the relationship between measured air leakage and gas use for participant homes.

Regression analysis is a tricky endeavor. Outliers, correlated predictor variables, and unobserved correlations with other variables can influence the results and lead to incorrect interpretation of the regression output. We therefore approach this analysis more as a double check of the simpler analysis of the difference in means between the two groups. In addition to the standard ordinary least squares (OLS) regression output, we also examined (unweighted) "robust" regression estimates. These are based on an iterative approach using a combination of Huber weights and biweights (as implemented "rreg" in Stata, version 7.0). The robust estimates were generally comparable to the OLS results.

In general, the regression results for natural gas use are comparable to the simple difference of means, but electricity savings are lower when external factors are controlled for in a regression model. The results also show that the index of perceived ability to save energy confounds the analysis, most strongly for electricity use. This index and energy use is positively correlated, and program participation is associated with a lower score on the index. This means that when homeowners' perceived ability to save energy is controlled for across the two groups, the estimated savings from the program are lower.

The analysis of the relationship between gas use and measured air leakage (for participants only) shows a strong positive correlation between air leakage and gas use. The results also suggest that equation for predicted infiltration load based on the blower door tests is about correct on average.

Model 1a — gas use as a function of size of home, thermostat setting, number of people, and program participation

$$nac = b_0 + b_1*sf + b_2*avgt + b_3*people + b_4*wesh$$

where:

nac = PRISM estimate of annual gas usage (therms)
sf = square footage of home (tracking data based)
avgt = calculated average thermostat setting (^oF)
people = number of people in the home
wesh = 1 if program participant; 0 if non-participant

```
                                                Number of obs    =       234
                                                R-squared        =    0.4620
------------------------------------------------------------------------------
         nac |      Coef.    Std. Err.      t    P>|t|    [90% Conf. Interval]
-------------+----------------------------------------------------------------
          sf |   .2072753    .0212906     9.74   0.000    .1721156    .2424351
        avgt |   19.21999    5.130326     3.75   0.000    10.74767    27.69231
      people |    11.3639    12.39284     0.92   0.360   -9.101884    31.82969
        wesh |  -119.8808    31.98234    -3.75   0.000    -172.697    -67.0645
       _cons |  -1043.308    361.3227    -2.89   0.004   -1640.003   -446.6126
------------------------------------------------------------------------------
notes: (1) screened to exclude homes with supplementary heating sources, large square
footage, and poorly determined NAC; (2) Weighted by county/county-group.
```

Model 1b — Model 1a, plus index of perceived ability to save energy

```
                                                Number of obs    =       215
                                                R-squared        =    0.4590
------------------------------------------------------------------------------
         nac |      Coef.    Std. Err.      t    P>|t|    [90% Conf. Interval]
-------------+----------------------------------------------------------------
          sf |   .2138017    .0228308     9.36   0.000    .1760852    .2515183
        avgt |     20.935    5.260365     3.98   0.000    12.24485    29.62515
      people |   2.403171     13.3721     0.18   0.858   -19.68761    24.49395
  prcvd_save |   21.04475    9.067063     2.32   0.021    6.065919    36.02359
        wesh |  -99.02728    32.94179    -3.01   0.003   -153.4473   -44.60727
       _cons |  -1271.577    373.4969    -3.40   0.001   -1888.596   -654.5584
------------------------------------------------------------------------------
notes: (1) screened to exclude homes with supplementary heating sources, large square
footage, and poorly determined NAC; (2) Weighted by county/county-group.
```

Model 2a — heating energy intensity as a function of thermostat setting and program participation

$$htg\_int = b_0 + b_1*avgt + b_2*wesh$$

where:

htg_int = heating energy intensity (BTU per square foot per heating degree day)
avgt = calculated average thermostat setting (^{o}F)
wesh = 1 if program participant; 0 if non-participant

```
                                                Number of obs    =       142
                                                R-squared        =    0.1203
------------------------------------------------------------------------------
     htg_int |      Coef.    Std. Err.      t    P>|t|    [90% Conf. Interval]
-------------+----------------------------------------------------------------
        avgt |   .0524586    .0186942     2.81   0.006    .0215061    .0834111
        wesh |  -.3754174    .1285367    -2.92   0.004   -.5882398    -.162595
       _cons |  -.7346398    1.244256    -0.59   0.556   -2.794794    1.325514
------------------------------------------------------------------------------
notes: (1) Screened to exclude homes with supplementary heating sources, large square
footage,  poorly determined NAC or heating use, and include only homes with multiple
measures of square footage data that agree to within 20%; (2) Weighted by county/county-
group.
```

Model 2b — Model 2a, plus index of perceived ability to save energy

```
                                                Number of obs    =       141
                                                R-squared        =    0.1124
------------------------------------------------------------------------------
     htg_int |      Coef.    Std. Err.      t    P>|t|    [90% Conf. Interval]
-------------+----------------------------------------------------------------
        avgt |   .0492261    .0198567     2.48   0.014    .0163472     .082105
  prcvd_save |   .0092211    .0287882     0.32   0.749   -.0384467    .0568889
        wesh |  -.3510122    .1303175    -2.69   0.008   -.5667932   -.1352312
       _cons |  -.5671251    1.393805    -0.41   0.685   -2.875002    1.740752
------------------------------------------------------------------------------
notes: (1) Screened to exclude homes with supplementary heating sources, large square
footage,  poorly determined NAC or heating use, and include only homes with multiple
measures of square footage data that agree to within 20%; (2) Weighted by county/county-
group.
```

Model 3 —heating energy intensity as a function of thermostat setting and air leakage (participants only)

$htg\_int = b_0 + b_1*avgt + b_2*achnat$

where:

htg_int = heating energy intensity (BTU per square foot per heating degree day)
avgt = calculated average thermostat setting (^{o}F)
achnat = estimated natural air changes per hour, calculated as:

achnat = (cfm_{50}/20)*60/volume, where:

cfm_{50} = measured air leakage (cfm @ 50 Pascals pressure difference)
volume = volume of home (ft^3)

```
                                                      Number of obs =      45
                                                          R-squared =  0.2745
------------------------------------------------------------------------------
     htg_int |      Coef.   Std. Err.      t    P>|t|     [90% Conf. Interval]
-------------+----------------------------------------------------------------
        avgt |   .0205349   .0205806     1.00   0.324    -.0140807    .0551504
      achnat |   6.087817   1.430739     4.26   0.000     3.681382    8.494251
       _cons |    .361082   1.430742     0.25   0.802    -2.045357    2.767521
------------------------------------------------------------------------------
notes: (1) includes only participant homes; (2) Screened to exclude homes with
supplementary heating sources, large square footage,  poorly determined NAC or heating
use, and include only homes with multiple measures of square footage data that agree to
within 20%; (3) unweighted analysis
```

Model 4—heating energy use as a function of square footage, thermostat setting, and predicted gas use for infiltration (participants only)

$$nahc = b_0 + b_1*sf + b_2*avgt + b_3*pred\_inf$$

where:

nahc = PRISM estimate of heating use (therms)
sf = square footage of home (tracking data based)
avgt = calculated average thermostat setting (^oF)
pred_inf = estimated heating consumption from infiltration (therms), calculated as:

$$pred\_inf = cfm_{50}*(1/20)*0.018*HDD_{60}*1440*(10^{-5})/0.9$$

Where

cfm_{50} = blower-door based air leakage (cubic feet per minute @ 50 Pascals)

1/20 converts air leakage at 50 Pascals pressure difference to estimated natural air leakage

0.018 converts cubic feet per minute to BTUs per minute per Fahrenheit degree difference between the inside and outside termperature

HDD60 = normal annual heating degree days (^oF-days)

1440 converts heating degree days to heating degree minutes

10^{-5} converts BTUs to therms

1/0.9 accounts for the heating system efficiency in meeting the calculated infiltration load

```
                                                      Number of obs =      65
                                                          R-squared =  0.6434
------------------------------------------------------------------------------
        nahc |      Coef.   Std. Err.      t    P>|t|     [90% Conf. Interval]
-------------+----------------------------------------------------------------
          sf |   .1318092   .0147903     8.91   0.000     .1071061    .1565123
        avgt |   8.018961    5.01512     1.60   0.115    -.3573894    16.39531
     predinf |   1.031021   .3058413     3.37   0.001     .5201986    1.541843
       _cons |  -472.8198   349.6636    -1.35   0.181    -1056.835    111.1952
------------------------------------------------------------------------------
notes: (1) screened to exclude homes with supplementary heating fuels, and homes with
poorly determined heating use; (2) unweighted analysis
```

Model 5a — electricity use as a function of square footage, number of people in the home and program participation

$$nac = b_0 + b_1*sf + b_2*people + b_3*wesh$$

where:

nac = estimate of annual electricity usage (kWh)
sf = square footage of home (tracking data based)
people = number of people in the home
wesh = 1 if program participant; 0 if non-participant

```
                                                Number of obs    =       232
                                                R-squared        =    0.3562
------------------------------------------------------------------------------
         nac |      Coef.    Std. Err.      t    P>|t|    [90% Conf. Interval]
-------------+----------------------------------------------------------------
          sf |   1.786975    .2585528     6.91   0.000    1.359981    2.213969
      people |   1048.998    192.2754     5.46   0.000    731.4598    1366.537
        wesh |    -395.91    411.9914    -0.96   0.338   -1076.304    284.4843
       _cons |    275.273    993.2259     0.28   0.782   -1365.016    1915.562
------------------------------------------------------------------------------
notes: (1) Screened to exclude homes with supplementary heating sources, large square
footage,  poorly determined NAC, or electric water heater; (2) Weighted by county/county-
group.
```

Model 5b — Model 5a, with index of perceived ability to save energy

```
                                                Number of obs    =       214
                                                R-squared        =    0.3881
------------------------------------------------------------------------------
         nac |      Coef.    Std. Err.      t    P>|t|    [90% Conf. Interval]
-------------+----------------------------------------------------------------
          sf |   1.546677    .2858731     5.41   0.000    1.074403     2.01895
      people |   981.1702    188.0704     5.22   0.000    670.4707     1291.87
  prcvd_save |   579.0818    110.4706     5.24   0.000    396.5802    761.5835
        wesh |   246.4669    453.6666     0.54   0.588   -503.0079    995.9418
       _cons |  -1925.868    1263.027    -1.52   0.129   -4012.439    160.7021
------------------------------------------------------------------------------
notes: (1) Screened to exclude homes with supplementary heating sources, large square
footage,  poorly determined NAC, or electric water heaters; (2) Weighted by
county/county-group.
```

Model 5c — Model 5a , with number of people in household broken out separately by age group

n_child = number of household members under 18 years
n_adult = number of household members 18-64 years
n_senior = number of household members 65+ years

```
                                                Number of obs     =       231
                                                R-squared         =    0.3590
------------------------------------------------------------------------------
         nac |      Coef.    Std. Err.      t    P>|t|    [90% Conf. Interval]
-------------+----------------------------------------------------------------
          sf |   1.770764    .2618345     6.76   0.000    1.338343    2.203186
     n_child |   981.7548    219.6842     4.47   0.000    618.9452    1344.564
     n_adult |   752.0856    445.7094     1.69   0.093     15.9939    1488.177
    n_senior |   -297.871    602.2333    -0.49   0.621   -1292.463    696.7206
        wesh |  -440.5455    412.6893    -1.07   0.287   -1122.104    241.0132
       _cons |   1141.498     1164.08     0.98   0.328   -780.9869    3063.983
------------------------------------------------------------------------------
notes: (1) Screened to exclude homes with supplementary heating sources, large square
footage,  poorly determined NAC, or electric water heaters; (2) Weighted by
county/county-group.
```

Model 5d — Model 5c , plus index of perceived ability to save energy

```
                                                Number of obs     =       213
                                                R-squared         =    0.4038
------------------------------------------------------------------------------
         nac |      Coef.    Std. Err.      t    P>|t|    [90% Conf. Interval]
-------------+----------------------------------------------------------------
          sf |   1.596064    .2809338     5.68   0.000    1.131941    2.060187
     n_child |    1006.26    218.3553     4.61   0.000    645.5213    1366.999
     n_adult |   483.9419    398.7508     1.21   0.226   -174.8236    1142.707
    n_senior |   159.6445    655.6744     0.24   0.808   -923.5773    1242.866
  prcvd_save |   544.2326    122.2811     4.45   0.000    342.2153    746.2499
        wesh |   118.4537    430.5315     0.28   0.783   -592.8157    829.7231
       _cons |  -896.9864    1298.218    -0.69   0.490   -3041.737    1247.765
------------------------------------------------------------------------------
notes: (1) Screened to exclude homes with supplementary heating sources, large square
footage,  poorly determined NAC, or electric water heaters; (2) Weighted by
county/county-group.
```

Model 6a — Heating usage as a function of HERS-predicted heating use

$Nahc = b_0 + b_1 * fhcons$

Where:

Nahc = Prism estimate of annual gas use for heating (therms)
Fhcons = REM/Rate prediction of annual gas use for heating (therms)

```
                                                      Number of obs =      84
                                                          R-squared =  0.5167
------------------------------------------------------------------------------
        nahc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      fhcons |   .5342012   .0563958     9.47   0.000      .422012    .6463904
       _cons |   257.7244   45.26657     5.69   0.000     167.6748    347.7741
------------------------------------------------------------------------------
```

notes: (1) screened to exclude homes with supplemental heating fuels and uncertainty in heating usage of more than 50%; (2) not geographically weighted; (3) program participants only.

Model 6b — Model 6a, plus calculated average thermostat setting

```
                                                      Number of obs =      81
                                                          R-squared =  0.5315
------------------------------------------------------------------------------
        nahc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        avgt |   8.088102   5.043652     1.60   0.113    -1.953038    18.12924
      fhcons |   .5326743   .0556813     9.57   0.000     .4218213    .6435273
       _cons |  -291.2252   347.9841    -0.84   0.405    -984.0083    401.5579
------------------------------------------------------------------------------
```

notes: (1) screened to exclude homes with supplemental heating fuels and uncertainty in heating usage of more than 50%; (2) not geographically weighted; (3) program participants only

Model 6c — Heating usage as a function of square footage

$$nahc = b_0 + b_1 * sf$$

where:

nahc = PRISM estimate of annual heating use (therms)
sf = home square footage

```
                                                      Number of obs =      84
                                                          R-squared =  0.4980
------------------------------------------------------------------------------
        nahc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          sf |   .1309717   .0143481     9.13   0.000     .1024288    .1595146
       _cons |   189.3754   54.13266     3.50   0.001     81.68828    297.0625
------------------------------------------------------------------------------
```

notes: (1) screened to exclude homes with supplemental heating fuels and uncertainty in heating usage of more than 50%; (2) not geographically weighted; (3) program participants only

Model 6d — Heating usage as a function of square footage and thermostat setting

$NAHC = b_0 + b_1*sf + b_2*avgt$

where:

NAHC = PRISM estimate of annual heating use (therms)
sf = home square footage
avgt = calculated average thermostat setpoint (F)

```
                                                      Number of obs =      81
                                                          R-squared =  0.5274
------------------------------------------------------------------------------
        nahc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    sf_best2 |   .1335848   .0140755     9.49   0.000     .1055627    .1616069
        avgt |   8.086432   5.065338     1.60   0.114    -1.997882    18.17075
       _cons |  -370.6826   351.0798    -1.06   0.294    -1069.629    328.2636
------------------------------------------------------------------------------
```

notes: (1) screened to exclude homes with supplemental heating fuels and uncertainty in heating usage of more than 50%; (2) not geographically weighted; (3) program participants only

Model 6e — Heating usage as a function of square footage, thermostat setting, and air leakage

$NAHC = b_0 + b_1*sf + b_2*avgt + b_3*cfm50$

where:

NAHC = PRISM estimate of annual heating use (therms)
sf = home square footage
avgt = calculated average thermostat setpoint (F)
cfm50 = blower door measurement of air leakage (cubic feet per minute at 50 Pascals pressure difference)

```
                                                      Number of obs =      82
                                                          R-squared =  0.5991
------------------------------------------------------------------------------
        nahc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          sf |   .1249116   .0132313     9.44   0.000     .0985702     .151253
       cfm50 |   .0840688   .0254932     3.30   0.001     .0333157    .1348219
        avgt |   8.564528    4.73281     1.81   0.074    -.8577739    17.98683
       _cons |  -470.7666    327.767    -1.44   0.155    -1123.301    181.7673
------------------------------------------------------------------------------
```

notes: (1) screened to exclude homes with supplemental heating fuels and uncertainty in heating usage of more than 50%; (2) not geographically weighted; (3) program participants only.

Appendix D — Instruments

This appendix contains:

- The cover letters sent to program participants and non-participants
- The contents of the questionnaire sent to all study recruits (the questionnaire was printed in booklet form in the mailing)
- The utility release form sent to all study recruits

members

Alliant Energy*

Consolidated Water Power Company

Madison Gas & Electric Company*

Manitowoc Public Utilities

Marshfield Electric and Water Department

Rice Lake Utilities*

Superior Water, Light and Power

Wisconsin Electric*

Wisconsin Public Power Incorporated

Wisconsin Public Service Corporation*

Xcel Energy*

participants

Badger Safe Energy Alliance

Citizens' Utility Board

Community Builders

Conserv Products, Inc.†

Cooperative Educational Service Agency 5

Earth Energy Systems

Kohler Company†

L&S Associates

Midwest Renewable Energy Association

Municipal Electric Utilities of Wisconsin*

National Association for the Advancement of Colored People

National Center for Appropriate Technology*

Opportunities Industrialization Center of Greater Milwaukee

Plumbing & Mechanical Contractors Association†

PRO-TEL, Inc.†

Public Service Commission of Wisconsin*

RENEW Wisconsin

University of Wisconsin Extension

University of Wisconsin-Madison*

University of Wisconsin-Stevens Point

Wisconsin Community Action Program Association

Wisconsin's Department of Administration Division of Energy

Wisconsin's Environmental Decade

Wisconsin Manufacturers & Commerce

Xexoxial Endarchy, Ltd.

* Representative serves on the Board of Directors

† Trade ally representative

August 1, 2001

WESH Homeowner
WESH Address
City, WI

I am writing to ask you to participate in a study that will compare the energy use in Wisconsin ENERGY STAR® homes to other new homes in Wisconsin. It will only take a few minutes to participate, and by doing so you can find out how *your* energy use compares with other new homes. As one of a limited number of Wisconsin ENERGY STAR homeowners your help is essential to our research.

What do I need to do? All you need to do is fill out the short survey, sign the waiver that gives us a one-time access to your gas and electric consumption records and return both in the postage paid envelope.

What's in it for me? The $2 we enclosed. (It isn't much but we wanted to provide a token of our appreciation.) Plus, later this year we'll send you a report showing how your household's energy use compares with other new homes in Wisconsin.

Who is the Energy Center of Wisconsin? The Center is a private, non-profit organization dedicated to research and demonstration to increase efficient and affordable use of energy.

Why does the Energy Center need to know how much energy my home uses? We are gathering this data to better understand how much energy Wisconsin ENERGY STAR homes use compared with other new Wisconsin homes. Our report will be used by the State of Wisconsin Focus on Energy Program to improve this program.

How was I selected? All Wisconsin ENERGY STAR homeowners are being asked to participate. We will also be requesting the same information from a sample of others who have recently built new homes.

Will I be bombarded with junk mail if I fill out this survey? No. We will keep your information completely confidential.

Whom can I call with questions? You can contact me at 608-238-8276 ext. 138
(or spigg@ecw.org) or Ed Carroll with the Wisconsin ENERGY STAR home program (608-249-9322 ext. 180, ed@weccusa.org) if you have questions.

Thank you in advance for your assistance.

Sincerely,

Scott Pigg
Senior Project Manager

members

Alliant Energy*

Consolidated Water Power Company

Madison Gas & Electric Company*

Manitowoc Public Utilities

Marshfield Electric and Water Department

Rice Lake Utilities*

Superior Water, Light and Power

Wisconsin Electric*

Wisconsin Public Power Incorporated

Wisconsin Public Service Corporation*

Xcel Energy*

participants

Badger Safe Energy Alliance

Citizens' Utility Board

Community Builders

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Cooperative Educational Service Agency 5

Earth Energy Systems

Kohler Company†

L&S Associates

Midwest Renewable Energy Association

Municipal Electric Utilities of Wisconsin*

National Association for the Advancement of Colored People

National Center for Appropriate Technology*

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University of Wisconsin Extension

University of Wisconsin-Madison*

University of Wisconsin-Stevens Point

Wisconsin Community Action Program Association

Wisconsin's Department of Administration Division of Energy

Wisconsin's Environmental Decade

Wisconsin Manufacturers & Commerce

Xexoxial Endarchy, Ltd.

* Representative serves on the Board of Directors

† Trade ally representative

August 1, 2001

Non WESH Homeowner
Non WESH Address
City, WI

The Energy Center of Wisconsin is conducting a research study of energy use in new Wisconsin homes. By participating in this study, you can find out how much energy *your* home uses compared to other new homes. Plus, you'll help improve programs designed to make Wisconsin homes more energy efficient.

What do I need to do? All you need to do is fill out the short survey, sign the waiver that gives us a one-time access to your gas and electric consumption records and return both in the postage paid envelope.

What's in it for me? The $2 we enclosed. (It isn't much but we wanted to provide a token of our appreciation.) Plus, later this year we'll send you a report showing how your household's energy use compares to other new homes in Wisconsin.

Who is the Energy Center of Wisconsin? The Center is a private, non-profit organization dedicated to research and demonstration to increase efficient and affordable use of energy.

Why does the Energy Center need to know how much energy my home uses? We are gathering this data to better understand how much energy is used in newly constructed Wisconsin homes. Our report will be used by the State of Wisconsin's Focus on Energy Program to improve energy efficiency programs in the state.

How was I selected? Your house was randomly selected from a list of homeowners who have recently received permits to build new homes in Wisconsin.

Will I be bombarded with junk mail if I fill out this survey? No. We will keep your information completely confidential. Only Energy Center staff knows who received the mailing.

Whom can I call with questions? You can contact me at 608-238-8276 ext. 138 (or spigg@ecw.org) if you have questions.

Thank you in advance for your assistance.

Sincerely,

Scott Pigg
Senior Project Manager

Home Owner Survey

1. What type of thermostat do you use in your home? *(Circle one number)*
    1. a clock or programmable thermostat
    2. a regular thermostat with temperature settings (Skip to Q.3)
    3. other (please describe):_____ (Skip to Q.3)

2. This past winter, did you use the timer or programmable features to automatically change the temperature at different times of the day or night?
    1. No
    2. Yes

3. This past winter, at what temperature did you usually keep your home…*(Fill in the blanks)*

    …when someone was awake at home? _____ degrees
    …during sleeping hours? _____ degrees
    …when no one was home? _____ degrees

4. On average, how many hours per day is someone home between 8 a.m. and 5 p.m. Monday through Friday? *(Fill in the blank)*

    Someone is home _____ hours per day

5. On average, how many hours per day is someone home between 8 a.m. and 5 p.m. Saturday and Sunday? *(Fill in the blank)*

    Someone is home _____ hours per day

6. Which of the following best describes the air conditioning in your home? *(Circle one number)*

    1. no air conditioning
    2. room air conditioner(s)
    3. central air conditioner(s)

7. Are any of the rooms in your home heated *only* with electricity? *(Circle one number)*

    1. No
    2. Yes

8. Do you have any *wood-burning* fireplaces? *(Circle one number)*

    1. No – Skip to Question 9
    2. Yes – Which of these statements best describes how often you used your *wood-burning fireplace(s)* this past winter?
        1. just about every day
        2. a few times a week
        3. a few times a month
        4. hardly ever
        5. never

9. Do you have any *wood-burning stoves*? *(Circle one number)*

    1. No – Skip to Question 10
    2. Yes – Which of these statements best describes how often you used your *wood-burning stove(s)* this past winter?

        1. just about every day
        2. a few times a week
        3. a few times a month
        4. hardly ever
        5. never

10. Do you have any *other* heating sources besides your main furnace or boiler? *(Circle one number)*

    1. No – Skip to Question 10
    2. Yes – (please describe_____)
       Which of these statements best describes how often you used your *other heating source(s)* this past winter? *(Circle one number)*

        1. just about every day
        2. a few times a week
        3. a few times a month
        4. hardly ever
        5. never

11. Which of the following fuels does your water heater use? *(Circle one number)*

    1. natural gas
    2. electricity
    3. other (please describe_____)

12. What is the approximate total square footage of the following parts of your home? *(Fill in the blanks)*

    Finished living areas (including finished basement area)_____square feet
    Unfinished basement area_____square feet

13. Below are some statements people have made about energy use. Please tell us how much you agree or disagree with these statements. *(Circle the number of your answer for each statement below)*

	Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree
"My energy bills are about as low as they can get."	1	2	3	4
"I am not interested in making energy-saving improvements to my home."	1	2	3	4
"I only use electricity when it's really needed; there's no way I could cut down."	1	2	3	4
"I have a great deal of control over how energy is used in this home."	1	2	3	4
"It's just not worth putting on more clothing in the winter to try to save a little energy."	1	2	3	4
"There's nothing more I can do to cut back on my home's energy use."	1	2	3	4
"I have to conserve energy in my home because I can't afford to pay higher utility bills."	1	2	3	4
"I am not interested in making my home more efficient"	1	2	3	4
"I would only conserve energy if I could not afford to pay for it."	1	2	3	4

14. Including yourself, how many people who live in this residence full-time are: *(Fill in the blanks)*

_____ 17 years old or younger
_____ 18-65
_____ Over 65
_____ Total number of household members

15. Which of the following categories best describes the purchase price of your home? *(Circle one number)*

1. Less than $100,000
2. $100,000 – $119,999
3. $120,000 – $149,999
4. $150,000 - $199,999
5. $200,000 - $249,999
6. $250,000 - $299,999
7. $300,000 or more

16. When did you first occupy your new home? *(Fill in the blanks)*

_____ (month) _____ (year)

Thank you for filling out this survey and assisting in our research.

Energy Center of Wisconsin
Authorization Form

I hereby give permission to the company/companies below to provide information to the Energy Center of Wisconsin or their designated agent for confidential use in connection with their survey.

This authorization covers the following data for the period from June 1, 1999 through December 31, 2001:

1) the total amount of fuels used by my household
2) the total price charged for fuels used by my household

Companies are authorized to provide this information by monthly periods or by delivery date, whichever applies. A photocopy of this authorization may be accepted with the same authority as the original.

Signature: _____

Date:_____

Home Owner
Street Address
City, WI

Phone Number (___)_____.

PLEASE PROVIDE US WITH THE FOLLOWING INFORMATION ABOUT THE COMPANIES THAT PROVIDE ELECTRICITY AND NATURAL GAS SERVICE TO YOUR HOME:

ELECTRICITY	PRINT FULL NAME OF ELECTRIC COMPANY
	ACCOUNT NUMBER (IF KNOWN)
NATURAL GAS	PRINT FULL NAME OF NATURAL GAS COMPANY
	ACCOUNT NUMBER (IF KNOWN)

ENERGY CENTER
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We show you how

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