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Prepared for the U.S. Department of Energy under Contract DE-AC03-76SF00098

DISCLAIMER

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THE RESIDENTIAL STANDARDS DEMONSTRATION PROGRAM:

OCCUPANT SURVEY ANALYSIS

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Prepared for the Office of Conservation, Bonneville Power Administration

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EXECUTIVE SUMMARY

We present the findings of a mail questionnaire sent to all participants in the Residential Standards Demonstration Program (RSDP) during the Summer of 1986. The primary objective of this investigation is to compare occupants of MCS ("super" energy-efficient) houses with occupants of "Control" ("current practice") houses to see whether the two groups are similar or different with respect to energy-related behavior, house characteristics, attitudes, and demographics.

The results indicate that the MCS and Control groups are different from one another, but the effect of these variables on space conditioning energy use is not uniform. In particular, major structural variables included:

- structural modifications to the home
- location of key appliances
- basement insulation
- presence of woodstove or fireplace
- presence and type of air-conditioning equipment

Major behavioral variables included:

- winter thermostat settings
- closing doors/vents when heating
- closing rooms when air-conditioning

The MCS group set higher winter thermostat settings and closed off rooms less frequently when heating than the Control group, suggesting greater space heating energy consumption due to lifestyle factors. On the other hand, the MCS group had higher appliance saturations (washing machines, clothes dryers, water heaters, and electric space heaters) and had more appliances located inside heated spaces (dishwashers, electric space heaters, and well pumps), suggesting less space heating energy consumption as a result of structural factors increasing internal gains. In conclusion, there is evidence of lifestyle differences that distinguish the MCS group from the Control group and that tend to *counteract* the thermal efficiency consequences of the structural differences between the two groups.

We also examined indoor environment problems noticed by the occupants and found condensation to be a problem in most MCS and Control households (60%), and its importance significantly varied room-by-room for each group. Mildew/mold was more of a problem for the Control group than for the MCS sample but affected a smaller percentage (less than 20%) of people than condensation. About 25% of each sample felt their home to be stuffy/humid, but there was no statistically significant difference between groups. Finally, there were problems in MCS households receiving and reading instructions for operating air-to-air heat exchangers, and these problems may have resulted in the large number (50%) of households reporting problems with their equipment (unpleasant drafts, repairs, and core freezing). The effect of these problems on space heating energy use is uncertain. It is possible that occupants may increase ventilation in the home during the winter to offset or reduce the negative effects of these problems. The increased ventilation may result in an increase in space heating consumption to maintain thermal comfort levels.

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CHAPTER 1. INTRODUCTION

The Pacific Northwest is currently experiencing a dramatic and exciting transformation in the way the region produces and consumes energy. Prompted by federal legislation and local initiative, the region is promoting the conservation of energy as the primary new energy resource. In the residential sector, energy efficiency standards for new construction have been proposed, and a demonstration program is underway to examine the costs and energy savings associated with building houses to levels of higher energy efficiency. In this report, we examine the participants in the demonstration program to determine the similarities and differences of people living in "super" energy efficient houses compared to occupants of "current practice" ("control") houses.

Prior to examining the occupants, we present an overview on the enabling federal legislation, the proposed residential conservation standards, the demonstration program, and the objectives of this investigation.

THE NORTHWEST POWER ACT

The Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P.L. 96-501) (the "Northwest Power Act") was the federal legislation that directed that priority be given to the lowest cost sources of energy for meeting the electric energy needs in the Pacific Northwest, and, if all else was equal, then energy conservation was to have priority over all other resources. The Northwest Power Act also called for the establishment of the Northwest Power Planning Council (the Council), and specifically identified the development of energy-efficient building standards (Model Conservation Standards) as one of the elements to be contained in the Council's Power Plan.

MODEL CONSERVATION STANDARDS

The Council adopted Model Conservation Standards (MCS) for new residential and commercial buildings in their 1983 Power Plan.[1] The MCS are designed to make new, electrically-heated residential houses more energy efficient by establishing minimum energy use levels ("energy budgets") for space heating. These performance standards vary by climate (there are three climate zones) as seen in Table 1.1. Climate Zone 1

[1]While the standards are for both residential and commercial buildings, the discussion and analysis that follow pertain to the residential sector. For a description of the development of the MCS, see Eckman and Watson, 1984.

encompasses most of the mild maritime climate west of the Cascades; Climate Zone 2 is the more extreme climate east of the Cascades except for higher elevations; those elevations and most of western Montana are in Climate Zone 3.[2]

Table 1.1. Model Conservation Standards for New Residential Buildings: Space Heating Targets by Climate Zone

	Climate Zones		
	1 Under 6000 HDD*	2 6000-8000 HDD*	3 Over 8000 HDD*
Single-Family	2.0 $kWh/ft^2/yr$	3.2 $kWh/ft^2/yr$	3.2 $kWh/ft^2/yr$
Multi-Family	1.2 $kWh/ft^2/yr$	2.3 $kWh/ft^2/yr$	2.8 $kWh/ft^2/yr$

*HDD = Annual heating degree days at a base of 65°F.

The MCS also offer a number of options to meet the energy budgets, such as insulation, glazing, heat pumps, solar features, and control of air leakage as shown in Table 1.2. This method of setting standards allows homebuilders wide design flexibility. Houses meeting the MCS are expected to use about one-third of the heating energy of an otherwise comparable house built to current standards.

The Council initially called for state and local governments and utilities to adopt the MCS by January 1986. It was expected that local or state government would adopt the standards in the form of building codes. These entitites would also be responsible for implementing and enforcing the codes. If political jurisdictions failed to adopt and enforce the standards or refused to carry out a program to achieve comparable energy savings, they would be subject to a minimum 10% surcharge on the wholesale power they purchase from the Bonneville Power Administration (BPA) (as stated in the Northwest Power Act).

[2]However, the climate zones associated with a particular building site were determined by the micro-climate heating degree days from the nearest weather station. Thus, Richland, Washington and Boise, Idaho have Climate Zone 1 houses despite being geographically in Climate Zone 2. Moreover, it is important to note that a house with 4001 heating degree days and one with 5999 heating degree days are both in the same climate zone despite a 50% difference in the severity of the weather.

Table 1.2. Types of Options for Meeting the Model Conservation Standards*

• Relatively high levels of ceiling insulation (R-30 to R-38) • Walls with insulation levels ranging from R-19 to R-31 • Underfloor insulation (over crawl spaces) of R-19 to R-30 • Perimeter insulation for slab-on-grade or basements (R-10 to R-15) • Double or triple-glazed windows with "thermal breaks" (insulating material in the window frames to "break" the thermal path by which heat is lost) • Insulated exterior doors • Control of air infiltration through careful caulking, weatherstripping, and installation of vapor barriers • Use of dehumidifiers to avoid humidity problems • Very low air infiltration designs incorporating continuous vapor barriers and air-to-air heat exchangers • "Sun-tempered" designs (south-oriented windows) • Passive solar designs (south-oriented windows and the inclusion of thermal mass) • Heat pumps as an alternative to high levels of insulation
*This table is derived from Eckman and Watson, 1984.

In December 1985, the Council revised their initial deadline and amended the standards to allow BPA and the utilities to offer marketing and financial assistance to help builders construct MCS houses (the BPA/Utility MCS Program). Utilities not participating in the Program may offer an alternative program so long as it is judged by BPA to produce equivalent savings. BPA has indicated that utilities must declare their option by January 1, 1987: participate in the Program or submit their own equivalent program.

RESIDENTIAL STANDARDS DEMONSTRATION PROGRAM

At the time the standards were adopted, there was no consensus within the building industry about either the additional costs involved in building to the standards or the energy savings which would result. To address these problems, the Council called for BPA to carry out a large-scale demonstration program of houses built to the standards. The result was the Residential Standards Demonstration Program (RSDP). As stated in the final version of the Council's Power Plan (released in late 1983), the RSDP had two basic, interrelated objectives: (1) demonstrate to the homebuilding industry what the MCS are, how to comply with them, and increase the industry's familiarity with them; and (2) obtain more accurate estimates of the average energy savings and incremental costs associated with the MCS. In addition, data regarding the characteristics of the homes (e.g., indoor air quality, solar access, and operation of air-to-air heat exchangers) were also to be collected. The activities designed to meet these objectives were initiated in early 1984 by the energy agencies of the Northwest states (the Washington State Energy Office, the Oregon Department of Energy, the Idaho Department of Water Resources, and the Montana Department of Natural Resources and Conservation) with funding from BPA. Discretion in designing and implementing the RSDP was given to the states, permitting a great amount of flexibility.[3]

To accomplish the first objective, briefings were held in the winter of 1984 throughout the region to inform homebuilders, architects, realtors, lenders, and members of the housing industry about the RSDP. In the spring of 1984, the states conducted builder training workshops which were open to the general public, but were particularly targeted to general contractors, subcontractors, designers, architects, local code officials, and others familiar with standard residential construction. A total of seven workshops were conducted in Washington, Oregon, and Idaho. Since the program was limited to the western portion of Montana, only two workshops were held in that state. Washington also scheduled seven additional sessions throughout the state.

The goal of the two-day workshops was to transfer a working understanding of the "how tos" and "how not tos" of very energy-efficient construction from current practicioners to those otherwise experienced builders who have not yet built super energy-efficient houses. The contents of the workshops included a description of: the model conservation standards, how to design an energy efficient house, construction documents, inspection procedures, monitoring of the program, available technical assistance, program requirements, and cost accounting procedures. The training materials included slides of on-site applications, hands-on demonstrations, and a detailed manual the builder could use during actual design and construction.

To accomplish the second objective, the RSDP conducted large-scale monitoring of both construction costs and energy use in approximately 400 "super" energy efficient (all-electric) houses. As part of the monitoring program, houses built to the MCS were "triple metered" as were a corresponding number of existing "Control" houses (i.e.,

[3]For more information on the design aspect of the program, see Hart and Selby, 1984.

houses built in recent years to current practice energy codes).[4] Triple metering involved the placing of separate kilowatt-hour meters on the heating circuit, the domestic hot water circuit, and the total load. Cooperating homeowners were paid to periodically record the meter readings and indoor and outdoor temperatures.

To achieve a more rigorous comparison, approximately 90 houses (a subset of the above 400) were built and monitored using a sophisticated multi-channel remote monitoring system to measure energy use, temperatures and other potentially important parameters every hour. These were sometimes matched pair houses which were two otherwise identical houses except that one was built to the MCS while the other one was built to the current energy code.

Studies comparing heating energy use and costs of houses built to the MCS with those of houses built to current codes were recently completed (Vine, 1986; Meier et al., 1986). In the near future, the energy and cost data will be examined together by BPA to evaluate the cost-effectiveness of building houses to the MCS.

SURVEY OBJECTIVES

Occupants of both the MCS and current practice houses were surveyed twice in the RSDP. Both surveys collected data primarily to assist the analysis of the thermal data (e.g., approximate internal heat generated by the occupants and their appliances) and to determine the appropriateness of the Control houses as a basis for comparison with the MCS houses.

In the first survey (Keating and Bavry, 1986), a subset of the entire MCS population was sampled because a number of the MCS houses had not been built nor occupied and several Control houses had not been selected at the time of the survey (conducted between March and May, 1985). The second survey (conducted during April and May, 1986), the focus of this report, had a number of other objectives: (1) collect information on *all* occupants of RSDP houses, (2) collect specific technical information that we were unable to obtain from ongoing equipment monitoring activities (e.g., the presence of mold and condensation, and operation of air-to-air heat exchangers), (3) address occupant-related questions interested parties (e.g., the four states, BPA, the Northwest Power Council, and Pacific Northwest Laboratories) would like answered, (4) examine the reliability of self-reported behavior by comparing the results of the second survey with the results of the first survey for those households participating in both surveys, and (5) help

[4] The selection of the Control sample is discussed in the next chapter.

explain differences between predicted and measured energy use and between high and low energy consumers.

ORGANIZATION OF REPORT

A summary of the content of the survey, the sampling procedures, and the response pattern are provided in Chapter 2. Major findings are presented in Chapter 3, and the analysis of the reliability of behavior is contained in Chapter 4. We discuss our conclusions in Chapter 5. Appendix A contains a copy of the questionnaire used in the survey, Appendix B contains detailed statistical tables for those questions for which statistics were computed, and Appendix C describes the method of analysis used in this report.

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CHAPTER 2. DATA COLLECTION

In this chapter, we discuss the nature of the two samples analyzed in this report, the contents of the mail questionnaire, the administration of the survey, and response rates and returns.

MCS AND CONTROL SAMPLES

The MCS sample was drawn from those households voluntarily participating in the RSDP program without regard to climate zone or state. As a result, the number of homes participating in the RSDP was very high for Washington and relatively few for Idaho (Table 2.1).

Table 2.1. Distribution of MCS and Current Practice Homes

	MCS	Control	Total
Idaho	35	39	74
Montana	57	60	117
Oregon	69	114	183
Washington	203	207	410
Total	364	420	784

The RSDP Control group (current practice houses) was composed of houses that were electrically heated and were built after 1977 to current, pre-MCS energy codes, or they were built earlier than 1978 and weatherized to approximately current construction standards. The four States used media advertising and builder referrals to locate households willing to agree to the requirements for being a Control home ("volunteers"). The States screened out extemely large, extremely small, and very unusual houses, as well as those which had unusual levels of insulation.

In the first year of the RSDP, occupants of both the MCS and Control homes were paid cash incentives to participate in the program and agreed to comply with the following requests:

- Allow their homes to be instrumented with special meters and temperature sensors;

- Read three meters (space heating energy use, water heating energy use, and total energy use) and two temperature sensors (indoor and outdoor) each week, and return pre-paid postcards containing the information for review and processing
- Abstain from burning wood for heat for the duration of the monitoring;
- Permit air quality and blower door (air infiltration) tests to be performed in their homes; and
- Answer an occupant survey.

In the second year of the RSDP, participants were paid cash incentives to participate in the program and agreed to comply with the above requests, except for the occupant survey. As described below, only one state required their participating households to respond to a **second** occupant survey (the focus of this report) while participation in a second survey was voluntary for the remaining states.

THE MAIL QUESTIONNAIRE

The survey instrument employed in this study was designed primarily by LBL staff, together with personnel from BPA's Office of Conservation, International Energy Associates Limited (a consulting company sub-contracted to conduct the mailing of the survey), and the States. Respondents in both the MCS and Control groups received the same survey. A sample survey is included in Appendix A of this report.

The first section of the survey instrument dealt with the characteristics of the house (especially, recent modifications) and the appliances in the house. The next two sections dealt with conditions in the house during the heating and cooling seasons (especially, thermostat settings). Next, there was a section covering periods when the home might have been unoccupied, followed by a section dealing with problems occupants might have been having with their homes (e.g., mildew, condensation, and odors). After this were several questions on the use and operation of air-to-air heat exchangers and an indoor air quality handbook. The next to last section contained attitudinal statements, and the final section included a series of demographic questions.

SURVEY ADMINISTRATION

The mailing approach was based on the Total Design Method proposed by Dillman (1978) and consisted of a three-wave mailing. The first wave was composed of the survey form, a hand-signed cover letter, and a stamped return envelope. The second wave was a thank-you/reminder postcard mailed to the entire sample one week after the first wave was mailed. The third wave was a second survey form, a new cover letter, and a return envelope mailed to nonrespondents after the fourth week of the process.

RESPONSE RATES AND RETURNS

Table 2.2 shows the overall distribution of respondents and non-respondents, broken out by MCS and Control groups for each state and for the entire sample. In order to calculate an accurate response rate, households no longer participating in the RSDP, or who had moved, or who had bad addresses were deleted from the "starting total" to construct the "sample base." Response rates were calculated by dividing the number of questionnaires received by the sample base. The response rate for the entire sample was 95.5%, an exceptionally high number for a mail survey. We had expected a lower response rate than the first survey (94.6%) since the MCS and Control homes had signed agreements with the States to respond to the first survey as part of their participation in the RSDP program, and participation in the second survey was considered by program managers as mostly voluntary.[1] Participation in the second survey was mandatory in Idaho where the fewest respondents lived. However, many participants in this survey did not participate in the previous survey (see Chapter 3), so that it is possible that these new participants felt that they were obligated to complete at least one occupant survey as part of their contract.

Based on previous surveys, we expected a higher response rate for the experimental (MCS) group than for the Control group, however, this did not prove to be the case. The response rate for the Control sample was slightly higher (96.5%) than the MCS sample (94.3%). The response rates for the entire sample did not substantially differ by state.

Upon receipt of the questionnaires from the respondents, the responses were edited to eliminate ambiguities and errors (Lerman and Bronfman, 1986). Questionnaire responses were transferred to coding forms from which the information was keyed into a raw data file. The raw data were entered using templates and visually inspected upon input so that keypunching errors could be kept at a minimum. Also, for 10% of the sample, the raw data were compared to the coding forms and corrections were made as warranted (0.2% errors were found). Range and logic checks were made in the cleaning of the data. After editing, the survey data were ready for analysis.

[1]Both the MCS and Control occupants received a cash incentive for each year of participation in the RSDP.

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Lerman, David and Benson Bronfman, **1986 Survey of Participants in the Residential Standards Demonstration Program**. International Energy Associates Limited, Portland, Oregon. 1986.

Table 2.2 1986 RSDP Survey Status by State

	Idaho			Montana			Oregon			Washington			Total		
Status	MCS	Control	Total	MCS	Control	Total	MCS	Control	Total	MCS	Control	Total	MCS	Control	Total
Received	33	38	71	50	57	107	61	104	165	173	188	361	317	387	704
Not Received	1	1	2	2	3	5	6	5	11	10	5	15	19	14	33
Refused	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1
Base	34	39	71	52	60	112	67	109	176	184	193	377	337	401	738
% Received of Base	97.1%	97.4%	97.3%	96.2%	95.0%	95.5%	91.0%	95.4%	93.8%	94.0%	97.4%	95.8%	94.1%	96.5%	95.4%
Starting Total	35	39	74	57	60	17	69	114	183	203	207	410	364	420	784
% Received of Total	94.3%	97.4%	95.9%	87.7%	95.0%	91.5%	88.4%	91.2%	90.2%	85.2%	90.8%	88.0%	87.1%	92.1%	89.8%
Inactive	0	0	0	0	0	0	0	1	1	17	9	26	17	10	27
Bad Address	0	0	0	5	0	5	1	0	1	0	1	1	6	1	7
Moved	1	0	1	0	0	0	1	4	5	2	4	6	4	8	12
Subtotal	1	0	1	5	0	5	2	5	7	19	14	33	27	19	46
% of Total	2.9%	0.0%	1.4%	8.8%	0.0%	4.3%	2.9%	4.4%	3.8%	9.4%	6.8%	8.0%	7.4%	4.5%	5.9%

CHAPTER 3. SURVEY RESULTS

In this chapter, we review the basic findings from our survey. We compare the results for both MCS and control groups. Appropriate tests of significance were selected for dichotomous, nominal, ordinal, and interval level variables. Details are presented in Appendix B, and a discussion of the analytical tests used in this report is contained in Appendix C. We do not report a difference as significant unless it is statistically significant at the .05 level of probability.[1] The tables in Appendix B provide the exact significance levels.

SAMPLE CHARACTERISTICS

As indicated in the previous chapter, we received questionnaires from 317 MCS households and 387 Control households (Table 2.1). For purposes of analysis in this report, we decided to exclude households in multifamily buildings and renters. There were no multifamily respondents in our survey, and 3.4% of the total sample were "non-owners" (renters or occupying without rent). Consequently, the sample size decreased from 704 to 678 (317 to 305 for the MCS sample, and 387 to 373 for the Control sample). As shown in Tables 3.1 and 3.2, most of the respondents for the two groups were located in Washington and climate zone 1. In terms of distribution, there was no statistically significant difference among states. However, there was a statistically significant difference among climate zones: compared to their counterparts, Control households were more likely to come from climate zone 1 and less likely to come from climate zone 2.

The sample sizes have changed in comparison to the first survey: increasing from 260 to 305 MCS households, and decreasing from 381 to 373 Control households. MCS households decreased from 39 to 32 in Idaho, from 58 to 57 in Oregon, and from 57 to 50 in Montana; however, they increased from 106 to 166 in Washington. Control households decreased from 43 to 38 in Idaho, from 62 to 56 in Montana, and from 197 to 180 in Washington; however, they increased from 79 to 99 in Oregon. In sum, the trend in attrition is similar for all sample groups except for the MCS group in Washington and the Control group in Oregon. We expected some attrition in the sample size as households decided to terminate their participation in the RSDP. The anomalies in this trend are easily explained: many MCS houses in Washington were under construction at the

[1] A significance level of 0.05 indicates that there is only a 5% chance that the finding is due only to random fluctuations in the data. It is highly likely that we are seeing a real difference instead of chance error.

Table 3.1. Distribution of Samples by State

	MCS	Control	Total
	Raw Score (%)	Raw Score (%)	Raw Score (%)
Idaho	32 (10.5)	38 (10.2)	70 (10.3)
Montana	50 (16.4)	56 (15.0)	106 (15.6)
Oregon	57 (18.7)	99 (26.5)	156 (23.0)
Washington	166 (54.4)	180 (48.3)	346 (51.0)
Total	305 (45.0)	373 (55.0)	678 (100.0)
Chi-Square = 5.96, Degrees of Freedom = 3, p = 0.1132 Number of Missing Observations = 0			

time of the first survey, and Oregon had a difficult time providing good addresses of Control homes in the beginning of their program.

The number of households coming from colder climates also changed since the first survey, decreasing from 139 to 123 in the coldest zone (Table 3.2). As in the first survey, there is a tendency for participants to come from warmer climates, perhaps indicating the aversion of households in cold climates to stop using their wood stoves and, hence, their unwillingness to participate in the RSDP (see Chapter 2).

We specifically investigated how many households participated in the second survey but not the first survey. Almost one-third (30.5%) of the MCS sample was new, while a smaller proportion (11.8%) of the Control sample was new, and this difference was statistically significant. Of particular concern for this analysis is the fact that the new respondents had less exposure to the test situation (the RSDP program) and its possible impact on attitudes and behavior, they had not been previously surveyed so that they were less sensitized than "second-time participants" in responding to these kinds of survey questions, and they had bought their houses during a different time period than the other respondents (who purchased their houses in time of recession with exceptionally high interest rates).

Table 3.2. Distribution of Samples by Climate Zone

	MCS	Control	Total
	Raw Score (%)	Raw Score (%)	Raw Score (%)
Less than 6000 HDD† (Climate zone 1)	184 (60.3)	262 (70.2)	446 (65.8)
6000-8000 HDD (Climate zone 2)	64 (21.0)	45 (12.1)	109 (16.1)
Greater than 8000 HDD (Climate zone 3)	57 (18.7)	66 (17.7)	123 (18.1)
Total	305 (45.0)	373 (55.0)	678 (100.0)

†HDD Annual heating degree days at a base of 65°F.

Chi-Square = 10.90, Degrees of Freedom = 2, p = 0.0043

Number of Missing Observations = 0

In summary, the total sample increased since the first survey with some regional differences among MCS and Control samples. The groups also differed in terms of being new to the study, and this "newness" may have some impact on their energy consumption as a result of differences in the amount of time participating in this energy conservation program, and of differences in socio-economic backgrounds (as evidenced in house purchases during different economic cycles).

STRUCTURE

Questions in this section pertain to structural modifications to the house, appliance saturation and usage, and the thermal integrity of basements. **Structural changes** have been made to the houses of both the MCS and Control groups. Since we expected more modifications to occur in older houses than in MCS houses, it is not surprising that we found statistically significant differences between the two groups in the following activities: adding rooms, insulation (wall, attic, or floor), new roof, and wood stove, installing weatherstripping, and improving the heating/cooling system. In order to examine more recent changes, we excluded Control households that moved into their house before 1982: statistically significant differences persisted for weatherstripping, wall insulation, attic insulation, and floor insulation.[2] It is important to note that 43 Control households made energy efficiency improvements (installed weatherstripping, added wall or floor insulation, added wood stove, or improved their heating/cooling system) to their houses after December 31, 1984 (Table 3.3), that is, *after* the households had been selected to participate in the RSDP, so that their thermal integrities are different than assumed when they were selected to participate in the RSDP. An analysis of the U-values of MCS and Control houses would give us a more definitive answer on whether the thermal integrities of the two groups are different. It is also interesting to note that 29 MCS households made some of the same energy improvements to their houses after December 31, 1984, probably reflecting the fact that some MCS houses had to be "improved" after post-construction inspections discovered deficiencies in the dwelling's energy-efficient features.

Table 3.3. Structural Modifications After December 31, 1984

	MCS	Control	Total
Added Rooms	8	12	20
Installed Weatherstripping	5	14	19
Added Wall Insulation	3	5	8
Added Attic Insulation	3	11	14
Added Floor Insulation	1	6	7
New Roof	0	0	0
Added Wood Stove	8	7	15
Improved Heating Cooling System	6	4	10

We examined the number of major electrical **appliances** reported by respondents and found no statistically significant differences between the MCS and Control groups for waterbed heaters, electric blankets, electric space heaters, televisions, specialized lights, and the total number of appliances.[3] However, we did find statistically significant differences between the two groups for other appliances: MCS households were more

[2]In the second survey, we did not ask when the house was built. This question was asked in the first survey, and the correlation for Control households in the first survey between the time when the household moved into the house and the date of house construction was low (Pearson's R = 0.43). Therefore, the date of moving in is not a good indicator of the age of the house.

[3]These appliance variables were analyzed using analysis of variance. Also, electric space heaters may have been interpreted by some participants to include electric baseboard heaters as well as portable space heaters.

likely to have dishwashers, jacuzzi/hot tub heaters, well pumps, and other appliances (e.g., computers, VCRs, and air-to-air heat exchangers).[4]

Because many of these appliances give off heat (internal gains) and, therefore, affect the heating and cooling loads of a house, we asked whether the appliances were located inside or outside a heated space. We found statistically significant differences between the two groups in the placement of four appliances: MCS households were more likely than Control households to have their washing machines, clothes dryers, and water heaters inside a heated area. MCS households were also more likely to have their electric space heaters outside a heated area than the Control sample.

The two groups also significantly differed in air-conditioning equipment (Table 3.4). MCS households were more likely to have air-conditioning than Control households (15.4% vs 7.5%), especially central air-conditioning.

We also investigated whether households required the frequent use of a special appliance (humidifiers, dehumidifiers, heaters, or air-conditioners) for health purposes and found no significant differences between the two groups. In fact, there were very few households where a particular appliance was required: the most frequently required equipment was a humidifier (3.8% of the total sample).

There was no statistically significant difference between the two groups as to whether they had a **basement** or not (40.1% of MCS households and 35.5% of Control households had basements); however, for those with basements, the groups differed in the parts of the basement insulated. MCS basement owners were more likely to insulate than Control basement owners (94.8% vs 88.0%).[5] MCS households were more likely to have insulated basement walls than Control households (63.6% vs 45.9%), while the Control group was more likely to have insulated both ceilings and walls than the MCS group (47.7% vs 32.7%).

HEATING

This section contains questions relating to thermostats and thermostat settings, heating behavior, thermal comfort, and performance of heating systems. There was no statistically significant difference between the two groups in the proportion of households

[4] These appliance variables had been recoded, with missing=0, and the other categories collapsed, so that they conformed to a 'Yes/No' format. These appliance variables were analyzed using difference of proportions.

[5] In this test, we selected only those households with basements and treated missing households as having no insulation in the basement. The variable was analyzed using difference of proportion test, and $z = 1.87$.

Table 3.4. Type of Air Conditioner

	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)
None	258 (84.6)	345 (92.5)	603 (88.9)
Central	43 (14.1)	17 (4.6)	60 (8.8)
Room	4 (1.3)	10 (2.5)	14 (2.1)
Both		1 (0.3)	1 (0.1)
Total	305 (45.0)	373 (55.0)	678 (100.0)
Number of Missing Observations = 0			

with a **central thermostat** (39.2% for MCS vs 43.8% for Control), nor was there a statistically significant difference in the type of central thermostat (clock thermostat vs standard thermostat). Most households (78.7%) used a standard thermostat that was adjusted by hand.

We examined self-reported **winter thermostat settings** in several different ways. Respondents were asked to record their winter thermostat settings for four different time periods: when people were at home and awake, when they were asleep, when no one was home during the day, and when no one was home for more than a day. Respondents could also indicate that their thermostat was set at the "off" position instead of an actual setting. Because of the problem of treating "off" values as temperature settings, we utilized three different approaches. In the first approach (Tables 3.5 and 3.6), we excluded all respondents with "off" values in our analysis of thermostat settings. In the second approach (Tables 3.7 and 3.8), we calculated the "off" setting as equal to a value 10° less than the lowest value found in any of the other categories. For example, if a household set their thermostat in the "off" position when no one was at home during the day or for more than one day, 65°F when everyone was asleep, and 70°F when people were at home and awake, then the thermostat settings for the first two time periods would be recalculated as 55°F. In the third approach (Tables 3.9 and 3.10), we examined the sensitivity of the second approach by recalculating with a value of 20° less than the lowest value of the other settings.

All three approaches, adjusting for the "off" response, resulted in the same conclusion: **winter thermostat settings were significantly higher for the MCS group than for the Control group under all conditions - at home and awake, asleep, no one at home, and gone for one day or more.** As shown in Tables 3.5 and 3.6, the highest mean thermostat settings occurred when people were at home and awake (69°F for the MCS group and 68°F for the Control group), and the lowest mean thermostat settings occurred when people were away from their home for more than one day (61°F for the MCS group and 57°F for the Control group). Thermostat settings were maintained in the middle of this range when people were at home and asleep or when there was no-one home during the day (64°F for the MCS group and 61°F for the Control group). Both groups did practice "night setback:" thermostat settings were lowered at night by 5 to 6 degrees Farenheit. The recalculations conducted in the other approaches resulted in negligible changes in the mean values for all the periods (no change for when people were home and awake). In sum, the difference between the means of the MCS and Control groups varied from 1° to 4° in each of these approaches, which translates into greater space heating requirements of 4% to 24% for MCS households (Keating and Bavry, 1986).

Table 3.5. Winter Thermostat Setting When At Home: Awake and Asleep "Off" Excluded

	Awake			Asleep		
	MCS	Control	Combined	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)
1-57°F	1	1	2	10	25	35
	(0.9)	(0.6)	(0.7)	(9.3)	(18.5)	(14.5)
58-62°F	2	9	11	33	62	95
	(1.7)	(5.6)	(4.0)	(30.8)	(45.9)	(39.3)
63-67°F	12	46	58	33	28	61
	(10.4)	(28.9)	(21.2)	(30.8)	(20.7)	(25.2)
68-72°F	94	97	191	30	18	48
	(81.7)	(61.0)	(69.7)	(28.0)	(13.3)	(19.8)
73-77°F	6	4	10	1	1	2
	(5.2)	(2.5)	(3.6)	(0.9)	(0.7)	(0.8)
78-82°F		2	2		1	1
		(1.3)	(0.7)		(0.7)	(0.4)
Total	115	159	274	107	135	242
	(42.0)	(58.0)	(100.0)	(44.2)	(55.8)	(100.0)
Mean	69.37	67.91	68.52	63.91	61.22	62.41
St. Dev.	3.07	3.28	3.27	4.97	5.66	5.53
Median	70.00	68.00	69.99	65.00	60.00	62.00
	Number of Missing Observations = 404			Number of Missing Observations = 436		

Table 3.6. Winter Thermostat Setting: No-one Home and Gone More Than One Day "Off" Excluded

	No-One Home			Gone More Than One Day		
	MCS	Control	Combined	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)
1-57°F	8 (8.0)	31 (24.4)	39 (17.2)	19 (19.6)	58 (50.4)	77 (36.3)
58-62°F	25 (25.0)	49 (38.6)	74 (32.6)	37 (38.1)	37 (32.2)	74 (34.9)
63-67°F	32 (32.0)	27 (21.3)	59 (26.0)	25 (25.8)	15 (13.0)	40 (18.9)
68-72°F	34 (34.0)	20 (15.7)	54 (23.8)	15 (15.5)	4 (3.5)	19 (9.0)
73-77°F	1 (1.0)		1 (0.4)	1 (1.0)		1 (0.5)
78-82°F					1 (0.9)	1 (0.5)
Total	100 (44.1)	127 (55.9)	227 (100.0)	97 (45.8)	115 (54.2)	212 (100.0)
Mean	64.66	61.06	62.64	61.47	57.28	59.20
St. Dev.	5.26	6.04	5.98	5.90	6.33	6.47
Median	65.00	60.00	63.00	60.00	56.00	60.00
	Number of Missing Observations = 451			Number of Missing Observations = 466		

Table 3.7. Winter Thermostat Setting When At Home: Awake and Asleep "Off" Recalculated as 10°F Less than Lowest Setting

	Awake			Asleep		
	MCS	Control	Combined	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)
1-57°F	1	1	2	12	43	55
	(0.9)	(0.6)	(0.7)	(10.6)	(27.2)	(20.3)
58-62°F	2	9	11	37	67	104
	(1.7)	(5.7)	(4.0)	(32.7)	(42.4)	(38.4)
63-67°F	12	46	58	33	28	61
	(10.4)	(28.9)	(21.2)	(29.2)	(17.7)	(22.5)
68-72°F	94	97	191	30	18	48
	(81.7)	(61.0)	(69.7)	(26.5)	(11.4)	(17.7)
73-77°F	6	4	10	1	1	2
	(5.2)	(2.5)	(3.6)	(0.9)	(0.6)	(0.7)
78-82°F		2	2		1	1
		(1.3)	(0.7)		(0.6)	(0.4)
Total	115	159	274	113	158	271
	(42.0)	(58.0)	(100.0)	(41.7)	(58.3)	(100.0)
Mean	69.37	67.91	68.52	63.43	59.77	61.30
St. Dev.	3.07	3.28	3.27	5.58	7.04	6.71
Median	70.00	68.00	69.00	65.00	60.00	60.00
	Number of Missing Observations = 404			Number of Missing Observations = 407		

Table 3.8. Winter Thermostat Setting: No-one Home and Gone More than One Day "Off" Recalculated as 10°F Less than Lowest Setting

	No-One Home			Gone More Than One Day		
	MCS	Control	Combined	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)
1-57°F	13 (11.9)	51 (32.9)	64 (24.2)	28 (25.5)	88 (57.9)	116 (44.3)
58-62°F	29 (26.6)	56 (36.1)	85 (32.2)	41 (37.3)	44 (28.9)	85 (32.4)
63-67°F	32 (29.4)	27 (17.4)	59 (22.3)	25 (22.7)	15 (9.8)	40 (15.3)
68-72°F	34 (31.2)	20 (12.9)	54 (20.5)	15 (13.6)	4 (2.6)	19 (7.2)
73-77°F	1 (0.9)		1 (0.4)	1 (0.9)		1 (0.4)
78-82°F		1 (0.6)	1 (0.4)		1 (0.7)	1 (0.4)
Over 82°F					1 (0.7)	1 (0.4)
Total	109 (41.3)	155 (58.7)	264 (100.0)	110 (42.0)	152 (58.0)	262 (100.0)
Mean	63.65	59.65	61.30	60.41	55.96	57.83
St. Dev.	6.47	6.97	7.04	6.60	6.60	6.94
Median	65.00	60.00	60.00	60.00	55.00	60.00
	Number of Missing Observations = 414			Number of Missing Observations = 415		

Table 3.9. Winter Thermostat Setting When At Home: Awake and Asleep
"Off" Recalculated as 20°F Less Than Lowest Setting

	Awake			Asleep		
	MCS	Control	Combined	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)
1-57°F	1	1	2	16	48	64
	(0.9)	(0.6)	(0.7)	(14.2)	(30.4)	(23.6)
58-62°F	2	9	11	33	62	95
	(1.7)	(5.6)	(4.0)	(29.2)	(39.2)	(35.0)
63-67°F	12	46	58	33	28	61
	(10.3)	(28.8)	(21.0)	(29.2)	(17.7)	(22.5)
68-72°F	94	97	191	30	18	48
	(81.0)	(60.6)	(69.2)	(26.6)	(11.4)	(17.7)
73-77°F	6	4	10	1	1	2
	(5.2)	(2.5)	(3.6)	(0.9)	(0.6)	(0.7)
78-82°F		2	2		1	1
		(1.3)	(0.7)		(0.6)	(0.4)
Total	115	159	274	113	158	271
	(42.0)	(58.0)	(100.0)	(41.7)	(58.3)	(100.0)
Mean	69.37	67.91	68.53	62.93	58.31	60.23
St. Dev.	3.07	3.28	3.27	6.72	9.34	8.64
Median	70.00	68.00	69.00	65.00	60.00	60.00
	Number of Missing Observations = 404			Number of Missing Observations = 407		

Table 3.10 Winter Thermostat Setting: No-one Home and Gone More than One Day "Off" Recalculated as 20°F Less than Lowest Setting

	No-One Home			Gone More Than One Day		
	MCS	Control	Combined	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)
1-57°F	17	58	75	32	95	127
	(15.6)	(37.4)	(28.4)	(29.1)	(62.5)	(48.59
58-62°F	25	49	74	37	37	74
	(22.9)	(31.6)	(28.0)	(33.6)	(24.3)	(28.2)
63-67°F	32	27	59	25	15	40
	(29.4)	(17.4)	(22.3)	(22.7)	(9.9)	(15.3)
68-72°F	34	20	54	15	4	19
	(31.2)	(12.9)	(20.5)	(13.6)	(2.6)	(7.3)
73-77°F	1		1	1		1
	(0.9)		(0.4)	(0.9)		(0.4)
78-82°F		1	1		1	1
		(0.6)	(0.4)		(0.7)	(0.4)
Total	109	155	264	110	152	262
	(41.3)	(58.7)	(100.0)	(42.0)	(58.0)	(100.0)
Mean	62.83	57.90	59.94	59.23	53.53	55.92
St. Dev.	8.25	9.30	9.20	8.54	9.06	9.27
Median	65.00	60.00	60.00	60.00	55.00	58.00
	Number of Missing Observations = 414			Number of Missing Observations = 416		

We also weighted average winter thermostat settings using two different approaches to obtain average winter thermostat settings. In the first approach (Table 3.11), we used information from another question on home occupancy during the day in which respondents indicated whether someone was at home during three different time periods: 8 AM to noon, noon to 4 PM, and 4 PM to 6 PM. For the time period not asked in the question (6 PM to 8 AM), we assumed 8 hours of sleep, and for the remaining 6 hours, we assumed someone was home and awake. As a result, the number of hours spent at home and awake, asleep, or no-one at home were multiplied by the respective thermostat settings, and then divided by 24 hours to obtain average daily winter thermostat settings. The second approach (Table 3.12) was similar to the first approach except we took into account whether people were home during the weekend (based on another question). Households that reported they were generally absent from their home on weekends were given "gone for more than one day" thermostat settings for weekend days. The remaining households were treated as if they spent 16 hours at home and awake each day, and 8 hours sleep, and weekend thermostat settings were calculated as in the first approach. Average daily temperatures were calculated as follows: ((average weekday temp * 5 days) + (average weekend temp * 2 days))/7 days. In both weighting approaches, we found statistically significant differences between the two groups (analysis of variance, $p = .0000$), with the MCS households reporting higher winter settings than the Control group.

In another analysis of winter thermostat settings, we examined people's comparisons of current thermostat settings with those set in their previous home (lower, higher, or about the same), and found no statistically significant differences. Almost one-half (49.1%) of the MCS and 57.6% of the Control group believed that there had been no change in their thermostat settings, and 12.5% of each group reported higher settings in their current residence. However, these findings become interesting when we combine them with those concerning current thermostat settings in the winter. About 38% of the MCS group and 30% of the Control group set their thermostat settings higher in their last home compared to the present. As indicated above, there is a significant difference in wintertime thermostat settings between the MCS and Control groups. Considering their tendencies to have had even higher thermostat settings in the past, we might reasonably conclude that the differences in wintertime thermostat settings in their last home were even more significantly different than they are now. In sum, the MCS and Control groups differed significantly before their participation in the RSDP, indicating that the two samples may not be from the same population.

Table 3.11. Average Wintertime Temperature Setting Considering Daytime Activities

	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)
1-57°F	1 (1.0)	13 (8.9)	14 (5.6)
58-62°F	4 (3.8)	35 (24.0)	39 (15.6)
63-67°F	56 (53.8)	68 (46.6)	124 (49.6)
68-72°F	39 (37.5)	28 (19.8)	67 (26.8)
73-77°F	4 (3.8)	1 (0.7)	5 (2.0)
78-82°F		1 (0.7)	1 (0.4)
Total	104 (41.6)	146 (58.4)	250 (100.0)
Mean	66.91	63.72	65.05
St. Dev.	3.38	4.90	4.60
Median	66.67	64.00	65.42
	Number of Missing Observations = 428		

Table 3.12. Average Wintertime Temperature Setting Considering Daytime and Weekend Activities

	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)
1-57°F		11	11
		(8.7)	(5.0)
58-62°F	4	29	33
	(4.3)	(22.8)	(15.1)
63-67°F	44	63	107
	(47.8)	(49.6)	(48.9)
68-72°F	40	23	63
	(43.5)	(18.1)	(28.8)
73-77°F	4	1	5
	(4.3)	(0.8)	(2.3)
Total	92	127	219
	(42.0)	(58.0)	(100.0)
Mean	67.31	63.68	65.20
St. Dev.	2.89	4.47	4.27
Median	67.00	64.29	65.48
	Number of Missing Observations = 459		

In addition to investigating the issue of central space heating, we examined the uses of zonal heating, basement heating, and wood-burning. In **zonal heating**, selected areas of home are heated (e.g., living room) while other areas are not heated (e.g., bedrooms). Approximately 60% of all households closed their doors and/or vents to prevent heating "extra" rooms. For those households with central thermostat control, this percentage decreased to 51%, much less (statistically significant) than households without central thermostat control (65%). There was a statistically significant difference between the RSDP groups in closing doors and/or vents to prevent heating rooms when the heater was on. The Control group (64.7%) was more likely to practice this energy-efficient behavior than the MCS group (52.4%). For those households with central thermostat control, these differences were greater: 59% of the Control group and 40% of the MCS group. For those households without central thermostat control, the differences between the RSDP groups were smaller, however, more households practiced this type of behavior: 69% of the Control group and 60% of the MCS group.

There was no statistically significant difference between the groups in keeping a bedroom window open while sleeping in the winter: approximately 86% of both samples left their bedroom windows closed. Of those that did open their bedroom window, MCS households were more likely to leave their bedroom door open as well, but the difference was not statistically significant. However, thermal modelling is impossible for homes with open windows and doors.

Approximately one-third of the total sample had **basements**, and there was no statistically significant difference between the two groups in providing heat to the basement. The MCS group was more likely to always have the basement heated, while the Control group had a slightly higher tendency to heat the basement only when it was occupied; however, these differences were not statistically significant.

There was a statistically significant difference between the groups in the presence of a fireplace, fireplace insert, or woodstove (Table 3.13). More Control households (68.4%) had a **wood-burning** facility than MCS households (52.0%). All RSDP participants were required not to burn wood as part of their contract to participate in the program. However, there was a statistically significant difference between the groups in their motivation in burning wood (Table 3.14). The MCS group burned wood primarily for special occasions and decoration while the Control group burned wood primarily for heat. This may reflect the fact that prior to the RSDP, Control households burned wood for heat, and their responses may more accurately represent their past behavior than their behavior during the past year in the RSDP. In contrast, MCS households have no pre-RSDP "home heating history" for their occupancy in MCS homes.

Table 3.13. Fireplace or Woodstove in House

	MCS Raw Score (%)	Control Raw Score (%)	Combined Raw Score (%)
Neither	144 (48.0)	113 (30.6)	257 (38.4)
Fireplace	75 (25.0)	129 (35.0)	204 (30.5)
Woodstove or Fireplace insert	77 (25.7)	104 (28.2)	181 (27.1)
Both	4 (1.3)	23 (6.2)	27 (4.0)
Total	300 (44.8)	369 (55.2)	669 (100.0)
Number of Missing Observations = 9			

We examined respondent's attitudes towards **thermal comfort** by examining three different questions. In the first question, households were asked whether it was essential to their health to have the house warm and comfortable in the winter. There was no statistically significant difference between the MCS and Control groups; approximately 75% of each group agreed with this statement. In the second question, households were asked whether they wanted to be able to wear light clothing in their home all year round. There were statistically significant differences between the two groups: MCS households agreed more strongly than their counterparts to this question (44.8% to 33.8%, respectively). And in the third question, households were asked whether they were willing to wear heavier clothing indoors during the winter so they could set their thermostat lower than they usually did. Again, there were statistically significant differences between the two groups: Control households were more likely to agree to this statement than MCS households (59.7% to 47.8%, respectively). Overall, it appears that MCS households were more inclined to value comfort than Control households which is reflected in their reported thermostat settings.[6]

[6] In addition to comfort, the last two questions may also be measuring "inconvenience," so that the evaluation of the responses is not entirely straightforward. Nevertheless, we believe these questions do measure thermal comfort as well.

Table 3.14. **Purpose of Woodstove or Fireplace Insert**

	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)
Used for Heat	27 (44.3)	78 (72.2)	105 (62.1)
Used for Decoration	34 (55.7)	30 (27.8)	64 (37.9)
Total	61 (36.1)	108 (63.9)	169 (100.0)
Number of Missing Observations = 509			

Households were asked about the thermal comfort of their homes, and approximately 70% of both groups felt it was easy to keep all their rooms comfortable. However, while a majority of both households believed that their heating system heated their home quickly, a number of MCS households (11.3%) felt that their home did not heat quickly enough (a statistically significant difference).

There was no statistically significant difference between the groups in their estimations of whether the household was wearing more or less clothing, compared to their last house: approximately 80% of both samples felt that they wore about the same. In focusing on those households that changed their clothing habits, most households in both groups now wear more clothing in the winter.

The **performance** of the heating equipment was very good since only a few households reported any equipment problems, and there was no statistically significant differences in the proportion of households that reported that equipment had broken down. The two types of equipment most often reported as broken for the MCS group were air-to-air heat exchangers (23) (see below) and baseboard heaters (12), and furnaces (28) and baseboard heaters (17) for the Control group. Furnace and baseboard heaters were reported as easily repaired by a majority of both groups (over 80%). In contrast, heat pump problems were easily repaired in only 50% of the (12) cases.

AIR-CONDITIONING

This section contains questions relating to thermostat settings, cooling behavior, cooling comfort, and performance of air-conditioners. Although heating use was considered to be the focus of our analysis in this paper, we asked questions about air-conditioning usage because a sizeable fraction of households did have this type of equipment (especially, the newer homes) and because its saturation and impact might become more important in the Pacific Northwest in the coming years. As mentioned previously, a statistically significant greater proportion of MCS households had air-conditioners than Control households (15.4% vs 7.5%), especially central air-conditioners (Table 3.4).

We examined self-reported **summer thermostat settings** in a similar fashion to our analysis of winter thermostat settings. Respondents were asked to record their summer thermostat settings for four different time periods: when people were at home and awake, when they were asleep, when no one was home during the day, and when no one was home for more than a day. Respondents could also indicate that their thermostat was set at the "off" position instead of an actual setting. Because of the problem of treating "off" values as temperature settings, we utilized three different approaches. In the first approach (Tables 3.15 and 3.16), we excluded all respondents with "off" values in our analysis of thermostat settings. In the second approach (Tables 3.17 and 3.18), we calculated the "off" setting as equal to a value 10^{O} greater than the highest value found in any of the other categories. For example, if a household set their thermostat in the "off" position when no one was at home during the day or for more than one day, $72^{O}F$ when everyone was asleep, and $70^{O}F$ when people were at home and awake, then the thermostat settings for the first two time periods would be recalculated as $82^{O}F$. In the third approach (Tables 3.19 and 3.20), we examined the sensitivity of the second approach by recalculating with a value of 20^{O} greater than the highest value of the other settings.

All three approaches, adjusting for the "off" response, resulted in the same conclusion: there were no statistically significant differences between the MCS and Control groups in any of the conditions - at home and awake, asleep, no one at home, and gone for one day or more. The lack of statistical difference may reflect inadequate sample sizes: few (20-30) people reported summer thermostat settings, presumably because few households had air-conditioners with thermostat control.

Both groups maintained higher settings (warmer temperatures) during the summer when no-one was home or when they were away from their house for more than one day (mean settings were 74-$75^{O}F$). When people were home (either awake or asleep), the mean thermostat settings were 72-$73^{O}F$. There was no evidence of "night setback."

Table 3.15. Summer Thermostat Setting When At Home: Awake and Asleep "Off" Values Excluded

	Awake			Asleep		
	MCS	Control	Combined	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)
1-57°F		1 (4.8)	1 (1.6)		1 (6.7)	1 (2.3)
58-62°F	1 (2.5)		1 (1.6)	2 (6.9)		2 (4.5)
63-67°F		1 (4.8)	1 (1.6)	1 (3.4)	3 (20.0)	4 (9.1)
68-72°F	15 (37.5)	6 (28.6)	21 (34.4)	12 (41.4)	4 (26.7)	16 (36.4)
73-77°F	11 (27.5)	7 (33.3)	18 (29.5)	4 (13.8)	4 (26.7)	8 (18.2)
78-82°F	13 (32.5)	6 (28.6)	19 (31.1)	9 (31.0)	3 (20.0)	12 (27.3)
Over 82°F				1 (3.4)		1 (2.3)
Total	40 (65.6)	21 (34.4)	61 (100.0)	29 (65.9)	15 (34.1)	44 (100.0)
Mean	74.18	73.05	73.79	73.45	70.73	72.52
St. Dev.	4.34	6.25	5.05	5.97	6.75	6.30
Median	75.00	75.00	75.00	72.00	70.00	72.00
	Number of Missing Observations = 617			Number of Missing Observations = 634		

Table 3.16. Summer Thermostat Setting: No-One Home and Gone More Than One Day "Off" Values Excluded

	No-One Home			Gone More than One Day		
	MCS	Control	Combined	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)
58-62°F	2 (7.4)		2 (5.0)	2 (8.3)		2 (6.1)
63-67°F		1 (7.7)	1 (2.5)	1 (4.2)	1 (11.1)	2 (6.1)
68-72°F	8 (29.6)	3 (23.1)	11 (27.5)	4 (16.7)		4 (12.1)
73-77°F	6 (22.2)	4 (30.8)	10 (35.0)	5 (20.8)	4 (44.4)	9 (27.3)
78-82°F	10 (37.0)	4 (30.8)	14 (35.0)	10 (41.7)	3 (33.3)	13 (39.4)
Over 82°F	1 (3.7)	1 (7.7)	2 (5.0)	2 (8.3)	1 (11.1)	3 (9.1)
Total	27 (67.5)	13 (32.5)	40 (100.0)	24 (72.7)	9 (27.3)	33 (100.0)
Mean	74.30	75.15	74.58	74.83	76.89	75.39
St. Dev.	5.50	6.60	5.81	6.44	6.54	6.43
Median	75.00	75.00	75.00	77.00	75.00	76.00
	Number of Missing Observations = 638			Number of Missing Observations = 645		

Table 3.17. Summer Thermostat Setting When At Home: Awake and Asleep "Off" Values Recalculated as 10°F Greater than Highest Setting

	Awake			Asleep		
	MCS	Control	Combined	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)
1-57°F		1 (4.8)	1 (1.6)		1 (6.7)	1 (2.3)
58-62°F	1 (2.5)		1 (1.6)	2 (6.9)		2 (4.5)
63-67°F		1 (4.8)	1 (1.6)	1 (3.4)	3 (20.0)	4 (9.1)
68-72°F	15 (37.5)	6 (28.6)	21 (31.1)	12 (41.4)	4 (26.7)	16 (18.2)
73-77°F	11 (27.5)	7 (33.3)	18 (29.5)	4 (13.8)	4 (26.7)	8 (18.2)
78-82°F	13 (32.5)	6 (28.6)	19 (31.1)	9 (31.0)	3 (20.0)	12 (27.3)
Over 82°F				1 (3.4)		1 (2.3)
Total	40 (65.6)	21 (34.4)	61 (100.0)	29 (65.9)	15 (34.1)	44 (100.0)
Mean	74.18	73.05	73.79	73.45	70.73	72.52
St. Dev.	4.34	6.25	5.05	5.97	6.75	6.30
Median	75.00	75.00	75.00	72.00	70.00	72.00
	Number of Missing Observations = 617			Number of Missing Observations = 634		

Table 3.18. Summer Thermostat Settings: No-One Home and Gone More Than One Day "Off" Values Recalculated as 10°F Greater than Highest Setting

	No-One Home			Gone More than One Day		
	MCS	Control	Combined	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)
58-62°F	2 (7.4)		2 (5.0)	2 (8.3)		2 (6.1)
63-67°F		1 (7.7)	1 (2.5)	1 (4.2)	1 (11.1)	2 (6.1)
68-72°F	8 (29.6)	3 (23.1)	11 (27.5)	4 (16.7)		4 (12.1)
73-77°F	6 (22.2)	4 (30.8)	10 (35.0)	5 (20.8)	4 (44.4)	9 (27.3)
78-82°F	10 (37.0)	4 (30.8)	14 (35.0)	10 (41.7)	3 (33.3)	13 (39.4)
Over 82°F	1 (3.7)	1 (7.7)	2 (5.0)	2 (8.3)	1 (11.1)	3 (9.1)
Total	27 (67.5)	13 (32.5)	40 (100.0)	24 (72.7)	9 (27.3)	33 (100.0)
Mean	74.30	75.15	74.58	74.83	76.89	75.39
St. Dev.	5.50	6.60	5.81	6.44	6.54	6.43
Median	75.00	75.00	75.00	77.00	75.00	76.00
	Number of Missing Observations = 638			Number of Missing Observations = 645		

Table 3.19. **Summer Thermostat Setting: At Home Awake and Asleep "Off" Values Recalculated as 20°F Greater than Highest Setting**

	Awake			Asleep		
	MCS	Control	Combined	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)
1-57°F		1 (4.8)	1 (1.6)		1 (6.7)	1 (2.3)
58-62°F	1 (2.5)		1 (1.6)	2 (6.9)		2 (4.5)
63-67°F		1 (4.8)	1 (1.6)	1 (3.4)	3 (20.0)	4 (9.1)
68-72°F	15 (37.5)	6 (28.6)	21 (31.1)	12 (41.4)	4 (26.7)	16 (18.2)
73-77°F	11 (27.5)	7 (33.3)	18 (29.5)	4 (13.8)	4 (26.7)	8 (18.2)
78-82°F	13 (32.5)	6 (28.6)	19 (31.1)	9 (31.0)	3 (20.0)	12 (27.3)
Over 82°F				1 (3.4)		1 (2.3)
Total	40 (65.6)	21 (34.4)	61 (100.0)	29 (65.9)	15 (34.1)	44 (100.0)
Mean	74.18	73.05	73.79	73.45	70.73	72.52
St. Dev.	4.34	6.25	5.05	5.97	6.75	6.30
Median	75.00	75.00	75.00	72.00	70.00	72.00
	Number of Missing Observations = 617			Number of Missing Observations = 634		

Table 3.20. Summer Thermostat Settings: No-One Home and Gone More Than One Day "Off" Values Recalculated as 20°F Greater than Highest Setting

	No-One Home			Gone More than One Day		
	MCS	Control	Combined	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)	Raw Score (%)
58-62°F	2 (7.4)		2 (5.0)	2 (8.3)		2 (6.1)
63-67°F		1 (7.7)	1 (2.5)	1 (4.2)	1 (11.1)	2 (6.1)
68-72°F	8 (29.6)	3 (23.1)	11 (27.5)	4 (16.7)		4 (12.1)
73-77°F	6 (22.2)	4 (30.8)	10 (35.0)	5 (20.8)	4 (44.4)	9 (27.3)
78-82°F	10 (37.0)	4 (30.8)	14 (35.0)	10 (41.7)	3 (33.3)	13 (39.4)
Over 82°F	1 (3.7)	1 (7.7)	2 (5.0)	2 (8.3)	1 (11.1)	3 (9.1)
Total	27 (67.5)	13 (32.5)	40 (100.0)	24 (72.7)	9 (27.3)	33 (100.0)
Mean	74.30	75.15	74.58	74.83	76.89	75.39
St. Dev.	5.50	6.60	5.81	6.44	6.55	6.43
Median	75.00	75.00	75.00	77.00	75.00	76.00
	Number of Missing Observations = 638			Number of Missing Observations = 645		

In addition to investigating the issue of central air-conditioning, we examined the use of **zonal cooling**. As in the heating analysis, there was a statistically significant difference between the groups in closing off rooms to prevent cooling rooms when the air-conditioner was on. The Control group (52%) was more likely to practice this energy-efficient behavior than the MCS group (20%). However, in contrast to zonal heating, households with central air-conditioners were more likely to close off their rooms than households with only room air-conditioners (60% versus 25%, respectively). While the small sample sizes prevent us from making statistical comparisons, it appears that MCS households are more likely to keep their rooms open when air-conditioning.

There was no statistically significant difference between the two groups in their feelings about the **comfort** of their home during the summer: approximately three-quarters of each group felt it was easy to keep their house comfortably cool during the summer. However, the two groups did significantly differ in their perception of possible reasons for overheating in the summer. While 63% of both groups felt there was no overheating, of those that did, more MCS households thought that south-facing windows were responsible (20.1% vs 17.0%), or did not know (7.1% vs 3.3%), while more Control households (12.7% vs 8.2%) thought that the lack of shading was the primary reason for overheating.

As mentioned previously, equipment performance was good, especially for air-conditioners (only 3 households reported problems), and, of these cases, repairing the air-conditioner was considered to be quite easy (66.7%).

TIME SPENT AT HOME

In addition to determining differences between the two households on how they heat and cool their home, it was important to find out whether there were any differences in the amount of time they spent at home during the day and during the week.[7] Since the major focus of this investigation is heating energy use, we asked people whether the house was occupied during selected time periods in the winter (8 AM to Noon, Noon to 4 PM, and 4 PM to 6 PM), and we found no statistically significant differences between the two groups. Approximately 60% of the total sample occupied their homes during the first two time periods, and over 85% from 4 PM to 6 PM.

[7]We previously included "time spent at home" in the weighting of winter and summer thermostat settings.

There was also no statistically significant difference between the households in the tendency to be gone for more than 7 days during the past year (approximately one-third of each group were gone). Furthermore, there were no statistically significant differences between the two groups in the number of days taken off for those people who were on vacation between October 1, 1985 and April 15, 1986 (the heating season).[8]

We asked a few questions about televisions in order to obtain a perspective on "sedentary lifestyles." We assumed that households that watched a lot of television spent more time at home using other appliances. Although the number of households with televisions was high in both groups, there was a significant difference between them. The Control group (99%) was more likely to own one than the MCS group (96%). There was no statistically significant difference in the number of televisions owned. For those owning a TV, there also was no statistically significant difference in viewing habits. In trying to determine how much time both groups spent watching television, we recoded non-owners as 0-2 hour viewers and retested the comparison. In this instance, there was a statistically significant difference (chi-square test, $p = 0.038$), indicating Control households watched TV more often than MCS households.

INDOOR ENVIRONMENT[9]

As part of our survey, we were interested in finding out about whether the occupants noticed any "problems" with their indoor environment, as reflected in mold/mildew, condensation, humidity, and odors, and how households assessed and responded to a booklet about indoor air quality.

There was a statistically significant difference between the two groups in reporting the presence of **mildew or mold** in the home: only 8.3% of the MCS group, compared to 16.4% of the Control group, reported mildew problems. For those reporting problems, we inquired about the location of the mildew problem (bathroom, kitchen, dining area, living room, or other areas) and found statistically significant differences in some of these areas. For the Control sample, most mildew problems occurred in the bedroom and the kitchen; for the MCS sample, most mildew problems occurred in the bedroom. Surprisingly, no one in either sample reported mildew to be a problem in the bathroom, although condensation (see below) was a major problem in this room.

[8] For the MCS group, mean = 2.23 days, standard deviation = 11.28, sample size = 304; for the Control group, mean = 1.37 days, standard deviation = 5.17, sample size = 373 (analysis of variance, $p = 0.19$).

[9] Indoor air quality contaminants (e.g., formaldehyde and radon) were measured in another investigation of the RSDP homes (see Reiland et al., 1985a and 1985b).

Approximately 60% of both samples experienced some kind of **condensation**. As above, for those reporting problems, we inquired about the location of the condensation (bathroom, kitchen, bedroom, dining area, living room, around humidifier, around heat exchanger, or other areas). Everyone who listed condensation to be a problem cited the bathroom as a major source. The Control group experienced significantly more condensation in the kitchen than the MCS group, while 7% of the MCS group experienced condensation around the air-to-air heat exchanger. In connecting condensation to events in the home (e.g., showering, cooking, sleeping, and washing clothes), all reported condensation when showering, but no one reported condensation while cooking. Although there was no statistically significant difference in the reporting of bedroom condensation, there was a significant difference in those reporting condensation when sleeping (22% of the MCS group vs 12% of the Control group). There were no statistically significant differences between the two groups for the other activities. The MCS group did report humidity problems when the air-to-air heat exchanger was off (see below).

Slightly more MCS households (26.2%) than Control households (20.6%) found their home to be **stuffy or humid**, although the difference was not statistically significant. In connecting stuffiness to events in the home (e.g., cooking, sleeping, and washing clothes), no significant differences were evident. One-quarter of those reporting problems cited cooking as the main source of stuffiness (particularly the Control group (31.6%)) while 10% of the total sample cited the other two activities. **Odors** were difficult to get rid of for about 16% of each group, and there were no statistically significant differences. In sum, the MCS group appeared to be consistently better off in the kitchen than their counterparts: less mildew, condensation, and stuffiness.

Each state energy office mailed a **booklet about indoor air quality** to each household participating in the RSDP. However, we found statistically significant differences in the percentage of MCS and Control households receiving this booklet: 70.4% for MCS vs 51.1% for Control. For those receiving the booklet, both groups felt the booklet was easy to understand (83%), and there was a similar likelihood that the booklet affected their behavior (approximately 8%). Because of the low impact of the booklet on behavior, the likelihood of the disproportionate distribution of the booklet in confounding the results is low.

AIR-TO-AIR HEAT EXCHANGERS

Air-to-air heat exchangers (AAHX) are heat-recovery ventilation systems which exchange warm, stale indoor air for colder, (typically) drier outdoor air during the heating season. The AAHX also reduce the level of indoor pollutants, including moisture, by replacing indoor air with outdoor air. BPA's environmental policies required that MCS dwellings have the same average infiltration rate as Control dwellings, and, therefore, it was decided to comply with this requirement by requiring all MCS dwellings to incorporate an AAHX. AAHX information and training was given to general contractors who installed most of AAHX units. Because of the importance of this subject, we asked a number of questions about AAHX operation and servicing and the occupants' satisfaction with this new technology. Because control dwellings were not required to have an AAHX, we do not compare the AAHX responses of MCS households with Control households.

Prior to analyzing these questions, we first examined a related question about exhaust fans, mechanical equipment used for ventilation. The two groups significantly differed in their possession and use of **exhaust fans** in the bathroom. Almost all Control households (89.7%) had exhaust fans while only 52.9% of the MCS group had them. This result reflects the fact that most MCS homes had air-to-air heat exchangers installed for general ventilation, often as a substitute for exhaust fans. MCS households differed in their use of these fans, with a higher proportion of usage for general ventilation purposes than was the case for Control households (5.3% vs 2.8%).

It is interesting to note that while **air-to-air heat exchangers** were required to be installed in all MCS homes, 6 MCS households reported that they did not have this device. These respondents may not know that they had the equipment, or they may have removed the heat exchangers after moving in. Similarly, because air-to-air heat exchangers are a relatively new technology in the area, we were surprised that 7 Control households reported that they had these devices. These respondents may have mistaken their heating equipment for heat exchangers, misunderstood the question, or they may have actually installed an AAHX.

At the time of occupancy, each MCS household was to have received a set of instructions for **operating** the heat exchanger. However, nearly 25% of the respondents who had an AAHX reported that they did not receive operating instructions (Table 3.21). Of those that received the instructions, nearly 50% found them less than clear (12% found them not clear at all). Accordingly, the potential for not operating the air-to-air heat exchanger properly is large. In fact, 25% of those that received instructions reported that they did not operate the heat exchanger exactly as recommended in the instructions, and 15% did not know how to respond to the question. On a positive note, 60% of those that received instructions operated the AAHX as directed.

Respondents were queried as to whether they had discovered better ways of operating the heat exchanger. Over 40% of the sample responded affirmatively and made a

Table 3.21. **Clarity of AAHX Instructions**

	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)
Did Not Receive Instructions	75 (25.5)	3 (60.0)	78 (26.1)
Did Not Read	4 (1.4)		4 (1.3)
Instructions Not Clear	26 (8.8)		26 (8.7)
Instructions Somewhat Clear	72 (24.5)	2 (40.0)	74 (24.7)
Instructions Clear	112 (38.1)		112 (37.5)
Don't Know	5 (1.7)		5 (1.7)
Total	294 (98.3)	5 (1.7)	299 (100.0)
Number of Missing Observations = 379			

number of suggestions, such as they use it only when needed (25.9%) and only with a timer (20.4% of the suggestions).

Owning an air-to-air heat exchanger does not necessarily mean it is operating all the time. In fact, 5% of the AAHX owners who responded to the AAHX use question reported that they never use the heat exchanger. We found AAHX use to be very bimodal: 42% used it for 1-4 hours per day and 30% used it for more than 18 hours per day.

In addition to operating the AAHX, we were interested in how this equipment was **maintained and serviced**. Most people had access to the heat exchanger (less than 1% reported it was out of reach), and 46% of the respondents felt confident that they understood the basic operations of the AAHX and could use the manual to solve any specific problem. Approximately 25% of the sample knew how to change the filter, but nothing else, and about 27% have elected to wait until some problem arises before attending to it.

Cleaning the filter of an air-to-air heat exchanger is one of the most important maintenance responsibilities of the homeowner. A small percentage of respondents (2.4%) reported that their AAHX did not have a filter while a majority of households (58.2%) changed the filter. About 40% of the sample reported that they had not yet changed the filter, and the most common reasons given for not changing the filter were the following: the filter did not need to be changed (37.7% of the reasons), they did not know there was a filter (15.6%), they did not know how to change the filter (10.4%), they could not reach the filter (9.1%), and they were unable to find the right size filter (7.8%).

A small percentage (6%) of the air-to-air heat exchangers had broken down. Of these households, over 27.3% were difficult to repair, 18.2% had not been repaired, and 54.5% were easy to repair.

In terms of **satisfaction**, approximately 10% of the sample felt that air-to-air heat exchangers were noisy, 70% slightly noisy, and 20% did not think that they were noisy at all. Similarly, about 14% of the sample felt that there were unpleasant drafts created by the AAHX while another 29% experienced drafts that they claimed were only a minor discomfort. A small percentage (6.4%) felt the drafts to be rather pleasant, and 51% experienced no drafts at all. Air-to-air heat exchangers are susceptible to having their core freezing, and 10% of the sample reported that this problem occurred (6 in zone 1, 6 in zone 2, and 12 in zone 3). As a final note, we constructed a variable which measured whether people who owned AAHX had problems with unpleasant drafts, repairs, or core freezing, and we found that 50% of AAHX owners had experienced at least one of these problems.

OCCUPANT CHARACTERISTICS

In this section, we examine the demographic attributes of the occupants of RSDP homes (income, household size and age composition, and education, age, and sex of respondent) and their attitudes.

The **household income** of the MCS group was statistically different than that of the Control group (Table 3.22). For example, 60% of the MCS group earned over $35,000 a year while this was true of only 45% of the Control group. Similarly, nearly 30% of the Control group earned less than $25,000, which was the case in only 12% of the MCS sample. When we compared MCS households with Control households who moved in after December 31, 1981 (recent homeowners), the differences between the two groups intensified.

Table 3.22. Household Income Before Taxes

		MCS	Control	Combined
		Raw Score (%)	Raw Score (%)	Raw Score (%)
1	$15,999 or less	6 (2.2)	33 (9.3)	39 (6.2)
2	$16,000 to $24,999	28 (10.1)	63 (17.8)	91 (14.4)
3	$25,000 to $34,999	77 (27.8)	97 (27.5)	174 (27.6)
4	$35,000 to $44,999	89 (32.1)	68 (19.3)	157 (24.9)
5	$45,000 to $59,000	43 (15.5)	65 (18.4)	108 (17.1)
6	$60,000 or more	31 (11.2)	25 (7.1)	56 (8.9)
7	Don't Know	3 (1.1)	2 (0.6)	5 (0.8)
	Total	277 (44.0)	353 (56.0)	630 (100.00)
	Number of Missing Observations = 48			

The average **household size** (number of occupants) did not statistically differ between the MCS and Control groups (3.20 occupants per household). There were also no statistically significant differences among the five age categories (Table 3.23). Most of the households were composed of 18-64 year olds.

There were no statistically significant differences among the six **education** categories for those responding to the survey in the MCS and Control groups. Over one-half of the MCS group (57.3%) and the Control group (52.7%) were college graduates or better. The respondents from the Control group, however, were more likely to be female and also not the person to whom the survey was addressed, so that the education percentages are closer than actually shown.

Table 3.23. Age Composition of Households*

	MCS	Control	Combined
	Raw Score (%)	Raw Score (%)	Raw Score (%)
Under 6 Years	123 (40.3)	143 (38.3)	266 (39.2)
6 to 10 Years	68 (22.2)	95 (25.5)	163 (24.0)
11 to 17 Years	66 (21.6)	86 (23.1)	152 (22.4)
18 to 64	293 (96.1)	351 (94.4)	644 (95.0)
Over 65	16 (5.2)	25 (6.7)	41 (6.0)

*Percentages relate to the proportion of households with at least 1 member in that age category.

There was no statistically significant difference between the MCS and Control groups in the mean **age** of the respondents to the survey. The differences in age distributions were not statistically significant between the two groups; however, more MCS respondents were from the 30-39 age group while Control respondents were more strongly represented in the 18-29 and 40-49 age groups.

There was a statistically significant difference between the two groups in the **sex** of the person responding to the survey: the MCS group was more likely to be a male while the Control group was more likely to be female.

Finally, respondents were queried about their level of support **(attitudes)** ("strongly agree" to "strongly disagree") for selected statements concerning energy conservation and thermal comfort. Both the MCS and Control groups "mildly agreed" that it was essential for their health to keep the house warm and comfortable in the winter. Both groups "mildly disagreed" that conservation was a hassle and they were tired of it, and that energy was not an important problem for them compared to other problems. On three other items, however, statistically significant differences between the groups were present. The MCS group was slightly more desirous of wearing light clothing in their home all year round, and they were less willing to wear warmer clothing indoors in the winter so that they could lower their thermostat. The largest difference was with regard to their perceptions of the effect of energy investments on their utility bills. Both groups felt that energy-efficient technologies made a noticeable difference, but the MCS group was much more adamant about this.

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CHAPTER 4. RELIABILITY OF BEHAVIOR

One of the objectives of conducting the second survey on participants in the RSDP was to determine the reliability (stability) of their behavior by comparing their responses in the second survey to their responses in the first survey. We focused on those households that responded to both surveys and examined those questions that were identical or very similar to one another. By comparing responses, we measured the reliability of responses over the test situations. High reliability may mean that their responses are good indices of the actual situation; low reliability may suggest people were guessing, untruthful, or changed between test situations.

Table 4.1 shows the results of the comparison between responses on similar items, or the same item, in both surveys. Presented are means and standard deviations for each item, grouped by similarity, as well as a correlation coefficient to specifically examine the relationship between item responses.[1]

There was some variation in the presentation of questions between the surveys, but often a simple reordering of the response categories produced essentially the same variable. In some instances, responses needed to be collapsed so that we could deal with the same response categories, or we had to rebuild a variable which had been fragmented (e.g., q52b and q52c q54). In some cases, some categories had to be dropped. Thus, for a few questions, the lack of consistency in responses (noted below) may be a function of different presentations of a particular question.

Responses to most items were highly stable: for example, household income, number of occupants under 6, between 6 and 17, and over 65, number of freezers, and number of waterbeds. Also, the correlation for the year occupants moved into their homes ("move-in year") was 0.96 (not shown in the table), a very good indicator of reliability. Most other items showed a moderate amount of variability.

Very low (reliability) correlations were found for a few items: type of respondent (person to whom the survey was addressed), number of clothes washers, number of electric blankets, air-conditioning, and use of the bathroom fan. In the second survey, the questionnaire was much more likely to be filled out by the spouse. In the second survey, all households had electric blankets. Thus, almost all of the change in response on the electric blanket question occurred in those households who previously had reported zero

[1] We used Lambda to measure the association for nominal level variables, Gamma for ordinal, and Pearson's correlation coefficient (r) for interval levels. All measures of association have an upper limit of one.

or one electric blanket (in the first sample, of those respondents who participated in both surveys, 60% (127) indicated that they did not have electric blankets). In the first survey, respondents were more likely to list general ventilation as the purpose for using the bathroom fan, compared to the second survey, when the bathroom fan was used only when the bathroom was occupied. Most of the air-conditioning changes occurred in households that previously reported no air-conditioning, but they reported in the second survey having air-conditioners (mainly room units). Most of the above differences were related to items which could be purchased within one year, so that changes in the saturation of these items are likely to occur. Approximately 3.0% (7) in the second survey said they had no air-conditioning, but previously said that they had room conditioners, and 3.0% (8) said that they previously had central conditioners.

There was a tendency for the means of winter thermostat settings to drift upwards since the first survey. The setting for the at-home and awake condition was the one with the least agreement. The thermostat setting standard deviations also changed in the two surveys. People were much more consistent (less variation) in the second survey than in the first survey.

We also examined reliability for the MCS and Control samples and found no statistically significant differences between the samples.

In summary, responses were fairly stable over time indicating that the data are trustworthy for the test situation. However, special attention should be given to appliance saturations and usage since our brief analysis indicates that changes in this area are likely to occur over time.

Table 4.1. Comparisons of Responses to Common Items Across Surveys

	Total			MCS			Control			Association for Total Sample Across Surveys	
Variable	Mean	S.D.	Sample Size	Mean	S.D.	Sample Size	Mean	S.D.	Sample Size	Association	Sample Size
Household income-old	4.10	1.07	510	4.25	0.93	200	4.01	1.13	310	Gamma = .90	484
Household income-new	3.27	1.03	502	3.49	0.85	192	3.14	1.11	310		
Person to whom addressed-old	1.01	0.12	518	1.01	0.10	204	1.02	0.13	314	Lambda = .0000	345
Person to whom addressed-new	1.15	0.36	534	1.12	0.34	212	1.17	0.38	322		
Occupants under 6-old	0.53	0.76	538	0.58	0.76	212	0.50	0.76	326	Pearson's R = .85	538
Occupants under 6-new	0.56	0.78	541	0.62	0.82	212	0.52	0.76	329		
Occupants 6 to 17-old	0.62	0.92	538	0.59	0.89	212	0.63	0.94	326	Pearson's R = .86	538
Occupants 6 to 17-new	0.67	0.96	541	0.64	0.98	212	0.68	0.95	329		
Occupants 18 to 65-old	1.94	0.72	538	1.93	0.59	212	1.95	0.79	326	Pearson's R = .65	538
Occupants 18 to 65-new	1.93	0.72	541	1.95	0.68	212	1.91	0.74	329		
Occupants over 65-old	0.09	0.38	538	0.08	0.36	212	0.10	0.40	326	Pearson's R = .86	538
Occupants over 65-new	0.10	0.39	541	0.08	0.36	212	0.10	0.41	329		
Therm.setting At Home-old	68.45	4.01	541	68.98	4.90	212	68.10	3.47	329	Pearson's R = .37	218
Therm.setting At Home-new†	68.58	3.20	218	69.28	3.38	83	68.12	3.03	135		
Therm.setting Asleep-old	61.92	6.38	528	63.05	6.49	209	61.18	6.19	319	Pearson's R = .65	193
Therm.setting Asleep-new†	62.32	5.48	193	63.72	5.12	78	61.38	5.55	115		
Therm.setting No-one at Home-old	60.39	7.68	517	61.65	8.31	206	59.56	7.12	311	Pearson's R = .52	178
Therm.setting No-one at Home-new†	62.79	5.90	180	64.93	5.12	73	61.32	5.99	107		

† Current winter thermostat settings were selected for comparison with the old; scores of 0 have been treated as missing.

Table 4.1 continued. Comparisons of Responses to Common Items Across Surveys

	Total			MCS			Control			Association for Total Sample Across Surveys	
Variable	Mean	S.D.	Sample Size	Mean	S.D.	Sample Size	Mean	S.D.	Sample Size	Association	Sample Size
#Refrigerators-old	1.08	0.28	539	1.08	0.28	211	1.08	0.28	328	Pearson's R = .70	362
#Refrigerators-new	1.16	0.38	362	1.185	0.39	130	1.15	0.38	232		
#Clothes Washers-old	0.98	0.17	539	0.98	0.17	211	0.97	0.16	328	Pearson's R = .15	529
#Clothes Washers-new	1.00	0.08	531	1.00	0.10	209	1.00	0.06	322		
#Freezers-old	0.61	0.56	539	0.62	0.56	211	0.61	0.56	328	Pearson's R = .84	474
#Freezers-new	0.69	0.55	476	0.71	0.53	183	0.61	0.56	328		
#Electric Dryers-old	0.97	0.18	539	0.97	0.19	211	0.97	0.17	328	Pearson's R = .53	527
#Electric Dryers-new	0.99	0.14	529	0.99	0.14	208	0.98	0.14	321		
#Waterbeds-old	0.38	0.66	539	0.38	0.68	211	0.38	0.65	328	Pearson's R = .84	477
#Waterbeds-new	0.43	0.72	479	0.46	0.76	182	0.41	0.70	297		
#Jacuzzi Heaters-old	0.06	0.26	539	0.06	0.26	211	0.06	0.26	328	Pearson's R = .55	452
#Jacuzzi Heaters-new	0.06	0.25	454	0.08	0.27	169	0.06	0.23	285		
#Electric Blankets-old	0.43	0.67	539	0.38	0.64	211	0.46	0.68	328	Pearson's R = -.00	206
#Electric Blankets-new	1.77	1.46	207	2.02	1.62	59	1.67	1.39	148		
Bathroom Fan-old	2.64	0.96	513	2.33	1.11	196	2.80	0.80	317	Lambda = .10	369
Bathroom Fan-new	3.64	0.82	386	3.52	0.68	103	3.68	0.87	283		
Air-Conditioning-old	1.09	0.38	470	1.10	0.42	160	1.08	0.35	310	Lambda = .20	469
Air-Conditioning-new	1.13	0.39	540	1.19	0.42	212	1.09	0.37	328		

CHAPTER 5. DISCUSSION AND CONCLUSIONS

The principal objective of this study is to compare occupants of MCS ("super" energy-efficient) houses with occupants of "control" ("current practice") houses to see whether the two groups are similar or different with respect to energy-related behavior, attitudes, and demographics. In Table 5.1, we present a summary list of variables statistically significant at the 0.05 level. We have organized the variables into two major groups: structural variables (which primarily reflect the physical condition of the house) and behavioral variables (which primarily describe the occupants and their energy-related behavior). We further divided each group into two sub-groups (major and minor), reflecting the relative importance of each variable on space conditioning energy use (as estimated by the authors). Our focus is on heating energy use, in particular, because of its importance in the Pacific Northwest, in the development of the Model Conservation Standards, and in several parallel research studies being conducted by BPA and the national laboratories.

The results indicate that the MCS and Control groups are different from one another, but the effect of these variables on space conditioning energy use is not uniform. In particular, the **major structural variables** included:

- structural modifications to the home
- location of key appliances
- basement insulation
- presence of woodstove or fireplace
- presence and type of air-conditioning equipment

The **major behavioral variables** included:

- winter thermostat settings
- closing doors/vents when heating
- closing rooms when air-conditioning

The MCS group set higher winter thermostat settings (q10) and closed off rooms less frequently when heating (q13) than the Control group, suggesting greater space heating energy consumption due to lifestyle factors. On the other hand, the MCS group had higher appliance saturations (washing machines, clothes dryers, water heaters, and electric space heaters (q3)) and had more appliances located inside heated spaces (dishwashers, electric space heaters, and well pumps (q3)), suggesting less space heating energy consumption as a result of structural factors increasing internal gains. Similarly, woodburning potentially has a great impact on space heating energy use, however, structural features might counteract this impact. For instance, although participants were paid not to burn wood, a significant number of Control households reported that they burned wood for heat (rather than for decoration), therefore, requiring less fuel for their space heating equipment. However, there is some uncertainty about when wood-burning occurred (see Chapter 3), and the addition of chimneys and flues might offset the reduced space heating load by increasing heat loss through greater ventilation.

In conclusion, there is evidence of lifestyle differences that distinguish the MCS group from the Control group and that tend to *counteract* the thermal efficiency consequences of the structural differences between the two groups. While the structure of MCS houses may be more efficient, the behavior of the inhabitants is more energy-consuming. MCS homeowners seem to have purchased their houses with energy efficiency as a critical motivation (Keating and Bavry, 1986). However, from the last survey, we also know that these people seem to be concerned about events that have a direct bearing on themselves, rather than the society at large. They have no altruistic motivation behind their search for an energy-efficient home. Results from our analysis indicate that they are particularly motivated by thermal comfort. Having invested in energy efficiency, they now want to enjoy their home and maximize their comfort. On the other hand, the Control group did not invest in super energy-efficient houses, but they do try to attain energy efficiency and thermal comfort through their behavior. For example, they take more trouble to close off unused rooms, only heat rooms when in use, adjust to lower wintertime and higher summertime thermostat settings, and wear heavier clothing during the winter. Instead of the building providing the energy efficiency, their behavior provides it. The goals of the two groups are probably the same: reduced costs and thermal comfort. But the strategies they have elected to pursue are significantly different. One has elected to invest while the other has decided to modify their behavior.

Other work has suggested socioeconomic status (SES) differences may be influential in choosing one of these approaches. For example, higher SES groups tend to respond to the needs for energy conservation by investment strategy, buying more efficient equipment and retrofitting. Lower SES groups tend to respond by behavioral changes, such as turning off unused lights, closing doors, and wearing heavier clothing in the winter (Becker et al., 1981; Winett and Geller, 1981). We also found significant SES differences between the MCS and Control groups: the MCS group is more likely than their counterparts to come from higher income groups (based on our survey) and from higher occupational levels (based on the previous survey). In summary, thermal efficiency differences between the MCS and Control houses will probably be depressed due to this countervailing tendency in behavior between the two socioeconomic groups.

Table 5.1. Summary Table of Significant Variables

	Variable	Statistic	p Value
STRUCTURAL			
Major			
q2a1	Added Rooms	Diff./Prop.	0.0214
q2b1	Installed Weatherstripping	Diff./Prop.	0.0000
q2c1	Added Wall Insulation	Diff./Prop.	0.0004
q2d1	Added Attic Insulation	Diff./Prop.	0.0000
q2e1	Added Floor Insulation	Diff./Prop.	0.0000
q2f1	Added New Roof	Diff.Prop.	0.0160
q2g1	Added Wood Stove	Diff./Prop.	0.0008
q2h1	Improved Heating Cooling System	Diff./Prop.	0.0424
q3b	Washing Machines Located Inside	Diff./Prop.	0.0000
q3c	Electric Dryers Located Inside	Diff./Prop.	0.0000
q3d1	Presence of Electric Heaters	Diff./Prop.	0.0264
q3e	Water Heaters Located Inside	Diff./Prop.	0.0000
q3g1	Presence of Well Pumps	Diff./Prop.	0.0198
q3j	Electric Space Heaters Located Inside	Diff./Prop.	0.0000
q5b	Parts of Basement Insulated	Chi-Square	0.0300
q14a	Presence of Fireplace or Woodstove	Chi-Square	0.0000
q21	Presence of Air Conditioner	Diff./Prop.	0.0012
q21	Type of Air Conditioning	Chi-Square	0.0050
q22	No. Individual Room Air Conditioners	Chi-Square	0.020
Minor			
q3a1	Presence of Dishwasher	Diff./Prop.	0.0008
q3p2&q3q2	Other Appliances	Diff./Prop.	0.0308
q8a	Exhaust Fan in Bathroom	Diff./Prop	0.0000
q27a	Mildew or Mold in Home	Diff./Prop.	0.0009
q27c	Mildew in Kitchen	Diff./Prop.	0.0146
q27f1	Mildew in Bedrooms	Diff./Prop.	0.0064
q28c	Condensation in Kitchen	Diff./Prop.	0.0300
q28h	Condensation Around Heat Exchanger	Diff./Prop.	0.0000
q29c	Condensation When Sleeping	Diff./Prop.	0.0098
BEHAVIORAL			
Major			
q10a	Winter Temperature When Home and Awake$^{\mu}$	ANOVA	0.0002
q10b	Winter Temperature When Home and Asleep$^{\mu}$	ANOVA	0.0001
q10c	Winter Temperature When No-One Home$^{\mu}$	ANOVA	0.0000
q10d	Winter Temperature When Gone More Than One Day$^{\mu}$	ANOVA	0.0000
	Average Winter Temperature$^{\mu}$	ANOVA	0.0000
q13	Close Doors/Vents	Diff./Prop.	0.0014
q24	Close Rooms When Air Conditioner On	Diff./Prop	0.0042

$^{\mu}$ Only one set of calculations presented (see Chapter 3).

Table 5.1 Continued. **Summary Table of Significant Variables**

Variable		Statistic	p Value
BEHAVIORAL			
Minor			
q1a	Move-In year	ANOVA	0.0000
q7	Presence of TV	Diff./Prop	0.0108
q7	TV Viewing (Non-Owners coded 0 Hours)	Chi-Square	0.0380
q8b	Use of Bath Exhaust Fan	Chi-Square	0.0000
q14b	Motivation for Wood-Burning	Chi-Square	0.0006
q15a	Moved In After Jan. 1	Diff./Prop.	0.0000
q20a	Reason for Over-Heated House	Chi-Square	0.0500
q44	Indoor Air Quality Booklet Received	Diff./Prop.	0.0000
q47b	Attitudes: Light Clothing All Year	ANOVA	0.0007
q47d	Attitudes: Difference in Utility Bills	ANOVA	0.0000
q47e	Attitudes: Willing to Wear Heavy Winter Clothing	ANOVA	0.0004
q49	Sex of Respondent	Diff./Prop.	0.0010
q54	Income	ANOVA	0.0001
	New to Second Survey	Chi-Square	0.0000
	Climate Zone	Chi-Square	0.0043

Some of the structural and behavioral differences between the two groups resulted from the sample selection process. Because MCS houses were recently constructed and occupied, most MCS participants recently moved into their houses (q1a, q15a) and made fewer structural modifications to their houses (q2a1, q2b1, q2c1, q2d1, q2e1, q2f1, q2g1, q2h1). Because air-conditioning is more often included as part of new construction, MCS homes had more air-conditioners (especially, central units) compared to older homes (where room units were more common) (q21, q22). Because MCS homes were required to install air-to-air heat exchangers for ventilation purposes and were paid not to burn wood, the presence and use of exhaust fans and wood stoves were reduced in MCS homes (q8a, q8b, q14a, q14b). Similarly, Control households were more likely to be represented in the milder climate zones (particularly, zone 1) where wood-burning is not as necessary as in the colder climate zones.

With regard to this project's secondary objectives (see Chapter 1), condensation (q28 q29) was a problem in most MCS and Control households (60%), and its importance significantly varied room-by-room for each group. Mildew/mold (q27) was more of a problem for the Control group than for the MCS sample but affected a smaller percentage (less than 20%) of people than condensation. About 25% of each sample felt their home to be stuffy/humid, but there was no statistically significant difference between groups. Finally, there were problems in MCS households receiving and reading instructions for operating air-to-air heat exchangers, and these problems may have resulted in the large number (50%) of households reporting problems with their equipment (unpleasant drafts, repairs, and core freezing). The effect of these problems on space heating energy use is uncertain. It is possible that occupants may increase ventilation in the home during the winter to offset or reduce the negative effects of these problems. The increased ventilation may result in an increase in space heating consumption to maintain thermal comfort levels.

The findings from this survey are similar to those reported in the first survey (Keating and Bavry, 1986). Based on a 0.05 significance level, statistically significant differences between the MCS and Control groups were found for the following variables common to both surveys: climate zone, air-to-air heat exchangers, air-conditioning, household income, and winter thermostat settings. It is important to reiterate a point made earlier about the different makeup of the samples in the two surveys. There were more MCS households (especially in Washington) and less Control households (except in Oregon) in the second survey than in the first survey, and 30% of the MCS sample were surveyed for the first time in the second survey while only 10% of the Control sample were new. These differences may qualify the extrapolation of the comparisons to their respective samples.

In addition to noting the statistically significant differences between the MCS and Control groups, it is important to note some definitional problems associated with these groups, clouding the interpretation of the results of the thermal analysis. First, 43 Control homes improved the energy efficiency of their houses (e.g., adding wall and floor insulation) *after* they had been selected to participate in the RSDP, so that their thermal integrities are different than assumed when they were selected to participate in the RSDP. An analysis of the U-values of MCS and Control houses would give us a more definitive answer on whether the thermal integrities of the two groups are different. Second, due to different types of building codes and code enforcement in the region (Vine, 1986), the concept of "current practice" is very loosely defined and variable and, therefore, selection of "control" homes is subject to an unknown bias. Third, some MCS households were designed to be more energy efficient than the proposed MCS standards, while others, in post-construction inspections, were found to be less energy-efficient than the proposed standards, so that the meaning of an MCS home and the energy-efficiency of uninspected MCS homes are questionable until an analysis of U-values has been conducted.

Finally, we would like to briefly comment on the generalizability of these results to broader populations. In the first survey, comparisons of the MCS and Control groups were made to a more representative group (participants in the Pacific Northwest Residential Energy Survey (PNWRES)), and Keating and Bavry (1986) found that the

RSDP samples were "younger, more professional, had more electric space and water heating fuels, kept their homes warmer, and were less concerned about community problems than the PNWRES respondents." In the second survey, we did not survey the PNWRES population; however, our findings for the RSDP groups are in agreement with the previous findings, so that we also conclude that the generalizability of the MCS results to the population of owners of electrically-heated, single-family homes is unsupportable.

We would like to thank the following people for their assistance in this project: Ken Keating and Phil Thor of the Bonneville Power Administration; the state energy offices of Idaho, Montana, Oregon, and Washington; Ben Bronfman, Dave Lerman, and their staff at International Energy Associates, Ltd.; and Rick Diamond, Bruce Nordman, and Alan Meier of the Lawrence Berkeley Laboratory.

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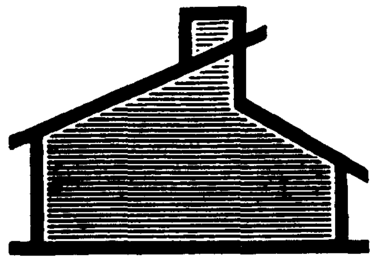
APPENDICES

APPENDIX A

CODEBOOK



Energy Use

in

Northwest Homes

Sponsored by
the Bonneville Power Administration
with the cooperation of the states of
Idaho, Montana, Oregon and Washington

In this first section, we are interested in learning about your house and the appliances you use. These questions will help us understand how electricity is used in residences.

1. When did you move into your house?

1A Year ____________ 1B Month ________________

2. Have you changed the *structure* of your house since moving in?
(Circle No or Yes for each choice; if Yes, fill in year and month or season)

			1	2		3
				If Yes, what year and month (or season?)		
2A	Added rooms	No	Yes	Year:	Month (Season):	
2B	Installed weatherstripping	No	Yes	Year:	Month (Season):	
2C	Added wall insulation	No	Yes	Year:	Month (Season):	
2D	Added attic insulation	No	Yes	Year:	Month (Season):	
2E	Added floor insulation	No	Yes	Year:	Month (Season):	
2F	New roof	No	Yes	Year:	Month (Season):	
2G	Added wood stove	No	Yes	Year:	Month (Season):	
2H	Improved heating/cooling system	No	Yes	Year:	Month (Season):	
	Other (Please specify:	~~No~~	~~Yes~~	Year:	Month (Season):	
2I	______ 1 ______			2		3
2J	______ 1 ______			2		3

3. **Which of the following appliances do you *regularly* use in your home? (Enter the number of the appliances; enter 0 if you have none.) Please indicate if the appliance is located outside the heated area of your home.**

		1	2	3
		Number (#)	Outside heated area?	
			Yes (#)	No (#)
3A	Dishwasher			
3B	Washing machine			
3C	Electric clothes dryer			
3D	Electric heater for hot tub, sauna, jacuzzi, or swimming pool			
3E	Water heater			
3F	Heat pump water heater			
3G	Well pump			
3H	Waterbed heaters			
3I	Electric blankets			
3J	Electric space heaters			
3K	Televisions			
3L	Specialized lights (Please specify: 1	2	3	4
3M	Refrigerator #1	1	2	3
3N	Refrigerator #2	1	2	3
3O	Food freezer (not in refrigerator -- free standing)	1	2	3
3P	Other (Please specify: 1	2	3	4
3Q	Other (Please specify: 1	2	3	4

4. Does anyone in your home have a health condition which *requires* the frequent use of humidifiers, dehumidifiers, heaters or air conditioners?
(Please circle the response for each choice)

4A	Humidifiers	Yes	No
4B	Dehumidifiers	Yes	No
4C	Heaters	Yes	No
4D	Air-conditioners	Yes	No

5. Do you have a basement?

5A
- 1 No, no basement (*GO TO QUESTION 7*)
- 2 Yes--Which parts of your basement *are insulated*? (Circle one)

5B
- 1 Basement not insulated
- 2 Ceiling
- 3 Walls
- 4 Both ceiling and walls
- 5 Don't know

6 **6. Is your basement heated?**
- 1 No, no heat in basement
- 2 Yes, but it is heated only when occupied
- 3 Yes, it is heated all the time

7 **7. How often do you use your television(s)? For example, 2 televisions x 2 hours per television = 4 hours)**
- 1 No television
- 2 0-2 hours per day
- 3 3-5 hours per day
- 4 6-8 hours per day
- 5 9 or more hours per day

8. Do you have an exhaust fan in your bathroom(s)?

8A
- 1 No, no exhaust fan (*GO TO QUESTION 9*)
- 2 Yes--How often is it used?

8B
- 1 Never
- 2 Only when someone is in the bathroom
- 3 All the time
- 4 When bathroom is unoccupied, for ventilation
- 5 Rarely, because air-to-air heat exchanger ventilates bathroom

This next section asks about conditions in your home during the *HEATING SEASON*.

9. Do you have a central thermostat to control the heat in your house?

9A
1 No, no thermostats at all (*GO TO QUESTION 11*)
2 No, we have several thermostats (*GO TO QUESTION 11*)
3 Yes--What type of central thermostat is it?

9B
1 A "clock thermostat" that sets the hours when the heat goes on or off.
2 A standard thermostat that has to be adjusted by hand
3 I don't know what type it is

10. In the winter, what temperature is your thermostat set at?

10A 1 When people are at home and awake: _______°F ☐ off
10B 2 When people are asleep: _______°F ☐ off
10C 3 When no one is at home during the day: _______°F ☐ off
10D 4 When no one is at home for more than a day: _______°F ☐ off

11 **11. Does your heating system heat your home quickly enough?**

1 Yes, the whole home heats quickly
2 No, the home does not heat quickly enough for us to be comfortable
3 Some rooms heat quickly, but it takes much longer to heat other parts of the house

12 **12. Is it easy to keep a comfortable temperature in all of the rooms you want heated?**

1 Yes, in all rooms
2 In some rooms, but not all
3 No, all rooms are often cold

13 **13. Do you close doors and/or vents to prevent heating rooms when the heater is on?**

1 Yes
2 No
3 Don't know

14. Does your home have a fireplace or a woodstove? (circle as many as apply)

14A
1 Neither
2 Yes, a fireplace
3 Yes, a woodstove or a fireplace insert--What is it used for? (Circle one)

14B
1 Heat
2 Special occasions (decoration).

IEALID 1
SAMPLE 1

15. **Did you move into this home after January 1, 1984?**

15A
1 No (*GO TO QUESTION 17*)
2 Yes--Compared to your previous home, do you wear (circle one):

15B
1 Warmer clothing in the winter
2 Lighter clothing in the summer
3 About the same as what I used to wear

16 16. **Compared to your previous home, are your current winter thermostat settings:**

1 Higher than before
2 Lower than before
3 About the same
4 Don't know

17 17. **During the heating season, does anyone in your home regularly keep a window open in the bedroom while sleeping, and if so, is the bedroom door open to the rest of the house? (Circle one)**

1 No, no bedroom windows open
2 Yes, bedroom window open, but bedroom door closed
3 Yes, bedroom window open, and bedroom door open

18. **In the winter, is there someone usually at home:**
(Circle the response for each period)

18A	Between 8 a.m. and noon	Yes	No
18B	12 noon to 4 p.m.	Yes	No
18C	4 p.m. to 6 p.m.	Yes	No

The next section asks about conditions in your house during the *COOLING SEASON.*

19 19. **Is it easy to keep your house comfortably cool during the summer?**

1 Yes
2 No
3 Don't know

20. If your home seems overheated in the summer, what do you think the most important reason might be: (Circle the most important reason, and please *select only one*).

20A
1 My house does not seem overheated in the summer
2 A lot of windows facing the sun
3 Poor ventilation
4 Over insulated
5 Under insulated
6 Not enough shading
7 Dark colors on outside walls of house
8 Air conditioner does not work properly
9 Too much heat from appliances
10 Other (Please specify: 20B ______)
11 Don't know

21 **21. Which type of air-conditioner do you have?**

1 No air-conditioner
2 Central (includes heat pump)
3 Room
4 Both central and room

If you have an *air conditioner*, please continue, otherwise, go to question 25.

---

22 **22. How many individual room air-conditioners do you have?**

0 None
1 One
2 Two
3 Three
4 More than three

23. At which temperature setting do you usually keep the main occupied space in your home during the summer (all temperatures in Fahrenheit (°F)):

23A 1 When people are at home and awake: ______°F ☐ off
23B 2 When people are asleep: ______°F ☐ off
23C 3 When no one is at home during the day: ______°F ☐ off
23D 4 When no one is at home for more than one day: ______°F ☐ off

24 **24. Do you close off any rooms when the air-conditioner is on?**

1 Yes
2 No

The next section asks about the occupancy of your home during the past year.

---

25. During the past year, was your home *unoccupied* for 7 days or more? If so, when did you leave (day, month, or season and year) and how long were you gone?

25A 1 No, didn't leave for 7 days or more
2 Don't know
3 Yes:

	1	2	3		4
25B Date #1				How Long?	
25C Date #2	MONTH	DAY	YEAR	How Long?	
25D Date #3				How Long?	

26 **26. During the past year, did you regularly leave your home unoccupied for long periods of time?**

1 No
2 Yes, for vacations
3 Yes, for most weekends
4 Yes, for vacations and most weekends
5 Yes, other

The next section asks about problems people may have in their homes.

---

27. If mildew or mold is ever a problem in your home, please indicate in which rooms: (Circle all that apply)

27A 1 No mildew or mold
27B 2 Bathroom
27C 3 Kitchen
27D 4 Dining Area
27E 5 Living room
6 Other (please specify: 27F ______)

28. **Does water condense on any surfaces in your home?**

28A 1 No, no condensation (*GO TO QUESTION 30*)
2 Yes--On which surfaces does condensation occur? (Circle all that apply):

28B 1 Bathroom walls, ceilings, windows or mirrors
28C 2 Kitchen walls, ceiling or windows
28D 3 Bedroom walls, ceilings, windows or mirrors
28E 4 Dining area walls, ceilings, windows or mirrors
28F 5 Living room walls, ceiling, windows or mirrors
28G 6 Around humidifier
28H 7 Around heat exchanger
8 Other (please specify: 28 I ____________________)

29. **When does condensation occur?** (Circle all that apply)

29A 1 When showering
29B 2 When cooking
29C 3 When sleeping
29D 4 When washing clothes
29E 5 No special time
6 Other (please specify: 29F ____________________)
29G 7 Don't know

30. **Is your house ever stuffy or humid?**

30A 1 No, never stuffy or humid (*GO TO QUESTION 31*)
2 Yes--When does it occur?

30B 1 When cooking
30C 2 When sleeping
30D 3 When washing clothes
30E 4 No special time
5 Other (please specify 30F ____________________)

31 31. **Is it hard to get rid of odors in your home?**

1 Yes
2 No

32 32. **Do you have an air-to-air heat exchanger?**

1 Yes
2 No
3 Don't know

The next few questions ask about your air-to-air heat exchanger. If you do not have one, please skip to question 42.

33 **33. Were the operating instructions for the heat exchanger clear?**

1 Did not receive instructions
2 Did not read instructions
3 The instructions were not clear
4 Somewhat clear -- I could understand most of the instructions
5 The instructions were clear
6 Don't know

34 **34. Do you try to operate the heat exchanger exactly as recommended in the instructions?**

1 Yes
2 No
3 Did not receive instructions
4 Don't know

35 **35. Is the heat exchanger noisy?** (Circle one).

1 Yes, very much so
2 Yes, but only at high speeds
3 It makes a slight noise, but you get used to it
4 No, I haven't noticed any noise

36 **36. Do you know how to service the heat exchanger?** (Circle one)

1 Yes, I've read the instructions and know what to do
2 Yes, in a general way, and when I need to do anything, I'll look it up in the manual
3 Yes, I know how to change filters, but that's all
4 Yes, I know what to do, but I am unable to reach the heat exchanger
5 No, but if something goes wrong I can check it out then
6 No, but if something goes wrong I can call a repair person

37. Have you discovered better ways to operate the heat exchanger?

37A
1 Yes (How? 37B)
2 No
3 Don't know

38 **38. Are there any drafts or air currents created by the heat exchanger?**
(Circle one)

1 Yes, in places the drafts are strong and unpleasant
2 Yes, but these are comfortable
3 Yes, but they are only minor discomforts
4 No, I haven't noticed any draft or air current created by the heat exchanger

39 **39. Have you had any problems with your heat exchanger core freezing?**

1 Yes
2 No
3 Don't know

40 **40. On the average, how many hours per day do you use your heat exchanger in the heating season?**

1 Never use heat exchanger
2 1-4 hours per day
3 5-8 hours per day
4 9-12 hours per day
5 13-18 hours per day
6 More than 18 hours per day
7 Don't know, it is controlled automatically by a timer
8 Don't know, it is controlled automatically by a humidistat
9 Don't know

41. Have you ever cleaned the filter on the heat exchanger?

41A
1 There is no filter
2 Yes
3 No (any particular reason? 41 B ______________________________)

42. Has any equipment broken down since you moved into your house? If so, please indicate the number of times (Circle all that apply):

42A 1 No (*GO TO QUESTION 44*)
2 Yes, the following equipment:

		Number of times broken down
42B 1	Heat pump	______
42C 2	Air-to-air heat exchanger	______
42D 3	Furnace	______
42E 4	Baseboard heater	______
42F 5	Air-conditioner	______

43. Was the equipment easy to get repaired?
(Circle all that apply)

	43A Heat Pump	43B Air-to-air Heat Exchanger	43C Furnace	43D Baseboard Heater	43E Air Conditioner
Yes, it was fairly easy to repair	1	2	3	4	5
No, it was very difficult, but it is repaired	1	2	3	4	5
No, and at the moment it is still not repaired	1	2	3	4	5

44 **44. Have you received a booklet about indoor air quality from your State Energy Office?**

1 Yes
2 No (*GO TO QUESTION 47*)
3 Don't know (*GO TO QUESTION 47*)

45 **45. In your opinion, was the booklet easy to understand?**

1 Yes, it was easy to understand
2 I could understand most of it, but not all
3 I could understand only some of it
4 No, I could not understand it
5 Don't know, because someone else read it
6 Don't know, because nobody read it

46. **Did any members of your household change their behavior in the house because of what was in the booklet?**

46A
1 Yes, (Please specify: 46B)
2 No, no changes were made because we did not understand it
3 No, no changes were made because we did not read it
4 No, no changes were made because we saw no need to change our behavior

47. **The following statements are about how you use energy in your home and other energy-related issues. Please indicate how much you agree or disagree with these statements by circling the appropriate number.**

		Strongly Agree	Mildly Agree	Neutral	Mildly Disagree	Strongly Disagree
47A	It's essential to our health to have the house warm and comfortable in the winter	1	2	3	4	5
47B	I want to be able to wear light clothing in my home all year round	1	2	3	4	5
47C	Trying to conserve energy is a hassle, and I'm tired of it	1	2	3	4	5
47D	All of the energy conservation equipment seems to promise so much, but I can't see that it makes much difference in my utility bill	1	2	3	4	5
47E	I am willing to wear heavier clothes indoors this winter so that I can set my thermostat lower than I usually do	1	2	3	4	5
47F	Compared to other problems, the energy problem is not very important to me	1	2	3	4	5

In this last section we ask some background information questions for statistical purposes. All of your answers are strictly *confidential*.

48 **48. What is your age?**

1 Under 18 years
2 18 to 29 years
3 30 to 39 years
4 40 to 49 years
5 50 to 64 years
6 65 years or over

49 **49. Please indicate your sex.**

1 Male
2 Female

50 **50. Do you own or rent this residence?**

1 Own or buying
2 Rent
3 Occupy without rent

51 **51. Are you the person to whom this survey was addressed?**

1 Yes, addressee
2 No, spouse of addressee
3 No, other family member of addressee
4 No, unrelated to addressee

52. How many people live in your home, including yourself? Please count all members who lived in your home for at least 6 of the past 12 months, whether or not they are related to you.

	Number
52 A People under 6 years old	______
52 B People 6 to 10 years old	______
52 C People 11 to 17 years old	______
52 D People 18 to 64 years old	______
52 E People 65 years or over	______

53 **53. How many years of education have you completed?**

1 Some high school
2 High school graduate
3 Some college
4 College graduate
5 Advanced degree
6 Other (Please specify: ______________________________)

54 **54. Please circle the number which best describes the total *combined* income before taxes for your household for 1985 (include money from Social Security, unemployment, etc.)**

1 Under $15,999
2 $16,000 to $24,999
3 $25,000 to $34,999
4 $35,000 to $44,999
5 $45,000 to $59,000
6 $60,000 and higher
7 Don't know

55. Today's date:

55A Month __________________ 55B Day _____, 1986

Is there anything else you would like to comment on in regard to this questionnaire or energy use in general?

COMMENTS: 56 A

56 B

IEALID 2
SAMPLE 2

THANK YOU FOR YOUR HELP!

RSDPID 1
RSDPID 2

APPENDIX B : STATISTICAL TABLES

Index of Variable Statistics

The following is an index of variables for which statistics have been computed. Some variables have no statistics connected to them, since they were applicable to only one of the samples, and hence did not figure into our comparisons. Other variables did not meet our criteria for the type of analysis used.

Table B-1 : Difference of Proportions Z Scores†

	MCS	Control	Total	Z Scores
q3a Dishwashers				-0.85
Proportion Inside*	95%	96%	96%	
Number of Appliances	255	278	533	
q3b Washing Machines				4.10
Proportion Inside*	82%	67%	73%	
Number of Appliances	265	330	595	
q3c Electric Clothes Dryers				4.32
Proportion Inside*	82%	67%	73%	
Number of Appliances	260	323	583	
q3d Jacuzzi/Pool Heaters				-0.41
Proportion Inside*	25%	31%	28%	
Number of Appliances	20	16	36	
q3e Water Heaters				5.15
Proportion Inside*	70%	49%	59%	
Number of Appliances	274	332	606	
q3f Heat Pump Water Heater				-0.28
Proportion Inside*	25%	33%	27%	
Number of Appliances	8	3	11	
q3g Well Pump				-0.79
Proportion Inside*	12.9%	18.4%	15.3%	
Number of Appliances	62	49	111	
q3h Waterbed Heaters				1.41
Proportion Inside*	97%	92%	94%	
Number of Appliances	115	116	231	
q3j Electric Space Heaters				4.78
Proportion Inside*	82.6%	98.6%	89.3%	
Number of Appliances	201	146	347	
q3k Televisions				-0.77
Proportion Inside*	95%	96%	96%	
Number of Appliances	411	546	957	

† With a two tailed test of significance, Z scores with a value greater than ±1.96 are significant at the .05 level.

* The proportion inside was obtained by dividing the number of appliances inside by the sum of appliances inside and outside.

Table B-1 continued : Difference of Proportions Z Scores†

	MCS	Control	Total	Z Scores
q3l Specialized Lights				0.41
Proportion Inside*	56%	54%	55%	
Number of Appliances	119	156	275	
q3m plus q3n Refrigerators				-1.34
Proportion Inside*	86.6%	89.9%	88.4%	
Number of Appliances	298	358	656	
q3o Freezers				1.48
Proportion Inside*	33.5%	26.4%	29.5%	
Number of Appliances	161	258	369	
q3p Other Appliances				0.36
Proportion Inside*	85.3%	83%	84.3%	
Number of Appliances	75	59	134	

† With a two tailed test of significance, Z scores with a value greater than ±1.96 are significant at the .05 level.

* The proportion inside was obtained by dividing the number of appliances inside by the sum of appliances inside and outside.

Table B-1 continued : Difference of Proportions Z Scores†

Question	MCS	Control	Total	Z Score
q2a1 Added Rooms				-2.30
Proportion Yes	3.8%	8.2%	6.2%	
Number of Observations	291	352	643	
q2b1 Installed Weatherstripping				-5.55
Proportion Yes	2.1%	14.7%	8.9%	
Number of Observations	290	348	638	
q2c1 Added Wall Insulation				-3.49
Proportion Yes	1.4%	7.2%	4.5%	
Number of Observations	290	349	639	
q2d1 Added Attic Insulation				-5.10
Proportion Yes	1.4%	12.1%	7.3%	
Number of Observations	288	355	643	
q2e1 Added Floor Insulation				-5.20
Proportion Yes	0.3%	9.7%	5.5%	
Number of Observations	288	351	639	
q2f1 Added New Roof				-2.41
Proportion Yes	0.0%	2.0%	1.1%	
Number of Observations	288	349	637	
q2g1 Added Wood Stove				-3.35
Proportion Yes	2.8%	9.3%	6.4%	
Number of Observations	288	353	641	
q2h1 Improved Heating/Cooling System				-2.03
Proportion Yes	2.1%	5.2%	3.8%	
Number of Observations	288	346	634	

† With a two tailed test of significance, Z scores with a value greater than ±1.96 are significant at the .05 level.

Table B-1 continued: Difference of Proportions Z Scores†

Question	MCS	Control	Total	Z Score
q3a1 Presence of Dishwasher[ι]				3.36
Proportion Yes	93%	85%	89%	
Number of Observations	305	373	678	
q3b1 Presence of Washing Machines[ι]				1.27
Proportion Yes	99%	97%	98%	
Number of Observations	305	373	678	
q3c1 Presence of Electric Clothes Dryer[ι]				1.66
Proportion Yes	97%	95%	96%	
Number of Observations	305	373	678	
q3d1 Presence of Jacuzzi/Hot Tub Heaters[ι]				2.22
Proportion Yes	8%	4%	6%	
Number of Observations	305	373	678	
q3e1 Presence of Water Heaters[ι]				1.005
Proportion Yes	97.4%	96%	96.6%	
Number of Observations	305	373	678	
q3f1 Presence of Heat Pump Water Heaters[ι]				1.8
Proportion Yes	3.0%	1.1%	1.9%	
Number of Observations	305	373	678	
q3g1 Presence of Well Pumps[ι]				2.33
Proportion Yes	21%	14.2%	17.3%	
Number of Observations	305	373	678	
q3m1&q3n1 Presence of Refrigerator[ι]				.77
Proportion Yes	99.3%	98.7%	99%	
Number of Observations	305	373	678	
q3o1 Number of Freezers[ι]				-.055
Proportion Yes	53.4%	55.5%	54.6%	
Number of Observations	305	373	678	
q3p2 & q3q2 Other Appliances[ι]				2.16
Proportion Yes	10.8%	6.2%	8.3%	
Number of Observations	305	373	678	

† With a two tailed test of significance, Z scores with a value greater than ±1.96 are significant at the .05 level.
ι Appliance variables with small ranges recoded as 'Yes/No'.

Table B-1 continued: Difference of Proportions Z Scores†

Question	MCS	Control	Total	Z Score
q4a Health Condition Requiring Humidifiers				0.70
Proportion Yes	4.1%	3.5%	3.8%	
Number of Observations	295	367	662	
q4b Health Condition Requiring Dehumidifiers				0.0
Proportion Yes	0.0%	0.0%	0.0%	
Number of Observations	290	363	653	
q4c Health Condition Requiring Heaters				-0.86
Proportion Yes	0.7%	1.4%	1.1%	
Number of Observations	292	366	658	
q4d Health Condition Requiring Air Conditioners				0.0
Proportion Yes	0.3%	0.3%	0.3%	
Number of Observations	290	364	654	
q5a Whether Building has Basement				1.20
Proportion Yes	40.1%	35.5%	37.6%	
Number of Observations	289	352	641	
q6 Basement Heated Continuously				0.66
Proportion Yes	54.2%	49.5%	51.8%	
Number of Observations	96	101	197	
q7 TV or Not TV (Recoded)				-2.55
Proportion Yes	96.3%	98.9%	97.8%	
Number of Observations	299	373	672	
q8a Exhaust Fan in Bathroom				-10.63
Proportion Yes	52.9%	89.7%	73.6%	
Number of Observations	289	370	659	
q9a Existence of Thermostat[ς]				-1.19
Proportion Yes	39.2%	43.8%	41.7%	
Number of Observations	293	361	654	
q13 Close Doors/Vents When Heater On				-3.2
Proportion Yes	52.4%	64.7%	59.2%	
Number of Observations	294	360	654	

† With a two tailed test of significance, Z scores with a value greater than ±1.96 are significant at the .05 level.

ς Recoded, 'No' categories collapsed.

Table B-1 continued: Difference of Proportions Z Scores†

Question	MCS	Control	Total	Z Score
q15a Moved in After Jan 1. 1984				16.11
Proportion Yes	97.0%	36.9%	64.1%	
Number of Observations	302	366	668	
q18a Someone Home 8am and Noon				-1.74
Proportion Yes	56.8%	63.6%	60.6%	
Number of Observations	287	352	639	
q18b Someone Home Noon and 4pm				-1.60
Proportion Yes	55.3%	61.6%	58.8%	
Number of Observations	284	349	633	
q18c Someone Home 4pm and 6pm				0.076
Proportion Yes	87.4%	87.2%	87.3%	
Number of Observations	293	360	653	
q19 House Cool in Summer				0.37
Proportion Yes	75.4%	74.1%	74.6%	
Number of Observations	280	359	639	
q21 Presence of Air Conditioning (Recoded)				3.26
Proportion Yes	15.4%	7.5%	11.1%	
Number of Observations	305	373	678	
q24 Closing Rooms When Air Conditioner On				-2.87
Proportion Yes	19.6%	51.9%	31.5%	
Number of Observations	46	27	73	
q25a Home Unoccupied More than Seven Days				-0.79
Proportion Yes	33.9%	36.9%	35.5%	
Number of Observations	289	358	647	
q26 Whether Left Home for Long Periods (Recoded)				-1.09
Proportion Yes	10.2%	12.9%	11.7%	
Number of Observation	305	373	678	

† With a two tailed test of significance, Z scores with a value greater than ±1.96 are significant at the .05 level.

Table B-1 continued: Difference of Proportions Z Scores†

Question	MCS	Control	Total	Z Score
q27a Mildew or Mold$^{\delta}$				-3.118
Proportion Yes (Mildew)	8.3%	16.4%	12.8%	
Number of Observations	300	366	666	
q27b Mildew in Bathroom				0.0
Proportion Yes	0.0%	0.0%	0.0%	
Number of Observations	300	366	666	
q27c Mildew in Kitchen				-2.44
Proportion Yes	1.3%	4.6%	3.2%	
Number of Observations	300	366	666	
q27d Mildew in Dining Area				-0.18
Proportion Yes	2.0%	2.2%	2.1%	
Number of Observations	300	366	666	
q27e Mildew in Living Room				0.71
Proportion Yes	1.7%	2.5%	2.1%	
Number of Observations	300	366	666	
q27f1 Mildew in Bedrooms				-2.73
Proportion Yes	3.0%	7.9%	5.7%	
Number of Observations	300	366	666	
q27f2 Mildew Elsewhere				-0.726
Proportion Yes	4.0%	5.1%	4.6%	
Number of Observations	300	366	666	

† With a two tailed test of significance, Z scores with a value greater than ±1.96 are significant at the .05 level.
δ Variable recalculated: if coded 'Yes' on any variable from q27b to q27e, or coded for q27f, scored 'Yes, Mildew Problem'; if coded 'No' on q27b to q27e, scored 'No Problem'.

Table B-1 continued: Difference of Proportions Z Scores†

Question	MCS	Control	Total	Z Score
q28a Condensation Any Surface in Home				-0.29
Proportion Yes	59.0%	60.1%	59.6%	
Number of Observations	305	373	678	
q28b Condensation in Bathroom				0.0
Proportion Yes	100.0%	100.0%	100.0%	
Number of Observations	177	221	398	
q28c Condensation in Kitchen				-2.17
Proportion Yes	26.0%	36.2%	31.7%	
Number of Observations	177	221	398	
q28d Condensation in Bedroom				-0.32
Proportion Yes	31.1%	32.6%	31.9%	
Number of Observations	177	221	398	
q28e Condensation in Dining Area				0.00
Proportion Yes	0.0%	0.0%	0.0%	
Number of Observations	177	221	398	
q28f Condensation in Living Room				-0.89
Proportion Yes	21.5%	25.3%	23.6%	
Number of Observations	177	221	398	
q28g Condensation Around Humidifier				-0.34
Proportion Yes	0.6%	0.9%	0.3%	
Number of Observations	177	221	398	
q28h Condensation Around Heat Exchanger				14.68
Proportion Yes	6.8%	.0%	3.0%	
Number of Observations	177	221	398	
q28i1 Condensation All Windows				1.75
Proportion Yes	14.7%	9.1%	11.6%	
Number of Observations	177	221	398	
q28i2 Condensation Skylights				1.65
Proportion Yes	4.0%	1.4%	2.5%	
Number of Observations	177	221	398	
q28i3 Condensation Other				-0.18
Proportion Yes	10.7%	11.3%	11.1%	
Number of Observations	177	221	398	

† With a two tailed test of significance, Z scores with a value greater than ±1.96 are significant at the .05 level.

Table B-1 continued: Difference of Proportions Z Scores†

Question	MCS	Control	Total	Z Score
q29a Condensation When Showering				0.00
Proportion Yes	100.0%	100.0%	100.0%	
Number of Observations	305	373	678	
q29b Condensation When Cooking				0.00
Proportion Yes	0.0%	0.0%	0.0%	
Number of Observations	179	222	401	
q29c Condensation When Sleeping				2.58
Proportion Yes	21.8%	12.2%	16.5%	
Number of Observations	179	222	401	
q29d Condensation When Washing Clothes				-1.45
Proportion Yes	4.5%	8.1%	6.5%	
Number of Observations	179	222	401	
q29e Condensation at No Special Time				0.00
Proportion Yes	100.0%	100.0%	100.0%	
Number of Observations	305	373	678	
q29f1 Condensation in Cold Weather				0.85
Proportion Yes	25.7%	22.1%	23.7%	
Number of Observations	179	222	401	
q29f2 Condensation Rainy Weather				-0.40
Proportion Yes	0.5%	0.9%	0.7%	
Number of Observations	179	222	401	
q29f3 Condensation Other				0.12
Proportion Yes	6.1%	5.9%	6.0%	
Number of Observations	179	222	401	

† With a two tailed test of significance, Z scores with a value greater than ±1.96 are significant at the .05 level.

Table B-1 continued: Difference of Proportions Z Scores†

Question	MCS	Control	Total	Z Score
q30a Home Stuffy or Humid				1.72
Proportion Yes	26.2%	20.6%	23.2%	
Number of Observations	305	373	678	
q30b Stuffy When Cooking				-1.46
Proportion Yes	21.3%	31.6%	26.3%	
Number of Observations	80	76	156	
q30c Stuffy When Sleeping				0.80
Proportion Yes	15.0%	10.7%	12.9%	
Number of Observations	80	75	155	
q30d Stuffy When Washing Clothes				-0.69
Proportion Yes	7.5%	10.7%	9.0%	
Number of Observations	80	75	155	
q30e Stuffy no Special Time				-0.42
Proportion Yes	25.0%	28.0%	26.5%	
Number of Observations	80	75	155	
q30f1 Stuffy When House Closed				-0.13
Proportion Yes	8.7%	9.3%	9.0%	
Number of Observations	80	75	155	
q30f2 Stuffy When AAHX Has Been Off				3.17
Proportion Yes	20.0%	9.3%	11.0%	
Number of Observations	80	75	155	
q30f3 Stuffy During Rain				-0.53
Proportion Yes	2.5%	4.0%	3.2%	
Number of Observations	80	75	155	
q30f4 Stuffy in Warm Weather				0.49
Proportion Yes	8.8%	6.7%	7.7%	
Number of Observations	80	75	155	
q30f5 Stuffy Other Times				-0.47
Proportion Yes	11.3%	13.8%	12.5%	
Number of Observations	80	75	155	

† With a two tailed test of significance, Z scores with a value greater than ±1.96 are significant at the .05 level.

Table B-1 continued: Difference of Proportions Z Scores†

Question	MCS	Control	Total	Z Score
q31 Hard to Get Rid of Odors				0.21
Proportion Yes	16.7%	16.1%	16.4%	
Number of Observations	305	373	678	
q32 Possess Heat Exchanger				24.38
Proportion Yes	98.0%	2.0%	53.0%	
Number of Observations	302	343	645	
q42a Whether Equipment has Broken Down				1.03
Proportion Yes	16.2%	13.3%	14.6%	
Number of Observations	290	3447	637	
q44 Indoor Air Quality Booklet Received				4.43
Proportion Yes	70.4%	51.1%	60.4%	
Number of Observations	243	262	505	
q49 Sex of Respondent				3.28
Proportion Male	71.2%	58.8%	64.3%	
Number of Observations	288	36	654	

† With a two tailed test of significance, Z scores with a value greater than ±1.96 are significant at the .05 level.

Table B-2 : Significance Probabilities from Oneway Analysis of Variance.

Question	MCS	Control	Total	F Probability
q1a Move In Year				0.0000
Mean	84.55	81.97	83.13	
Standard Deviation	0.52	2.78	2.45	
Number of Observations	296	364	660	
q3h1 Number of Waterbed Heaters$^{\mu}$				0.20
Mean	0.49	0.41	0.45	
Standard Deviation	0.73	0.69	0.71	
Number of Observations	261	337	598	
q3i1 Number of Electric Blankets				0.07
Mean	2.00	1.65	1.77	
Standard Deviation	1.56	1.39	1.46	
Number of Observations	87	173	260	
q3j1 Number of Electric Space Heaters				0.10
Mean	1.80	1.54	1.65	
Standard Deviation	2.04	1.77	1.90	
Number of Observations	232	311	543	
q3k1 Number of Televisions				0.10
Mean	1.63	1.73	1.69	
Standard Deviation	0.82	0.85	0.84	
Number of Observations	296	368	664	
q3l2 Number of Specialized Lights				0.90
Mean	0.78	0.74	0.76	
Standard Deviation	2.15	4.19	3.47	
Number of Observations	169	231	400	
q3p2 Number of Other Appliances#1				0.70
Mean	1.08	1.06	1.07	
Standard Deviation	0.27	0.29	0.28	
Number of Observations	78	70	148	
q3q2 Number of Other Appliances#2				0.80
Mean	1.06	1.08	1.07	
Standard Deviation	0.35	0.29	0.32	
Number of Observations	33	23	56	
Total Number of Appliances (Sum of q3)				0.60
Mean	10.70	10.50	10.60	
Standard Deviation	4.04	4.98	4.58	
Number of Observations	305	373	678	
q7 Number of Hours TV's Used Owner's Only				0.07
Mean	3.15	3.27	3.21	
Standard Deviation	0.84	0.81	0.83	
Number of Observations	288	369	657	

$^{\mu}$ Other appliance variables, with small ranges, were recoded and appear in difference of proportions tables.

Table B-2 continued : Significance Probabilities from Oneway Analysis of Variance.

Question	MCS	Control	Total	F Probability
Temperature Calculations with "Off" Excluded				
q10a Winter Temperature Home and Awake				0.0002
Mean	69.37	67.91	68.52	
Standard Deviation	3.07	3.28	3.27	
Number of Observations	115	159	274	
q10b Winter Temperature Asleep				0.0001
Mean	63.90	61.20	62.53	
Standard Deviation	4.98	5.66	5.53	
Number of Observations	107	135	242	
q10c Winter Temperature No-one Home				0.0000
Mean	64.66	61.06	62.63	
Standard Deviation	5.26	6.04	5.98	
Number of Observations	100	128	228	
q10d Winter Temperature Gone One Day or More				0.0000
Mean	61.47	57.29	59.20	
Standard Deviation	5.90	6.32	6.47	
Number of Observations	97	115	112	
q23a Summer Temperature Home and Awake				0.41
Mean	74.17	73.05	73.79	
Standard Deviation	4.34	6.25	5.05	
Number of Observations	40	21	61	
q23b Summer Temperature Asleep				0.18
Mean	73.45	70.73	72.52	
Standard Deviation	5.97	6.75	6.30	
Number of Observations	29	15	44	
q23c Summer Temperature No-One Home				0.67
Mean	74.30	75.15	74.57	
Standard Deviation	5.50	6.61	5.81	
Number of Observations	27	13	40	
q23d Summer Temperature Gone One Day or More				0.42
Mean	74.83	76.90	75.39	
Standard Deviation	6.44	6.55	6.43	
Number of Observations	24	9	33	

Table B-2 continued : Significance Probabilities from Oneway Analysis of Variance.

Question	MCS	Control	Total	F Probability
"Off" calculated as 10°F less than lowest setting				
q10a Winter Temperature Home and Awake				0.0002
Mean	69.37	67.91	68.52	
Standard Deviation	3.07	3.28	3.27	
Number of Observations	115	159	274	
q10b Winter Temperature Asleep				0.0000
Mean	63.43	59.77	61.30	
Standard Deviation	5.58	7.04	6.71	
Number of Observations	113	158	271	
q10c Winter Temperature No-one Home				0.0000
Mean	63.65	59.65	61.30	
Standard Deviation	6.47	6.97	7.04	
Number of Observations	109	155	264	
q10d Winter Temperature Gone One Day or More				0.0000
Mean	60.41	55.96	57.82	
Standard Deviation	6.59	6.50	6.94	
Number of Observations	110	151	262	
Average Winter Temperature (q10 q18)$^{\phi}$				0.0000
Mean	66.91	63.72	65.04	
Standard Deviation	3.38	4.90	4.60	
Number of Observations	104	146	250	
Average Winter Temperature (q10 q18 q26)$^{\epsilon}$				0.0000
Mean	67.31	63.68	65.20	
Standard deviation	2.89	4.47	4.27	
Number of Observations	92	127	219	

$^{\phi}$ Based on 'Off' = Lowest - 10° calculations; Average based on 8 hours sleep, 6 hours home and awake, then hourly settings determined by q18 responses.

$^{\epsilon}$ As in previous calculation, except that weekend activities considered, derived from q26 responses.

Table B-2 continued : Significance Probabilities from Oneway Analysis of Variance.

Question	MCS	Control	Total	F Probability
"Off" calculated as $10^{O}F$ greater than highest setting				
q23a Summer Temperature Home and Awake				0.41
Mean	74.18	73.05	73.79	
Standard Deviation	4.34	6.25	5.05	
Number of Observations	40	21	61	
q23b Summer Temperature Asleep				0.18
Mean	73.45	70.73	72.52	
Standard Deviation	5.97	6.75	6.30	
Number of Observations	29	15	44	
q23c Summer Temperature No-One Home				0.67
Mean	74.30	75.15	74.56	
Standard Deviation	5.50	6.60	5.81	
Number of Observations	27	13	40	
q23d Summer Temperature Gone One Day or More				0.42
Mean	74.83	76.89	75.39	
Standard Deviation	6.44	6.55	6.43	
Number of Observations	24	9	33	

Table B-2 continued : Significance Probabilities from Oneway Analysis of Variance.

Question	MCS	Control	Total	F Probability
"Off" calculated as $20^{\circ}F$ less than lowest setting				
q10a Winter Temperature Home and Awake				0.0002
Mean	69.37	67.91	68.52	
Standard Deviation	3.07	3.28	3.27	
Number of Observations	115	159	274	
q10b Winter Temperature Asleep				0.0000
Mean	62.90	58.31	60.23	
Standard Deviation	6.72	9.34	8.64	
Number of Observations	113	158	271	
q10c Winter Temperature No-one Home				0.0000
Mean	62.83	57.90	59.94	
Standard Deviation	8.25	9.30	9.19	
Number of Observations	109	155	264	
q10d Winter Temperature Gone One Day or More				0.0002
Mean	59.23	53.53	55.92	
Standard Deviation	8.54	9.06	9.07	
Number of Observations	110	152	262	
"Off" calculated as $20^{\circ}F$ greater than highest setting				
q23a Summer Temperature Home and Awake				0.41
Mean	74.18	73.05	73.79	
Standard Deviation	4.33	6.25	5.05	
Number of Observations	40	21	61	
q23b Summer Temperature Asleep				0.18
Mean	73.45	70.73	72.52	
Standard Deviation	5.97	6.75	6.30	
Number of Observations	29	15	44	
q23c Summer Temperature No-One Home				0.66
Mean	74.30	75.15	74.58	
Standard Deviation	5.50	6.61	5.81	
Number of Observations	27	13	40	
q23d Summer Temperature Gone One Day or More				0.42
Mean	74.83	76.89	75.89	
Standard Deviation	6.44	6.55	6.43	
Number of Observations	24	9	33	

Table B-2 continued : Significance Probabilities from Oneway Analysis of Variance.

Question	MCS	Control	Total	F Probability
q25b4 Number of Days Gone Date 1				0.44
Mean	16.46	14.66	15.42	
Standard Deviation	23.27	9.89	16.89	
Number of Observations	91	124	215	
q25 Total Number of Days Gone (Recoded)$^{\eta}$				0.96
Mean	47.00	40.00	42.20	
Standard Deviation	21.86	26.41	24.57	
Number of Observations	305	373	678	
q47a Essential To Have Warm House				0.17
Mean	1.93	1.04	1.99	
Standard Deviation	0.99	1.06	1.03	
Number of Observations	301	366	667	
q47b Light Clothing All Year Round				0.0007
Mean	2.75	3.08	2.90	
Standard Deviation	1.23	1.21	1.21	
Number of Observations	301	367	668	
q47c Conservation a Hassle				0.18
Mean	4.15	4.04	4.08	
Standard Deviation	1.11	1.10	1.10	
Number of Observations	302	366	668	
q47d No Difference in Utility Bill				0.0000
Mean	3.62	3.15	3.37	
Standard Deviation	1.43	1.17	1.31	
Number of Observations	301	362	663	
q47e Willing to Wear Heavy Winter Clothing				0.0004
Mean	2.84	2.50	2.66	
Standard Deviation	1.24	1.18	1.22	
Number of Observations	299	365	664	
q47f Energy Not Important Problem				0.23
Mean	3.97	3.88	3.92	
Standard Deviation	1.04	1.04	1.04	
Number of Observations	301	366	667	

η Sum of q25b4 to q25d4; Missing coded 0.

Table B-2 continued : Significance Probabilities from Oneway Analysis of Variance.

Question	MCS	Control	Total	F Probability
q48 Age of Respondent				0.96
Mean Category	3.44	3.44	3.44	
Standard Deviation	1.01	1.07	1.04	
Number of Observations	301	369	670	
q52a Number Occupants Under 6 Years				0.56
Mean	0.57	0.54	0.55	
Standard Deviation	0.78	0.76	0.77	
Number of Observations	305	373	378	
q52b Number Occupants 6 to 10 Years				0.40
Mean	0.30	0.34	0.32	
Standard Deviation	0.61	0.63	0.62	
Number of Observations	305	373	678	
q52c Number of Occupants 11 to 17 Years				0.59
Mean	0.35	0.32	0.33	
Standard Deviation	0.77	0.65	0.70	
Number of Observations	305	373	678	
q52d Number of Occupants 18 to 64 Years				0.44
Mean	1.94	1.89	1.92	
Standard Deviation	0.68	0.74	0.71	
Number of Observations	305	373	678	
q52e Number of Occupants over 65 Years				0.30
Mean	0.07	0.10	0.09	
Standard Deviation	0.33	0.40	0.37	
Number of Observations	305	373	678	
Total Number of Occupants				0.74
Mean	3.23	3.19	3.20	
Standard Deviation	1.43	1.35	1.39	
Number of Observations	305	373	678	
q53 Years of Education				0.36
Mean Category	3.61	3.54	3.57	
Standard Deviation	1.03	0.98	1.01	
Number of Observations	271	330	601	
q54 Income				0.0001
Mean	3.83	3.41	3.59	
Standard Deviation	1.21	1.40	1.33	
Number of Observations	274	351	625	

Table B-3 : Significance Probabilities from Chi-Square Test

Question	MCS	Control	Total	Chi-Square Probability	Cramer's V
q5b Parts of Basement Insulated				0.03	0.18
Number of Observations	110	111	221		
q6 Heating of Basement				0.71	0.05
Number of Observations	116	126	242		
q7 TV Viewing - Owners Only (Recoded)				0.14	0.09
Number of Observations	288	369	657		
q7 TV Viewing - Owners and Non-Owners				0.0382	0.11
Number of Observations	299	373	657		
q8b Use of Bath Exhaust Fan				0.0000	0.40
Number of Observations	150	323	473		
q9b Type of Central Thermostat				0.30	0.07
Number of Observations	115	157	272		
q11 Whether Home Heats Quickly				0.035	0.10
Number of Observations	292	364	656		
q12 Easy to Keep Comfortable				0.65	0.03
Number of Observations	300	368	668		
q14a Presence of Fireplace or Woodstove				0.0000	0.20
Number of Observations	300	369	669		
q14b Motivation for Woodburning				0.0006	0.28
Number of Observations	61	108	169		
q15b Clothing : Present / Past				0.70	0.04
Number of Observations	278	126	404		
q16 Winter Thermostat : Present / Past				0.22	0.08
Number of Observations	279	125	404		
q17 Bedroom Window Open				0.40	0.05
Number of Observations	305	369	674		
q17 Bedroom Door Open; Open Window Only				0.31	0.13
Number of Observations	40	54	94		
q20a Reason for Overheated House				0.05	0.17
Number of Observations	249	318	567		
q21 Type of Airconditioning (Recoded)				0.005	0.38
Number of Observations	47	28	75		
q22 No. Individual Room Air Conditioners				0.02	0.34
Number of Observations	46	26	72		
q26 Type of Vacation (Recoded)				0.18	0.25
Number of Observations	31	48	79		

Table B-3 continued : Significance Probabilities from Chi-Square Test

Question	MCS	Control	Total	Chi-Square Probability	Cramer's V
q45 Booklet Easy to Understand[ς]				0.76	0.03
Number of Observations	166	132	298		
q46a Booklet Changed Household Behavior				0.14	0.13
Number of Observations	169	136	305		
q51 Addressee				0.17	0.07
Number of Observations	303	370	673		

ς Collapsed to get minimum expected cell values to at least 3. 'Don't Knows' recoded missing.

APPENDIX C. METHOD OF ANALYSIS

Prior to describing the analytical tests used in this report, we first discuss the primary objective of this report: the comparison of MCS households and Control households. Our analysis has proceeded within the framework of the experimental tradition, where one compares treatment variables, typically through a comparison of mean responses. Our aim has been a simple one: to compare households in terms of energy-related behavior, attitudes, and demographics, across the test situation (houses built to MCS standards versus houses built to current energy-performance levels). The critical issue for us is to determine whether the comparison of test situations is potentially confounded with differences in energy-consuming lifestyles. Accordingly, one of the primary objectives of the occupant survey analysis is to see if the inhabitants of both test situations are the same, in terms of energy-related behavior, or whether they differ. If they are the same population (the MCS and Control groups are the same), as indicated by an investigation of their energy-related behavior, attitudes and demographics, then we can assume that lifestyle factors are in effect controlled for in the experimental analysis of energy use. If the two groups are not the same, then care will have to be taken in the energy analysis so that the structural factors are not confounded with lifestyle factors.

As an illustrative example, it is possible that the people who live in MCS houses have a different commitment to energy conservation, or approach energy conservation with a different strategy, than people in the Control houses, and, as a consequence, the two groups have different energy consumption patterns. One group may be more likely to use highly energy-intensive appliances than the other group, and, therefore, live a generally energy-intensive lifestyle. In contrast, the other group may assiduously observe certain conservation practices (e.g., keeping the drapes closed in the evening, and closing unused rooms to decrease the heating load), resulting in less energy consumption. If the two comparison groups systematically vary in these kinds of behaviors, then differences in energy consumption between the two groups may be a function of the different lifestyles of their inhabitants, rather than the type of home construction. In summary, we have tried to determine whether the groups do in fact differ, or whether they are the same, so that observed differences in energy consumption might be correctly attributed to different construction standards.

Based on the above perspective, we decided to approach this analysis in a conservative manner: we felt the focus of this analysis should be to prove that the samples were the same, rather than different. Conservatism in the analysis proceeds from the assumption that the groups are different, and that we should be cautious in infering otherwise.

Within this kind of analysis, the danger is of not accepting a significant difference when there is one.

Our approach is somewhat the reverse of the usual analytical position. Typically, one is concerned about accepting a significant difference when there is none, because in most analyses the interest of the experimenter is in demonstrating the influence of the test condition. In our case, we have an interest in there being no influence from the test situation - it would make life easier for us if the MCS and Control groups are the same in terms of lifestyle.

Analytical conservatism typically requires using stringent alpha (significance) levels for the determination of significance, so that the difference has to be very strongly revealed before it will be accepted as significant. Hence, analysts will often set an alpha level of 0.01. In our case, however, this will merely make it more difficult to find the differences between the groups, and nurture the error of falsely asserting that the groups are the same. Consequently, in our case, we believe it to be more conservative to set an alpha level of 0.05.

Where possible, an **analysis of variance (ANOVA)** was performed. The major requirement with ANOVA is that the criterion variable be at least intervally scaled. ANOVA was used for all interval levels of measurement, except where ranges were extremely small. This was sometimes the case in the appliance section (question 3), where ranges were often from 0 to 1. Where ranges were small, the appliance variables were recoded dichotomously, and treated with other dichotomous variables in a difference of proportions analysis (see below). ANOVA was also used with some ordinal data, in particular the attitudinal questions (strongly agree to strongly disagree), where the model's assumptions were considered to be only marginally violated without much loss to the integrity of the test statistic. Two tests for the homogeneity of variance were performed, Cochrans' and the Bartlett-Box test. Significance levels were not small, for the most part, and with the sample sizes, there was enough similarity in the number of observations when the ANOVA was used, that the ANOVA is probably robust enough to weather any violations here.

If the variables were measured at the nominal level, **chi-square** was used. The chi-square is limited in use to those situations where all expected cell sizes are at least 3. Where expected cell sizes are less than three, variable categories can be collapsed were possible, until this criteria is met. This was not possible in one situation (question q43). The chi-square is a test for independence, not of association or strength of association. Hence, in the statistical tables, the chi-square p value is accompanied by the **Cramer's**

V statistic. Cramer's V is a chi-square based descriptive statistic which provides a normalized measure of association, and has an upper limit of 1.

The dichotomous variables, which include all variables where the response was either a yes or a no, were analysed using **difference of proportions**. The difference of proportions test requires independent observations, independent samples, and assumes a random sample. These assumptions were also not completely realized in that some matching did occur between the samples. The large sample sizes, however, to some extent ameliorate the problems arising because of these violations.

For the analysis of the **reliability** of respondents, a simple measure of association of responses across surveys was used, appropriate to the level of measurement. For nominal level variables, Lambda was used, for ordinal, Gamma, and for interval, Pearson's R.

Although we are only comparing two sets of means, we are not immune to the possibilities of errors associated with multiple comparisons. Accordingly, we set the "experimentwise significance level" at 0.05, which means that across all comparisons the possibility of falsely rejecting a true hypothesis is 5 in 100. With multiple comparisons, the pairwise significance level must be modified to take into consideration the total number of comparisons being made. Consequently, we employed a "Sequentially Rejective Bonferroni" (SRB) procedure which modifies particular alpha (α) in a stagewise manner, after ranking for significance by p value (Holm, 1979). This was applied not only to the analysis of variance, but to all the statistics, with the comparisons treated as a whole, i.e. with one test including all comparisons, as well as comparisons confined to similar variables, such as by groups of attitudinal variables, demographics, or energy-consumption behavior. Using this procedure, the significant findings reported in this paper remained resilient.

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