REPORTED VERSUS ACTUAL THERMOSTAT SETTINGS: A MANAGEMENT PERSPECTIVE

Peter M. Gladhart, Jeffrey S. Weihl and Shirlee Krabacher
Institute for Family and Child Study
Michigan State University

ABSTRACT

The ability of occupants to accurately report their thermostat settings is an important issue for conservation research and policy. Since the thermostat setting is so strongly and directly related to fuel consumption, energy conservation researchers are concerned to know if reports of dialing down should be given credence. Previous research has suggested that people underreport their thermostat settings by 3 to 5°F.

An in-depth study of ten low-income weatherization program participants provides further evidence of this effect. Electronic monitoring of thermostat setting behavior was combined with extensive ethnographic data. We interviewed the study participants after each winter season to determine day, evening and night time thermostat settings. We then compared this to the average recorded settings for the entire winter season. Four to six of the respondents reported a setting within 2 degrees of each observed mean setting for each season. The mean discrepancy for each season was between 2 and 3°F. There was considerable consistency in these results from one year to the next. In nearly every case the reported settings were less than the observed mean settings.

Ethnographic reports and graphical evidence of management strategies and family schedules suggest why some people can report much more accurately than others. People with a constant setting strategy should be more accurate than those with complex, irregular or no strategies, but some of them give biased accounts. The fact that many with irregular patterns of thermostat setting have only modest discrepancies suggests that their estimates have the properties of means, with variations distributed rather evenly above and below the estimate. Within a group of householders, some will overestimate their settings, helping to offset those who underestimate them.

The average discrepancy of 2 to 3°F found here is probably the range of perceptual error in noting and recalling actual settings, and we think it unreasonable to expect people to be more accurate. The discrepancies reported in the literature to date are sufficiently similar that we may begin to think of a two to three degree underestimate as a provisional standard adjustment for reported thermostat settings in winter time.

REPORTED VERSUS ACTUAL THERMOSTAT SETTINGS: A MANAGEMENT PERSPECTIVE[1]

Peter M. Gladhart, Jeffrey S. Weihl and Shirlee Krabacher
Institute for Family and Child Study
Michigan State University

The ability of occupants to accurately report their thermostat settings has been an important issue in residential energy conservation research. Knowledge of the interior temperatures of homes is required for estimates of energy lost to the environment, but actual measurement of interior temperatures is difficult and expensive. If occupants' reports of their thermostat settings could be relied upon, these could be used to infer temperatures and in turn estimate energy losses. Thermostat reports could also be used to infer the savings realized from campaigns that encourage people to dial down in winter or up in the summer. Since the thermostat setting is so strongly and directly related to fuel consumption, scientists and policy makers are concerned to know if occupants' reported thermostat settings should be given credence.

Studies that have compared reported thermostat settings with actual measured settings or internal temperatures have found that occupants are fairly accurate on the average (within 2°F), but individual differences can be substantial. Generally occupants believe that their thermostats are set lower than they are observed to be. Hirst and Goeltz (1985) cite a report by Beck, Doctors and Hammond (1980) that 14% of a sample underreported and 9% overreported their setting compared to the reference of 68°F. Stovall and Fuller (1987) found that people overwhelmingly underestimated their night time sleeping temperatures. Vine and Barnes (1988) found reported settings on average 2°F less than measured temperatures but with a standard deviation of 4°F. Ternes and Stovall (1988) found occupants could correctly identify their house temperatures to within ± 2°F 50-70% of the time. When they were incorrect, the actual values were higher than reported values in nearly all cases. Kempton and Krabacher (1987) found a consistent under reporting of 2-3°F comparing self reports to continuously monitored data from seven houses.

ACCURACY OF SELF REPORTED THERMOSTAT SETTINGS

There are several questions of interpretation and measurement that must be resolved before we can understand a reported thermostat setting: Is the respondent the person who controls the thermostat, or is that control shared with others in the house? Is the respondent reporting the "normal" or "usual" setting, or some ideal or socially correct setting? How consistently is the thermostat set to the "usual" setting? If the respondent is in a position to "know" the setting, is that reported accurately or with some bias? What standard of comparison should be used to verify the reported settings?

People have differing ideas of how thermostats work and accordingly they manipulate them in different ways. Some regard the thermostat as an internal feedback mechanism, others as a valve that controls the amount of heat flow (Kempton & Montgomery, 1982; Kempton, 1986). Evidence from the households studied in the present project indicates that some people at times treat the thermostat as a simple switch with two positions: heat and no heat. These different behavior patterns, or in some cases management strategies, can affect the ability of house occupants to report a "usual" setting that agrees with the observed mean. People who try to maintain a constant setting only need to know that figure and accurately report it. People who set the thermostat up or down according to the time of day or the nature of their activities will find the accuracy of their reports limited by the regularity of these patterns (Weihl, 1987). Where several people in the same house set the thermostat, when they have irregular daily schedules, or when the thermostat is moved in a random fashion in response to perceived comfort, the potential accuracy of a single report of the "usual" setting is problematic indeed.

Previous research has used estimates or measurements of mean daily interior temperatures or thermostat settings across entire heating seasons as the standard of comparison by which to judge the accuracy of a single self report of the "usual" thermostat setting. In this analysis we follow the same practice, focusing primarily upon recorded thermostat settings because that is the behavior that people employ to regulate their home temperatures and, presumably, the data they are best able to report. We use ethnographic reports, graphical evidence of management strategies, and family schedules to explain and qualify the congruence or difference between mean measured settings and self reports.

DATA

Household Profiles

The data for this paper are drawn from a study of 10 homes in Lansing, Michigan whose thermostat settings and internal temperatures were continuously monitored over two winter seasons as part of an investigation of occupant response to the weatherization of low-income homes (Gladhart, Krabacher, Weihl, 1987). Data were collected using electronic monitoring techniques and ethnographic interviews.

The household head had not completed high school in four cases, had finished high school in five, and was attending community college in one case. One house was occupied by a single retired woman, whose relatives stayed in the house to look after her during periods of ill health. Two were three generation households headed by women. Seven were two generation households consisting of young to middle aged adults and children. Some households included nonrelated adults as regular residents.

Reported annual income in 1985/86 ranged from less than $5,000 to a high of $17,000. Seven out of ten had household incomes of less than $8,000. All households were eligible to receive some type of public assistance, although some received assistance only sporadically. Eight households had their gas and some other utilities paid directly by the state Office of Social Services. Five of the households were black, and five were white.

Table I. Selected family characteristics, January 1986.

Family #	Household Heads Ages	Education	Children Ages	Income	Employment # Jobs	Comments
10	31-32	12; 12	1,10,11,12	$ 7,000	2 pt. time	
11	28-34	12; 14	8,11	$10,000	2 pt. time	
12	33-34	12; 13	8,11,14	$17,000	2 fl. time	wife studies
13	29-32	9; 11	6, 8	$ 8,000	1 fl. time	* wife studies
14	32	11	8,10,12	<$ 5,000	none	*
15	45	8	1,1,18,21	$ 8,000	none	! dtrs study
16	28-29	10; 11	5	$13,500	1 fl. time	
17	43	12	1,12,15,19	$ 8,000	none	**
18	30-30	11; 12	11,13	$ 6,000	1 pt. time	occasional
19	57	12	none	$ 7,000	disabled	moved 2nd yr.

* additional adult and infant moved in for second season
** adult son moved in second season, pt. time employed
! Two adult daughters and infants moved out, replaced by daughter 20, two grandsons aged 2 and 9 between seasons.

Automatic Instruments

Temperature and thermostat setting data were gathered by microprocessor controlled instruments (see Weihl et al., 1983). The temperature at the thermostat was measured with a modified thermistor probe (temperature sensitive resistor) mounted in the thermostat housing. Thermostat settings were measured using custom modified thermostats. A potentiometer mounted on the pivot point of the thermostat setting dial measured the setpoint to within 0.5°F. Sensor inputs were converted to appropriate units at the microprocessor and output to standard cassette tapes via an interface. Data were output at 15 minute, hourly, and daily intervals.

The temperature probes and potentiometer were calibrated at the time of installation and at the beginning of the second heating season to insure that the temperature and setting at the thermostat matched those being recorded. These were also checked for drift periodically throughout the experiment and corrected as necessary. No attempt was made to calibrate the setpoint dial of the thermostat to the thermostat temperature gauge, although generally these registered within one or two degrees of one another.

Ethnographic Interviews

Open ended interviews were conducted both before and after weatherization. These interviews focused on occupant perceptions of their energy related behavior, as well as their perceptions of how their house, appliances and energy systems worked. Occupants were also asked about their thermostat and ventilation management habits or strategies in order to better interpret instrument gathered data.

ANALYSIS

Reported Settings

Although we explained at the beginning of the project that our instruments would record their thermostat settings and we installed a new, calibrated thermostat in their homes, we tried to do as little as possible to call the participants' attention to this fact during the experiment so as to minimize our impact on their behavior. For this reason, we did not question them during the heating season when they were actually setting the thermostat. We interviewed the study participants once after each winter season, asking them who set the thermostat and where that person or persons usually set their thermostat during the day, during the evening and during the night when people were sleeping. This gave us six reported settings, three for each season.

Mean Observed Settings

Using mean settings and temperatures recorded over 15 minute intervals, and the respondents' reported waking and sleeping schedules to delimit "day", "evening" and "night", we computed mean values for the entire winter season and compared them to the reported settings. This criterion places a high premium on consistency: the household that adheres to the "usual" setting ninety percent of the time will score much better than one that follows that pattern forty or sixty percent of the time. As defined by respondents, daytime began between 6:30 and 9:00 A.M., evening between 4:00 and 4:30 P.M., and night between 11:00 P.M. and 1:30 A.M. In interviews for the second season, we instructed them to consider daytime as 8:00 A.M. to 4:00 P.M., but the boundary between evening and night remained their reported bedtime, generally between 11 and 12.

The reported and observed settings and temperatures for the winters of 1986 and 1987 are reported in Tables II and III, respectively. The differences between reported settings and observed settings or temperatures for day, evening and night were calculated and averaged. These mean values are also reported in Tables II and III along with the minimum of the two means. A minus value indicates that the report was lower than the observed setting.

In both years eight households under estimated and two over estimated their settings. Four households had a mean discrepancy in settings of 2°F or less in both years. Ternes and Stovall (1988) found that reported thermostat settings often more closely matched the observed temperature than the observed setting at the thermostat. Using this criterion, five households reported the mean measured temperature to within 2°F in 1986, four in 1987. If we consider the most favorable evidence, the minimum average discrepancy was 2.1°F for six households in each year.

The average discrepancy in reported and observed settings over the ten households was -1.9°F in 1986 and -2.8°F in 1987. The average minimum discrepancy was -1.3°F in 1986 and -2.3°F in 1987. If house 11 is excluded for 1987 (for reasons explained below), the average minimum discrepancy for 1987 was -1.7°F.

Table II. Reported and observed thermostat settings and interior temperatures, winter 1986 (degrees F).

House	Day Reported Setting	Day Observed Setting	Day Observed Temp	Evening Reported Setting	Evening Observed Setting	Evening Observed Temp	Night Reported Setting	Night Observed Setting	Night Observed Temp	Mean Difference Setting	Mean Difference Temp.	Mean Difference Min. Diff.
10	73.5	75.4	75.3	73.5	75.1	75.8	73.5	75.3	75.5	-1.8	-2.0	-1.8
11	65.0	68.7	65.8	70.0	69.1	66.7	70.0	69.7	66.0	-0.8	2.2	-0.8
12	72.0	72.2	73.9	72.0	71.8	73.6	72.0	72.5	73.3	-0.2	-1.6	-0.2
13	65.0	75.8	69.5	69.0	73.8	68.8	69.0	76.7	69.4	-7.8	-1.6	-1.6
14	72.0	74.2	74.2	72.0	74.2	74.2	70.0	74.1	73.6	-2.8	-2.7	-2.7
15	75.0	77.2	74.1	75.0	77.2	74.1	70.0	75.5	73.1	-3.3	-0.4	-0.4
16	68.0	70.6	73.2	68.0	70.6	73.2	65.0	71.9	73.5	-4.0	-6.3	-4.0
17	72.0	76.1	77.5	72.0	76.1	77.5	73.0	76.7	76.3	-4.0	-4.8	-4.0
18	68.0	65.7	69.6	68.0	65.7	69.6	68.0	66.7	69.4	2.0	-1.5	-1.5
19	75.0	69.3	67.4	75.0	69.4	70.3	65.0	64.9	65.5	3.8	3.9	+3.8
								Study	Mean	-1.9	-1.5	-1.3

Table III. Reported and observed thermostat settings and interior temperatures, winter 1987 (degrees F).

House	Day Reported Setting	Day Observed Setting	Day Observed Temp	Evening Reported Setting	Evening Observed Setting	Evening Observed Temp	Night Reported Setting	Night Observed Setting	Night Observed Temp	Mean Difference Setting	Mean Difference Temp.	Mean Difference Min. Diff.
10	78.0	79.2	75.0	78.0	79.2	75.0	78.0	79.2	75.0	-1.2	3.0	-1.8
11	70.0	75.3	77.1	67.0	75.2	78.8	65.0	74.3	75.7	-7.6	-9.9	-0.8
12	70.0	72.9	74.1	73.0	72.8	74.1	73.0	73.1	73.9	-0.9	-2.0	-0.2
13	73.0	77.8	74.4	73.0	77.6	74.4	72.0	77.9	73.8	-5.1	-1.5	-1.6
14	72.0	70.4	74.5	72.0	68.2	74.9	71.0	70.0	73.6	2.1	-2.7	-2.7
15	71.0	78.0	75.0	80.0	80.4	77.5	70.0	81.0	78.2	-6.1	-3.2	-0.4
16	65.0	69.8	70.0	71.0	69.9	69.9	71.0	70.3	69.3	-1.0	-0.7	-4.0
17	72.0	75.1	75.5	72.0	75.5	76.3	69.0	75.6	75.8	-4.4	-4.9	-4.0
18	69.5	69.6	68.9	69.5	69.4	69.4	71.0	69.4	68.8	0.5	1.0	-1.5
19	73.0	75.7	74.8	73.0	76.2	75.7	65.0	73.4	72.1	-4.8	-3.9	+3.8
								Study	Mean	-2.8	-2.5	-2.3

Thus, using six reports for each household derived from interviews conducted between April and May in 1986 and February through March in 1987, 10 households were able to report their mean daily temperature or thermostat setting with an average accuracy under 3°F. However in 1986 the mean discrepancy for evenings was -0.9°F, for daytime -2.0°F, and for night time, -2.9°F. In 1987 the corresponding figures were -1.6°F, -3.0°F and -3.9°F. Thus the respondents were least accurate for the period when the external temperature was lowest and the potential for heat loss greatest. Even if the reported setting is corrected for the average error found in this study, it would still slightly underestimate the cumulative temperature differential for the day.

Thermostat Setting Patterns

There appear to be two major factors influencing these results, the consistency of thermostat setting, and the amount of error in the report itself. These factors are illustrated in Figures 1, 2 and 3, which are plots of 15 minute observations during a one month period the first winter. Families 12, 13, 16 and 18 always set the thermostat within a narrow range and varied it little over the 24 hour period. Family 12 reported a setting of 72°F which was accurate to within a degree both years (Figure 1). Families 13 and 16 reported settings for the winter of 1985/86 that were almost never observed during February, 1986 (Figure 2). However the reported settings for family 13 were within 1.6°F of the recorded mean temperature at the thermostat (see Tables II and III). The calibration of the thermostat setting may have been several degrees higher than the dial the family referred to, or they may have been using the temperature gauge of the thermostat as a reference point. Regrettably, we had not identified this discrepancy at the time of the interview and failed to ask for an explanation.

Family 14 is an example of greater variation in settings. Their reports approximated the mean settings during the first winter within two to four degrees, but the February mode was 75°F, based on Figure 3. Family 15 reported a daytime setting of 75°F and a night time setting of 70°F during the first winter. These settings appear in Figure 4, and a clear setback (between 2:00 A.M. and 9:00 A.M.) is apparent, but at least three people regularly set the thermostat in this house, so their seasonal average was higher, with only a slight mean nighttime setback. A double setback pattern is clearly evident for house 19 in Figure 5, although the pattern has considerable scatter. Inspection of the data in the correct temporal sequence confirms that the scatter (especially in Figure 4), reflects the irregularity of the setback attempts.

Overall Patterns. A number of families reported that they set the thermostat several degrees higher or lower during some part of a 24 hour day. Others said that they kept a constant temperature. When the mean hourly settings were plotted against the time of day for each year, one half of these agreed with the reports of no change, or set ups or set downs. These were periods of several hours in length with one to three degrees difference in setting from another block of time. Thus half of the time respondents correctly reported their general pattern even if they predicted larger changes then those that appear in the seasonal averages.

Setpoint Change Behaviors: Before Weatherization. The main components of thermostat change behavior are illustrated in Figures 6, 7 and 8. Figure 6 shows the percentage of days with a recorded a change in the thermostat setting of at least 1°F during the day. Figure 7 illustrates the average number of changes per day and Figure 8 the average size of change for those days when a change in setting was recorded.

All of the families changed the thermostat at least some of the time, from a low of 15.6% of the days measured (house 10) to a high of 100% (house 19). Most of the families moved the thermostat setting nearly two days out of three, but this does not necessarily reflect setback behavior. In some cases no regular pattern by time of day was evident, suggesting that the changes are dictated solely by discomfort on the part of some resident in that house.

A very sharp pattern of double setback is evident at two houses, 15 and 19. Family 15 changed the thermostat on about 90% of the days recorded. It averaged 4.2 changes per day with an average thermostat change of 10.2°F. Family 19 changed the thermostat setting on 100% of the days recorded, making an average of 6.5 changes per day of 8.6°F. Some of the changes were irregular, so they don't show up on a graph of the average thermostat setting by time of day (compare Figures 4 and 5).

Family 10 had the lowest frequency of thermostat changes, the fewest changes on days when a change was made, and the largest average size of change. This family rarely moved the thermostat, but on some warmer days at the end of March it was set quite low during the daytime and returned to a more normal setting when outside temperatures dropped. Families 12 and 13 changed the thermostat about every other day, usually moving it twice and by a small amount, but there was no pattern by time of day. Family 17 changed the thermostat on 80% of the days, but the timing was irregular so that little variation appeared in the mean setting by time of day.

Setpoint Change Behaviors: After Weatherization. After weatherization most households adjusted the thermostat less. The percentage of days when there was a thermostat change was 71.9% in the winter of 1985/86 and 62.4% the following winter. The average number of changes per day dropped from 3.4 to 2.8 and the average size of the change dropped from 6.7 to 5.6°F. The size or the frequency of changes in either year do not appear to be systematically related to the relative accuracy of the families' reports, as measured by their mean settings in Tables II and III. Family 11 changed the procedure by which they paid their energy bills between the first and second winters, and they also changed their thermostat setting. The occupant of house 19 became ill at the beginning of the second season and was replaced by a relative who lived alone in the house. For this reason Figures 6, 7 and 8 contain columns showing mean values excluding families 11 and 19 as well as means of the entire group.

We believe that in responding to our questions, families reported their modal behavior, or their intended modal behavior, they didn't attempt to compute a mean setting. For the five families who consistently set their thermostats in a narrow range, the mean and mode coincided closely. For families who were less consistent, the coincidence between the reported and mean setting was more problematical, and the divergences between actual and reported behavior more often were on the high side. Properly framed interview questions should be able to establish those households with simple schedules of waking and sleeping and use of the house, and reported consistency of thermostat setting. (Some people say, "I always keep my thermostat at __.") We do not know how to predict consistency of behavior and the amount by which the reported *intended mode* will be less than the actual mean.

THERMOSTAT MANAGEMENT PRACTICES

Management Objectives

The families we studied manage their energy use for health, comfort, and economy. Families 10 and 15 had young infants at the beginning of the study and they kept the thermostat set high enough to protect the infants' health during the winter, "never less than 75" in the case of Family 15. Family 10 kept theirs set at 73-74°F except when bathing the baby, when they would set it to 80°F. Family 11 observed that their children were much healthier during the second winter after they raised their thermostat setting, but it wasn't clear that this was a specific measure taken to reduce the number of visits to the doctor. The occupant of house 19 had periodic difficulty breathing that necessitated auxiliary oxygen supplies and careful management of her home temperature and her activity levels to maintain her health and comfort. She would set her thermostat to about 75°F while she was awake and then put a house coat over her clothes and sit with a blanket if necessary to be warm without raising further the temperature of the house. She would set the thermostat down while she went out during the day because it frequently made her ill to return to a hot house.

All families stressed comfort as an important theme in regulating their thermostat, and in ventilating their homes in summer. In the winter their homes were drafty and cold, and they would set their thermostats so as to be warm enough, while not letting their bills get too high. For several families this objective was expressed: keep the bills as low as possible, as long as it doesn't get too cold. Everyone stressed economy in their discussion of their attempts to have their children keep the doors closed during the winter, turn off the lights and the water faucets, and not touch the thermostat except when directed to. Some people reported use of blankets and afghans to keep warm, or the use of heavy socks while in the house. They would also hang blankets over doors to control drafts. Most had plastic sheeting over their windows during the first season in an attempt to keep warm.

Changing Management Strategies

Family 11 changed its overall energy and financial management strategy between the first season and the second, one of the consequences being a higher thermostat setting. As social assistance recipients they received a heating allowance based upon their family composition, not upon the energy demands of their house. During the first season they took the responsibility of paying this allotment to the utility company. For the second season they arranged to have their allotment sent directly to the utility company by the Department of Social Services, thereby insuring themselves against fuel cutoffs for delinquent payments. They also raised their average thermostat setting 7.7 degrees, but forgot this when they were interviewed in the middle of the second winter. Families responded to the weatherization of their homes by raising their observed winter thermostat setting an average of 0.9°F. This takeback effect is discussed fully in another paper prepared for this conference (Weihl, Gladhart and Krabacher, 1988).

Comfort Preferences and Dwelling Conditions

Both interviewing and casual observation indicated that most of these families preferred to dress lightly while in their homes, they didn't want to be bundled up in coats and jackets. Most did not have the heavy natural fiber sweaters and other clothing that make it more comfortable to sit around in a cold, drafty house. Thus, a higher thermostat setting was the most common reaction to feeling too cold. Similarly, all but one family lacked any window coverings other than light curtains, and the presence of cold and drafty windows further encouraged higher thermostat settings.

In homes where more than one person adjusted the thermostat, it was because family members had different preferences for temperatures, or they had different schedules of working and sleeping. People seemed to have quite consistent internal perceptions of the "right" temperature. For example, the thermostat in house 10 was changed during October of 1986, and the new one appears to have been calibrated so that the thermostat setting when the circuit would close and turn on the furnace was consistently about 5°F higher than the temperature reading at the thermostat. The occupants' response was to set the thermostat about 5°F higher so that the effective interior temperature as recorded by our probe in the thermostat was a remarkably constant 75°F for both years.

Management Strategies and Consistency of Family Schedules

The most accurate report of a setback schedule can be undermined by the irregularity of a person's daily schedule. The occupant in house 19 was a retired woman who lived alone except during periods of illness when her granddaughter would spend the nights with her. She reported that she set her thermostat at 75°F while she was up but set it down to 65°F while sleeping and to 60°F while gone during the day, because it made her ill to return to a hot house.

Figure 5, a plotting of the thermostat setting for house 19 from February 21 to March 14, 1986, clearly shows the pattern the resident described. The thermostat was set between 73 and 77°F about 8:30 in the morning, down to about 60°F at 12:30 and back up near 75°F between 4:30 and 5:30 P.M., then down around 65°F at 11:30 P.M. However there is considerable variation in the times of her comings and goings, and some days she seems to have stayed home, or left the thermostat up when she went away. It would also appear that on one day she left in the afternoon and did not return until the next day. Consequently the mean setting traced on the graph has sloping shoulders on the setbacks rather than the sharp steps implied by her description.

Managing the Unmanageable

A widowed head of a three generation household lived in house 15. One adult daughter worked part time and a daughter-in-law with infant twins was a part time student in the community college. A 10 year old grandson often slept at the house and he and his friends played in and around the house in the afternoons. The winter before weatherization they reported keeping their thermostat between 70 and 80°F, "never less than 75", because of the twins. Figure 4 bears out their report, suggesting they set and reset their thermostat because of the comfort requirements of a number of different people. Except for setting the thermostat down at night, there seems little evidence of management here.

In fact, management in the sense of controlling and guiding of the interior temperature was hardly possible in house 15 before weatherization. Before weatherization, all the internal temperatures tracked the curve of the external temperature, practically unrelated to the height of the thermostat setting. The thermostat really did function as a valve, letting in enough heat to keep the leaky house sufficiently above the external temperature to be comfortable, somewhere between 72 and 75°F. After weatherization the internal temperatures, especially that at the thermostat, tracked the thermostat itself. A principle effect of the weatherization was thus to bring the internal temperatures and comfort levels much more under the control of the occupants, making thermostat management efforts more effective and presumably more rewarding.

SUMMARY

Household occupants are surprisingly accurate in reporting their mean thermostat settings for entire seasons, within two to three degrees when averaged over only ten families. This is probably the range of perceptual error in noting and recalling actual settings, and we think it unreasonable to expect people to be more accurate. Examination of the impact of various thermostat management strategies suggest why some people can report much more accurately than others. People with a constant setting strategy should be more accurate than those with complex, irregular or no strategies, but some of them give biased accounts. The fact that many with irregular patterns have only modest discrepancies suggests that their estimates have the properties of means, with variations distributed rather evenly above and below the estimate. Within a group of householders, some will overestimate their settings, helping to offset those who underestimate them. The discrepancies reported in the literature to date are sufficiently similar that we may begin to think of a two to three degree underestimate as a provisional standard adjustment for reported thermostat settings in winter time.

FOOTNOTES

1. Our research is part of the MSU Family Energy Project in the Institute for Family and Child Study, College of Human Ecology. This work is supported by the Michigan Agricultural Experiment Station, Project 3152. The research was performed under a contract with Oak Ridge National Laboratory, Project 19X-55913C: Monitoring Interactions of Energy Use Behavior and Residential Retrofits. This is Michigan Agricultural Experiment Station Journal Article No. 12687.

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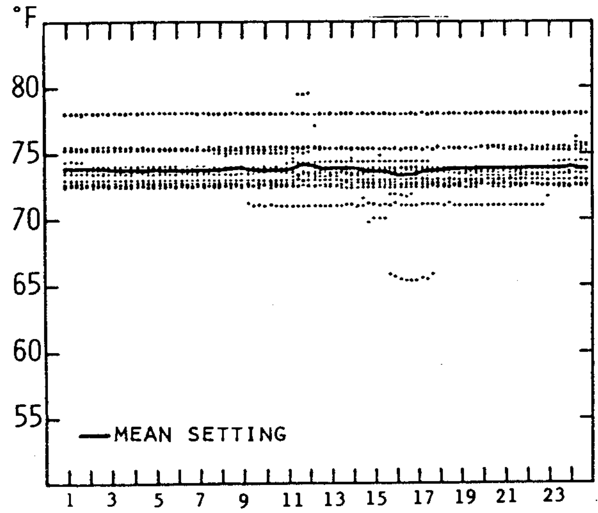

Figure 1. House 12. Feb 8-Mar 7,86

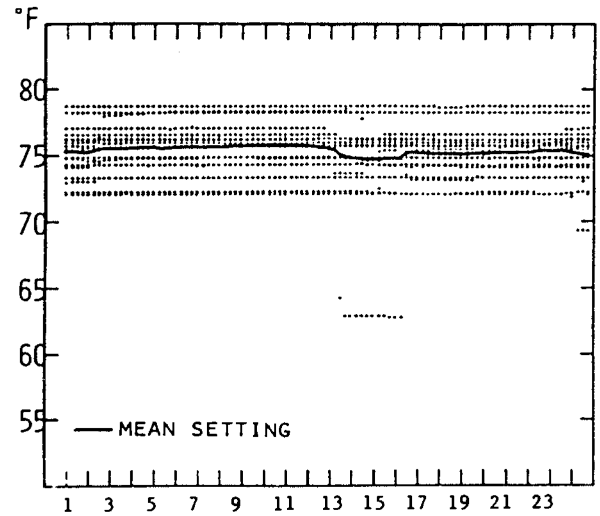

Figure 2. House 13. Feb. 1-28, 1986

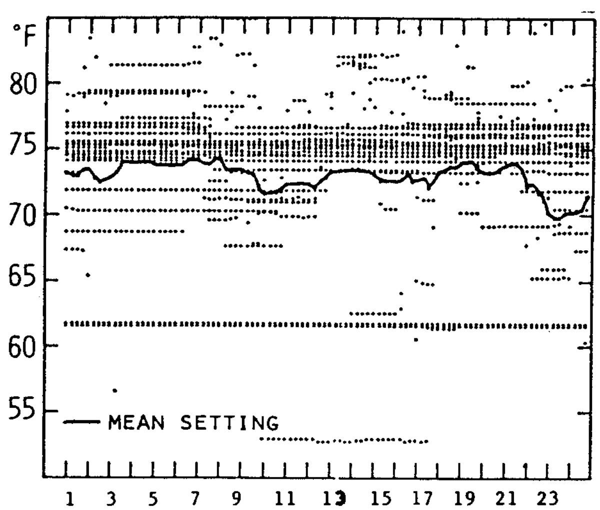

Figure 3. House 14. Feb. 1-28.86

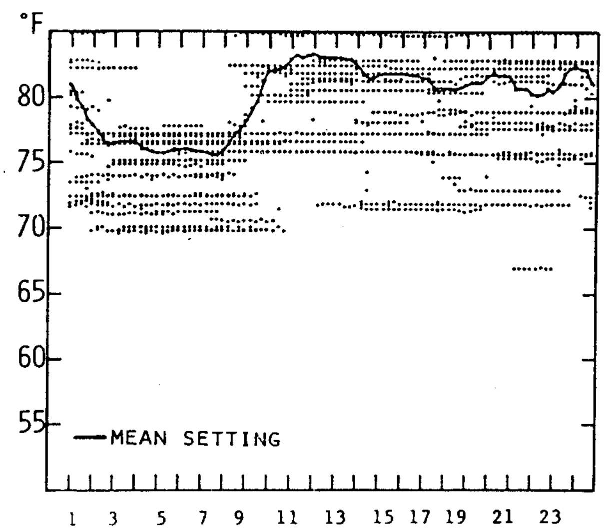

Figure 4. House 15. Feb.1-21,86

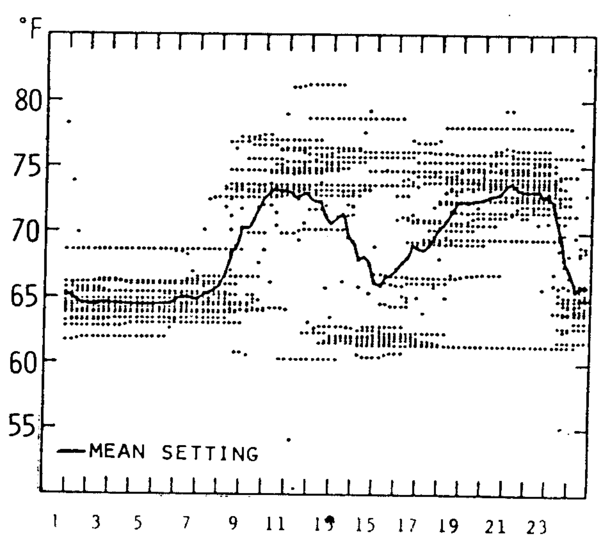

Figure 5. House 19. Feb 21-Mar 14,86

Thermostat settings by time of day - military time.

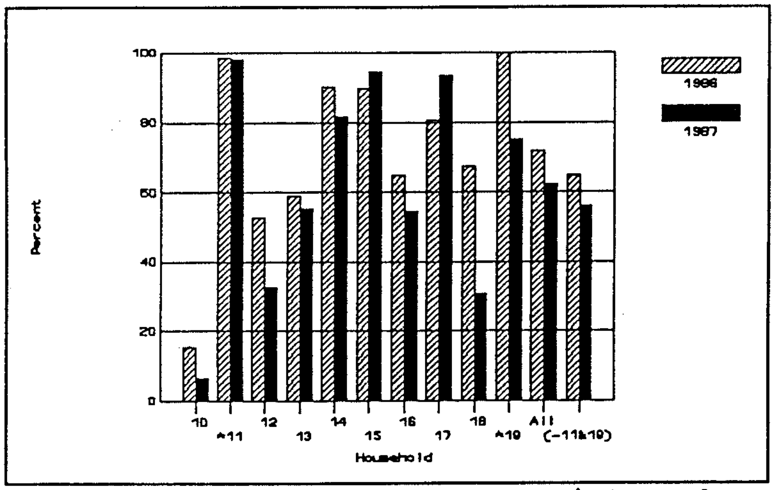

Figure 6. Percent of all winter days with thermostat setting changes.

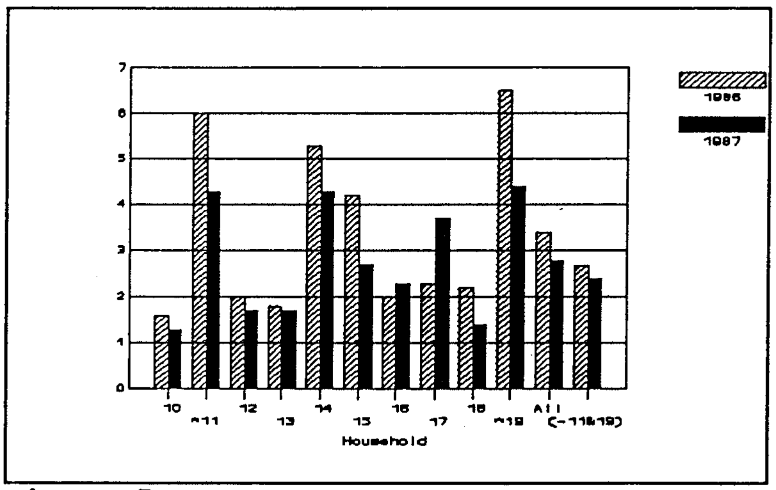

Figure 7. Mean number of thermostat changes per winter day.

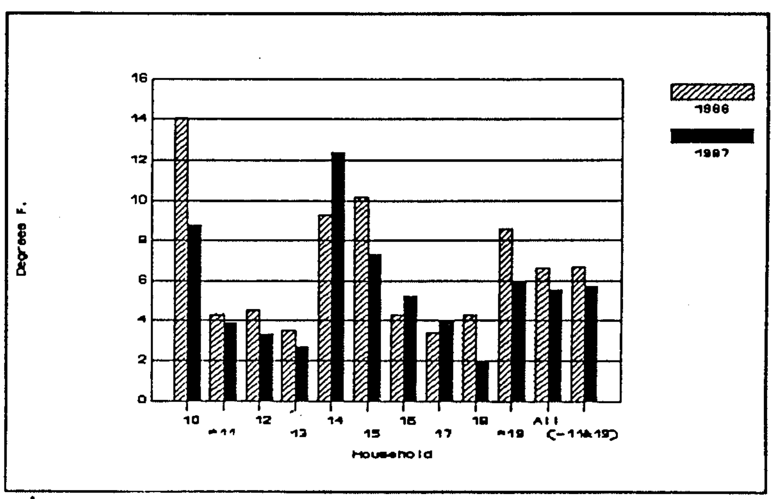

Figure 8. Mean number of degrees F per winter thermostat change.