The Takeback Effect in Low Income Weatherization: Fact or Fiction?

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ABSTRACT

Occupant behavior has been suspected in causing unexpectedly low energy savings resulting from weatherization programs. A belief that occupants will "take back" in increased comfort or decreased management some of the potential savings of weatherization has come into vogue. This view implies that occupants may feel more comfortable dialing up their thermostats a few degrees, or with being less vigilant about thermostat setback, in homes they feel are now energy efficient.

Ten low-income weatherization program participant households were studied to examine how occupant behavior might change after homes are weatherized. Electronic monitoring of thermostat setting behavior was coupled with ethnographic data, utility billing data, and blower door tests to determine if behavior changed, and if so, why. Generally thermostat setting behavior changed very little. Behavioral changes that did occur were usually due to factors unrelated to the weatherizing of the house. This paper puts these results in the context of previous studies of the takeback effect and concludes that very little takeback is evident.

THE "TAKEBACK EFFECT" IN LOW-INCOME WEATHERIZATION: FACT OR FICTION?[1]

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INTRODUCTION

Residential retrofit evaluations have been unable to account for the substantial differences between predicted energy conservation and actual energy savings. Typically, post-retrofit analyses find that the expected levels of energy conservation predicted by audits and technical models are not realized. It has been hypothesized that much of this gap may be the result of changes in occupant behavior and that occupants may be "taking back" some of the potential energy savings in increased comfort (i.e. higher heating and lower cooling thermostat settings).

Only recently has the "takeback effect" been critically examined. This article reports on a study of the takeback effect among low-income weatherization participants in Lansing, Michigan, and places these results in the context of the growing body of evidence regarding the existence of the "takeback effect".

THE GAP BETWEEN ACTUAL AND PREDICTED CONSERVATION

Inaccurate prediction of energy conservation in residential retrofit programs is a serious obstacle to presenting conservation as an alternative source of energy. Since conserved energy is now often seen as cheaper and easier to obtain than other supplies of energy, the accurate prediction of its potential is important to agencies planning for meeting future energy needs. Lack of reliability is a major objection against considering conserved energy as a viable way of meeting future energy needs.

Similar problems affect the design and application of low-income weatherization programs. The implied goal of low income weatherization programs is to reduce energy consumption though capital improvement in order to reduce direct energy payment subsidies to low income families. The inability to accurately predict actual energy savings not only makes the selection of the most effective retrofit actions problematic, but also makes it difficult to justify low-income weatherization as a cost-effective tool for reducing energy consumption.

The gap could be caused by poor models, bad audits, poor weatherization, inappropriate weatherization program design or application, or occupant effects, notably raising the thermostat temperature. For energy conservation professionals it is tempting to attribute the bulk of the gap to the takeback effect and occupant behavior rather than to our own models, audits, or weatherization program designs.

THE TAKEBACK EFFECT: DEFINITION AND DISCUSSION

The central premise underlying the "takeback effect" is that occupants may perceive their newly weatherized houses to be sufficiently more energy efficient after weatherization that their energy costs have been significantly lowered. Behaviors such as raising winter (and lowering summer) thermostat settings and opening up closed off rooms can result from the rational economic calculations of occupants to purchase more comfort based on a fixed energy budget. Alternately, less regular thermostat setback and more window and door opening behavior can be interpreted as less effective or vigilant management caused by a perception by the occupant that rigorous management is less productive (fewer dollars saved per unit of time spent) or necessary in a more efficient house.

What are the reasons for suspecting that occupant behavior is a major factor underlying the predicted/actual conservation gap? Occupant behavior can impact the gap in two ways. First, behaviors can deviate significantly from those assumed by models and audits, causing errors in the calculations of potential conservation. Secondly, changes in occupant behavior after weatherization could lead to them taking back some of the potential savings. Since the gap has been observed in different weatherization programs, using different modeling assumptions, it is logical to first look at the takeback effect or at changes in occupant behavior after weatherization.

Researchers have noted (Stern and Aronson, 1984; Kempton et al., 1985; Kempton and Montgomery, 1982) that occupant behavior is not understandable from a purely "economically rational" model. Behaviors affecting energy use can be affected not only by economic variables, but by type of end use, social values, lifestyles, and family schedule. These factors may affect post-retrofit thermostat setting behavior in ways that might lead to elevated thermostat settings. Kempton and Montgomery, and Kempton et al. demonstrated that consumers have cognitive models regarding energy and economic calculation that differ from expert models. These "folk models" and consumer biases are affected by both the cognitive salience of specific energy end uses and of the units used to measure energy consumption and conservation. Such models could account for seemingly irrational consumer behavior leading to takeback.

Since the goal of explaining the gap is to reduce it, it is important to find out if indeed the takeback effect is the most important factor, one of several critical factors, or not a major factor. It is particularly important to separate out the effects of occupant behavior from the other factors since occupant behavior is perhaps the hardest to control from a weatherization program perspective. If indeed takeback effects are significant, strategies to increase the effectiveness of weatherization programs will be markedly different from the technical, administrative, quality control, and conceptual strategies associated with other potential causes of the gap.

PREVIOUS FINDINGS

Because the takeback effect is a relatively recent concern in weatherization, data are scarce and often inferential in nature. The studies of the takeback effect to date have used a number of different methods. Some utilizing self reported data or utility data have indicated the existence of a takeback effect, but none, including this study, utilizing measured thermostat or interior temperature have found evidence of takebacks large enough to account for a large part of the gap.

Vine (1986) proposed that thermostat reduction in the face of the energy crises of the 1970s may be a transitory in nature and that once the crises were perceived as being over the significant savings resulting from lower winter and higher summer thermostat settings could be reduced or eliminated. He speculated that such a "rebound effect" could already have occurred in homes that have been weatherized. He analyzed occupant reports of their thermostat setting behavior in a large number of utility studies. Since no data were gathered regarding installation of conservation equipment or participation in weatherization programs, household participation in audits was used as an approximation. Vine postulated that households that had audits performed would be more likely to have weatherized their houses and thus more susceptible to the rebound effect, thus they would have higher winter thermostat settings than non-audit participants. In fact there were no significant differences between non-audit and audit groups.

Inferring Behavior from Utility Data

Hirst and White (1985) studied 242 electrically heated households which participated in the Bonneville Power Administration's retrofit programs in 1982 and 1983. They used the Princeton Scorekeeping Method (PRISM) for disaggregating electrical heating and baseload consumption from utility records. Using Fels and Goldberg's methods (1984) they separated the changes in the heating component into changes in baseload, changes in thermal performance of the structure, and changes in interior temperature.

Hirst and White calculated that interior temperature increased by 0.4°F among the 1982 participants and by 1.3°F in the 1983 sample. A control group left their interior temperatures relatively unchanged. They further calculate that 5% of the potential energy savings due to the weatherization, were "taken back" in the first sample and 25% were taken back in the second.

Since the collection of utility data is comparatively cheap, and large samples can be used and the results can be generalized to large populations. However the use of inference rather than direct measurement is an important disadvantage. The precision of the Fels and Goldberg method for disaggregating the effects of interior temperature changes from the effects of structural changes must also be demonstrated, especially in cases where small changes in behavior or structural performance are inferred.

Inferring Behavior from Interior Temperature

Dinan's (1987) and Stovall and Fuller's (1987) analyses of 252 participant households in the Hood River Conservation Project used instrument collected data (total and space heating electricity consumption, and interior temperature) to measure takeback effects directly. Both studies found statistically significant increases in interior temperature after retrofit. The increase, 0.6°F, was quite small, accounting for only 6.4% of the gap between predicted and actual savings for that project. The analysis also showed that low-income households demonstrated a higher degree of takeback (0.9°F), than did the mid and higher income households.

Research which uses monitored interior temperature eliminates some of the uncertainties in dealing with only billing data. One level of inference is eliminated in separating occupant effects from structural performance. Data can also be gathered at a much finer level (at 15 minute, or hourly intervals) than monthly utility billing data permits, and analyses using this data will have much greater precision. However, like the Fels and Goldberg method, this method uses interior temperature as a proxy for thermostat setting data, and occupant behavior must be inferred.

Questions also arise when inferring thermostat setting behavior from interior temperature (measure or inferred). Can increased interior temperatures be reasonably attributed to higher thermostat settings or to an increased thermal capacitance of the dwelling? That is, does the house now cool off sufficiently slower that interior temperature more reflects the thermostat setting rather than the exterior temperature?

Self-Reported Behavior

As an alternative to inferring thermostat setting from interior temperature measures, Duckert (1985) reports on a weatherization program in Minnesota using occupant reported data. One third of the program participants reported increasing their thermostat settings after the energy conservation actions were taken. The magnitude of this increase was not reported.

Because thermostat setting data was occupant reported it is hard to interpret. On one hand researchers are skeptical in some ways about the accuracy of self-reported thermostat setting data in general (Hirst and Goeltz 1985, Kempton and Krabacher 1986, Gladhart et al. 1988) and regarding behavior after weatherization in particular (Terness and Wasserman 1988). On the other hand the difficulties with self-reported thermostat setting behavior have always emphasized a strong bias for reported settings *lower* than actual and for *overemphasizing* how much energy conservation occurred. Since the data in this study report higher thermostat settings, counter to the expected bias, it is not clear whether to give them little credence or to suspect that the takeback effect was even stronger than reported.

Directly Measured Behavior

More recently, studies have attempted to measure actual thermostat settings. Terness and Wasserman (1987) collected interior temperature and thermostat setting data from 15 households participating in the Weatherization Assistance Program in Wisconsin. This study found that, in general, occupants maintained the same thermostat setting management practices after weatherization and that "consistent changes in the indoor temperature due to retrofit installation (indicating a possible take-back effect) were not observed" (p. 52). The study also made some important findings regarding the relationships between household temperature and thermostat setpoint:

> Thermostat (actual) temperature and setpoint values could not always be inferred from each other. The average value of one over a time period did not necessarily indicate the average value of the other. Moreover, a change in one following retrofit installation was not necessarily accompanied by a change in the other. (pp 52-53)

These findings suggest that the use of interior temperature as proxies for thermostat setting behavior may be inappropriate or problematic. This is especially problematic when the second inferential step of inferring interior temperature from fuel bills (as in the Fels & Goldberg method) is added. The findings argue for more direct monitoring of actual thermostat setting behavior when thermostat setting data is required.

MICHIGAN TAKEBACK STUDY

This paper augments the previous studies by reporting on the indepth study of ten Lansing, Michigan low-income weatherization program participants. The project, conducted by the Institute for Family and Child Study at Michigan State University, much like the Wisconsin project, used a multi-method approach to intensively investigate actual behavior in a small number of residences. The prime interest of the project was to identify energy management strategies, and to examine whether they were changed subsequent to weatherization. Specific objectives were: 1) to determine if the takeback effect is apparent in a small sample of low-income weatherization program participants, 2) to identify energy consumption behavioral changes that occur after weatherization which would influence conservation in either a positive or a negative manner, 3) to formulate some idea of the magnitude of behavioral changes after weatherization, 4) to try and explain on a case-by-case basis, changes in energy consumption after weatherization with reference to a broad spectrum of factors.

Research Design

The project utilized an energy behavior monitoring system, previously designed at MSU (Weihl, Kempton, and DuPage 1983), to measure several behavioral and space heating variables. This system was installed in the homes of low-income weatherization participants for a period covering two winters, between which retrofits were performed. The study uses pre-post test and case-study formats, applying a variety of methods before and after weatherization. The project was primarily interested in measuring occupant behavior in the form of thermostat setting activity and ventilation activity.

Ten low-income weatherization participant households in Lansing, Michigan made up the study group. All received some type of public assistance, although some received it only sporadically. Five of the households were black and five were white. Households were selected by the weatherization agency on the basis of similar house type and size. Since the research was presented as a part of the weatherization program (ostensibly to evaluate the performance of the retrofits), and there was virtually no refusal rate, when contacting occupants, we believe that the occupants were typical of program participants in general.

The houses in the project were all single family, two story wood frame homes. The age of the houses ranged from 50 to 80 years; seven were 50 to 60 years old. They were of similar size, 1100 to 1400 square feet of living space, used natural gas for heating fuel, and were generally in poor repair and very leaky. All occupants reported serious comfort defects in their homes which generally prompted their participation in the low-income weatherization program. None of the participants dropped out of the study.

Data Collection

Data were collected using four methods: utility metering, ethnographic interviews, blower door tests, and automatic instrumentation. The instrumentation was designed to be unintrusive and to influence occupant behavior as little as possible. Typically sensors, wiring and instruments could not be seen or heard by occupants. Previous experience with this instrument package indicate that occupants were minimally influenced by the instrumentation.

The instrument package typically monitored exterior temperature, thermostat setting, three interior temperatures (one at the thermostat), exterior door open-time (all doors), window open-time (usually three or four which were reported as the most used), and furnace run-time. Temperature data were generally accurate to within 0.1°F and run-time data were accurate to within 2 seconds per "event". Thermostat setting data were also very accurate (to at least 0.1°F), in fact the sensor could detect adjustments much more accurately than could the thermostat dial itself.

The results of the ethnographic data are not presented in this report, for analysis of this data, see Gladhart et al. (1987) and Gladhart et al. (1988).

Results

The data analyzed in this report were gathered in the winters of 1986 and 1987. Weather during the two winter data collection periods was surprisingly comparable as average degree days were similar. No fall or springlike weather occurred during these periods. No households turned off their furnaces, nor did exterior temperature get sufficiently warm to significantly heat the houses to or above normal thermostat settings (either of which would have made thermostat setting interpretation more problematic).

Important changes significant to interpreting energy use occurred in two households. In one occupants paid their energy bills (from a welfare allotment) themselves the first winter, but after weatherization their bills were paid directly by the department of social services to the utility under their "vendor program" (this house is referred to as house 11 in the subsequent text). The lone occupant of one house was hospitalized during the second winter and relatives occupied her house while she was gone (household 19).

Weather Adjusted Natural Gas Consumption. Table I. reports the weather adjusted gas consumption for the ten households (numbered 10-19). The difference between the rate of fuel used before and after weatherization ranges from a decrease of 0.066 Therms per degree day to an increase of 0.026, but on the average fuel consumption decreased by 0.023 Therms per degree day. Consumption change percentages range from -21% to +15%. The average change in fuel consumption rate was a decrease (or savings) of 10% after weatherization. Excluding the two households (11 and 19) which changed occupants or energy billing from the experimental analysis, the average fuel consumption for the remaining households dropped by 0.033 Therms per day, or 15%. Indicating that the weatherization generally had a substantial impact on energy use. Subsequent discussion will use only averages excluding houses 11 and 19 since our study was looking for changes due to the retrofit, not due to changes in occupancy or billing.

Table I. Winter Gas Consumption

House	'86 Therm/DD	'87 Therm/DD	Difference Therm/DD	%
10	0.217	0.182	-0.035	-16%
11	0.178	0.204	0.026	14%
12	0.211	0.163	-0.048	-23%
13	0.273	0.274	0.001	0%
14	0.141	0.125	-0.016	-12%
15	0.330	0.264	-0.066	-20%
16	0.217	0.170	-0.047	-22%
17	0.239	0.211	-0.028	-12%
18	0.127	0.104	-0.023	-18%
19	0.160	0.169	0.009	6%
Average	0.209	0.187	-0.023	-10%
*Average	0.219	0.187	-0.033	-15%

(* excluding 11 & 19)

Seven out of ten houses show a decrease in the rate of fuel consumption after weatherization, one house showed little change, and two consumed more fuel. The number of Therms per degree day used for heating before weatherization ranged from 0.127 to 0.330. After weatherization consumption ranged from 0.104 to 0.274.

Based on the energy savings in this sample, under normal conditions (where the occupancy or bill paying method do not change) a saving of 15 percent of fuel (or a mean annual savings of $87.55 at $0.49/Therm) is our best estimate of what might be expected from similar weatherization of the homes of other low income families.

Blower Door Tests. The best available quantification of the effects of weatherization derive from pre and post weatherization blower door tests. Average results of two measures, Equivalent Leakage Area (pre 3.34 ft^2, post 2.42 ft^2), and Air Changes per Hour @ 50 Pascals pressure (pre 17.25, post 12.24), demonstrate that weatherization improved all the houses in the sample decreasing infiltration by roughly a third, but some households registered bigger gains than others.

Average Winter Thermostat Settings. Figure 1 shows mean winter thermostat settings for each house during the two seasons. After weatherization six out of ten of the houses in the sample raised their thermostat settings by as much as one degree. The average increase excluding houses 11 and 19 was only 0.9°.

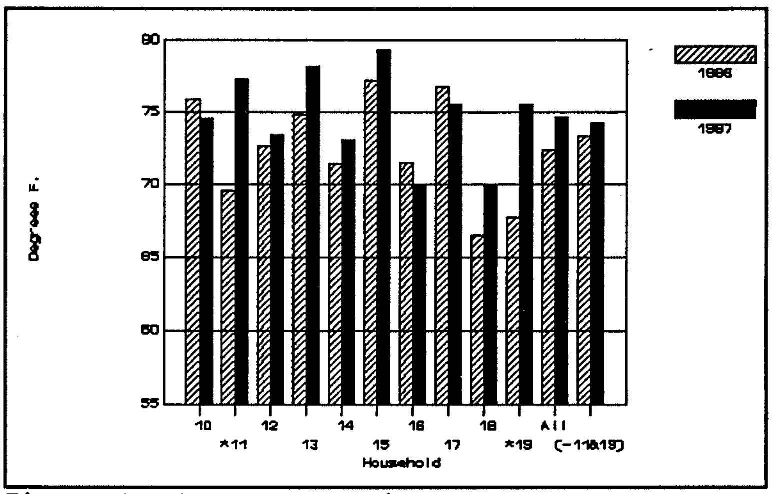

Figure 1. Mean winter thermostat settings.

Daily High and Low Thermostat Settings. Figure 2 shows the changes in mean daily high and low thermostat settings that occurred after weatherization. The mean daily high (excluding 11 & 19) rose by an average of 0.3°F which is less than the 0.9°F increase in overall average thermostat settings. Houses 11 and 19 show the largest increase in the mean daily high, but neither by as much as the 7.7°F and 7.8°F mean thermostat increases in the same houses. This same pattern is evident in all of the houses that increased their overall average during the winter of 1987. Three houses registered substantial declines in the mean daily high.

The mean daily low thermostat setting increased 1.4F° during the second winter (excluding 11 and 19). The small increase in mean thermostat setting is probably more the result of higher daily low settings than increased daily high settings. Four houses decreased the mean daily low.

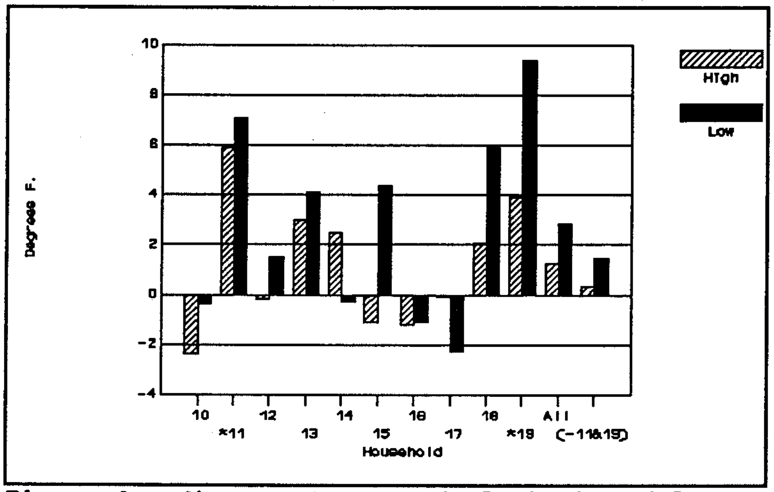

Figure 2. Changes in mean daily high and low thermostat settings after weatherization.

Thermostat Manipulation. Figures 3, 4 and 5 summarize the degree to which households manipulated their thermostats during the two winters. Before weatherization all of the houses changed the thermostat at least some of the time, from a low of 15.6% of the days measured to a high of 100%. Most of the houses moved the thermostat setting nearly every day, but this does not necessarily reflect setback behavior. In most (eight of ten) cases no regular setback pattern is evident, suggesting that much of the thermostat manipulation is dictated chiefly by discomfort on the part of some resident in that house.

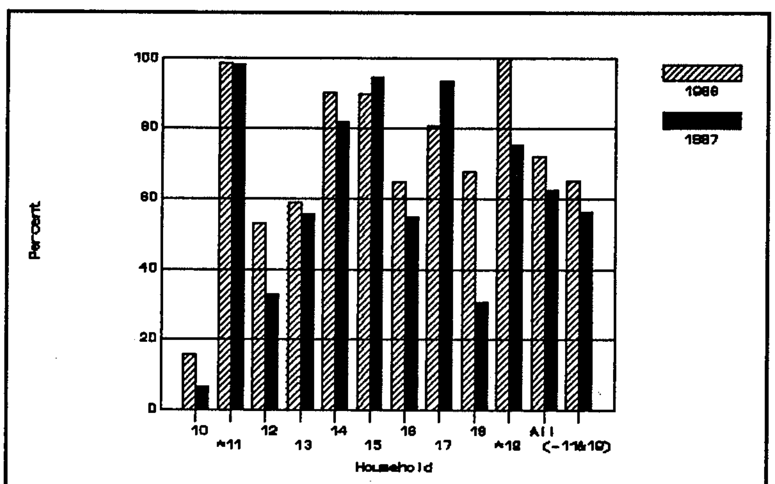

Figure 3. Percent of all winter days with thermostat setting changes.

After weatherization most households manipulated their thermostat considerably less. The percentage of days when there was a thermostat change was 71.9% in the first winter and 62.4% the following winter. The average number of changes dropped from 3.4 to 2.8 and the average size of the change dropped from 6.7°F to 5.6°F.

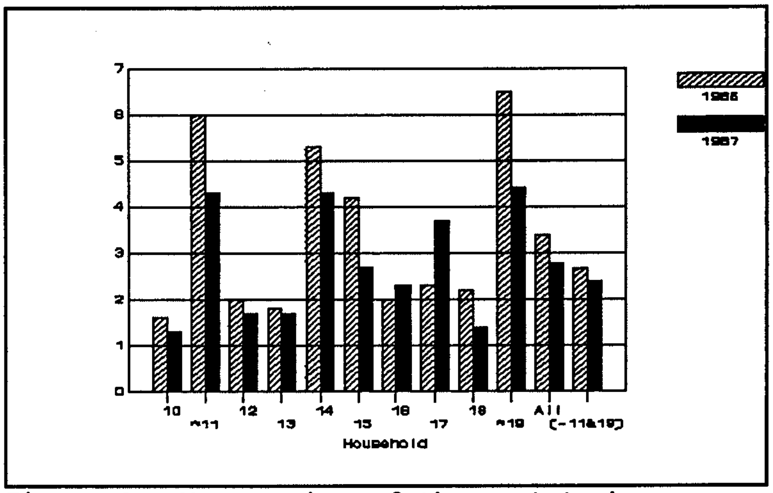

Figure 4. Mean number of thermostat changes per winter day.

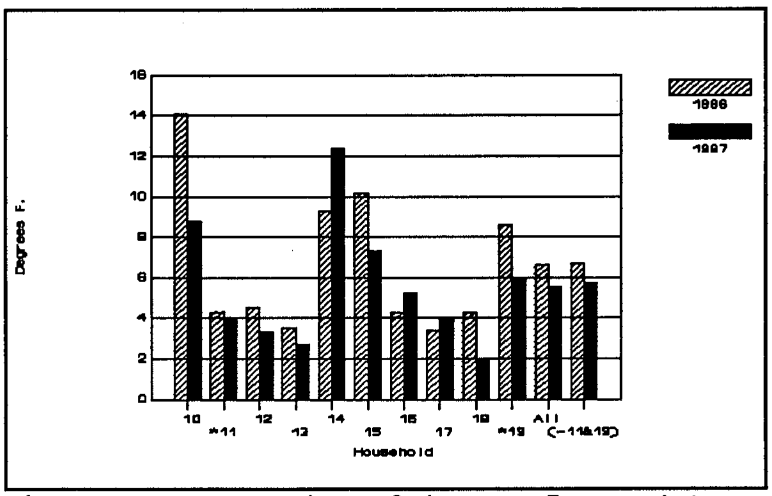

Figure 5. Mean number of degrees F per winter thermostat change.

The changes in the frequency, number, and size of thermostat manipulations may reflect increased resident comfort and less need to manipulate the thermostat to maintain a comfortable temperature in the house. This seems particularly likely in those households that had higher average thermostat settings. It is possible, especially in low-income households, that weatherization can improve structural performance so that interior temperature is more responsive to thermostat setting than to exterior temperature, such that occupants perceive less of a need to manipulate their thermostats (such a perception might explain Duckert's description of self-reports of takeback).

Discussion

The eight families with stable experimental conditions show very little takeback effect: the daily mean thermostat setting increased by 0.9°, the mean daily high increased by 0.3° and the mean daily low increased by 1.4°. Families decreased the percent of days when they changed the thermostat, the number of times per day it was changed and the average size of the change.

The most significant changes in thermostat setting from one season to the next were caused by changes in household composition or changes in family schedules, factors that had nothing to do with takeback. People were managing their energy to stay comfortable before weatherization, and they continued to respond to the came criteria after weatherization. The internal temperature preference of individuals seems quite stable over a two year period of time.

Statistical models of monitored furnace run-time were calculated for each house, using several thermostat setting parameters (daily means, daily highs, daily lows) for both seasons (except house 10, which had missing data). With exterior temperature held constant, the changes in thermostat setting behavior from pre to post weatherization (mean increase of 0.9°F) were found to account for (excluding houses 11 and 19) a 1.7% increase in the post weatherization furnace run-time. The 15% drop in gas consumption is therefore not likely to have been much greater, had thermostat setting behavior remained the same.

Thus, in the Michigan sample there was very little evidence of significant takeback. Major thermostat setting behavioral changes were caused by factors unrelated to takeback. The main behavioral response to weatherization seems to have been to maintain the thermostat management strategy evident before weatherization, modified by slightly higher mean daily low thermostat setting, less frequent thermostat manipulation and thermostat setting changes of smaller magnitude.

CONCLUSIONS

The results of the Michigan takeback study support the findings of previous research which found only slight evidence of takeback. Taken together these findings (excepting Hirst and White's 1983 sample) suggest that there may indeed be a tendency for some minor takeback after weatherization in some cases, but that the takeback effect is probably not the major "culprit" causing the gap between estimated and actual weatherization energy conservation. There may however be some behavioral responses related to frequency and magnitude of thermostat setting behavior which are related to weatherization.

REFERENCES

Dinan, Terry M. An Analysis of the Impact of Residential Retrofits on Indoor Temperature Choice. Oak Ridge National Laboratory, Oak Ridge, TN. ORNL/CON-236. 1987.

Duckert, Joseph M. "Household Energy Use in the Year 2000". In Families and the Energy Transition. John Byrne, David Schulz and Marvin Sussman (eds). pp 269-285. New York: The Hawthorne Press. 1985.

Fels, Margaret, and Miriam Goldberg. "Using Billing and Weather Data to Separate Thermostat from Insulation Effects". Energy. Vol. 9, No. 5. 1984.

Gladhart, Peter M., Shirlee Krabacher, and Jeffrey S. Weihl. Final Report, Project 19-X55913C: Monitoring Interactions of Energy Use Behavior and Residential Retrofits. Institute for Family and Child Study. Michigan State University, East Lansing, MI. 1987.

Gladhart, Peter M., Jeffrey S. Weihl and Shirlee Krabacher. "Reported versus Actual Thermostat Settings". Paper presented at the 1988 Summer Study, American Council for an Energy Efficient Economy. Pacific Grove, CA. 1988.

Hirst, Eric and Richard Goeltz. "Accuracy of Self-Reports: Energy Conservation Surveys". The Social Science Journal. Vol. 22, No. 1. pp 19-30. 1985.

Hirst, Eric, and Dennis White. Indoor Temperature Changes After Retrofit: Inferences Based on Electricity Billing Data for Nonparticipants and Participants in the BPA Residential Weatherization Program. Oak Ridge National Laboratory, Oak Ridge, TN. ORNL/CON-182. 1985.

Kempton, Willett, Craig K. Harris, Joanne G. Keith, and Jeffrey S. Weihl. "Do Consumers Know 'What Works' in Energy Conservation?". In Families and the Energy Transition. John Byrne, David Schulz and Marvin Sussman (eds). pp 115-134. New York: The Hawthorne Press. 1985.

Kempton, Willett, and Shirlee Krabacher. "Thermostat Management: Intensive Interviewing used to Interpret Instrumentation Data". In Energy Efficiency: Perspectives on Individual Behavior. Willett Kempton and Max Neiman (eds). pp 245-262. American Council for and Energy Efficient Economy. 1986.

Kempton, Willett and Laura Montgomery. "Folk Quantification of Energy". Energy-The International Journal. Vol 7(10):817-827. 1982.

Stern, Paul, and Elliot Aronson (eds). Energy Use: The Human Dimension. New York: W.H. Freeman and Co. 1984.

Stovall, Therese K. and Len C. Fuller. Effect of Lifestyle on Energy Use Estimations and Predicted Savings. Oak Ridge National Laboratory, Oak Ridge TN. Draft report ORNL/CON-241. 1987.

Ternes, M. P., and D.M. Wasserman. Field Test Evaluation of Conservation Retrofits of Low-Income, Single Family Buildings in Wisconsin: Occupant Behavior and House Thermal Characteristics in Fifteen Energy Conservation

Retrofitted Houses. Oak Ridge National Laboratory, Oak Ridge, TN. Draft report. ORNL/CON-228. 1987.

Vine, Edward. "Saving Energy the Easy Way: An Analysis of Thermostat Management". In Energy Efficiency: Perspectives on Individual Behavior. Willett Kempton and Max Neiman (eds). pp 121-134. American Council for an Energy Efficient Economy. 1986.

Vine, Edward, Paul Craig, James Cramer, Thomas Dietz, Bruce Hackett, Dan Kowalczyk, and Mark Levine. "The Applicability of Energy Models to Occupied Houses: Summer Electric Use In Davis". Energy, vol. 7, no. 11, pp 909-925. 1982.

Weihl, Jeffrey S., Willett Kempton and David DuPage. "An Instrument Package for Measuring Household Energy Management". Conference Proceedings - Families and Energy: Coping with Uncertainty. Michigan State University, East Lansing, MI, pp. 629-641. 1983.

NOTES

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