JOURNAL OF APPLIED BEHAVIOR ANALYSIS 1979, 12, 173-184 NUMBER 2 (SUMMER 1979)

EFFECTS OF SELF-MONITORING AND FEEDBACK ON RESIDENTIAL ELECTRICITY CONSUMPTION

RICHARD A. WINETT, MICHAEL S. NEALE, AND H. CANNON GRIER

INSTITUTE FOR BEHAVIORAL RESEARCH, INC., SILVER SPRING, MARYLAND

Prior research has indicated that frequent feedback could reduce residential electricity consumption by 10% to 15%. However, because feedback was primarily given in written form, this procedure might not be practical. The present study evaluated a potentially more practical feedback procedure during peak-use periods with high electricity consuming households. The study was conducted during the winter in an upper-middle class neighborhood of almost identical, all-electric townhouses (N = 71) that averaged about 170 KWH per day per household for a monthly bill of over $200. Twelve households received daily written feedback. Sixteen households (self-monitoring) were taught to read their outdoor electricity meter and to record KWH used every day. A comparison group was composed of 14 households that had volunteered to participate and 29 others that had only given permission to have their meters read. During a 1-month period that the procedures were in effect, the feedback group reduced consumption by 13% and the self-monitoring group by about 7%. These reductions, relative to the comparison group, were maintained during an early spring 1-month follow-up period and, to a lesser extent, during a 6-week warm spring period. Self-monitoring participants were highly reliable and persistent meter readers. Reductions in electricity use were reported by households to be largely attributable to lowering of the heat thermostat, and large monetary and KWH savings were found. Techniques to make self-monitoring cost-effective important components of the self-monitoring procedure, methods to apply self-monitoring more broadly, and plans to combine behavioral procedures with physical technology are discussed.

DESCRIPTORS: behavioral community psychology, feedback, self-monitoring, energy consumption, energy conservation, households

Recent studies have demonstrated that frequent (at least several times per week) or continuous feedback can reduce residential energy consumption by as much as 10 to 15% (Becker, 1978; Hayes & Cone, 1977; Kohlenberg, Phillips, & Proctor, 1976; Palmer, Lloyd, & Lloyd, 1978; Seligman & Darley, 1977; Winett, Kaiser, & Haberkorn, 1977; Winett, Neale, Williams, Yokley, & Kauder, in press). Studies using feedback on monthly bills or weekly statements have shown equivocal results (Hayes & Cone, in press; Seaver & Patterson, 1976; Winett, Kagel, Battalio, & Winkler, 1978; Kohlenberg, Note 1). Feedback has been primarily provided through written means. There seems to be agreement between behavioral researchers and policymakers that, if methods could be developed to provide inexpensive feedback, this simple procedure could contribute to national energy conservation efforts (Winett & Neale, in press).

In order to provide feedback in an inexpensive way, in-house feedback monitors are being developed, field tested, and, in some cases, already marketed. These monitors digitally display energy consumption in energy units or dollars, cumulative use, and may also have the capacity to cue for overuse (Kohlenberg et al., 1976; Kohlenberg, Note 2; Omang, Note 3); other.

Research reported here was supported principally by Grant No. 5S07-RR05636-11 from the Division of Research Resources of the National Institutes of Health. Reprints may be obtained from Richard Winett, Psychology Department, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

even simpler, feedback devices are also being developed (Becker & Seligman, in press).

However, every residence is already equipped with a potential feedback device—the conventional energy meter. Despite the "no cost" availability of this device, there is considerable skepticism about its use for feedback. These meters are generally located outside the residence, usually have dials that move in different directions, and record energy units cumulatively via the dials. Of the several hundred participants in studies that the senior author has conducted in energy conservation, virtually no one knew how to read a meter or had ever tried; most participants did not know its location. As energy meters are rapidly read by meter readers (in one study readings were reliably recorded and interpreted at a rate of 1 per min [Winett et al., in press]), it seemed likely that residential consumers could quickly learn to read their own meters.

Daily meter readings may have a feedback effect if a number of other procedures that were part of effective feedback methods are incorporated into the recording process (e.g., Winett et al., in press). These methods include ways to keep track of and chart use, compare daily use to prior baseline consumption, correct for weather changes, and attempt to reach a specified reduction goal. These same factors may be important in using even sophisticated feedback monitors, and the overall approach parallels therapeutic work in self-control (Richards, 1977).

It is also important that conservation tactics be used with appropriate *target groups* at *optimal times*. For example, feedback has reduced electricity consumption in low, middle, or high users by about 13% (Winett et al., in press). However, the low users only averaged about 10 KWH per household per day in the late spring, while the high users averaged about 30 KWH per household per day during the same period. During the very hot part of the summer, the lower users (small townhouses with window air conditioning units) only averaged about 20 KWH per household per day, while the higher users (detached houses, central air conditioning) averaged between 80 and 100 KWH per household per day. Thus, the same procedure could have a much more pronounced effect, in terms of KWH saved, if it were used with high consumers during peak-use (seasonal) times.

The purposes of this study were (a) to ascertain if residential consumers could be quickly taught to read their electricity meters and reliably and frequently monitor their consumption; (b) to see if a "self-monitoring" procedure could reduce electricity consumption if residents were also provided with weather correction and conservation information; and (c) to further assess the timing and targeting idea by evaluating the effects of the procedures on very high-use residential consumers during another peak-use period for all-electric homes, the winter.

METHOD

Setting

The study was conducted in a suburban Maryland townhouse community near Washington, D.C., from January to May 1978. All participants' townhouses had three levels and about 19,000 cubic feet of living space. Every townhouse was about 8 yr old, was all-electric, and had a Lux-Aire three-coil electric furnace with a capacity of 51,000 BTUs. The attics of the townhouses were originally fitted with 3 in. of blown-in foam insulation. The outside walls had 3½ in. of fiber glass batting; the adjoining walls were only concrete blocks. There was no ceiling insulation or basement insulation. Virtually every townhouse had installed storm windows and doors. Electricity meters were located outside, near the front steps, of each residence.

Participants and Recruitment Procedures

All participants were recruited following a door-to-door procedure used previously in a summer study (Winett et al., in press). A staff person first gave each participant household a detailed written description of the project that included a consent form to be signed by an adult member

Table 1
Baseline Electricity Consumption of the Groups

		Household KWH per day			*Household KWH per month*[a]		*Household $ per month*[b]	
Group	N	*Mean*	*Range*	*S.D.*	*Mean*	*Range*	*Mean*	*Range*
Feedback	12	161	116-269	38	4830	3480-8070	$193	$139-$323
Self-Monitoring	16	160	125-220	26	4800	3750-6600	$192	$150-$264
Comparison								
Volunteer	14	168	109-289	45	5040	3270-8670	$202	$131-$347
Non-Volunteer	29	183	103-251	36	5490	3090-7530	$220	$124-$301
Sample	71	171	103-289		5130	3090-8670	$205	$124-$347

[a]30-day month.
[b]Based on 4¢ per KWH.

of the household. The following day, the staff person returned to the residence to ascertain the household's decision concerning participation. Households that had not reached a decision or in which residents were not home were personally called on again the next day. However, unlike the earlier summer study, cold and wet weather hampered personal contact, and group meetings, described below, were held in a nearby church, not outside the participants' residences. With these procedures, 60% of participants initially interviewed (compared to 75% in Winett et al., in press) were recruited into the study.

Participants varied in age (25 to 65 yr) but were similar in income (gross family income of about $40,000). During a 3-week January baseline,[1] households consumed a mean of 171 KWH per day (range, 103 to 289 KWH), for a mean winter monthly bill of about $205 when fuel adjustment and taxes were included. Thus, this townhouse community was a "high use" area.

Assignment to Group

Prior to the start of procedures, 45 participants were randomly assigned to either a feedback, self-monitoring, or comparison group. Three feedback participants decided not to participate before the meeting. In order to increase the *N* in the self-monitoring group (the prime focus of the study), one comparison participant was moved to the self-monitoring group, also before the start of procedures. In addition, it was possible to read the meters of 29 households in the same area that had declined to participate when they were initially called on. These "nonvolunteer participants" were not only used to provide a large comparison group but also to ascertain the effects of volunteer status on energy consumption, an issue in prior energy research (Kagel, Battalio, & Walker, in press). Table 1 summarizes the baseline consumption patterns of the groups in the study.

Methods and Procedures for Feedback and Self-Monitoring[2]

To equate conditions between the feedback and self-monitoring groups, both groups attended separate meetings where they received an explanation of the rationale of the study and their particular procedures. Both groups were given conservation information emphasizing thermostat control, a special booklet that also emphasized thermostat control and showed sav-

[1]Baseline readings were recorded after participants were recruited. It is possible that the difference between the study participants' baseline consumption and the nonvolunteer comparison group's baseline consumption (see Table 1) was attributable to social processes occurring during recruitment. If this were the case, the findings of the study would present a conservative estimate of potential conservation.

[2]All feedback and self-monitoring materials are available from Richard A. Winett.

ings from retrofitting and better use of appliances (Federal Energy Administration, 1977), and a packet of procedural forms.

Feedback. The daily feedback procedure replicated forms and methods used previously (Winett et al., in press). Every day for a period of 28 consecutive days after the meeting day, each participant household received a feedback sheet at the door (no personal contact). The sheets were color coded and had an ascending series of smiles or frowns that corresponded to percentage decreases or increases in electricity consumption. Each day's sheet indicated the household's prior day's KWH consumption, its percentage increase or decrease from baseline (with weather correction, see below), the relationship of the decrease to a reduction goal chosen by the household in the meeting, and an estimate of the household's monthly electricity bill in dollars, based on its prior day's use.

Self-monitoring. The self-monitoring group's meeting followed the same format as the feedback meeting except that, through verbal and written instructional methods, participants were taught to read their electricity meters. Instruction required about 10 min per household, and one participant per household was required to pass a quiz on meter reading. Each self-monitoring participant also received four weekly meter reading recording forms. These forms contained the meter dials, and participants were instructed to mark the position of the dials, return to the inside of their house, and interpret the reading. A space was provided so that each day a KWH difference could be calculated from the prior day's readings. The form also contained a graph for plotting their daily KWH use and a place for their baseline use and reduction goal in KWH (e.g., 160 KWH baseline, 10% reduction goal = 144 KWH per day).

The first day's reading was put on the recording form by a staff person. The day after the meeting, which was the participants' first reading and first KWH difference, participants were telephoned to assure the accuracy of their readings (using the project's meter readings). The recording forms were devised so that a carbon copy was picked up by a staff person after each recording week. For the first 3 weeks, participants received a short note the next day indicating the adequacy (accuracy, KWH differences) of their readings. No feedback was given on the magnitude of KWH use.

For 28 consecutive days after their meeting, self-monitoring participants received a note at their door that showed their *expected use* for the prior day in percentage terms. Expected use was based on the weather correction system described below. The participants had been instructed to ascertain if their prior day's use had been above or below expected use (prior day's use ÷ baseline use × 100 compared to expected use). For example, if their prior day's use = 80 KWH, baseline = 100 KWH, and expected use was 90%, they were (80% versus 90%) below the expected use.

Participants in either the feedback ($N = 4$) or self-monitoring ($N = 6$) group not attending the meeting received information and instruction in their homes.

Experimental Design

The group design was selected to provide a control for weather conditions. Previous within-subject design energy research has either focused on nonheating or noncooling energy use (e.g., Hayes & Cone, 1977) or has attempted to use correction procedures to equate baseline and intervention conditions, an approach with demonstrated limitations (Blakely, Lloyd, & Alferink, Note 4).

Dependent Measure

Electricity meters were read every day at about the same time by a staff person, yielding a KWH use for each household each day. Our earlier research, using about 500 overlapping meter readings, had shown that reliability approaching 100% was achieved when the meter reader only marked dial forms and research staff later interpreted readings (Winett et al., in press). In the present study, only one reliability check was performed involving overlap of a staff person and the meter reader[3] on 15 readings. Agreement was 100%.

Self-monitoring participants usually read their meters in the morning, as did the study's meter reader. To calculate the reliability of the self-monitoring participants' readings, their readings were compared to those of the meter reader each day.

Correction Factors

Expected use for the self-monitoring group and percentage change for the feedback group were derived from a daily weather correction factor based on the comparison (volunteer and nonvolunteer) group's total prior day's KWH use divided by the comparison group's total daily baseline KWH average. This proportion was changed to a percentage (e.g., 110%, 87%) to yield the self-monitoring group's expected daily use. For the feedback group, each household's prior day's KWH use divided by each household's daily baseline KWH use was then divided by the weather correction factor to yield a percentage use score, which was converted to a percentage reduction. For example, if a household's prior day's use was 200 KWH, baseline use was 220, and the weather correction factor was 125%, the household reduced by 27% ($200 \div 220 = .91$; $.91 \div 1.25 = .73 = 73\%$, or a 27% reduction). Thus, the weather correction factor was directly tied to KWH use in a specific neighborhood, taking into account the particular day's and prior day's weather, residential structure, lifestyle, etc.

In order to eliminate from the data households where residents were on vacation or away for a short time, a household in any group was dropped from the data on any day that their prior day's KWH use, divided by daily baseline KWH use, divided by the weather correction factor, was less than .50.[4] This correction system was used for data during the baseline, intervention, and follow-up parts of the study, and about 2% of the data were not used following this procedure.

RESULTS

Mean daily KWH consumption for each household during a 21-day baseline for the four groups was subjected to ANOVA. While there were no significant differences between groups at baseline, $F(3, 67) = 1.66$, $p > .05$, the nonvolunteer comparison group used more KWH per household than the other three groups (see Table 1).

Daily Use during Baseline, Intervention, and Follow-Up

Figure 1 shows the groups' mean daily household consumption during the baseline, intervention, and follow-up phases of the study. The volunteer and nonvolunteer groups' data are combined because these two groups' consumption did not significantly differ from each other during any phase of the study (see below). Mean household use is plotted daily during the baseline and intervention phases, and weekly during the follow-up phases. Because KWH consumption in each group was not exactly the same, each day's (or week's) use is presented in terms of percentage of baseline. An approximate KWH scale is provided, and the top part of the figure shows the high and low temperature for each day (or week).

During the 3-week baseline, the groups overlapped in percentage use. In the intervention period, the feedback and self-monitoring groups were consistently below the (combined) comparison group. The feedback group used less than the self-monitoring group. These patterns

[3]Mike Weinberg did an extremely conscientious job as experimental meter reader, performing his task every day at the same time, despite snow, sleet, and rain.

[4]For example, if the prior day's use was 63 KWH, baseline was 120 KWH per day, and the weather correction factor was 1.10, this household would be dropped from that day's data ($63 \div 120 = .525$; $.525 \div 1.10 = .477$).

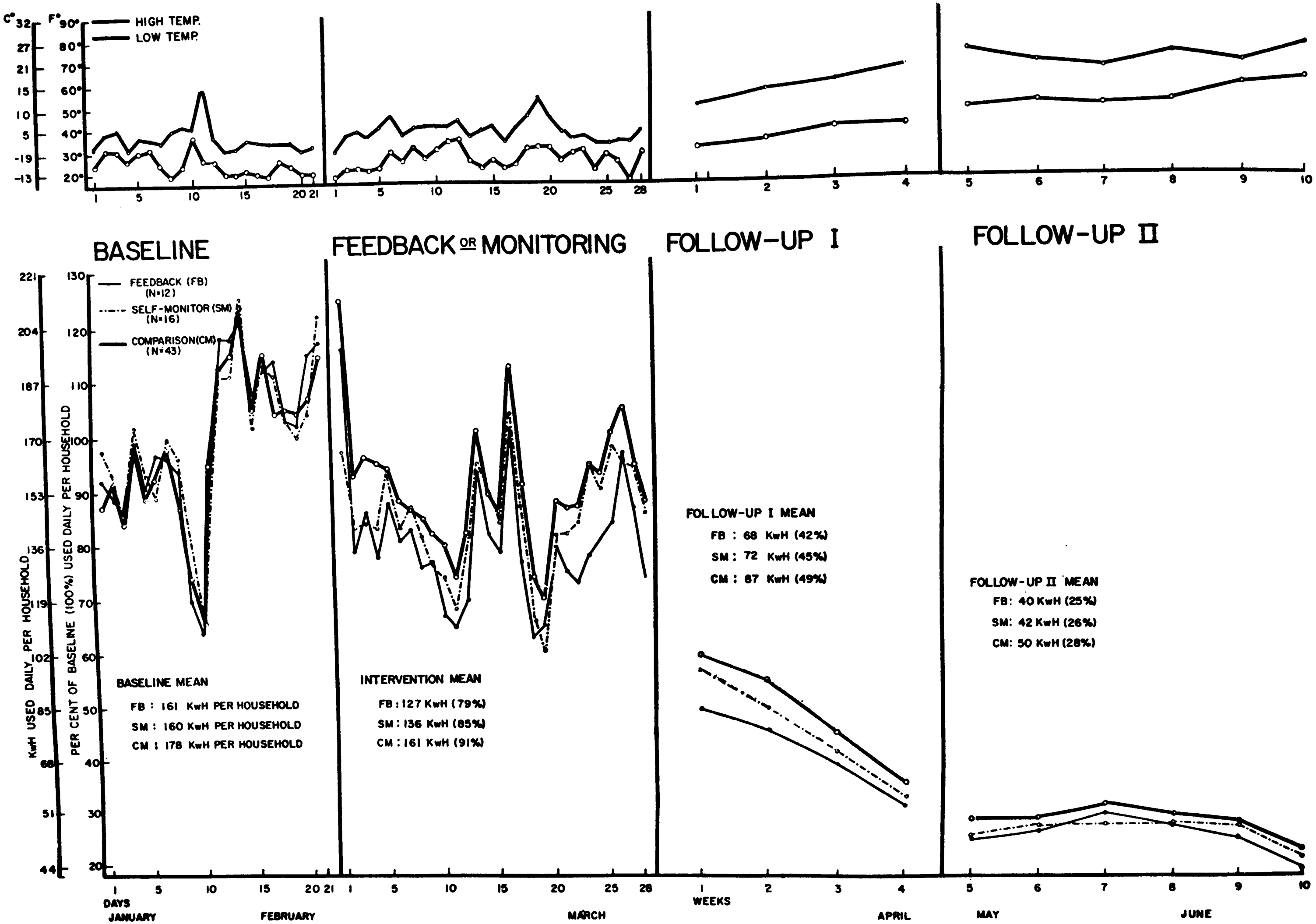

Fig. 1. Daily consumption of the Feedback (FB), Self-Monitoring (SM), and (Combined) Comparison (CM) groups in percent baseline and KWH during baseline and intervention. Weekly consumption during two follow-up periods is also shown, and the daily or weekly high and low temperatures are indicated in the upper panel.

persisted during a 4-week (1) and 6-week (2) follow-up period.

Electricity consumption closely followed the daily (or weekly) high temperature. The intervention period was slightly warmer than the baseline period, the first follow-up period marked the onset of spring, and the second follow-up period corresponded to warm spring weather. Although the pattern of differences apparently persisted during the warmer follow-up phases, consumption was much lower during these phases than during the baseline or intervention phases. There was no evidence of differential response by the groups to temperature during any phase of the study.

Household Use during Intervention and Follow-Up (1 + 2)

For each household, a percentage of baseline score was derived by dividing the mean daily KWH use during intervention by the mean daily KWH use during baseline. A three-group (feedback, self-monitoring, volunteer comparison) ANOVA indicated significant differences between groups during intervention, $F(2, 39) = 7.55$, $p < .005$. One-tailed t-tests indicated that feedback (79%) differed from both the volunteer comparison group (89.5%), $t(24) = 3.59$, $p < .005$, and the self-monitoring group (85%), $t(26) = 2.23$, $p < .025$. The self-monitoring group differed from the volunteer comparison group, $t(28) = 1.66$, $p < .10$.

An ANOVA with the volunteer comparison group (89.5%) and the nonvolunteer group (91.5%) was not significant, $F(1, 41) < 1$. The mean consumption of the two comparison groups was 91%. Based on the combined comparison group's use, the feedback group reduced consumption by about 13% and the self-monitoring group by about 7%.[5]

For the follow-up periods, a percentage of baseline score for each household was derived for each period, using the same procedure as for the intervention period. In the first period, a three-group (feedback, self-monitoring, volunteer comparison) ANOVA indicated significant differences between groups, $F(2, 39) = 4.73$, $p < .025$. One-tailed t-tests indicated that the feedback group (42%) differed from the volunteer comparison group (48%), $t(24) = 2.95$, $p < .005$, and the self-monitoring group (45%), $t(26) = 1.76$, $p < .05$. The self-monitoring group differed from the volunteer comparison group, $t(28) = 1.49$, $p < .10$.

An ANOVA with the volunteer comparison group (48%) and nonvolunteer comparison group (50%) was not significant, $F(1, 41) < 1$. When the combined comparison group (49%) was used as a base, the feedback group reduced about 14% and the self-monitoring group about 8% during the first follow-up period.

In the second follow-up period, an ANOVA with the feedback group (25%), self-monitoring group (25%), and volunteer comparison group (28%) was not significant, $F(2, 39) = 1.45$, $p > .05$. An ANOVA with the volunteer (28%) and nonvolunteer (28%) comparison groups was not significant, $F(1, 41) < 1$. However, compared to the combined comparison group (28%), the feedback group reduced about 11% and the self-monitoring group about 7% during the second follow-up period.

Thus, during the intervention and follow-up periods, the feedback group and self-monitoring group reduced electricity consumption by about 13% and 7% respectively, based on the combined comparison group's use. The volunteer and nonvolunteer comparison groups did not differ in use during these phases of the study.

Individual Household Responsiveness

In order to assess the responsiveness of individual households to the intervention conditions, the groups were examined to determine the number of households using more than 90% of

[5]A percentage of reduction between treatment groups and the comparison group during phases of the study was calculated by: $100 - (\text{percentage treatment group} \div \text{percentage comparison group} \times 100)$. Example from intervention period: Feedback 79%, Comparison 91%. $100 - (79 \div 91 \times 100) = 100 - 87 = 13\%$.

their daily baseline mean during the intervention period. In the combined comparison group, 28 of 43 households (65%: 20 of 29 nonvolunteer, 70%; 8 of 14 volunteer, 57%) used more than 90% of their baseline mean compared to 3 of 16 (19%) in the self-monitoring group and 0 of 12 (0%) in the feedback group. During the first follow-up period, 19 of 43 (44%: 13 of 29 nonvolunteer, 45%; 6 of 14 volunteer, 43%) in the combined comparison group, but only 3 of 16 (19%) self-monitoring households, and 1 of 12 (8%) feedback households, used more than 50% of their daily baseline mean.

Thus, overall, the feedback and self-monitoring conditions yielded consistent (by day, week, and household) and statistically significant electricity savings during the intervention and first follow-up period. Feedback was found to be more effective than self-monitoring, and nonvolunteer and volunteer comparison households performed about the same. The differences that were obtained during intervention were maintained during a 1-month follow-up period and, to a lesser extent, during a warmer 6-week follow-up period.

KWH and Dollar Savings

Table 2 indicates savings in KWH and dollars during the intervention and first follow-up period. Using the combined comparison group's use (91% of baseline) during the intervention period, an "expected use" for the same period was derived for the self-monitoring and feedback groups. It was expected that the average self-monitoring household would use 145 KWH per day during this period, but each self-monitoring household averaged 136 KWH per day. This represents a per household savings of 9 KWH per day, 270 KWH per month, or about $11 per month, under the prevailing rate structure. It was expected that each feedback household would use 146 KWH per day, but only 127 KWH per day were used. Each feedback household was, thus, saving 19 KWH per day, 570 KWH per month, and about $23 per month.

An examination of Table 2 shows that, although effects were maintained during the first follow-up period, the savings were only about 60% of those during the intervention period

Table 2

Mean electricity consumption and savings in KWH and dollars during intervention and followup (1).

	Feedback	*Self-Monitor*	*Comparison*
	BASELINE		
Average per household	161 KWH	160 KWH	178 KWH
	INTERVENTION		
Average per household	127 KWH	136 KWH	161 KWH
Percentage of baseline	79%	85%	91%
Expected average per household	146 KWH	145 KWH	—
Savings per day per house	19 KWH	9 KWH	—
Savings per month[a]	570 KWH	270 KWH	—
Dollar savings per month[b]	$23	$11	—
	FOLLOW-UP		
Average per household	68 KWH	72 KWH	87 KWH
Percentage of baseline	42%	45%	49%
Expected average per household	79 KWH	78 KWH	—
Savings per day per house	11 KWH	6 KWH	—
Savings per month[a]	330 KWH	180 KWH	—
Dollar savings per month[b]	$13	$7	—

[a]30-day month.
[b]Based on 4¢ per KWH.

because of the warmer weather and lower consumption.

Self-Monitoring Data

Of all possible readings (i.e., not including vacation days) 91% (355/390) were made by the participants. Of those read, 96% (342/355) showed the correct difference between two days' readings. Because of the very high KWH use, a 15-KWH per hour discrepancy was allowed between the self-monitoring reading and the project meter reader. Using this criterion, there was 96% agreement (342/355) between the self-monitoring readings and the meter reader's recordings. Forty-three readings were reported as recorded within 10 minutes of the meter reader's recordings. Forty-one of these readings (95%) were within five KWH of the meter reader's recordings. Seventy-six percent of participants' weekly recordings were done within two hours of each other (including weekends). In only 50% of the possible instances did participants plot their graphs.

Thus, self-monitoring participants consistently and accurately recorded their meter readings. The one participating household that stopped its recordings after the first week failed to reduce its electricity use (i.e., used 94% of baseline).

Questionnaire Data

Follow-up questionnaire data were available from all 28 participants in the feedback and self-monitoring groups.[6] Respondents generally indicated a range of conservation practices (thermostat lowering, insulation) before the start of the project, and additional thermostat lowering and lowering of hot water temperature during the project. Because respondents indicated, on an initial recruitment form, their usual thermostat setting, it was possible to derive a thermostat difference score between the reading on the initial form and that given on the follow-up form. The difference score was then correlated with each household's percentage of baseline, yielding a significant correlation, $r = .74$, $p < .001$. Thus, about 55% of the electricity reductions in this project seem attributable to (self-reported) lowering of the heat thermostat.

The average day and night thermostat setting reported on the initial recruitment form was about the same for the feedback group (67.6°F) and the self-monitoring group (67.1°F), but feedback reported a larger mean thermostat setting change than self-monitoring (3.8° vs. 1.9°).

Additional data indicated (a) 9 of 11 responding feedback participants felt that KWH feedback was more important than price feedback, and (b) little communication about energy use was reported with neighbors.

Consumer evaluations of procedures and the project were positive. For example, on the questionnaire, daily feedback received a rating of 4.4 by feedback participants in terms of its help in conservation efforts (5 = very helpful, 1 = useless); daily self-monitoring received a score of 4.1 by self-monitoring participants on the same scale. On an open-ended comment section of the questionnaire concerning the project in general, all comments were judged by the authors to be positive.

DISCUSSION

The results of the study support the notion that considerable savings in electricity use can accrue when feedback or monitoring procedures are implemented during seasonal peak-use periods with high-use consumers. The effectiveness of the procedures was also indicated by the consistency of the results by day (week) and by household. Reductions achieved in the study were apparently primarily attributable to one simple behavior—changing the thermostat setting—and evidence for maintenance of effect was also found. It may well be that once consumers try relatively simple and presumably nonaversive conservation behaviors and can see tangible savings through feedback or self-monitoring procedures, then such practices may be maintained without frequent feedback. Obvi-

[6]The questionnaire is available from Richard A. Winett.

ously, the question of maintenance of effect is a crucial one in energy conservation and needs more research. However, maintenance was also found in a prior electricity conservation study (Winett et al., in press).

The large curtailment of electricity consumption with the arrival of spring indicated that the bulk of the electricity used by these consumers was for heating. For example, by late spring, households were consuming only about 20% of their winter baseline. Timing the interventions for the much colder winter period thus maximized the savings in KWH and dollars.

The results of the study also indicate that volunteering to participate in a conservation project did not significantly reduce consumption. There was no difference in consumption between volunteer and nonvolunteer comparison groups during the phases of the study.

With minimal training and prompting, consumers, who before the study had never read their electricity meters, could become highly persistent and reliable meter readers. Teaching self-monitoring was relatively inexpensive, and this strategy is one that should be tried on a wider scale. Before noting some ways that self-monitoring may be used more broadly, it is important to indicate some weaknesses in the approach that may be improved in subsequent projects.

Small, inexpensive hand calculators could be given to residents to figure exactly their daily percentage increase or decrease using their prior day's KWH use, their baseline average, and the weather correction (expected use) figure. Residents could be more fully instructed in graphing procedures, and the importance of recording at about the same time each day could be stressed. In this way, it may be possible for self-monitoring to approach feedback in effectiveness.

Daily expected (weather corrected) use information is routinely available from many utility companies (Russo, Note 5). This information could be presented to consumers through the media, creating the possibility of an inexpensive weather correction "service" for self-monitoring residential (and, possibly, commercial) consumers.

Since prompting and feedback *may* be essential for self-monitoring to be maintained, smaller neighborhood projects may be more effective than much bigger projects. Community residents could be trained to provide the instruction, feedback, and prompting; and energy lines into a neighborhood could be used to generate *local,* more salient, daily expected use figures. Creating interpersonal interaction concerning energy conservation (apparently lacking in this project) has been found to further promote savings (Slavin, Wodarski, & Blackburn, in press) and can be developed at the neighborhood level. This plan would be compatible with many recent discussions of more appropriate level technology (Schumacher, 1973).

In this project, though, self-monitoring incorporated many prompting and feedback procedures that are expensive and seemingly efficacious (alone) in promoting behavior change. Conducting meetings, instructional sessions, and telephone contact are costly aspects of this project. Daily notes on expected use and weekly notes on monitoring performance are also expensive components of the monitoring process used here and may have served as additional prompts to increase the probability of participants' complying with procedures (Winett, 1978; Winett, Stewart, & Majors, 1978). Parts of the self-monitoring "package" and its timing and targeting with different types of consumers need to be refined and evaluated before self-monitoring can be disseminated as a cost-effective approach to residential energy conservation.

However, even in their present form, feedback and self-monitoring show some promise in terms of a cost-benefit analysis. The total expenditure[7]

[7]Expenditures included all costs (for all phases of the project) for travel, recruitment, meetings, folders, paper, meter readings, reliability checks, feedback or expected use notes, data interpretation time, and additional staff and secretarial time. Research institute overhead costs were not included.

per household by the project for the feedback condition was about $26. During the 4-week intervention and 10-week followup period, each household saved about $44 from expected expenditures based on the comparison group's use during this same period and the marginal cost per KWH. For the self-monitoring households, for the same period, about $22 was expended and $26 saved per household. As noted above, additional research is needed to ascertain if self-monitoring can be made as cost-effective as written feedback. Importantly, though, it appears from our analyses that effects must be maintained and procedures implemented with high users during peak-use periods if self-monitoring is to be cost-beneficial for areas of the country where the marginal cost per KWH remains below about $.04.

The future of behavioral procedures in energy conservation, however, may be more closely linked to their incorporation with hardware or appliances to promote longer run conservation. For example, the several self-monitoring practices noted above may also be important in the more effective use of in-house feedback monitors (Becker & Seligman, Note 6). Methods are needed to convince consumers to retrofit their homes, to purchase appliances on a life-cycle basis, or procure alternative systems based on wind or solar energy (Winett & Neale, in press; Geller, Brasted, & Augustine, Note 7). Marketing strategies for physical technology may well include rebate systems, evaluated in prior years by behavior analysts (Hayes & Cone, 1977; Winett & Nietzel, 1975). Then, too, we need to begin applying our procedures, alone or in conjunction with physical technology, in the commercial and governmental sectors (Geller et al., Note 7).

While the merging of behavioral technology with hardware will probably be a major thrust in the next few years, the continual rise of energy prices almost assures that even the crudest short-run procedures (e.g., written feedback) can be cost-beneficial if the procedures are appropriately timed and targeted to higher users (Winett & Neale, in press). It remains to be seen if rising prices and energy legislation can create a national commitment to conservation, so that both the impetus and funds are available to evaluate various approaches to energy conservation.

REFERENCE NOTES

1. Kohlenberg, R. J., Barach, R., Martin, C., & Anschell, S. *Experimental analysis of the effects of price and feedback on residential electricity consumption.* Unpublished manuscript, University of Washington, 1977.
2. Kohlenberg, R. J. Various experiments in residential energy conservation. In R. A. Winett (Chair), *Social psychological approaches to consumer energy conservation.* Symposium presented at the meeting of the American Psychological Association, Toronto, 1978.
3. Omang, J. Switching "OFF" for smiles: Daily checks by homeowners urged as a means of cutting electricity use. *Washington Post,* January 16, 1978.
4. Blakely, E. Q., Lloyd, K. E., & Alferink, L. A. *The effects of feedback on residential electrical peaking and hourly kilowatt consumption.* Unpublished manuscript, Drake University, Department of Psychology, 1977.
5. Russo, J. E. *A proposal to increase energy conservation through provision of consumption and cost information to consumers.* Unpublished manuscript, University of Chicago, 1977.
6. Becker, L. S., & Seligman, C. Preliminary evaluation of an energy feedback conservation program. In R. A. Winett (Chair), *Social psychological approaches to energy conservation: From basic research to real world applications.* Symposium presented at the meeting of the Eastern Psychological Association, Washington, D.C., 1978.
7. Geller, E. S., Brasted, W. S., & Augustine, M. N. A community education model for energy conservation: Implementation, evaluation, and implication. In R. A. Winett (Chair), *Social psychological approaches to energy conservation: From basic research to real world applications.* Symposium presented at the meeting of the Eastern Psychological Association, Washington, D.C., 1978.

REFERENCES

Becker, L. S. Joint effect of feedback and goal setting on performance: A field study of residential energy conservation. *Journal of Applied Psychology,* 1978, **63**, 428-433.

Becker, L. S., & Seligman, C. Reducing air conditioning waste by signalling it is cool outside. *Personality and Social Psychology Bulletin,* in press.

Federal Energy Administration. *Tips for energy savers.* Washington, D.C.: Federal Energy Administration, Conservation and Environment, 1977.

Hayes, S. C., & Cone, J. D. Reducing residential electricity energy use: Payments, information, and feedback. *Journal of Applied Behavior Analysis,* 1977, **10**, 425-435.

Hayes, S. C., & Cone, J. D. Reduction of residential consumption of electricity through simple monthly feedback. *Journal of Applied Behavior Analysis,* in press.

Kagel, J. H., Battalio, R. C., & Walker, J. M. Volunteer bias in experiments in economics: Specification of the problem and some initial data for small scale field studies. In V. S. Smith (Eds.), *Research in experimental economics* (Vol. 1). Greenwich, Conn.: J.A.I. Press, in press.

Kohlenberg, R. J., Phillips, T., & Proctor, W. A behavioral analysis of peaking in residential electricity energy consumption. *Journal of Applied Behavior Analysis,* 1976, **9**, 13-18.

Palmer, M. H., Lloyd, M. E., & Lloyd, K. E. An experimental analysis of electricity conservation procedures. *Journal of Applied Behavior Analysis,* 1978, **10**, 665-672.

Richards, C. S. Assessment and behavior modification via self-monitoring: An overview and bibliography. *JSAS Catalog of Selected Documents in Psychology,* 1977, **7**, 15. (Ms. No. 1428)

Schumacher, E. M. *Small is beautiful.* New York: Harper & Row, 1973.

Seaver, W. B., & Patterson, A. H. Decreasing fuel oil consumption through feedback and social communication. *Journal of Applied Behavior Analysis,* 1976, **9**, 147-152.

Seligman, C., & Darley, J. M. Feedback as a means of decreasing residential energy consumption. *Journal of Applied Psychology,* 1977, **62**, 363-368.

Slavin, R. E., Wodarski, J. S., & Blackburn, B. L. A group contingency for electricity conservation in master-metered apartments. *Journal of Behavior Analysis,* in press.

Winett, R. A. Prompting turning-out lights in unoccupied rooms. *Journal of Environmental Systems,* 1978, **7**, 237-241.

Winett, R. A., Kagel, J., Battalio, R. C., & Winkler, R. A. The effects of rebates, feedback, and information on electricity conservation. *Journal of Applied Psychology,* 1978, **63**, 73-80.

Winett, R. A., Kaiser, S., & Haberkorn, G. The effects of monetary rebates and feedback on electricity conservation. *Journal of Environmental Systems,* 1977, **6**, 329-341.

Winett, R. A., & Neale, M. S. Psychological framework for energy conservation in buildings: Strategies, outcomes, directions. *Energy and Buildings,* in press.

Winett, R. A., Neale, M. S., Williams, K., Yokley, J., & Kauder, H. The effects of individual and group feedback on residential electricity consumption: Three replications. *Journal of Environmental Systems,* in press.

Winett, R. A., & Nietzel, M. Behavioral ecology: Contingency management of residential energy use. *American Journal of Community Psychology,* 1975, **3**, 123-133.

Winett, R. A., Stewart, G., & Majors, J. S. Prompting techniques to increase the return rate of mailed out questionnaires. *Journal of Applied Behavior Analysis,* 1978, **11** (in press).

Received May 1, 1978
Final acceptance November 15, 1978