THE EFFECTS OF MONETARY REBATES AND DAILY FEEDBACK ON ELECTRICITY CONSERVATION

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ABSTRACT

The purpose of this study was to continue investigations of practical, inexpensive methods to promote residential electricity conservation. Following a one week baseline period, six experimental apartments were placed on a graduated rebate system for one week where reductions in electricity use earned participants money. Six apartments served as untreated controls for the remainder of the study. In the following week, half the experimental apartments only received daily written feedback on their electricity use compared to their baseline level and the daily use of control apartments, while the other three apartments were placed on a half payment rebate system. For the next four weeks, all six experimental apartments only received daily written feedback. Relative to the control apartments, the full rebate system yielded a 30 per cent reduction in electricity use while the half rebate and feedback systems yielded 15 per cent. These results were variable across apartments and days. Feedback tended to be less effective on warm days when central air conditioning units were in frequent use. The results of the study were seen as pointing toward the development and evaluation of feedback devices on cooling and heating units.

Psychologists in the role of developing interventions or evaluating proposed or recently enacted programs have become increasingly involved in resource conservation and other environmental problems [1]. Applications of the behavioral paradigm have stressed direct efforts to change conservation behaviors and direct measurement of

effects, e.g., energy conservation. Intervention strategies have primarily focused on reinforcement and feedback procedures.

Winett and Nietzel evaluated a monetary rebate system in which volunteer community residents received graduated weekly payments for reducing their electricity and natural gas consumption from a prior recorded baseline level (based on meter readings) [2]. The rebate schedule provided $2 for a 5-9 per cent reduction, $3 for a 10-20 per cent reduction and $5 for a reduction greater than 20 per cent. Another group matched to the rebate group on prior energy use received extensive information about energy conservation, information also made available to the rebate group. Participants in the rebate group reduced their electricity consumption (23%) significantly more than the information group (8%). There was, however, no group differences in use of natural gas, the major energy source for heating during the winter the study was conducted. In addition, the effects of providing feedback on weekly energy use were not clear since feedback was part of the rebate system but not included as part of the information package.

Hayes and Cone found that a rebate system similar to the one used in Winett and Nietzel yielded comparable reductions in electricity use [3]. Even leaner rebate schedules in the order of 25 per cent of the Winett and Nietzel payments resulted in reductions of 27 per cent from baseline. Daily written feedback on electricity use was part of the rebate systems and was also used alone. Feedback resulted in variable, lesser amounts (15%) of reduction, a result consistent with Palmer, Lloyd and Lloyd who conducted a similar study [4]. In these two studies, however, the recorded electricity use was not associated with heating or cooling.

Seaver and Patterson in a project run during the winter in the Northeast gave a group of consumers feedback on their current fuel oil consumption used for heating compared to the previous winter [5]. Included in the feedback which was part of the customer's bill was information on monetary savings or loss based on their consumption level. This same type of feedback was given to another group but, in addition, this group received a decal which said, "We Are Saving Oil," if, in fact, they had saved oil compared to their use the prior winter. Only the group receiving feedback and the decal reduced the amount of oil they consumed between the receipt of the special bill and a second delivery. The use of oil by the feedback alone group was comparable to a control group.

In a study conducted during the hot summer months in Texas where daily air conditioning use was very prevalent, Kagel, Battalio,

Winett, and Winkler found that only a rich rebate system similar to Winett's and Nietzel's yielded reductions (11%) in electricity use over the ten weeks of the study [6]. A low rebate system (about 25% of Winett and Nietzel) resulted in shorter-term reductions, while weekly feedback and information failed to curtail electricity use.

There appear to be several directions that this work can follow in attempting to develop practical procedures to promote energy conservation. While large rebates have generally resulted in energy conservation, their implementation seems impractical. Psychologists working in this area have conceptualized rebates in reinforcement terms. Rebates in economic terms are price changes [7]. Receiving a rebate for reduced energy use means that the price of energy has been reduced for the consumer. However, the high rebate schedule used in Winett and Nietzel, Hayes and Cone and Kagel et al. amounted to price changes in the order of several hundred per cent [2, 3, 6]!

The further study of feedback, however, seems promising since the cost factor compared to rebate systems is markedly reduced. The studies reported in this paper suggested that daily feedback was somewhat effective while feedback given on a weekly or a longer schedule was not effective. However, in Hayes and Cone and Palmer et al. where daily feedback was used, electricity consumed by participants was not used for heating or cooling purposes [3, 4]. Thus, while daily feedback might be effective for curtailing minor electricity use, its role in heating or cooling remains unclear.

Recent discussion and experimental work has also emphasized the potential of feedback if its saliency and proximity can be increased [8]. For example, Kohlenberg, Phillips and Proctor placed meters inside the homes of three families [9]. These meters indicated whether a family was overusing energy during a peak-load period (8-11 AM; 5-9 PM) by having a light flash when the family surpassed their baseline level. A large rebate system resulted in a decrease in peak period energy use, but feedback alone also yielded some minimal reductions. While the purpose of the Kohlenberg et al. study was in demonstrating that the peak load pattern could be shifted, and not in effecting energy savings per se, similar feedback meters have been proposed as a method of energy conservation.

The purpose of the present study was to further investigate daily feedback in a situation where electricity was used for lighting, appliances, and air conditioning. Following a rich rebate system, feedback alone was given to some participants for five weeks. Other

participants received feedback for four weeks with a half rebate system placed in between the large rebate system and feedback as a "shaping" method. The study was conducted from late March to the middle of May with temperatures varying between 84° and 27°.

Method

SETTING

A thirty unit apartment complex in Lexington, Kentucky was the setting for the study. The complex had eighteen units, six on each of three floors, on one side occupied primarily by students and other young persons, while the other side contained twelve apartments, four on each of three floors, occupied primarily by older residents. The eighteen unit side was chosen as the experimental site because electricity meters for all the apartments were arranged on one panel behind the apartments allowing for daily reading without entering the unit. In addition, each apartment's central air conditioning unit was labeled and located in the same side of the building as the meters.

RECRUITMENT OF PARTICIPANTS

A letter detailing the purpose of the study and a consent sign-up form was left at each of the eighteen apartments. Three days later a short reminder note was also left at each apartment. Interested persons were to fill-out the sign-up form and deposit the form in a specially marked box located outside the manager's apartment. These procedures resulted in seven participant apartments.

In order to secure enough participants so that there were six experimental units and six control units with two experimental and two control units from each of the three floors, direct door to door solicitation followed the initial sign-up period. Since the controls only agreed to have their electricity meter read, solicitation only required about thirty minutes to enlist five more apartments.

REQUIREMENTS

Participants in the experimental group agreed to have their electricity meter read daily and receive daily notes with the understanding that they might receive monetary rebates. Participants also agreed to the installation of an indoor-outdoor thermometer in their apartment. The thermometer was part of a special air

conditioning procedure that was activated only once during the project. Control participants only agreed to have their meter read.

PARTICIPANTS

The participants were students or recent college graduates. As a group they tended to be consistently away from their apartments most of the day and sporadically away on weekends. Experimental units' average electricity use during a one week baseline period was 28 KWH per day (range—18-49) and the control units' average was 24 KWH per day (range—13-35).

PROCEDURE

Following a one week baseline, all six experimental units were placed on a high rebate system for one week (Monday-Sunday). The rebates followed a graduated payment system for reductions in electricity use. To allow for weather variations and control for the apartment's location, reductions were calculated following the formula:

$$\frac{\dfrac{Ed}{Eb}}{\dfrac{\dfrac{C_1.\,d}{C_1.\,b} + \dfrac{C_2.\,d}{C_2.\,b}}{2}}$$

Where:

E = experimental unit
d = electricity use for that day
b = average daily use during baseline
C = control unit
1. + 2. = the two control units on the same floor as the experimental unit

Thus, the reduction level of each experimental unit was calculated from its daily use, prior baseline level, and the daily use level and baseline level of the two control units located on the same floor as the experimental unit. Per cent increase or decrease in electricity use was conveyed to experimental participants by a *daily* note left at the apartment on the following morning (Monday-Thursday) or in the evening following the readings (Friday-Sunday). In addition to per cent increase or decrease, the note indicated their average increase or decrease for the week and their expected earnings for the week.

The rebate schedule provided payments of $2 for a 5-9 per cent

reduction, $3 for 10-20 per cent, $5 for 21-30 per cent and $7 for a reduction greater than 30 per cent. The rebate system represented a nonpractical price reduction in electricity of between 300-400 per cent (based on an average use of 180 KWH per week at 3¢ per KWH) [7]. Because of its long term infeasibility and the existence of replicated results with similar payment systems, the high rebate system was terminated after one week [2, 3].

Included in a letter describing the procedure were two identical *information* sheets telling participants six ways to conserve electricity: reduce the use of major appliances; moderate the use of air conditioning; on warm sunny days close the drapes; do not use air conditioning when the windows are open; reduce the use of hot water, turn out unnecessary lights. Two information sheets always accompanied a note describing the procedure in effect for a given week.

In week two (Monday-Sunday), three experimental units were placed on a rebate system that had payments *50 per cent* of the first system. The largest reducer from the prior week on floor one was placed on this system as was the largest reducer from the third floor. The smallest reducer from the second floor was the third experimental unit. The other three experimental units continued to receive only a daily *feedback* note indicating their increased or decreased use relative to their baseline and the two control units' use, and their average increase or decrease for the week.

In weeks three-six, all experimental units only received *feedback*. For weeks five and six, three units were involved in a procedure entailing rebates for curtailed air conditioning use as measured by reading a thermometer placed inside the apartment but visible to an outside observer. The procedure was operative when the high temperature for the day equalled or exceeded 78°, a temperature only attained once during that two week period. Thus, all experimental units were essentially only receiving feedback for a period of either four or five weeks. Despite being placed on the same procedure for four or five consecutive weeks, a weekly note and two information sheets was still given to each apartment describing the procedure.

DEPENDENT MEASURE

The dependent measure consisted of daily meter readings allowing calculation of KWH used per day for the six experimental and six control units. The meter reader[1] was unaware of which

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[1] Richard Graef did an excellent job as meter reader.

apartments were experimental or control units, or experimental conditions. All readings were done at 6:30 PM. A second uniformed reader[2] read meters five times during the study at 6 PM. Allowing for a difference between the two readings of three KWH, the two readers agreed on 96.6 per cent of their readings.

In order to have an estimate of air conditioning use, the primary observer checked prior to and after reading meters whether an apartment's air conditioning unit was in use.

Interviews were conducted with all experimental participants at the conclusion of the study to ascertain conservation measures undertaken and reactions to the procedures.

Results

Because of the small N and the great variability (below) displayed in daily individual apartment electricity use, the data were not subjected to formal statistical analyses. Rather the data are presented in graphic and tabular form.

Figure 1 presents daily group data for the six experimental and six control units for per cent increase or decrease from each unit's baseline level. The high temperature for each day is also displayed. The mean high temperature during the baseline week was 63°(F) (range 59°-74°) while for the six experimental weeks the average was 67°, (range 53°-84°).

The least variability and greatest difference between groups was found under the high rebate system. During the half rebate feedback condition, large differences (average = 30%) existed favoring the experimental units except for days five and six, two warm days. For the first feedback week, large differences (average = 30%) existed between the groups favoring the experimental units except for days five-seven, three warm days. During the second feedback week when it was warm everyday, the experimental units failed to show a substantially lower (average 23%) use level than the controls only on day three. For the third feedback week, on days five and six there were not substantial differences (average 18%) favoring the experimental units. For the last feedback week, only on day six was there not a substantial difference (average 21%) favoring the experimental units.

On thirty-three of forty-two days the experimental units reduced their electricity use more (range = 1-45%, average = 25%) than the control units. For the four feedback alone weeks, the experimental

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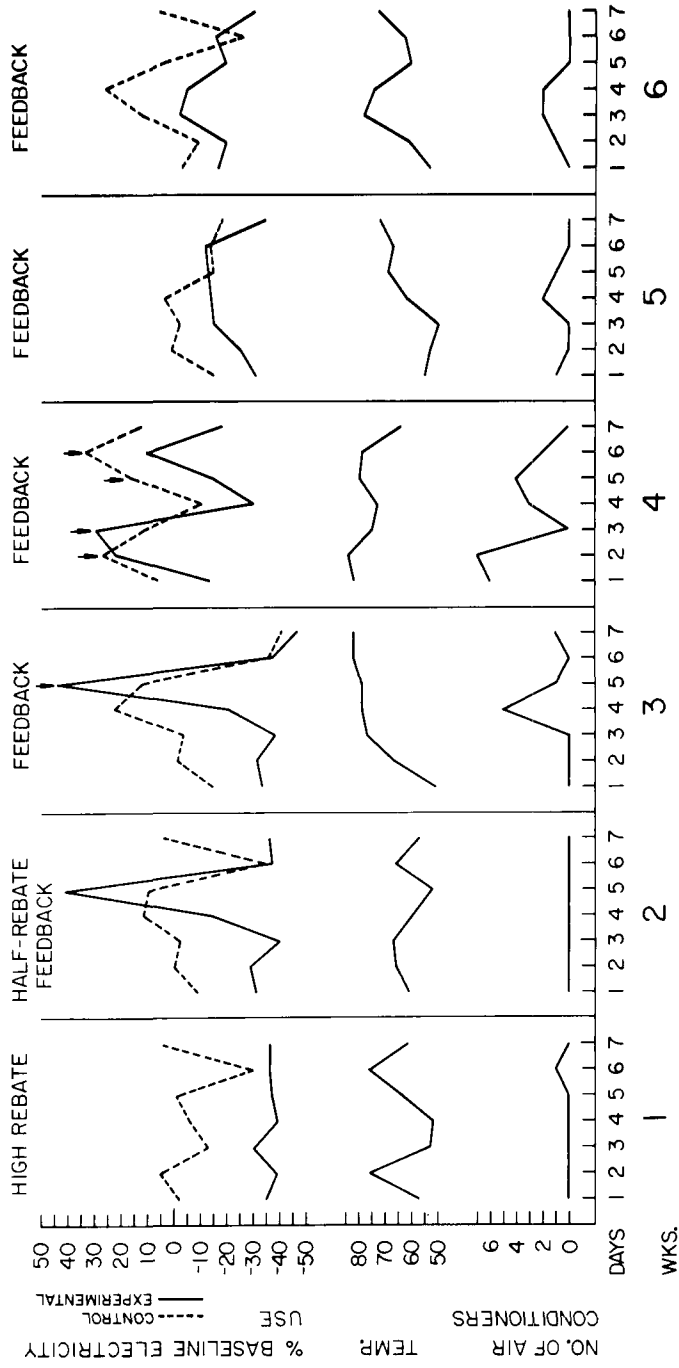[2] Janet Beadle was the second observer.

Figure 1. Electricity use of experimental and control groups as a function of baseline level under rebate and feedback condition for six weeks (42 days); high temperature each day and number of air conditioning units observed on.

Table 1. Electricity Use as a Function of Baseline

Group	Floor	Unit	High	Half-feedback	Feedback	Feedback	Feedback	Feedback	Ave
E	1	1	− 8	+18(f)	+15	+33	+20	+12	+15
E	1	2	−41	−38(1/2)	−43	−30	−28	−22	−34
C	1	1	+22	+12	+ 3	+ 3	+ 7	− 3	+ 7
C	1	2	−13	0	+ 1	+18	−34	− 6	− 6
E	2	3	−54	−72(f)	−72	−73	−68	−59	−67
E	2	4	−20	− 6(1/2)	−10	+ 9	−11	− 7	− 7
C	2	3	− 6	− 1	− 9	− 1	− 1	− 2	− 3
C	2	4	−10	−46	−54	−30	− 4	−31	−25
E	3	5	−34	−16(f)	+ 9	+10	+ 2	− 8	− 1
E	3	6	−57	−39(1/2)	−25	+42	−38	−17	−14
C	3	5	− 6	+16	+10	+30	− 9	+27	+12
C	3	6	−29	+10	+ 1	+62	−10	+20	+ 9
E	—	all	−36	−20	−22	− 2	−21	−17	−20
C	—	all	− 6	− 3	− 8	+14	− 8	+ 1	− 2

units reduced their electricity use more (range = 1-35%; average = 23%) than the control units on twenty-one of twenty-eight days.

Table 1 presents individual weekly apartment electricity use represented as a function of the baseline level. Two of the experimental units reduced their electricity use every week [2, 3], one experimental unit reduced its electricity use by greater than 17 per cent every week but one [6], and another experimental unit reduced its electricity use by greater than 6 per cent except for one week [4]. One experimental unit averaged baseline use [5], while another unit increased its electricity use (15%) [1]. However, an extremely large and consistent reduction pattern was found for one of the experimental units [3].

For the control units, one apartment regularly decreased electricity use [4], two apartments showed a low (average 4.5%) amount of reduction [2, 3], and three apartments irregularly increased their electricity use by an average of 9 per cent [1, 5, 6].

Table 1 (bottom) also presents group by week electricity use. After the high rebate week, the difference between the experimental and control groups averaged about 15 per cent.

Because of the marked reductions shown by experimental unit 3 and control unit 4, a per cent use score for the experimental vs. control units was obtained subtracting out these two units. For the high rebate week, the five experimental units reduced their use by 31 per cent and the five control units increased by 5.5 per cent. For the following weeks the figures were - 10% vs. +6%, - 12% vs. +1%, +12% vs. +23%, - 12% vs. - 8%, and - 6% vs. +7%, or an average difference between experimental and control apartments of 11.5 per cent per week.

Except for experimental unit 3 that reduced electricity use all forty-two days, experimental unit 2 that reduced forty of forty-two days, and control unit 4 that reduced thirty-four of forty-two days, other units displayed variable daily electricity use probably a function of time at home and air conditioning use. An extreme example was experimental unit 6. Electricity use figures for the third week were: -39%, -66%, -73%, -35%, +124%, -77% and -9%. For the fourth week the figures were: -32%, +83%, +140%, -47%, +22%, +90%, +37%. This unit was the most frequently observed user of air conditioning.

HALF REBATE VS. FEEDBACK

An examination of Table 1 indicates that three of the units on the half rebate continued to reduce their electricity use during week two compared to two units decreasing during this week on feedback alone. However, the relative increase compared to the prior week for the three half rebate and three feedback units was about the same. In addition, a comparison of week three with week one and two indicated little difference in the increased use of electricity.

AIR CONDITIONING

The primary meter reader's observations provided an estimate of air conditioning use. Since observations were made at 6:30 PM, the effects of using air conditioning on KWH consumption should be apparent on the following day's reading. At the bottom of Figure 1, the number of air conditioning units observed in use are noted. Arrows indicate on the electricity use graph a day following the observation that three or more apartments were using air conditioning, all occurring under feedback conditions. For these five days, there was on the average no difference between the experimental (+19%) or control (+20%) group's use of electricity. The largest users of air conditioning were experimental and control units 6.

POST INTERVIEWS

Interviews were conducted with occupants of all experimental apartments on the last day of the study. Apartment 3's occupants indicated that partly in response to being in the project and partly because of a high electricity bill, a malfunctioning hot water heater was fixed after the baseline period. The repair of this appliance and some limited conservation efforts led to marked reductions. The

occupants of apartment 2 reported curtailing cooking and watching TV, and did not use air conditioning. The occupants of apartment 6 reduced lighting and air conditioning; they indicated that their air conditioning thermostat was set at 78°. All occupants of these apartments agreed that feedback was useful to them but all suggested the idea of one large prize offered to the largest reducer. These three apartments' average reduction during the six weeks was 38 per cent.

Apartment 4 indicated only limited conservation efforts involving turning out lights. Their interest apparently diminished after the high rebates ended. Apartment 5 indicated they conserved a great deal *before* the project began although additional efforts were made to curtail lighting. Apartment 1 engaged in some limited conservation efforts before the project and added no new behaviors. Together these three apartments increased their electricity use by 3.7 per cent.

Discussion

The major conclusion of this study is that daily feedback on electricity consumption, preceded by a high rebate system, can result in an average reduction of 10-15 per cent in electricity use in an apartment setting. Feedback alone was given for a period exceeding those used in Hayes and Cone [3] and Palmer et al. [4] and the use of a control group showed that the reduction of the experimental group while fluctuating with weather conditions, each week exceeded the control group's reduction. The data suggested, however, that feedback was not effective during very warm days when air conditioning was frequently used and that feedback's effects were variable across the participants. A high rebate system, probably impractical, achieved marked reductions that replicated prior studies while a half rebate system was apparently no more effective than feedback alone [2, 3]. It is still unclear what effects feedback alone would have if it were not preceded by high monetary payments.

Cool weather during the last two weeks of the study precluded evaluating a specific air conditioning curtailment procedure involving feedback and rebates. The feedback given in this study was not directly tied to air conditioning use, so that the use of feedback with air conditioning (or heating), the major source of residential electricity consumption, should be investigated next.

A plan for air conditioning curtailment would have a number of components. The consumer would first be advised to check the

functioning of that system. Such routine checking as evidenced from the results from experimental apartment 3 can yield substantial savings. Information, perhaps in the form of wall charts placed near the thermostat [1], could indicate that for every degree the thermostat is set below 78° means an 8 per cent increase in energy use [6]. A shaping procedure involving rebates and feedback can be devised to help consumers gradually place their thermostat at higher settings. It is also possible that a feedback device placed next to the thermostat could show the consumer the amount of energy being used, increases or decreases from a base period, and predicted costs [9]. Other indicators on the device might readily show over-use, or serve to cue behaviors such as the use of a dehumidifier that might also curtail air conditioning.

While this plan may appear technologically feasible and effective, it is important that this proposal and similar ideas be carefully field tested. For example, it is unclear how many consumers would purchase such a device. It is equally unclear how much reduction in energy consumption might be associated with use of the device by potential consumers who may already be conservation-minded [6]. The mixed results to date of conservation studies suggest the need for continued systematic research, but, at most, cautious optimism.

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