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A RESIDENTIAL HIGH EFFICIENCY FURNACE REPLACEMENT PROGRAM IN ILLINOIS AN EXAMINATION OF ENERGY SAVINGS AND RELATED CONSUMER BEHAVIOR

BY

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This paper presents the results of a study of the energy savings achieved from a low- to middle-income high-efficiency furnace replacement program and an examination of other energy conservation measures and lifestyle changes taken by program participants. The program paid from 20 to 80 percent of the cost to replace low-efficiency residential furnaces with high-efficiency natural gas units. Eligibility for funds was based upon household income levels.

A paper on the evaluation methodology was presented during the Evaluation Design Session at the Chicago Evaluation Conference in August 1987. The results from this study are now available and are presented here. The study demonstrates several evaluation and data quality problems that limited study goals, required changes in methodology and reduced the confidence in the study conclusions. The evaluation methodology incorporates an examination of both pre- and post-program weather-adjusted household consumption records for both an experimental and a control group. The study uses two methodologies in the examination of these data. The first method uses the PRISM Scorekeeping program. The second method uses weather-adjusted changes in monthly consumption. Two evaluation methods were used because half of the participants' consumption data was of insufficient quality to be accepted by the PRISM program. The control groups for both comparisons consisted of the examination of two years of preprogram energy consumption records for program participants enrolling during the last year of the program. This consumption was compared to the pre- and post-test periods for the earlier "test group" participants. This method provides a comparison of energy consumption for identically self-selected participants from a test group taking part in the program and a control group that has yet to take part, over an identical period of time, within the same geographical area.

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INTRODUCTION

The Illinois Department of Energy and Natural Resources (ENR) implemented the Home Energy Loan Program (HELP) in 1984 under the provisions of the Solar Bank Program. The HELP program provided grants to banks to buy-down the principal of an energy conservation loan taken out by homeowners installing energy conservation measures in their homes. The program was targeted at the middle to low-income households and provided from 20 to 80 percent of the cost to install program-approved conservation measures. The upper limit of the target audience was established by an income cap of 120 percent of the area's median household income. Income levels were verified through the households' federal income tax return for the prior year. Individual applications for the program were completed by each household and submitted to the participating bank where the loan applications received preliminary approval and sent to ENR for final approval. Loans were processed by the bank as a conventional personal loan with program payments made by ENR and were sent directly to the participating bank. Each bank used the program payment to buy-down the principal of the loan. Customer payment schedules were then established to recover the remaining principal plus interest on the unpaid balance. Each applicant was required to submit an RCS home energy audit provided by the applicant's utility company or by ENR. Most conservation actions recommended by the audit showing a positive payback were approved for funding through the HELP program.

The program was promoted primarily by two methods. The first was through the participating banks which viewed the program as a service to their current customers and a method of gaining new customers. Several banks placed posters in their lobbies, notified customers by mail or informed people when they applied for a home improvement loan. Second, the program was promoted through heating contractors who viewed it as a way to sell furnaces to households that would have otherwise fixed their old furnaces or purchased less expensive, less efficient furnaces. Contractors promoted the HELP program in their stores and through the mass media. This helped establish furnace replacements as the most frequently funded conservation action.

ENR developed only a small number of window posters and flyers to assist with program promotion. Because the Federal Solar Bank Program regulations prohibited the spending of program funds for advertising or promotional activities, primary promotion responsibility was left to the private sector using the HELP program as a sales incentive.

The HELP program operated for two years (Jan. 84 to Jan. 86) providing 3,129 loans before funds were depleted. Of these, a little over 2,100 loans went toward furnace replacements and about 1,000 went for other conservation actions. During the first six months of the program, applications averaged between 20 and 50 a month, climbing to an average of 200 a month by the end of the first year. Applications averaged about 200 a month throughout the second year of the program. By the end of the second year, networking by the program participants provided continued demand for services after program termination.

EVALUATION METHODOLOGY

Sample Selection

Because this program primarily funded furnace replacements, measurements of changes in energy consumption had to be made over at least one heating season before and after furnace replacement. In addition, in order to establish a control group consisting of individuals who had selected themselves to be part of the program, it was necessary to divide the total participant population into two groups. The first group consists of those individuals taking part in the program from April 1984 through September 1984. For evaluation purposes, this group is identified as the test group. The control group for this evaluation consists of individuals participating from April 1985 through September 1985. Because these participants entered the program after the test group examination period, their historic consumption records for the pretest and post-test periods are used as a control group for adjusting program-induced energy savings. This separation of participants into the test and control groups meant that a total of only 220 individuals could be selected for the test group. This number of participants for the test group required that all 220 individuals be selected for possible examination in the study. The selection of the control group participation period (the same time period as the test group, one year later) allowed a total of 1,140 potential participants for the control group.

Energy Consumption

The design of the evaluation was established as a pretest and post-test examination of the first year program participants' energy consumption as compared to a control group consisting of the second year participants. This method allowed an examination of energy consumption of the control group for a two-year period prior to their enrollment in the program. These records could then be compared to the test group's consumption one year before and one year after program conservation measures were installed. For purposes of this evaluation, only homes heated with natural gas both before and after the study period were selected for examination.

Computer Model For Energy Consumption

The computer model used for this evaluation was PRISMonPC, version 4.0, released October 1986, also known as PRISM, the The Princeton Scorekeeping Method. This model is provided by the Center for Energy and Environmental Studies at Princeton University and is an accepted standard for examining changes in building energy consumption over an extended period of time (see Fels, 1986).

Weather Adjustments To Household Consumption

To simplify the evaluation, the study was limited to major metropolitan areas where at least 100 (test and control group) participants could be grouped around a single weather station providing daily temperature readings required by the PRISM program. Daily temperature readings were then obtained from the National Oceanic and Atmospheric Administration and entered into the computer model. This model uses regression to normalize the natural gas consumption of each household for variations in weather over a specified meter reading period.

Survey For Behavior Changes

Over any multi-year evaluation test period, most households make changes in their lifestyles that affect energy consumption. These changes can be births, deaths, moving, illness, vacations, home additions, other conservation actions, etc. In order to obtain some indication of which households selected for this study made major changes in their lifestyles that are expected to affect energy consumption patterns, a behavior change survey was mailed to both the test group and the control group. The survey, while too extensive to be included within the page limitations of this paper, is available on request from the Evaluation Unit, Illinois Department of Energy and Natural Resources (217/785-3445). The behavior change survey asked a wide range of questions concerning changes in both family and household characteristics and had a 70+ percent response rate. Questions included in the behavior change survey asked respondents to report the use or installation of additional conservation actions over the test period. Actions were listed in menu form enabling respondents to check if the action was or was not taken both before and during the test period. Actions listed on the menu included: ceiling, attic or roof insulation; sidewall insulation; basement or foundation insulation; weather-stripping on doors or windows; storm doors or storm windows; replacement windows; water heater blankets; wood stoves; setback thermostats; lowered water temperatures; lowered space heating temperatures; use of portable room heaters; and an open-ended question for "other" conservation actions taken. Additional questions included in the survey asked respondents to report changes in the following areas: number of people living in the home, number of

rooms heated, size of the home, major illnesses, annual income of household members and an open-ended question on "other" behavior changes that affect consumption. The survey also asked questions concerning the purchase of new or replacement appliances, changes in the type of fuel used for space heating, water heating, cooking and drying clothes.

Problems Requiring Design and Sampling Changes

Several problems surfaced during the course of this study that required changes to the evaluation design. These changes reduced the level of statistical confidence associated with the study conclusions by decreasing the population sample size. However, management confidence in the study findings remained strong since two separate examination methods discussed below independently reached similar conclusions. That is, we are not strongly interested in determining precise energy savings, we are more interested in knowing if savings occurred and the estimated range for those savings.

Following the selection of the study groups and the identification of individuals living in metropolitan areas with weather stations, fewer than 150 individuals remained in the test group and about 720 individuals remained in the control group. The names and addresses of these individuals were sent to the five natural gas utility companies serving the four selected cities and their surrounding areas. The utility companies were asked to supply the natural gas meter files for their customers who were selected for the study. We asked for meter reading dates and the number of therms consumed between meter readings for a period including the 1983-84 and the 1984-85 heating seasons. One of the utility companies reported that they did not maintain consumption records for their customers beyond a three-year period and were therefore unable to comply with the request. Another utility company requested over $5,000 to obtain their records. Each of these utility companies and their associated participants were eliminated from the study. Of the three utility companies remaining, one provided monthly meter readings for their participants but was unable to provide the exact meter reading dates. Because PRISM requires exact dates for its meter files (to normalize consumption) the consumption data provided by this utility were excluded from PRISM examination. However, these data were examined for pretest and post-test consumption changes for the test and control groups using a standard monthly, heating degree-day adjusted, normalized consumption method, commonly know as the "slash and burn" (see Mills, 1987) technique. These results are presented in this report along with the PRISM results. The remaining two utility companies provided the consumption records as requested. However, one reported it could only locate HELP program participants by the name listed on the HELP program records files rather than by a name and/or address search routine. Since utility records and HELP program applications often did not list the same individual in each household, several utility records could not be located via the name only search routines.

An additional problem associated with all of the utility data received was the quality of readings. Many homes in the remaining sample had estimated readings instead of actual readings. Some homes had estimated readings for over 70 percent of their billing periods. Others had estimated readings every other month. Others would skip readings for several months by sending bills based on last year's readings. The utility would then send an estimated or actual reading to bring the account up to date and to adjust for errors in billing. As a result many homes had to be eliminated from the study because of poor data quality.

Each of these problems eliminated members of the original sample of program participants. Since the sample included all participants within the time frame needed to examine winter consumption records and the program was relatively small, we were unable to use additional participants to build up the sample size. As a result, the evaluation methodology was changed to include two primary methods for examining utility consumption records rather than just the PRISM method. Both the PRISM results and the "slash and burn" results are presented in this study. While separately these results cannot be considered definitive, together they provide a strong case for establishing a range of savings for the HELP program.

An additional problem associated with a reduced sample size became apparent when the results of the behavioral survey were examined for the effects of other conservation actions or behavioral changes on energy consumption. No single conservation action or behavioral change was reported with enough frequency to make factor analysis of the effects of the change meaningful. Therefore, the behavior changes and other conservation actions taken by the participants are reported to show the frequency of such changes within the target group rather than to predict their effect on household consumption.

EVALUATION RESULTS

Changes In Energy Consumption

The results of the PRISM comparison of the test and control groups revealed an average drop in energy consumption of 22.2 percent compared to the control group. The average change in consumption for the test group was -19.2 percent while the average change in consumption for the control group was +3.0 percent. The range of changes for the test group was from -61.3 percent to +36.1 percent and from -21.5 to +74.7 percent for the control group. A total of 41 test group homes were examined using PRISM while 57 were examined from the control group. Only homes with R^2 values of .80 or better were included in these data. However the majority of homes had R^2 values above .90. As acceptable R^2 values were increased, the number of homes remaining in the sample

decreased while the level of savings calculated through PRISM increased. In order to maintain a reasonably acceptable R^2 value and still keep as large a sample as possible,.80 was established as the lowest acceptable R^2 value for this study.

The results from the examination of the households using the average weather adjusted monthly consumption method or the "slash and burn" technique revealed an average test group savings of 14.7 percent compared to the control group. The average change in consumption for the test group was -14.4 percent while the average change for the control group was +0.3 percent. The range of changes for the test group was from a 67 percent reduction to a 72 percent increase in consumption. The range of changes for the control group was from a 52 percent decrease to a 73 percent increase in consumption. A total of 54 test group homes were examined with the "slash and burn" technique, while 88 homes were in the control group.

Table I. Changes in energy consumption.

	Percent Change	Sample Size
PRISM		
Test Group	-19.2	41
Control Group	+ 3.0	57
SLASH AND BURN		
Test Group	-14.4	54
Control Group	+ 0.3	88

Level Of Confidence In Study Results

A total of 95 test homes and 145 control homes survived to the end of the evaluation in both the PRISM files and the "slash and burn" files. While we would have preferred to keep sample size above the $95^{+}_{-}5$ percent standard, we found it necessary to drop below this standard for this study and accept $80^{+}_{-}5$ percent for each evaluation methodology. While these sample sizes are somewhat small by most evaluation standards, they are quite suggestive when we consider that both independent evaluation methodologies found similar high levels of energy savings. In addition, a similar preliminary study of the HELP program was conducted in 1985. This study, published in 1986 by the Illinois Department of Energy and Natural Resources, examined a test group of 188 very early program participants and found a 15 to 20 percent weather-adjusted reduction in household energy consumption. The results from the earlier preliminary study verified a similar range of savings.

When the results of all three independent studies are grouped together, their results provide management with verification of the large savings potential of furnace replacement programs.

Table II. Summary of study results

YEAR AND METHOD OF STUDY		STUDY RESULTS
1985	Monthly Weather Adjusted Consumption Changes	15 to 20 % Savings
1987	Monthly Weather Adjusted Consumption Changes	14.7 % Savings *
1987	PRISM Scorekeeping Method	22.2 % Savings *

* Adjusted for changes in control group consumption

Changes In Energy Related Behaviors

When presented with a menu of changes in lifestyles that have some effect on household energy consumption, several participants reported having made or experienced such changes. While the small sample size limits our examination of the effect these changes have on household energy consumption, the frequency of occurrence for some of the changes is highly suggestive. If future program evaluation sample sizes are sufficient, factor analysis may be used to determine the influence of behavior changes on household energy consumption. However, it is also valuable to know that within the low- to middle-income homeowner targets of the HELP program, behavior changes occur with significant frequency to have an effect on the energy consumption levels. Evaluations, such as this one, that cannot factor out the effects of changes in household behavior risk higher levels of uncertainty in evaluation findings.

The behavior changes reported in Table III (below) occurred in both the test group and the control group. At first appearance there seems to be little significant difference between the changes reported by either group that would have a major effect on energy consumption. However, here again this conclusion is hampered by a sample size too small for a statistical comparisons. That is, the similarities or differences between the test group and the control group may not be reflected if a larger sample were possible.

Other Conservation Actions Taken By Participants

In addition to the behavior changes previously discussed, many participants reported energy conservation actions taken over and above the furnace replacements. Again, there is little indication that the test group reported different frequencies of conservation actions than the control group. However, a larger sample size is needed to confirm or deny any statistically

Table III. Energy-related behaviors reported by HELP Participants.

AREA OF CHANGE	-PERCENT TAKING ACTION- TEST GROUP	CONTROL GROUP
Change in winter thermostat setting.	42	46
Change in number of people living in the home.	29	29
Change of $3000.00/year or more in household income.	28	27
Change in number of rooms heated in the winter.	26	22
Change in the number of employed household members.	16	15
Periods of 3 weeks or more of vacant home.	14	9
First time purchase of a major household appliances.	12	9
Extended illness of a household member.	6	14
Change in the size of the home.	6	1
Change in fuel used for drying clothes	4	4
Change in fuel use for heating water.	4	2
Change in fuel used for air-conditioning.	4	1
Change in fuel used for heating the home.	2	0
Change in fuel used for cooking.	2	1

Caution: Test Group N = 51
Control Group N = 81

Table IV. Other energy conservation actions taken by program participants during the study period.

CONSERVATION ACTION	-PERCENT TAKING ACTION- TEST GROUP	CONTROL GROUP
Lowered hot water temperature.	61	46
Weather-stripping on doors or windows.	49	37
Lowered space heating temperature.	43	47
Added insulation to ceiling or attic.	37	33
Raised air-conditioning temperature.	36	43
Installed automatic setback thermostat.	29	29
Installed storm doors.	26	23
Installed storm windows.	23	11
Added sidewall insulation.	22	25
Installed replacement windows.	22	16
Added basement or foundation insulation.	14	21
Installed wood stove or fireplace.	5	1

Caution: Test Group N = 51
Control Group N = 81

significant changes in the actions taken by these groups. What is certain, however, is that during the test period both program participants and nonparticipants reported taking a considerable number of other conservation actions that may have an influence on energy consumption levels. The energy conservation actions reported are provided in Table IV.

FREE-RIDER EFFECTS

Included in the behavioral change survey were two questions addressing the free-rider problem associated with energy conservation programs. A free-rider is a program participant who would have taken the same action, even if the program did not exist. This issue complicates the evaluation of program effectiveness because there is no clear way to determine what an individual will do in the absence of program services. With this in mind, we asked each participant if he/she would have taken the same energy conservation measure without the program assistance. The results revealed a near 50-50 response split in the test group. That is, 51 percent said they would not have taken the same action without the program, while 49 percent said they would have taken the same action. In the next question, the test group was asked if they would have installed the same furnace or a less expensive, less efficient furnace without the HELP program. Here respondents had a wider range of response choices and provided the following answers.

Survey question: If you installed a new energy-efficient furnace as part of the HELP program do you think you would have installed that **SAME** furnace or a less expensive, less efficient furnace if the HELP program were not available?

Possible Answers	Percent Response
1. Would have installed a less expensive, less efficient furnace.	29
2. Would have installed a high-efficiency furnace anyway.	33
3. Would not have installed a new furnace.	20
4. Don't know or not sure.	4
5. Other	14
Caution N = 51	

This question indicates that 33 percent of the respondents would have installed a high-efficiency furnace similar to the one installed through the HELP program. It also appears that between 49 and 53 percent ((29+20=49) and (29+20+4=53)) would have chosen not to install a furnace or would have installed a less efficient furnace without the HELP program. These results seem

to establish the free-rider effect at about one third of program participants. However the comments written on the surveys by the participants seem to confuse the free-rider issue even more than what people said they would or would not have done. For example, in several cases the same individuals that said they would have taken the same action without the program also commented that they were too poor to replace the furnace without program assistance. These comments make us think that the "same action" meant that several participants were reporting that they would have had to do "something" about the furnace. Likewise, some respondents who said they would have installed a high-efficiency furnace anyway also reported that they were thankful for the program because they did not know how they were going to obtain enough money to fix a poorly operating or inoperative furnace. Because of these comments, it seems certain that the responses to the free-rider questions are not valid indicators of free-rider participants. Perhaps people, especially in the low-income sector, think any new furnace is a high-efficiency furnace and respond accordingly. The justification for this reasoning is that unpublished market research conducted by ENR revealed that most people in the low- and middle-income sectors think all new homes are energy efficient just because they are new. If this same condition applies to furnaces, then the responses to our free-rider questions are invalid for determining free-rider effects and a new set of questions or methodology will need to be developed.

PROGRAM COST/BENEFIT

The HELP program spent an average of $900.00 per participant over the life of the program. This includes the cost of conservation loans, program administration, and the limited outreach activities funded through the program. The average natural gas consumption of the HELP participant was .182 therms per degree day before program participation. This figure was reduced by 15 to 22 percent or an estimated saving from .027 to .040 therms per degree day. The National Oceanic and Atmospheric Administration reports an average of 6102 population-weighted heating degree days in Illinois for the 52-year period from 1931 to 1983. If we multiply the estimated savings for the HELP program participants by the average heating degree days, we obtain an average estimated savings in natural gas consumption from 165 to 244 therms a year. At the average heating season (Nov-Feb, 1988) weighted cost of residential natural gas of $.514 cents per therm for HELP program participants, the expected savings for each participants is from $84.80 to $125.42 a year.

The simple payback period required to recover program costs as savings to the individual household is from 10.6 years, to 7.2 years. Simple payback is used to calculate program payback because natural gas prices in Illinois have

stabilized and are projected by ENR to remain stabilized in the near future. Additional or more detailed cost/benefit calculations are excluded from this study because they are of limited interest to ENR or the program managers.

IMPORTANCE AND USE OF EVALUATION RESULTS

Demonstration Of Program Savings

The important outcome of this evaluation is the indication that the program is accomplishing its goal of saving energy. That is, it is a program doing exactly what it was designed to do. Additionally, with energy savings averaging 15 to 22 percent and total program costs averaging less than $900.00 per participant, we feel this program is very cost effective when compared to other cold-belt weatherization programs. Further, we believe that since this program replaced furnaces which were shown to be inefficient by an RCS audit, we can project these savings over the expected 25 to 30 year life of the new furnace.

Documentation For Additional Loan Program

The results from this study and the earlier "preliminary study" of the HELP program were critical in obtaining agency support for an additional $1.5 million needed to offer a similar program to rural Illinois homes. This program received funding and is currently operating in Illinois.

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