EVALUATION OF THE UTAH INSTITUTIONAL CONSERVATION PROGRAM: PRELIMINARY RESULTS

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Introduction

Energy conservation programs often have explicit or implicit economic efficiency goals. While programs may be justified with sustainable society, environmental, or equity arguments, even the most hardened environmentalist or advocate for low-income households understands "getting the most bang from the energy conservation buck."

In this paper, part of a larger project funded by the Utah Energy Office (UEO), we present some preliminary results from our evaluation of the Utah Institutional Conservation Program (ICP). This work was preceded by another project which identified program evaluation possibilities at the UEO and led to an evaluation of the Utah Weatherization Assistance Program (Miller, 1988; Miller, 1989).

There is a large and growing literature on evaluation of residential energy conservation programs, but only a few studies of programs for institutional buildings (Davis, 1987; Utah Energy Office and Idaho Department of Water Resources, 1988). During the course of this study, we began to understand why this is the case. Institutional programs are much more difficult to evaluate.

Our main purpose here is to report preliminary estimates of percent savings in natural gas consumption due to energy conservation measures (ECMs) installed under the Utah ICP. As part of the larger project, we will also measure savings in electricity consumption, add this to the natural gas savings, and calculate the discounted present value of benefits and cots of the program. Our eventual goal is to be able to compare these ICP results with those of our previous evaluation of the Utah Weatherization Assistance Program.

In the process of developing and presenting these preliminary results for natural gas, we comment on the evaluation problems and challenges we have encountered to date, often with reference to our previous experience in residential program evaluation. We also compare ICP percent natural gas savings under three different methodologies: PRISM, FASER, and an internal UEO method.

The Utah Institutional Conservation Program

The UEO, an independent agency of the State of Utah, uses federal funds to subsidize energy conservation in institutional buildings. From the inception of the program in 1979 through December 1988, the UEO has distributed over $7.3 million, on a 50% matching basis, for the installation of ECMs in schools and hospitals. Installation has been completed or is nearing completion in 359 buildings and work on another 44 buildings began on September 1, 1988. ECMs include, among others, boiler modifications, vestibules, insulation, lighting reductions, and monitoring control equipment.

In addition to the installation of ECMs, 818 walk-through energy audits have been completed, and technical assistance audits have been completed on 454 buildings.

The ICP Evaluation Sample

We encountered significant data problems in our evaluation of the Utah ICP. Initially, we expected to have information on 359 institutions — all schools — for which we thought conservation measures had been installed. Our initial preliminary sample is considerably smaller.

After deleting institutions for which the ECMs were not yet completed, we were left with 306 possible sample observations. To facilitate accurate measurement of pre- and post-ECM energy consumption, we decided to obtain nine years of meter reading data from the major Utah utilities — Mountain Fuel Supply Company and Utah Power and Light Company. Early conversations with utility personnel indicated this would be possible. Based on this expectation, we deleted 96 institutions not in the service area of the major utilities. Our sample was down to 210.

After work on the project had begun, we learned that it would not be possible to obtain more than the last three years of meter data for sample institutions. We reluctantly turned to individual technical audits for pre-ECM consumption data and to follow-up reports from the institutions for post-ECM data. Reporting differences between the pre- and post-ECM periods required that we delete an additional 32 institutions from the sample. Nineteen institutions were deleted because they received more than one grant. The sample then numbered 159.

An additional 49 institutions were late with their first year utility reports. For 34 institutions, monthly post-ECM data could not be found, and 9 institutions had other post-ECM data problems. The initial sample had shrunk from over 350 institutions to 67.

Residential vs. Institutional Conservation Program Evaluation

Compared to residential energy conservation programs, measurement of energy savings from institutional programs is considerably more problematic. Some of the comparative difficulties are illustrated in Table 1.

In residential programs, ECMs are installed in a short time period, resulting in a short time lag between the end of a pre-ECM consumption period and the beginning of a post-ECM period. Three years of utility meter data, the maximum available to us from Mountain Fuel Supply Company, are sufficient to generate adequate pre- and post-ECM consumption samples. As shown in Table 1, three years of recent meter data resulted in a raw sample of 281 Low-income Weatherization Assistance Program participants. For all observations, the time period from the beginning of the pre-ECM consumption period to the end of the post-ECM period was 25 months. In contrast, our institutional raw sample of 67 observations required a total sample period of 8.5 years and a median pre-post time lag of 6.0 years.

The longer the time lag, the greater the possibility that structural or behavioral changes can affect energy use. Even in procedures could be developed to eliminate "bad institutions" from the sample, the corresponding reduction in sample sizes would be problematic. For our residential sample, the use of a household survey to identify structural or behavioral changes still left us with a "good house" sample of 95 observations. The larger sample size in residential programs also allows the deletion of observations with the aid of non-survey information such as PRISM output. For our residential sample, we deleted houses with pre- or post-period PRISM R^2 values of less than 0.9. With smaller institutional sample sizes, and generally poorer temperature normalization statistical results, such a luxury in normalization accuracy is not feasible. In fact, to maintain a reasonable sample size, we kept institutions in the sample as long as the pre- and post-PRISM R^2 statistic was greater than 0.6. The result of this is evident from the comparative R^2 information in Table 1.

Finally, we note the relatively larger pre-post improvement in temperature statistical fits in the institutional sample, and the large increase in median estimated reference temperature, from 66°F to 71°F.

Alternative Temperature Normalization Methods

Accurate measurement of energy savings from a conservation program requires adjustment and control for factors affecting energy use other than the ECMs installed under the program. For our preliminary estimates presented in this paper, we attempt to control only for changes in the size (square feet) of the institution, and temperature differences (heating degree days). Development of relevant control groups to account for other general changes in energy use behavior is, at present, not completed. Establishing control groups is another evaluation procedure hampered by the long time period involved with institutional evaluation samples. Three alternative temperature normalization procedures are described in the following subsections.

Table 1. Characteristics of Utah Institutional and Residential Program Evaluation Samples

Sample Characteristic	Institutional Program	Residential Program
Sample time bounds	7/1/78 - 1/1/87	1/1/85 - 2/28/88
Pre/post time period	Median = 72 mos.	25 mos. for all
Raw sample size	67	281
"Clean" sample size	57	95
Sample adj. method	$R^2 > .60$	$R^2 > .90$; res.survey
Consumption data	TA and Followup	Utility meter readings
Med. PRISM R^2 - Pre	.85	.95
Med. PRISM R^2 - Post	.93	.96
Med. Ref. Temp. - Pre	66	62
Med. Ref. Temp. - Post	71	64

The PRISM Method

PRISM (Fels, 1986) is rapidly becoming the standard temperature normalizing technique for program evaluation. It is a reasonably "user friendly" computer software package utilizing regression analysis, monthly pre- and post-ECM energy consumption data, and daily mean temperature data to calculate pre- and post-ECM normalized annual energy consumption. For each 12-month period, PRISM estimates a linear regression equation which relates energy consumption to a constant term and heating degree days. Since the value for heating degree days is calculated with respect to a reference temperature, PRISM uses an iterative procedure that selected the temperature that maximizes the value of the R^2 statistic. Annual average long-term heating degree days are then used with the estimated equation to calculate normalized annual consumption.

PRISM can handle a large sample of program participants at one time, yields estimates of energy savings directly, and provides information on regression statistics, baseload and temperature-dependent consumption, and estimated reference temperatures. PRISM output also is valuable in screening the data set for bad observations.

The FASER Method

An alternative method of weather normalization is the advanced energy analysis option in FASER — the Fast Accounting System for Energy Reporting (OmniComp, 1986). The program documentation begins with the rather formidable caveat:

> *The advanced energy analysis option is intended for only the most knowledgeable energy professionals who understand the fundamentals of building energy usage, building balance point temperature, and variable degree days. If you're not experienced in these areas, this feature is probably not for you. [OmniComp, Inc., p. PV-12]*

We consider ourselves among those blessed with such knowledge, yet FASER is so cumbersome as to be nearly inapplicable in a program evaluation with large samples.

For each institution, FASER estimates a summer and winter normalizing regression similar to that in PRISM. A month having more than 50 heating degree days is a winter month; a month having more than 50 cooling degree days is a summer month. Regression parameters are estimated for the pre-ECM consumption period using degree day data for this period. Adjusted baseline consumption is calculated using degree day data from the post-ECM consumption period and the estimated pre-ECM regression parameters. No adjusted baseline is calculated if the regression R^2 statistic is less than 0.5. Energy savings are then calculated as the difference between the adjusted baseline and raw post-ECM consumption.

FASER is designed primarily as an energy accounting system. Unlike PRISM, FASER must be applied independently for different accounting periods. For example, to run FASER, an account must be established which, in turn, requires a baseline year. The difficulty arises from the fact that different institutions in the sample often have different baselines. In our sample, we had to create five different accounts and a separate weather file for each account. Even within one accounting period, separate analysis had to be done for institutions with different baseline years. For large samples, this becomes increasingly difficult and time-consuming.

Another shortcoming with FASER is that long-term average temperature information is never included int he analysis. Energy consumption is normalized between two periods, but these two periods may both differ from long-term average temperature patterns and this might distort estimates of energy savings over the life of the ECMs — critical information for economic analysis of conservation program effects. For these and other more minor reasons, we are not optimistic about the usefulness of the FASER temperature normalization method, especially for large samples.

The UEO Method

An internal UEO method has been used to measure temperature-adjusted energy use per square foot for selected institutions in the Utah ICP (UEO and Idaho Department of Water Resources, 1986, p. 23). In this method, pre- and post-ECM consumption per square foot is divided by the total degree days in the period to yield consumption per square foot per degree day. Possibly the greatest advantage of this method is simplicity.

Percent differences can then be calculated from the pre- and post-savings per square foot per degree day. While a percent savings estimates is usually the goal of this method, savings estimates can be obtained if an appropriate no-ECM baseline level of consumption can be obtained. Savings would then be estimated as the product of the percent change in consumption per square foot per degree day and the no-ECM consumption baseline. Pre- or post-ECM consumption, or an average of the two, are possibilities for the baseline, but not the best numbers. Neither is a temperature-normalized annual consumption as one would obtain from, say PRISM output. The UEO method has the same conceptual shortcoming as FASER. Long-term average heating or cooling degree days never enter the analysis, so neither pre- nor post-consumption is ever normalized for "average" temperatures.

A Comparison of Preliminary Estimates of Percent Changes in Natural Gas Consumption

Alternative estimates of percent changes in natural gas consumption in the Utah ICP appear in Table 2. These are preliminary estimates for two reasons. First, we are in the process of acquiring three years of metered consumption data from Mountain Fuel Supply Company. While this will not be a sufficient time period to provide both pre- and post-ECM consumption data for any institution in our sample, it may improve the reliability of some post-ECM data and also increase our sample size, as several institutions had to be dropped from the sample due to inadequate post-ECM data. Second, the estimates are not adjusted for factors other than temperature and square feet differences. We are in the process of developing utility-wide institution-specific control groups to take account of energy consumption behavior that might have occurred without the ICP.

The results in Table 2 appear in three sets, without a square foot adjustment, with a square foot adjustment (pre- and post-ECM estimates divided by the square feet in the period), and for a sub-sample of 39 institutions where square feet did not change between the two periods. In addition to the three methods described above, we present results for raw consumption data, *i.e.*, estimates with no temperature normalization.

Table 2 contains information on median and mean estimates of natural gas savings, as well as minimum and maximum values. To the right of the median column is the mid-quartile range divided by the square root of the sample size. This statistic is a measure of dispersion of the median and is analogous to the standard error of the mean (Parzen, 1979).

As is often the case in program evaluation samples, the data remain dirty, with large outliers indicated by the extreme values, especially the minimum value. For this reason, we prefer the median estimates, as these are less influenced by extreme values. Note the influence of the large negative minimum values on the mean estimates.

Some general patterns emerge from Table 2. First, for the sets of estimates both with and without the square foot adjustment (N = 57), temperature normalization increases the estimated of percent savings. Second, square foot adjustment increases percent savings. This is expected. Of the 18 institutions with changes in square feet, only two experienced reductions. Third, the general magnitude of percent savings is in the rank order of PRISM, FASER, and UEO, with the latter the largest, although the amount of the differences among the methods is less than we had expected.

The most disturbing information in Table 2 comes from the third set of estimates — the 39 institutions which had no change in square feet. We would expect this to be a "cleaner" sample and would hope that the estimated

Table 2. Preliminary Estimates of Percent Changes in Annual Institutional Natural Gas Consumption with Alternative Measurement Methods

Method	n	Median	$(Q3\text{-}Q1)/\sqrt{n}$	Mean	Std. Error	Min.	Max.
Without Square Feet Adjustment							
Raw Con.	57	-1.4	5.3	-8.0	4.6	-159.1	26.7
PRISM	57	2.7	4.6	-4.5	4.7	-187.5	28.5
FASER	57	3.5	6.3	-4.1	4.0	-95.3	29.2
With Square Feet Adjustment							
Raw Con.	57	2.4	5.2	-2.1	4.2	-104.6	35.2
PRISM	57	6.3	4.8	1.5	4.0	-98.5	33.3
FASER	57	7.1	6.2	1.5	3.9	-68.8	35.3
UEO	57	8.7	5.0	2.1	4.0	-95.5	31.9
Sample with No Change in Square Feet							
Raw Con.	39	-2.7	7.0	-10.2	4.7	-104.6	20.2
PRISM	39	-1.6	5.9	-5.6	4.5	-82.9	22.8
FASER	39	-3.7	7.4	-8.0	4.6	-68.8	23.6
UEO	39	-3.1	5.3	-5.6	4.4	-83.4	23.2

percent savings magnitudes would closely match those where the square foot adjustment was made on the larger sample. These estimates differ radically from the others. This leads us to conclude that we should be cautious about the square foot adjustment, recognizing that it might be biasing savings estimates upward.

A rigorous comparison of the three temperature normalization methods appears in Table 3. We used individual institution estimates under the three methods as variables for simple correlation, rank correlation, and regression comparison across institutions. There is a remarkable similarity between the results of the three methods — much more than we would have expected given the differences in the methodologies described in the last section.

Table 3. Correlation, Rank Correlation, and Linear Regression Comparisons of Alternative Estimates of Percent Natural Gas Savings in the Utah Institutional Conservation Program[a]

Comparison Test and Estimating Method	Simple Correlation	Rank Correlation	Regression
PRISM-FASER	.881	.926	B = 0.91 R^2 = .78
PRISM-UEO	.997	.994	B = 1.01 R^2 = .99
UEO-FASER	.879	.923	B = 0.90 R^2 = .77

[a]All methods are on the 57 observation sample and include temperature normalization and adjustment for changes in square feet. In the regression equations, the estimate from the first of the estimating method pair is the dependent variable and the constant term is suppressed.

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