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EQUITY IMPLICATIONS OF UTILITY ENERGY
CONSERVATION PROGRAMS

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ABSTRACT

EQUITY IMPLICATIONS OF UTILITY ENERGY CONSERVATION PROGRAMS?*

This paper uses the Residential Energy Consumption Survey undertaken by the Energy Information Administration in 1990 to estimate the statistical association between household income and participation in electric utility energy conservation programs and the association between participation and the electricity consumption. The results indicate that utility rebates, energy audits, load management programs and other conservation measures tend to be undertaken at greater frequency by high income households than by low income households. Participants in conservation programs tend to occupy relatively new and energy efficient residences and undertake conservation measures other than utility programs, which suggests that utility sponsored programs are substitutes for other conservation investments. Electricity consumption during 1990 is not significantly less for households participating in utility programs than for nonparticipants, which also implies that utility conservation programs are displacing other conservation investments. Apparently, utility programs are not avoiding costs of new construction and instead are transferring wealth, particularly to high income participating households.

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1. Overview

An increasing number of electric and gas utilities are implementing integrated resource plans (IRP), with the objective of finding the least cost way of meeting the demand for energy services. IRP is being supported by the U. S. Department of Energy (DOE), by many state public utility commissions and by the conservation proponents as a way to put conservation programs on a competitive basis with energy supply alternatives. The President and Vice President (1993), in *The Climate Change Action Plan*, assert that utilities are projecting expenditures of \$23 billion on demand side management (DSM) programs by the year 2000.

Just as utilities are participating in the integrated resource planning (IRP) process in increasing numbers, the process is being subject to increasing scrutiny. The skeptics argue on empirical grounds that utility energy conservation programs have higher costs and lower benefits than estimated by utilities and conservation advocates (Joskow and Marron, 1992, Nichols, 1993). The proper criteria for selecting conservation programs are also subject to controversy. Numerous tests have been used, such as a no losers test, a rate impact measure, and a total resource cost. This paper is not concerned with the benefit tests of IRP, but with their potential equity effects.

The two major concerns of economic policies are *efficiency* and *equity*. Most of the controversy surrounding IRP is with efficiency, which means defining and measuring net benefits. There has been less interest in the equity impacts of these programs; although energy savings programs are being undertaken for low income populations. The equity concern that has appeared focuses on the distribution of benefits between program participants and other ratepayers. For instance, a representative of a nonparticipating firm may oppose IRP programs because a competitive firm receives a subsidy that enhances its competitive advantage at the expense of higher rates to the non-participating firm. The literature on IRP is characterized by a noted absence of studies of the effects of utility energy conservation programs on the personal distribution of income. Utilities, their commissioners and conservation proponents appear averse to presenting empirical evidence of the income distribution effects of these programs. Equity concerns are not totally lacking, though, because utilities often have programs designed to subsidize low income customers. Also, the Federal Government allocated \$1.6 billion during fiscal year 1991 to assist low income households to meet the costs of home energy, however this support was not directed towards conservation (U.S. Department of Health and Human Services, 1992).

The main purpose of this paper is to provide empirical evidence on the equity implications of utility sponsored DSM programs in the residential sector. One finding is that the highest income earners are the most frequent participants in utility conservation programs, with the lowest income families seldom participating in such programs. However, over a broad range of income classes, participation rates do not appear income sensitive. Secondly, participants in utility funded programs tend to occupy residences that are already more energy efficient than those occupied by nonparticipants. Participants in utility funded programs occupy newer, more energy efficient homes and also participate in a larger number of conservation

programs than non-participants. Such participants may be free riders¹ in utility programs, however a different explanation is suggested. In the electricity demand model estimated in this study, participation in residential utility conservation programs in 1990 is not statistically associated with a reduction in electricity use during 1990. Utility programs may not be successful at encouraging participants to make a net reduction in their energy consumption. However, where the costs of utility sponsored conservation programs are passed on to ratepayers, the programs tend to result in higher electricity prices, which encourage all consumers to reduce consumption.

2. The Data Base

The primary data base for this study is the 1990 Residential Energy Consumption Survey (RECS) conducted by the Energy Information Administration (EIA). The EIA conducts numerous energy surveys and has undertaken eight household energy consumption surveys since 1978. The 1990 survey is a random sample of 5095 households representing 94 million single family and multi-family households nationwide. The present study uses the survey data tape, which is publicly available. The EIA publishes its survey results in two major volumes, one reflecting household energy consumption and expenditures and the other defining the housing characteristics of residential energy consumers.² The housing characteristic report contains extensive tabulations of responses to questions regarding energy conservation measures undertaken by households.

Many of the households in the RECS are served by electric utilities that do not offer energy conservation programs to residential customers. To appropriately identify the variables that are associated with participation in these energy conservation programs, the sample was restricted to those customers who could potentially participate in a utility program. The EIA conducts an annual survey of electric utilities using Form EIA-861, "Annual Electric Utility Report", where one question relates to demand side management. The utility is required to indicate ("Yes" or "No") whether it has a "utility-administered program that is designed to reduce system demand and/or electricity use". The utility is not asked to indicate which of the various demand side management (DSM) measures it undertakes; however, the utility is asked to estimate load reductions and energy savings due to DSM. The data in RECS were merged with the utility data to select those residential households residing in electric utility service territories that offered utility conservation programs. The resulting subsample contains 3367 households. The EIA, in its household energy consumption report, also merged these two data

¹The term "free rider" is used here to denote an investment that is subsidized by a utility that would have been undertaken in the absence of the subsidy. The economics literature (Broadway and Wildasin, 1984) considers a free rider to be the beneficiary of a good, like national defense, that cannot be excluded from purchase through the price system.

²The EIA reports are listed in the references with the following identification numbers: (DOE/EIA-032(90)) and (DOE/EIA-0314(90)). The EIA also publishes a third volume, which is a regional supplement - (DOE/EIA-0321(90)/S).

sets (DOE/EIA -321(90)) and concluded that of the 64.4 million single-family households in the United States, about 45.8 million were served by electric utilities that had DSM programs.

3. Income and Program Participation

This section is a summary of the RECS results on participation in electric utility energy conservation programs by income class. Table 1 presents RECS survey estimates of the distribution of households by income class in terms of sample size and percent of households. The income classes are defined to correspond to those used by the EIA. As the subsample indicates, 19.9 percent of the households earned \$50,000 or more in 1990, while 13.8 percent of the households earned less than \$10,000. The remaining columns indicate participation in utility sponsored conservation programs by these income classes.

The RECS survey asks the respondent whether the family participated in any electric utility energy conservation program during 1990. The survey considers five utility programs and asks the respondent to identify which programs the family participated in. One conservation program is a rebate, where the customer receives a rebate from the utility for purchasing an electricity using device that is more expensive, but more energy efficient, than required by federal energy efficiency standards. A second program, termed load control, is intended to redistribute electricity demand away from peak periods and thereby reduce utility marginal costs. Thirdly, utilities, generally through contractors, perform energy audits of households and bear at least a share of the expense. The fourth and fifth programs are combined here as "other" utility conservation programs.

The conservation participation results refer to the percentage of households in the country within an income class that participates in the respective conservation program. For instance, just under 2 percent of the families with incomes under \$10,000 in 1990 participated in any utility conservation program during that year; however, about 8.84 percent of the households with incomes in excess of \$50,000 participated in such programs.³ Just over 5 percent of the households with annual incomes between \$10,000 and \$50,000 participated in any conservation program during 1990 and this percent is similar across income classes. Overall, approximately 5.79 percent of the total number of eligible households participated in a electric utility conservation program in 1990; but, as suggested in Table 1, this participation was skewed in favor of high income households and lower for the two lowest income classes.

This general pattern of participation in conservation programs overall also applies to each specific program. Participation by the lowest two income groups in all conservation programs is negligible. In the middle income groups, about 1 percent of the households participated in each of the specific utility programs and this result appears similar across programs and income

³LaBlanc et. al. (1992) surveyed 33 utility DSM programs for low income households and found that 4.3% of eligible households participated per year. This higher participation rate than observed with the RECS data may be due to different definitions of low income or to numerous other factors.

sub-classes. Households in the highest income group - above \$50,000 - were more likely than other households to participate in the various programs. The only exception to this result is the energy audit, which receives roughly similar participation across income classes, with the two lowest income classes again being non-participants. Overall, the highest income class has the largest percent participation in electric utility energy conservation programs and the lowest income classes, the lowest percent participation.⁴ The similar overall participation across these programs indicates that the EIA is correctly identifying the main utility programs, which are rebates, load control and energy audits.

4. Participation in DSM

The observation that high income households are more likely to participate in utility sponsored conservation programs compared with their low income counterparts implies that the benefits are likely to be received in disproportionate share by the upper income households. However, income should not be assumed to be the single causal variable. One explanation of this result is that high income households have lower discount rates with respect to the purchase and use of energy durables and therefore are more willing to invest in energy conservation investments than low income households.⁵ With this explanation, utility programs provide an effective incentive to undertake cost-effective energy conservation investments. An alternative hypothesis is that high income households would have made the conservation investments in the absence of the utility sponsored programs and they are therefore merely redistributing their conservation efforts. If the first hypothesis holds, energy is being saved by the persons who are most able to make efficient investment decisions. If the second hypothesis is applicable, energy is not being saved and the utility programs are simply a wealth transfer to the upper income classes.

To distinguish between these hypotheses, the RECS data is used to estimate the relationship between income, participation and numerous other variables affecting participation. The RECS data base allows identification of a number of household characteristics, in addition to income, that are associated with participation in electric utility conservation programs. A cross-tabulation between these household characteristics and participation conveys an impression of a possible behavioral link. The household characteristics are measured in terms of sample means (with EIA population weights), first using the sample of those who participated in one or more utility programs and second, those who did not participate. Table 2 first reproduces the above result by showing that participants in one or more programs during 1990 have an average income of \$39,355, while non-participants have an average income of \$32,550. The

⁴The data in Table 1 convey an impression, but do not contain a large enough sample to support significance tests. The total number of participants in the sample is 175, which produces a small number of participants in each cell in Table 2.

⁵Train (1985) reviewed ten studies that estimated implicit discount rates in energy related investments and observed that each of the studies concluded that high income households invested as if they had lower discount rates than low income households.

head of household of participating families also has, on average, one more year of education than nonparticipants.

An electricity intensive home is defined by the EIA as one that uses electricity for space heating, water heating and/or space cooling. Just over 31 percent of the participating households have electricity intensive residences, while only 23.4 percent of the nonparticipants reside in electricity intensive dwellings. Water heating, space heating and cooling are major uses of electricity and also offer an important opportunity to save energy. Utility programs are frequently targeted on these uses.

A common perception in the conservation literature is that renter occupied dwellings have fewer conservation measures than owner occupied dwellings.⁶ The RECS sample data, at first sight, confirms this result. In the sample of nonparticipants in electric utility programs, owners outnumber renters by about 2.4 to 1. However, in the sample of participants, owners outnumber renters by almost 5 to 1. These data indicate that renters are less likely than owners to participate in utility sponsored conservation programs. However, the data do not indicate whether a residence of given age, size and region has fewer conservation features if it is renter occupied than if it is owner occupied.

Participants tend to reside in newer residences than nonparticipants. The mean year of construction for residences of participants is 1962, which is 6 years newer than residences of non-participants. The EIA makes this same observation by noting that 39 percent of the households reside in units built in or after 1980, while only 22 percent of the nonparticipants reside in units of this recent vintage (EIA, 1993, page 45). Newer homes (just like commercial buildings) tend to use less energy than older homes. The RECS survey data imply that households with the greatest opportunity to save energy are not the most frequent participators in utility programs.

The attributes of utility program participants are further defined by tabulating the average number of conservation measures and insulation characteristics contained in each housing unit. The RECS survey asks several questions that indicate the energy intensity of a residence. One series of questions inquires about the insulation characteristics of the residence, that include: storm windows, storm doors, wall insulation and roof or ceiling insulation. Responses indicating the presence of each insulation characteristic in a household were used to calculate the sample mean for participants and for nonparticipants. As depicted in Table 2, participants tend, on the average, to reside in homes with 1.51 insulation features, while nonparticipants reside in housing units with an average of 1.25 insulation features. The most common insulation feature is roof or attic insulation, followed by wall insulation, with far fewer residences having storm windows or doors. However, participants in utility conservation programs tend to reside in housing units that have, on the average, more insulation features than non-participants.

⁶ There have been few empirical studies of this issue; but one empirical test of this hypothesis using EIA commercial sector data revealed that it is invalid (Sutherland, 1991).

The potential of a household to save energy with utility conservation programs may also be indicated by the number of conservation measures already undertaken by the household. Presumably, the smaller the number of existing conservation measures, the greater is the opportunity for additional cost-effective energy savings. The RECS survey asks whether the household added any of the following during the last three years: weather stripping, caulking, temperature set-back when gone, temperature set-back at night, tune-up of heating equipment and water heater insulation? Responses to questions on these six behavioral characteristics were totaled for each household in the sample and the mean number of characteristics were computed for participants and for nonparticipants. Participant families in the RECS sample undertook an average of 2.48 conservation measures during the last three years (from 1990), while nonparticipants undertook an average of 1.63 conservation measures per household during this time. Participants in utility programs in 1990 have previously undertaken more conservation measures than non-participants and they live in newer homes that are already better insulated. These data suggest that the residences that are benefiting from utility programs are more energy efficient and probably not the residences with the greatest opportunity to save energy.

The mean age of heating and cooling equipment in the residences is estimated as an indicator of whether the most cost effective investments are being encouraged by utility participation. Presumably, older the heating and cooling equipment is less energy efficient and affords a better opportunity to benefit from utility programs. The RECS survey contains equipment age data by age category, such as less than 2 years, from 2 to 4 years, 5 to 10 years, 10 to 19 years, where the age categories are denoted by a 1 through 4. Table 2 presents the mean of the age categories as a rough indicator of actual age. As depicted in the table, participants on average have newer water heaters, space heating and space cooling systems than nonparticipants. Utility programs do not necessarily focus on this relatively newer equipment and the age of the equipment may be a proxy for the age of the residence. However, this relative newness suggests that the energy saving investments with the highest payoff are not being encouraged by utility programs.

The profile of participants can also be indicated by their perception of the energy efficiency of their housing unit. The RECS respondents were asked to indicate their perception of the quality of insulation in their dwelling. The specific question is "Overall, would you say that this (house/apartment) is well insulated, or poorly insulated?" As seen in Table 2, 35.7 percent of the nonparticipant respondents indicated that their residences were well insulated, whereas 43.0 percent of the participants stated that their residences were well insulated. We observe, again, that an indicator of existing energy efficiency in a residence is positively associated with participation in utility programs.

According to the RECS data, households with high incomes have a higher than average probability of participating in utility conservation programs than other households and the reverse holds with low income households. However, income may not be the dominant or driving variable. The results in Table 2 present a set of characteristics that apply to DSM participants. On average, participants have higher incomes than nonparticipants, but they also have higher levels of education and reside in newer homes with newer heating and cooling

equipment. Participants also tend to have more insulation features in their residences; they perceive them as being better insulated and they undertake more conservation measures than nonparticipants. Participants may undertake effective conservation measures, but they appear to be energy conscious independent of utility programs. One issue is whether residential utility programs add to this energy savings, or, whether they merely encourage a redistribution of conservation efforts.

These sample averages expressed in Table 2 indicate the association between participation and various characteristics, but they do not indicate how the probability of participating may change due to a change in each of these variables. The relationship between changes in these variables and the probability of participating is estimated using a logit model. The dependent variable is the probability of participating, which is set equal to 1 for those households who participated in one or more utility programs and a 0 otherwise. The model is estimated with the sample of potential participants in utility conservation programs. The independent variables are taken from Table 2.

In the logit model, P_i is the probability that a household participates in one or more utility energy conservation programs and is expressed as

$$P_i = 1/(1 + e^{-\beta X}),$$

where X denotes the observations of all independent variables. The model is transformed into linear form by expressing the log of the odds of participating in a utility program. The logit model of participation becomes

$$\log[P_i/(1 - P_i)] = -\beta X,$$

which is estimated using maximum likelihood.

One purpose of this model is to estimate the simple association between income and participation in utility sponsored DSM programs. The data in Tables 1 and 2 suggest a positive relationship between income and participation in utility programs; however this association is not linear across income groups, but differs primarily with the lowest and highest income groups. The income variable is redefined using one dummy variable ($Y_{low} = 1$) for income levels below \$10,000 and 0 otherwise and another dummy ($Y_{high} = 1$) for income levels above \$35,000 and 0 otherwise. Using this measure of income, a simple logit model is⁷

⁷The signs of the coefficients are the opposite of what may be expected intuitively. For instance, a negative coefficient means that an increase in the variable increases the probability of participating. This result can be verified by noting the sign of the partial derivative with respect to P_i .

$$\log[P_i/(1 - P_i)] = 2.91 + 1.13 Y_{\text{low}} - 0.30 Y_{\text{high}},$$

(0.00) (0.00) (0.06)

which confirms the previous result that high income households are more likely to participate in utility conservation programs. The numbers in parentheses are P values that indicate the probability that a coefficient is equal to zero. This equation replicates the results of Table 2 by implying (algebraically) that the probability of participating is about .052, but it decreases to .017 for low income households and increase to .068 for high income households. High income households benefit disproportionately from utility sponsored programs and low income households fail to benefit as much as average income households.

These results depict a statistical association between income and participation, which is one purpose of this study, but they do not imply that income is a causal variable encouraging participation. The variables in Table 2 were considered candidates to provide a more complete model of participation. Preliminary estimates indicated that several variables have a low probability of being significantly different from zero. Simple correlation coefficients between participation and each independent variable are of the sign expected from the results in Table 2, but the coefficients are in the range of about .05 to .10. Furthermore, some of the independent variables are positively correlated, such as income, education, the number of conservation measures and the age of residence. The age of space heating, cooling and water heating equipment are also positively correlated. After deleting the insignificant and likely collinear variables, the estimated model is

$$\log[P_i/(1 - P_i)] = 3.58 + 0.87 Y_{\text{low}} - 0.03 Y_{\text{high}} - 0.39 \text{ CONSERV}$$

(0.00) (0.02) (0.84) (0.01)

$$+ 0.01 \text{ VINTAGE} - 0.13 \text{ WELL-INS}$$

(0.03) (0.23)

where we again observe that relatively low income level households are estimated to have lower than average odds of participating in utility programs, with only a two percent chance that the coefficient is equal to zero. In the simpler model presented above, that included only high and low income levels, each variable is significant and the coefficient for high income has only a six percent chance of being equal to zero. However, when the number of conservation measures undertaken (CONSERV) is added to the model, the high income dummy variable becomes insignificant. Income and the number of conservation measures undertaken are positively correlated, with the latter variable statistically crowding out income when the variables are used together.

The CONSERV coefficient in the above equation indicates that the probability of participating in a utility sponsored DSM program is positively and significantly ($P=.01$) associated with the number conservation measures already undertaken by the household. That is, households participating in utility programs also undertake other energy conservation

measures.⁸ These results are consistent with those obtained for vintage, where households in newer residences are more likely to participate in utility programs. The comparison of sample means in Table 2 also indicated that the older the residence, the lower is the probability of participating in a utility program. Those households that responded that their residence was well insulated (WELL-INS) appear to have an increased probability of participating in DSM programs, but the coefficient is not highly significant. Other variables appearing in Table 2 are insignificant when included in the above equation. The failure of the ownership variable to be significantly associated with participation may result from its correlation with other variables, such as income.

One result of this section is that the probability of participating in a utility sponsored conservation program varies directly with income, but primarily at the highest and lowest income levels. However, income is not the single, or even dominant causal variable, because participation is associated with a set of household characteristics that relate to energy conservation.

5. Electricity Consumption and DSM

The statistical result that participation in utility sponsored energy conservation programs is higher among high income groups than low income groups was expected. Perhaps surprising though, is that participation is positively associated with the newness of residences, the newness of the heating (space and water) heating equipment and the number of insulation features and conservation measures. Because these housing units are already energy efficient, the results suggest that electric utility programs may not save as much energy as expected. This hypothesis is tested by estimating the statistical association between participation in utility programs and the reduction in electricity consumption.

To estimate the statistical relationship between participation and electricity consumption, an electricity demand model is estimated where participation is one independent variable. The RECS 1990 survey is the data base and the sample is again restricted to residential households that could potentially participate in utility sponsored DSM programs. The model is designed to explain the variations in electricity consumption between households using variables associated with electricity use. We particularly wish to quantify the reduction in electricity use due to participating in utility DSM programs.

The electricity demand model estimated here uses the same variables that appear in most other models, such as price, income, a weather indicator variable and various household

⁸If participating results in an increase in the CONSERV variable, this reverse causality would bias the estimates. CONSERV reflects measures undertaken over the last three years and includes different variables than participation, which only reflects the current year.

characteristics.⁹ Electricity consumption should be positively related to household income, square feet of residence and number of people in the house. Consumption should be inversely related to household newness because newer homes are presumably more energy efficient. Consumption should be inversely related to the price of electricity, which is measured here as the average price per Btu of electricity used. A dummy variable reflecting electricity for heating water is used separately. A dummy variable for electricity used for space heating is multiplied by heating degree days to capture the joint effect of weather and electricity using heating equipment on total consumption. Similarly, a dummy variable is used for electricity used for space cooling and multiplied by cooling degree days to capture the joint effects of weather and equipment on consumption. An owner-renter dummy variable is also included to reflect different incentives or agency problems associated with renting. The final variable is the utility DSM variable, which is a dummy variable denoting whether a household participated in one or more utility sponsored conservation measures during the sample year. The hypothesis is that participation reduces electricity consumption, which is, of course, the main objective of these programs.

Some specification choices were resolved before the final results were obtained. Equations estimated with education and income separately and used together indicate that income is more significant and a preferable explanatory variable. Income is therefore retained in the model and not education. Previous evidence from EIA national surveys in the commercial sector (Sutherland 1991, 1992) indicates that the regression estimates are statistically different across the four Census regions. The model was estimated separately for each of the four regions and then by restricting the coefficients to be identical across regions. The statistical (Chow) test of whether the models could be regarded as stable over the four regions was rejected. The model was estimated in double log form, except for the dummy variables which were not transformed. Log-linear regression estimates of the electricity consumption model are presented in Table 4 for each of the four Census regions. The sample sizes for the four models range from 789 to 876 and the models produce R^2 values from .58 to .65, which are respectable for cross section estimates. Overall, the estimates appear consistent and reasonable. Income, square feet and number of people in the household have positive and significant coefficients. The electricity using equipment - heating, cooling and water heating - is highly significant and positive in each region. The coefficient of the price of electricity is negative, less than 1 and highly significant in each region.

The utility conservation participation variable is not significantly negative in any region; in fact, it is consistently insignificant. Apparently, participation in utility conservation programs does not lead to a reduction in electricity consumption, at least during that same year. The failure of participation in utility DSM measures to produce a significant association with consumption was at first surprising, but this result was obtained by the EIA using the same data set (EIA, 1993). The EIA appears to conclude that participants in general do not use less

⁹Bohi (1981) is a good literature review of energy demand models including residential electricity demand functions.

electricity than nonparticipants, but if participants were restricted to those with electricity intensive homes, then participants save energy.¹⁰ This hypothesis is tested, even though this subclass of participants does not reflect the overall measure of DSM programs. The participation dummy was multiplied by an electricity intensive dummy to identify participation by electricity intensive households. The model was estimated in both linear and log linear form. To conserve space only the DSM regression results are presented. As seen in Table 5, a significantly negative coefficient is obtained for the Northeast, but in general the coefficients are insignificant for the aggregate and regional model in both linear and log linear form. The insignificant statistical association between DSM participation and household electricity consumption appears robust; it is obtained in linear and log linear estimates using all eligible households and electricity intensive households.

4. Summary

Electric utility energy conservation programs are a multi-billion dollar business and are continuing to expand. The apparent objective of these programs is to provide an environmentally clean and relatively lower cost alternative to building additional power plants. The contention is frequently made that utility conservation programs have lower avoided costs than supplying additional energy. One result of this study - based on a national sample of households during 1990 - is that participation in residential utility DSM programs is not statistically associated with a reduction in electricity use. If these programs are not saving energy, the cost of additional energy supply is not being avoided. Where the costs of utility programs are passed through to ratepayers such costs must be reflected as rate increases.

The results here indicate that electric utility DSM programs save energy, but through the behavior of all customers rather than participants. If residential DSM programs are financed by ratepayers but do not reduce electricity consumption, they must result in rate increases that bear most heavily on nonparticipants. The significantly negative price elasticity of electricity, along with these rate increases, implies that utility DSM programs reduce consumption by encouraging all customers to conserve energy.

Various explanations of the failure of DSM programs to save energy have appeared in the literature: the snap-back effect, the free rider effect and the cross-subsidization effect. The snap-back effect asserts that the installation of energy efficient equipment encourages a more intensive use of this equipment. A cross-subsidy results when an electric utility subsidizes an electricity using technology that crowds out the purchase of an alternative fuel that would have been purchased in the absence of the subsidy. Electric utilities may consider energy conservation programs as a business opportunity to expand their market share by displacing gas, oil or other fuels. By offering rebates to purchase electricity using devices, customers are encouraged to use electricity instead of natural gas or other fuels. The data used here do not

¹⁰The insignificant participation coefficients could reflect a sample selection bias, which occurs if large electricity users are more likely to be program participants. By restricting the sample to electricity intensive households, this potential bias is reduced.

permit explanations in terms of these three effects; however, an alternative explanation is suggested - households participate in utility conservation programs, not to save energy, but to make themselves better off in the sense of increasing their income. We hypothesize that the estimated failure of these utility programs to reduce household energy consumption is explained by a substitution effect.

The initial objective of this study was to estimate the income distribution effects of utility residential DSM programs. We observe that high income households tend to participate in utility conservation programs more frequently than low income households. Although this result is not widely acknowledged, it was certainly expected and was observed previously by the EIA using the same national residential survey. The benefits of utility programs are enjoyed disproportionately by high income households, but the costs are incurred disproportionately by low income households. According to the 1990 RECS, households earning less than \$10,000 per year in 1990 spent an average of \$518 on electricity during the year, which is just over 5 percent of their income. In contrast, households earning more than \$50,000 spent an average of \$1076, but this amount is less than 2 percent of their annual income (DOE/EIA-0321(90), p. 66). An increase in the price of electricity imposes a larger cost on low income families as a share of their income than on high income families and in this sense is regressive. Furthermore, the association between high income and conservation measures undertaken indicates that high income families may be more likely to use conservation measures to reduce the impact of the rate increases, compared with low income families. The income distribution effects of utility residential conservation programs must be to increase income inequality.¹¹

The effects of residential DSM programs on income distribution are not the whole story. Participants in utility programs have a set of characteristics that differentiate them from nonparticipants. On average, their homes are newer, their heating and cooling equipment is newer, their homes are better insulated and participants also undertake more conservation measures on their own. Participants are more likely to report that their homes are well insulated than are nonparticipants. Participants are undertaking significant conservation measures in the absence of utility programs. Utility conservation programs may not be producing a net reduction in energy consumption because participants may be substituting such programs for other conservation measures which they would have undertaken. Utility programs may permit participants to undertake conservation measures similar to what they would have undertaken and to be compensated for doing so. The EIA (DOE/EIA-0321(90) p. 37) reaches this same

¹¹ Utility residential DSM programs probably have less of an income redistributive effect than other conservation programs, such as energy efficiency appliance standards. Utility programs are voluntary and as such they merely transfer wealth, but apparently do not distort investment choices. In contrast, appliance standards redistribute income first by restricting choices available, which has a larger effect on low income households. Secondly, the resulting loss of consumer surplus takes a relatively larger bite out of the income of low income households.

conclusion by noting that a set of household attributes is associated with significant energy saving and these attributes - and not participation - tend to account for different energy consumption patterns between participants and nonparticipants.

The need to verify energy savings from utility DSM programs is currently an issue of major concern. The recommendation that energy efficient investments be metered is appearing frequently, even though the cost of metering is a major cost of the entire DSM program. The results obtained here indicate that metering at the appliance level will not accurately estimate energy savings. Although increased metering may indicate a large amount of energy being saved by the specific appliance being metered, households may have undertaken the same amount of energy conservation measures without the utility program. Metering cannot identify what the participant gave up in order to participate in the utility program and it therefore cannot measure the net contribution to energy savings. Metering can measure energy consumption and perhaps estimate the snap-back effect; but metering cannot identify the free rider effect, cross subsidization, or the substitutability between various conservation measures.¹²

The substitution effect is not the only feasible interpretation of these results. Perhaps the utility programs save energy in the years following their participation. Perhaps the DSM variable is measured with an error that prevents reliable estimation. The crowding-out effect may be only a partial explanation for the insignificant association between DSM participation and electricity consumption. Even so, the households that are participating in utility programs are not those with the greatest potential to save energy. Relatively high participation from households in newer dwellings with relatively new heating and cooling equipment and households that have a relatively large number of insulation features and conservation measures each suggests that households are already relatively energy efficient. Utility conservation programs contained in the RECS data base do not appear effective in attracting households that have the greatest opportunity to save energy.

This result appears to be a paradox - those households who apparently would benefit the most by saving energy and reducing energy costs do not frequently participate in the utility conservation programs; whereas those households who apparently would benefit the least in terms of savings are the most frequent participants. The explanation of this result follows from the definition of the word "benefit."¹³ From the perspective of DSM proponents, the benefit of conservation programs to participants is reduced energy consumption, or, perhaps the decreased present value of costs for energy services. From an economics perspective, the benefit to a household is its increase in economic well-being, which is measured as an increment

¹² Nichols (1992) reports that a free rider effect is typically estimated to be in the range of 3 to 37 percent. The absence of estimated significant DSM savings (Tables 3 and 4) suggests that a broader type of crowding-out may be occurring.

¹³The implications derived in this and the next paragraph were stimulated by the work of Nichols (1993).

to consumer surplus. Conceptually, a utility subsidy, such as a rebate has two components. The first is a bribe (or incentive), which is the minimum compensation required by the customer to undertake an investment (in conservation) that the customer would not otherwise undertake.¹⁴ The second component is a wealth transfer, termed consumer surplus, which is the amount of the rebate over and above the minimum required to encourage a conservation investment. The economic appeal of a rebate to a participant is its consumer surplus and not the compensation required to encourage an otherwise unattractive investment decision. The value of the rebate is highest to a participant who is a free rider and lowest when the entire rebate is required to change a purchase decisions. In general, the larger the share of the rebate that is consumer surplus, the greater the appeal to participants and the less the amount of energy that will be saved. Also, the larger the share of the rebate required to encourage energy savings, the less will be the benefit to customers.¹⁵ To restate this result: if a rebate is highly valued by recipients, it will result in little energy being saved; but if it encourages extensive energy savings, it will not make participants much better off. The empirical result that utility programs are affecting the wrong households - in terms of potential energy savings - is actually an immediate implication of the economic theory of consumer behavior, which says that consumers purchase goods because of their net benefits as measured by consumer surplus.

A utility DSM program, say, a rebate for an energy efficient investment, may be viewed as reducing the price of that investment to the customer. A basic principle of demand analysis indicates that the responsiveness (price elasticity) of program participation to this price reduction is greatest where the program has close substitutes. The closest substitute to a utility subsidized investment is the same investment without the subsidy - which is the free rider effect. The second closest substitute presumably would be an alternative conservation measure. The least closest substitute could be an activity that is not energy related. Elementary demand theory suggests the generalization: the greater the participation responsiveness to a utility conservation program, the less will be the energy saved per participant, primarily because these participants are displacing other energy saving measures. Proponents of conservation programs use program participation rates as an indicator of program success. High participation indicates an increase in consumer surplus (or wealth transfer) to participants, but does not indicate energy saving. The main empirical results of this study are that participants in utility programs typically have higher than average incomes (Table 1) and they often have a set of characteristics associated with energy conservation (Table 2). We also fail to observe a statistical association between DSM participation and electricity use (Table 3). One implication is that utility conservation

¹⁴The bribe does not make the person better off, because by definition, it is the minimum amount required to induce investment and leave the person on his or her initial indifference curve. In simple economics, the bribe is the substitution effect which leaves the participant on the same indifference curve, whereas the income effect is the measure of the participants increase in welfare.

¹⁵This statement reflects only the immediate impact on customers and neglects environmental quality and avoided costs, which are, of course, a crucial part of DSM programs.

programs are redistributing wealth from low to high income households. Secondly, utility programs are encouraging a substitution of conservation efforts from those that households judge to be cost effective and would have undertaken to those subsidized by ratepayers.

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Table 1

Participation in Electric Utility Conservation Programs
By Income Class

1990 Family Income		Percent Participation In Income Class					
Income Classes	Number	Percent	Any Program	Rebate	Load Control	Energy Audit	Other
Less than \$5,000	133	4.0	1.50	0.75	0.75	0.00	0.00
\$5,000 to \$9,999	329	9.8	1.82	0.61	0.00	0.61	0.61
\$10,000 to \$14,999	393	11.7	5.09	1.02	0.51	1.78	1.27
\$15,000 to \$24,999	602	17.9	4.98	0.83	1.66	2.16	1.66
\$25,000 to \$34,999	588	17.5	5.27	1.36	0.85	2.04	1.36
\$35,000 to \$49,999	651	19.3	5.53	1.38	2.61	0.77	1.38
\$50,000 or more	671	19.9	7.45	2.09	3.73	1.64	2.09
TOTAL	3367	100	5.20	1.28	1.78	1.49	1.43

Source: Energy Information Administration, 1990 RECS data file

Note: The numbers in "Any Program" will not necessarily equal the sum of the individual program columns because households can participate in more than one program.

Table 2
Characteristics of Participants in
Electric Utility Conservation Programs

Characteristics	Participants	Non-Participants
Income	\$38,189	\$32,232
Education	13.7 years	12.8 years
Electric Intensive ¹ (%electric)	57.1 %	43.5 %
Own/Rent (% owners)	85.1%	69.5%
Number of People Per Household	2.96	2.71
Year Constructed	1963	1960
Number of Insulation Features in Residence	1.51	1.28
Number of Conservation Measures Taken	2.94	1.67
Age of Main Heat Equip.	3.28	3.87
Age of Hot Water Heater	3.13	3.57
Age of AC Equipment	4.35	5.04
Well Insulated ?	40.6%	35.0%

¹ The EIA definition of an intensive user of electricity is used here and it refers to electricity used for space heat, main water heat and/or central air conditioning (DOE/EIA-0321(90) page 37).

Source: Energy Information Administration: Public Use Data File. Comparable published data can be found in the Energy Information Administration, Housing Characteristics 1990: Residential Energy Consumption Survey, DOE/EIA-0314(90), May 1992 and in the Energy Information Administration, Household Energy Consumption and Expenditures 1990: Residential Energy Consumption Survey, DOE/EIA-0321(90), U.S. Department of Energy, Washington DC, February, 1993.

Table 3
Regional Regression Estimates of
Electricity Consumption in 1990

Census Regions

	Northeast	Midwest	South	West
Intercept	8.12 (29.43)	8.22 (32.47)	7.89 (24.90)	6.25 (21.64)
Income	0.14 (7.38)	0.04 (2.01)	0.05 (2.38)	0.04 (1.61)
Square Feet	0.23 (8.57)	0.17 (1.14)	0.26 (7.96)	0.32 (9.06)
Vintage	0.01 (0.39)	0.02 (1.14)	0.04 (2.38)	0.02 (1.14)
No. of People	0.35 (13.24)	0.39 (14.96)	0.34 (13.25)	0.35 (12.73)
Elec. W.H.	0.27 (7.06)	0.30 (8.51)	0.28 (8.08)	0.57 (12.81)
AC * CDD	0.04 (6.75)	0.04 (10.03)	0.04 (8.12)	0.04 (7.04)
Heat * HDD	0.06 (10.11)	0.05 (9.08)	0.03 (5.10)	0.04 (6.65)
Price Elec.	-0.92 (-13.44)	-0.72 (-11.43)	-0.81 (-9.42)	-0.32 (-5.69)
Owner	0.06 (1.60)	0.17 (4.95)	0.11 (3.15)	0.23 (5.84)
Utility Cons.	-0.04 (-0.69)	0.02 (0.31)	-0.04 (-0.70)	-0.10 (-1.43)
Sample Size	876	896	789	806
R ²	0.65	0.65	0.58	0.61

Notes: The model is estimated in double log form, where all variables are transformed into logs except the dummy variables.

Table 4
Regression Estimates of Utility
Conservation Participation
By Electricity Intensive Households

Census Region	Linear Model	Log Linear Model
Northwest	-5111.40 (-2.35)	-0.33 (-2.07)
Midwest	2667.63 (1.14)	0.17 (1.12)
South	-299.74 (-0.23)	-0.03 (-0.40)
West	-1651.52 (-0.95)	-0.25 (-1.84)
Aggregate Model	-8355.60 (0.99)	-0.89 (-1.55)

Note: The dependent variable is kWh per household in 1990 and the independent variables are intended to those in Table 3.