EVALUATION OF UTILITY HOME ENERGY AUDIT (RCS) PROGRAMS

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ABSTRACT

For a variety of reasons, particularly the federally mandated Residential Conservation Service (RCS), most electric and gas utilities provide free or low-cost energy audits to their residential customers. Many utilities also offer financial incentives (low- or zero-interest loans, rebates) to encourage installation of measures recommended in the audits.

Recently, detailed quantitative evaluations have been conducted of these programs in a few locations. This paper reviews the findings of evaluations conducted in the Pacific Northwest, California, Wisconsin, Minnesota, Michigan, and Connecticut concerning the energy savings that can be attributed to these programs. The key feature of these evaluations is their reliance on actual fuel consumption records (electricity, natural gas, and fuel oil bills).

RCS programs in these states yield incremental energy savings for program participants of approximately 3 — 5%. That is, households who receive home energy audits take conservation actions that reduce their annual fuel bills by 3 — 5% more than the saving experienced by program nonparticipants. Financing programs in Minnesota and the Pacific Northwest lead to substantially larger savings: the combination of audits and subsidized loans yields incremental savings for participants of about 15% of preprogram energy consumption.

Assessing the economic worth of RCS programs is particularly difficult (and very site-specific) because of factors such as future fuel prices, differences between marginal and average fuel prices, discount rates, and differences in how the programs are implemented. The meager evidence on RCS program cost-effectiveness suggests that the economic benefits are generally small and sometimes negative.

INTRODUCTION

As part of the federal Residential Conservation Service (RCS; U.S. Congress, 1978 and U.S. Department of Energy, 1982), most electric and gas utilities offer their residential customers on-site home energy audits. During the 1981/82 program year, about one million RCS audits were conducted (Morris et al., 1983); approximately the same number of audits were conducted the following year (Centaur, 1983).

Unfortunately, little is known about the performance of the RCS program, either at the local or national levels. Questions remain concerning energy savings that can be directly attributed to the program; cost-effectiveness of the program to participants, nonparticipating ratepayers (who may pay for the program through gas and electric rates), utility stockholders, and society as a whole; and alternatives to the RCS that might stimulate greater residential energy-efficiency improvements at lower cost.

This lack of information is important for at least three reasons. First, the RCS program is expensive. A typical audit costs the utility $100 or more; state and federal government expenses associated with managing the program increase this cost by about $10/audit. The measures that households install because of audit recommendations cost several hundred dollars. Second, the RCS program is used by some utilities as an alternative to construction of new energy supply systems; that is, energy audits are expected to deliver "conservation energy" resources at prices below those of conventional supply resources. Third, the RCS is surrounded by controversy over its cost, need, and possible intrusion into the marketplace (Centaur, 1983; SRC, 1983; U.S. Department of Energy, 1984; U.S. General Accounting Office, 1982).

This paper summarizes information obtained from several recent evaluations of RCS and RCS-like programs. The following sections discuss RCS program performance in terms of participation rates, energy savings, and cost-effectiveness.

Before discussing the RCS program itself, it is useful to consider the broader picture of U.S. residential energy use. Between 1960 and 1973, residential energy use grew from 8 to almost 15 QBtu, with an average growth rate of 4.4%/year. During the following decade, energy use first declined, increased, and then declined again; the net effect was no change in energy use between 1973 and 1983.

On a per household basis, energy use increased steadily from 1960 through 1972, with an average growth rate of 2.7%/year (Fig. 1). Since then, residential energy use per household declined 20%, from 215 to 172 MBtu. Declines were particularly sharp between 1978 and 1981, probably because of the 1979 Iranian oil cutoff and subsequent increases in fuel prices. Government and utility conservation programs may also have affected energy use. In addition to uncertainty over the factors that caused this decline, we are generally ignorant about the ways in which the reductions were realized. That is, we do not know the extent to which technical efficiency improvements (e.g., attic

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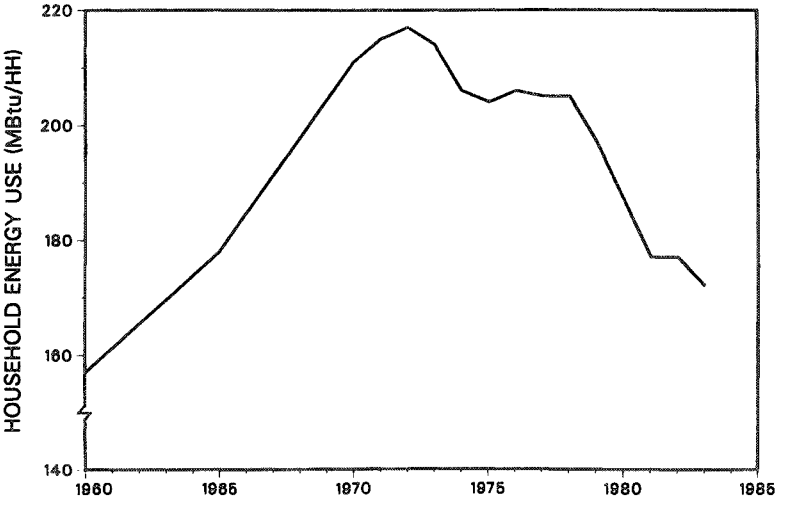

Fig. 1. Per household residential energy use, 1960 — 1983. Figures for 1982 and 1983 are author's estimates. Data are from the Bureau of the Census (1982 and 1983) and the Energy Information Administration (1983a and b).

insulation) and operational changes (e.g., thermostat settings) contributed to this 20% saving. Energy use was nearly constant between 1981 and 1983, probably because fuel supplies were abundant and prices were relatively stable.

PARTICIPATION IN THE RCS PROGRAM

Based on information from 37 states, 2.0 million RCS audits were conducted during the first two programs years (April 1981 through March 1983; Centaur, 1983). Unfortunately, these data do not include all relevant audits. For example, the Tennessee Valley Authority conducted 658 thousand audits in their Home Insulation Program between 1977 and 1983. During 1982 and 1983, 209 thousand audits were conducted in the Pacific Northwest as part of the Bonneville Power Administration's Residential Weatherization Program. Many of these TVA and BPA audits are not included in the RCS totals.

About 60 million households throughout the U.S. are eligible for RCS program services. However, only 50 million live in states with approved RCS programs. Further, RCS rules allow utilities to offer audits to their customers gradually over time, to avoid long backlogs. Data from 21 states and 14 non-regulated utilities show that 5.6% of the households offered an audit in 1982 requested one, far greater than the 2%/year response rate implied by the ratio of completed audits to eligible households (U.S. Department of Energy, 1984).

There was considerable variation among states and utilities in RCS participation rates. Delaware, Michigan, Vermont, Washington, and Wisconsin had rates that exceeded 5%/year. At the other extreme, rates were particularly low in Kentucky, Ohio, Pennsylvania, West Virginia, Louisiana, Mississippi, and North Carolina. The reasons for this large variation are not known, but probably relate to utility marketing and the potential for cost-effective conservation in each utility service area. Also, changes in the Federal government attitude toward RCS (initial support of, followed by hostility to, the program) and the current "benign" national energy supply situation probably affected state and utility support of the program.

Another important aspect of RCS program participation, beyond low participation rates, concerns differences between participants and nonparticipants. An evaluation of the Connecticut RCS (Hirst et al., 1983b), for example, included comparison of program participants with Connecticut households in general. RCS participants had substantially higher incomes than did Connecticut households in general. Virtually all the households in the evaluation sample owned their homes and lived in single-family units; only 64% of Connecticut households owned their homes and only 61% lived in single-family homes. In addition, participants had higher incomes, had more people in their household, had lived in their present home for fewer years, and were more likely to own air conditioners than the population in general.

These findings concerning differences between RCS participants and nonparticipants are similar to those found in evaluations of other RCS programs and residential programs in general. Participants tend to be younger, have higher incomes, larger homes, more education, and are more likely to live in single-family homes and own their homes than nonparticipants.

Because low-income households are eligible for free retrofits from the federal Weatherization Assistance Program (WAP), participation by higher income households in RCS may not raise serious equity problems. However, RCS is financed by electricity and gas rates (rather than by federal taxes, which support WAP); thus low-income high-energy-using households may disproportionately pay RCS program costs. In general, however, high income households consume more energy (and therefore pay a larger share of RCS program costs) than do low-income households. Also, lower-middle-income households not eligible for WAP and not participating in RCS may be most affected by RCS. The average increase in utility bills due to the RCS program is about $2/year; thus the equity effect is small.

RCS PROGRAM ENERGY SAVINGS

The bottom line for the RCS, as for most energy conservation programs, is the energy saving that can be directly attributed to the program. This requires analysis of the difference between actual postprogram energy consumption for participants and what postprogram consumption would have been without the program. The former term can (at least in principle) be measured with sufficient data. The second term, however, cannot be observed and must be

inferred, based on theory and data. Few evaluations of RCS measure program performance using actual fuel consumption records; most evaluations rely on household self-reports of recent conservation actions and the influence of the RCS audit on their decisions to install these measures. It is unlikely that such an indirect approach can yield reliable answers; the best source of information on program performance is actual household fuel bills. Six evaluations that use billing data are available; their findings are reviewed below.

Michigan's evaluation of their RCS program relied on household electricity and natural gas bills, obtained from samples of both participants and nonparticipants (Table I). Their data and analyses show small but statistically significant savings for homes that use natural gas for heating and water heating and larger savings for homes that use electricity for heating and water heating (Kushler and Saul, 1983).

Table I. Annual energy saving per participant attributable to the Michigan RCS program

	Participant energy saving (MBtu/year and Percent of preprogram consumption), by fuel type	
	Natural gas[a]	Electricity[b]
Space heating	5.3 (3.4%)	3.9 (9.6%)
Water heating	0.8 (2.7%)	2.7 (6.1%)

[a]10 ccf of natural gas = 1 MBtu.
[b]293 kWh = 1 MBtu (end-use conversion of electricity).

Source: Kushler and Saul (1983).

Evaluation of the Minnesota RCS program (Hirst et al., 1983c) also included analysis of a companion pilot program that offered low-interest loans to finance installation of retrofit measures recommended in the RCS audit. Analysis of actual natural gas bills showed a net RCS program saving of about 5 MBtu/year for RCS participants (3% of preprogram use) and a saving of about 20 MBtu/year (12% of preprogram use) for households that received both an audit and a loan. Households eligible for the loan who received an audit but not a loan showed no incremental energy saving (i.e., they saved no more energy than did program nonparticipants). We obtained a similar finding in evaluation of the Bonneville Power Administration Residential Weatherization Pilot Program (Hirst et al., 1983a). The program included free home energy audits plus zero-interest, deferred-payment loans to finance retrofit of recommended measures. Energy savings for households that received both an audit and a loan averaged 12 MBtu/year (3500 kWh, a 13% net saving); the net saving for audit only households was zero.

Literature reviews and interviews conducted by several contractors for the U.S. Department of Energy during the latter half of 1983 uncovered only a few utility and state evaluations of RCS programs that relied on actual fuel bills. A few of the studies identified are not considered here because of methodological flaws in analysis or limitations in data. For example, some evaluations used very short postaudit time periods to assess program energy savings; that is, they allowed insufficient time for households to respond to audit recommendations. Some approaches merely summarized the fuel use data and conducted no analyses to adjust consumption for changes in weather from year-to-year or for differences across households in demographic and structure characteristics. Altogether, data and analyses from six states seemed to yield reliable results concerning RCS program energy savings (Table II); none of these evaluations were from the southern half of the U.S.

Table II. Summary of energy-saving estimates for RCS programs[a]

State/utility	Dominant heating fuel	Net energy saving per participant (MBtu/year)[b]
Connecticut	oil	9[c]
Michigan	gas	6
Wisconsin/Wisc. Power & Light	gas	3[d]
Minnesota/Northern States Power	gas	5
California/Pacific Gas & Electric	gas	3
Washington/Seattle City Light	electricity	5[d,e]

[a]These analyses are based on actual fuel consumption records for samples of both RCS participants and nonparticipants. Only about one year of postaudit data was used in these evaluations to assess savings; additional data and analysis are needed to determine the long-term effects of these programs on energy savings.

[b]These savings are those that can be directly attributed to the RCS program (i.e., the increase in savings beyond that which would have occurred without RCS).

[c]Because of data quality problems with fuel oil data, this estimate is an average of ones based on engineering analysis (16 MBtu) and analysis of actual fuel bills (2 MBtu).

[d]These estimates are for RCS-like programs operated in 1978 and 1979.

[e]Electricity converted at 293 kWh/MBtu (end-use energy).

The range in estimated energy saving is small given the diversity in data collection, analytical techniques, location, and program operation. If these six data points are roughly indicative of program performance, then one might conclude that the RCS program yields an average saving of 4 — 5 MBtu/year one

year after program participation. Analysis of two years of postprogram fuel bill data, in Michigan's RCS program and the Bonneville Power Administration (BPA) pilot program, showed that energy savings increased during the second postprogram year. The electricity saving directly attributable to the BPA program (Hirst et al., 1983d) increased from 3500 kWh (13% of preprogram use) one year after participation to 3800 kWh two years after participation for audit + loan households. Households that received a BPA energy audit but did not obtain a retrofit loan showed no net electricity saving during the year following their audit. However, in the second postaudit year, the net saving for these households averaged 2000 kWh (8% of preprogram use). Thus, the estimates given here might best be viewed as the short-run response to RCS audits.

RCS PROGRAM COST-EFFECTIVENESS

Adequately assessing RCS program worth is difficult for several reasons (Fig. 2). First, there are different perspectives from which to view the program. These include program participants, nonparticipating ratepayers (who share in the cost of these programs), the utility and its stockholders, and society as a whole. Analysis of cost-effectiveness from each persepctive is likely to yield different results.

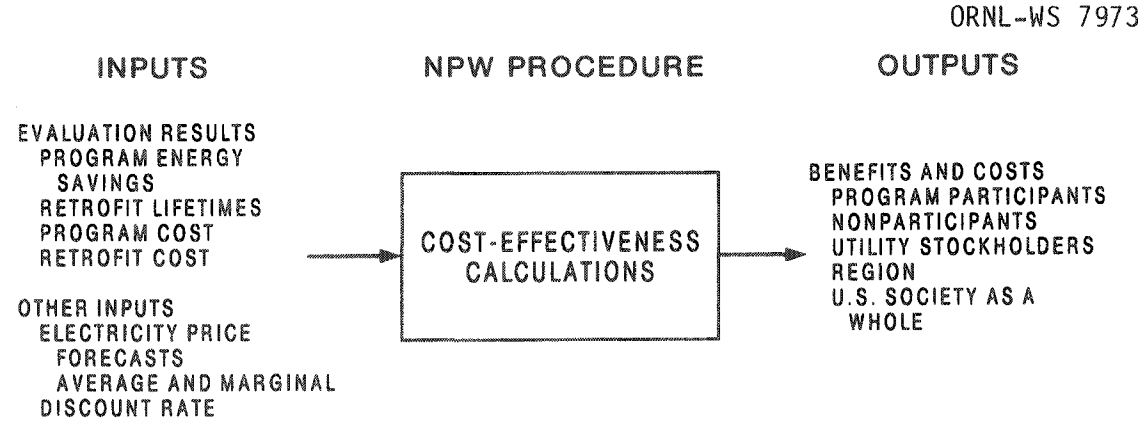

Fig. 2. Schematic showing inputs to, and outputs from RCS program cost-effectiveness calculations.

Second, estimates of program worth are sensitive to the data and assumptions used in the analysis. For example, small differences in the discount rate or marginal cost of electricity or natural gas can have large effects on estimated cost-effectiveness.

Third, one needs information on program costs, program energy savings, and marginal and average costs of fuel for many years into the future. For example, if a program encourages installation of retrofit measures with an

average lifetime of 20 years, then one must calculate the costs of energy production, transmission and distribution — with and without the program — for 20 years into the future.

Fourth, many of the inputs to a cost-effectiveness analysis such as fuel prices, program costs, customer response rates, differences between marginal and average fuel prices, and utility operating characteristics are highly site-specific. As a result, cost-effectiveness conclusions about one utility's RCS program cannot be applied directly to other RCS programs.

Finally, RCS programs may yield benefits beyond energy savings. Participants and society benefit when participating households increase the comfort of their homes after installation of conservation measures. Economic theory suggests that some of the benefits of technical efficiency improvements will be taken in reduced operating costs (as measured by energy savings) and some will be taken as increased comfort (e.g., higher space heating temperature settings after retrofit). In addition, society benefits from avoidance of negative environmental impacts associated with the supply of fuels, and reduction of national security and balance-of-payments problems associated with oil imports. There may also be regional economic benefits of the RCS program, such as increases in the value of participants' homes because of retrofit and increased employment. Finally, utility provision of RCS services may increase customer and state regulatory goodwill toward the utility, resulting in less opposition to rate increases than would otherwise occur.

Using information assembled by Centaur (1983) from states in which evaluations included both program energy savings (based on actual fuel bills) and retrofit costs, we computed crude "social" benefit/cost ratios for RCS. The three states for which such "complete" data were available are Connecticut, Michigan, and Minnesota. The B/C ratio is based on average (not marginal) residential fuel prices for the 1982/83 heating season and real discount rates of 5 and 10%.

At a 5% discount rate, the incremental benefits (value of participant net energy saving) of the RCS in these three states exceeds the incremental costs of the program (audits, administration, additional retrofits installed); the B/C ratios range from 1.2 to 1.4. At a 10% discount rate, the programs have B/C ratios slightly below 1.0.

It is difficult to interpret these cost-effectiveness estimates because they are for only three states, are based on average rather than marginal fuel costs, assume that fuel prices do not increase in the future, and ignore all social (nonfuel price) benefits of the RCS program. Nevertheless, the numbers suggest that the direct economic benefits of RCS are probably small.

Our analysis of the Minnesota RCS program economics (Hirst et al., 1983c) used marginal gas prices (assumed to remain below average prices during the lifetime of RCS-induced retrofits) in computing benefit/cost ratios for nonparticipating ratepayers and society in general (Table III). As a consequence, the RCS is economically unattractive to nonparticipants and

Table III. Cost-effectiveness results for Minnesota's RCS Program[a]

Real discount rate (%)	Benefit/cost ratio		
	Participants	Nonparticipating gas ratepayers	Society
2	1.8	-0.5	1.1
5	1.5	-0.4	0.9
8	1.2	-0.4	0.8

[a]The marginal cost of natural gas is assumed to remain $1/MBtu below the average cost. These calculations assume that the participant energy saving is 15 MBtu/year for retrofits with a lifetime of 14 years; comparable figures for nonparticipants are 10 MBtu/year and 13 years. The audit cost $145, of which $10 was paid by participants. Retrofit expenditures averaged $550 among participants and $300 among nonparticipants.

economically neutral to the state. In Michigan, on the other hand, the marginal cost of gas is higher than the average cost; as a consequence, the Minnesota RCS would be economically attractive in Michigan from all perspectives. This emphasizes our earlier point about how site-specific these cost-effectiveness results are.

ALTERNATIVES TO RCS

A number of suggestions have been offered to reduce RCS program costs, increase participation rates, and/or increase program energy savings (Aronson and Stern, 1984). Many of these involve regulatory or legislative changes that would reduce the prescriptive requirements of the current program. For example, the required master lists of contractors and financial institutions, and the utility offer to arrange for financial assistance and a contractor are rarely used. Therefore, it might make sense to delete these requirements and thereby reduce program operation costs.

Other suggestions involve alternative marketing strategies to increase audit requests, particularly from groups not now participating in the program; simplified audits that cover fewer of the complicated and difficult to analyze measures (particularly renewables) to reduce audit costs; and postaudit activities to encourage greater installation of recommended measures such as installation of low-cost measures during the audit, followup phone calls, or financial assistance (e.g., low-interest loans or rebates) to install these measures.

Unfortunately, the available evidence (data and analysis) on these RCS alternatives is, if anything, even more meager than the evidence concerning RCS itself. The only issue for which some data are available concerns the effects of low- and zero-interest loans (Table IV). Experience, primarily in

Table IV. Summary of energy-saving estimates for audit plus loan programs[a]

State/utility	Net energy saving per participant (MBtu/year)
Minnesota/Northern States Power	20
Washington/Seattle City Light	11
Washington/Puget Sound Power & Light	13
Oregon/Portland General Electric	10
Pacific Northwest/	
Bonneville Power Administration	12
Pacific Power & Light	12

[a]These analyses are based on actual fuel consumption records for samples of both participants and nonparticipants. The estimates are for electrically heated homes (converted at 293 kWh/MBtu) for all cases except for Minnesota (gas-heated homes).

the Pacific Northwest (Burnett, 1982; Hannigan and King, 1982; Weiss and Newcomb, 1982; Hirst et al., 1983a and c; McCutcheon, 1983), shows that the addition of a loan to a home energy audit program greatly increases program energy savings, by a factor of roughly three.

On the other hand, the utility cost of these loans is high in terms of administration and subsidized interest payments. Whether the value of the increased energy saving is sufficient to offset the cost of the loan depends very much on the particular circumstances in the utility service area where the program is offered. For example, the BPA zero-interest loan program is cost-effective to the utility system and the region, while a similar low-interest loan program in Minnesota is not (Hirst et al., 1983a and c). The difference in results is due primarily to differences between marginal cost and average price. BPA's marginal electricity cost is higher than the average electricity price, while in Minnesota the marginal cost of gas is below the average price.

CONCLUSIONS

The federal Residential Conservation Service, mandated by the 1978 National Energy Conservation Policy Act, is intended to improve energy efficiency of existing homes. Its main feature is an on-site home energy audit conducted by the household's local electric or gas utility. Information collected during the audit is used to present recommendations to the household on ways to reduce home energy use.

During its first two years of operation, two million RCS audits were conducted. Recent attempts to assess the performance of RCS lead to several conclusions:

1. Very little comprehensive evaluation of RCS and RCS-like programs has been done by utilities, state energy offices, or the U.S. Department of Energy. As a consequence, more than five years after passage of its enabling legislation, we know little about the benefits and costs of RCS, or about the key features of RCS programs (e.g., marketing, auditor training, audit technique, followup to encourage installation of recommended measures) that contribute to program success or failure.

2. Participation in RCS has been lower than initially anticipated. It is unclear whether participation rates are low because of limited utility marketing of the program or because consumers neither need nor want home energy audits.

3. Households who participate in RCS are generally demographically "upscale." Relative to nonparticipants, those who receive audits tend to have higher incomes, more education, larger homes, and live in single-family homes that they own.

4. In the few (six) cases where careful evaluations were conducted, using actual fuel consumption records, results show small but statistically significant energy savings. Data from Connecticut, Michigan, Minnesota, Wisconsin, Washington, and California suggest an average energy saving for RCS participants of about 5 MBtu/year (3 — 5% of preprogram fuel use). Long-term savings may be higher, because existing analyses used only about one year of postaudit data.

5. The combination of low participation rates and modest energy savings suggests that the impact of RCS on national energy consumption is very small. At current participation rates and energy savings, the total impact after five years of RCS operation would be a reduction in residential energy use of 0.2%. Between 1973 and 1983, per household energy use declined 20% in the U.S. Viewed against this historical background, RCS energy savings are rather small.

6. While estimates of program energy savings showed some consistency across states and utilities, variation in estimates of program cost-effectiveness is much greater. This is a consequence of two factors. One is the different perspectives from which RCS can be assessed. The second factor concerns assumptions on discount rates and the marginal social costs of fuels saved by RCS.

7. Several alternatives to the RCS have been proposed. These alternatives seek to reduce the prescriptive nature of the present program, reduce program operation costs, and increase participation and subsequent retrofit. Unfortunately, even less empirical evidence

concerning the advantages and disadvantages of these alternatives (except for subsidized loan programs, which show much larger energy savings than do audit-only programs) is available than exists on the RCS program itself. It is therefore difficult to judge the value of RCS alternatives in terms of their likely effects on program energy savings and program costs.

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