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RESIDENTIAL HOME AUDITS: AN EMPIRICAL ANALYSIS OF THE ENER$AVE PROGRAM

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ABSTRACT

The purpose of residential home audit programs is to encourage energy conservation by providing homeowners with information concerning retrofit actions which are economically feasible. One particular type of home audit program, the Class B audit, is based on a computerized analysis of the home. This study examined the impact of one Class B audit, the ENER$AVE program operated by the Canadian federal government. A longitudinal analysis of approximately 1400 households, a majority of whom participated in the program, concluded that the ENER$AVE program had little or no effect on homeowners' conservation activities. These results coupled with other findings question the effectiveness of Class B audits in general.

To combat rising energy costs many homeowners consider improving the energy efficiency of their homes through retrofitting. One of the barriers they may face is a lack of knowledge as to what actions should be taken. Government departments, utilities, and others have recognized this and have offered home audits as a means of reducing or removing this knowledge barrier and encouraging

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energy conservation. Home audits can generally be described as a service which, based on an assessment of the energy integrity of a dwelling, provides the user with a number of recommendations concerning retrofit actions.

A wide variety of home audit programs have been implemented in the United States and Canada. For example, in one review, twenty-two different home audit programs were identified and they represented just a small fraction of those in existence [1]. The programs range from home planning kits which provide the "do-it-yourself" consumer with ideas and guidelines for energy savings to formal home energy audits conducted by a trained energy evaluator who makes specific recommendations and, in some instances, helps the homeowner find contractors and funds to complete the recommended retrofit actions.

One issue with these programs is their effectiveness in achieving energy conservation by homeowners. While the cost-per-household of providing information can be determined (in some cases less than $1.00 per household for simple "do-it-yourself" information kits to over $125.00 per household for an inspection by a trained auditor), the effectiveness in terms of energy conservation actions and actual energy saved is far less certain.

The objective of this article is to examine the effect of a computerized audit, the ENER$AVE program, operated by the Canadian Federal Government. Since the inception of the program in 1977, a personalized computer home energy audit has been provided for over 300,000 households in Canada. Through an analysis of a sample of 1,451 households, some of whom participated in the ENER$AVE program, and all of whom were questioned two years later concerning conservation actions taken, an assessment of the ENER$AVE program will be presented. Specifically, the analysis will consider:

- if households who participated in the ENER$AVE program were more interested in conservation;
- if completion of the ENER$AVE questionnaire itself acted as a stimulus for conservation activities; and
- if conservation recommendations received by households via ENER$AVE acted as a stimulus for conservation activities.

The article begins with a discussion of the homeowner's decision to retrofit and how the different types of home audit programs might influence the decision. This is followed by a description of the ENER$AVE program, the research design, and analysis. Conclusions are then drawn based on the preceding discussion and analysis.

BACKGROUND

The homeowners decision to improve the energy efficiency of the dwelling is somewhat complex because of the technical expertise required and the number of actions that could be taken. For example, insulation can be installed in a

number of areas, weatherization can be done, and furnace improvements can be made. The homeowner cannot determine which actions are economically worthwhile without some specific information on the condition of the dwelling and possibly some rank ordering of the economic payoffs from various actions. Home audits are designed to provide part or all of this information depending on the class of audit undertaken.

As shown in Table 1, there are three general classes of home audits, the simplest being a do-it-yourself audit (Class C), a second level audit where the homeowner completes the home description information and the analysis is done with the aid of a computer program (Class B), and the most sophisticated (Class A) involving a home inspection by an energy auditor. The major variations occur within Class A audits where "packages" may be introduced which provide the homeowners with a complete insulation service including financing and guarantees for both workmanship and materials. Further, the individual conducting the energy audit may act merely as an information provider or as a salesperson who encourages the homeowner to invest in the recommended conservation actions.

There has been no systematic study of the relative effectiveness of the three classes of programs. Class B and C audits have been criticized because the analysis of the heating system is often based on inadequate information. In particular, because of underestimating by-pass heat losses, do-it-yourself handbooks (Class C) or computer programs (Class B) will usually fail to give people advice that will minimize the cost of improving the energy performance of the house [2]. Further, Class B and C audits seldom make recommendations concerning improving the air tightness of the home, the factor some consider most critical in home energy efficiency [3]. These audits have also been criticized because of their failure to recognize that each house is, to some extent, unique and requires some degree of individual attention. Another problem is that Class B audits base their recommendations on the heating cost estimates provided by the homeowner. Unfortunately, many homeowners' estimates of these costs are frequently incorrect [4].

On the other hand, while Class A audits can be tailor-made for both the home and homeowner, the cost is considerably higher than either a B or C audit. There is no empirical evidence to show that Class A audits have achieved greater homeowner conservation actions or energy savings than either Class B or C audits. Of particular interest would be a cost/benefit analysis across the three types of audits to determine the proportion of homeowners among a target population who had an audit conducted and, of these, the proportion who engaged in conservation actions and the savings in energy that resulted. The fundamental question to be answered is whether or not any type of home audit can be a cost-effective means of promoting retrofits of homes [5].

Only limited research is available on the evaluation of home audit programs and usually only one type of program was examined. For example, study of

Table 1. Specific Characteristics of Home Audit Programs

	Examples[a]		
Characteristics	*Class A*	*Class B*	*Class C*
Home inspection	energy auditor	homeowner	homeowner
Data analysis	computer analysis, possibility of auditor analysis as well	centralized computer analysis	homeowner with instructions
Information from audit	comprehensive recommendations, payback, R.O.I.	limited number of recommendations, payback	homeowner calculates
Post-audit information	may recommend suppliers	usually none	none
Additional services	may offer package service including: – contract work – work and materials guarantee – financial subsidies	many provide information on available grants or tax credits	none

[a] Class A audits can generally be described as those where a trained individual inspects the owner's home, assesses the effects of various conservation actions (possibly with the aid of computer analysis), and then provides the homeowner with information concerning the costs and payoffs of the various conservation actions. Class B audits usually require the homeowner to conduct the inspection, then send the results to a central office where a computer analysis is conducted and returned to the homeowner with recommendations. Class C audits usually provide the homeowner with a workbook which contains instructions for auditing the home and directions for calculating energy savings.

Project Conserve, Minnesota's computerized home energy audit (Class B), concluded that while costs per participant of Project Conserve were small, so were the apparent benefits [6]. Only 4 per cent of those who received the Project Conserve offer (the computerized home audit was mailed to 540,000 residential customers of a utility) claimed that it influenced their conservation actions.

One study that compared a type of Class A audit with a Class C audit found no significant differences in actual energy consumption between:

1. houses which had undergone an audit by a trained energy advisor;
2. houses that were sent a "do-it-yourself" kit; and
3. control homes [7].

However, there were a number of difficulties with this study, including measurement problems with energy use and differences in energy use levels between the groups which severely limit the validity of the findings [5].

One review of home energy audit programs concluded that there was insufficient evidence currently available to determine what type of audit program may be most effective in encouraging conservation [5]. A similar conclusion reached is that the evaluation of home energy conservation programs must be given much more serious attention because of our lack of knowledge in this area [1]. While the limited evidence available suggests that home energy audits have had a minimal impact on householders' conservation behavior, it is clear that more empirical work is required before any definitive conclusions can be reached. By obtaining a better understanding of this field, improvements in the design and operation of audit programs can be achieved. With this in mind, the next section of this article will provide an empirical examination of the ENER$AVE program.

THE ENER$AVE PROGRAM

The ENER$AVE program, a Class B type home audit is a free information service operated by Energy, Mines and Resources Canada. Its purpose is to help homeowners save energy and money by improving the heating integrity of their homes. Participants in the program fill out the ENER$AVE questionnaire giving data on the age of the home, its construction, size and shape, as well as the amount of existing insulation, the type and cost of heating fuel used, and the thermostat settings during the winter. The questionnaire is returned to ENER$AVE and a computer analysis of the questionnaire is conducted. The homeowner is then sent a set of recommended home insulation procedures. Recommendations on weatherstripping, storm windows, and thermostat setback are also made where appropriate. For each recommendation, detailed estimates of the associated material and labor costs, projected fuel and dollar savings, and the payback period are provided.

METHODS

In late 1978, a research study was conducted for Consumer and Corporate Affairs Canada which provided baseline information on energy consumption and conservation patterns in Canadian households [8]. The respondents for this study were panel members of a marketing research firm and the information was collected by means of a mail questionnaire. As part of this study, respondents were asked to complete the ENER$AVE questionnaire. Of the 1,952 households contacted, 1,588 completed the ENER$AVE questionnaire, and subsequently received the computer assessment provided by ENER$AVE. In late 1980, approximately two years later, the respondents who remained on the panel were

recontacted and 1,451 completed questionnaires which, among other things, asked them if they had done a number of conservation actions. Among these actions were those which might have been recommended by ENER$AVE. For six of the eight conservation actions recommended by ENER$AVE, information was available to determine:

1. whether the household had completed the ENER$AVE questionnaire in 1978 (of the 1,451 households, 1,081 or 74% completed ENER$AVE and 370 or 26% did not);
2. if the household had completed ENER$AVE whether or not any action was recommended (for example, only 5% received a recommendation to install storm windows whereas 70% received a recommendation to add insulation in the basement); and
3. whether the household had taken conservation actions prior to completing ENER$AVE, since completing ENER$AVE, or not at all.

Thus, an examination of ENER$AVE can be conducted by measuring the reported home energy conservation activities of three groups of households:

1. those who completed the ENER$AVE questionnaire and a conservation action was recommended;
2. those who completed the ENER$AVE questionnaire and a conservation action was not recommended; and
3. those who did not complete the ENER$AVE questionnaire.

SAMPLE DESCRIPTION

Sample Characteristics

Because the sample households were drawn from a consumer panel, the possibility of sample bias relative to the total Canadian population could exist [9]. The major difference between the sample and the population was home ownership. Approximately three out of five (62%; 1976 Census) households in the population own their homes whereas 87 per cent of the sample owned their own homes, only 13 per cent rented their accommodation. This bias was considered desirable because there is a greater potential for energy conservation among homeowners and they have more control over their energy usage. Further, programs such as ENER$AVE are most relevant for those that pay energy costs directly. In summary, homeowners are the target audience for most residential energy conservation policies.

Comparisons on a number of other socio-demographic characteristics support the contention that other than home ownership differences that sample reflects the Canadian population. By way of summary, the sample had the following characteristics: 84 per cent lived in single-detached homes; 6 per cent lived in apartments; 6 per cent lived in duplex/triplex/fourplex, and 4 per cent in other

accommodation. The average age of the houses was thirty-one years old. The fuel used to heat the home was oil in 40 per cent of households, natural gas in 37 per cent, electricity in 16 per cent, and other was 7 per cent. English was the major language of 78 per cent of the households, French in 21 per cent, and other languages spoken was 1 per cent. The average age of the female head of household was forty-eight, average family income was $19,000, an average of 3.2 people lived in each household, 88 per cent of the sample were married, and the median education level was high school graduation.

Two points should be made before the analysis is presented. First, under "real world" conditions, householders who complete the ENER$AVE questionnaire do so on a voluntary basis and because they are interested in the program. In this study, householders were asked to complete the ENER$AVE questionnaire and may have done so as part of their commitment to the panel (to which they belonged) and not because of interest. Consequently, these respondents may, generally, be less interested in the results than householders who complete the questionnaire on a "voluntary" basis. If any bias existed between this sample and the population that completed ENER$AVE, it would tend to reduce the impact of ENER$AVE in this study.

The second point is concerned with whether all the households, including those who rented their accommodation or lived in a multiple unit dwelling, should be included in the analysis. Clearly, households who rent, even though they may pay the heating bills, have little incentive to "invest" in retrofit activities in a dwelling which they do not own. Similarly, for those who live in multiple unit dwellings, even if they own them, may be constrained from retrofitting because of structural problems. For these reasons, it was decided that the following analysis would include only those respondents who resided in a single family dwelling and owned it. This decision removed approximately 15 per cent of the sample from the analysis.

ANALYSIS

Overview

The six conservation activities of the households based on whether they had completed ENER$AVE or had an action recommended, are presented in Table 2. For all six activities, the group defined as "Completed ENER$AVE – Action Not Recommended" had a higher proportion of "Done More Than Two Years Ago." This is understandable because if a household had engaged in the conservation activity (e.g., added insulation in the attic) prior to completing ENER$AVE, then the ENER$AVE analysis would recognize this and no action would be recommended.

While the above mentioned category and most others are logical, two categories appear to be confusing. First, some of the "Action Recommended"

Table 1. Households Reporting Conservation Behavior, by ENER$AVE Response (Percentages)

Reported Conservation Behavior	Completed ENER$AVE: Action Recommended (Group 1)	Completed ENER$AVE: Action Not Recommended (Group 2)	Did Not Complete ENER$AVE (Group 3)	Total
Installed weatherstripping and caulking				
—Done within last two years	52	45	45	46
—Done more than two years ago	26	41	36	39
—Not done	22	14	19	15
	100	100	100	100
N =	65	869	146	1080
Installed storm windows				
—Done within last two years	36	23	31	25
—Done more than two years ago	48	55	49	54
—Not done	16	22	20	21
	100	100	100	100
N =	44	777	134	955
Added insulation in attic				
—Done within last two years	40	36	33	38
—Done more than two years ago	38	44	39	41
—Not done	22	20	28	21
	100	100	100	100
N =	530	384	145	1059
Added insulation in walls				
—Done within last two years	24	13	20	17
—Done more than two years ago	25	36	24	31
—Not done	51	51	56	52
	100	100	100	100
N =	253	613	137	1003
Added insulation in basement				
—Done within last two years	25	22	28	25
—Done more than two years ago	26	50	28	32
—Not done	49	28	44	43
	100	100	100	100
N =	626	236	138	1000
Added insulation over unheated area				
—Done within last two years	19	17	18	18
—Done more than two years ago	20	23	18	22
—Not done	61	60	64	60
	100	100	100	100
N =	81	461	99	641

group reported having done the activity prior to completing ENER$AVE. For example, considering adding insulation to the attic, 40 per cent of Group 1 reported doing this activity prior to completing ENER$AVE yet the analysis recommended adding insulation. Two possible explanations can be suggested:

1. the level of insulation added was insufficient and further insulation was justified; or
2. the household's reporting was inaccurate and the conservation activity occurred after completing ENER$AVE (i.e., within the last two years).

The second confusing category concerns the "Action Not Recommended" category (Group 2). Some of these households engaged in the conservation activity even though it was not recommended. For example, 36 per cent of this group added more insulation to the attic after receiving the ENER$AVE analysis which did not include that recommendation. Again, two explanations can be offered:

1. inaccurate household reporting (they had actually done the activity prior to ENER$AVE, not after); or
2. these households planned to add more insulation regardless of what ENER$AVE recommendations were made.

The analysis will consider these possible problems by addressing three questions:

1, *Self Selection:* Did the households who completed the ENER$AVE questionnaire have a greater interest in energy conservation than those who did not complete the ENER$AVE questionnaire?
2. *ENER$AVE as a Stimulus:* Did the act of completing the ENER$AVE questionnaire lead to a greater level of conservation activities?
3. *The Impact of a Recommended Action:* Did those households who received a "conservation action recommendation" from ENER$AVE engage in a higher level of conservation actions?

Self-Selection

The most appropriate test for self-selection was to determine if the three groups differed on the proportion who reported doing the conservation activity more than two years ago, prior to completing ENER$AVE. Recognizing that some recall problems may exist, any resulting bias should impact on all three groups equally. Therefore, it is reasonable to assume that a good indicator of interest in conservation is the level of households engaging in conservation activities prior to completing ENER$AVE. For the purpose of this analysis, the activity levels aggregated across all conservation actions will be examined in order to assess the possible aggregate effects of self-selection. A later section of the analysis will deal with the six individual conservation activities.

Table 3. Distributions and Contrast Analysis – Done Activity More Than Two Years Ago: Total Activities (Percentages)

A. DISTRIBUTIONS	Completed ENER$AVE		Did Not Complete ENER$AVE	
Total Conservation Activities	*Action Recommended (Group 1)*	*Action Not Recommended (Group 2)*	*(Group 3)*	*Total*
–Done more than two years ago	30	42	33	37
–Done last two years or not done	70	58	67	63
	100	100	100	100
N =	1599	3340	799	5738

B. CONTRAST ANALYSIS

Contrast	P_1	P_2	N_1[a]	N_2	*t*	*Level of Significance*
Group 1 and 2 versus Group 3	.38	.33	823	133	1.13	–
Group 1 versus Group 2	.30	.42	267	557	-2.63	.01
Group 1 versus Group 3	.30	.33	267	133	- .61	–
Group 2 versus Group 3	.42	.33	557	133	2.05	.04

[a] Because there were repeated measures (six) for each household, the sample size has been reduced by a factor of six.

The results presented in Table 3 reveal that a significantly higher proportion of the Group 2 households reported doing the activities more than two years ago. As shown in the contrast analysis, Group 2 households (those who had completed ENER$AVE but had not received an action recommended) were more likely to have done the activities prior to completing ENER$AVE. The "prior" activities of Group 1 and Group 3 were not statistically different and when Groups 1 and 2 (the ENER$AVE completers) were contrasted with Group 3 (the ENER$AVE non-completers), the activities were not statistically different.

On the basis of this analysis it could be concluded that, as measured by prior conservation activities, the "Action Not Recommended" group had a greater interest in conservation. The two other groups, "Action Recommended" and "Did Not Complete" were similar in terms of activities and therefore assumed similar in terms of conservation interests. Given these results, the following analysis will control for the differences in the "Action Not Recommended" group by removing the category "Done More Than Two Years Ago." This will allow for a relatively straightforward examination of the impact of ENER$AVE for all three groups.

Table 4. Distributions and Contrast Analysis – Done Activity Within Last Two Years: Total Activities (Percentages)[a]

A. DISTRIBUTIONS	Completed ENER$AVE		Did Not Complete ENER$AVE	
Total Conservation Activities	Action Recommended (Group 1)	Action Not Recommended (Group 2)	(Group 3)	Total
–Done within last two years	44	48	45	46
–Not done	56	52	55	54
	100	100	100	100
N =	1112	1947	533	3592

B. CONTRAST ANALYSIS

Contrast Analysis	P_1	P_2	N_1[b]	N_2	t	Level of Significance
Group 1 and 2 versus Group 3	.46	.45	510	89	.18	–
Group 1 versus Group 2	.44	.48	185	325	-.89	–
Group 1 versus Group 3	.44	.45	185	89	-.16	–
Group 2 versus Group 3	.48	.45	325	89	.51	–

[a] The response "Done More Than Two Years Ago" has been excluded from this analysis.
[b] Because there were repeated measures (six) for each household, the sample size has been reduced by a factor of six.

Was ENER$AVE A Stimulus?

The possibility exists that the act of completing the ENER$AVE questionnaire, regardless of whether an action was recommended or not, could have acted as a stimulus for the households. That is, the questionnaire required respondents to obtain a number of facts about their dwelling (e.g., are doorways weatherstripped? Are there drafts around windows?) which may have sensitized respondents in some manner towards the energy efficiency, or lack thereof, of their dwelling. The appropriate contrast analysis is to compare the conservation activities of Groups 1 and 2 versus Group 3. As shown in Table 4, no significant differences were found in the proportion of conservation activities done within the last two years between *any two groups.* In fact, the most surprising result is the similarity in proportions for all three groups. In conclusion, the act of completing the ENER$AVE questionnaire did not act as a stimulus for conservation activities.

The Impact of a Recommended Action

The basic purpose of the ENER$AVE home audit is to encourage households to engage in *appropriate* conservation actions. Appropriate actions, which are recommended, are based on the computerized assessment of the dwelling. In

theory, to be judged as having any effect, the ENER$AVE program should lead to greater conservation actions in those situations where the program recommends an action (i.e., Group 1). As shown in Table 4, this did not occur. Group 1 households did not engage in more conservation actions than either of the other two groups. In conclusion, the results of this study suggest that ENER$AVE had no effect on encouraging conservation activities.

As a final step, the analytic sequence, indicated by Tables 2 and 3, was repeated for each of the six conservation behaviors (see Table 2 for the individual actions). The results support the findings at the aggregate level. That is, Group 2 households had a higher proportion of "Done More Than Two Years Ago" than either Group 1 or Group 3 and the differences were statistically significant ($p < .05$) for three of the six actions. In considering the impact of ENER$AVE, only two actions were significantly different between the groups ($p < .05$). Considering that twenty-four contrasts were conducted, two significant findings could easily be attributed to chance.

In reviewing the results at both the aggregate and individual action level it seems reasonable to conclude Group 2 households were most interested in conservation as measured by prior activities. The act of completing the ENER$AVE questionnaire and receiving the results did not lead to greater conservation activity.

DISCUSSION

There are a number of possible explanations for these results including:

1. A homeowners decision to engage in certain conservation activities may not be influenced by information provided by ENER$AVE. For example, weatherstripping a home may be determined more by a "comfort" motive (i.e., drafts make the home uncomfortable) than by an "economic" motive which is the basis for ENER$AVE recommendations.
2. The ENER$AVE recommendations may have not been considered highly credible by the homeowners who received them because:
   - the program was free with the result that homeowners may have questioned its validity;
   - homeowners supplied the information for the audit and if the homeowners supplied "guesses" for some of the information (e.g., thickness of basement wall insulation) they may question the recommendations because they knew the "inputs" were questionable; and
   - many of the ENER$AVE recommendations are based on rather simple rules (e.g., if less than a specified level of insulation in the attic, the program recommends adding insulation) and this may have created some credibility issues.

3. As a final possibility, it may be that information alone, as provided by ENER$AVE, was insufficient incentive to act, and that information in combination with loans or grants are needed to motivate householders to act.

At a more general level, the characteristics of this Class B audit may also limit its effectiveness. For example, while the *sponsoring organization* (a federal government department) should not have any credibility problems, participants may question the organization's expertise. Every Canadian household is eligible for the ENER$AVE program and because there is no *target market,* the heterogeneity of participants may reduce its impact. The *promotional activities* for the program are very general, mainly newspaper advertisements, and this broad brush approach may lead to some confusion concerning what the program can do for homeowners. The program is free and this *pricing strategy* may affect the credibility of the information. Considering the specific characteristics of the audit, the *home inspection* and *data analysis* are based on information provided by the homeowner which can affect the accuracy of the "input" information. The "output" *information* provided by the audit may not be relevant for the homeowner. Finally, the ENER$AVE program does not offer any *post-audit information* or *additional services* per se. This lack of follow-up may also inhibit the program's effectiveness.

Unfortunately, the present study cannot test the validity of these possible explanations. What is required is an in-depth study of the reasons why homeowners do or do not act on ENER$AVE recommendations. It may be that the lack of response to ENER$AVE is due to external factors (e.g., household financial constraints). If this is the case, linking ENER$AVE to a loan or grant program may improve its impact. On the other hand, if it is found that ENER$AVE lacks credibility or is defective for any of the other reasons mentioned, then modifications to ENER$AVE, or programs of this type, could be made.

The assessment of the ENER$AVE program, a Class B audit, concluded that the program had little impact on homeowners' energy conservation actions. It appears that the homeowners in this study decided to either perform or not perform conservation activities independent of completing the ENER$AVE questionnaire or the information received through the ENER$AVE program. As a marketing technique designed to encourage energy conservation, the ENER$AVE program could be judged to have had little or no effect. In-depth study of the reasons for its ineffectiveness might suggest modification that would increase its impact.

At a more general level, the effectiveness of Class B audits should be questioned. Studies of two Class B audits have concluded that the programs have had, at best, a marginal impact on conservation actions. It may be that the other types of audits, Class A or C, are better vehicles for communicating information to homeowners and encouraging them to take conservation actions.

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