The Role of Home Energy Audits in Facilitating Residential Retrofits

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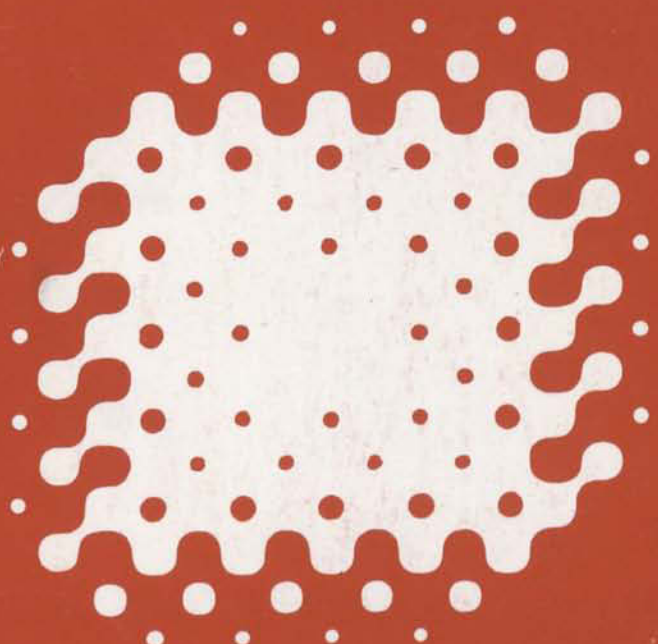

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FOREWORD

This publication is one of several in a continuing series of consumer energy conservation research reports documenting studies carried out under the direction of the Consumer Research and Evaluation Branch of Consumer and Corporate Affairs Canada. The energy research activity in consumer products and consumer lifestyles began in the spring of 1978 as part of Canada's federal energy research effort. Prior to 1978, Canada's energy research had typically focussed on supply issues and the demand research being conducted was overwhelmingly technological in nature. This Branch has been directed to examine the consumer behaviour sector of the energy demand equation by the Interdepartmental Panel on Energy Research and Development, the body charged with coordinating Canada's energy research effort.

The energy conservation activity of the Branch is directed towards the achievement of the following goals:

1. to develop a basic understanding of consumer attitudes, knowledge and behaviour with respect to energy and resource use, and the importance that consumers place on this aspect of their lifestyles;

2. to perform policy and program analysis research in high priority areas and to identify policies and programs with a high potential for conservation; and

3. to provide consultative services in the design of conservation program evaluations, and to carry out evaluation research studies.

This report by Deutscher and Munro develops a framework for studying consumer decision-making with respect to home energy audits and their role in promoting insulation retrofit. As space heating accounts for approximately 70 per cent of residential energy use, the development of effective conservation programs directed towards this area is most important.

The study gives particular consideration to be barriers that exist to the use of home audits. More important, it examines the progression from an audit to a retrofit decision. This study constitutes an important input which should help policy makers move towards closing the gap between potential and actual energy savings in the home heating sector.

It should be understood that the findings, interpretations and recommendations contained in this report are those of the authors and do not necessarily imply their endorsement by Consumer and Corporate Affairs Canada. The purpose of this open publication policy is to ensure that the research environment is conducive to the production of high quality and objective scientific studies.

Geoffrey A. Hiscocks
Director
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EXECUTIVE SUMMARY

The central objective of this report is to develop a framework for studying decisions about energy audits conducted in Canadian homes. The fundamental question facing Canadian policy-makers is whether or not these audits can be a cost-effective means of promoting retrofits of homes.

The answer to this fundamental question is not a simple one. In theory, it would appear that a home audit program could effectively complement other programs currently offered to Canadians -- specifically, the Enersave computer audit program and the federal government's information dissemination (pamphlet-oriented) efforts. This conclusion is based on an analysis of the residential retrofit decision-making process. Examination of this process pointed out several significant barriers to reaching a decision to retrofit. Many of these barriers could be effectively circumvented by a program which featured a trained auditor who could diagnose problems, recommend solutions and motivate retrofit behaviour.

On the other hand, a home audit program is of necessity an expensive one. Costs of $60 - $100 per audit have been experienced in similar programs in the United States. As well, there is as yet no clearly documented evidence supporting the conclusion that such a program is worthwhile. In the United States, legislation was passed in November 1979 requiring major gas and electric utilities to provide home energy audits. From the findings of this report, it appears that research into defining the relevant costs and benefits of such a program in Canada should be conducted before such a program is enacted.

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INTRODUCTION

Managing the energy problem that confronts Canada poses a serious challenge for public policy makers. The response to this challenge has been a commitment to achieve energy self-reliance within the next decade (Energy, Mines and Resources Canada, 1976). While substantial resources have been devoted to the development of energy supplies, these efforts must be complemented by a curtailment of energy demand if self-reliance is to become a reality (Gander and Belaire, 1978). This need to curb demand has provided the impetus for government to undertake an extensive research program directed at developing policies to encourage energy conservation (McCabe and Cullen, 1978).

The support for energy conservation appears warranted when one considers the major costs, delays and uncertainties associated with developing alternative sources of supply. Furthermore, with many of the potential alternatives currently in existence (such as nuclear power or coal) there are major threats of environmental problems. To find and develop new energy resources is expected to be an extremely expensive and time-consuming task. Approaches emphasizing conservation rather than production are appealing because the decision to conserve produces immediate effects, without a lag for developing technology.

Residential space heating represents an important domain in which to encourage energy conservation. Excluding transportation, space heating accounts for approximately 70 per cent of residential energy use or 15 per cent of Canada's total energy use (Cullen, 1979). The technology for reducing heat loss from dwellings is available today. It offers potential energy savings of approximately 30 per cent (Cullen, 1979). Furthermore, conservation through retrofitting does not involve major adjustments to consumers' lifestyles, and it offers potential economic returns to the consumer. This last feature is particularly important. Past research has demonstrated that consumers are reluctant to engage in conservation behaviour that results in major changes in current lifestyles and that most conservation behaviour can be traced to a financial motive (Anderson and Cullen, 1978; McDougall, Ritchie and Claxton, 1979). In conclusion, the space heating domain appears to be one where policies which are both effective and politically attractive (persuasive rather than mandatory) can be implemented.

The objective of this paper is to discuss the feasibility of a home energy audit program as a means of encouraging homeowners to improve the thermal efficiency of their homes by increasing attic and wall insulation, using weather stripping on windows and doors and similar measures. This process is called retrofitting. The report begins by describing the decision-making process that most homeowners would go through in making and implementing a decision to retrofit. Examination of this process reveals a number of barriers that a potential energy conserver must overcome before his home is retrofitted. Next, an evaluation of current efforts directed at stimulating conservation in the space-heating sector is provided. Both information-based programs and economic incentive programs are examined. The discussion then concentrates on the potential role of a home audit program and its impact on the decision-making process. The effectiveness of current attempts to use home audit programs is evaluated and a typology of potential programs is developed. The paper concludes with directions for future research to assist in designing and implementing home energy audit programs.

CHAPTER I

THE DECISION-MAKING PROCESS UNDERLYING RETROFITTING HOMES

Decision-Making Processes in Consumer Research

Central to most models of consumer behaviour is the concept of a decision-making or problem-solving process (e.g., Howard and Sheth, 1969; Engel, Blackwell and Killat, 1978). Typically, consumer decision-making is viewed as having five distinct phases: (1) problem recognition; (2) search for information; (3) alternative evaluation; (4) choice; and (5) evaluation of outcomes. The decision-making process perspective contributes to a better understanding of how decisions are reached and provides important information for deciding marketing techniques. Knowledge about the relative importance of various information sources, the criteria used to evaluate alternatives and so on, serves as a valuable basis for both formulating strategies and assessing their effectiveness.

Public policy makers could also benefit from adopting this perspective in their efforts to shape the behaviour of individuals. Day (1976) imposed a similar process perspective, the hierarchy-of-effects model, in assessing the effects of information disclosure requirements. The model postulates that there is a hierarchical ordering of possible effects such that prior cognitive effects are a necessary condition for subsequent changes in attitudes and behaviour. An important conclusion that surfaced from the author's evaluation was that before legislation about information disclosure is faced there is a pressing need for: a) a conceptual basis for understanding how buyers use information, and b) clarification of the objectives to be used by providing the additional information. The decision-making process perspective offers a useful frame of reference for research dircted at satisfying this need.

From the above discussion, an examination of the decision-making process related to retrofitting homes is in order. This perspective will be used to structure the discussion of current and potential efforts to encourage retrofitting of homes.

The Decision to Retrofit

Table 1 presents a simple model of the decision-making process for retrofitting the home. It outlines the major stages in the process and the potential barriers that inhibit progress from one stage to the next. These barriers frequently are related to a lack of information about how to proceed and a lack of confidence in making the necessary decisions. The process begins with the consumer recognizing that there could be excessive heat loss in the home. The transition from ignorance to awareness and concern for this problem is complicated by the fact that heat loss is not readily visible and is highly dependent upon the physical characteristics of the individual's home. Energy use also tends to be a by-product of more basic desires (e.g., comfort, transportation, convenience) and often is not a salient concern for most individuals. The impending severe price increases and the potential energy shortages might stimulate a greater concern for energy use among consumers. To date, very little is known about what motivates homeowners to consider retrofitting their homes.

Once the problem is recognized, the consumer must assess the available alternatives for action. To do so entails acquiring both a general knowledge of the means to reduce residential heat loss and specific information on solutions relevant to the individual's situation. Since few individuals are likely to possess this knowledge, they must turn to external sources of information. The complexity of the problem is such that information on potential solutions is likely to be difficult to comprehend and process since it tends to be very general, requiring homeowners to be able to adapt it to their own dwellings.

The process is complicated further by the fact that the solutions (e.g., weatherstripping, insulation, furnace modification) are likely to vary in terms of costs, time to implement and potential savings. The homeowner must then develop appropriate criteria for evaluating these alternatives. This type of decision-making is not one in which most consumers have much experience. Furthermore, the problem will often dictate more than one action (e.g., add insulation and install storm windows).

Table 1

Model of the Decision-Making Process to Retrofit the Home

Stages in the Process	Potential Barriers
IGNORANCE OF THE PROBLEM	Lack of motivation
AWARENESS OF THE PROBLEM	Lack of knowledge to identify whether a problem exists
GENERAL KNOWLEDGE OF POTENTIAL SOLUTIONS	Difficulties in acquiring and comprehending available information
KNOWLEDGE OF SPECIFIC ENERGY-SAVING MEASURES FOR THE INDIVIDUAL'S PROBLEM SITUATION	Lack of information about specific problems present in the dwelling
CONVICTION TO ACT	Difficulties in determining the costs/benefits of various measures
RETROFIT BEHAVIOUR	Lack of decision-making skills Financial constraints Problem with contractors Time constraints General procrastination
POST-DECISION EVALUATION	Judging the quality of the work performed Time delay in realizing the benefits
OTHER POST-DECISION ACTIONS	Factors obscuring the benefits (e.g., inflation)

The benefits from retrofitting the home will occur in the future. Unfortunately, these benefits (i.e., energy saved) will not be as obvious to the investor, especially if he is not accustomed to thinking in terms of long-run operating costs, as the costs of retrofitting were; in fact, the savings may even be obscured by fuel bills that remain high because of price increases (Russo, 1977). The uncertainties surrounding the alternatives make the evaluation process very difficult for the homeowner.

Once the homeowner has decided to retrofit the home, the next concern is how to implement the desired action. Depending upon the complexity of the task and the skills of the individual, the homeowner may decide either to make the necessary modifications himself/herself or to contract them out. Both alternatives require further search effort and evaluation on the homeowner's part; in essence, a new decision-making process is started. Should the homeowner decide to work with a contractor to implement the desired modifications, there may be further difficulties. Recent research has shown that problems with contractors in the home-repair and maintenance sector are prime contributors to dissatisfaction among consumers (Ritchie and Claxton, 1978). Moreover, for many homeowners this stage also involves making a decision about financing any investments required. This added complexity often results in the homeowner delaying implementation. All these factors can be significant barriers between a conviction to act and actually getting the retrofitting done.

Once the home has been retrofitted, there is an evaluation of the decision. Determining the quality of the work performed constitutes one part of the post-decision evaluation. Since homeowners often lack the necessary skills required to conduct this evaluation, this can be a very frustrating experience. The uncertainties and time delays associated with the benefits from retrofitting make it difficult for the homeowner to determine whether the decision was worthwhile or not. Consequently, homeowners who decide to retrofit might be well-advised not to discuss their decision too much with their neighbours!

Not all homeowners are expected to experience these types of problems in the decision-making process. Some have had considerable experience in related types of behaviours (e.g., home repair and maintenance) and possess the necessary skills to process and apply the available information to the problem area. These homeowners are likely to have confidence in their ability to make a sound decision. However, for many homeowners, the decision-making process is bound to cause considerable anxiety.

Information Avoidance Strategies

The problems in deciding to retrofit may be so great that homeowners adopt what Ray and Dunn call an information avoidance strategy (1978). Their study of purchasers of major services, found little evidence of a rational decision-making process. Very little information relating to problem recognition was processed; consequently, purchasers tended to be unaware of their specific needs and of how they should make the decision. There also appeared to be little or no search for information on alternative actions. Consumers believed that the available information was either inadequate or too technical to comprehend. The process often terminated with the consumers being dissatisfied with the choice and seeking redress through complaints. This lack of a formal decision-making process is consistent with the findings from a recent review of the literature on consumers' prepurchase behaviour (Olshavsky and Granbois, 1979).

The uncertainties and complexities associated with deciding to retrofit a home indicates that the same phenomenon may exist here. Research is needed to determine the types and most appropriate sources of information required at different stages in the decision-making process and to understand the barriers which discourage conservation through retrofitting.

As well, very little is known about what motivates people to retrofit their homes. The prospect of financial savings, estimated in terms of payback figures or percentage of fuel savings supposed to result from conservation measures, may convince homeowners to act. However, the desire to save money may be undercut by the belief that conservation involves substantial effort and inconvenience. It is also possible that conservation measures have been undertaken as a result of other forces. That is, a change in attitude might follow conservation behaviour rather than cause it.

A better understanding of the factors that enter into the decision to retrofit a home would mean that programs could be more effectively designed and implemented. The research should also distinguish segments of homeowners with different needs and energy patterns. Great economies are possible if the most suitable strategy can be developed for each major segment.

CHAPTER II

EXISTING PROGRAMS TO ENCOURAGE ENERGY CONSERVATION

The technology to achieve considerable energy savings in the residential home heating sector is available (Cullen, 1979). The objective for policy makers is to close the gap between potential and actual energy savings by encouraging homeowners to adopt this technology. A framework outlining the potential strategies for achieving this and other conservation objectives is provided in Evans, Ritchie, and McDougall (1979).

With few exceptions, policy makers have relied on two basic approaches for encouraging energy conservation in the residential heating sector: information programs and economic incentives. A brief description of these programs and an assessment of their effectiveness follows.

Information Programs

Information about the nature of the energy problem continues to be disseminated through the mass media by both public and private institutions. However, the messages the consumer receives do not always convey a consistent impression. For example, media reports on oil and gas finds or decisions to export natural gas surpluses to the United States are likely to negate any effects of messages portraying an energy shortage.

A recent study of Canadian consumers supports this notion (McDougall, Ritchie and Claxton, 1979). The research indicated that consumers are not keenly aware of the energy problem and, therefore, do not see energy conservation as a serious need. The authors concluded that there is a clear need to explain the energy problem more convincingly. Similar results were reported in a major U.S. study (Milstein, 1977).[1]

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1. A more extensive discussion of existing and potential information programs can be found in "Overview Topic Paper on Mass Media Energy Conservation Communication Policies" by Patricia and Ilan Vertinsky, February, 1979.

Consumers would likely be more receptive to appeals to conserve energy in heating their homes if they had a better understanding of the energy problem. The superiority of economic appeals (i.e., save money by saving energy) over nationalistic appeals (i.e., our country is facing a serious energy problem) offers some validity to this position (Craig and McCann, 1977; 1978). It is unlikely that general mass media appeals will be sufficient. However, they can be used to create a favourable atmosphere for the introduction of complementary programs (e.g., "how to" materials and financial incentives).

In addition to general mass media appeals, substantial information on effective conservaion has been disseminated. The practical home-heating conservation materials developed by Energy, Mines and Resources Canada: 100 Ways to Save Energy and Money in the Home, Keeping the Heat In, Billpayers Guide to Furnace Servicing and District Heating For Small Communities are good examples. Industry and public interest groups have also responded by providing similar information, such as Consumer Reports and the extensive conservation advertising by Ontario Hydro.

Other than monitoring the number of requests for information booklets (Kelley, 1978), there has been little effort to research the effectiveness of providing this information. This void is not unlike that experienced with other ongoing information programs (Day, 1976). The traditional problems encountered in designing and implementing evaluation research tend to be compounded by confusion over program objectives.

Wilkie (1974) noted that the goals of information programs can range from an emphasis on recall knowledge and awareness variables to an emphasis on attitudes and behaviour. The objectives of a particular information program should dictate the criterion variables employed in evaluating that program's effectiveness (Bettman, 1975).

Ideally, information on how to conserve energy used in heating the home would stimulate a hierarchy of effects much like that predicted by Day (1976). Awareness, comprehension and consideration of the information would contribute to a positive attitude towards energy conservation. This positive attitude would lead homeowners to retrofit their homes. The information program would not only yield the desired behaviour, but would increase homeowners' confidence in their ability to make informed, rational decisions.

The paucity of research evidence available makes it difficult to gauge how close the actual effects of information programs are to the desired effects. However, one measure of this program's impact on consumers' knowledge of energy conservation facts if provided in a recent Canadian study:

> While respondents claimed a relatively high knowledge of energy facts, actual knowledge was considerably lower. In particular, their knowledge of the amount of energy that could be saved through various conservation actions (e.g., turning down thermostats by a specific number of degrees) was poor. In fact, respondents consistently attributed less energy savings to the various conservation actions than was actually the case. (McDougall, Ritchie and Claxton, 1979, p. 8)

One possible explanation for these rather discouraging results is that consumers have to request the information booklets by mail. This distribution strategy tends to reach only a committed section of the population. The gap between "seekers" and "non-seekers" of information has been well documented in previous research efforts (e.g., Thorelli, Becker, and Engledow, 1975).

It is also possible that the information being disseminated may not be completely relevant to homeowners' needs. The decision-making process described in Table 1 highlighted a transition from a general knowledge of ways to reduce heat loss in the home to knowledge of specific solutions that meet the peculiarities of individuals' homes. The information booklets contribute to the general knowledge level but do not adequately address the transition to household-specific solutions.

The type of information being provided may be difficult for the consumer to process and comprehend. Not having full appreciation for the relevance and meaning of the information, homeowners are likely to adopt an information avoidance strategy. Efforts to educate consumers on the value and use of the information may therefore be a necessary complement to information programs. The requirement for consumer education has surfaced with other attempts at introducing consumer information programs (Thorelli, 1972).

Information programs should be designed from the perspective of the user, not the provider, of information (McEwen, 1978; Capon and Lutz, 1979). This suggests that research is required to determine: 1) what information is needed by homeowners contemplating retrofitting their homes; and 2) how that information can best be delivered. Identification of consumer segments should permit more efficient targeting of these efforts.

Even with an improved information environment and favourable attitudes, there are a number of remaining potential barriers (e.g., costs and implementation problems) that could prevent homeowners from engaging in conservation behaviour. The effects of situational factors on the attitude - behaviour relationship have been well documented in the literature on attitudes (e.g., Ajzen and Fishbein, 1977; Bell, 1975; Eagley and Himmelfarb, 1978). Until these barriers are removed, these information programs are unlikely to increase conservation behaviour.

Economic Incentive Programs

Nemetz (1979) recently compiled an overview of economic incentives for energy conservation at the consumer level (e.g., tax incentives, rebates, grants, loans and subsidies). The study contributed the following conclusions about programs in Canada:

1. there is very little legislation directed at reducing energy use by consumers in Canada;

2. much of the legislation that is expected to affect energy use was not designed with this specific purpose in mind;

3. some tax relief and cost assistance programs are expected to increase energy use (e.g., natural gas tax rebate and removal of taxes on gasoline and diesel oil in Alberta); and

4. of the legislation that should contribute to a relative decrease in energy use, only the removal of taxes on energy conservation material can be considered as solely directed towards this purpose.

One example of the available incentive programs is the federal government's home insulation program (CHIPS). The program offers taxable grants up to a maximum of $350 for the materials and $150 for the labour involved in implementing conservation measures (e.g., insulation, weatherstripping, caulking and venting). Originally, the program was restricted to homes built prior to 1946 but it has recently been modified to include homes built before January 1961. To date, it has met with only moderate success. Many homeowners are not aware of the program, are confused over eligibility requirements, or consider the taxable grant too low for the effort involved.

Private industries also offer incentives to homeowners to insulate their homes. For example, Esso and Fiberglas Canada Ltd. are cooperating in a program allowing rebates to Esso customers who insulate their homes (Probe Post, 1979). The customer rebate amounts to a credit on their Esso home heating oil account equal to 10 per cent of the cost of the insulation.

Data on recent U.S. legislation using economic incentives were also assembled (Nemetz, 1979).[2] Although the data revealed substantial legislation, many of the earlier programs were targeted specifically at elderly, handicapped and low-income groups. The major thrust tended to be one of equalization rather than energy conservation. However, the more recent programs indicate a greater concern for this second objective.

The recent origin of many of these programs severely restricts an accurate assessment of their effectiveness. Canadian policy makers could gain valuable insights for formulating programs by closely monitoring the progress of U.S. efforts.

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2. An alternative source of data on programs in the United States is the "State-By-State Energy Assistance Guide" in The Energy Consumer, Vol. 1, No. 5, October 1979, pp. 9-19.

One could speculate that the effectiveness of economic incentive programs will be limited. The incentives might serve to motivate homeowners to consider the energy waste problem and the possibility of alleviating it. Although such programs lessen the financial burden of implementing an improvement, they do not contribute to overcoming the other barriers (e.g., lack of information and knowledge) that surface in the decision-making process. These remaining obstacles will continue to impede retrofitting behaviour and contribute to consumers' frustration with the process.

In summary, the current information and economic incentive programs play an important role in encouraging homeowners to retrofit their homes. However, there are a number of barriers which limit their effectiveness in encouraging conservation behaviour. An integrated mix of programs is necessary to overcome the major barriers that confront homeowners in their decisions to retrofit their homes. This paper advocates a personal home audit program which would complement existing programs and provide the basis for an integrated effort to achieve energy conservation objectives in the home-heating sector. The next section examines the role of such a home energy audit plan in relation to the retrofit decision-making process and the barriers discussed earlier.

CHAPTER III

THE ROLE OF A HOME ENERGY AUDIT PROGRAM

The type of home audit program advocated in this paper is an energy audit in which the estimates of costs and savings for various action alternatives are based on an inspection of the residence of an eligible customer by a qualified auditor. A discussion of alternative home audit programs will be provided in a subsequent section of the paper.

The role of the home energy audit program is outlined in Table 2. The program is viewed in relation to the decision-making process to retrofit the home, the problems that plague that process, and current efforts to encourage energy conservation in the residential home heating sector. A home audit program is expected to:

1. identify whether the individual has excessive heat loss in his or her home;

2. provide general information on ways to conserve energy in the home;

3. provide specific solutions to improve the thermal efficiency of the individual's home;

4. assist in the decision-making process by providing data on costs, benefits and payback periods for different conservation measures;

5. possibly facilitate implementation of the improvements by assisting the homeowner in dealing with contractors and financial agencies; and

6. possibly insure that the measures installed comply with standards.

The advantages of the home audit program materialize primarily through the process by which the above information is delivered. A detailed on-site inspection by a well-trained auditor can pinpoint peculiarities of the individual's home (e.g., thermostat located by the front door), as well as the usual targets of insulation, caulking and storm windows. This process not only alleviates some of the difficulties that homeowners have in identifying problems in their homes, but it offers tailored solutions to these problems. More important, the auditor can explain in simple terms why specific actions

Table 2

Role of the Home Audit Program in the Retrofit Decision-Making Process

	Stage in Decision-Making Process	Problems/ Barriers	Current Programs	Home Audit Programs	Environmental Forces
A.	Ignorance of the problem	. Lack of motivation			. Increasing costs of energy
		. Lack of knowledge to identify whether a problem exists	. Mass media advertising of the general problem of waste through heat loss	. Identifies whether the individual has a problem of excessive heat loss	. Mass media on energy problem - national and international
B.	Awareness of the problem	. Difficulties in acquiring and comprehending available information			
C.	General knowledge of potential solutions	. Lack of information about specific problems present in the particular dwelling	. "How to save energy" information . Enersave questionnaire	. Provides general knowledge of ways to reduce heat loss	
D.	Knowledge of specific solutions to individual's problem situation	. Difficulties in determining the costs/benefits of various measures - lack of decision-making skills		. Identifies specific conservation measures that address the individual's problem	
E.	Conviction to act	. Financial constraints . Problems with contractors . Time constraints . General procrastination	. Economic incentives	. Assists in the decision-making process by explaining the costs/benefits of the recommended measures	. Excessive inflation-budget constraints . High interest rates increase financial costs
F.	Retrofit behaviour	. Judging the quality of the work performed . Time delays in benefits		. Could facilitate implementation by assisting in dealing with contractors and financial agencies	. Recommending a procedure for getting the work done
G.	Post-decision evaluation	. Factors obscuring the benefits . Difficulties in evaluating the soundness of the decision		. Ensures that the measures installed comply with standards	
H.	Other post-decision actions	. Overall lack of confidence leading to frustration and dissatisfaction			

are recommended. This process is a highly effective means of imparting the knowledge required for energy conservation. It complements current efforts by facilitating the processing and comprehension of information distributed by other means.

The concepts of long-term operating cost and payback period could be explained by the auditor to assist the homeowners in deciding what actions to take. The auditor could also outline the dependence of savings on such factors as weather and the possibility that fuel price increases may obscure significant improvements in fuel bills. This last issue caused considerable frustration and anger among consumers (Russo, 1977). Consumers need to be educated on how to evaluate the success of the retrofits they make and to have realistic expectations regarding improvements. The home audit program could be instrumental in satisfying this need.

Information about reliable contractors, available financing, tax credits and other government energy programs could also be provided to homeowners. Such information should contribute to alleviating some of the barriers to implementing home improvements.

The information and the manner in which it is provided in the home audit program should enhance homeowners' confidence in their ability to make sound decisions as well as their satisfaction with the decision-making process. Experience with past information programs offers some support for this position (Day and Brandt, 1974). Improvements in homeowners' decision-making ability are more likely to result in an increased number of retrofitted homes.

The key to the success of the home audit program is the auditor:

> Since the auditor mediates between the homeowner and the audit, the auditor's competence and persuasiveness can make or break the audit. For this reason, the auditor should be seen as a prime source of motivation. (Bailey, 1979, p. 4)

A training program should prepare auditors to perform effectively.

In addition to facilitating the decision-making process, the homeowner's agreement to have a home energy audit performed constitutes a degree of commitment to conserving energy. The homeowner might perceive this commitment as resulting from internal motivations and rely on these inner feelings to guide subsequent behaviour (e.g., retrofitting the home).

This is similar to the "foot-in-the-door" paradigm that has surfaced in both the social psychology (e.g., Pliner et al., 1974; Seligman, Bush and Kirsch, 1976) and marketing literature (e.g., Scott, 1976; 1977; Reingen, 1978). The basic premise of the paradigm is that individuals who comply with an initial request and attribute this to some internal motivation (e.g., their beliefs or attitude) are more likely to comply with a subsequent larger request. The conditions shaping their initial behaviour will affect how individuals use that behaviour to infer their attitudes and/or to guide subsequent behaviour.

Attitudes toward energy conservation tend to be favourable already, but there is little action on the basis of these attitudes. Altering self-perceptions through an initial behavioural request may encourage energy conservation behaviour (Scott, 1977). However, these views are highly speculative and need to be addressed in future research efforts.

There is very little empirical evidence for how a home energy audit program would encourage more homeowners to retrofit their homes. The position advocated here is based primarily on the belief that a well-executed program would alleviate some of the major problems that confront homeowners in deciding to retrofit the home so that they would be more likely to take actions to improve the thermal efficiency of their homes. Research is needed to substantiate these claims before resources are committed to such a program.

So far, the discussion has focused on the potential of home audit programs for overcoming or circumventing some of the barriers to residential retrofitting. The next section describes and evaluates the actual experience with audit-based programs in Canada and the United States.

CHAPTER IV

CURRENT EXPERIENCES WITH HOME ENERGY AUDIT PROGRAMS

The Enersave Program

Thus far, Canadian homeowners have been offered relatively little in home audit programs compared to their U.S. counterparts. The major exception is the Enersave program offered by Energy, Mines and Resources Canada. This program provides a computerized analysis of a house's thermal efficiency based upon a homeowner's responses to a questionnaire which deals with the home's energy-consuming proportions (e.g., insulation, types of windows, etc.). The homeowner then receives a list of suggested improvements (e.g., insulation, caulking, adding storm windows, thermostat reductions and weatherstripping) and estimates of what it will cost to make the improvements and how much will be saved by making them. More than 250 000 homeowners have filled in the questionnaire since the program was started in September, 1977,[1] but there has been no reported follow-up on the results of the audits in terms of home improvements made on energy saved.

The Enersave program is an example of the Class B audits which will be discussed further later in the paper. In this program, no visits to homes by trained auditors are necessary. Undoubtedly, programs like these can be a very effective means of providing information about what energy-conserving improvements can be made in a home. Viewed in terms of the barriers that consumers experience in deciding to retrofit, presented in Table 1, a Class B audit can handle two problems experienced by homeowners very effectively: 1) difficulties in applying general knowledge about energy conservation methods to the specific problem situation in their homes; and 2) difficulties in determining the costs and benefits of various retrofit measures.

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1. Based on a statement by John Forman, Technical Assistant for the Enersave Program, as reported in The London Free Press, Saturday, Nov. 3, 1979.

However, there are also substantial segments of homeowners who have delayed retrofitting decisions for other reasons. They might lack confidence about actually performing the necessary home modifications (either doing the retrofitting measures themselves or hiring an outside contractor). Or they might just never get around to providing the data necessary for the computer analysis either through procrastination or through lack of confidence in their ability to make the necessary measurements. For these people a Class A audit, which entails a trained analyst actually visiting the home, is much more likely to result in a retrofit. More will be said about the role of these auditors in the retrofit process later in this paper. At this point, however, it seems that a Class A audit program could be an effective complement to a Class B audit program by providing the opportunity for a trained individual to make the necessary measurements for a particular dwelling, explain the recommended modifications to the homeowner, and motivate him to get them done.

Aerial Thermography

The Ontario Department of Energy is currently testing a program which combines thermography and a computerized audit form comparable to the Enersave questionnaire. The procedure involves taking aerial thermograms (i.e., temperature maps) of a particular city or location. Homeowners are then encouraged to visit convenient sites where a consultant will show them thermograms of their homes and interpret the results. If there appears to be excessive heat loss, the homeowner is asked to complete a questionnaire which captures the specifics of the home (e.g., insulation levels). One to four weeks later, specific recommendations and related cost/benefit data are mailed to the homeowner.

This program was tested in three Ontario communities: Peterborough, Kingston and St. Catharines. Data from the Peterborough and Kingston experience indicate that 30 to 40 per cent of all homeowners visited the locations to view the thermograms. A follow-up study to determine the program's effectiveness was conducted in Peterborough. A survey revealed that of those homeowners who viewed the thermograms and were told they had a problem, 30 to 40 per cent had followed through with some of the recommendations and an

additional 45 per cent intended to make improvements. A cost/benefit analysis indicated that the potential savings would more than compensate for the costs of offering the program to that community.[2]

Involvement by Private Industry

The Canadian industrial sector offers very little in the way of home audit services for homeowners. Texaco Canada Incorporated recently introduced a free home comfort analysis program in three cities: Toronto, Ottawa and Montreal. The service includes testing furnace efficiency and appraising current insulation levels of the home. The insulation inspection is often performed by a representative of a local insulation firm. The services provided by this program and similar ones offered by other oil companies tend to reflect a greater concern for attracting new accounts than for conserving energy.

The Energy-Efficient Program

Fifteen electric utility companies, members of the Canadian Electrical Association, have recently designed the Energy-Efficient Program, aimed at improving the resistance of houses to heat loss and ensuring the efficiency of households' major energy-consuming appliances and equipment. The guidelines can be applied to any home, regardless of the type of heating used.

The program, targeted primarily at contractors, was set up to encourage the adoption of energy-efficient measures in the home beyond those required by current building codes. The service involves a do-it-yourself audit which is set up like a scorecard. Points are given for energy-efficient measures adopted and deducted for major deficiencies. A total score exceeding a minimum required level qualifies the home as being energy-efficient. The builders of these energy-efficient homes benefit from an advertising program which acknowledges their efforts.

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2. Data provided in a telephone interview with John Quinn, Ontario Department of Energy.

Although no formal evaluation of this program has been conducted, a recent study involving home builders offers some insights (Quelch and Thirkell, 1979). The research examined the decision-making process of parties (e.g., home builders) involved in "imposed" choice purchases of furnaces, space heaters, water heaters, and kitchen and laundry appliances within Canada. The results indicated that builders purchase energy-using equipment for pre-installations in new residential housing on the basis of price. The energy efficiency of equipment options often is not considered. These findings suggest that the apparent concern builders have for minimizing their costs might negate any efforts to encourage them to adopt energy-efficient measures beyond those required by law.

Home Energy Audits in the United States

Recent legislation In the United States, some utility companies and heating-oil dealers have been promoting home energy audits for several years. The federal Department of Energy's new Residential Conservation Service Program will make home audits the norm nationwide within the next year (Federal Register, 1979). The major features of that program are captured in Table 3. Briefly, federal law now requires that electrical and gas utilities be able to provide comprehensive audits involving on-site inspections, projected cost/benefit analysis of conservation measures, financing arrangements for retrofits and post-installation inspections for any residential customer.

Audits where homeowners provide data on the residence The most common type of audit offered is the mail-in, computer-processed questionnaire typified by the U.S. federal government's "Project Conserve". This program, which now services homeowners in about 15 states, is comparable to the Canadian government's Enersave Program.

A number of individual utility companies and state energy agencies have developed their own computer-processed audit forms. Other power companies offer a do-it-yourself scorecard type of audit (e.g., National Energy Watch) similar to the type employed in Ontario Hydro's program.[3]

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3. A useful source for information on which states and utilities offer home audits is the "State-by-State Energy Assistance Guide" in The Energy Consumer, Vol. 1, No. 5, October 1979, pp. 9-19.

Table 3

Brief Summary of the Residential Conservation Service Program

A. Purpose of the program: to encourage the installation of energy conservation measures, including renewable resource measures, in existing houses by residential customers of larger gas and electric utilities as well as by residential customers of home heating suppliers.

B. Utilities covered: any utility which during the second preceding calendar year had either:

1. sales of natural gas for purposes other than resale which exceeded 30 million cubic metres; or

2. sales of electrical energy for purposes other than resale which exceeded 750 million kilowatt-hours.

C. Customer eligibility: any person who:

1. owns or occupies a residential building; and

2. receives a fuel bill from a covered utility or participating home heating supplier for fuel used in such residential building.

D. Scope of the program benefits: the program will entitle the eligible customer to the following benefits:

1. an on-site inspection of the residence by a qualified auditor* to determine the appropriateness of various conservation measures ranging from the traditional conservation practices (e.g., caulking, insulation, weatherstripping) to renewable resource measures (e.g., solar heating and cooling systems);

2. an estimate of the energy cost savings and of installation costs for the various conservation measures;

3. a warranty which certifies that an energy conservation or renewable resource measure, except caulking and weatherstripping, will have a useful life of at least three years;

4. assistance from the covered utility or participating home heating supplier in receiving either bids for the installation of program measures or a list of installers who have agreed to install the program measures at or within the prices estimated in the audit results;

5. financing arrangements for the supply and installation of any program measure;

6. a post-installation inspection to ensure that the measures comply with the relevant standards; and

7. an opportunity to voice any complaints and to seek redress through the conciliation conference and specified procedures.

E. If a state prefers to institute its own program, the proposed program must satisfy the criteria specified by the federal Department of Energy. The criteria are such that state programs are unlikely to vary significantly from the federal program.

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* Class B audits, i.e., audits performed by the eligible customer and mailed to the utility for analysis, are also permitted if they meet certain criteria.

Research evidence to gauge the effectiveness of these fill-in-the-blank audits is sparse. However, these programs are expected to face similar limitations to those outlined in the discussion of the Enersave program.

Class A audits A few states have introduced, and others have experimented with, what are known as Class A audits. In a Class A audit, a trained individual inspects the owner's home, sizes up the major problem areas and then suggests measures to remedy the situation. The additional services provided (e.g., providing cost/benefit data, financing, a list of qualified contractors and inspection of measures adopted) in the audit programs tend to vary by state.

The major gas and electric companies in New York and Oregon are required by their state governments to perform in-home audits on request. In Wisconsin only the gas utilities are required to conduct audits. Even though the costs per audit are estimated to range from $60 to $100, the homeowner is not usually charged directly for the service. The exception is New York State where companies are allowed to charge a maximum fee of $10. The costs of the audits are added to the company's cost structure which is used to determine energy prices. This way, the costs of the audits are indirectly passed on to all customers.

Many of the audit programs are of relatively recent origin. For this reason, it is difficult to find accurate assessments of their effectiveness in encouraging homeowners to retrofit their homes. The research findings that are available tend to be incomplete or of dubious validity.

The New York State Program The 1979 interim report on the New York State Home Insulation and Energy Conservation Act Program offers some general insights into the effectiveness of different types of home audits (Anderson, 1979). The Home Insulation and Energy Conservation Act (HIECA) requires the nine major electric and gas utilities in the state to offer their customers a program of energy audits and to arrange for financing the installation of energy conservation measures. The programs began in the various utility franchise territories in June 1978.

A customer is offered three classes of home energy audit under the program: Class A, B and C. With a Class A audit, the utility inspector feeds the information gathered on his visit to the customer's home into a computer and analyses it. The results are provided to the customer immediately in most cases. This audit takes an average of two hours to perform and the customer is charged $10. For a Class B audit, the customer collects the data according to instructions provided by the utility. The company processes the information and returns the results to the customer. The cost is limited by the Commission to a maximum of $3. The customer choosing a Class C audit receives workbooks which include instructions for auditing the home and directions for calculating energy savings. The calculations lead the customer to the same audit results as provided in the Class A or B. audit. There is no charge for the Class C audit.

All three audits include the traditional measures, such as insulation needs, caulking and weatherstripping, storm windows and doors. The audit results are given to the customer in terms of the number of years it would take each measure to pay for itself in energy savings. In addition, the utility gives the customer a list of "approved" local contractors who can install the various measures. A one-year guarantee on workmanship and materials is offered. Arrangements are also made with at least two local banks to make loans to customers for energy conservation improvements.

Highlights of the progress made by the program are outlined in Tables 3 and 4. The number of audit and loan requests for the period June 1978 through July 1979 are provided in Table 3. The total number of audits requested during this period represents approximately 10 to 12 per cent of the targeted one million multiple dwelling family units in New York State. What the data fails to show is the marked increase in customer response to the programs that occurred over the fall and winter months. This increase was attributed to environmental influences (e.g., fuel price increases and threat of shortages) and a more aggressive advertising campaign. The earlier months of the program were also plagued with start-up problems.

Table 4

Key Program Elements Under the Home Insulation and Energy Conservation Act, June 1978 through July 1979

Utility	Audit Requests			Loan Requests	
	Class A	Class B	Class C	Number	Amount ($)
Brooklyn Union	168	254	1 265	2	2 092
Central Hudson	354	433	8 796	2	2 797
Con Edison	5 701	335	24 000	24	22 694
LILCO	2 727	796	6 314	56	89 000
NFGD	507	232	10 750	159	242 537
NYSE&G	174	72	19 371	95	129 945
Niagara Mohawk	3 106	295	12 367	98	176 412
Orange & Rockland	1 550	690	3 641	27	27 129
Rochester G&E	928	117	3 587	73	116 761
TOTAL	15 215	3 224	90 091	536	809 367

Source: New York State Home Insulation and Energy Conservation Act Program: 1979 Interim Report, by Shirley R. Anderson, September, 1979.

A summary of the program results in terms of cost and energy savings for the October 1978 to March 1979 period is included as Table 5. The energy savings are based on installations financed through the program and an estimate of installations implemented without the program's financial assistance. The estimate was based on a survey of customers who requested either a Class A or B audit. An analysis of the steps taken by customers who requested a Class C audit was not conducted. The results indicated that a total of about 40 to 50 per cent of the customers who had a Class A or B audit proceeded to install some energy conservation measures either with financing through the utility company or independently.

The total program cost of $953,233 was about 1,5 times the program savings of $620,365 over the period from October 1978 to March 1979. However, these costs generate savings which will continue as long as the house continues to be occupied. The energy savings reported also do not include those that might occur from homeowners requesting a Class C audit. Overall, the program coordinators were pleased with the program's achievements thus far.

Field experiments A recent field experiment attempted to measure the energy savings from a residential audit program (Meier, 1979). The energy use of homes receiving an in-home audit was compared to the energy use for three other groups of homes: homes in which owners performed their own audits, homes where neither type of audit was carried out, and, finally, the average energy use for the area, including both rental units and residential homes. Comparisons were made both within groups (e.g., energy use in the year before the audit versus energy use in the year after the audit) and between groups (e.g., inspected homes versus do-it-yourself homes).

The results were disappointing in that no significant energy conservation was detected in comparing a group with its own past energy use and with comparable groups over time. The audit appeared to have no effect on energy use. A follow-up telephone interview indicated that individuals in the inspected homes did not adopt substantially more conservation measures than the do-it-yourself homeowners.

Table 5

Summary of Results of Home Insulation and Energy Conservation Act Programs, October 1, 1978 to March 31, 1979

I. Effect of the Program on Conservation of Fuel and Energy

Installations Financed through Utilities' Programs	
Annual Savings of Gas	1 416 million $m.^3/yr.$*
Annual Savings of Oil	261 236 l./yr.
Annual Savings of Electricity	46 275 kwh./yr.
Installations Not Financed through Utilities' Programs	
Annual Savings of Gas	11 823 million $m.^3/yr.$
Annual Savings of Oil	1 478 609 l./yr.
Total Annual Savings	
Annual Savings of Gas	13 139 million $m.^3/yr.$
Annual Savings of Oil	1 737 845 l./yr.
Annual Savings of Electricity	46 275 kwh./yr.

II. Cost Savings to Participating Customers

Installations Financed through Utilities' Programs	
Gas Heat Customers	$44,314/Yr.
Oil Heat Customers	$30,892/Yr.
Electricity Heat Customers	$ 3,205/Yr.
Installations Not Financed through Utilities' Programs	
Gas Heat Customers	$367,204/Yr.
Oil Heat Customers	$174,750/Yr.
Total Cost Savings to Participating Customers	$620 365/Yr.

III. Expense to Ratepayers

Expenses Related to Audits	$627 614
Inspection Expenses	$ 1 741
Program Advertising Expenses	$173 999
Reporting Expenses	$ 2 708
Interest Differential Expenses	$ 1 944
Miscellaneous Administrative Expenses	$145 227
Total	$953 233

IV. Revenues Related to Audits

Class A Audits	$57 985
Class B Audits	$ 1 428
Total	$59 413

Source: New York State Home Insulation and Energy Conservation Act Program: 1979 Interim Report, by Shirley R. Anderson, September, 1979.

* million $m.^3/yr.$ means million cubic metres per year

However, there are a number of factors in the study which severely limit the validity of these findings. There were problems with variations in weather and overlapping billing periods which resulted in rather crude measures of energy use. These measurement problems increase the chances of error and could account for the lack of noticeable changes in energy use, particularly when such a small number of conservation measures were adopted by both audited groups.

The comparisons between groups are also questionable. There were significant differences in energy use among the groups before any audits were performed. The inspected homes used significantly less energy in the first year than did homes in either the do-it-yourself group or the control group. It is possible that there were greater opportunities for energy savings in these last two groups. This would challenge the reliability of the dependent variable which was a count of the number of conservation measures adopted. Taking the percentage of recommended actions adopted by homeowners in the two groups might have constituted a better dependent measure for this study. There was also no comparison of conservation measures adopted by homeowners in the inspected and do-it-yourself groups receiving audits to those homeowners who were not audited. Given the problematic measure of energy use and the lack of appropriate comparisons, it would be erroneous to conclude that the audits had no effect on conservation.

The New Jersey Department of Energy recently conducted a similar field experiment. It was designed to test the effectiveness of seven different types of home audits: thermographic surveys, informal walk-through audits, Updated Project Conserve with and without an auditor, an on-site portable computer audit, Enercom and a self-administered workbook audit. These are described in greater detail in Table 6. Each of the seven audits was administered to 80 homes in East Brunswick, New Jersey. Eighty homes which were not audited formed the control group. Actual energy consumption, energy conservation intentions, and conservation measures adopted by residents were monitored after the audits were performed. Appraisals of the audits and reasons for retrofitting the home were also collected.

Table 6

Description of the Home Audits Tested in the New Jersey Department of Energy's Field Experiment

1. Thermography Survey -- Two infrared photographs covering 75 per cent of the wall and roof area of the house are taken from a van and analyzed off-site to determine the house's heat loss. Appropriate retrofits are recommended and sent to the homeowner by mail with the pictures. Payback calculations are included. The homeowner is given the telephone number of a technician who can explain the photographs and their implications for energy conservation.

2. Informal Walk-Through Audit -- Homeowners are provided with a booklet which guides them through an inspection of their homes. The booklet consists of a series of questions and recommendations covering a large number of areas. Cost and savings figures are not included.

3. Updated Project Conserve Without an Auditor -- Homeowners fill out questionnaires about their homes' characteristics and their energy habits. This information is processed through a computer program which recommends appropriate retrofits and the recommendations are mailed to the homeowners.

4. Updated Project Conserve With an Auditor -- Trained auditors inspect the homes and fill out the questionnaires. The information is analyzed after the visit and recommendations are mailed to the homeowners.

5. Portable Computer Audit -- Heat loss and operating cost information is calculated for homeowners on-site with a portable computer that has been appropriately programmed and can give instant calculations of the financial savings available from various combinations of retrofit procedures.

6. Enercom -- Trained auditors inspect the homes and use the homeowner's telephone to dial the data into a central computer. A voice hookup attached to the telephone allows the computer to speak instantaneously to the homeowner and deliver recommendations.

7. Self-Administered Workbook Audit -- Homeowners are given a workbook loosely based on Project Retrotech but redesigned to be specific to New Jersey. Homeowners must do their own measuring and calculations to obtain payback periods for various retrofits.

The final results of this experiment are currently being documented. A preliminary report indicated that residents preferred having the auditors gather the relevant information rather than conducting the audit themselves. However, the auditors, who were primarily data collectors, did not induce substantially different intentions to conserve. Measures of conservation behaviour are currently being tabulated. Residents also appeared to be unwilling to pay more than $15 for the audit; many believed that the audits should be free.

Since the preliminary analysis did not include any statistical tests for significance, the results should be interpreted with caution. Also, the auditors in this experiment were primarily data collectors, in the sense that they filled out the questionnaire for the homeowner, and therefore extrapolation from the results should be limited to that type of audit service. The experiment appears to be well designed and implemented and the final report should provide valuable insights into the effectiveness of different types of audits.

Conclusion

The National Energy Conservation Policy Act requires investor-owned utilities in every state to establish residential conservation service programs similar to those described above. This represents a major commitment to the concept of a home energy audit. However, there is little research evidence available to support this commitment or to suggest which type of audit program, if any, might be most effective. Future research should address these concerns and provide some guidance for policy makers who are contemplating introducing a home audit program.

The next section of the paper outlines the consideration necessary in developing an audit program and possible alternatives for each decision.

CHAPTER V

A TYPOLOGY OF AUDIT PROGRAMS

The following paragraphs will discuss factors that must be considered in constructing an audit program. These can be grouped into four sets:

1. Pre-Audit Considerations
   - sponsorship of the audit
   - promotion of the audit program

2. Audit Procedures
   - data collection methods
   - data analysis
   - results

3. Payment Plans
   - subsidization for the audit program
   - financing the retrofit

4. Post-Audit Considerations
   - inspection and guarantees of retrofitting
   - evaluation of the program

Within each subsection described above, the possible alternatives will be described briefly. A description of attempted home audit programs will be presented later.

Pre-Audit Considerations

The factors included in this section relate to the organization and sponsorship of the home audit program and the way in which it is promoted.

Sponsorship of the audit Audit programs could conceivably be offered by the federal, provincial or local governments, by a utility company or by private enterprise. At present, there is no research which describes potential consumer reactions to these alternatives. Consumers would undoubtedly evaluate the credibility of the sponsor and the amount of risk they would face in dealing with that source. For instance, many homeowners might be expected to prefer private enterprise over the government as an efficient deliverer of services. However, they would likely prefer to have home audits done by an impartial source, as opposed to a party who would gain directly from their decision to retrofit. For this reason, an insulation contractor would not be seen as a credible auditor.

Promotion of the audit program The most carefully designed and implemented home audit program is doomed to failure unless its benefits can be effectively communicated to the public. Some of the early attempts at audit programs in the United States have experienced difficulty in even giving away audits (e.g., Meier, 1979). Alternative means for communicating potential benefits to homeowners appear to be:

1. advertisements;

2. publicity in local newspapers and radio and television programs;

3. speeches to special interest groups (e.g., parent-teacher associations; and

4. direct mail appeals sent either to all households or to specially targeted ones.

Unfortunately, there is a total lack of research on the efficacy of these alternatives. In the few existing audit programs in the United States, heavy emphasis is placed on generating publicity in local media.

Audit Procedures

This section focuses on factors concerned with the performance of the audit itself -- for example, collection and analysis of data, and presentation of results.

Data collection methods Probably the most commonly used method of classifying home audit energy conservation programs is by considering how the audit is performed or, more precisely, who collects the data. In the Class A audits described earlier, a trained auditor performs a home inspection and suggests improvements that will be cost-efficient in saving energy. The degree of technical sophistication on the part of the individuals who perform the audits can vary widely. Most often, cost-benefit considerations preclude the use of technical specialists and the audits are performed by individuals who have had some training but who possess no special initial qualifications.

A second category of audit is exemplified by Canada's Enersave program, which was described and evaluated in more detail earlier. In this type of program (called a Class B audit in the typology advanced above) the homeowner performs the data collection for his own audit according to a set of guidelines which are usually given in a questionnaire format. This data is mailed to a central processor, which returns a set of home energy conservation recommendations.

A final type of audit is less commonly used because it requires thermographic equipment which is both expensive and hard to acquire. Some insulation contractors provide a thermogram of a housing unit after an insulation job is complete. On a larger scale, in a project which was described in more detail earlier in this report, aerial thermograms were used to identify homes with heat loss problems in three Ontario communities.

Data analysis The basic issue in this section concerns whether or not computer analysis is employed for evaluating energy-saving characteristics of homes. In audits where the homeowners collect their own data and send it in to a central analysis centre, a computer is usually used for analysis and recommendation. In situations where a trained auditor visits the home, a computer may or may not be employed. The auditor could collect data which he submits for analysis immediately after the audit, he could use a portable computer terminal to perform the analysis on-site, or he could rely on his own judgement for making recommendations.

Results Considerable variation can occur in the form of the results of the audit. At its simplest, an audit could simply produce a list of recommended procedures for the home. In addition, the audit usually provides cost estimates for the individual improvements and projections of the savings which could be expected to result.

It would also be possible for the auditor to provide the homeowner with the names of contractors who could perform the suggested work. In some circumstances, an informal auditor could also describe government subsidy programs to the homeowner who was considering retrofitting and, if it were necessary, offer suggestions for financing the project.

Service that goes beyond the simple list of possible improvements helps an auditor move from the role of provider of information, which a computer could theoretically do almost as well, into the role of motivator. Explanation of payback periods for different home improvements and assistance regarding contractors and financing helps a homeowner to overcome some of the key barriers in the retrofitting decision-making process. Again, however, there has been no systematic research which describes the magnitude of the effects that these forms of assistance have on homeowners' decisions to retrofit.

Payment Plans

This section describes the alternatives for financing home audits and the subsequent retrofitting.

Subsidization of the audit program Most of the existing audit programs in the United States are heavily or completely subsidized. Cost estimates for audit, which typically last 1 1/2-2 hours, are usually in the range of $60 to $100 each. Frequently, the audits are provided at no charge to the homeowner because consumers seem reluctant to invest money to find out if, by spending more money, they could realize energy savings. In a paper presented at a 1979 energy conference, Melissa Bailey reported:

> Polls we have taken in New Jersey indicate an unwillingness by the homeowners to pay for an audit. If $15 were charged, 29 per cent could pay. Of this 29 per cent, only half would pay $35.
>
> On the other hand, there exists a definite possibility that payment for the audit itself will improve the chances of the recommendations being implemented in a retrofit. This possibility has not yet been researched at all. (M.L. Bailey, 1979, p. 5)

Financing the retrofit If an audit program is successful, it will result in a number of retrofit jobs on homes. An optional part of the program could involve financing packages designed to overcome the cost barrier for homeowners who cannot afford major investments. Programs of low-interest guaranteed loans backed by the government or

utility companies would ensure that financial considerations did not prevent homeowners from taking advantage of the savings that retrofitting could provide. Repayment schedules for such loans could be geared to the actual savings resulting from upgrading the homes.

Post-Audit Considerations

Inspection and guarantees of retrofitting If the audit program included a guarantee of work performed by recommended contractors, such a policy would help to overcome the barriers to retrofitting behaviour caused by consumer skepticism in dealing with contractors. Rather than having the government guarantee the retrofitting job directly, it might be feasible to recommend only established contractors who were of sufficient stature that they could provide a meaningful guarantee on their work themselves. With or without the guarantee, it would be feasible for the same agency who performed the audit to provide an inspection after the recommended work was performed.

Evaluation of the program Evaluation is the final issue which needs to be addressed in designing a complete retrofitting program. How should the success or failure of the program be measured? Though there are some appropriate intermediate measures (e.g., number of audits conducted, number of retrofits resulting from the audits) the most suitable indication of success is the energy savings resulting from the program. Even then, decisions should be made about just what constitutes an acceptable level of energy saving for a dollar invested in an audit program. Consistent with Day's (1976) suggestions, these decisions should be made before an audit program is ever begun.

CHAPTER VI

IMPLICATIONS FOR FUTURE RESEARCH

The decision-making process related to retrofitting has provided the basis for much of the discussion in this paper. The rationale for this approach stems from a belief that programs targeted at influencing retrofit action are based on assumptions about the process consumers go through in order to arrive at such a decision. However, there is little research evidence available to suggest that current program efforts are based on a sound understanding of the decision-making process and the factors that influence it.

This apparent gap in the knowledge about the process that homeowners go through when deciding whether to retrofit their homes represents an important avenue for future research. The following issues need to be addressed in this research:

1. What factors motivate homeowners to consider retrofitting their homes?

2. What types of sources of information are needed at different stages in the decision-making process?

3. What are the major problems or barriers that impede homeowners from engaging in retrofit behaviour?

4. Are there segments of homeowners with different needs and energy use patterns that can be identified?

The knowledge gained from these research efforts would contribute to designing and implementing more effective programs aimed at increasing retrofit action.

These new insights would also pave the way for research directed at evaluating the effectiveness of different programs. A better understanding of the factors affecting the decision to retrofit the home would also contribute to the setting of more realistic objectives for the various programs. The criteria specified by these objectives would result in more valid tests of the effectiveness of current and potential programs.

Policy makers would also benefit from evaluation research that pre-tests programs before any major resource commitments are made. Externally valid field experiments can provide valuable insights into whether the merits of a particular program warrant a full-scale introduction. In other words, they would provide the data necessary to do a rigorous cost/benefit analysis. The research would contribute to a more effective and efficient allocation of valuable resources.

In summary, more research effort is warranted. Policy makers stand to gain valuable insights into the factors affecting homeowners' decisions to retrofit their homes. This knowledge should contribute to the development of more effective programs to encourage homeowners to retrofit their homes. Closing the gap between potential and actual energy savings in the home heating sector would move policy makers closer to realizing their objective of energy self-reliance within the next decade.

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