

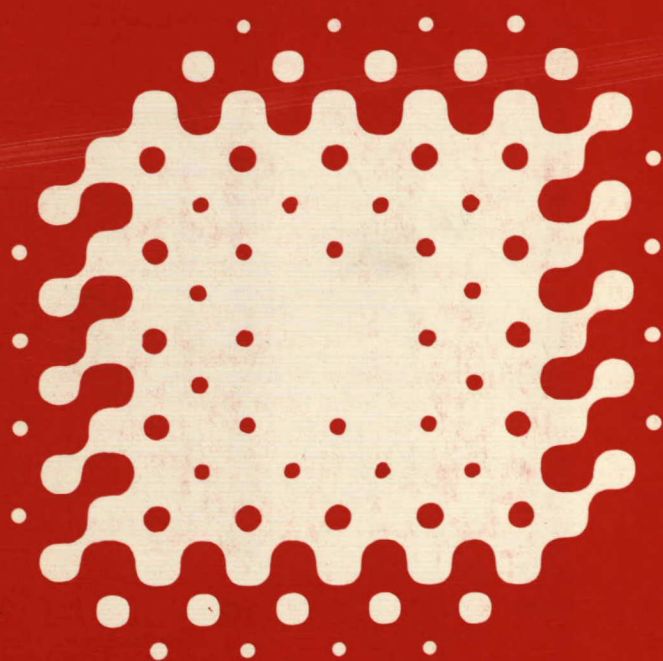
Energy Cost Indicator Demonstration Program:

A Report on Canadian and United States Field Experiments

Pierre Filiatrault
R. Bruce Hutton
Gary A. Mauser



Canadian
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Association



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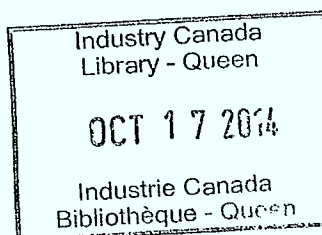
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ENERGY COST INDICATOR DEMONSTRATION PROGRAM:
A REPORT ON CANADIAN AND UNITED STATES FIELD EXPERIMENTS

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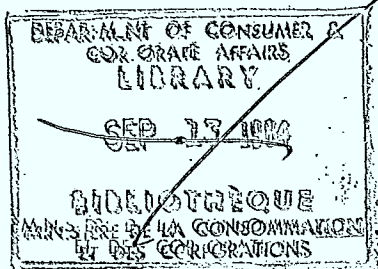
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Policy Research, Analysis and Liaison Directorate
Policy Coordination Bureau
Consumer and Corporate Affairs Canada

The analysis and conclusions of this study do not necessarily reflect the views of the Department.



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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 Bureau. 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 focused on supply issues, and the demand research being conducted was overwhelmingly technological in nature. The Bureau 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 objectives of the Bureau in the energy conservation area are:

1. to develop a basic understanding of consumer attitudes, knowledge and behaviour with respect to energy resource use, and of 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 Pierre Filiatrault, R. Bruce Hutton and Gary A. Mauser presents the results of four joint U.S.-Canada field experiments on the effects of providing immediate feedback on energy consumption or consumer behaviour. It draws from research in the areas of psychology and communications, as well as from a series of studies on energy consumption feedback funded by the U.S. Department of Energy. Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada; the Canadian Electrical Association (Reference no. 920 U 211); the U.S. Department of Energy; and the participating utilities.

It should be understood that the findings, interpretations and recommendations contained in this report are those of the authors and do not necessarily reflect the views of 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.

A handwritten signature in black ink, appearing to read 'T. Russell Robinson', with a long, sweeping underline.

T. Russell Robinson
Assistant Deputy Minister
Bureau of Policy Coordination

SUMMARY

This report presents the results of four field experiments, two in Canada and two in the United States, which examined homeowners' use of an electronic feedback device, the Energy Cost Indicator (ECI), over a one-year period. This is the first large-scale study of the impact of feedback on energy consumption involving both representative samples of homeowners and long-term use of a feedback device. The objectives of the study were to measure changes in: (1) home consumption of natural gas and electricity, (2) individual awareness of, and attitudes toward, energy conservation, and (3) energy conservation activities.

In both of the Canadian test sites (Montreal and Vancouver), ECI households were found to use significantly less energy than households in other conditions. Savings ranged from 3.5% to 5.1% of annual household energy consumption. The Education condition did not differ significantly from the controls in either city. No significant differences were found in either of the field experiments in the United States.

Attitudes toward the ECI were extremely positive, despite widespread mechanical difficulties with the device. Respondents said the ECI helped them conserve energy by increasing their awareness of what uses energy and by motivating them to conserve because they could see the costs mounting up. The conservation activities reported most frequently by ECI respondents were: (1) setting back the temperature on the water heater, (2) setting a lower temperature on the washer, (3) keeping the lights off when one is not in the room, and (4) turning the household thermostat down at night.

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INTRODUCTION

In the fall of 1979, Canada and the United States entered into a cooperative agreement to conduct a series of international field experiments on the effectiveness of feedback as a means of encouraging energy conservation. In these field experiments, a prototype feedback device was used: the Energy Cost Indicator (ECI). This report presents the results of four field experiments, two in Canada and two in the United States, designed to replicate the ECI experiment in residential households.

Field experiments were chosen to ensure that cause and effect would be clearly identifiable within a realistic environment. The experimental design guaranteed that the only differences that would exist across experimental conditions would be those manipulated by the researchers. Replication of the field experiment in a variety of North American cities permitted the results to be generalized with greater confidence than would have been possible from a single study in any one location.

Feedback: Historical Perspective

The basis for the ECI project is the concept of feedback. A number of experiments in psychology and communications have shown that immediate and understandable feedback on the effects of one's actions enables one to better control those actions, just as a dieter is assisted by a scale. It has been shown repeatedly that feedback during an individual's learning of a specific task improves both rate and level of learning. Feedback can also improve motivation to perform the task. The effectiveness of feedback in motivating sustained changes in behaviour (e.g., continuing to adjust thermostat or turn off unnecessary lights) has been shown to depend primarily on the kind, amount and immediacy of the feedback.

The possibility of encouraging energy conservation was a natural outgrowth of the early feedback research results. Subsequent small-scale studies in the energy feedback area reported that consumers were generally unaware of the rate of energy consumption associated with specific appliances or behavioural patterns. The standard utility bill in particular was not perceived as a useful conveyor of this type of energy usage data, did not follow closely enough in time to actual energy usage to function effectively as a feedback mechanism and many times was only an estimate of actual consumption because the meter had not been read recently.

Starting in 1975, the U.S. Department of Energy (DOE) began to fund a series of research projects designed to explore the usefulness of feedback in the context of energy conservation. The most ambitious of these studies were conducted by Princeton University in the community of

Twin Rivers, New Jersey. At the same time, other academic researchers and research institutes began to focus attention in the area. While individual results vary across the many studies, it appears that an average saving of 10% is not unreasonable for households receiving energy feedback.

While encouraging, these early studies did not provide adequate support for the formulation of specific government policy, primarily because the procedures used for providing feedback (typically, student labour) were not conducive to large-scale efforts. Consequently, in 1977 DOE began a research and development process that eventually led to the ECI. The process included focus groups to explore acceptance of potential information formats, laboratory experiments related to human factor issues, a small-scale field test and technical research to determine feasibility.

The Energy Cost Indicator (ECI)

The ECI measures total household usage of electricity and natural gas. Measures of energy cost including "energy cost today," "energy cost next hour," "energy cost yesterday," "energy cost this month to date" may be selected by the resident and viewed on a LED display, always in dollars and cents. The cost figure is based on an average cost per kilowatt hour (electricity) and/or therm¹ (natural gas) for an average home for the particular utility area. It does not directly reflect the actual utility rate structure, due to the complexity of typical rates (e.g., declining or inverted blocks, fuel adjustment). For a more complete explanation of the ECI, see the Appendix.

Report Format

The report is divided into five chapters. The first describes the research design and methodology. Chapters II, III and IV present the results of the four field experiments (Hydro-Québec, B.C. Hydro, Pacific Gas & Electric, Dallas Power & Light). Chapter V discusses a number of important issues and implications that emerge from the study.

1. 1 therm = 1×10^5 BTUs = 100 cu. ft.

Chapter I

RESEARCH DESIGN AND METHODOLOGY

The research design and methodology were developed taking into account the need for a design that: (1) could be used across the four test cities without being altered; (2) would be efficient in terms of cost and ease of implementation; and (3) would facilitate answers to a variety of questions relevant to policymakers, private industry and residential homeowners regarding the impact of the Energy Cost Indicator (ECI).

Research Objectives

Overall objectives were necessarily broad in scope in order that the program might serve as a useful source of information to the above-mentioned parties. Consequently, the primary research objectives included measurement of change on natural gas and electricity consumption; awareness of energy-related factors in the household, particularly high-energy-using devices and behaviours; attitudes toward energy conservation practices and products (including the ECI); purchase intentions and past purchases of energy-saving or energy-efficient products; and energy conservation behaviour not directly related to products. Based on these objectives, the study focused on behavioural measures involving energy consumption and product purchase, and on the educational value of the monitor as reflected in change in attitude and level of awareness.

Research Design

A post-test-only control group design was chosen (see Table 1), and four conditions were operationalized as follows:

- ECI: Subjects received the ECI plus energy conservation materials and an appliance survey.
- Education: Subjects received energy conservation materials and an appliance survey.
- Control: Subjects received an appliance survey.
- Blind control: Subjects were unaware they were participating in the study.

Table 2 presents the participating utilities, the location of each study and the experiment dates. Each field experiment consisted of four steps: the sampling plan, conduct of the study, collection of energy usage data and post-test personal interviews.

Drawing the Sample

The objectives of the sampling procedure were to enable the results to be generalized to the target population -- residential homeowners -- and to provide a basis for determining the effectiveness of information feedback and increased awareness of energy consumption in the home. A "universe" of prescreened household accounts was generated from each service area and screened according to the following criteria: (1) single-unit dwelling, (2) owner occupied, (3) occupied by present residents for at least 12 months, (4) residents plan to remain for at least one more year, (5) good credit rating, (6) three-prong electricity outlet available, (7) household energy consumption falls between pre-specified minimum and maximum.

In Montreal and Dallas, the sample was restricted to all-electric homes, while in Vancouver and Vacaville the sample included homes using both natural gas and electricity.

Following the initial screening, the universe was ordered on annual energy consumption and stratified into quartiles (U_1 - U_4). In the final sampling procedure, successive random samples were drawn from each quartile and randomly assigned to one of the four experimental conditions. This process produced the following representative matrix:

	<u>ECI</u>	<u>Education</u>	<u>Control</u>	<u>Blind control</u>	<u>Total</u>
U_1	25	25	25	25	100
U_2	25	25	25	25	100
U_3	25	25	25	25	100
U_4	25	25	25	25	100
	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
Total	100	100	100	100	400

Random assignment of households to alternative experimental conditions guaranteed the equivalence of conditions prior to the experiment. Theoretically, if all households were treated identically, with the exception of course of the experimental manipulations, the cause of any differences across conditions would be readily identifiable.

Table 1
Experimental Design

	Experimental condition			
	ECI	Education	Control	Blind control ^a
Random assignment	yes	yes	yes	yes
Initial contact	yes	yes	yes	no
Received ECI for 12 months	yes	no	no	no
Energy conservation information	yes	yes	no	no
Interviewed at end of study	yes	yes	yes	no
Energy consumption recorded for 24 months	yes	yes	yes	yes
Number of households	100	100	100	100

^aData for these subjects were analyzed only on an aggregate level. Complete anonymity was preserved.

Table 2
The Four Field Experiments

Locality	Participating utility	Experimental period
Vacaville, California	Pacific Gas & Electric	November 1980 - November 1981
Vancouver, B.C.	B.C. Hydro	May 1981 - May 1982
Dallas, Texas	Dallas Power & Light	July 1981 - July 1982
Montreal, Quebec: Richelieu	Hydro-Québec	December 1981 - December 1982
Laurentides	Hydro-Québec	January 1982 - January 1983

Conduct of the Study

The process for eliciting customer participation was crucial to the success of the overall demonstration. The general outline for the conduct of the study was as follows: (1) DOE/CCAC primer letter to create awareness; (2) initial telephone contact to elicit participation; (3) assignment to condition; (4) utility letter to verify participation; (5) second telephone contact to inform of role and set up appointment; (6) appointment; (7) installation of equipment and/or delivery of educational material (when necessary).

All households in the ECI condition received an information packet designed to help them make the best use of the ECI. The most important piece was the booklet "Power Play." This booklet was developed by DOE and "Canadianized" by CCAC for use in the two Canadian test sites (see Appendix).

All households in the ECI and Education conditions received a packet of conservation educational materials which contained basically the same information across all cities. In the United States, the DOE-designed booklet "Low Cost, No Cost Energy Savers" was used, while in Canada it was decided to use materials developed by Energy, Mines and Resources Canada, "100 Ways to Save Energy" and "Keeping the Heat In," and available in both French and English.

Households in the Control group were contacted by a representative and informed of their role in the experiment, as were households in the ECI and Education groups, but were not, of course, given any energy conservation materials. This condition was necessary to be able to determine if an experimental effect was attributable to use of the ECI, the educational materials or a combination of the two.

Households in the Blind Control group, beyond a disguised screening contact, were not contacted. This condition permitted a further check on how well the experimental results could be generalized.

Energy Use Records

Household energy use was the primary dependent variable in this study. B.C. Hydro and Pacific Gas & Electric (PG&E) monitored both gas and electricity consumption as a part of their regular billing cycle (every month for PG&E and every other month for B.C. Hydro). Hydro-Québec and Dallas Power & Light (DP&L) monitored only household electricity consumption (Hydro-Québec did so monthly and DP&L did so quarterly as well as providing regular meter readings). In all localities, meter readings were collected for the year prior to the experimental period as well as during the experimental year. This provided a statistical control for any initial group differences.

Homeowner Interview

At the conclusion of the experimental period, homeowners in three of the four experimental conditions -- all but the Blind Control group -- were interviewed at home by professional interviewers. Four types of questions were asked: (1) awareness of energy conservation, (2) attitudes toward energy conservation practices and products, (3) decisions made in the preceding year regarding energy conservation, and (4) perception of the ECI as a potential new product.

Chapter II

QUEBEC FIELD EXPERIMENT

Introduction

Hydro-Québec was the fourth utility to launch a field experiment on the effectiveness of the ECI. The original research design was followed closely in Montreal except that, for administrative purposes, the sample was drawn not from the city itself but from two suburban areas (Richelieu and Laurentides). Statistical tests showed that there were no significant differences in behavioural, attitudinal or socio-demographic variables between the two areas, thus validating their equivalence.

A total of 998 households were randomly selected according to the agreed-upon criteria and then grouped into quartiles. Two hundred households were assigned to the Blind Control condition, and 100 were withheld. Of the remaining 798, 370 were contacted by telephone and randomly assigned to one of the three other experimental conditions: ECI, Education and Control. A total of 319 homeowners agreed to participate and 300 were withheld. Exactly 400 households started the experiment: 50 per condition per area, giving a total of 200 households in Richelieu and 200 in Laurentides.

The experiment ran from December 1981 to December 1982 in Richelieu and from January 1982 to January 1983 in Laurentides. Consumption data for a total of 372 households were retained for analysis (87 in ECI, 93 in Education, 96 in Control and 96 in Blind Control). A total of 271 homeowners of the 300 original households in all conditions but Blind Control (92 in ECI, 96 in Education, and 83 in Control) agreed to answer the post-test questionnaire (130 in Laurentides and 141 in Richelieu). Consumption and questionnaire files were merged, and a total of 225 matched cases were retained (including 83 respondents in the ECI condition). A final merger with the ECI usage file left a total of 75 usable cases in the ECI condition.

Analysis

Behaviour. As may be seen in Table 3, household energy consumption shows strong seasonal fluctuations. In the first months of the experiment, households in all conditions increased their consumption over that of the previous year (see Figure 1), but in spring, energy consumption dropped below the previous year's level in every experimental condition. Note that the ECI condition increased less than any other condition at first when the averages increased, and then decreased more than the others later on when the averages decreased. An analysis of variance of the annual change in total energy consumption among experimental conditions proved to be significant at the 0.05 level (Table 4).

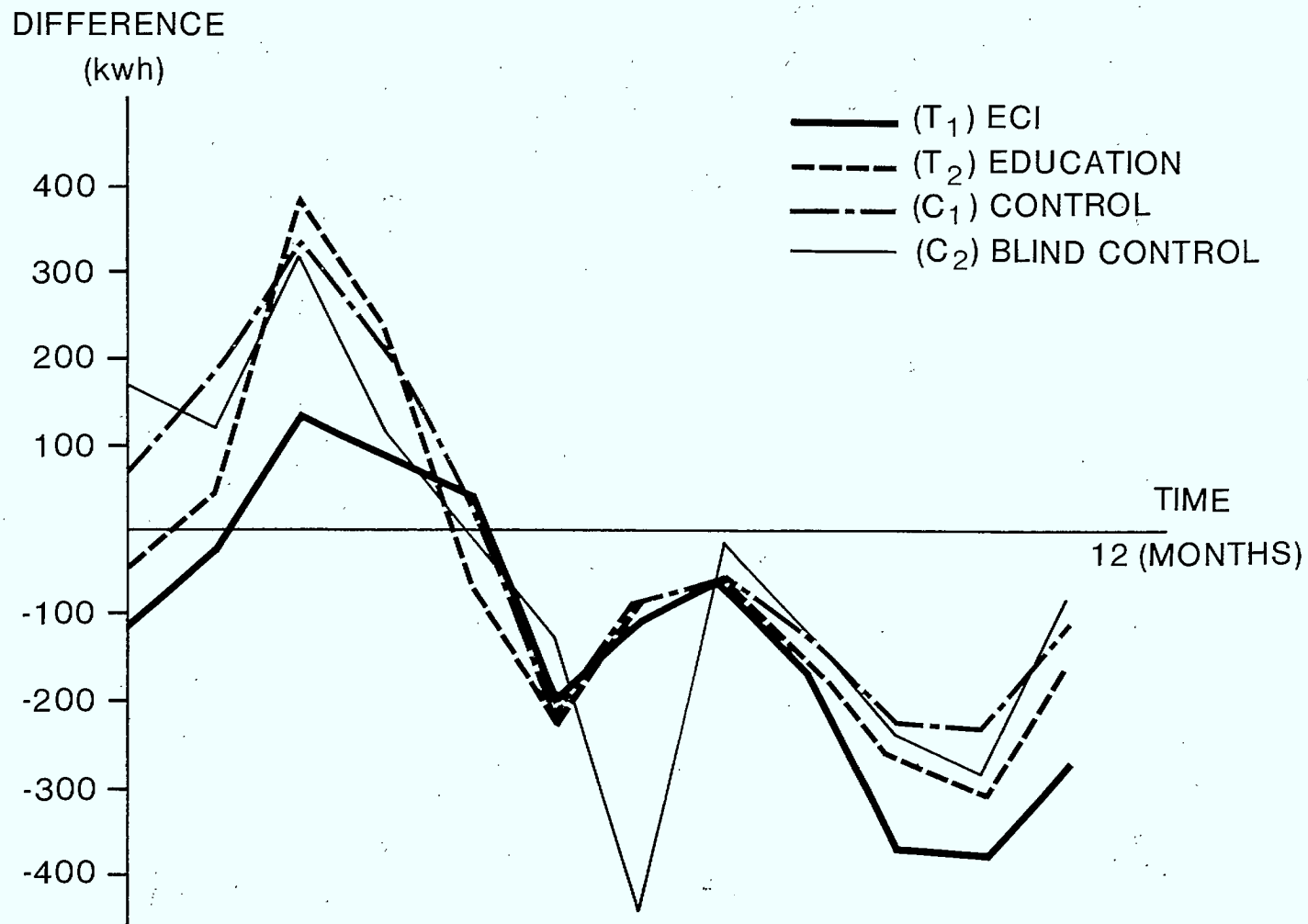
Table 3

Monthly Consumption (KW•h)
Experimental Condition

Month	Mean of four conditions		ECI		Education		Control		Blind control	
	1980	1981	1980	1981	1980	1981	1980	1981	1980	1981
	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982
1	4678	4693	4548	4434	4812	4753	4751	4813	4602	4772
2	4032	4106	3895	3864	4162	4201	4034	4208	4038	4154
3	3174	3463	3142	3280	3233	3604	3216	3554	3104	3417
4	2564	2719	2537	2618	2603	2827	2583	2787	2535	2647
5	1807	1808	1851	1888	1864	1812	1803	1839	1711	1695
6	1427	1226	1467	1256	1445	1213	1428	1201	1368	1235
7	1260	1071	1239	1137	1181	1085	1145	1045	1473	1018
8	1176	1123	1244	1181	1228	1163	1158	1102	1073	1049
9	1371	1216	1386	1213	1404	1240	1371	1227	1323	1183
10	1870	1594	1875	1510	1890	1630	1870	1637	1843	1599
11	2675	2374	2609	2229	2707	2404	2664	2429	2720	2434
12	3464	3306	3331	3057	3544	3387	3537	3408	3442	3372

Figure 1

DIFFERENCE IN MONTHLY CONSUMPTION BETWEEN
EXPERIMENTAL YEAR AND PREVIOUS YEAR



T-tests for annual change in kilowatt hours were significant at the 0.10 level between the ECI and Education conditions, at the 0.05 level between the ECI and Control conditions and at the 0.01 level between the ECI and Blind Control conditions; the tests were not significant between Education and either of the Control conditions, nor between either of the Control conditions themselves.

There was a high frequency of use of the ECI (see Table 5). The average annual usage per function was 470.8 for This Month, 638.4 for Yesterday and 878.5 for Next Hour, with a mean total for all three functions of 1985.7. Thus subjects pressed an ECI function an average of 5.4 times per day. One can see in Figure 2 that, after an almost exponential drop in usage in the first months, usage then levelled off to approximately one touch per day per function, with a resurgence of interest at the onset of winter.

Attitudes. Cost of energy was judged to be a "very serious" or "somewhat serious" issue by 96.7% of respondents (Table 6), emerging as one of the more important social issues, along with inflation and unemployment. The brochures distributed to households in the ECI and Education conditions explaining how to save energy were judged to be "useful" (66.2%) or "somewhat useful" (25.5%) by most respondents (Table 7); no significant differences were found between the two groups. Subjects in the ECI condition judged the indicator as "useful" (59.5%) or "somewhat useful" (22.5%) in conserving energy (Table 8). The Cost Today and Yesterday functions of the ECI were evaluated the most favourably; the This Month and Next Hour functions were judged less favourably (Table 8).

The number of energy conservation activities undertaken during and after the study was reported by subjects and tabulated (Table 9) with regard to three variables: experimental condition, annual consumption percentage change and ECI usage level. The number of activities that respondents intended to do after the study was the same for the three experimental conditions, but the number of activities reported undertaken during the study was substantially higher for the ECI and Education conditions, averaging respectively 4.98 and 5.01 activities, while the Control condition had only 4.25 activities. The number of activities that respondents intended to do after the study was roughly similar for high savers and low savers; but high savers (a 5.03 average versus 4.57) claimed they had undertaken many more activities during the study. Finally, low users of the ECI reported more conservation activities undertaken during the study than did high users; moreover, they intended to do more activities after the study than high users. There were no significant differences in knowledge of energy-saving behaviour (Table 10) among subjects in any of the three conditions.

Table 4

Analysis of Variance: Total Household Energy Consumption
(Absolute Annual Differences)

Condition	N	Mean consumption (kW•h)		Annual change in kW•h
		1980/1981	1981/1982	
ECI	87	29 081	27 554	-1 523
Education	93	30 081	29 321	- 760
Control	96	29 561	29 252	- 309
Blind control	96	28 726	28 582	- 275

F ratio = 2.770

Probability = 0.041

Significance = $T_1-T_2 = 0.10$; $T_1-C_1 = 0.05$; $T_1-C_2 = 0.01$; $T_2-C_1 =$ not significant; $T_2-C_2 =$ not significant; $C_1-C_2 =$ not significant.

Table 5

Frequency of ECI Usage (N = 75)

Frequency	Function			All functions
	This month	Yesterday	Next hour	
0 - 199	16	3	9	1
200 - 399	27	31	18	2
400 - 599	14	17	11	5
600 - 799	11	8	9	10
800 - 999	2	5	8	4
1000 +	5	11	20	53
	—	—	—	—
Number of respondents	75	75	75	75
Mean total usage	470.8	638.4	878.5	1985.7

Figure 2

AVERAGE MONTHLY USAGE OF THE ECI
(FREQUENCY PER FUNCTION)

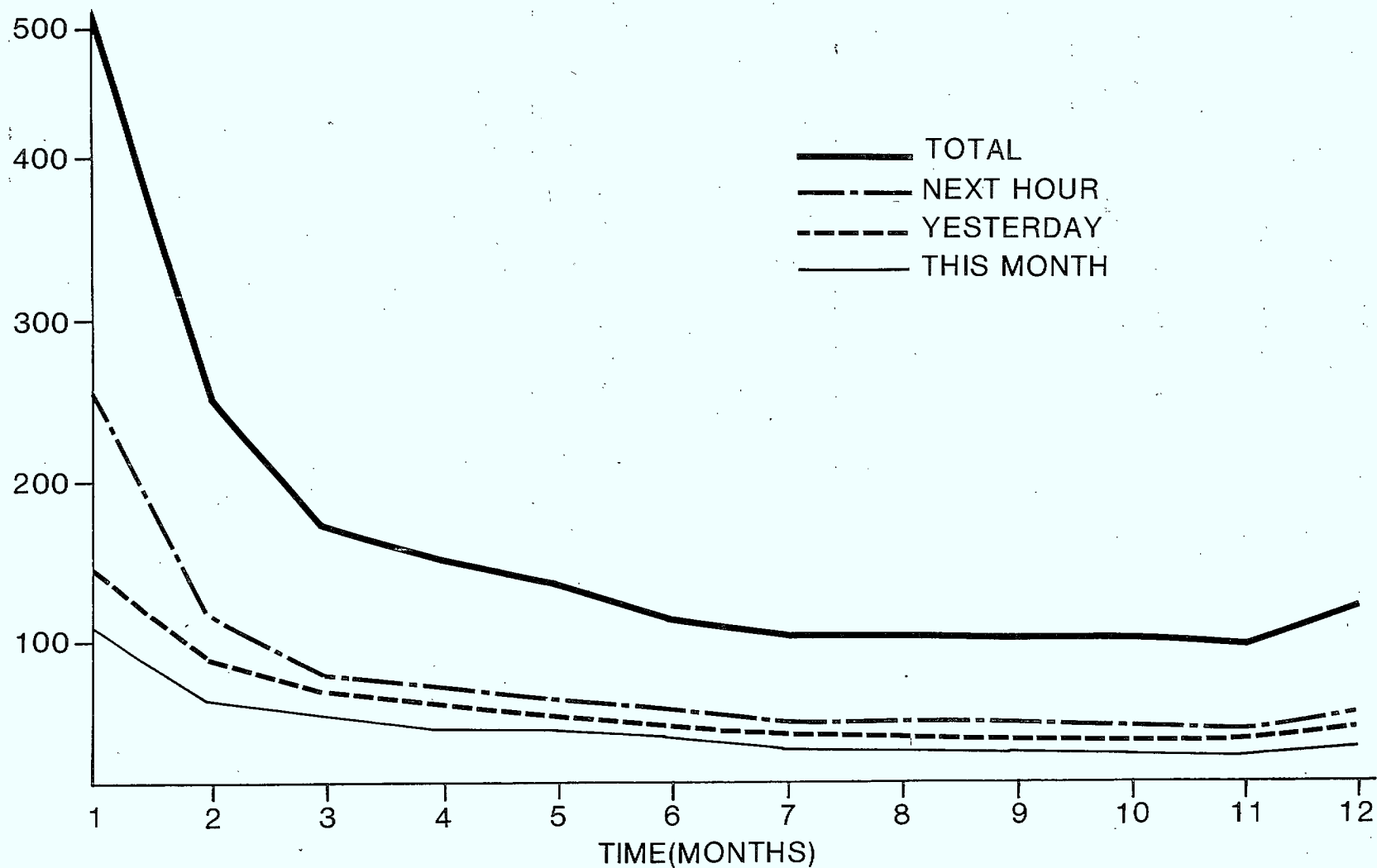


Table 6

Perceived Seriousness of Social Issues (N = 271)^a

Evaluation	Issues					
	Inflation (%)	Bilin- guilism (%)	Cost of energy (%)	Unem- ployment (%)	Pollution (%)	Value of dollar (%)
Very seriously	63.1	11.4	59.8	77.9	24.0	26.9
Somewhat seriously	33.9	39.1	36.9	19.2	36.5	39.9
Not too (not at all) seriously	2.9	49.5	3.3	3.1	39.5	33.2
Total (rounded)	100.0	100.0	100.0	100.0	100.0	100.0

^aQuestion 3: "Now, we would like to ask you about a number of issues. For each issue, please tell me how seriously you feel each one affects us in Canada today." Asked of all respondents.

Table 7

Perceived Usefulness of Education Material

Condition	Usefulness			
	Useful	Somewhat useful	Somewhat useless	Total
ECI	47 64.4%	20 27.4%	6 8.2%	73 46.5%
Education	57 67.9	20 23.8	7 8.3	84 53.5
Total	104	40	13	157
Total (rounded)	66.2%	25.5%	8.3%	100.0%

Chi square = 0.269
 Degrees of freedom = 2
 Significance = 0.874

Table 8

Perceived Usefulness of ECI

Variable	Usefulness				Total (rounded)
	Useful	Somewhat useful	Neither useful nor useless	Somewhat useless or useless	
Cost today	71 79.8%	10 11.2%	2 2.2%	6 6.7%	89 100.0%
Yesterday	60 67.4	20 22.5	4 4.5	5 5.6	89 100.0
This month	51 57.3	17 19.1	11 12.4	10 11.2	89 100.0
Next hour	57 64.8	14 15.9	6 6.8	11 12.5	88 100.0
ECI	53 59.6	20 22.5	8 9.0	8 9.0	89 100.0

Table 9

Reported Energy Conservation Activities

Variable	N	Reported activities done		Average	
		Before	During	To be done after	During and after
Experimental condition:	(255) ^a				
ECI	83	436 (5.25) ^b	233 (2.81)	180 (2.17)	(4.98)
Education	90	444 (4.93)	271 (3.01)	180 (2.00)	(5.01)
Control	82	413 (5.04)	168 (2.05)	180 (2.20)	(4.25)
Actual annual consumption change:	(254)				
High saver	127	650 (5.12)	377 (2.97)	262 (2.06)	(5.03)
Low saver	127	630 (4.96)	307 (2.42)	273 (2.15)	(4.57)
ECI usage level:	(75) ^c				
High user	44	167 (5.39)	92 (2.96)	61 (1.97)	(4.93)
Low user	31	208 (4.73)	138 (3.13)	104 (2.36)	(5.49)

^aAfter merging attitudinal data file to experimental data file.

^bAverage number of activities per subject.

^cAfter merging ECI usage data file to attitudinal data file and to experimental data file.

Table 10

Household Activity That Will Save Most Energy

Condition	Knowledge					Total
	Shutting off lights	Lowering thermostat on water heater	Shorter showers	Lowering thermostat at night	Others	
ECI	5 5.4%	9 9.8%	8 8.7%	65 70.7%	5 5.4%	92 100.0%
Education	5 5.2	7 7.3	8 8.3	70 72.9	6 6.3	96 100.0
Control	2 2.4	12 14.5	4 4.8	61 73.5	4 4.8	83 100.0
Total (rounded)	12 4.4%	28 10.3%	20 7.4%	196 72.3%	15 5.2%	271 100.0%

Chi square = 3.800
 Degrees of freedom = 8
 Significance = 0.8747

Table 11

Purchase Intentions

	Intention			Total
	Buy	Lease	Others	
Number of subjects	21 22.8%	48 52.2%	23 25.0%	92 100.0%

A majority of subjects preferred to lease an indicator rather than purchase one (Table 11), and felt that a government subsidy was desirable if such an instrument were made available on the market (Table 12). The most preferred subsidy was a direct government refund to consumers. The most popular explanation (Table 13) as to how the ECI helped save energy was that it helped "to motivate conservation because of dollar expenses shown on display" (56.5%), followed by it helped "to figure each individual appliance's usage" (46.7%) and "to increase knowledge of what uses energy in the house" (45.7%).

Table 12

Government Subsidy

	Income tax deduction	Government refund or other	Government grant to manufacturer	No subsidy	Total
Number of subjects	19 20.7%	32 34.8%	14 15.2%	27 29.3%	92 100%

Explaining changes in consumption. The conditions were analyzed according to actual annual consumption change (Table 14) and perceived annual consumption change (Table 15). Subjects were divided into two groups: high savers and low savers. As expected from the previous analysis of variance, there are more high savers in the ECI group than in the Control group (Table 14). The difference is significant at the 0.05 level. Energy consumption perception for the year prior to the experimental year is significantly different at the 0.001 level (Table 15). An almost equal number of subjects in the ECI and Education conditions believed that their consumption decreased, although more subjects in the ECI condition were in the high-saver group. Both high and low savers had the correct perception of their consumption change: the difference in perception is statistically significant at the 0.001 level (Table 16). However, there is no significant relation between actual change in annual consumption and ECI usage level (Table 17), even though high users of the indicator (67.7%) conserve more energy than low users (55.8%). Approximately the same proportion of high and low users preferred to lease rather than buy the indicator (Table 18).

Segmentation analysis. The behavioural and attitudinal data were analyzed with regard to various sociodemographic variables (e.g., income, education, occupation, house size, experimental condition, energy conservation level and ECI usage level. No significant differences were found across either sociodemographic groups or experimental conditions.

Table 13

Ways ECI Helped Save Energy (N = 92)

Ways ECI helped ^a	Yes	No
Allowed me to budget consumption over the month	7 7.6%	85 92.4%
Helped me figure each individual appliance's usage	43 46.7	49 53.3
Allowed me to do small experiments to test out different ways of saving	29 31.5	63 68.5
Increased my awareness that my house is always using energy	35 38.0	57 62.0
Increased my knowledge of what uses energy in my house	42 45.7	50 54.3
Increased my children's awareness of energy in the house	7 7.6	85 92.4
Motivated me to conserve because I could see the dollars mounting up on the display	52 56.5	40 43.5
It made me feel good because I could see the results of my efforts to save	22 23.9	70 76.1

^aAsked of ECI households only.

Table 14

Experimental Condition and Actual Consumption Change

Condition	Actual consumption change		
	High saver	Low saver	Total
ECI	51 62.2%	31 37.8%	82 32.3%
Education	41 45.6	49 54.4	90 35.4
Control	35 42.7	47 57.3	82 32.3
Total	127 50.0%	127 50.0%	254 100.0%

Chi square = 7.345
 Degrees of freedom = 2
 Significance = 0.025

Table 15

Experimental Condition and Perceived Consumption Change

Condition	Perceived consumption change			Total
	Increase	Decrease	Same	
ECI	5 6.9%	47 65.3%	20 27.8%	72 31.3%
Education	7 8.1	52 60.5	27 31.4	86 37.4
Control	15 20.8	29 40.3	28 38.9	72 31.3
Total	27 11.7%	128 55.7%	75 32.6%	230 100.0%

Chi square = 13.471
 Degrees of freedom = 4
 Significance = 0.001

Table 16

Actual vs. Perceived Consumption Change

Actual consumption change	Perceived consumption change			
	Increase	Decrease	Same	Total
High saver	10 8.6%	84 72.4%	22 19.0%	116 50.4%
Low saver	17 14.9	44 38.6	53 46.5	114 49.6
Total	27 11.7%	128 55.7%	75 32.6%	230 100.0%

Chi square = 27.113
 Degrees of freedom = 2
 Significance = 0.001

Table 17

ECI Usage and Actual Consumption Change

ECI usage	Actual consumption change		
	High saver	Low saver	Total
High usage	21 67.7%	10 32.3%	31 41.9%
Low usage	24 55.8	19 44.2	43 58.1
Total	45 60.8%	29 39.2%	74 100.0%

Chi square = 0.633
 Degrees of freedom = 1
 Significance = 0.426

Table 18

ECI Usage and Purchase Intentions

ECI usage	Purchase intention		
	Buy	Lease	Total
High usage	10 29.4%	24 70.6%	34 61.8%
Low usage	5 23.8	16 76.2	21 38.2
Total	15 27.3%	40 72.7%	55 100.0%

Chi square = 0.020

Degrees of freedom = 1

Significance = 0.887

Summary and Conclusions

A strong effect was found in the Hydro-Québec field experiment. An analysis of variance of the annual changes in household energy consumption was significant at the 0.05 level. The ECI condition was the only condition to differ significantly from the control conditions. Households in the ECI condition decreased their energy consumption more than did households in any other experimental condition. The Education condition fell between the ECI condition and the Controls: it did not differ significantly from the Control conditions, and differed only slightly from the ECI conditions.

Use of the ECI was high for the first few months and then dropped off rapidly. Over the year, households used the ECI (by pushing its functions) 5.4 times per day. No correlation was found between the extent of a household's use of the ECI and the size of its energy savings.

The ECI was perceived as useful in helping to conserve energy by most subjects. The Cost Today function was judged to be the most useful function. Subjects in the ECI and Education conditions reported a substantially higher number of energy conservation activities during the experimental year than did those in the Control group. Reported activities were also more numerous for households that saved more energy. Respondents said the ECI helped them save energy by motivating them, by displaying energy costs and by increasing their knowledge of what uses energy in the house. Subjects preferred to lease rather than buy the indicator.

Chapter III

B.C. FIELD EXPERIMENT

Introduction

B.C. Hydro was the second utility to launch a field experiment investigating the effectiveness of the ECI following the proposed experimental design. A sample of 400 residential accounts was selected using probabilistic sampling techniques from a single billing cycle in the Greater Vancouver region.¹ Selected households using both natural gas and electricity were then screened according to the agreed-upon criteria.²

The experiment ran from May 1981 to May 1982. At the end of the experimental year, over 90% of the households in each condition had successfully completed the study: 93 households in the ECI condition, 95 in the Education condition, 90 in the Control condition and 91 in the Blind Control condition. In the post-test interview, the completion rates were similar: 93 in the ECI condition, and 92 in both the Education and Control conditions.

It is important to remember that the ECI was a prototype. As such, a certain number of technical difficulties were expected with the device during the study. Sixty-one of the 100 households in the ECI condition requested B.C. Hydro to repair their ECI at least once. A total of 119 trouble calls were made to these households, but only 14 households required 3 or more visits. The bulk of these calls were due to relatively minor problems (e.g., batteries failing during a power outage); and most of them cropped up during the first four months of the study. However, almost half (48%) of the households interviewed reported having problems with their unit. The net effect of these technical difficulties could have attenuated the effectiveness of the ECI.

Analysis

Behaviour. The most important question concerns the effect of the field experiment. Table 19 presents the average household consumption over the two-year period, and Table 20 shows the results of the analyses of variance for total household energy consumption (i.e., combined gas and electricity consumption). As may be readily seen, both analyses of

1. All households in a billing cycle have their meters read on the same day every other month.

2. See Chapter I, p. 4.

variance show a significant F test. This effect is due to the mean of the ECI condition being significantly below those of the other conditions, using the Newman-Keuls procedure at the 0.05 level. This difference increases when problem households are removed from the analysis: from 1171 kW·h to 614 kW·h equivalents. When analyzed separately, there is a significant effect for gas consumption but not for electricity consumption. This is probably due to the relative ease of saving energy in household space heating.

Table 19

Mean Energy Consumption (Gas & Electricity)
(KW·h Equivalents/Household)

	ECI	Education	Control	Blind control
July 1980	4086	3841	3573	3589
September 1980	3153	3142	2690	2752
November 1980	4919	4789	4713	4849
January 1981	8423	8122	8112	8032
March 1981	7593	7415	7302	7384
May 1981	5994	5796	5828	5683
July 1981	3444	3660	3357	3460
September 1981	2792	2994	2615	2524
November 1981	5262	5247	5230	5218
January 1982	9017	8800	8975	8856
March 1982	8538	8580	8574	8537
May 1982	6025	5933	6025	5706

Table 20

Analyses of Variance: Total Household Energy Consumption^a
(Absolute Annual Differences)

Condition	N	Mean value	Standard deviation	F
ECI	86	1171.74	5055.28	2.590 ^b
Education	95	2276.16	3460.91	
Control	88	2570.40	2282.43	
Blind control	90	2196.75	2754.54	
ECI (problem-free) ^c	41	614.50	6756.80	2.877 ^d
Education	95	2276.16	3460.91	
Control	88	2570.40	2282.43	
Blind Control	90	2196.75	2754.54	

^aHousehold gas and electricity consumption combined (reported in kilowatt hour equivalents).

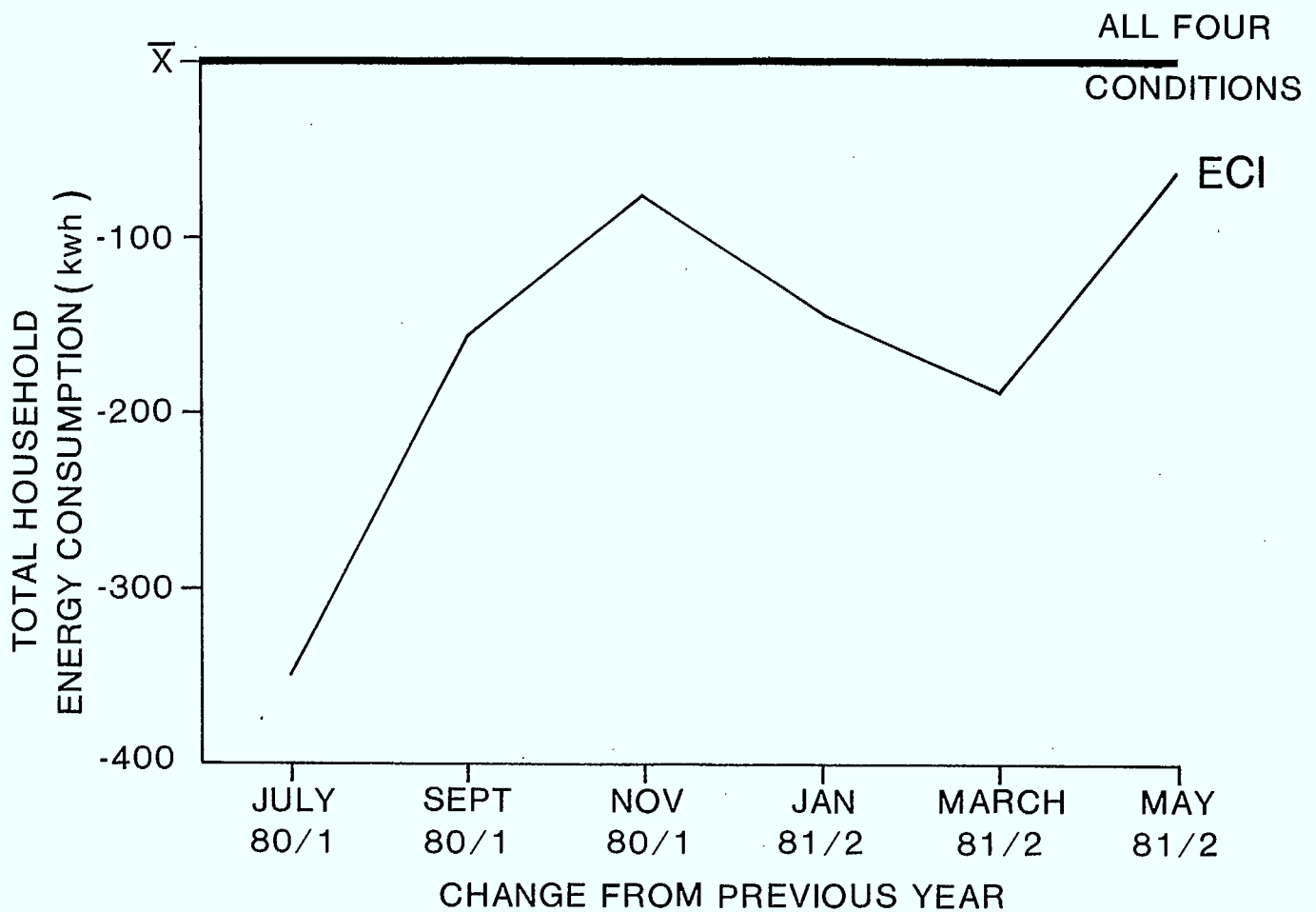
^bDegrees of freedom = 3, 355; probability = 0.053; significant at the 0.10 level.

^cECI (problem-free) condition includes only those households which did not report having problems with ECI in the post-test interview.

^dDegrees of freedom = 3, 310; probability = 0.036; significant at the 0.05 level.

It appears that the ECI's biggest impact was in the first few months after its installation. Figure 3 compares the mean household energy consumption for the ECI condition with the mean of all households in the field experiment. Differences were largest soon after installation and then tapered off. However, the downturn in consumption in March, towards the end of the experiment, suggests that the ECI may continue to influence behaviour long after its installation.

Figure 3
RELATIVE ENERGY SAVINGS IN ECI CONDITION
ACROSS TIME



The frequency of ECI usage across time parallels the pattern of energy savings. Figure 4 shows the monthly frequency of use of each of three energy cost functions: Next Hour, Yesterday and This Month.³ Clearly, interest in the ECI was largest immediately after its installation, followed by an additional surge of interest at the onset of winter. In both cases, household energy use decreased shortly thereafter.

Attitudes. In May 1982, at the end of the experimental year, homeowners in all conditions except Blind Control were interviewed at home by professional interviewers. Interviews took approximately 45 minutes to complete. Topics covered included perceived seriousness of social issues, attitudes toward energy conservation, knowledge of household energy consumption, behaviour patterns and intentions. For the sake of brevity, only the highlights are presented below.

Table 21 compares respondents' perceptions of the seriousness of several issues. As may be seen, the cost of energy is viewed as one of the more serious issues affecting Canadians today. It is rated as "very serious" or "somewhat serious" by 96.4% of respondents, coming just after inflation (97.5%), slightly ahead of unemployment (95.3%) and the value of the dollar (90.6%), and far ahead of pollution (77.6%) and bilingualism (38.0%). This order strongly resembles that found in national surveys of the Canadian public in 1979 and 1980.⁴ When respondents' attitudes are compared across the three experimental conditions, respondents in the ECI and Education conditions tend to judge energy costs as more serious or important than do respondents in the Control condition.

Differences are also found across conditions when respondents are asked which household activity can save the most energy (Table 22). Respondents in the ECI condition are less likely to mention turning off lights and more likely to say "turning down the thermostat on the water heater," than are respondents in the other conditions. More respondents in both the ECI and Education conditions know that "adjusting the thermostat at night before going to bed" will save energy than do respondents in the Control condition. Strikingly, only respondents in the Control condition feel that "taking shorter showers" is an effective step to save energy.

3. Because Cost Today was continuously displayed, no count of its frequency of use was possible.

4. Gordon H.G. McDougall and Gerald Keller, *Energy: Canadians' Attitudes and Reactions (1975-1980)* (Ottawa: Consumer and Corporate Affairs Canada, 1981), p. 17.

Figure 4
FREQUENCY OF USE OF ECI ACROSS TIME
(MEAN FREQUENCY/HOUSEHOLD)

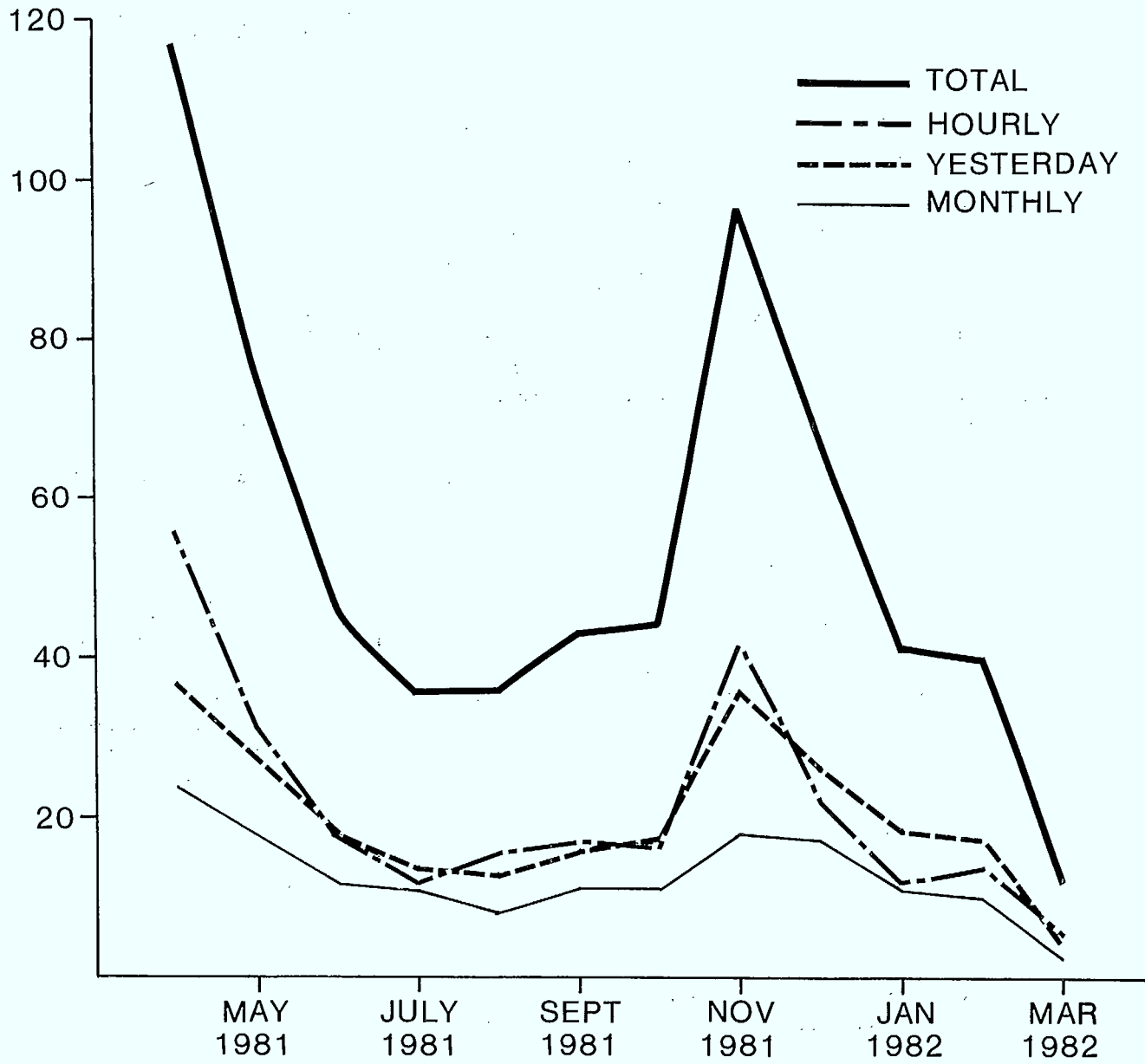


Table 21

Perceived Seriousness of Social Issues^a

	Very seriously (%)	Somewhat seriously (%)	Not too seriously (%)	Not at all seriously (%)	Don't know (%)	Total (rounded)
Inflation (N)	83.7	13.8	0.7	0.7	1.1	100.0 (276)
Bilingualism (N)	13.0	25.0	36.2	24.3	1.4	100.0 (276)
Cost of energy (N)	73.9	22.5	2.9	0.4	0.4	100.0 (276)
Unemployment (N)	84.1	11.2	3.3	0.7	0.7	100.0 (276)
Pollution (N)	32.2	45.4	18.3	2.6	1.5	100.0 (273)
Value of dollar (N)	73.5	17.1	5.1	1.1	3.3	100.0 (275)

^aQuestion 3: "Now, we would like to ask you about a number of issues. For each issue, please tell me how seriously you feel each one affects us in Canada today." Asked of all respondents.

Table 22

Household Activity That Will Save Most Energy^a

Activity	ECI (N = 93)	Education (N = 92)	Control (N = 92)
Keep lights turned off when not in use	8.7%	19.6%	15.2%
Turn down the thermostat on the water heater	18.5	9.8	14.1
Keep the refrigerator door closed as much as possible	1.1	--	1.1
Take shorter showers	5.4	5.4	15.2
Adjust the thermostat at night before going to bed	53.3	55.4	44.6
Adjust the drapes/shades	2.2	--	2.2
Wash more clothes at a time	4.3	3.3	3.3
Cook with fewer burners	--	4.3	1.1
Don't know/no answer	6.5	2.2	3.3
	<u>100.0%</u>	<u>100.0%</u>	<u>100.0%^b</u>

^aQuestion 10: "In general, what do you feel is the one activity that can be done in a home to save the most energy?"

^bIndividual figures may not add up to total because of rounding.

Most respondents (over 80%) in both the ECI and Education conditions rated the educational materials distributed in these conditions as "useful" or "somewhat useful" (Table 23). These materials included "100 Ways to Save Energy" and "Keeping The Heat In," both produced by Energy Mines and Resources Canada, as well as a variety of materials provided by B.C. Hydro. Despite these strong ratings, the Education condition did not have as strong an effect as the ECI condition on homeowners' actual behaviour.

Most respondents in the ECI condition (76.4%) rated the ECI as either "useful" or "somewhat useful" in helping them conserve energy (Table 24). While all functions were seen as useful by most respondents, the most useful were held to be Cost Today and Yesterday.

Despite the perceived usefulness of the ECI, few respondents (37%) were willing to pay for the device they had (Table 25). Respondents thus appear to value the prototype less than the concept of an ECI device. Of those who were willing to purchase, very few would pay over \$100. More people said that, if the option were available, they would rather lease than purchase a device like the ECI.

Consistent with these feelings, Table 26 shows that more respondents are opposed to government subsidization of the ECI than in favour of it. The few who do favour subsidies lean toward a refund or an income tax deduction.

Explaining changes in consumption. The ECI appears to have helped homeowners save energy principally by increasing their awareness of what uses energy around the house and of the fact that their home is always using energy, and by motivating them to conserve because they could see, on the LED display, costs mounting up (Table 27). While very few homeowners reported using the ECI to budget consumption, larger proportions claim to have used it to do small experiments (either testing appliances or patterns of behaviour). Moreover, sizeable percentages reported taking some steps to reduce energy consumption during the experimental year (Table 28). Over 40% of the households in the ECI condition reported doing onetime behaviours (e.g., turning down the temperature on the hot water heater) or repetitive actions (e.g., setting the household thermostat back each night).

The ECI group reported doing the most activities to save energy during the experimental period, with the Education group coming second (see Table 28). This increase may be due to use of the ECI, since there were no differences across experimental conditions in activities reported taken before the experiment started. The energy conservation activities reported most frequently by respondents in the ECI condition were: (1) setting back the temperature on the water heater, (2) setting a lower temperature on the washer, (3) keeping the lights off when not in use, and (4) turning the thermostat down at night. These same activities also emerged from the results of the open-ended questions.

In an effort to understand why some households used less energy than others during the experimental year, two groups were identified in the ECI condition: low savers, those households that increased their consumption more than the average, and high savers, those that decreased consumption (or increased less than the average) from the pre-test year.⁵

5. The distribution of changes from the pre-test year to the experimental year was split at the median change score. Since the average household increased consumption, some households in the lower half actually increased their consumption slightly.

Table 23

Perceived Usefulness of Energy Conservation Educational Materials

Question	ECI (N = 93) ^a	Education (N = 92) ^a
Generally, did you find [the EMR and B.C. Hydro] booklets... ^b		
Useful	38.0%	37.8%
Somewhat useful	43.0	44.6
Neither useful or useless	10.1	10.8
Somewhat useless	3.8	4.1
Useless	3.8	2.7
Don't know	1.3	--
	100.0% (N = 79) ^c	100.0% (N = 74) ^c

^aHouseholds which participated in the study.

^bAsked only of respondents who answered "yes" to question 61, indicating that they remembered the EMR and B.C. Hydro booklets.

^cHouseholds which completed the post-test interview.

Table 24

Perceived Usefulness of ECI and Displays in Helping Conserve Energy^a

	ECI	Cost today (%)	Yesterday (%)	This month (%)	Next hour (%)
Useful	45.2	60.2	55.9	34.4	37.6
Somewhat useful	31.2	26.9	24.7	33.3	20.4
Neither useful nor useless	9.7	5.4	4.3	15.1	10.8
Somewhat useless	4.3	2.2	4.3	5.4	14.0
Useless	7.5	2.2	5.4	8.6	10.8
Don't know/no answer	2.2	3.3	5.4	3.3	6.5
	100.0% ^b	100.0% ^b	100.0% ^b	100.0% ^b	100.0% ^b

^aQuestion 40 asked only of respondents in ECI condition (N = 93).

^bIndividual figures may not add up to total because of rounding.

Table 25

Purchase Intentions for the ECI

Question	Condition		
	ECI (N = 93)	Education (N = 92)	Control (N = 92)
Would you be willing to pay for the energy cost indicator you now have?			
Yes	37.0%	__a	__a
No	63.0		
	100.0%		
How much would you pay? ^b			
\$ 0 - 50	26.5%	__a	__a
51 - 100	28.6	--	--
101 - 150	6.1	--	--
151 - 200	8.2	--	--
201 - 250	0.0	--	--
More than 250	0.0	--	--
Don't know/no answer	30.6	--	--
	100.0%		
If such a device were on the market, do you think people would prefer to purchase it or rent it?			
Purchase	26.1%	26.7%	33.7%
Rent	40.2	36.7	34.8
Neither rent nor purchase	22.2	17.8	20.7
Don't know/no answer	10.9	18.9	10.9
	100.0%	100.0%	100.0% ^c

^aQuestion not asked of respondents in this condition.

^bAsked only of those respondents who were willing to pay for their ECI (N = 49).

^cIndividual figures may not add up to total because of rounding.

Table 26

Government Subsidization of the ECI

Question	Condition		
	ECI (N = 93)	Education (N = 92)	Control (N = 92)
If this device were available in retail stores, do you think that it is important enough for government to subsidize its purchase?			
Yes	44.1%	44.6%	35.9%
No	49.5	46.7	62.0
Don't know/no answer	6.5	8.7	2.2
	<u>100.0%</u>	<u>100.0%</u>	<u>100.0%^a</u>
What kind of subsidy do you feel would be the most appropriate? ^b			
Income tax deduction	21.5%	30.0%	34.3%
Government refund	33.3	42.5	22.9
Government grant to the manufacturer	26.2	10.0	17.1
Other	14.3	5.0	17.1
Don't know	4.8	12.5	8.6
	<u>100.0%^a</u>	<u>100.0%</u>	<u>100.0%</u>
	(N = 42)	(N = 40)	(N = 35)

^aIndividual figures may not add up to total because of rounding.

^bAsked only of respondents who answered "yes" to previous question (44a/58b) that they thought government subsidization was appropriate.

Table 27

Ways the ECI Helped Save Energy

Ways ECI helped ^a	Yes	No
Allowed me to budget consumption over the month	14.3%	85.7%
Helped me figure each individual appliance's usage	34.9	65.1
Allowed me to do small experiments to test out different ways of saving	41.8	58.2
Increased my awareness that my house is always using energy	76.5	23.5
Increased my knowledge of what uses energy in my house	65.1	34.9
Increased my children's awareness of energy in the house	31.6	68.4
Motivated me to conserve because I could see the dollars mounting up on the display	60.2	39.8
It made me feel good because I could see the results of my efforts to save	31.3	68.8

^aAsked of ECI households only.

Table 28

Energy Conservation Activities Reported Done During Study^a

	ECI (N = 93)	Education (N = 92)	Control (N = 92)
Purchase heat pump	--	--	--
Put in attic insulation	10	10	13
Put in wall insulation	6	7	4
Install weatherstripping	9	14	10
Install storm doors/windows	4	8	6
Install solar water heater	--	--	--
Purchase automatic setback thermostat	1	--	3
Buy energy-efficient appliances	6	12	10
Set back temperature on water heater	23	12	15
Insulate hot water tank	4	6	1
Set lower temperature on washer	19	16	14
Insulate ductwork	2	1	--
Reset antisweat switch on fridge	3	4	1
Turn off pilot light (winter)	4	1	--
Turn thermostat down at night	18	7	3
(If central air) turn thermostat up at night	--	--	--
Adjust drapes/shades	12	6	2
Keep lights off when not in use	19	14	6
Take shorter showers	17	6	3
Other	7	3	3
Total activities reported	164	127	94

^aQuestion 13: "I am going to read a list of activities which can help decrease energy usage. For each item I read, please indicate which of the categories on this card best describes what you have done or plan to do about each activity."

While there were very few significant relationships found between the knowledge or attitude variables and the level of conservation, the results were consistent with prior research. Homeowners' perceptions of consumption tended to agree with their actual consumption (Table 29). Households where the cost of energy was viewed as a serious problem, or where the ECI was seen as useful, tended to be high savers.

Table 29

Frequency of ECI Usage and Energy Conservation^a

	Very often	Often	Sometimes	Not very often	No answer	Total (rounded)
High savers (N)	53%	16	21	8	3	100% (38)
Low savers (N)	40%	24	21	13	3	100% (38)

^aUsage frequency was determined by asking respondents in the ECI condition (Question 16): "On an ongoing basis, how often would you say that you or your family used the ECI?" Conservation level was determined by looking at changes in annual household energy consumption from the pre-test year to the year of the experiment.

Frequency of ECI use did not significantly correlate with household energy savings (Pearson $r = 0.07$). However, there was a slight tendency for households that used the ECI more frequently to be high savers, but the relationship was very weak. Finally, with respect to socioeconomic variables, there was a slight (insignificant) tendency for richer households, and those with larger houses, to be low savers.

Socioeconomic variables. The socioeconomic profiles of the three conditions in the experiment were compared to validate their equivalence. This was confirmed. No significant differences were found across the conditions on any of the socioeconomic variables (i.e., house size, family size, occupation, education, or income). Furthermore, in an effort to identify segments of the population that would be particularly susceptible to the ECI, homeowners' responses to the ECI were compared across socioeconomic categories. No striking differences emerged. Thus socioeconomic variables are not important in terms of determining general attitudes toward energy conservation, or more specifically, the response to the ECI.

Conclusions

A small but significant effect was found in the B.C. field experiment. Households in the ECI condition used significantly less energy than did households in the other conditions (1176 kW·h equivalents or 3.5% of annual household energy consumption). No other experimental differences were found. Moreover, these results are somewhat attenuated due to the inclusion in this analysis of households that had technical difficulties with their ECI. When these households are removed from the analysis, the difference between the ECI condition and the others increases dramatically to 1733 kW·h equivalents or 5.1% of annual household energy consumption.

Savings were made exclusively in gas consumption. Apparently this is due to the relative ease of saving energy in household space heating. In the post-test interview, respondents in the ECI condition reported taking more, and more effective, steps to save energy than did respondents in the other conditions.

The ECI appeared to have its largest impact immediately after it was installed. Households in the ECI condition tended to use the ECI most frequently and to take the most steps to reduce energy consumption during the first few months of the experiment. Both use and energy savings taper off after the initial period except for a brief flurry of interest associated with the onset of winter.

In the post-test interview, the cost of energy was judged among the most serious issues affecting Canadians today, along with inflation and unemployment. Respondents in the ECI and Educational conditions tended to judge energy costs as more serious than other respondents. Respondents in the Control condition were less knowledgeable about household energy consumption and about what steps to take in reducing energy costs.

Most respondents in the ECI condition rated both educational materials and the ECI as useful or somewhat useful in helping them save energy. The Cost Today and Yesterday functions were judged as the most useful by most respondents. If the option were available, respondents preferred to lease rather than purchase the device. Very few respondents said that they were willing to pay for the ECI they had; even those who did would not pay over \$100 for the device. Significantly, support for government subsidization was not strong. No striking differences were found with respect to general energy-related attitudes or specific response to the ECI for any of the standard socioeconomic variables.

The ECI appears to have helped homeowners save energy by increasing their awareness of what uses energy around the house and of the fact that their house never stops using energy, and by motivating them to conserve because they could see costs mounting up on the LED display. The energy conservation activities reported most frequently by

respondents in the ECI condition were: (1) setting back the temperature on the water heater, (2) setting a lower temperature on the washer, (3) keeping the lights off when no one is in the room, and (4) turning the thermostat down at night.

Chapter IV

UNITED STATES FIELD EXPERIMENTS

Introduction

In the United States, two field experiments were completed.¹ The experiment in Vacaville, California, conducted by Pacific Gas & Electric (PG&E) was the first of the four Canada-U.S. experiments to become operational (November 1980). The Dallas, Texas, experiment conducted by Dallas Power & Light (DP&L) followed in July 1981.

Analysis

Both experiments provide useful information for policymakers, utilities and private sector parties in terms of the role of feedback in energy conservation. Results are presented separately for each experiment. The analysis focuses on changes in consumption, differences between conditions based on the post-test interview and identification of potential segments based on response to the ECI.

Results of the PG&E experiment. The PG&E experiment included both natural gas and electricity consumption data. Both regular monthly meter readings and special same-day monthly readings were provided for analysis. Tables 30, 31 and 32 summarize the consumption analysis.

In each table two separate analyses are reported.² The first analysis deals with the total sample of homes. The second removes those subjects who reported having trouble with the ECI or were determined to be outliers in terms of consumption (i.e., outliers were defined as those households with radically different energy consumption patterns).

1. Originally three studies had been planned. The third was to take place in the Tennessee Valley Authority (TVA) service area. Because of the uniqueness of the TVA supply area, however, the timing and experimental constraints were not met. A subsequent separate report will be issued on the TVA experience if the obligations are met.

2. It should be noted that the original sample of 100 per condition was reduced in the initial analysis due to deviations from the original sampling plan. Two-wire and three-wire designed homes were not equally distributed among conditions. Consequently, all two-wire homes were removed from the sample, which significantly reduced the sample size for the Education and Control conditions. Since the Blind Control group could not be contacted, it contains both and, therefore, is somewhat different from the three other conditions.

Table 30

Analyses of Variance: Total Household Energy Consumption
(Absolute Annual BTU Differences)

Condition	N	Mean value ^a	Standard deviation	F
ECI	95	-150.96	172.89	1.803 ^b
Education	76	-140.25	142.23	
Control	65	-178.19	170.68	
Blind control	98	-119.75	153.90	
ECI (problem-free) ^c	60	-143.82	168.79	1.786 ^d
Education	76	-140.25	142.23	
Control	65	-178.19	170.68	
Blind control	98	-119.75	153.90	

^aMean values represent absolute differences in consumption between pre- and post-tests.

^bDegrees of freedom = 3, 330; p = 0.15, insignificant.

^cECI (problem-free) condition includes only those households which did not report having problems with their ECI in the post-test interview.

^dDegrees of freedom = 3, 295; p = 0.15, insignificant.

Table 31

Annual Gas Consumption (Therms). -- Absolute Change

Condition	N	Mean value ^a	Standard deviation	F
ECI	95	-155.88	153.62	1.508 ^b
Education	76	-149.61	125.19	
Control	65	-180.43	156.28	
Blind control	98	-132.98	128.17	
ECI ^c	60	-144.84	144.21	1.595 ^d
Education	76	-149.61	125.19	
Control	65	-180.43	156.28	
Blind control	98	-132.98	128.17	

^aMean values represent absolute change.

^bDegrees of freedom = 3, 330; $p = 0.21$, insignificant.

^cSample reduced by subjects reporting problems with ECI.

^dDegrees of freedom = 3, 295; $p = 0.19$, insignificant.

Table 32

Annual Electricity Consumption (kW•h) -- Absolute Change

Condition	N	Mean value ^a	Standard deviation	F
ECI	95	144.17	1433.14	0.773 ^b
Education	76	274.38	1089.46	
Control	66	115.71	1201.73	
Blind control	99	388.88	1505.82	
ECI ^c	60	31.08	1416.54	1.113 ^d
Education	76	274.38	1089.46	
Control	66	115.71	1201.73	
Blind control	99	388.88	1505.82	

^aMean values show increasing energy consumption.

^bDegrees of freedom = 3, 332; $p = 0.51$, insignificant.

^cSample reduced by subjects reporting problems with ECI.

^dDegrees of freedom = 3, 297; $p = 0.34$, insignificant.

None of the three tables shows significant differences in consumption. Total BTU consumption did decrease over the test period, but all three groups show about the same percentage reduction (Table 30). Gas consumption decreased even more, but again the percentage reduction was about equal across the three groups (Table 31). The ECI group shows a slight directional advantage. Electricity consumption actually increased slightly for all three conditions during the test (Table 32).

While the presence of the ECI did not produce significant changes in consumption, it is possible that it had an effect on other variables of consumer response, such as awareness, knowledge, attitudes, intentions or behaviour in general. An analysis of the post-test questionnaire provides insight into these potential effects.

Table 33 lists the responses to the first question asked of all subjects, "What do you feel is the best solution to today's energy problems?" As can be seen, there are clear differences. Conservation is the second most mentioned alternative (25.8%) in the ECI condition, closely following promoting the use of solar (28.9%). Promoting the use of solar is also the leader in both the Education and Control conditions (Education = 26.0%, Control = 32.8%), but conservation ties for third in the Education condition (14.3%) and is fourth in the Control condition (13.4%).

A series of other questions related to awareness and knowledge show clear differences among the conditions (Table 34). More people in the ECI condition believed their gas and electricity consumption actually decreased during the study. In fact, while gas consumption did decrease, electricity consumption actually rose slightly.

Additionally, the ECI group was more knowledgeable about energy use in the home. More people in the ECI condition knew that turning down the thermostat at night saves the most energy (ECI = 57.0%, Education = 41.9%, Control = 35.6%), and that by setting back the thermostat by ten degrees during the winter they could save between 11.0% and 20.0%. In addition, they were more likely to realize the importance of hot water in energy use. Finally, in a set of questions not reported in Table 34, both the ECI and Education conditions were more likely to realize that the highest summer energy user was space cooling (ECI = 60.8%, Education = 70.1%, Control = 50.7%) and that the highest winter energy user was space heating (ECI = 63.9%, Education = 66.2%, Control = 52.2%). The highest response rate for the Control condition for these questions was the "don't know" category.

Attitudes toward the ECI and its components were extremely positive. Overall, 77.3% of subjects in the ECI condition had a favourable attitude toward the ECI. This percentage is even more remarkable given the number of problems encountered with the device. Additionally, high favourable responses were recorded for each of the functions, with a slight preference being shown for Cost Today (81.4%). The Cost Today function was also felt to be the most useful (45.4%), followed by the Next Hour function (32.0%).

Over 80% of subjects in the ECI condition reported that the ECI was useful in helping them conserve energy. Under different circumstances, subjects in the Education and Control conditions were also asked how useful the ECI would be after having it explained to them. A majority in both conditions felt it would be useful.

When asked how the ECI helped them save, the three reasons mentioned most often by the ECI condition were: "it increased my awareness that my house is always using energy" (48.5%), "motivated me to conserve because I could see the dollars mounting up on the display" (40.2%), and "increased my knowledge of what uses energy in my house" (36.1%).

Table 35 shows the percentage of energy-saving activities that subjects intend to do, and report having done during the study. While there are no strong differences, it appears the ECI condition plans to do more activities; no real differences occur, however, on the behaviour side.

The final set of questions directed at the ECI condition involved purchase intentions for the device (Table 36). Subjects were asked if they would be willing to pay to keep their ECI. Almost 70% said they would pay. Of those subjects who said they would pay, 35% would have been willing to pay \$100 or less. Over 20% were willing to pay between \$101 and \$250. Almost 40% did not answer. In the Education condition 29.9% said they would not buy it; 34.3% said they would not in the Control condition. In both conditions virtually no one was willing to pay more than \$100 for one.

Two important facts emerge from the analysis above. The first is that the ECI did not produce any significant differences in consumption between conditions. The second is that a great majority have a favourable attitude toward the ECI. Consequently, it may be possible to identify segments within the ECI condition that will be more responsive to the concept. In order to explore this possibility, the ECI condition was divided into two groups -- those above the median and those below the median in percentage change in consumption. Table 37 summarizes the results.

Table 37 presents only the most enlightening questions. In the awareness and knowledge area, the high-saver group is more aware that gas consumption decreased and perceives that electricity consumption decreased. High savers are clearly more likely to know more about the extent of savings that result from adjusting the thermostat at night.

Two significant differences occur for gas savers in reporting how the ECI helped them save. High savers were more likely to say it helped them budget ($p \leq 0.1$) than low savers were. Low savers felt it increased their awareness ($p < 0.05$). Not surprisingly, high savers (for gas) were significantly more likely to pay for the ECI ($p < 0.1$).

Table 33

Solutions to the Energy Problem

Question	Condition		
	ECI (N = 97)	Education (N = 77)	Control (N = 67)
Best alternative to the energy problem:			
Promote nuclear power	16.5%	15.6%	19.4%
Increase U.S. oil and gas production	6.2	14.3	4.5
Conservation	25.8	14.3	13.4
Promote use of solar	28.9	26.0	32.8
Develop synthetic fuels	3.1	9.1	4.5
Give business a free hand	3.1	9.1	1.5
Increase government funding	3.1	1.3	1.5
No answer	13.4	10.4	22.4
	100.0% ^a	100.0% ^a	100.0%
Second best alternative to the energy problem:			
Promote nuclear power	10.3	10.4	9.0
Increase U.S. oil and gas production	12.4	18.2	20.9
Conservation	15.5	13.0	11.9
Promote use of solar	21.6	24.7	14.9
Develop synthetic fuels	16.5	13.0	14.9
Give business a free hand	6.2	3.9	3.0
Increase government funding	2.1	6.5	3.0
No answer	15.5	10.4	22.4
	100.0% ^a	100.0% ^a	100.0%

^aIndividual figures may not add up to total because of rounding.

Table 34

Differences Among Conditions: Awareness/Knowledge

Question	Condition		
	ECI (%)	Education (%)	Control (%)
Compared to the year before this study, has your average monthly gas <i>consumption</i> increased, decreased or stayed the same? ^a			
Increased	4.8	13.2	11.5
Decreased	75.9	61.8	65.4
Same	19.3	25.0	23.1
	100.0	100.0	100.0
Compared to the year before this study, has your average monthly electricity <i>consumption</i> increased, decreased or stayed the same? ^b			
Increased	14.5	18.2	33.3
Decreased	63.9	53.0	33.3
Same	21.7	28.8	33.3
	100.0 ^c	100.0	100.0 ^c
In general, what is the one thing in a home that can be done to save the most energy? ^a			
Keep lights off	16.5	25.8	28.9
Turn down water heater thermostat	8.9	9.7	13.3
Keep refrigerator door closed	0.0	3.2	2.2
Take shorter showers	6.3	6.5	8.9
Adjust night thermostat	57.0	41.9	35.6
Adjust shades and drapes	3.8	4.8	2.2
Wash more clothes at a time	1.3	1.6	6.7
Cook with fewer burners	6.3	6.5	2.2
	100.0 ^c	100.0	100.0

Table 34 (cont.)

Question	Condition		
	ECI (%)	Education (%)	Control (%)
Besides space heating, the one area in most homes that leads the list in terms of energy use is... ^a			
Lights	12.0	21.9	--
Hot water	32.0	21.0	--
Clothes washer	8.0	9.4	--
Dishwasher	16.0	3.1	--
Refrigerator/freezer	32.0	43.8	--
	100.0	100.0 ^c	
If you set back your thermostat in the winter by 10 degrees, what percent consumption savings would you expect? ^a			
0-10%	25.0	29.4	--
10-20%	46.9	29.4	--
21-30%	15.6	26.5	--
31-40%	3.1	5.9	--
41-50%	9.4	8.8	--
	100.0	100.0	

^aAt least one of the cells did not meet the criteria for minimum cell size; therefore, chi square analysis was inappropriate.

^bChi square = 13.06 with 4 degrees of freedom; probability ≤ 0.01 .

^cIndividual figures may not add up to total because of rounding.

Table 35

Differences Among Conditions: Intentions/Behaviour

Question ^a	Condition		
	ECI (%)	Education (%)	Control (%)
Number of energy saving activities subjects plan to do: ^b			
Zero	5.1	8.2	15.9
One	32.1	36.1	29.5
Two	25.6	24.6	25.0
Three	11.5	19.7	18.2
Four	11.5	8.2	9.1
Five	11.5	1.6	0.0
Six	2.6	1.6	2.3
	100.0 ^c	100.0	100.0
Number of energy saving activities done during the study: ^b			
Zero	17.9	14.8	11.4
One	16.7	13.1	20.5
Two	10.3	16.4	9.1
Three	12.8	16.4	13.6
Four	16.7	13.1	25.0
Five	9.0	8.2	13.6
Six	9.0	8.2	4.5
Seven	3.8	4.9	2.3
Eight	1.3	3.3	0.0
Nine	1.3	0.0	0.0
Ten	1.3	1.6	0.0
	100.0 ^c	100.0	100.0

^aNumbers represent average over a multiple-item question.

^bAt least one cell did not meet the minimum criteria for size; therefore, chi square analysis was inappropriate.

^cIndividual figures may not add up to total because of rounding.

Table 36

Purchase Intentions for the ECI

Question	Condition		
	ECI (N = 97)	Education (N = 77)	Control (N = 67)
Would you be willing to pay for the cost indicator you now have?			
Yes	68.7%	--	--
No	31.3	--	--
	100.0%		
How much would you pay?			
\$ 0 to \$ 50	20.6%	36.4%	26.9%
\$ 51 to \$100	14.4	11.7	9.0
\$101 to \$150	13.4	1.3	1.5
\$151 to \$200	5.2	--	3.0
\$201 to \$250	2.1	--	1.5
More than \$250	5.2	--	--
No answer	39.2	20.8	23.9
Wouldn't buy	--	29.9	34.3
	100.0% ^a	100.0% ^a	100.0% ^a

^aIndividual figures may not add up to total because of rounding.

Table 37
ECI User Profiles

Question	Consumption % Change			
	High saver		Low saver	
	Gas	Elec.	Gas	Elec.
I. Awareness/knowledge				
Compared to the year before this study, has your average monthly gas <i>consumption</i> increased, decreased or stayed the same? ^a				
Increased	0.0	0.0	9.8	9.1
Decreased	85.7	84.6	65.9	68.2
Same	14.3	15.4	24.4	22.7
	100.0	100.0	100.0 ^b	100.0
Compared to the year before this study, has your average monthly electricity <i>consumption</i> increased, decreased or stayed the same? ^c				
Increased	14.6	10.5	14.3	17.8
Decreased	68.3	78.9	59.5	51.1
Same	17.1	10.5	26.2	31.1
	100.0	100.0 ^b	100.0	100.0
If you set back your thermostat during the winter by 10 degrees, what percent consumption savings would you expect? ^a				
0-10%	15.8	13.3	38.5	35.3
11-20%	57.9	60.0	30.8	35.3
21-30%	10.5	20.0	23.1	11.8
31-40%	5.3	6.7	0.0	0.0
41-50%	10.5	0.0	7.7	17.6
	100.0	100.0	100.0 ^b	100.0
II. Attitudes/preferences				
In what ways did the ECI help you save?				
Budget consumption over month ^d	21.1	14.7	7.7	14.0
Figure individual appliance usage	44.7	44.1	35.9	37.2
Do small experiments	28.9	38.2	35.9	27.9
Increased awareness ^e	47.4	61.8	76.3	61.9
Increased knowledge of what uses energy	50.0	55.9	41.0	37.2
Increased children's awareness	18.4	23.5	17.9	14.0
Motivated me to conserve	55.3	52.9	46.2	48.8
Made me feel good to see results	15.8	17.6	7.7	7.0

III. Intentions

Would you be willing to pay for the ECI you now have?^f

Yes	78.6	76.9	58.5	61.4
No	21.4	23.1	41.5	38.6
	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>

IV. Demographics

House size^a

Less than 1,000 sq. ft.	0.0	2.6	4.8	2.2
1,000 - 1,499 sq. ft.	11.9	15.4	21.4	17.8
1,500 - 1,999 sq. ft.	57.1	56.4	54.8	55.6
2,000 - 2,499 sq. ft.	21.4	15.4	14.3	20.0
2,500 - 2,999 sq. ft.	7.1	7.7	2.9	2.2
3,000 - 3,499 sq. ft.	2.4	2.6	2.4	2.2
3,500 - over	0.0	0.0	0.0	0.0
	<u>100.0^b</u>	<u>100.0^b</u>	<u>100.0^b</u>	<u>100.0</u>

Male education^a

Grammar school	0.0	0.0	0.0	0.0
Some high school	0.0	0.0	0.0	0.0
Completed high school	4.5	23.8	22.2	21.1
Some college	22.7	33.3	33.3	21.1
Completed college	54.5	33.3	27.8	52.6
Graduate school	18.2	9.5	16.7	26.3
	<u>100.0^b</u>	<u>100.0^b</u>	<u>100.0</u>	<u>100.0</u>

^aAt least one of the cells did not meet the criteria for minimum cell size; therefore, chi square analysis was inappropriate.

^bIndividual figures may not add up to total because of rounding.

^cChi square = 7.27 with 2 degrees of freedom for electricity; probability ≤ 0.05 .

^dChi square = 2.81 with 1 degree of freedom for gas; probability ≤ 0.10 . Electricity did not meet minimum criteria for cell size.

^eChi square = 5.58 with 1 degree of freedom for gas; probability ≤ 0.05 .

^fChi square = 3.00 with 1 degree of freedom for gas; probability ≤ 0.08 .

Finally, while a number of demographic variables were tested, only two showed any differences. High gas savers have slightly larger homes, and they are more educated.

Results of the DP&L experiment. DP&L is an all-electric utility. It was the second U.S. utility to conduct the experiment and the third overall. Table 38 presents the results of the consumption analysis. It should be noted that the small sample sizes are due to the difficulties DP&L had in procuring the ECIs and in recruiting subjects.

Table 38

Total Consumption (kW•h) -- Absolute Change

Condition	N	Mean value ^a	Standard deviation	F
ECI	34	-1449.44	4470.32	0.966 ^b
Education	36	- 326.50	2856.78	
Control	34	- 256.38	2446.60	
Blind control	34	- 259.82	3783.76	

^aMean values represent absolute change.

^bDegrees of freedom = 3, 134; probability \leq 0.41.

Once again, no significant differences occur among conditions. That the ECI condition shows a larger average saving than either of the other two conditions is not statistically significant, due to the high variance and small sample size.

Even though consumption differences did not reach statistical significance, it might be expected that differences would occur for other levels of consumer response. An analysis of the post-test questionnaire, previously reported, provides some insightful information.

Table 39 indicates that a greater percentage of subjects in the ECI condition knew their consumption had actually decreased during the test period (ECI = 34.3%, Education = 13.9%, Control = 11.1%). All three conditions were equally knowledgeable regarding the behaviour that could save the most energy. Over 40% in each condition said nighttime

adjustment of the thermostat would save the most. The ECI group was slightly more knowledgeable about the importance of turning down the water heater thermostat. There were no significant differences between the ECI and Education conditions in response to questions about the second highest energy user and potential savings from thermostat setback, although percentages were in the right direction.

Attitudes toward the ECI and its components were extremely positive. The most useful information was perceived to be the Cost Today data (74.3%), which was the option that was continuously shown. The educational booklet was viewed as useful by 54.3% of the ECI subjects. Overall, 91.5% of these subjects had a favourable attitude toward the ECI. Over 80% also had a favourable attitude toward each of the functions. Not surprisingly 88.6% of the subjects felt the ECI was useful in helping to conserve energy. The highest percentage (31.4%) cited its motivational properties as being the reason. Again, these are surprisingly high numbers given that 65.7% reported having some problem with their ECI during the study.

Table 40 shows the purchase intentions of the ECI group. Clearly their interest in purchasing was less than that of the ECI subjects in the PG&E experiment (cf. Table 36). Also, all three groups appear unwilling to pay over \$50 for such a device.

The ECI user profile was not analyzed because of the small sample size. It might, however, be expected that the same general profile would emerge from this group as well, given the similarity of results in the previous analyses.

Conclusions

Two facts clearly emerge from the analyses presented above. First, the ECI did not produce significant differences in consumption among conditions. Second, even though the presence of the ECI did not result in behaviour differences, attitudes toward the ECI were extremely positive, despite widespread mechanical difficulties with the device.

Supporting the positive attitudes toward the ECI are several results that indicate differences across other early levels of consumer response. Subjects in the ECI condition appear to be somewhat more aware of home energy use and knowledgeable about those factors that save. A high percentage of them expressed a willingness to purchase such a device, although the amount they were willing to pay varied.

Finally, there is some indication that the ECI is more attractive to certain types of subjects. Those with higher education and larger homes appear to have benefitted the most from having an ECI.

Table 39

Home Energy Use

Question	Condition		
	ECI (%)	Education (%)	Control (%)
Compared to the year before this study, has your average monthly electricity <i>consumption</i> increased, decreased or stayed the same?			
Increased	28.6	41.7	52.8
Decreased	34.3	13.9	11.1
Same	20.0	8.3	5.6
No answer	17.1	36.1	30.5
	100.0	100.0	100.0

In general, what is the one thing in a
home that can be done to save the most
energy?

Keep lights off	28.6	38.9	38.9
Turn down water heater thermosts	14.3	5.6	11.1
Keep refrigerator door closed	0.0	5.6	2.8
Take shorter showers	2.9	2.8	0.0
Adjust night thermostat	42.9	41.7	44.4
Adjust shades and drapes	2.9	2.8	2.8
Wash more clothes at a time	0.0	2.8	0.0
Cook with fewer burners	5.7	0.0	0.0
	100.0 ^a	100.0 ^a	100.0

Table 39 (cont.)

Question	Condition		
	ECI (%)	Education (%)	Control (%)
Besides space heating, the one area in most houses that leads the list in terms of energy use is...			
Lights	25.7	36.1	--
Hot water	25.7	22.2	--
Clothes washer	5.7	5.6	--
Dishwasher	2.9	2.8	--
Refrigerator/freezer	11.4	8.3	--
No answer	28.6	25.0	--
	100.0	100.0	
If you set back your thermostat in the winter by 10 degrees, what percent consumption savings would you expect?			
0-10%	40.0	33.3	--
11-20%	22.9	16.7	--
21-30%	2.9	8.3	--
31-40%	0.0	0.0	--
41-50%	2.9	2.8	--
No answer	31.3	38.9	--
	100.0	100.0	

^aIndividual figures may not add up to total because of rounding.

Table 40

Purchase Intentions for the ECI

Question	Condition		
	ECI (N = 35)	Education (N = 36)	Control (N = 36)
Would you be willing to pay for the cost indicator you now have?			
Yes	45.7%	--	--
No	42.9	--	--
No answer	11.4	--	--
	<u>100.0%</u>		
How much would you pay?			
\$ 0 to \$ 50	40.0%	75.0%	69.4%
51 to 100	2.9	11.1	5.6
101 to 150	8.6	--	5.6
151 to 200	2.9	--	8.3
201 to 250	--	--	--
More than 250	2.9	--	--
No answer	42.9	--	2.8
Wouldn't buy	--	13.9	8.3
	<u>100.0%^a</u>	<u>100.0%</u>	<u>100.0%</u>

^aIndividual figures may not add up to total because of rounding.

Chapter V

ISSUES AND IMPLICATIONS

Experimental Issues and Implications

Although experimental designs have not been as popular in energy research as have other methodologies (e.g., surveys, econometric studies), there are significant advantages to the experimental design that other methodologies simply do not have. For one, the field experiment is the best design for determining cause and effect while at the same time providing a realistic environment. This balance of being able to attribute cause and effect and maintain a more "real world" setting than common laboratory experiments was particularly important in the case of the ECI study. This is because one of the primary beneficiaries of the information from this study is the private sector, whose need is primarily for insight into the acceptance and effect of such devices in an environment as close to the real world as possible.

Within this general experimental framework, a number of other characteristics made the ECI study a unique energy research undertaking and provided important insight into product effects. First, the study called for cooperation among various sectors, the broadest level being that between Canada and the United States. Cooperation was also needed among utilities, utility associations, manufacturers and universities in each country over an extended period of time. The continued cooperation and support at each level was a positive outcome of the study.

Second, the study incorporated hardware as an integral component of the design. A number of lessons were learned in this area in terms of how to manage the hardware component in the context of such a study.

Third, the test took place over a one-year period in order to account for seasonal and certain experimental effects. Additionally, it allowed for adequate measurement of multiple dependent variables including cognitive, affective and behavioural measures.

Finally, one of the most important factors in the study was the use of a replicated design. While each city was studied using a common methodology, it is of course impossible simply to aggregate the results. Due to the differences in starting dates, local weather conditions, etc., each city must be viewed as a replication. To the extent that the same conclusions emerge in each city, the results increase in power and reflect the real world better than any single study could.

The inclusion of the characteristics described above necessarily produces problems as well as benefits. Among the problems encountered in this study were a difficulty in controlling the operationalization of the design (e.g., drawing the sample, installing meters); problems of reliability with the prototype ECI and timing in getting access to it; natural complexities involved in coordinating with the large number of people involved at the different levels of the study (e.g., changes in personnel, and differing agendas and philosophies); and the difficulty inherent in interpreting results in replicated studies.

The consequences of engaging in complex cooperative studies provide several important implications from a policy perspective. First, consideration should be given to more extensive use of field experimental studies that incorporate replicated designs. Even though results may be harder to interpret in the traditional sense, they are more likely to provide results that come closer to reflecting real world effects. However, there are a few provisos to be observed. One key need is to establish an adequate communication system among participating parties. This might include the setting up of formal reporting channels. A second important factor is adequate control when working with hardware. Prototypes should be properly tested before going into the field. Reliability must be assured, and there should be adequate numbers of replacement meters.

In summary, field experiments can be done and should be encouraged. The use of a more scientific approach to research can help define energy conservation policies and provide important marketing insights.

Policy Issues and Implications

A number of policy-related issues and implications have arisen out of this study regarding the concept of feedback. In order to view the issues in the correct context, it must be realized that this research was not designed to test the prototype ECI and to determine the optimality of that information. Rather, it was designed to test the concept of feedback as a way to encourage conservation and to provide information to marketers.

The primary implication of the study is that there is evidence to support the energy-saving potential of a feedback device. The availability of the ECI produced both increases in awareness, knowledge and attitudes toward conservation and actual energy savings. Savings were accomplished through a variety of actions including repeat behaviours and purchases as well as one-time behaviours and purchases. Results were mediated, however, by a number of situational variables (e.g., reliability of hardware, current level of readiness to respond, weather). It is clear that feedback devices will not produce savings in every household. The recognition of the existence of segments is key to any policy supporting feedback devices.

Because of the variance in response to the ECI by households, it is recommended that primary responsibility for marketplace acceptance be left to the private sector. Its ability to define marketplace needs and wants, develop appropriate product assortments, and market the products is a strength of the free enterprise system that should be taken advantage of.

However, this does not mean that government cannot play an important role in the acceleration of consumer acceptance of feedback devices, by providing, for example, subsidies or tax credits. Further joint studies could be undertaken in order to reduce private sector risk and test new alternatives. For example, the potential of feedback in the commercial sector or with time-of-day pricing presents alternatives for research. Multimethod studies should be encouraged as well as the more traditional but limited econometric and survey research studies.

Finally, the government has at least two other important roles in this context. The first is to help solve the problem of the current necessary interaction of billing meters and the feedback device. The integrity of the billing meter must be protected. The second issue is to screen for unscrupulous manufacturers or advertisers of products that may be deemed feedback, but in fact are not.

Marketing Issues and Implications

It is clear that the private sector not only played an important role in the current study, but also has a vital role in the future. This is true for two major reasons. First, the ECI concept shows potential as a consumer product that can lead to energy savings. Second, the existence of differential demand schedules and market segments make acceptance of feedback devices conform to classic marketing strategies, of which the private sector is the most capable of implementing. Specifically, the private sector should be encouraged to develop and produce a variety of more efficient, reliable and easy-to-install feedback devices.

A number of potentially useful strategies and tactics emerged from the study. For example, consumers should be given the choice of leasing or purchasing feedback devices. Alternative devices varying in price, complexity, and information should be available. Homebuilders provide a particularly good market for feedback devices. The device could be part of the overall energy package and be included in the purchase price. Other potential roles for the ECI include use in master-metered buildings, audit programs, and other conservation programs.

Conclusions

Several important conclusions can be drawn from the ECI study. Most importantly, the ECI has been shown to have a positive impact on consumer awareness and knowledge of household energy use and to help homeowners to reduce energy consumption. Additionally, consumers expressed favourable attitudes toward the ECI.

One of the key findings that emerged as a result of the replicated design centres was the differential impact of the ECI. The identification of segments according to consumer response level has important marketing implications. The findings are consistent with the existence of a "hierarchy of effects" among consumers.¹ That is, before a consumer can behave in a particular way he or she must first be aware of the need to behave and be knowledgeable about the behaviour and its consequences. This series of beliefs combine to form an attitude toward the product or concept. A positive attitude is then reflected in appropriate intentions and behaviours. This notion of a hierarchy would explain the results in the current study.

Canadians seemed more ready to respond to conservation and conservation products than did their U.S. counterparts. Results of the post-test questionnaire show Canadians already have high levels of awareness and knowledge regarding energy-related issues, such that no significant differences were found between conditions. The U.S. consumers, on the other hand, showed lower initial awareness and knowledge, and consequently those in the ECI condition showed significant improvement when compared to the Control condition. Interestingly, even the ECI conditions in the United States did not achieve as positive a response to some questions in this area as did the Control conditions in Canada. The greater readiness on the part of Canadians to respond to energy conservation clearly stems from their higher level of conservation awareness. This may be stimulated by government information and education campaigns.

It is not surprising then to find the consumption measures showing a better response by the Canadian cities compared to the U.S. cities. In both Canadian experiments, ECI households used significantly less energy than other conditions and reported taking more corrective actions. In one of the U.S. cities, the ECI condition showed savings but not enough to reach statistical significance. It might also be noted that the results are all the more impressive given the technical difficulties with the ECI experienced in all cities.

1. For further information about the concept of a "hierarchy of effects" see J.F. Engel and R.D. Blackwell, *Consumer Behavior*, 4th ed. (Chicago: Dryden, 1982); and E. Rogers and F. Shoemaker, *Communications Innovations* (New York: The Free Press, 1973).

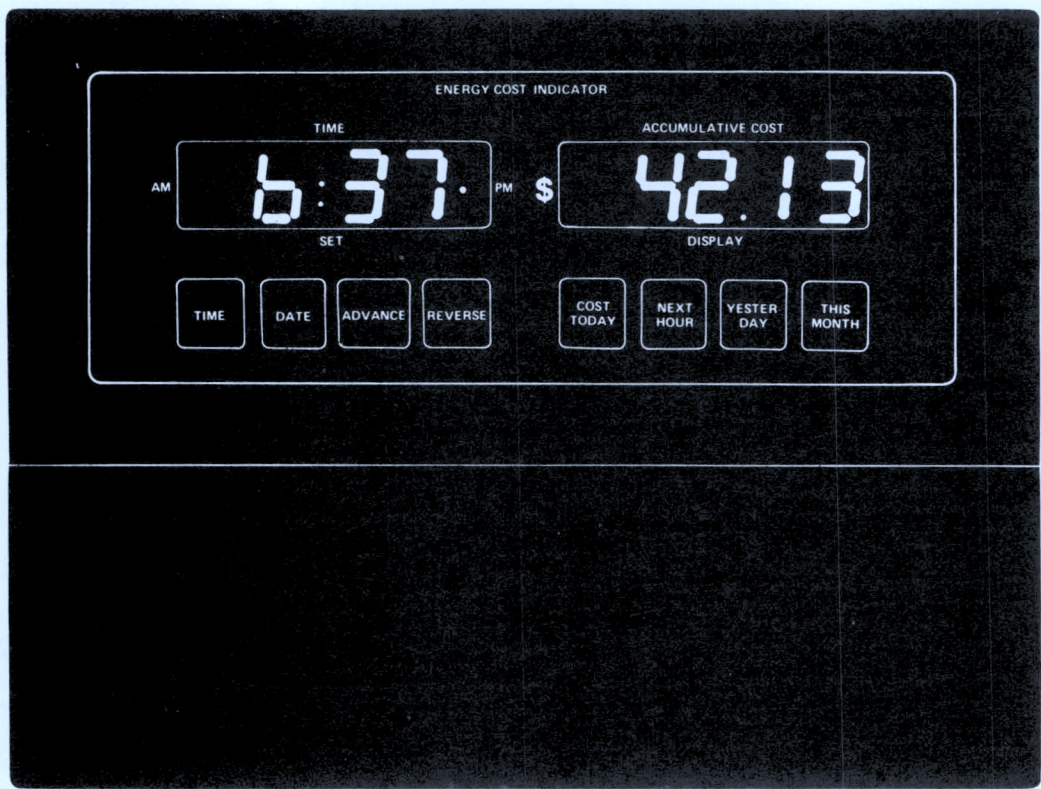
Other findings include the fact that most households viewed energy and energy costs as a serious problem. Conservation was viewed as a positive alternative. Attitudes were highly positive toward the ECI across all cities and conditions. The primary reasons were that the ECI helped motivate households to save (because they could see the cost mounting) and it increased their overall knowledge and awareness of energy use. Although all of the functions were judged useful, the "cost today" function was the most popular.

In summary, two primary conclusions emerge. Feedback can and does produce positive responses in terms of energy conservation. Second, this study demonstrates the power of a properly designed field experiment in evaluating policy and marketing options for decision makers. Despite the usual uncontrollable variables (e.g., weather, prices, politics), the design allowed for a relatively unambiguous evaluation of the impact of feedback. The replicated nature of the design serves to increase confidence and provide a more realistic assessment of impact.

APPENDIX

ENERGY COST INDICATOR BOOKLET

ENERGY COST INDICATOR



Your energy cost indicator is an electronic instrument that offers a challenge. The challenge is to see if you can break your own energy record. Right now, you don't know what your energy record is because you have never had a device like this to measure the amount of electricity and natural gas you use, minute-by-minute, hour-by-hour, and day-by-day.

With your cost indicator, you can watch the energy dollars mount up. You can also do something about it. Let's say that the indicator tells you that you used \$4 worth of home energy last Tuesday. This Tuesday, you try to get it down to \$3.50. Maybe next Tuesday, you can cut it to \$3. Just think, \$0.50 is \$182.50 a year.

As you continue to break your own daily and weekly records, you will save more and more money. Energy costs are increasing at an alarming rate. We can't guarantee that this indicator will make your costs go down, but we believe they won't go up nearly as high as they would have without it. In fact, with the enclosed brochure "100 Ways to Save Energy and Money in the Home" and the cost indicator, we think you can trim your energy usage substantially.

HOW DOES IT WORK?

The cost indicator is set up like a taxi meter. It shows the cost of electricity and natural gas your home is using at any given moment without disrupting or altering the flow in any way. Every time an appliance uses a bit of electricity or a whiff of gas, the indicator registers the cost. The numbers continue to increase throughout the day.

HOW DOES IT SAVE MONEY?

The device connects your habits and appliances directly to your wallet. This takes some of the mystery out of saving energy. You may have wondered how much you could really save by turning down the thermostat at night, or by using the clothesline instead of the dryer. Now you can find out.

You can use the indicator to get an approximation of your monthly energy expenditures before the bill arrives. As it is now, you can only be sure of your energy costs when your utility bills arrive in the mail. Then you know conservation would have been worth the effort. But it is too late – you have already used the energy. A burst of energy-saving zeal usually fades out long before the next bills arrive. With the indicator you get continuous accounting. If it shows that you have overspent by the 15th of the month, you still have 15 days to bring costs back under control.

The device serves as a prodder and a cheerleader. You can imagine how hard it would be to carry on a diet

without a scale to measure the ups and downs. Unless you are self-motivated, you need that feedback to help you shed additional pounds. The same is true for energy. That daily or even hourly reminder will help you save.

HOW MUCH CAN YOU SAVE?

It depends on you. Our guess is that this device will have a profitable influence on your habits. With the suggestions contained in the booklet **100 Ways to Save Energy and Money in the Home** to give you a few good ideas – and the cost indicator to prod, congratulate and keep track of your efforts – you can't help but succeed. The indicator itself uses an insignificant amount of electricity : less than one dollar per year.

FEATURES OF THE INDICATOR

The indicator's calculations are based on several factors, including the average rate your family has been paying for gas and electricity in the past, and recent utility cost increases in your area. The indicator numbers will approximate, but not duplicate, the actual energy costs paid by your family.

Time and date:

You can use the indicator as a digital clock. You can reset the clock in either a forward or reverse direction with the buttons below the clock readout without affecting energy information.

Battery carryover:

The indicator automatically switches to battery power if there is an electrical failure or interruption of service to your house. The device will operate on batteries for at least 48 hours so the information stored in the device won't be lost during the power outage.

Cost today:

If you don't push any button, the digital display shows **cost today** information. **Cost today** is the cumulative total cost of your electricity and natural gas consumption since midnight. The amounts accumulate until the next midnight, when the calculations start all over again. If **cost today** does not revert to zero, the cost shown is the daily fraction of any fixed-based utility charge shown on your bill. **Cost today** figures are displayed on the indicator until you push one of the other buttons. After 15 seconds the device returns automatically to **cost today**.

Yesterday:

You probably don't want to stay up until midnight to get your total for the day. **Yesterday** tells you the total amount of energy your house used in the 24-hour period from midnight to midnight. You can read it at any time during the day to get yesterday's results.

Next hour:

This reading tells you how much energy you will use in an hour if you keep going at the same rate. Let's say your heating system is operating, you are baking bread, the television is turned on, and the clothes dryer is whirling. If you want to know how much it will cost to keep everything operating the same way for an hour, **next hour** will give you the answer. **Next hour** is useful as a reminder of how costly household activities can be. If you are spending 50 cents just for an hour, imagine what it would cost over the month!

This month:

This is the indicator's long memory. It keeps track of the amount of energy you have used since midnight on the first day of the month. Anytime you push this button, you can find out your total energy cost up to the present minute.

Let's say it has been a very cold week and you want to know how the temperature is affecting your energy bills, or perhaps you have experimented with some thermostat adjustments and want to know what is happening to your energy consumption. You can read **this month** at any point to measure your progress.

WHAT YOUR COST INDICATOR WON'T TELL YOU

There is about a 15-second lag between the moment the electricity or gas is used and the moment the numbers register on the indicator. After you plug in an appliance, you have to wait 15 seconds before its operation is reflected on the display.

The money that the indicator says you have spent will approximate but not match the charges on your utility bills. This happens because the utility companies billing periods are likely to be different than the indicator's own schedule, which starts on the first day of the month. Utility rates are in constant flux, due to surcharges and adjustments, and the indicator cannot keep up with all these variables. Also, utility companies don't always read each meter every month and they send bills that are only estimates of your actual consumption.

So the correlation between the indicator and your utility bills will not be exact, but it is good enough for a sneak preview. Since you are measuring your energy-saving progress against your own past record, a to-the-penny match-up with the actual utility bill is not that important. The cost indicator works best for big calculations. Its ability to figure the energy cost of running a small appliance is somewhat limited.

Weather also influences the cost indicator results. You might be in the middle of a furious effort to break last week's record on energy use. Then the outside temperature drops by 15 degrees. That means your heating system works harder, which makes your energy costs go up. So it will appear that your energy-saving efforts have not been successful even though they have been. Your costs would have risen even higher during this cold spell if you had not been cutting back with the indicator. If temperature drops during one of your indicator test periods, it may be helpful to do the test again when the temperature levels off.

Of course, you can use the indicator to estimate the cost of weather, which should give you a clue as to the cost of operating the heating system and, later, the air conditioner. If you read the indicator regularly, and also keep track of the temperature outside, you can see how much the energy bills jump with the heat and cold.

HOW TO TAKE ADVANTAGE OF THE INDICATOR

Take a look at the **cost today** reading as you pass by the indicator a few times during the day. You will begin to see some patterns. The numbers may creep up by pennies in the late evening and early morning hours, and then jump by quarters and half dollars during periods of heavy household activity. These high-cost periods, once noticed, can become specific targets for energy savings.

Every evening, you can get daily totals at a glance. This gives you ammunition with other members of the household, especially the ones who keep the lights burning or forget to turn off the back-up heaters, or waste hot water.

A periodic punch at the **this month** button will let you in on how things have been going since the first day of the month. If it looks like your budget is being squeezed, you can fight back before it's too late.

RUSH HOUR

You will probably notice that your energy costs creep along and then take big jumps a couple of times a day. Those jumps occur during rush hours, when all the members of the family are home taking showers, running hair dryers, cooking dinner, and shoving clothes in the laundry. These rush hour periods usually happen in the morning and then again in the evening. They are good targets for energy saving.

You can determine the cost of peak hours by reading the indicator just before morning activities get rolling, say at 7 AM, and then again when people are about to leave the house, say at 8:30 AM. You can take the same kind of readings during the evening rush hour, say at 6 PM and then again at 9 PM.

The rush hour reduction has importance beyond your own personal savings. It may indirectly benefit the entire community. Utility companies have particular trouble meeting the high energy demand during these peak or rush hour periods, when appliances are turned on at the same time all over the area.

If a large number of people cut back during the rush, it means that utility companies will not have to build so many new generating plants. That means

fewer environmental problems and fewer rate hikes in the future.

The following chart will help you record the cost of energy consumed in the home during peak hours. By noting this information for several consecutive days, it should be easier for you to identify and focus your conservation effort on the most important weekly trends.

COST OF ENERGY CONSUMPTION DURING PEAK PERIODS

1 Morning rush

- A Cost today at ___AM : \$ _____
B Cost today at ___AM : \$ _____
C Energy cost for morning rush (B minus A) : \$ _____

3 Weekly record of energy costs during peak periods (week from _____ to _____)

2 Afternoon rush

- A Cost today at ___AM : \$ _____
B Cost today at ___AM : \$ _____
C Energy cost for afternoon rush (B minus A) : \$ _____

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
ENERGY COST FOR MORNING RUSH							
ENERGY COST FOR AFTERNOON RUSH							

NABBING THE SPOILERS

You already have the general idea that most of your energy money is getting out through the heating system, water heater, stove, clothes dryer, and air conditioner, but there may be some surprises. Sometimes, a hidden spoiler can be adding a lot to your energy bills and may have escaped your detection. The cost indicator can uncover the culprits.

The indicator can help you measure the energy consumption of large appliances and major devices in the house. You can use it to perform spot tests. For instance, let's say you want to figure out the energy cost of running a back-up heater. First, make sure everything is turned off in the house, and lower the thermostat so that your heating system is not in operation. If the **Cost today** figure is not going up, then you know the house isn't using energy. Next, plug in the back-up heater, wait 15 seconds, and push the **Next hour** button on the indicator. The number you see will be the cost to run the heater for an hour. A little figuring and you should know the cost of running it for a month or a year. Don't forget to turn on the appliances you had previously unplugged!

Most large appliances cycle on and off; they don't run constantly. Refrigerators, water heaters, air conditioners, heating systems and ovens consume energy sporadically and intermittently. With short-term experiments using the **Next hour** button, appliance cycling may affect the results. If **Next hour** tells you it will cost \$1 to keep the heating system in operation, that doesn't take into account that it will turn off for some of that time.

CASH ON THE THERMOSTAT

You have probably heard that even small adjustments in thermostat settings save a great deal of money. Night setback, for instance, is supposed to be one of the most lucrative energy-saving measures. In a couple of days, you can determine how much it will benefit you.

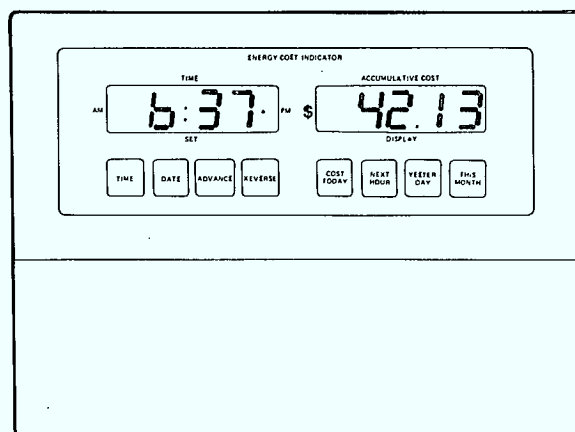
On the first night of the test, go to bed with the furnace thermostat set at the regular level. On the following morning, read **Yesterday**. This will give you the energy cost for the first night.

On the first night of the test, go to bed with the furnace thermostat set at the regular level. On the following morning, read **Cost today**. This will give you the energy cost for the first night.

On the next night, set the thermostat back to about 13°C (55°F) before you go to bed. You can get cozy with extra quilts or blankets. The next morning, read **Cost today** again. This will give you the energy cost for the second night, when the thermostat was set back. If all indoor and outdoor conditions remained roughly the same for the two-day test, the difference in the two readings will provide a good estimate of the value of night setbacks.

ENERGY SAVINGS RESULTING FROM THERMOSTAT SETBACKS

- 1 **First night of test**
 - A Thermostat set at: °C (°F)
 - B Cost **Cost today** reading: \$
- 2 **Second night of test**
 - A Thermostat set at: °C (°F)
 - B Cost **Cost today** reading: \$
- 3 **Money saved in one night** (2B minus 2A): \$



DAILY ENERGY PULSE

At various intervals of the day, say every 4 hours, you can write down the amount shown on the **Cost today** display. At the same time, you can note the activities that have taken place during that interval. Putting the cost numbers together with the activities will give you a better energy picture of your house.

The sample daily report shows you how it works. At 7 AM, **Cost today** read 50¢. That's how much energy money it took to get from midnight to 7 AM. Not much was happening during those hours, so 50¢ reflects the minimum operating cost for this particular home, or about \$0.07¢ an hour. This typically represents the minimum level of operation when only the refrigerator, deep freezer, a couple of lights, and perhaps the heating system or air conditioner are in service.

At 11 AM, on the second reading, the **Cost today** figure went up to \$1.52. In 4 hours, the house had gobbled up \$1 worth of electricity and natural gas, or double the amount used in the previous 7 hours. Two loads of clothes were washed and put through the dryer, and the thermostat was set at 18°C (65°F).

At 3 PM, **Cost today** registered \$2.10. Nothing unusual was happening, except that the furnace thermostat had been turned down by one degree.

At 7 PM, **Cost today** had soared to \$3.15. The

children had taken showers, a lasagna was baking in the oven, more lights had been turned on, the television was in constant operation, and the thermostat was set higher at 20°C (68°F).

Finally, at 11 PM, **Cost today** indicated that the household spent a total of \$3.65 on electricity and gas since midnight the day before. At this rate, the monthly energy bill will exceed \$100.

DAILY REPORT ON ENERGY CONSUMPTION

Day of week: Wednesday
 Date: November 12, 1980
 Outside temperature: 5°C (41°F) (optional)
 Total cost today: \$ 3.65 at 11 PM

Hour	Cost today reading	Activities
MIDNIGHT		
1 h		
2 h		
3 h		
4 h		
5 h		
6 h		
7 h	→ \$0.50	→ Furnace set overnight at 13°C (55°F).
8 h		
9 h		
10 h		
11 h	→ \$1.52	→ 2 loads of clothes, dryer, thermostat raised to 18°C (65°F).
12 h		
13 h		
14 h		
15 h	→ \$2.10	→ Thermostat reduced to 17°C (64°F), nobody home
16 h		
17 h		
18 h		
19 h	→ \$3.15	→ 2 showers, hair dryer, cooked lasagna, TV on, lights on, thermostat set at 20°C (68°F)
20 h		
21 h		
22 h		
23 h	→ \$3.65	→
MIDNIGHT		

PLOTTING THE PULSE

Once you take your daily energy pulse, you might want to plot it on a graph. This graph makes it even easier to see the patterns of energy use, the times of high guzzle and low trickle. After you try a few of the ideas given in the **100 Ways** booklet, you might want to plot the pulse again to see if the pattern looks different.

The following graph is based on the sample household just given. The procedure is quite simple: for each hour at which a reading was taken, mark a point on

the graph at the corresponding cost level. In our example, at 7 AM (horizontal axis) there is a point on the graph corresponding to \$0.50 (vertical axis); the next point corresponds to 11 AM and \$1.52, and so on. When all the points are in, you simply draw a line between each of them. A blank graph is provided to help you plot the daily energy consumption profile of your family.

PROFILE OF DAILY ENERGY COST

Day of week:

Wednesday

Date:

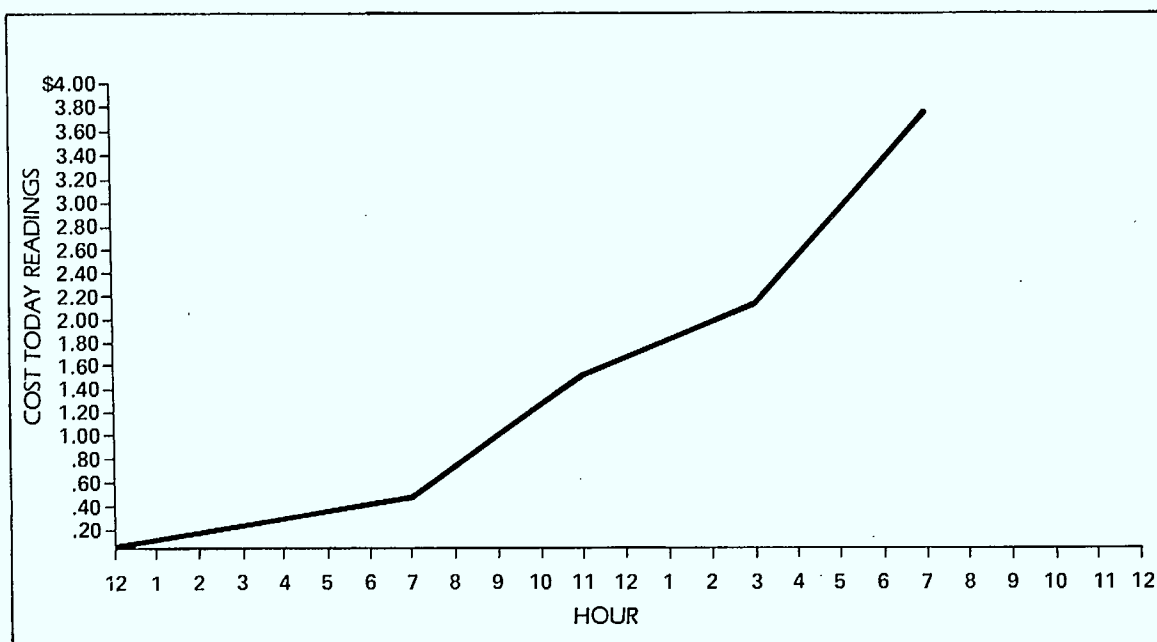
November 12, 1980

Outside temperature:

5°C (41°F)

Total energy cost today:

\$ 3.65 at 11 PM



A FOUR-WEEK ENERGY CONSERVATION PROGRAM

This is the challenge . . . to go on a 4-week energy diet and cut 20 percent off your consumption. You start by figuring what you use now. Pick a week, and write down the energy cost for each day. You can do it by reading **Cost today** at roughly the same time late in the evening, or you can use the **Yesterday** display remembering that the number shown today reflects the cost for yesterday. The following chart will help you organize the numbers for your benchmark week.

Now you are ready to fight for the 20 percent. Try to make the cost for the second week lower than the one registered for the first week. You can do it by applying some of what you learned in the booklet **100 Ways to Save Energy and Money in the Home** or by practicing some energy-saving techniques you have learned elsewhere.

You may not reach your goal right away. If you don't get it during the second week, try again in the third week. Just the daily routine of reading the indicator should give you a clearer picture of the best

places to cut back. If your energy costs aren't getting any lower, try to check your daily activities to determine why. Don't forget the weather. You can't expect to save 20 percent if the outside temperature drops down suddenly.

Some families tend to repeat the same appliance routine on the same day each week . . . Mondays for laundry, Sundays for the big dinner, etc. If your family follows such a pattern, you can try to make the energy cost for each Monday lower than that for the preceding Monday, and so on. Once you achieve your target reduction, try to hold it, much as you would after reaching your goal on a weight-loss diet. The longer you can hold it, the more money you will save.

MONTHLY REPORT ON ENERGY CONSERVATION PROGRAM

Period from _____ to _____.

Energy cost	Week one	Week two	Week three	Week four
Monday				
Tuesday				
Wednesday				
Thursday				
Friday				
Saturday				
Sunday				
Total for week nine				

A CHALLENGE FOR EACH SEASON

Energy costs vary so much from one season to the other that you might want to repeat your four-week conservation experiment at different times of the year, applying the energy-saving techniques most suitable for each season. If you succeed in cutting back your energy consumption by 20 percent throughout the year, you will achieve substantial money savings.

DAILY REPORT ON ENERGY CONSUMPTION

Day of week: Wednesday
 Date: November 12, 1980
 Outside temperature: 5°C (41°F) (optional)
 Total cost today: \$ 3.65 at 11 PM

Hour	Cost today reading	Activities
MIDNIGHT		
1 h		
2 h		
3 h		
4 h		
5 h		
6 h		
7 h	→ \$ 0.50	→ Furnace set overnight at 13°C (55°F)
8 h		
9 h		
10 h		
11 h	→ \$ 1.52	→ 2 loads of clothes dryer, thermostat raised to 18°C (65°F).
12 h		
13 h		
14 h		
15 h	→ \$ 2.10	→ Thermostat reduced to 17°C (64°F), nobody home
16 h		
17 h		
18 h		
19 h	→ \$ 3.15	→ 2 showers, hair dryer, cooked lasagne
20 h		TV on, lights on, thermostat set at
21 h		20°C (68°F)
22 h		
23 h	→ \$ 3.65	→
MIDNIGHT		

COST OF ENERGY CONSUMPTION DURING PEAK PERIODS

1 Morning rush

A Cost today at ___ AM : \$ _____
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 C Energy cost for morning rush (B minus A) : \$ _____

3 Weekly record of energy costs during peak periods (week from _____ to _____)

2 Afternoon rush

A Cost today at ___ AM : \$ _____
 B Cost today at ___ AM : \$ _____
 C Energy cost for afternoon rush (B minus A) : \$ _____

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
ENERGY COST FOR MORNING RUSH							
ENERGY COST FOR AFTERNOON RUSH							

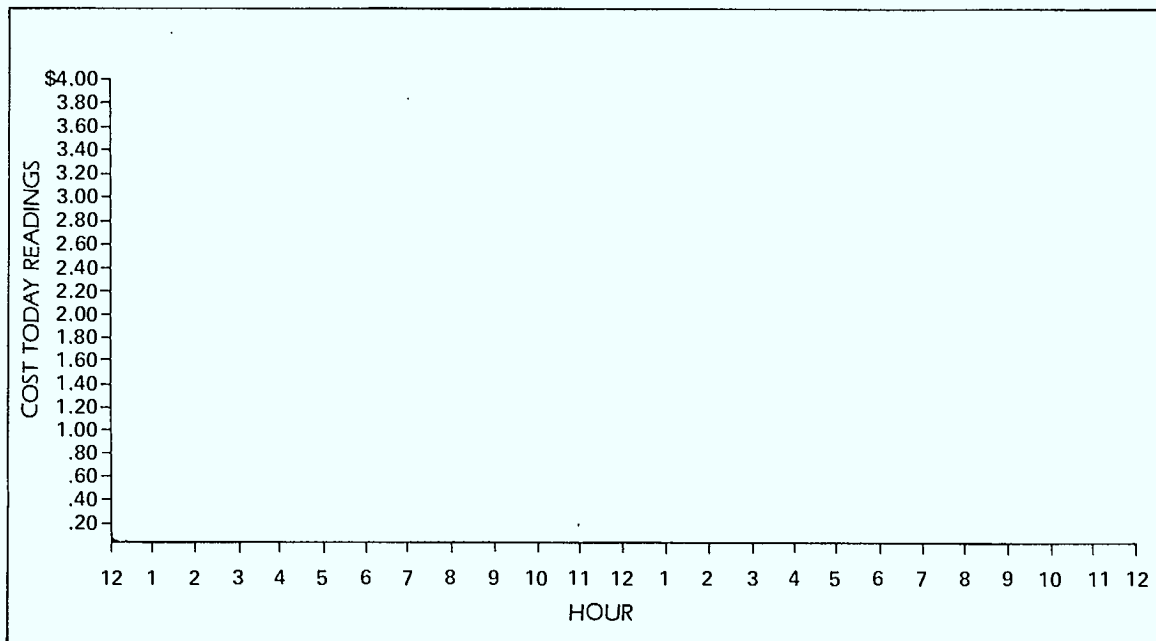
PROFILE OF DAILY ENERGY COST

Day of week:

Date:

Outside temperature:

Total energy cost today:



UACG/CCAC

18176

DATE DUE
DATE DE RETOUR

[illegible]

38-296

Canada 