Estimating the Impacts of Voluntary Programs: Results from a Recent Study on the Canadian Industry Program for Energy Conservation

Lee Ann Westfall, Mallika Nanduri, and Glenda Taylor
Natural Resources Canada, Office of Energy Efficiency

ABSTRACT

The Canadian Industry Program for Energy Conservation (CIPEC) is a long-standing Government of Canada initiative that helps industry define energy efficiency targets, and develop and implement plans to achieve those targets. CIPEC measures and reports on the energy efficiency progress of its members in its annual report. However, due to the behavioural and voluntary nature of the program, conventional methods of impact analysis cannot readily assess the energy efficiency improvements that are solely attributable to CIPEC. To that end, Natural Resources Canada's Office of Energy Efficiency recently conducted a study (with POLLARA Inc.) using discrete choice-related analyses to quantify the influence that CIPEC service, product and program attributes have had on the energy-related choices of CIPEC program participants compared to non-participants (i.e., the rest of business and industry).

The study models the sole impact of key CIPEC program components on changes in energy consumption and estimates the percentage of overall market effects exclusively attributable to CIPEC activities. Specifically, the study isolates the 5-year change in energy consumption solely attributable to the CIPEC program by using analysis of covariance to remove key extraneous factors that could potentially mask the program's true impact. A direct link between energy-related decisions and participation in the CIPEC program is evident. Results also demonstrate that participants utilize a range of program elements to varying degrees.

Background

The Canadian Industry Program for Energy Conservation (CIPEC) is a sector-based, industry-government collaborative initiative delivered by Natural Resources Canada's (NRCan's) Office of Energy Efficiency (OEE). CIPEC promotes energy efficiency to enhance the economic competitiveness of Canadian industry, by helping them develop and implement plans for improving the energy efficiency of their operations. Since 1975, CIPEC's network has grown to 25 sector Task Forces and is made up of 45 trade and business associations representing more than 5,000 companies. CIPEC's reach now extends to 98% of secondary industrial energy demand in Canada. CIPEC's sector task forces identify potential improvements in their respective sectors and provide progress tracking and reporting processes. These task forces also serve to identify common needs and provide information on issues such as energy management and communications through CIPEC's twice-monthly newsletter.

An equally important component of CIPEC is Industrial Energy Innovators (IEI), a voluntary, company-based initiative that works in conjunction with CIPEC. Almost 400

Canadian industrial processing companies have registered as IEIs, making a commitment to energy efficiency and supporting for Canada's goal of reducing GHG emissions. Benefits to IEI participants include learning of significant energy savings opportunities and receiving valuable energy management tools. Companies are also given special opportunities to showcase their success in energy efficiency and support for Canada's goal of reducing greenhouse gas emissions[1].

Project Context and Study Objectives

The OEE was established within NRCan in 1998 with a mandate to renew, strengthen and expand Canada's commitment to energy efficiency, and with a particular focus on addressing Canada's commitments to the Kyoto protocol.[2] Part of the OEE mandate involves assessing the energy saving and GHG reduction impact of its market transformation programs, which presently number 16. Such assessments enable the OEE to:

1. Develop a better understanding of overall program performance and program effectiveness; and
2. Meet its various performance reporting requirements in a transparent and regular fashion.

Estimating the energy and GHG impacts of programs like CIPEC requires knowledge about how the programs are affecting their targeted market segments, be it in terms of changes in market structure, or in terms of changes in the energy-consuming behaviour of these market segments. Without this information, the OEE is unable to properly quantify the energy savings resulting from program activities in the targeted sector of the economy. In other words, the *impact attribution, or net impacts*, of the program (the impact resulting solely from program activities) cannot be quantified.

The idea of using Discrete Choice Theory (DCT) methods to estimate impact attribution for the OEE's programs was first suggested by a member of the National Advisory Council on Energy Efficiency, a committee made up of industry and academic energy experts who provide the OEE with strategic direction and advice. This particular individual, who works for an Ontario natural gas utility, had a great deal of success employing DCT-related methods for estimating attribution and program impacts of utility programs. On his advice, the OEE commissioned a feasibility study in 2000 that examined the potential for applying DCT-related methods to address the problem of attribution and for evaluating the impacts of OEE programs. Based on the outcomes of the feasibility study, and on the fact that CIPEC is a "flagship" program for the OEE, it was selected for an impact attribution study using DCT-related methods.

---

[1] For a more in-depth understanding of the CIPEC program, its impacts and results, readers are referred to the paper "Canadian Industry Program for Energy Conservation: Improving Industrial Energy Efficiency in Canada" being presented in Panel 3 of this conference – Policies and Programs to Achieve Industrial Energy Efficiency & Sustainability.

[2] When the Canadian government signed the Kyoto Protocol in 1997, they agreed to reduce Canada's greenhouse gas (GHG) emissions to 6 percent below 1990 levels between 2008 and 2012.

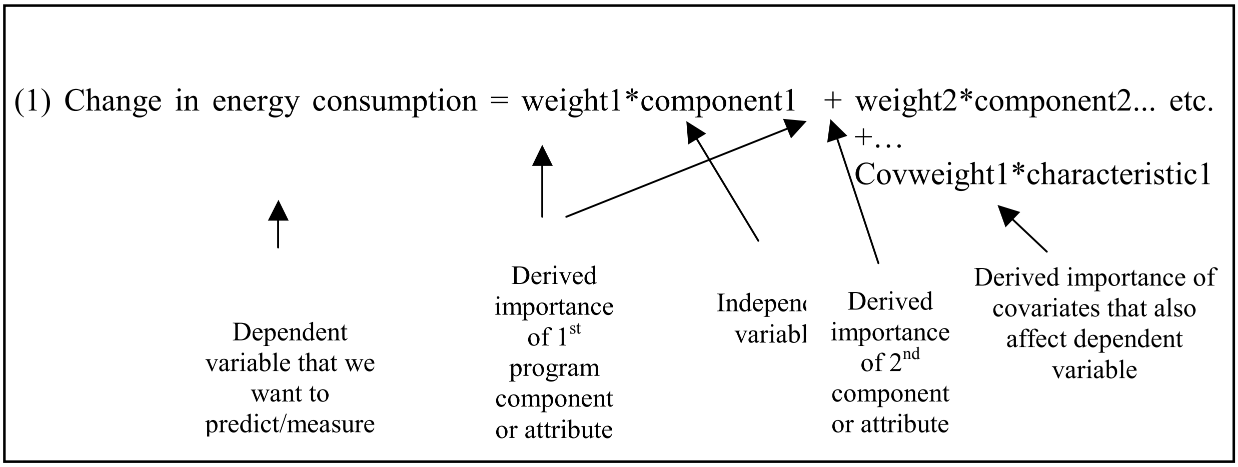
The key objectives of the study, which was conducted by POLLARA in early 2002 (POLLARA, Inc., 2002), include the following:

1. Estimation of overall market effects that are solely attributable to CIPEC initiatives;
2. Development & application of a discrete choice approach capable of obtaining the information required to meet the first objective; and
3. Quantification of the impact of CIPEC in terms of energy savings, if possible

Methodology

DCT methods and analyses are often used to quantify the influence that service, product and/or program attributes or elements have on the choices of individuals or organizations. The key tenet of the Decompositional Model of choice behaviour forms the basis of several DCT and DCT-related methods. A feasibility study published by Deal and Mountain highlights the notion that "the advantage of DCT models is that they can help isolate the impact of efficiency programs while controlling for much other ongoing variation in other explanatory variables [2001, p.4].

As it applies to program evaluation, decisions or choices are a function of the program elements or components that make up the program. Program components tend to vary with respect to their importance and their impact on choices, and the main advantage of many DCT methods is that they can measure the influence individual program elements have on the behaviour of program participants. Given that DCT and DCT-related methods can be used to model the sole impact of each CIPEC program component on changes in the energy consumption of program participants, it was selected as the approach to be used in this study. The algorithm underlying the theory is presented in equation (1) below.



Equation 1 depicts the three types of variables analyzed in the study. *Dependent variables* are the ones we want to predict using the *independent variables* (CIPEC program elements) - in this case, the objective was to see how well participation in CIPEC program elements predicted or impacted indices of energy consumption change. *Covariates* are the extraneous factors that could also effect a change in energy consumption (i.e., weather, changes in organizational size and production).

The main dependent variable used in the analysis was the "Total Facility Change in Energy Consumption" over the last 5 years. "System-Specific Changes in Energy Consumption" were also examined. The following set of independent variables were utilized because they eliminate colinearity, maximize the number of respondents and cover all the major CIPEC program elements:

- CIPEC Newsletter
- Employee Awareness Kit
- Boiler & Heater Guide
- Motor Systems Guide
- Sector Benchmarking studies
- Sector Energy Efficiency books
- CIPEC Web Sites
- CIPEC Task Force Meetings
- Energy Sector Days
- Energy Monitoring & Tracking workshops
- Spot the Energy Savings Opportunity workshops
- Energy Master Plan workshops
- Industrial Innovators Initiative
- NRCan funding for energy audit in last 5 yrs

The overall impact of the program was also examined based on whether respondents were participants or non-participants. Respondents were classified as a way of identifying missing data. Each independent variable was treated as a discrete or "class" variable with arbitrary values of 1, 0 and -1. Those participating in a particular element were assigned a value of "1" for the variable representing the element and those not participating in an element were assigned a value of "0". To get the purest group of participants and non-participants, the few that indicated that they did not know were assigned a value of "-1" for the variable. Respondents that had a missing value were excluded from the entire statistical analysis.

The most important extraneous factors or covariates for analysis were identified as:

- The impact of weather on energy consumption;
- The change in the size of businesses;
- The change in production volume;
- Industry[3];
- Number and types of systems in the facility; and
- The types of fuel sources utilized[4]

Given that changes in the last three factors identified above are embedded or linked, to a certain extent, with the first three factors, and given the potential for significant multicollinearity, only the impacts of weather, changes in the size of businesses, and changes in production volume

[3] The industrial sector includes, construction and mining, as well as all manufacturing.

[4] Electricity and natural gas are the sources of fuel that are consumed the most. Electricity represents over half of energy bills for 43% of firms. Natural gas constitutes over half of energy consumption for 16% of firms; 66% of firms use natural gas. While almost a third of firms use propane (35%) and diesel (30%) these fuel sources generally constitute less than 25% of the energy bills among firms that use them.

were explicitly considered in the analysis itself[5]. The steps taken to estimate equation 1 and to calculate the change in energy consumption that could be realistically attributed to CIPEC are described in the following sections.

Questionnaire Design, Sampling and Data Collection

The survey questionnaire for the study was designed by POLLARA, in consultation with the CIPEC project authorities. A random sample of firms was selected to take part in a telephone survey. The sample of firms included both participants and non-participants in CIPEC components. A participant was defined as an individual or organization that had received a CIPEC newsletter or attended one or more CIPEC workshops. Those that have not actively participated in program components (non-participants) represented the Control Group and those that have participated in program components (participants) represented the Treatment Group. The random sample of non-participating firms was extracted from the Info Canada business population database and the sample of participating firms was randomly extracted from a list of CIPEC participants.

To ensure representation of participants of each CIPEC program component and to ensure sufficient industry-level representation (mining/oil & gas and manufacturing) among non-participants, 1,223 interviews were completed. The ideal would have been to divide the number of completions equally between participants and non-participants. However, following examination of the available sample of participants, it was decided that 450 completed interviews would be possible among participants and 773 among non-participants. Most respondents' scope of authority was a single facility. As such, the results should be considered a valid representation of Canadian facilities, as opposed to organizations as a whole.

Data Analysis

The analysis of survey data was conducted using inferential statistics that could effectively identify changes in energy consumption that were solely attributable to various CIPEC program components. Specifically, analysis of covariance or ANACOVA was used. ANACOVA helped improve the discrete choice model so that the effects of the covariates (namely business size, impact of weather, and changes in production volume) that could mask the sole impact of CIPEC program components were removed. This was especially important insofar as participants could systematically differ from non- participants in terms of characteristics such as business size.

Important results from the ANACOVA procedure included results for the type three sum of squares (TYPE III SS*)* and LSMEANS. Results for the TYPE III SS indicates the degree of change in energy consumption solely due to specific CIPEC program components. F-tests are used to determine if the TYPE III SS results are statistically significant. If significant, this would indicate that a CIPEC program component has a significant impact on energy consumption with the effects of all other factors removed. This test therefore provides an estimate of the statistical significance of the sole impact attributable to each CIPEC program element.

The results of the LSMEANS procedure show what the adjusted average change in energy consumption is, for example, among those that attended a CIPEC workshop with the

[5] Specifically, production volume and business size already account for variation in energy consumption due to: type of industry, systems and fuel sources.

effects of all other factors removed. These results show exactly how much of the sole impact on energy reduction each CIPEC program component has.

Results: Energy Consumption Reductions Attributable to CIPEC

Table 1 summarizes the impact on total facility energy consumption changes over the last 5 years attributable to CIPEC program elements. The first ANACOVA analysis examined the impact of the CIPEC program overall (listed as Analysis #1 in the table), while the second ANACOVA analysis examined the impact of each program element on total facility energy consumption changes (Analysis #2 in the table). The four columns of Table 1 represent, in order:

1. The **dependent variable** is the same for both analyses – 5-Year Energy Consumption Change (total facility);
2. One variable for Analysis #1 (Participation in CIPEC – yes or no) and multiple independent variables for Analysis #2 (each CIPEC program element);

3. & 4. The third and fourth columns present the "LSMEANS". These are the mean percentage 5-year change in energy consumption, adjusted to remove the effects of the covariates (i.e. weather, change in company size and production), for participants and non-participants respectively. In Analysis #1, the adjusted means reflect the impact of the CIPEC program overall. In Analysis #2, the impact of each individual CIPEC program element is shown.

These adjusted means are only shown for independent variables that are significantly related to energy consumption. All differences between Participants and Non-Participants are statistically significant.

Table 1 shows that CIPEC has indeed helped industry to reduce its energy consumption over the last 5 years.

Table 1. Impact on Total Facility 5-Year Energy Consumption Change Attributable to the CIPEC Program

(Note: "+" = increased energy consumption; "– " = decreased energy consumption)

Dependent Variable	Independent Variable	Adjusted Mean Consumption Change (LSMEANS – removes effects of covariates)	
		Participants in CIPEC Program or Element	Non-Participants
Total Facility 5-Year Energy Change	**ANALYSIS #1 – Impact of Overall Participation on Overall 5-Year Energy Change**		
	CIPEC Participation Overall	+2.2%	+5.2%
	ANALYSIS #2 – Impact of Participation in CIPEC Program Elements on Total Facility Overall 5-Year Energy Change		
	Motor Systems Guide	+6.5%	+30.1%
	Energy Sector Days	+15.2%	+28.1%

*Source: POLLARA Inc. 2002.

In other words, after extraneous factors are removed, Analysis #1 shows that the 5-year mean change in energy consumption among CIPEC program participants is an increase of only

2.2%, which is 2.4 times lower than the adjusted mean increase of 5.2% among non-participants.[6]

ANACOVA Analysis #2 shows that the Motor Systems Guide & Energy Sector Days are the two program elements that were significantly associated with a change in energy consumption. After extraneous factors are removed, the analysis shows that the *adjusted* mean 5-year change in energy consumption among Motor Systems Guide participants is an increase of 6.5%, which is 4.6 times lower than the adjusted mean increase of 30.1% among non-participants. Similarly, the *adjusted* mean 5-year change in energy consumption among Energy Sector Days participants is an increase of 15.2%, which is 1.5 times lower than the adjusted mean increase of 28.1% among non-participants.

Analysis #2 revealed little largely due to the small sample sizes associated with participating in any one CIPEC program element. It is important to note that all program elements were tested simultaneously. Although these results may not appear to be significantly associated with a change in energy consumption at this time, they do in fact have an impact on energy consumption and CIPEC should continue to fund all other program elements. Moreover, the results of Analysis #2 are not stable due to limited statistical power (caused by a combination of small sample sizes and small effect sizes). For this reason, conducting an additional analysis within a 3-year period should allow for more adequate sample sizes to be obtained to solidify the results.

Table 2 presents the results of ANACOVA analyses 3 through 6. Each of these examined the overall impact of CIPEC program participation on system-specific energy consumption changes over the last 5 years.

Table 2. Impact on <u>System-Specific</u> 5-Year Energy Consumption Change Attributable to the CIPEC Program

Dependent Variable (System-specific, 5-year energy consumption changes)	**Independent Variable**	**Adjusted Mean Consumption Change (LSMEANS – removes effects of covariates)**	
		Participants in CIPEC Program or Element	**Non-Participants**
Analysis #3: Boiler System	Overall Participation in CIPEC Program	0.0%	+6.9%
Analysis #4: Dryer System	Overall Participation in CIPEC Program	+4.8%	+11.6%
Analysis #5: Water System	Overall Participation in CIPEC Program	-0.2%	+4.2%
Analysis #6: HVAC System	Overall Participation in CIPEC Program	+1.4%	+5.1%

*Source: POLLARA Inc. 2002.

Table 2 indicates that for CIPEC participants with boiler systems, energy consumption remained constant. Energy consumption for non-participants, on the other hand, increased an adjusted average of 6.9% over 5 years. Average energy consumption increases among participants' dryer systems were less than half (with an increase of only 4.8%) compared to non-participants (with an increase of 11.6%). Participant water system energy consumption decreased slightly (-0.2%) over the last 5 years, which compares favourably to an increase of 4.2% among non-participants. Finally, the energy consumption of participant's building heating, ventilation and air conditioning systems increased an average of only 1.4% compared to 5.1% for non-participant HVAC systems. It is important to note that these savings are not attributed to a particular CIPEC program element; they are attributed to participating in CIPEC overall.

[6] <u>Technical note</u>: The R-Squared for Analysis #1 is 0.29, indicating that the analysis accounts for 29% of the variation in energy consumption change (POLLARA Inc. 2002.). This is considered quite good for research of this type.

Conclusions

This study measures the real (as opposed to simulated) effects of the CIPEC program. Random samples of those currently participating (to varying degrees) and those not participating are extracted from their respective population. The relationships between participation and energy-consumption related choices are quantified. The effects of extraneous factors such as size of business and industry type were eliminated statistically so that the sole impact of each CIPEC initiative is estimated.

The discrete choice approach is appropriate for this project because it provides explicit and formal methods for quantifying the relationship between choices (i.e., whether to make changes that will impact energy consumption) and participation in CIPEC program components. The preceding analyses isolate the market effects of the CIPEC program and quantify, using a discrete choice approach, the impact of CIPEC in terms of energy savings.

After extraneous factors are removed, ANACOVA Analysis #1 shows that the *adjusted* mean 5-year change in energy consumption among CIPEC program participants is an increase of only 2.2%, which is 2.4 times lower than the adjusted mean increase of 5.2% among non-participants. Isolating the effects of the CIPEC program (Analysis #1) reveals that participation in the program reduced energy consumption changes over 5-years by more than half on a total facility basis. The impact was even greater for specific systems: boiler systems, dryer systems, water systems and HVAC systems, suggesting that perhaps CIPEC should consider providing additional services focusing on production machinery. ANACOVA Analysis #2 identified which program elements had the greatest impact on the energy consumption of the participants. Analysis #2 found that running production machinery and building HVAC are by far the most prominent uses of energy. Not surprisingly, electricity and natural gas are the most commonly and heavily used sources of fuel. Accordingly, the CIPEC program will ultimately achieve the most effective outcome by placing priority on these two energy uses and these two fuel uses (POLLARA Inc. 2002).

References

Deal, K. and Mountain, D., Marketing Decision Research Inc. 2001. *The Use of Discrete Choice Modeling for Evaluating Energy Efficiency Programs*. Natural Resources Canada. Ottawa, Canada.

Natural Resources Canada. 2002. *Canadian Industry Program for Energy Conservation Annual Report 2000-01*. Ottawa, Canada.

POLLARA Inc. 2002. *Determining Impact Attribution for the Canadian Industry Program for Energy Conservation (CIPEC).* Natural Resources Canada. Ottawa, Canada.