Incentives and Fuel Switching in Multifamily Residential Construction

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In recent years, natural gas has made considerable inroads for space and water heating in single family dwellings in British Columbia, but it has achieved only limited penetration in multifamily dwellings because of market barriers. B.C. Hydro has attempted to address this constraint through a pilot incentive program that subsidized installation of natural gas space heating in new multifamily residential construction.

This study uses a multiple lines of evidence approach to examine key issues pertaining to market acceptance and program impact. The methodologies employed are market penetration analysis and discrete choice modelling. The study makes a number of findings relevant to planning of a possible future fuel switching program. First, the pilot achieved a substantially higher rate of penetration in the rental segment than in the owner occupied segment of the market. Second, the pilot achieved a substantial overall rate of market penetration. Third, capital cost, natural gas price, electricity price and building type are all statistically related to the rate of market penetration. Fourth, incentive levels are a significant factor in program take-up.

Introduction

In recent years, natural gas has made considerable inroads in British Columbia for space and water heating in single family dwellings due to cost and efficiency advantages. However, natural gas has achieved only limited penetration in multifamily dwellings because of market barriers, in particular the difficulties developers have in recouping higher capital costs for natural gas space heating through higher selling prices or higher monthly rents. Since population growth is expected to be strong in British Columbia over the next decade, and since a large share of new housing units will be multifamily dwellings, this market represents a potential substantial increase in electricity demand on a system which may begin to experience distribution constraints.

B.C. Hydro, together with the natural gas utilities in British Columbia, has attempted to address the factors constraining increased use of natural gas in multifamily residential construction through a pilot incentive program which subsidized installation of natural gas space heating in new multifamily residential construction, the Residential Natural Choice pilot. This paper reports on the results of the market evaluation that was undertaken of this pilot. The outline of the paper is as follows. The next section provides a brief overview and description of the pilot program. The following three sections deal with the study approach, the market penetration analysis and the discrete choice modelling analysis. The final section discusses conclusions and implications of the study for possible future programs in this area.

Background and Pilot Description

Background and Rationale for the Pilot

As a space heating fuel, natural gas has several advantages over electricity in British Columbia. First, even allowing for higher initial or capital costs, natural gas is cheaper than electricity for space heating over the lifetime of the equipment. Second, if the incremental source of electricity is thermal generation, it is more efficient to burn fuel directly for heating rather than indirectly by first producing electricity. Third, burning natural gas directly for heating purposes may result in a lower volume of harmful emissions.

Despite these advantages of natural gas as a heating fuel, natural gas has achieved only limited penetration in multifamily dwellings. In 1991, at the time the program was being launched, less than ten percent of new apartment construction was being built with natural gas space heating. The main reason for this was the substantially higher capital cost of installing natural gas rather than electric

space heating equipment. It is apparently difficult for developers to recoup the higher capital costs through either a higher selling price (for condominiums) or higher monthly rents (for rental apartments). (Canadian Resourcecon 1991).

Pilot Description

The Residential Natural Choice began in September 1991 and remained open for subscription until March 1992. The goals of the pilot were to promote natural gas as a space heating fuel in new residential multifamily dwellings and to gain an understanding of the impact of alternative incentive levels on developer fuel choice.

The design of the pilot emphasized several key features. First, there was to be a cost sharing of the rebate between B.C.Hydro and the three gas utilities, with B.C.Hydro contributing about two dollars for every dollar contributed by the gas utilities. Second, to get as wide a range of experience as possible, the pilot was not limited with respect to location, although marketing efforts were focussed on the Lower Mainland, i.e., Vancouver, its suburbs and the Lower Fraser Valley. Third, rebates offered per unit were deliberately varied for different developments in order to test market acceptance at various rebate levels. Fourth, the program was targetted at apartment developments, although one rowhouse development also participated.

Major developers were approached and given information on the nature and purpose of the pilot. Although there was no broad-based marketing or formal information or advertising of the pilot, the majority of the larger developers were contacted personally. Developers had to ensure that buildings used natural gas for both water heating and space heating. If natural gas fireplaces were installed, they had to have an efficiency of at least 65 percent. Proposals from developers were carefully reviewed, particularly with a view towards an accurate understanding of the likely reduction in electricity consumption and the associated capital costs. A decision was made on what incentive, if any, to offer a developer and an offer was made. Initial interest was expressed for about 30 developments with offers made for 21 of these and agreements concluded for 15 projects. Fourteen of these agreements were for apartment projects and one was for a row house development. Before the rebate payment was made, an inspection was undertaken and suitable documentation completed.

Evaluation Issues and Approach

A preliminary review of program files and interviews with present and former program staff identified three key issues to be examined in the study. These issues included the following:

- identification of key market segments and estimation of pilot market penetration for each segment;
- determinants of space heating fuel choice in new multifamily dwellings;
- impact of alternative incentive levels on participation in the pilot.

In analyzing these issues, a multiple lines of evidence approach was used. This approach uses a variety of data sources to compensate for the fact that in certain evaluations no single source provides adequate information on all of the evaluation issues of interest. This approach often employs two or more data analysis techniques, each technique being used to address one or more evaluation issues (Louis 1994, Cook and Campbell 1979).

Table 1 summarizes the evaluation issues, data sources and methodologies for this study. This study used two major analysis techniques: market penetration analysis and discrete choice modelling. Different data sources and samples were used for the two types of analysis. The key point in market penetration analysis is to estimate the proportion of units participating in the program as a share of the total units in the relevant market segment. Data sources for this methodology included program records, a baseline survey, and official records of apartment starts and completions.

Discrete choice modelling was used to examine the determinants of space heating fuel choice and the impact of alternative incentive levels on the decision to use natural gas as the space heating fuel. Both probit and logit models were estimated. A partial effect analysis was used to estimate the impact of alternative incentive levels. Data sources for the discrete choice modelling included program records, a survey of program clients, and previous baseline surveys by B.C. Hydro. These methodologies are discussed in more detail in the next section.

Table 1. Evaluation Issues, Data Sources, Methodologies

Evaluation Issues	Data Sources	Methodologies
1. Identification of market segments and degree of market penetration by segment	• Program records • Apartment completion data	• Market segmentation and market penetration analysis
2. Determinents of space heating fuel choice	• Program records • Survey of program clients • Baseline survey	• Discrete choice models
3. Impact of alternative incentive levels	• Program records • Survey of program clients • Baseline survey	• Partial effects analysis

Market Penetration Analysis

The key objective of the market penetration analysis was to estimate the degree of market penetration achieved by the pilot, both for the market as a whole and for key segments.

A key preliminary issue was the definition of the market and the market segments of interest. The initial plan for the pilot was that it would be open to a diversity of projects with respect to location, size, climate and market segment in order to gain as wide a range of experience as possible, as long as the project contained 30 or more units. But in fact the marketing focussed on developers building low-rise and high-rise apartments in the Lower Mainland of British Columbia (i.e. Vancouver and the Lower Fraser Valley). It was decided that new apartments in the Lower Mainland was the best definition of the target market. The most useful segmentation involved tenure, i.e. strata title vs. rental units. Strata title units are individually owned units or condominiums. Rental units refer to units in buildings in which all units are rented.

From September 1991 to March 1992, 15 projects with a total of 1356 units received funding under the Residential Natural Choice Program. Ten of these were apartment projects in the Lower Mainland, which were completed between January 1993 and July 1993 and these were used as the participant group for the market penetration analysis. They included five strata title buildings and five rental buildings with a total of 966 units as indicated in Table 2. Of the five other projects, three were not completed by July 1993, one was a townhouse rather than an apartment project and one was outside the Lower Mainland.

Table 2. Market Share of Residential Natural Choice Units in Apartment Projects Completed in Vancouver CMA, January - July 1993

Tenure	RNC (Units)	Vancouver CMA (Units)	Program Share (Percent)
Strata	471	3049	15.4
Rental	495	945	52.4
Total	966	4004	24.1

This set of 10 buildings participating in the program during the reference period can be compared with the set of apartment completions (for buildings of 30 units or more) for the Vancouver Census Metropolitan Area (CMA) for the period from January 1993 to July 1993. Information supplied by Canadian Mortgage and Housing Corporation indicates that there were 4,004 such units, 3,059 units in strata buildings and 945 units in rental buildings as shown in Table 2.

Overall market penetration of the pilot program was thus 24.1 percent of completions for the period January 1993 to July 1993. The penetration rate varied substantially between the two market segments being about 15.4 percent for the strata segment and 52.4 percent for the rental segment.

Statistical Modelling

The key objectives of the statistical modelling were to explore the determinants of space heating fuel choice and to estimate the impact of alternative incentive levels on choice of space heating fuel.

Discrete Choice Modelling

This part of the study examines the determinants of space heating fuel choice. The dependent variable is thus a discrete variable, i.e., a "1" if natural gas is the space heating fuel and a "0" if electricity is the space heating fuel. Interviews with developers and program staff suggested that several factors play a key role in the choice of space heating fuel. The variables included in the statistical analysis are described in Table 3 and their sample characteristics are given.

Table 3. Definition of Variables and Sample Characteristics (N = 132)

Variable	Definition
Space	Natural gas space heating = 1; electric space heating = 0 (mean = 0.409, st. dev. = .494)
Capcost	Incremental per unit capital cost of natural gas space heating in 1992 Canadian dollars, net of incentives (mean = $933.86, st. dev. = $161.17)
Gasprice	Price of natural gas in 1992 Canadian dollars per gigajoule (mean = $4.81, st. dev. = $.13)
Elecprice	Price of electricity in 1992 Canadian cents per gigajoule (mean = 5.06 cents, st. dev. = .13 cents)
Building	Building type where rowhouse development = 1, townhouse development = 0 (mean = .288, st. dev. = .454)

The first factor affecting space heating fuel choice is the relative capital costs of alternative space heating methods. The gross capital cost differential between natural gas and electricity was estimated at $1000 per unit, based on discussions with developers. For row houses, the typical alternatives considered are forced air furnaces ($3000) and electric baseboard resistance ($2000). For apartments, the typical alternatives considered are gas hot water baseboard ($2500) and electric baseboard resistance ($1500). The net capital cost differential is calculated by subtracting the rebate offered from the $1000 gross capital cost differential. The average rebate offered was $415.71 with a standard deviation of $132.45, for the 21 projects offered rebates. The expected sign on the capital cost coefficient is negative.

The second factor is the price of natural gas. Because the period from project design to completion averages about a year, the natural gas price prevailing 12 months before project completion was used. This price is in constant 1992 Canadian dollars per gigajoule. Various lag structures on natural gas prices were also tried in the regression analysis, but the coefficients of these additional price terms were insignificant. The expected sign on the price of natural gas coefficient is negative.

The third factor is the price of electricity. Again, the electricity price in constant 1992 dollars, lagged 12 months from project completion was used. The trailing block rate was used in the analysis. Using various lag structures on electricity prices again did not improve the statistical results. It may be worth noting that using current prices at the time of decision making is equivalent to assuming static expectations on the part of decision makers. The expected sign of the electricity price coefficient is positive.

The fourth factor is the building type for the development. The penetration rate of natural gas space heating in row house developments before launch of the pilot was about 50 percent compared to a rate of about 8 percent for apartments. One reason for this may be that the proportion of owner occupied dwellings as opposed to rental dwellings is higher for row houses than apartments. The expected sign of the dummy variable indicating a row house development is positive.

The sample for the regression analysis consists of 132 developments for which suitable data was available in the project files or in previous studies undertaken by B.C. Hydro. These developments were completed in 1990, 1991, 1992 or 1993. Samples of developments from various years were used in the analysis because the electricity and gas rates were common through the relevant service territory in a given year. Further details on the data sources are included in Tiedemann, 1994.

Because of the discrete nature of the dependent variable (i.e. space heating fuel), the model was estimated using a logit model and a probit model. The logit model and the probit model explicitly take into account the discrete nature of the dependent variable and possess superior statistical properties (Amemiya 1981, Johnston 1984). The models are quite similar, with the main difference in the

distributions being in the tails. The logit and probit models were estimated by maximum likelihood using the Newton-Raphson method. For each of these two models, the estimates converged in just four iterations.

The regression results are given in Table 4. All of the coefficients have the anticipated signs (no particular sign was expected for the constant term). T-statistics are shown in parentheses below the regression coefficients. For each model, the coefficient of incremented capital costs is significant at the 1 percent level. The coefficient of natural gas price is significant at the 11 percent level for the logit model and the 10 percent level in the probit model. The coefficient of electricity price is significant at the 10 percent level in the logit model and the 5 percent level in the probit model. The coefficient of the building type term is significant at the 1 percent level for both models.

Table 4. Regression Results (dependent variable is space heating type where 1 = natural gas, 0 = electricity, N = 132)

Variable	Logit Model	Probit Model
Constant	2.5764 (.254)	1.2478 (.211)
Capcost	-.0086*** (-4.201)	-.0052*** (-4.489)
Gasprice	-3.2237 (-1.635)	-1.8814* (-1.665)
Elecprice	3.9088* (1.653)	2.3594** (1.712)
Building	2.3929*** (5.015)	1.4478*** (5.233)
Log-likelihood	-66.80	-66.66
Log-likelihood with constant only	-89.30	-89.30
Chi-sq. (4)	45.00 (.0000)	45.28 (.0000)

1. Figures in parentheses are t-ratios for regression coefficients and probability values for the Chi-squared statistic.

*Significant at 10% level.
**Significant at 5% level.
***Significant at 1% level.

The Chi-squared statistic indicates that the explanatory variables taken as a group are highly significant in explaining space heating fuel choice. In other words, the size of incremental capital costs net of the rebate or incentive, natural gas price, electricity price and building type are, as a group, significant determinants of the choice of space heating fuel.

Partial Effects

For a linear model with no interaction terms, marginal or partial effects of a unit change in a dependent variable are given by the regression coefficient. This is not true of the probit and logit functions, and it is necessary to determine the relevant partial derivatives. Following usual practice, the partial effects are calculated at the sample mean.

The partial effects are shown in Table 5. The estimated impacts are all quite large. For example, a one dollar increase in the rebate offered (which reduces the net incremental capital cost by one dollar) increases the probability of using natural gas heating by 0.2 percent. Since the coefficient on the constant term is statistically insignificant, the regressions were run again without the constant. There was relatively little effect on the regression coefficients or estimated partial effects. It is worth noting that the magnitudes of the estimated changes for the two models are quite similar.

Table 5. Partial Effects of Explanatory Variables (increase in probability of natural gas space heating)

Variable	Logit Model	Probit Model
Capcost	-.0020	-.0020
Gasprice	-.7222	-.7644
Elecprice	.9057	.9269
Building	.5558	.5674

Conclusions and Implications

This paper illustrates how market penetration analysis and regression modelling can be used to examine program acceptance and impact issues in a pilot demand side management project. The study made four key findings. First, the pilot's market penetration rates differed substantially by market segment being about 15 percent in

the strata segment and 52 percent in the rental segment for an overall penetration rate of 24 percent. Second, despite a low intensity marketing effort the pilot achieved a substantial penetration rate. Third, incremental capital cost, natural gas price, electricity price and building type are all significant determinants of fuel choice. Fourth, the rebate level, which reduces the incremental capital cost of the natural gas alternative, has a substantial effect on the selection of natural gas space heating.

These findings have several implications for planning a future fuel switching program. First, the new apartment market has distinct market segments and efforts at encouraging fuel switching may be more successful by emphasizing the rental segment rather than the strata segment of the market. Second, the marketing approach employed, which emphasized direct utility contact with the relatively small number of significant developers rather than expensive broad-based advertising, is an effective way to achieve good levels of market penetration. Third, rebates levels are crucial: the program can significantly influence the rate of program take-up through its choice of incentives.

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