Transforming a Commercial Boiler Market

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ABSTRACT

Natural gas fired boilers are the major sources of hot water for hydronic space heating and domestic hot water purposes in British Columbia. In 1995, typical new commercial boiler efficiency levels in the evaluated jurisdiction were about 75%, with mid-efficiency boilers (efficiency above 85%) and high efficiency boilers (efficiency above 90%) having a combined market share of about 30%. Although life cycle cost analyses suggested that mid-efficiency and high-efficiency boilers were almost always cost effective, customer surveys suggested that market barriers were preventing transformation of the commercial boiler market to use economically effective technologies. To overcome these barriers, the Efficient Boiler Program offered marketing and promotion, technical assistance and advice, and financial assistance to customers installing new commercial boiler programs. This paper reports on a process, market and impact evaluation undertaken of the BC Gas Efficient Boiler Program.

Introduction

Natural gas fired boilers are the major sources of hot water for hydronic space heating and domestic hot water purposes in British Columbia. In 1995, typical new commercial boiler efficiency levels were about 75%, with mid-efficiency boilers (efficiency above 85%) and high efficiency boilers (efficiency above 90%) having a combined market share of about 30%. Although life cycle cost analyses suggested that mid-efficiency and high-efficiency boilers were almost always cost effective, customer surveys suggested that market barriers were preventing transformation of the commercial boiler market to use economically effective technologies. To overcome these barriers, the BC Gas Efficient Boiler Program offered marketing and promotion, technical assistance and advice, and financial assistance to customers installing new commercial boiler programs.

The first stage BC Gas Efficient Boiler Program began in 1995, with applications closing at the end of 2000, and installations continuing through the end of 2001. The program provided customer incentives and technical advice to encourage the installation of mid efficiency and high efficiency boilers in new buildings and retrofit situations. The goal of the program was to reduce energy bills and increase the efficiency of space heating systems in new construction and retrofits and to reduce peak day energy consumption. Reducing energy bills and increasing the efficiency of space heating systems provides value to commercial customers and helps to retain the natural gas load in the face of competition for other energy sources. Reducing peak day consumption reduces the need to expand the natural gas distribution system with consequent savings to BC Gas and its customers. More specifically the program provides the following benefits to BC Gas' commercial customers: (1) lower space heating costs through natural gas savings; (2) lower water heating costs if boilers are used for domestic water heating; (3) improved operating efficiency through appropriate boiler sizing; and (4) improved reliability from back-up systems when a multiple boiler system is used.

Although mid efficiency and high efficiency boilers are cost effective for many commercial customers, market barriers have inhibited appropriate levels of market penetration. These market barriers include the following: (1) higher initial or first costs for boilers and ancillary equipment and installation for mid efficiency and high efficiency boilers than for standard efficiency boilers; (2) limited contractor awareness and knowledge of the benefits and features of mid and high efficiency boiler systems; (3) limited customer awareness and knowledge of the benefits and features of mid and high efficiency boiler systems; (4) some initial problems with premature failure of high efficiency, condensing boiler systems; and (5) higher retrofit piping costs for condensing boilers. To overcome these barriers, the BC Gas

Efficient Boiler Program provided marketing and promotion, technical assistance and advice, and financial incentives for commercial customers installing new boiler systems. For mid efficiency boilers, BC Gas paid customers up to 75% of the cost difference between a standard versus a mid efficiency boiler system up to a maximum of $2.00 per 1000 Btuh. For high efficiency boilers, BC Gas paid customers up to 75% of the cost difference between a standard versus a high efficiency boiler system up to a maximum of $15.00 per 1000 Btuh. The incentives were calculated on space heating loads only, because the space heating load has the greatest implications for natural gas distribution peak, although more efficient boilers would also increase the energy efficiency of other loads on the boiler.

While planning this evaluation, an internet search was undertaken to identify other natural gas utilities in North America that have energy conservation programs for their commercial customers. Although emphasis was on efficient boiler programs, any utility programs found that were primarily directed at reducing natural gas consumption in commercial buildings were reviewed. This search found seven major energy conservation programs with about twenty participating utilities all together. Each of these seven programs is summarized with a focus on: (1) types of equipment eligible for an incentive; (2) capacity ranges eligible for an incentive; (3) efficiency levels eligible for an incentive; and (4) size of the incentive, expressed in Canadian or United Sates dollars as appropriate. These programs are summarized in Table 1, with sources for this information included in the references section at the end of the paper.

Table 1. Comparison of Utility Boiler Programs

	Eligible equipment	Incentive level
BC Gas	Mid efficiency boilers High efficiency boilers	75% of incremental cost to $2.00 per MBtuh 75% of incremental cost to $15.00 per MBtuh
Gaz Metropolitain	Mid efficiency boilers High efficiency boilers Superior efficiency hot water tank	$1,000 to $5,900 depending on capacity Up to $20,000 depending on capacity $1,000 to $5,900 depending on capacity
Enbridge	Mid efficiency boilers High efficiency boilers Combination water and space heating systems Energy management systems Building envelope upgrades	$0.05 /$m^3$ of gas saved for one measure or $0.10/$m^3$ of gas saved if 3 measures installed to $30,000 per building
Gas Networks (BSG, BG, NEGC, FG&E, KSED and NSTAR Gas)	Mid efficiency boilers High efficiency furnaces High efficiency water heaters Low intensity infrared heating equipment	US$500 US$200 US$100 US$500 per unit
Pacific Gas and Electric	Mid efficiency boilers Efficient water heaters	US$2.00 per MBtuh US$2.00 per MBtuh
California utilities (PG&E, SCE, SCG, SDG&E)	Mid efficiency boilers High efficiency boilers Small central furnaces	US$0.34 per annualised therm at 10% savings to US$0.80 per annualised therm at 30% savings above Title 24
CenterPoint/Minnegasco	New heating system Heating system retrofit	10% of equipment costs to US$1,000

Data and Method

Because of the complexity of the Efficient Boiler Program, we used a multiple lines of evidence approach. Initial data collection involved a review of program documents, interviews with program staff, interviews with engineering consultants and manufacturers' representatives, and a focus group with BC Gas staff that explored a variety of issue involving program planning and implementation. Based on this information, the project team developed a preliminary program profile, defined issues for the study and developed the methodology. It was determined that telephone surveys would be the best way to collect valid information while minimizing the response burden on customers and trade allies. Table 2 summarizes the evaluation issues, data sources and methods for this study.

Table 2. Evaluation Issues, Data Sources and Methods

Evaluation issue	Data sources	Methods
1.Examine the rationale for the Efficient Boiler Program	Program documents Interviews	Logic framework
2.Assess customer awareness and satisfaction of program	Program interviews Surveys	Cross tabulations
3.Exanine preferred means of program communication	Program interviews Surveys	Cross tabulations
4.Identfiy program barriers and opportunities	Program interviews Surveys	SWOT (strengths, weaknesses, opportunities, threats) analysis
5.Assess the state of market transformation	Literature review Surveys	Cross tabulations
6.Assees free riders	Interviews Surveys	Free rider analysis
7.Assess program experience	Interviews Surveys	Cross tabulations
8.Assess gross and net energy and carbon dioxide savings	Program data Weather data Surveys	Engineering algorithms

Program Rationale

The rationale for the Efficient Boiler Program was that by providing potential boiler purchasers with: (1) information on the advantages of energy efficient (EE) boiler systems, (2) technical advice and assistance to facilitate decision making, and (3) financial incentives to reduce the pay back period, that larger numbers of more efficient boilers would be installed. In support of this rationale, the program undertook four main program activities: (a) program development; (b) program marketing; (c) technical advice and support; (d) financial incentives. Review of program documents, interviews with program staff, and analysis of survey results was used to build a program logic model as shown in Table 3. Review of the model suggests that there are valid and plausible linkages among inputs, outputs, purpose and goal for each of the program activities. The Efficient Boiler Program has a valid and persuasive rationale, the basic design involving targeted incentives to reduce financial barriers and build a critical mass of activity is sound, and the specific levels of incentives chosen for mid efficiency and high efficiency boiler systems are appropriate.

Table 3. Logic Framework Analysis

	Program development	Program marketing	Technical advice and support	Financial incentives
Inputs	Assess barriers and opportunities	Advertising and promotions	Specifications and technical advice	Financial incentives paid
Outputs	Program addresses customer needs	Customer/trade ally awareness	Knowledge of EE boilers	EE boiler payback period reduced
Purpose	Increase the installation and efficient use of mid-efficiency and high-efficiency natural gas boiler systems in new buildings and retrofits			
Goal	Reduce energy bills, reduce energy consumption and reduce greenhouse gas emissions in new buildings and retrofits			

Customer Satisfaction and Awareness

Sources of program awareness vary substantially by respondent group, reflecting the fact that different clients use a variety of information channels, as shown in table 4. The most important sources are BC Gas representatives, engineering consultants and mechanical contractors, word of mouth and advertising. Levels of awareness are reasonably high. Respondents were asked how satisfied they were with various program components using a five-point scale where one is not at all satisfied and five is very satisfied. Respondent satisfaction with information on the Efficient Boiler program, with the level of incentives offered for high efficiency boilers, and with the overall program are generally high. Respondent satisfaction with technical advice and assistance on boiler selection, with the level of incentives offered for mid-efficiency boilers, with the range of equipment eligible for an incentive and with the application procedure are generally lower, but are still reasonably high.

Table 4. Customer Satisfaction (mean on 5-point scale)

	Participants	Dropouts	Controls	Trade allies	Manufacturers
Program information	3.9	3.2	4.4	3.8	3.9
Technical advice	3.4	3.2	4.0	2.8	2.2
Incentives mid-efficiency	3.6	2.2	3.0	3.0	1.6
Incentives high-efficiency	3.8	3.2	4.0	3.5	4.1
Eligible equipment range	3.4	2.4	3.6	3.3	3.5
Application procedures	3.6	2.6	3.9	3.3	2.6
Overall program	3.8	3.0	3.6	3.4	2.9

Customer Communications

Survey respondents were asked to state their most preferred methods of learning about BC Gas energy efficiency programs as shown in Table 4. For customers, these included direct mail, E-mail, BC Gas website and BC Gas representatives. For trade allies and manufacturers these included direct mail, E-mail and BC Gas representatives. Respondents were asked to state their second most preferred methods of learning about BC Gas energy efficiency programs. For customers, these included direct mail, E-mail and BC Gas representatives. For trade allies and manufacturers these included direct mail, BC Gas website and BC Gas representatives.

Table 5. Preferred Means of Communications (percent)

	Participants (n = 62)	Dropouts (n = 7)	Controls (n = 25)	Trade allies (n = 19)	Manufacturers (n =8)
Direct mail	16	29	36	16	12
E-mail	5	14	32	37	50
BC Gas website	6	29	-	10	-
BC Gas representative	14	14	12	11	25
Journals/literature	19	6	22	-	-
Consultants/contractors	5	-	4	-	-
BC gas workshops	5	-	-	16	-

Barriers and Opportunities

All respondents were asked a series of questions about the importance of factors encouraging the installation of efficient boilers. Respondents were asked a series of questions about the importance of factors encouraging the installation of efficient boilers. The following program opportunities were statistically significant in terms of importance for all groups: recommendations from trade allies; lower energy operating costs; higher boiler efficiency; appropriate boiler sizing; and financial incentives through the program. The following program barriers were statistically significant in terms of importance for all groups: limited knowledge of efficient boilers; uncertainty that savings will be realized; high equipment costs for efficient boilers; high installation costs for efficient boilers; and concerns about reliability of efficient boiler system. We bring these factors together in the SWOT (strength, weakness, opportunity, threat) analysis in Table 6, and we conclude that although the program has done a credible job of leveraging opportunities and reducing barriers to the installation of mid efficiency and high efficiency boilers, but it still has opportunities for improvement.

Table 6. SWOT Analysis

	Current	Future
Positive	Key strengths include: (1) technology promises lower energy consumption and energy costs; (2) BC Gas' knowledge and reputation are available to help sell the technology; (3) boiler program offers environmental benefits by reducing GHG emissions as gas consumption is reduced	Key opportunities include: (1) penetration of efficient boilers in BC(is still relatively low with significant future market potential; (2) reduce future peak day loads and consequent BC Gas capital requirements; (3) program offers good potential for load retention especially in the Southern Interior and North which have
Negative	Key weaknesses include: (1) limited customer and trade ally knowledge of technology/advantages of higher efficiency boilers; (2) high incremental capital costs of efficient systems key barrier to participation; (3) limited engineering consultant and contractor capability to effectively design and implement projects	Key threats include: (1) improperly designed or installed systems may fail prematurely; (2) condensing boilers require sophistication monitoring and management capabilities; (3) there is a growing awareness and interest in air source and ground source heat pumps and electric heat that could erode BC Gas' core market

Market Transformation

The process evaluation surveys collected estimates of the number of boilers sold at various efficiency levels, which further allowed the shares of standard efficiency, mid efficiency and high efficiency boilers to be calculated for 1995. For the current survey, manufacturers were asked to estimate the size of the boiler market and the shares of standard efficiency, mid-efficiency and high efficiency boilers in 2001. The market share of high efficiency boilers increased from 7% to 10%, the market share of mid efficiency boilers decreased from 23% to 21%, and the market share of standard efficiency boilers decreased from 70% to 69% between 1995 and 2001. This is consistent with a gradual move towards a more efficient boiler market. In particular, the 10% share for high efficiency boilers is substantially higher than the 2% share for high efficiency boilers in the United States. However, it should be noted that the sample sizes in this study are relatively small.

Table 7. Sales and Market Share of Boilers by Efficiency Level

Efficiency level	Number of boilers sold		Share of boilers sold (%)	
	1995	2001	1995	2001
Standard	1050	1555	70%	69%
Mid-efficiency	345	470	23%	21%
High-efficiency	105	225	7%	10%
Total	1500	2250	100%	100%

Free Riders

Free riders are customers who received a financial incentive through the program but would have installed a mid efficiency or high efficiency boiler in the absence of the program. If the respondent had received a financial incentive through the Efficient Boiler Program, the respondent was asked how important the incentive was in the decision to install an efficient boiler (where 5 was very important and 1 very unimportant), and a weighted score was then calculated to produce a free rider rate of 0.18 as shown in Table 8, which compares favourably with other evaluations.

Table 8. Free Riders

	Important. (5)	(4)	(3)	(2)	Not (1)	Score (1 –FR)
Weight	1.00	0.75	0.50	0.25	0.00	
Share	0.57	0.18	0.19	0.03	0.03	
Product	0.57	0.14	0.10	0.01	0.00	0.82

Boiler Replacement and Reliability

Customers were asked the reasons for replacing the boiler, where multiple responses were permitted. Survey Main reasons for boiler replacement were to improve boiler efficiency, because of anticipated boiler failure, to reduce energy costs, as part of a mechanical retrofit and as part of a regular life cycle replacement program as shown in Table 9. Customers were also asked to assess the reliability of their boiler systems on a five-point scale where one is poor and five is excellent. Their average ratings were 3.8 for participants, 4.1 for drop outs and 4.2 for controls. This suggests that customer impressions of the relatively low reliability of efficient boilers systems remain a constraint on adoption.

Table 9. Reasons for Boiler Replacement (%)

	Participants	Drop outs	Controls
Improve boiler efficiency	38	67	39
Life cycle replacement	27	33	54
Boiler failure	19	-	23
Anticipated boiler failure	23	-	-
Reduce energy costs	23	-	-
Other/don't know	19	-	8

Gross and Net Savings

Normalized weather-adjusted billing data was used to estimate the gross impact of higher efficiency boilers on natural gas consumption. For retrofits, gross savings were defined as pre-retrofit consumption minus post–retrofit consumption. For new buildings, there is no pre-retrofit building to serve as a baseline, so we calculated gross annual savings as control group consumption minus new building participant consumption. Gross energy savings were 232 TJ per year. Net savings were defined as gross savings times one minus the free rider rate. Net savings were 190 TJ per year. Carbon dioxide savings were then estimated using an emissions factor of 33.35 tonnes of carbon dioxide per terajoule, which yields an emissions reduction for carbon dioxide savings total 6.35 kilotonnes as shown in Table 10.

Table 10. Energy and Carbon Dioxide Savings

	Unit savings (GJ)	Number of buildings	Gross savings (TJ)	1 – FRR	Net savings (TJ)	CO_2 (ktonnes)
Retrofit (same fuel)	1,964.7	80	157.18	0.82	128.88	4.30
Retrofit (new fuel)	18,515.3	3	55.55	0.82	45.55	1.52
New buildings	404.3	48	19.41	0.82	15.91	0.53
All installations	-	131	232.14		190.34	6.35

Lessons Learned

Providing Value to Customers. Natural gas markets have experienced a high degree of price volatility over the past several years, and some experts believe that this price volatility may be an ongoing characteristic of the natural gas market in North America. A high degree of price volatility has negative impacts on many commercial and institutional customers, particularly those who have limited ability to hedge against higher prices. Since natural gas prices tend to be particularly high during the space heating season, measures to reduce space heating loads of commercial and institutional customers can be particularly useful in helping to shield these customers from the adverse impacts of natural gas price fluctuations.

Benefits of Demand Side Management to Gas Utilities. From a utility perspective, demand side management programs have two potential benefits. First, if the marginal cost of increased supply is

greater than the marginal benefit of increased sales, the utility is financially better off if it can postpone or avoid increased sales. This situation is most likely to apply for an end use such as space heating that has a high degree of coincidence with system peak, since meeting a highly peak coincident marginal load requires costly distribution investments. Second, many customers have diversified loads such as water heating, drying and cooking that have different load profiles over the day and over the year. Supporting customers with diversified loads helps to keep load factors up and rates down.

Further Opportunities. The Efficient Boiler Program has had considerable success in capturing selected market segments where opportunities in terms of customer knowledge, access to capital and reasonable pay back periods are present. Other segments have been more difficult to capture because of the presence of informational, financial or technical barriers. Based on survey information and a review of the relevant literature, the best opportunities for a new program are in the institutional, office and multifamily residential sectors. In addition, new buildings are a critical sector for a new program, particularly for high efficiency or condensing boilers, and are also socially important because once opportunities for energy efficient investment are lost, major systems may not be upgraded for twenty years or more.

Role of Trade Allies. This evaluation study has found that trade allies play a key role in determining the choice of boiler system in both new buildings and retrofits. Consulting engineers, manufacturer's representatives and architects are important sources of knowledge and expertise for developers, property owners and building managers who often lack detailed knowledge of the advantages and disadvantages of alternative boiler systems. Although many trade allies have good knowledge and extensive experience with mid efficiency and high efficiency boiler systems, other trade allies lack adequate familiarity with, and knowledge of, these efficient technologies. This is a significant barrier to the widespread technology of higher efficiency boiler systems, especially for condensing boilers. Additional efforts with trade allies can strengthen promotional efforts, increase program awareness and improve participation rates.

Customer Awareness and Knowledge. This evaluation study has also found that while many consumers are knowledgeable about higher efficiency boiler systems, the level of knowledge of other consumers on efficient boiler systems is not adequate. This reduces their ability to make informed decisions on boiler system choice. These less informed consumers lack, in particular, appropriate information on the cost and reliability of efficient boiler systems. They may also have inadequate knowledge of how to maintain and manage efficient boiler systems. Additional efforts to provide education and training for customers and to provide technical advice and assistance for engineering consultants and contractors will enhance market transformation in the boiler market.

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