# GROUND SOURCE HEAT PUMP MARKET DEVELOPMENT STRATEGY

## *– Executive Summary --*

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# EXECUTIVE SUMMARY

## 1. INTRODUCTION

This document summarizes a proposed Market Development Strategy for Ground Source Heat Pump (GSHP) market penetration in Canada. This Strategy, which is presented in full in the companion document entitled *Ground Source Heat Pump Market Development Strategy*, was developed under contract by Marbek Resource Consultants, in association with CSML, Dennis Edell and Phil Elliott. The Strategy provides a blueprint for the development and implementation of collaborative actions designed to establish a viable GSHP industry in Canada.

The Strategy is based on a life-cycle cost analysis of GSHP applications in various non-residential buildings in Canada, and a detailed assessment of the GSHP market, from the perspectives of both the industry and the end user. Development of the Strategy was undertaken in full consultation with key stakeholders in the GSHP industry.

The balance of this Executive Summary is presented in three sections:

- Overview
- Strategic Framework
- Potential for a Sustainable Industry
- Summary of the Market Development Strategy
- Summary of Roles
- Annex: The GSHP Life-Cycle Cost Assessment

For reasons of brevity, references and data sources have not been included in this Executive Summary. For this information, please refer to the full report.

## 2. OVERVIEW

### *The Product*

A heat pump uses the basic refrigeration cycle to extract and transfer heat. A ground source heat pump (GSHP) is a type of water loop heat pump that uses the earth or ground water as sources of heat in the winter, and as a "sink" for heat removal from the building space in the summer. Heat is removed from the earth (heating mode) or transferred to the earth (cooling mode) through a liquid, usually water or antifreeze solution.

There are two main types of GSHP systems: open loop and closed loop. The open loop system draws water from a well, lake or river and discharges it back to the source. Closed loop systems use a sealed pipe buried in the ground that circulates an antifreeze solution. The pipe can be installed in horizontal or vertical loops.

Water loop heat pumps used in GSHP applications are available in sizes from 1.5 to 300 kW (0.5 to 60 tons). The costs range from $800 to $1000/ton for the common size ranges. Higher tonnage equipment tends to display lower costs per ton. Costs for the loop are in the range of $1000/ton for horizontal loops and $1500-$1700/ton for vertical loops.

### *Current and Projected Sales*

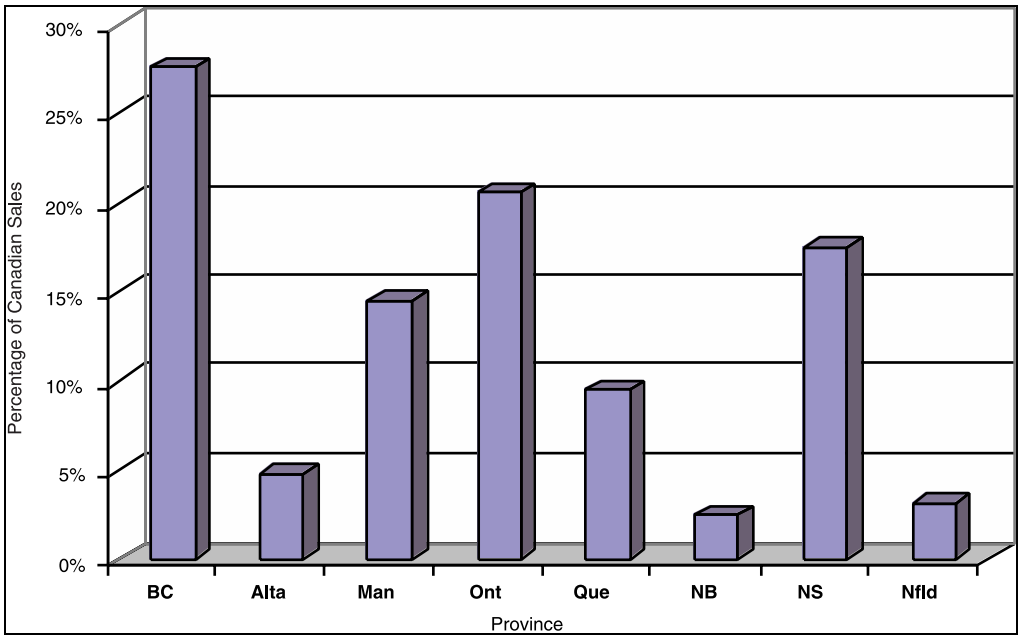
The market for GSHP sales generally falls into two major categories: new installations and replacement. For replacements, there are three possible sub-markets: replacement of an existing heat pump at the end of its useful life; replacement of the HVAC system at the end of its life; and replacement of the HVAC system prior to the end of its life (accelerated replacement, typically during a major energy retrofit or renovation).

In Canada, the 1997 sales of GSHPs in the non-residential sector are estimated to fall between 600 and 750 units. Exhibit ES-1 profiles these sales by province. B.C., Ontario and Nova Scotia represent about 63% of total sales. These sales figures underscore that GSHPs have achieved virtually no market penetration in the non-residential sector. We conservatively estimate that GSHP installations represent ***less than 1 % of the total non-residential HVAC market.***

For the residential market, estimated sales range from approximately 900 to 1500 units in 1997. Approximately 38% of the sales appear to have occurred in Ontario.

Manufacturers do indicate a high degree of optimism for the non-residential market. Projected annual sales growth for the 1999-2002 period is in the range of 10% -20% per annum. Conversely, for the residential market the projections are more conservative, falling between 2% and 5% growth per annum.

**Exhibit ES-1**
**Estimated 1997 GSHP Sales in the Non-Residential Sector:**
**By Province**




## 3. STRATEGIC FRAMEWORK

In this section we consider a number of technology marketing concepts used to predict and encourage the diffusion of new technologies.

**GSHPs represent a distinct and innovative product.** We know from our market assessment that the GSHP is an innovation requiring accelerated adoption. The market research has shown that the Canadian market associates the product with a high degree of risk, because of a lack of awareness and understanding. GSHP is still new to most adopters in both the commercial and residential sectors.

Moreover, **the GSHP is what is known as a discontinuous innovation.** Discontinuous innovations require changes in consumer behaviour or industry channels. Such innovations typically present unique barriers to adoption. Discontinuance is one of the biggest barriers to the penetration of GSHPs.

The technology adoption life-cycle is a concept that tracks the diffusion of a new technology or innovation through a number of consumer stages, each one defined by the degree to which market adoption occurs. In both the non-residential and residential markets, the **GSHP is still largely at the earliest stage in the technology adoption life-cycle,** in which the buyers are a small group characterized as "innovators"**.**

The key to the diffusion of any innovation is the ability to reduce the uncertainty or risk associated with the innovation. There are several diffusion attributes of a technology that help us identify the technology's ability to overcome uncertainty and achieve potential adoption. The key attributes have been divided into five categories, presented below with our assessment of the status of GSHP relative to these attributes:

| Perceived Attribute | Description | GSHP Residential | GSHP Non-Residential |
|---|---|---|---|
| Relative Advantage | The degree to which GSHP will perform better than any other space conditioning system. | **Opportunity** | **Opportunity** |
| Divisibility | Ability to try on a limited basis before full adoption. | **Barrier** | **Neutral** |
| Communicability | How well does the technology communicate benefits. | **Barrier** | **Barrier** |
| Compatibility | How closely does a GSHP system compare to conventional HVAC systems. | **Barrier** | **Barrier** |
| Complexity | How easy is it to understand both the benefits and features of the technology. | **Barrier** | **Barrier** |

To address the challenges posed by the need for accelerated adoption of GSHP technology, the critical requirement for change rests with the GSHP industry. The industry needs to make fundamental improvements in marketing and promotion of the product, combined with improved technical capability. In the non-residential market, uncertainty relates directly to the lack of familiarity by key influencers in this market – contractors, engineers and architects.

There is also need for change from a government policy perspective. Simply put, there is a need for government to recognise and support earth energy as a significant and viable source of energy and, hence, offer comparable treatment relative to other forms of energy (oil, natural gas, nuclear etc.).

## 4. POTENTIAL FOR A SUSTAINABLE INDUSTRY

### *Market Opportunities*

The ability to penetrate to the mainstream non-residential market is driven by the relative advantage of GSHP vs. other options, as confirmed in our life-cycle cost analysis. The following three non-residential market opportunities are listed in order of market opportunity:

- **Non-residential applications in regions not served by gas:** This market may be the easiest to penetrate as the cost advantages of GSHP are compelling.
- **Head-to-head with gas:** We believe that our life-cycle cost results present a compelling argument for the GSHP industry to consider gas-served regions as an attractive market.

- **Specialty applications:** There are applications where GSHP can provide a cost-effective solution unique to GSHP technology. This may include, for example, sites where renewable energy sources are mandated, or in northern permafrost applications.

The relative advantage of GSHP in non-residential market applications such as high schools, prisons, and seniors residences may be strong enough to drive a robust market for GSHP. This advantage is amplified when the following conditions exist:

- There is a significant heat load.
- The building owner is prepared to invest in a system with a greater than 10 year payback.
- The building owner is credit-worthy.

For the residential market, the possible residential market segments include homes not served by natural gas distribution and new residential sub-divisions. However, the GSHP industry growth projections are more conservative than for the non-residential sector…between 2% and 5% per annum. In the residential sector the first cost barrier becomes a particularly critical challenge to market growth, and therefore is likely to result in a small niche market for GSHP in Canada. In the absence of financial incentives, it will be difficult to move the technology past the early adopter stage.

***Sustainability***

A conclusion of this study is that there is a potential for a strong, sustainable market leading the increased diffusion of GSHP technology. Our conclusions are based on the following factors, among others.

- *Experience with the Geothermal Heat Pump Consortium*

In the U.S., the Geothermal Heat Pump Consortium (GHPC), a partnership of government, industry and over 240 utilities, has shown that an important first step to sustainability of this industry is a commitment from government to aggressively support GSHP market development and to build alliances and initiatives within a coalition of stakeholders. The GSHP has been particularly successful in garnering key partnership support from the electric utilities for a broad range of infrastructure improvements such as training, technical support, and inclusion of GSHPs in performance contracting carried out in federal facilities.

- *ESCO Experience*

Energy performance contracting (EPC) has become a big business in Canada…sales are approaching $400 million per annum. EPC is a turn-key engineering and management solution for non-residential facilities. The energy management investment risk is effectively transferred from the customer to the ESCO.

United States GSHP manufacturers report increases in sales of GSHP of 22% over the past year, and indicate that a good deal of this is due to the efforts of ESCOs that promote GSHP. We believe that Canadian ESCOs could similarly have positive impact on GSHP sales.

- *Experience with Ontario Hydro's Rebate Program*

In Canada, utility support of the GSHP technology has been limited. However, one major thrust into the GSHP market was the Ontario Hydro program. During the program's four year life, the industry expanded with the entry of small HVAC dealers, the start-up of Canadian manufacturers, and steep increases in sales across many sectors. This activity was stimulated by minimal promotion, and a grant that covered less than 20% of the capital cost of the system. Perhaps the real lesson of the program was the catalytic effect of the participation of Ontario Hydro. The utility brought to the table its credibility and affinity with its customer base. The industry responded based on the implied endorsement of the GSHP technology.

- *The LCC Analysis*

By far the greatest indicator of market potential is this study's finding that GSHP can compete with natural gas for non-residential applications. This conclusion is based on the life-cycle cost analysis, summarized in the Annex of this Executive Summary.

Where building owners can commit to owning and/or occupying their buildings for a period of 20 years or more, the LCC can amortize the system financing based on a 20 year term. Under this scenario the first costs disadvantage is overcome by the operating efficiencies of GSHP.

Similarly, best practice system design now used by the GSHP industry offers significant first cost reductions. By sizing GSHP systems to 75% of the heat load, the loop size can be reduced, lowering the installed cost dramatically. Any shortfall in heating capacity will occur only at peak times, roughly 2% of the heating days. And additional heat can be provided by low cost resistance or gas-fired back up systems.

With this new data, GSHP can confidently pursue a large non-residential market based on its cost competitive advantage.

## 5. SUMMARY OF THE MARKET DEVELOPMENT STRATEGY

This section summarizes the proposed Market Development Strategy, which has been developed based on the analysis and considerations highlighted above. *The primary objective of the Market Development Strategy is to provide the GSHP Industry and NRCan with the foundation for development and implementation of collaborative actions designed to grow and sustain the industry in Canada.*

The overall Market Development Strategy consists of 11 individual strategies:

### STRATEGY #1: SET MEASURABLE GOALS FOR A SUSTAINABLE INDUSTRY

The commitment of resources to the promotion of GSHP must be tied to measurable goals that relate to the creation of a sustainable industry.

### STRATEGY #2: ESTABLISH A PROGRAM WITH A THREE YEAR COMMITMENT TO ACHIEVING THESE GOALS

A defined program with measurable goals over a set period of time presents a defined challenge to stakeholders and the GSHP industry. We recommend a three year GSHP initiative with achievable goals in all areas of Canada within this period.

### STRATEGY #3: CREATE AN ALLIANCE: CANADIAN GEOTHERMAL ENERGY COALITION (CGEC) FOR THE SOLE PURPOSE OF MANAGING THIS PROGRAM

A concerted and integrated effort is required to achieve these goals within 3 years. This effort will be driven by a coalition of public and private sector stakeholders established for the express purpose of implementing the program within a limited time period.

### STRATEGY #4: POSITION THE GSHP OPTION

Positioning is aimed at articulating a clear position for GSHP technology compared to other space conditioning options in the minds of purchase decision makers. GSHP is an integrated technology that offers unique benefits compared to other options, including natural gas systems.

### STRATEGY #5: REDUCE TECHNICAL UNCERTAINTY

To alleviate technical uncertainty, market influencers must be provided with the information they need to reduce their sense of uncertainty. The strategy would be designed to address the technical advantages of the product. It would also focus on the primary technical problems through initiatives such as an integrated design and LCC calculation standards manual and software; bid spec guidelines; updated installation guidelines; building design integration manual for architects; and technical resources such as a website, reference sites, and monitored sites.

### STRATEGY #6: CREATE INSTALLER TRAINING MANUAL AND CERTIFICATION PROGRAM

Standardized installation training materials for GSHP installers and a certification program will be developed and made available to manufacturers and their Canadian distributors. However, **delivery** of training and installer certification will be the responsibility of the industry.

### STRATEGY #7: COMMITMENT BY GOVERNMENT TO THE GSHP OPTION

Federal and Provincial governments would issue a procurement policy directive to apply a uniform LCC method for every new or replacement space conditioning system in government

buildings. In addition, all energy efficiency initiatives for government buildings would be targeted to persuade program mangers to include the GSHP option within the program guidelines (in particular, through the FBI, CBIP and Innovators programs).

### STRATEGY # 8: CREATE AWARENESS FOR THE GSHP OPTION

An integrated marketing communications campaign will be designed to make purchase decision makers aware of the GSHP option. While this campaign could utilize different media, it would likely include: public relations activities, seminars, mailings, advertising in trade publications, attendance at trade shows, and a website.

### STRATEGY #9 : DEVELOP SALES MATERIALS

Creation of a comprehensive and flexible GSHP presentation kit directed at non-technical decision makers is an important step. To secure buy-in to the GSHP option, non-technical executives require a basic understanding of GSHP benefits, features, and relative advantage.

### STRATEGY #10: UTILIZE INNOVATIVE FINANCING

New and innovative financing will foster growth in the GSHP industry. Because of the higher first cost of GSHP systems, lowering the borrowing cost or appropriately structuring the term of the loan can significantly increase the relative advantage of GSHPs. Some suggested financing schemes include energy credits, loop financing, site feasibility study financing, buying down the cost of term borrowing, lengthening amortization of loans, and environmental credits.

### STRATEGY #11: INVEST IN R&D

Like all technologies, GSHP is dynamic and there are several areas where the technology could be enhanced. GSHP offers many unique benefits and technical challenges that will benefit from ongoing research and development, including areas germane to Canada's climate or geology.

## 6. SUMMARY OF ROLES

Stakeholder commitment and participation is a requirement for making this program work. Suggested roles and responsibilities for key stakeholder groups are outlined below.

### NRCan

Like its counterpart in the United States, initially NRCan will be the champion for GSHP in Canada. Its contribution may include seed money for the consultative stage as well as administrative support until the major stakeholders have bought into the program and a coalition is up and running. Later NRCan may contribute funding within a pre-set cost sharing formula that spreads the costs across all the stakeholders.

**Electrical Utilities**

Canadian electrical utilities must play an active role in supporting this program, and it is in their interest to do so. What they bring to the program in terms of customer relationships and credibility is the basis of most successful energy efficiency initiatives.

**Government Building Managers**

Facilities managers at federal buildings, and program managers of Federal Building Initiatives, should factor both the environmental and economical benefits of a GSHP option into their evaluation of space conditioning system installations and retrofits. Provincial Government building managers and program managers should also be actively encouraged to incorporate a GSHP option into their evaluation of space conditioning in provincial buildings and schools.

**Canadian Earth Energy Society (CEES)**

The members of CEES can play a pivotal role as the industry champions of this technology in Canada. There are a number of issues and activities that will benefit from CEES's industry knowledge. For example, CEES can take the lead in updating and preparing installer training modules, or in spearheading a certification program tied to training and installation standards.

**Manufacturers**

There is little expectation for significant developmental funding from manufacturers outside of CEES. However, they will be asked to support the recommendations set out here; to participate in setting standards and training; and to cost-share and follow-through on promotional initiatives.

**Contractors, Dealers and Distributors**

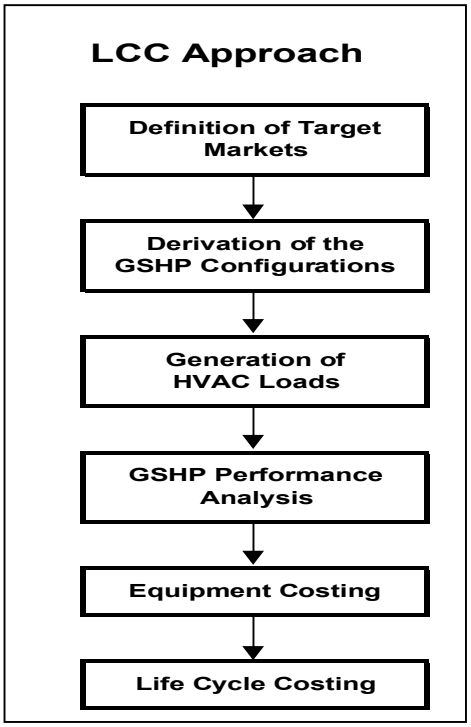
A key role for the program is to work with manufacturers to engender confidence among their dealers and installers as to the efficacy of the technology, the practicality of the system design, and the availability of support and assistance during and after the installation and commissioning. Training, certification and after sales support for control logic and software are means by which CGEC can build a cadre of committed dealers and contractors.

# ANNEX: THE GSHP LIFE-CYCLE COST ASSESSMENT

This Annex presents an assessment of the cost competitiveness of GSHP applications in the non-residential market. The "measure" of competitiveness is the life-cycle cost (LCC) of the system, in comparison to one or more competing systems. *The primary objective of the LCC analysis was to compare the financial performance of GSHP systems, over the useful lives of these systems, with conventional space conditioning options, in a small selection of possible target markets.*

### *LCC approach*

A five step approach, as shown on this page, was used to carry out the LCC analysis. Two of these stages – the derivation of the GSHP configuration and the costing of equipment – are particularly critical and often contentious elements of the GSHP LCC analysis. We chose to apply an iterative approach to these LCC elements. Initially, a "conservative" approach to configuring and costing the system was applied. This reflected an intention to use what is well accepted within the GSHP industry.




However, during the market assessment portion of this study, discussions with several leading edge practitioners revealed proven GSHP applications that advanced the cost and performance optimization of the systems. Consequently, following an initial draft of LCC scenarios, the client was presented with, and approved, several key changes to the LCC assumptions. Those changes are reflected in the results presented in this document.

### *Results*

As elaborated below, the LCC results reinforce the assertions of the GSHP industry that these systems can compete effectively on a cost basis with conventional space conditioning systems. These results provide a positive foundation for the Market Development Strategy.

Exhibits ES-2 and ES-3 summarize the results of the core scenario LCC analysis and payback periods. The tables show the capital and replacement costs. The capital costs for the GSHP system are separated into the heat pump and loop costs. The replacement costs are for those systems that have a shorter life than the 20 years assigned to GSHP systems. Both O&M and energy costs are also shown in the table. The energy costs are separated into cooling, heating and incremental demand costs applicable only to the GSHP system, since the baseline system is assumed to be either gas or oil heating.

Finally, both the LCC and payback periods are shown in the last three columns. The LCC shows both the total life-cycle cost and a "pass/fail" score. This score is simply a comparison of the

GSHP LCC vs. the base case system. A pass is indicated by a lower total LCC of the GSHP system compared to the baseline. A score of "marginal" is subjectively applied to those GSHP systems that have higher LCCs but are within 10% of the base case. The payback period is shown in years.

The tables show the following results:

- Of the total 135 GSHP options, covering 12 building types and four geographical regions, only 10 did not generate life-cycle costs below that of the base case system.

- Six of the 10 scenarios that did not pass are comparisons with gas base case systems. Gas prices (per unit of energy input) tend to be lower than either electricity or oil.

- Eight of the 10 scenarios that did not pass actually fall into the category of "marginal", suggesting that even in these situations, the GSHP systems could compete successfully.

- Payback periods are shown to range from 0 (those cases that show a lower capital cost for the GSHP system compared to the base case) to a high of 40 years for elementary schools in Toronto. The average payback period for all the segments and regions is approximately 6 years with most falling in the 4 to 8 year range.

- The buildings with the best payback periods are the offices (both the high tech and the suburban office) which have payback periods of 0 years. The next segments with the best payback periods are arenas and curling rinks which show payback periods of 1 to 5 years. The third best segment is the high school with payback periods of 4 to 6 years.

- The cost increment of the GSHP system is lower in the office segment and some of the curling rinks. This is due to the trade-off in mechanical equipment between the base case and the GSHP configuration.

- Both from an LCC and payback period standpoint, the potential "winners" cut across all of the target building segments. The "weakest" results pertain to the elementary schools. This appears to be due to the fact that these buildings are assumed to have a very low seasonal heating load.

As previously noted, the focus of the LCC analysis has been on GSHP applications in new construction. Of course, existing non-residential facilities represent a much larger space conditioning market. Some observations of how the LCC might change under a retrofit scenario are presented below:

- The applicability of GSHP systems in existing buildings is realistically limited to situations of large building renovations where all the mechanical equipment is being replaced. Such conditions assume the requirement for new distribution systems (both air and water systems). There would be very little difference between such a scenario and new construction and therefore no practical limitations to install GSHP systems.

- Cost comparisons and equipment tradeoffs between the competing system and the GSHP system would be similar to new construction. As an example, consider a school renovation where only the building shell remains. Such a renovation could equally consider the use of classroom cabinets as the baseline alternative or ceiling mounted heat pump with a ground loop as the GSHP alternative.

- There could be pronounced differences in the LCC results depending on whether the renovation also includes improvements of the building thermal envelope. Generally, the thermal performance of a new building is much better than a comparable existing building. For this reason existing buildings will normally have larger heating plants and higher heating energy use per unit floor area, compared to a similar new facility. Under these circumstances, the LCC of GSHP systems might actually be lower and compare more favorably with the base case systems.

***Sensitivity analysis***

The final LCC outputs are built from a complex foundation of inputs pertaining to both technical performance and costs. Accordingly, a sensitivity analysis was applied to test for the possible impacts on the LCC of varying selected input costs and performance. The key observations are as follows:

- None of the changes adversely affect the comparison with the oil based systems. This indicates that the GSHP can be quite "robust" in its ability to compete in the oil market.

- Only one variable brings the GSHP system LCC above that of the gas base case system – an increase in the GSHP system cost. The relatively steep slope of the GSHP cost line indicates that this variable is the most sensitive of the inputs.

**Exhibit ES-2**

**Results of Life Cycle Costing - Comparison to Gas Base Case**

| Building Segment | Location | | Loop Type | Capital Cost | Loop Cost | Replace Cost | O&M Cost | Region Specific Energy Cost | | | Region Specifc LCC | | Paybck Period |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Cooling | Demand | Space Heat | | | |
| | | | | ($) | ($) | ($) | ($) | ($/y) | ($/y) | ($/y) | ( $ ) | (pass/fail) | (years) |
| **New Elementary Schools (32,000 ft_)** | | | | | | | | | | | | | |
| | Montreal | base | | 104,481 | | 45,965 | 4,650 | 1,008 | | 8,194 | 252,562 | | |
| | | GSHP w Elec | horizontal | 93,635 | 63,000 | 0 | 2,325 | 428 | 3,690 | 3,570 | 254,947 | Marginal | 13.6 |
| | | GSHP w FF | horizontal | 104,742 | 63,000 | 0 | 3,825 | 428 | 3,690 | 3,522 | 280,305 | Fail | 26.5 |
| | Toronto | base | | 115,290 | | 50,720 | 4,650 | 1,458 | | 6,375 | 250,616 | | |
| | | GSHP w Elec | horizontal | 103,322 | 63,000 | 0 | 2,325 | 619 | 1,770 | 4,982 | 261,522 | Marginal | 18.3 |
| | | GSHP w FF | horizontal | 113,050 | 63,000 | 0 | 3,825 | 619 | 1,770 | 4,818 | 284,366 | Fail | 41.9 |
| | Vancouver | base | | 110,786 | | 48,739 | 4,650 | 550 | | 4,090 | 213,577 | | |
| | | GSHP w Elec | horizontal | 72,595 | 42,000 | 0 | 2,325 | 234 | 1,890 | 1,918 | 177,101 | Pass | 1.3 |
| | | GSHP w FF | horizontal | 80,774 | 42,000 | 0 | 3,825 | 234 | 1,890 | 1,900 | 199,837 | Pass | 8.3 |
| **Senior Complexes (84,000 ft_)** | | | | | | | | | | | | | |
| | Moncton | base | | 513,734 | | 64,280 | 15,750 | 4,292 | | 44,243 | 1,170,362 | | |
| | | GSHP w Elec | horizontal | 555,060 | 126,000 | 0 | 7,875 | 1,467 | 17,220 | 15,201 | 1,091,096 | Pass | 7.6 |
| | | GSHP w FF | horizontal | 576,839 | 126,000 | 0 | 9,375 | 1,467 | 17,220 | 14,971 | 1,125,342 | Pass | 9.7 |
| | | GWHP | well | 555,060 | 27,000 | 0 | 7,875 | 1,467 | 17,220 | 15,201 | 992,096 | Pass | 1.5 |
| | Toronto | base | | 614,560 | | 76,896 | 15,750 | 4,968 | | 29,396 | 1,131,350 | | |
| | | GSHP w Elec | horizontal | 612,480 | 126,000 | 0 | 7,875 | 2,109 | 8,195 | 20,488 | 1,118,117 | Pass | 10.8 |
| | | GSHP w FF | horizontal | 630,336 | 126,000 | 0 | 9,375 | 2,109 | 8,195 | 19,731 | 1,143,271 | Marginal | 13.2 |
| | | GWHP | well | 612,480 | 32,000 | 0 | 7,875 | 2,109 | 8,195 | 20,488 | 1,024,117 | Pass | 2.6 |
| | Vancouver | base | | 587,479 | | 73,892 | 15,750 | 2,112 | | 23,750 | 1,018,107 | | |
| | | GSHP w Elec | horizontal | 535,419 | 84,000 | 0 | 7,875 | 897 | 6,010 | 8,690 | 849,864 | Pass | 1.8 |
| | | GSHP w FF | horizontal | 550,087 | 84,000 | 0 | 9,375 | 897 | 6,010 | 8,589 | 878,268 | Pass | 2.8 |
| | | GWHP | well | 535,419 | 21,000 | 0 | 7,875 | 858 | 6,010 | 8,441 | 784,045 | Pass | 0.0 |
| **High Technology Facilities (75,000 ft_)** | | | | | | | | | | | | | |
| 3-Storey, 25,000 ft_ footprint | Toronto | base | | 393,184 | | 0 | 10,000 | 4,612 | | 14,639 | 685,001 | | |
| | | GSHP w Elec | horizontal | 255,360 | 84,000 | 0 | 7,500 | 1,958 | 8,850 | 11,159 | 628,668 | Pass | 0.0 |
| | | GSHP w FF | horizontal | 270,624 | 84,000 | 0 | 9,000 | 1,958 | 6,018 | 10,782 | 627,155 | Pass | 0.0 |
| | | GWHP | well | 255,360 | 25,000 | 0 | 7,500 | 1,110 | 8,850 | 11,159 | 561,350 | Pass | 0.0 |
| **Recreational - Curling Rink (12,000 ft_)** | | | | | | | | | | | | | |
| | Toronto | base | | 35,811 | | 0 | 2,750 | 3,780 | | 2,432 | 125,295 | | |
| | | GSHP w Elec | horizontal | 21,800 | 14,000 | 0 | 875 | 1,843 | | 1,791 | 80,074 | Pass | 0.0 |
| | | GSHP w FF | horizontal | 24,178 | 14,000 | 0 | 1,125 | 1,843 | | 1,729 | 84,292 | Pass | 0.6 |
| | Winnipeg | base | | 35,811 | | 0 | 2,750 | 2,240 | | 2,786 | 113,367 | | |
| | | GSHP w Elec | horizontal | 21,800 | 14,000 | 0 | 875 | 1,092 | | 1,199 | 66,885 | Pass | 0.0 |
| | | GSHP w FF | horizontal | 24,178 | 14,000 | 0 | 1,125 | 1,092 | | 1,179 | 71,523 | Pass | 0.5 |

**Exhibit ES-2 (continued)**
**Results of Life Cycle Costing - Comparison to Gas Base Case**

| Building Segment | Location | | Loop Type | Capital Cost | Loop Cost | Replace Cost | O&M Cost | Region Specific Energy Cost | | | Region Specifc LCC | | Paybck Period |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Cooling | Demand | Space Heat | | | |
| | | | | ($) | ($) | ($) | ($) | ($/y) | ($/y) | ($/y) | ( $ ) | (pass/fail) | (years) |
| **Recreational - Hockey Arena (25,000 ft_)** | | | | | | | | | | | | | |
| | Montreal | base | | 55,622 | | 0 | 4,500 | 9,000 | | 3,420 | 224,733 | | |
| | | GSHP w Elec | horizontal | 64,433 | 35,000 | 0 | 1,750 | 4,585 | | 1,369 | 175,065 | Pass | 4.8 |
| | | GSHP w FF | horizontal | 69,189 | 35,000 | 0 | 2,250 | 4,585 | | 1,353 | 184,576 | Pass | 5.6 |
| **Mid-Size Hotel (2-3 Star) (113,000 ft_)** | | | | | | | | | | | | | |
| 240 Suite Hotel | Montreal | base | | 423,238 | | 211,619 | 14,000 | 6,768 | | 85,556 | 1,534,752 | | |
| | | GSHP w Elec | vertical | 504,484 | 140,000 | 0 | 7,000 | 2,873 | 26,568 | 32,342 | 1,319,802 | Pass | 5.9 |
| | | GSHP w FF | vertical | 526,263 | 140,000 | 0 | 8,500 | 2,873 | 26,568 | 31,835 | 1,351,335 | Pass | 6.6 |
| | Toronto | base | | 467,021 | | 233,510 | 14,000 | 11,448 | | 62,050 | 1,393,870 | | |
| | | GSHP w Elec | vertical | 556,672 | 140,000 | 0 | 7,000 | 4,860 | 9,824 | 41,766 | 1,319,623 | Pass | 9.5 |
| | | GSHP w FF | vertical | 574,528 | 140,000 | 0 | 8,500 | 4,860 | 9,824 | 40,168 | 1,336,524 | Pass | 10.3 |
| | Vancouver | base | | 448,778 | | 224,389 | 14,000 | 3,520 | | 43,568 | 1,108,020 | | |
| | | GSHP w Elec | vertical | 521,397 | 122,500 | 0 | 7,000 | 1,430 | 4,857 | 15,697 | 928,469 | Pass | 6.1 |
| | | GSHP w FF | vertical | 533,297 | 122,500 | 0 | 8,500 | 1,430 | 4,857 | 15,512 | 953,278 | Pass | 6.7 |
| **Motel / Travel Lodge (22,000 ft_)** | | | | | | | | | | | | | |
| 60 Suite Days Inn Motel | Montreal | base | | 84,648 | | 50,067 | 4,125 | 1,325 | | 16,667 | 316,860 | | |
| | | GSHP w Elec | horizontal | 100,897 | 28,000 | 0 | 2,050 | 562 | 4,982 | 6,309 | 265,398 | Pass | 5.4 |
| | | GSHP w FF | horizontal | 105,253 | 28,000 | 0 | 3,550 | 562 | 4,982 | 6,210 | 283,513 | Pass | 7.1 |
| | | GWHP | well | 100,897 | 16,000 | 0 | 2,050 | 562 | 4,982 | 6,309 | 253,398 | Pass | 3.9 |
| | Toronto | base | | 93,404 | | 55,246 | 4,125 | 2,225 | | 12,089 | 289,734 | | |
| | | GSHP w Elec | horizontal | 111,334 | 28,000 | 0 | 2,050 | 944 | 1,770 | 8,150 | 266,132 | Pass | 8.3 |
| | | GSHP w FF | horizontal | 114,906 | 28,000 | 0 | 3,550 | 944 | 1,770 | 7,839 | 281,375 | Pass | 11.4 |
| | | GWHP | well | 111,334 | 16,000 | 0 | 2,050 | 944 | 1,770 | 8,150 | 254,132 | Pass | 6.1 |
| | Vancouver | base | | 89,756 | | 53,088 | 4,125 | 685 | | 8,471 | 233,739 | | |
| | | GSHP w Elec | horizontal | 104,279 | 24,500 | 0 | 2,050 | 278 | 945 | 3,131 | 191,656 | Pass | 5.7 |
| | | GSHP w FF | horizontal | 106,659 | 24,500 | 0 | 3,550 | 278 | 945 | 3,095 | 208,410 | Pass | 7.6 |
| | | GWHP | well | 104,279 | 14,000 | 0 | 2,050 | 278 | 945 | 3,042 | 180,285 | Pass | 4.1 |
| **Suburban Office (mid-sized) (56,000 ft_)** | | | | | | | | | | | | | |
| 3-Storey, 18,750 ft_ footprint | Moncton | base | | 246,508 | | 0 | 9,375 | 2,900 | | 15,717 | 525,813 | | |
| | | GSHP w Elec | vertical | 160,099 | 56,000 | 0 | 4,690 | 1,146 | 4,150 | 9,252 | 404,972 | Pass | 0.0 |
| | | GSHP w FF | vertical | 169,669 | 56,000 | 0 | 6,190 | 1,146 | 4,150 | 8,995 | 426,752 | Pass | 0.0 |
| | Montreal | base | | 267,242 | | 0 | 9,375 | 2,376 | | 16,722 | 551,391 | | |
| | | GSHP w Elec | vertical | 173,565 | 63,000 | 0 | 4,690 | 1,009 | 9,225 | 6,837 | 450,213 | Pass | 0.0 |
| | | GSHP w FF | vertical | 183,940 | 63,000 | 0 | 6,190 | 1,009 | 9,225 | 6,738 | 474,344 | Pass | 0.0 |
| | Toronto | base | | 294,888 | | 0 | 9,375 | 3,445 | | 10,979 | 532,024 | | |
| | | GSHP w Elec | vertical | 191,520 | 63,000 | 0 | 4,690 | 1,462 | 2,950 | 8,211 | 424,502 | Pass | 0.0 |
| | | GSHP w FF | vertical | 202,968 | 63,000 | 0 | 6,190 | 1,462 | 2,950 | 7,928 | 447,902 | Pass | 0.0 |
| | Vancouver | base | | 283,369 | | 0 | 9,375 | 1,677 | | 11,321 | 506,154 | | |
| | | GSHP w Elec | vertical | 184,039 | 56,000 | 0 | 4,690 | 681 | 2,520 | 4,524 | 361,930 | Pass | 0.0 |
| | | GSHP w FF | vertical | 195,040 | 56,000 | 0 | 6,190 | 681 | 2,520 | 4,475 | 387,185 | Pass | 0.0 |

**Exhibit ES-2(continued)**
**Results of Life Cycle Costing - Comparison to Gas Base Case**

| Building Segment | Location | | Loop Type | Capital Cost | Loop Cost | Replace Cost | O&M Cost | Region Specific Energy Cost | | | Region Specifc LCC | | Paybck Period |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Cooling | Demand | Space Heat | | | |
| | | | | ($) | ($) | ($) | ($) | ($/y) | ($/y) | ($/y) | ( $ ) | (pass/fail) | (years) |
| **Retail (Strip Mall)** | | | | | | | | | | | | | |
| | Montreal | base | | 48,488 | | 36,366 | 3,000 | 950 | | 5,611 | 151,745 | | |
| | | GSHP w Elec | horizontal | 39,608 | 28,000 | | 1,500 | 403 | 1,422 | 2,349 | 123,317 | Pass | 4.9 |
| | | GSHP w FF | horizontal | 46,336 | 28,000 | | 1,750 | 403 | 1,422 | 2,315 | 132,173 | Pass | 7.0 |
| | Toronto | base | | 53,504 | | 40,128 | 3,000 | 1,361 | | 4,191 | 147,412 | | |
| | | GSHP w Elec | horizontal | 43,706 | 24,500 | | 1,500 | 578 | 597 | 3,157 | 125,463 | Pass | 5.4 |
| | | GSHP w FF | horizontal | 50,586 | 24,500 | | 1,750 | 578 | 597 | 3,049 | 133,738 | Pass | 8.4 |
| **Residential Subdivison** | | | | | | | | | | | | | |
| | Toronto | base | | 120,000 | | 1,200 | | 4,899 | | 10,832 | 278,489 | | |
| | | GSHP | vertical | 186,000 | | | | 2,080 | | 9,153 | 296,287 | Marginal | 14.7 |
| | Winnipeg | base | | 120,000 | | 1,200 | | 2,883 | | 24,040 | 391,065 | | |
| | | GSHP | vertical | 186,000 | | | | 1,224 | | 11,863 | 314,487 | Pass | 4.8 |
| | Kamloops (B( | base | | 120,000 | | 1,200 | | 3,706 | | 16,419 | 322,682 | | |
| | | GSHP | vertical | 186,000 | | | | 1,506 | | 9,618 | 295,211 | Pass | 7.3 |
| **High Rise Condominium (95,000 ft_)** | | | | | | | | | | | | | |
| | Toronto | base | | 140,621 | | 52,000 | 7,700 | 1,685 | | 23,989 | 485,622 | | |
| | | GSHP w Elec | horizontal | 132,596 | 77,000 | | 3,850 | 715 | 5,310 | 16,012 | 463,756 | Pass | 9.2 |
| | | GSHP w FF | horizontal | 140,136 | 77,000 | | 3,850 | 715 | 5,310 | 15,394 | 465,233 | Pass | 9.4 |
| | Winnipeg | base | | 155,168 | | 52,000 | 10,500 | 998 | | 32,489 | 606,255 | | |
| | | GSHP w Elec | horizontal | 133,376 | 105,000 | | 5,250 | 424 | 14,170 | 13,758 | 568,286 | Pass | 8.0 |
| | | GSHP w FF | horizontal | 141,696 | 105,000 | | 5,250 | 424 | 14,170 | 13,527 | 574,339 | Pass | 8.6 |
| | Kamloops | base | | 149,107 | | 52,000 | 7,700 | 1,690 | | 21,454 | 468,660 | | |
| | | GSHP w Elec | horizontal | 128,166 | 77,000 | | 3,850 | 687 | 5,670 | 7,695 | 380,929 | Pass | 4.3 |
| | | GSHP w FF | horizontal | 136,161 | 77,000 | | 3,850 | 687 | 5,670 | 7,620 | 388,188 | Pass | 4.9 |
| **High School (127,000 ft_)** | | | | | | | | | | | | | |
| | Moncton | base | | 490,680 | | 65,000 | 20,300 | 5,986 | | 35,139 | 1,117,594 | | |
| | | GSHP w Elec | horizontal | 447,488 | 189,000 | | 9,450 | 3,044 | 8,850 | 17,615 | 1,018,997 | Pass | 5.6 |
| | | GSHP w FF | horizontal | 455,808 | 189,000 | | 9,450 | 3,044 | 8,850 | 17,001 | 1,021,290 | Pass | 6.1 |
| | Kamloops | base | | 552,270 | | 85,000 | 18,900 | 4,826 | | 21,296 | 1,018,818 | | |
| | | GSHP w Elec | horizontal | 430,008 | 189,000 | | 9,450 | 1,961 | 9,750 | 8,373 | 908,974 | Pass | 4.3 |
| | | GSHP w FF | horizontal | 438,003 | 189,000 | | 9,450 | 1,961 | 9,750 | 8,299 | 916,238 | Pass | 4.8 |

**Exhibit ES-3**

**Results of Life Cycle Costing - Comparison to Oil Base Case**

| Building Segment | Location | | Loop Type | Capital Cost | Loop Cost | Replace Cost | O&M Cost | Region Specific Energy Cost | | | Region Specifc LCC | | Paybck Period |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Cooling | Demand | Space Heat | | | |
| | | | | ($) | ($) | ($) | ($) | ($/y) | ($/y) | ($/y) | ( $ ) | (pass/fail) | (years) |
| **New Elementary Schools (32,000 ft_)** | | | | | | | | | | | | | |
| | Moncton | base | | 96,375 | | 42,399 | 4,650 | 1,253 | | 9,168 | 255,946 | | |
| | | GSHP w Elec | horizontal | 86,370 | 63,000 | 0 | 2,325 | 495 | 2,490 | 5,624 | 256,722 | Marginal | 12.8 |
| | | GSHP w FF | horizontal | 91,212 | 63,000 | 0 | 3,825 | 495 | 2,490 | 5,475 | 274,822 | Marginal | 20.8 |
| | Montreal | base | | 104,481 | | 45,965 | 4,650 | 1,008 | | 12,292 | 293,775 | | |
| | | GSHP w Elec | horizontal | 93,635 | 63,000 | 0 | 2,325 | 428 | 3,690 | 3,570 | 254,947 | Pass | 6.6 |
| | | GSHP w FF | horizontal | 104,742 | 63,000 | 0 | 3,825 | 428 | 3,690 | 3,604 | 281,110 | Pass | 9.9 |
| | Toronto | base | | 115,290 | | 50,720 | 4,650 | 1,458 | | 9,563 | 282,678 | | |
| | | GSHP w Elec | horizontal | 103,322 | 63,000 | 0 | 2,325 | 619 | 1,770 | 4,982 | 261,522 | Pass | 8.5 |
| | | GSHP w FF | horizontal | 113,050 | 63,000 | 0 | 3,825 | 619 | 1,770 | 4,882 | 284,992 | Marginal | 13.3 |
| | Vancouver | base | | 110,786 | | 48,739 | 4,650 | 550 | | 6,135 | 234,148 | | |
| | | GSHP w Elec | horizontal | 72,595 | 42,000 | 0 | 2,325 | 234 | 1,890 | 1,918 | 177,101 | Pass | 0.8 |
| | | GSHP w FF | horizontal | 80,774 | 42,000 | 0 | 3,825 | 234 | 1,890 | 1,941 | 200,238 | Pass | 3.5 |
| **Senior Complexes (84,000 ft_)** | | | | | | | | | | | | | |
| | Moncton | base | | 513,734 | | 64,280 | 15,750 | 4,292 | | 44,243 | 1,170,362 | | |
| | | GSHP w Elec | horizontal | 511,995 | 126,000 | 0 | 7,875 | 1,695 | 11,529 | 24,250 | 1,083,239 | Pass | 6.6 |
| | | GSHP w FF | horizontal | 526,922 | 126,000 | 0 | 9,375 | 1,695 | 11,529 | 23,528 | 1,105,807 | Pass | 7.7 |
| | | GWHP | well | 511,995 | 27,000 | 0 | 7,875 | 1,695 | 11,529 | 24,250 | 984,239 | Pass | 1.3 |
| | Montreal | base | | 556,945 | | 69,687 | 15,750 | 3,456 | | 58,333 | 1,348,054 | | |
| | | GSHP w Elec | horizontal | 555,060 | 126,000 | 0 | 7,875 | 1,467 | 17,220 | 15,201 | 1,091,096 | Pass | 3.5 |
| | | GSHP w FF | horizontal | 576,839 | 126,000 | 0 | 9,375 | 1,467 | 17,220 | 15,360 | 1,129,160 | Pass | 4.3 |
| | | GWHP | well | 555,060 | 27,000 | 0 | 7,875 | 1,467 | 17,220 | 15,201 | 992,096 | Pass | 0.7 |
| | Toronto | base | | 614,560 | | 76,896 | 15,750 | 4,968 | | 44,094 | 1,279,192 | | |
| | | GSHP w Elec | horizontal | 612,480 | 126,000 | 0 | 7,875 | 2,109 | 8,195 | 20,488 | 1,118,117 | Pass | 4.7 |
| | | GSHP w FF | horizontal | 630,336 | 126,000 | 0 | 9,375 | 2,109 | 8,195 | 20,025 | 1,146,158 | Pass | 5.6 |
| | | GWHP | well | 612,480 | 32,000 | 0 | 7,875 | 2,109 | 8,195 | 20,488 | 1,024,117 | Pass | 1.1 |
| | Vancouver | base | | 587,479 | | 73,892 | 15,750 | 2,112 | | 35,625 | 1,137,554 | | |
| | | GSHP w Elec | horizontal | 535,419 | 84,000 | 0 | 7,875 | 897 | 6,010 | 8,690 | 849,864 | Pass | 1.1 |
| | | GSHP w FF | horizontal | 550,087 | 84,000 | 0 | 9,375 | 897 | 6,010 | 8,826 | 880,600 | Pass | 1.6 |
| | | GWHP | well | 535,419 | 21,000 | 0 | 7,875 | 858 | 6,010 | 8,441 | 784,045 | Pass | 0.0 |
| **High Technology Facilities (75,000 ft_)** | | | | | | | | | | | | | |
| 3-Storey, 25,000 ft_ footprint | Toronto | base | | 393,184 | | 0 | 10,000 | 4,612 | | 21,958 | 758,625 | | |
| | | GSHP w Elec | horizontal | 255,360 | 84,000 | 0 | 7,500 | 1,958 | 8,850 | 11,159 | 628,668 | Pass | 0.0 |
| | | GSHP w FF | horizontal | 270,624 | 84,000 | 0 | 9,000 | 1,958 | 6,018 | 10,929 | 628,592 | Pass | 0.0 |
| | | GWHP | well | 255,360 | 25,000 | 0 | 7,500 | 1,110 | 8,850 | 11,159 | 561,350 | Pass | 0.0 |
| **Recreational - Curling Rink (12,000 ft_)** | | | | | | | | | | | | | |
| | Toronto | base | | 35,811 | | 0 | 2,750 | 3,780 | | 3,648 | 137,526 | | |
| | | GSHP w Elec | horizontal | 21,800 | 14,000 | 0 | 875 | 1,843 | | 1,791 | 80,074 | Pass | 0.0 |
| | | GSHP w FF | horizontal | 24,178 | 14,000 | 0 | 1,125 | 1,843 | | 1,753 | 84,531 | Pass | 0.4 |
| | Winnipeg | base | | 35,811 | | 0 | 2,750 | 2,240 | | 4,179 | 127,380 | | |
| | | GSHP w Elec | horizontal | 21,800 | 14,000 | 0 | 875 | 1,092 | | 1,199 | 66,885 | Pass | 0.0 |
| | | GSHP w FF | horizontal | 24,178 | 14,000 | 0 | 1,125 | 1,092 | | 1,207 | 71,797 | Pass | 0.4 |

**Exhibit ES-3 (continued)**
**Results of Life Cycle Costing - Comparison to Oil Base Case**

| Building Segment | Location | | Loop Type | Capital Cost | Loop Cost | Replace Cost | O&M Cost | Region Specific Energy Cost | | | Region Specifc LCC | | Paybck Period |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Cooling | Demand | Space Heat | | | |
| | | | | ($) | ($) | ($) | ($) | ($/y) | ($/y) | ($/y) | ( $ ) | (pass/fail) | (years) |
| **Recreational - Hockey Arena (25,000 ft_)** | | | | | | | | | | | | | |
| | Montreal | base | | 55,622 | | 0 | 4,500 | 9,000 | | 5,130 | 241,933 | | |
| | | GSHP w Elec | horizontal | 64,433 | 35,000 | 0 | 1,750 | 4,585 | | 1,369 | 175,065 | Pass | 4.0 |
| | | GSHP w FF | horizontal | 69,189 | 35,000 | 0 | 2,250 | 4,585 | | 1,379 | 184,835 | Pass | 4.7 |
| **Mid-Size Hotel (2-3 Star) (113,000 ft_)** | | | | | | | | | | | | | |
| 240 Suite Hotel | Montreal | base | | 423,238 | | 211,619 | 14,000 | 6,768 | | 128,333 | 1,965,041 | | |
| | | GSHP w Elec | vertical | 504,484 | 140,000 | 0 | 7,000 | 2,873 | 26,568 | 32,342 | 1,319,802 | Pass | 2.8 |
| | | GSHP w FF | vertical | 526,263 | 140,000 | 0 | 8,500 | 2,873 | 26,568 | 32,691 | 1,359,735 | Pass | 3.1 |
| | Toronto | base | | 467,021 | | 233,510 | 14,000 | 11,448 | | 93,075 | 1,705,942 | | |
| | | GSHP w Elec | vertical | 556,672 | 140,000 | 0 | 7,000 | 4,860 | 9,824 | 41,766 | 1,319,623 | Pass | 4.2 |
| | | GSHP w FF | vertical | 574,528 | 140,000 | 0 | 8,500 | 4,860 | 9,824 | 40,789 | 1,342,616 | Pass | 4.5 |
| | Vancouver | base | | 448,778 | | 224,389 | 14,000 | 3,520 | | 65,352 | 1,327,140 | | |
| | | GSHP w Elec | vertical | 521,397 | 122,500 | 0 | 7,000 | 1,430 | 4,857 | 15,697 | 928,469 | Pass | 3.6 |
| | | GSHP w FF | vertical | 533,297 | 122,500 | 0 | 8,500 | 1,430 | 4,857 | 15,947 | 957,555 | Pass | 4.0 |
| **Motel / Travel Lodge (22,000 ft_)** | | | | | | | | | | | | | |
| 60 Suite Days Inn Motel | Montreal | base | | 84,648 | | 50,067 | 4,125 | 1,325 | | 25,000 | 400,683 | | |
| | | GSHP w Elec | horizontal | 100,897 | 28,000 | 0 | 2,050 | 562 | 4,982 | 6,309 | 265,398 | Pass | 2.7 |
| | | GSHP w FF | horizontal | 105,253 | 28,000 | 0 | 3,550 | 562 | 4,982 | 6,377 | 285,149 | Pass | 3.2 |
| | | GWHP | well | 100,897 | 16,000 | 0 | 2,050 | 562 | 4,982 | 6,309 | 253,398 | Pass | 1.9 |
| | Toronto | base | | 93,404 | | 55,246 | 4,125 | 2,225 | | 18,133 | 350,534 | | |
| | | GSHP w Elec | horizontal | 111,334 | 28,000 | 0 | 2,050 | 944 | 1,770 | 8,150 | 266,132 | Pass | 4.0 |
| | | GSHP w FF | horizontal | 114,906 | 28,000 | 0 | 3,550 | 944 | 1,770 | 7,960 | 282,562 | Pass | 4.8 |
| | | GWHP | well | 111,334 | 16,000 | 0 | 2,050 | 944 | 1,770 | 8,150 | 254,132 | Pass | 2.9 |
| | Vancouver | base | | 89,756 | | 53,088 | 4,125 | 685 | | 12,706 | 276,342 | | |
| | | GSHP w Elec | horizontal | 104,279 | 24,500 | 0 | 2,050 | 278 | 945 | 3,131 | 191,656 | Pass | 3.5 |
| | | GSHP w FF | horizontal | 106,659 | 24,500 | 0 | 3,550 | 278 | 945 | 3,180 | 209,241 | Pass | 4.3 |
| | | GWHP | well | 104,279 | 14,000 | 0 | 2,050 | 278 | 945 | 3,042 | 180,285 | Pass | 2.5 |
| **Suburban Office (mid-sized) (56,000 ft_)** | | | | | | | | | | | | | |
| 3-Storey, 18,750 ft_ footprint | Moncton | base | | 246,508 | | 0 | 9,375 | 2,900 | | 15,717 | 525,813 | | |
| | | GSHP w Elec | vertical | 160,099 | 56,000 | 0 | 4,690 | 1,146 | 4,150 | 9,252 | 404,972 | Pass | 0.0 |
| | | GSHP w FF | vertical | 169,669 | 56,000 | 0 | 6,190 | 1,146 | 4,150 | 8,995 | 426,752 | Pass | 0.0 |
| | Montreal | base | | 267,242 | | 0 | 9,375 | 2,376 | | 25,083 | 635,493 | | |
| | | GSHP w Elec | vertical | 173,565 | 63,000 | 0 | 4,690 | 1,009 | 9,225 | 6,837 | 450,213 | Pass | 0.0 |
| | | GSHP w FF | vertical | 183,940 | 63,000 | 0 | 6,190 | 1,009 | 9,225 | 6,905 | 475,985 | Pass | 0.0 |
| | Toronto | base | | 294,888 | | 0 | 9,375 | 3,445 | | 16,469 | 587,242 | | |
| | | GSHP w Elec | vertical | 191,520 | 63,000 | 0 | 4,690 | 1,462 | 2,950 | 8,211 | 424,502 | Pass | 0.0 |
| | | GSHP w FF | vertical | 202,968 | 63,000 | 0 | 6,190 | 1,462 | 2,950 | 8,038 | 448,980 | Pass | 0.0 |
| | Vancouver | base | | 283,369 | | 0 | 9,375 | 1,677 | | 16,981 | 563,090 | | |
| | | GSHP w Elec | vertical | 184,039 | 56,000 | 0 | 4,690 | 681 | 2,520 | 4,524 | 361,930 | Pass | 0.0 |
| | | GSHP w FF | vertical | 195,040 | 56,000 | 0 | 6,190 | 681 | 2,520 | 4,589 | 388,297 | Pass | 0.0 |

**Exhibit ES-3 (continued)**
**Results of Life Cycle Costing - Comparison to Oil Base Case**

| Building Segment | Location | | Loop Type | Capital Cost | Loop Cost | Replace Cost | O&M Cost | Region Specific Energy Cost | | | Region Specifc LCC | | Paybck Period |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Cooling | Demand | Space Heat | | | |
| | | | | ($) | ($) | ($) | ($) | ($/y) | ($/y) | ($/y) | ( $ ) | (pass/fail) | (years) |
| **Retail (Strip Mall)** | | | | | | | | | | | | | |
| | Montreal | base | | 48,488 | | 36,366 | 3,000 | 950 | | 8,417 | 179,965 | | |
| | | GSHP w Elec | horizontal | 39,608 | 28,000 | 0 | 1,500 | 403 | 1,422 | 2,349 | 123,317 | Pass | 2.9 |
| | | GSHP w FF | horizontal | 46,336 | 28,000 | 0 | 1,750 | 403 | 1,422 | 2,372 | 132,724 | Pass | 4.0 |
| | Toronto | base | | 53,504 | | 40,128 | 3,000 | 1,361 | | 6,286 | 168,490 | | |
| | | GSHP w Elec | horizontal | 43,706 | 24,500 | 0 | 1,500 | 578 | 597 | 3,157 | 125,463 | Pass | 3.1 |
| | | GSHP w FF | horizontal | 50,586 | 24,500 | 0 | 1,750 | 578 | 597 | 3,091 | 134,150 | Pass | 4.7 |
| **Residential Subdivison** | | | | | | | | | | | | | |
| | Toronto | base | | 120,000 | | 1,200 | | 4,899 | | 10,832 | 278,489 | | |
| | | GSHP | vertical | 186,000 | | | | 2,080 | | 9,153 | 296,287 | Marginal | 14.7 |
| | Winnipeg | base | | 120,000 | | 1,200 | | 2,883 | | 24,040 | 391,065 | | |
| | | GSHP | vertical | 186,000 | | | | 1,224 | | 11,863 | 314,487 | Pass | 4.8 |
| | Kamloops (B | base | | 120,000 | | 1,200 | | 3,706 | | 16,419 | 322,682 | | |
| | | GSHP | vertical | 186,000 | | | | 1,506 | | 9,618 | 295,211 | Pass | 7.3 |
| **High Rise Condominium (95,000 ft_)** | | | | | | | | | | | | | |
| | Toronto | base | | 140,621 | | 52,000 | 7,700 | 1,685 | | 35,983 | 606,271 | | |
| | | GSHP w Elec | horizontal | 132,596 | 77,000 | | 3,850 | 715 | 5,310 | 16,012 | 463,756 | Pass | 3.5 |
| | | GSHP w FF | horizontal | 140,136 | 77,000 | | 3,850 | 715 | 5,310 | 15,634 | 467,589 | Pass | 3.9 |
| | Winnipeg | base | | 155,168 | | 52,000 | 10,500 | 998 | | 48,733 | 769,653 | | |
| | | GSHP w Elec | horizontal | 133,376 | 105,000 | | 5,250 | 424 | 14,170 | 13,758 | 568,286 | Pass | 3.1 |
| | | GSHP w FF | horizontal | 141,696 | 105,000 | | 5,250 | 424 | 14,170 | 13,852 | 577,529 | Pass | 3.4 |
| | Kamloops BC | base | | 149,107 | | 52,000 | 7,700 | 1,690 | | 32,181 | 576,561 | | |
| | | GSHP w Elec | horizontal | 128,166 | 77,000 | | 3,850 | 687 | 5,670 | 7,695 | 380,929 | Pass | 2.4 |
| | | GSHP w FF | horizontal | 136,161 | 77,000 | | 3,850 | 687 | 5,670 | 7,835 | 390,295 | Pass | 2.7 |
| **High School (127,000 ft_)** | | | | | | | | | | | | | |
| | Moncton | base | | 490,680 | | 65,000 | 20,300 | 5,986 | | 35,139 | 1,117,594 | | |
| | | GSHP w Elec | horizontal | 431,456 | 203,000 | | 10,150 | 2,541 | 12,450 | 19,328 | 1,071,060 | Pass | 8.5 |
| | | GSHP w FF | horizontal | 438,996 | 203,000 | | 10,150 | 2,541 | 12,450 | 18,755 | 1,072,972 | Pass | 8.6 |
| | Toronto | base | | 574,720 | | 85,000 | 18,900 | 7,171 | | 35,771 | 1,210,462 | | |
| | | GSHP w Elec | horizontal | 447,488 | 189,000 | | 9,450 | 3,044 | 8,850 | 17,615 | 1,018,997 | Pass | 2.7 |
| | | GSHP w FF | horizontal | 455,808 | 189,000 | | 9,450 | 3,044 | 8,850 | 17,240 | 1,023,631 | Pass | 3.0 |
| | Kamloops BC | base | | 552,270 | | 85,000 | 18,900 | 4,826 | | 31,944 | 1,125,922 | | |
| | | GSHP w Elec | horizontal | 430,008 | 189,000 | | 9,450 | 1,961 | 9,750 | 8,373 | 908,974 | Pass | 2.6 |
| | | GSHP w FF | horizontal | 438,003 | 189,000 | | 9,450 | 1,961 | 9,750 | 8,512 | 918,329 | Pass | 2.9 |