

# **GSHP MARKET GROWTH IN CANADA: FUTURE OPPORTUNITIES, INCENTIVE PROGRAMS AND LABOUR MARKET STRATEGIES**

*Ted Kantrowitz, BA, MBA, Vice-President, Canadian GeoExchange Coalition  
Denis Tanguay, BA, MA (Economics), President & CEO, Canadian GeoExchange Coalition  
1030 Cherrier – Bureau 405, Montréal (Québec) Canada H2L 1H9*

**Abstract:** In recent years, the growth of GSHP markets in Canada has shown a counter-intuitive inverse relationship between installations in residential markets and single unit housing starts. Clearly, the various government and utility incentive programs available in Canada had a positive impact. However, analysis appears that the GSHP industry in Canada may not yet be ready to grow sustainably on its own environmental and economic merits. Evidence shows that market growth now relies on exogenous factors such as high fossil fuel prices and financial and incentive assistance programs. Although the authors see many opportunities for GSHP in Canada, there are still key non financial barriers to be overcome. Discipline in the labour market and standards / regulation may be a key to market growth in the medium and long term. This study is an initial effort to demonstrate that incentive programs have a lesser impact in the long term than thoughtful market development strategy.

**Key Words:** market transformation, ground source heat pump, heat pump price, residential applications

## **1 INTRODUCTION**

After five years of intense industry association work to design and deploy a major market transformation initiative, the Canadian GeoExchange Coalition has certified more than 14,000 residential ground source heat pumps (GSHPs) in Canada, within its Global Quality GeoExchange™ Program®. The Canadian GSHP industry grew thirteen times between 1996 and 2009, going from a low of 442 installations to more than 15,000. Clearly, something has gone well in Canada.

Despite this success, CGC now regards the future with some apprehension. We believe recent growth was artificially boosted by generous incentive programs. Such rapid growth is not sustainable unless the industry shows its capacity to address some fundamental market barriers. We also think the recent industry growth cannot be sustained without a better understanding of the consumer decision making process. Finally, we believe that future industry growth is at risk because of the mixed and wrong signals with regards to training and accreditation of industry “professionals.” In this paper, we sequentially look at these issues with the perspective of formulating new industry driven strategies.

## **2. INCENTIVE PROGRAMS, UNEVEN EFFECTS**

In researching this paper, we first examined Canadian documents on market development strategies and industry barriers. To get as solid an understanding of potential impediments to market growth as possible, we included other countries in our review. Overall, we looked at sixteen studies and papers published in Canada, the United States, the United Kingdom and France and retained the three most important barriers raised by the authors in each. In some cases, distinguishing between barrier 1, 2 and 3 was a challenge because they were not

explicitly or clearly expressed. In other cases, we grouped look-alike barriers into one. A summary of our research is presented in Table 1 below.

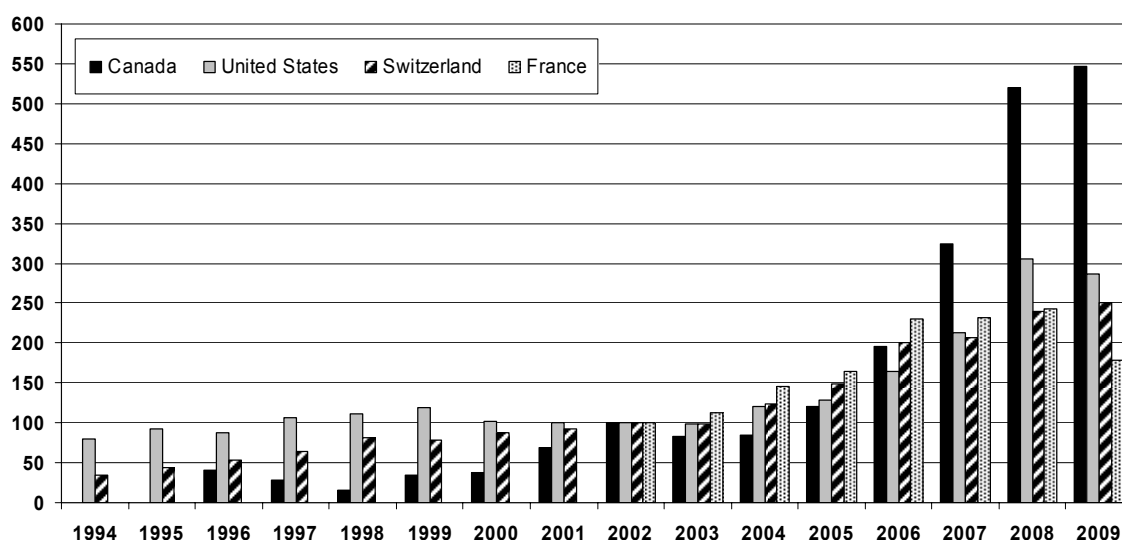
	Barrier No. 1	Barrier No. 2	Barrier No. 3
<b>Canada</b>			
<i>Marbek [1999]</i>	Technology discontinuance	High first cost	Lack of awareness
<i>CGC [2004]</i>	High first cost	Lack of awareness	Lack of professionals
<i>Caneta [2004]</i>	Discontinuous innovation and uncertainty or risk of non performance	High first cost	Lack of awareness
<b>United States</b>			
<i>National Earth Comfort Program [1994]</i>	High first cost	Lack Confidence or trust in the technology	Lack of design and installation infrastructure
<i>Geo-Heat Center [1995]</i>	High first cost	Low cost of natural gas	Lack of manufacturers, dealers and loop installers
<i>FEMP [1998]</i>	Confidence or trust in the technology	Lack of technical foundation	Lack of data to conduct credible life-cycle analysis
<i>NGWA [2003]</i>	Lack of awareness	High first cost	High prices payable to industry professionals
<i>Ally [2006]</i>	High cost	Local regulations	Contractor performance
<i>Hugues [2008]</i>	High first cost	Lack of awareness	Lack of industry infrastructure
<i>Navigant Consulting [2009]</i>	High first cost	Lack of awareness	Lack of supporting sales, installation, and service infrastructure
<i>Liu [2010]</i>	High first cost	Lack of awareness	Limited design and industry infrastructure
<b>United Kingdom</b>			
<i>NHBC Foundation [2007]</i>	Installation cost	Unfamiliarity by building designers	Lack of guidance and standards
<i>Le Feuvre [2007]</i>	High capital cost	Single phase electricity, limited installer capacity, poor government support	Limited public awareness
<i>Gupta [2008]</i>	Initial cost	Lack of expertise familiar with the technology	Low capacity of the power (single phase electricity)
<i>Le Feuvre [2009]</i>	Electricity distribution network	Competition with the gas distribution network	Thermal efficiency of housing stock
<b>France</b>			
<i>Jaudin [2010]</i>	Lack of awareness	Lack of official technical skills	-

**Table 1: GSHP Industry Barriers in the Literature**

This table is both interesting and disturbing as it shows that regardless of the country, and regardless of the timeframe (1994 to 2010), there are two barriers that authors agree are recurrent: 1) high first cost and; 2) lack of awareness. Professional and technical skills – i.e. training - didn't appear in the top three positions in most studies although the broader topic of industry infrastructure did. The barriers identified in 1994 are mostly the same in 2010, signifying no substantial change in the sixteen years concerned.

In Figure 1 below, we show the growth in the number of installations in four different countries with significant sales volume (minimum of 10,000 units) from 1994 to 2009. The number of units for each country was indexed to 100 in 2002 for the sake of international comparison and to take into account population sizes.

Some context about government interventions will help us understand some of the Figure's implications. In Canada, in the early 1990s, the government of the province of Ontario had a financial assistance program and 6,749 Ontario home owners decided to install a GSHP. The program was a tremendous success in terms of market penetration but was followed by mediocre sales, declining to absolute bottom in 1998 when only 442 units were installed in all Canada. In all likelihood, no more than 200 units were installed in Ontario in that year. No matter how we look at it, the massive financial assistance program did not generate sustained market activity and no industry infrastructure was built or maintained, though private training of some 2,000 individuals during 1990 – 2000, did occur. Years of unfocused industry direction and failed attempts by individual actors to control a declining market, followed. From a market transformation perspective, this was essentially a failure.



Source: Canadian GeoExchange Coalition, 2010

**Figure 1: Ground Source Heat Pump Units (2002=100)**

About at the same time, a small but loud industry group publicly confronted the federal government for not attaining some confusing industry development targets, which had been set at the request of this same group. Faced with this hostility, the Canadian federal government and a handful of leading electric utilities decided to pull their resources together to create the Canadian GeoExchange Coalition in 2002 mandating staff to initiate a market transformation initiative. After a pilot project phase, staff delivered essential industry infrastructure tools in 2005 which led to the creation of linked financial assistance programs in the first half of 2007.

Canada is not the only country which flirted with disaster. In Jaudin (2010) we learn that France also attempted to develop its GHSP market in the 1980s but, in the words of the author, the program was “a major failure”. In retrospect, it appears that the program was based on the wrong premise, essentially a short term reaction to the oil crisis.

The United States also attempted to move its markets through public interventions. Between 1995 and 1999, through the National Earth Comfort Program (NECP), it is reported by Hugues [2008] that about \$60 million were spent in the promotion of GSHP. From 1998 to 2001, millions of dollars were also spent under the Federal Energy Management Program (FEMP) to help introduce GSHP in Federal facilities.

While sales increased throughout the two programs, as shown in Figure 1, the market then declined and remained flat for 5 years. In fact, annual sales did not surpass the 1997 level until 2004. This is almost a decade of zero growth. We cannot objectively affirm, in retrospect, that these two programs were a success.

There are good lessons to learn from these three attempts to increase GSHP market share. The obvious observation is that financial assistance programs fed huge demand for a very short period of time, followed by a significant drop. Essentially, these programs temporarily send artificial price signals to the market.

In Canada in recent years, with the cumulative effect of federal and provincial grants, a customer could qualify for over \$10,000 in financial assistance to buy a system. With an average price of about \$25,000 for horizontal loops and \$30,000 for vertical loops, this is a price subsidy of about 40 %. For open loop systems, with an average price of about \$20,000,

the programs account for more than 50 % of the initial cost. In addition, in a special post-recession stimulus program in 2009, the federal government implemented an additional home retrofit tax credit for a maximum of \$1,350; all GSHP systems qualified for the maximum amount.

One would hope that over the past four or five years of subsidization, industry would have tried to take the growth opportunity to rethink its internal process and try to change its customer sales proposition. However, as prices now begin to float back to their natural, i.e. unsubsidized, levels, we see no evidence of this. We have however seen evidence of ample profit-taking, egregiously so from some areas of the value chain. Overall, GSHP systems are as expensive today as they were pre-program, meaning that no economy-of-scale effect has been engaged by the programs. In addition, in some provinces, provincial sales tax harmonization also has increased sales taxes or even added new sales taxes.

In short, the competitive position of the GSHP industry has actually worsened from where it was before the implementation of the financial assistance programs. This is not what was expected or hoped for, but we think it was in fact highly predictable.

### 3 UNDERSTANDING HIGH FIRST COSTS

As we have seen earlier, high first cost is the single most important market barrier identified by industry stakeholders. There is a question worth asking: high cost of what exactly? Are we talking about the price of the heat pump unit? Or maybe we are talking about the price of the loop? If not, then perhaps labour price is the key?

As most knowledgeable industry and market analysts would agree, each of these components account for roughly one third of a GSHP system price. So which part of the GSHP system has a compressible price structure? If the answer is none, high first cost may never be resolved.

In any normal product-centred industry, high first cost is something which is addressed by increased production capacity. It is assumed that economies of scale will be reached and prices will automatically come down as the volume of sales grows. This hypothesis begs another question: *at what point will the ground source heat pump industry reach the level where economies of scale can materialize?* In other words, how big is big enough - when will the price of the system or the price of heat pumps or any system components, decrease?

As we saw in Figure 1, GSHP installations increased significantly in Canada in recent years. Yet, over the period, the price of the system as a whole increased in real dollars, as shown in Table 2.

	2007	2008	2009	2010
<b>Closed Horizontal Loop (n=4510)</b>	\$6 352	\$7 174	\$7 411	\$7 685
y/y price change (%)	-	12,9%	3,3%	3,7%
average system size (BTU)	45810	41945	42127	41613
<b>Closed Vertical Loop (n=2206)</b>	\$9 954	\$9 783	\$10 290	\$10 798
y/y price change (%)	-	-1,7%	5,2%	4,9%
average system size (BTU)	37172	36855	36650	37148

Source: Canadian GeoExchange Coalition

**Table 2: Average GSHP System Cost per Ton (Heat Pump Rated Capacity) – Canada (Current Canadian \$)**

It is an economist's commonplace that a relatively large manufacturer, or a group of them, because of their dominant market position, could exercise predatory pricing with the hope of getting rid of the smaller players. However, if micro manufacturers were able to compete with larger players, this suggests that prices are fairly rigid and that manufacturers are pricing their products at or near their real costs to manufacture.

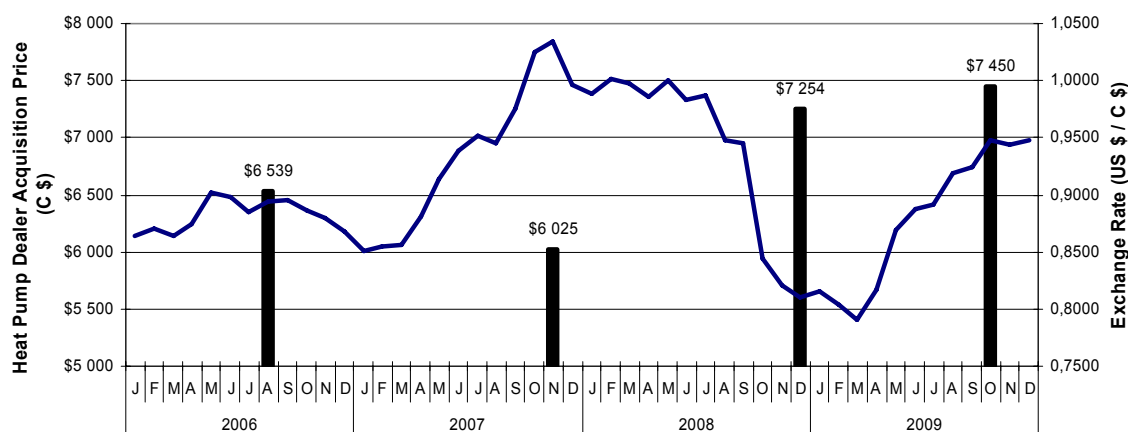
As the largest manufacturers are listed on the stock market, public review of their financial statements would immediately reveal this strategy. We analysed these statements and found no evidence that manufacturers have done so. We conclude that manufacturers are not exercising predatory pricing.

While large manufacturers may set the price and be price leaders, smaller manufacturers could behave as price takers and compete freely with their bigger counterparts. In fact, if unit prices are going up as the industry grows, it suggests that economies of scales are not realized, and that the dominant firms could well be facing rising marginal production costs. If this is the case, dominant manufacturers would be forced to raise their price to maintain current profitability and to maintain shareholder dividends.

With rising marginal production costs, stimulus programs are actually counterproductive since by increasing demand at artificial prices they would contribute to industry's overall economic inefficiency. When this is happening, removing the incentive usually leads to a sharp decline in demand. (And if prices go up and the demand for GSHP is elastic, demand will decline faster than prices increase.) If prices go up in this scenario, micro manufacturers could still benefit from constant marginal costs and offer heat pump units at lower prices while gaining market share. This is in fact exactly what happened in Canada in recent years.

Price rigidity in the market can also reflect economic inefficiencies in the supply chain. There are indeed many intermediaries between the GSHP manufacturer and the final customer. Each of these intermediaries is a profit taker which builds additional rigidity in the overall price structure in exchange, hopefully, for value. Here again, smaller manufacturers may gain some market advantage by having a leaner supply chain. But unsuspected factors can also contribute to reinforce price rigidity.

Figure 2 and Table 3 show an example of a Canadian GSHP dealer cost for heat pump units. As the US manufacturer is paid in \$US, exchange rates have no short term impact, *ceteris paribus*, on their revenues. However, exchange rate movements are somewhat reflected in the final price to dealers.



Source: Canadian GeoExchange Coalition. Exchange rates: Bank of Canada.

**Figure 2: Heat Pump Acquisition Price and Canada – US Exchange Rate**

In 2007 for example, Canada-US exchange rates improved in favour of Canadian importers of US manufactured heat pumps by 20 % during the year. In this case, the Canadian distributor reduced his price to the dealer by only 8 % that year, keeping the difference in exchange rate profit.

In 2008, when the exchange rate declined 20% however, the distributor increased its price to the dealer by exactly 20%. In other words, when the exchange rate worked in his favour, the distributor captured part of the exchange benefits but in 2009 when the situation reversed, the full deterioration of the exchange rate was passed along to the dealer. In fact the distributor increased his base price to the dealer by three percent. At the end of the transaction, it is likely that the customer never saw any of this favourable economic activity.

	2006	2007	2008	2009	$\Delta P$ (2009/2006)	$\Delta P$ (2009/2007)
<b>Dealer Cost (C\$)</b>	\$6 539	\$6 025	\$7 254	\$7 450	\$911	\$1 425
<i>Month delivered</i>	<i>(August)</i>	<i>(November)</i>	<i>(December)</i>	<i>(October)</i>		
<i>y/y price change (%)</i>		-7,9%	20,4%	2,7%	13,9%	23,7%
<b>Exchange Rate (US \$ / C \$)</b>	0,8942	1,0340	0,8100	0,9480	6,0%	-8,3%
<i>y/y price change (%)</i>		15,6%	-21,7%	17,0%		
	<i>(August)</i>	<i>(November)</i>	<i>(December)</i>	<i>(October)</i>		
<b>Exchange Rate (US \$ / C \$)</b>	0,8856	1,0254	0,8209	0,9244	4,4%	-9,8%
<i>y/y price change (%)</i>		15,8%	-19,9%	12,6%		
<i>Month delivered - 1</i>	<i>(July)</i>	<i>(October)</i>	<i>(November)</i>	<i>(September)</i>		

Source: Canadian GeoExchange Coalition. Exchange rates: Bank of Canada.

**Table 3: Heat Pump Dealer Acquisition Cost (typical 4-ton, 2-stage unit)**

Since prices were maintained artificially low by financial assistance programs, both the customers and the dealers were lured. Indeed, in the case study presented here, the price of heat pump unit increased by 14 % over 4 years despite favourable exchange rates, despite generous financial assistance programs to the consumer and despite inflation between January 2006 and December 2009 holding steady at only 6.1 %.

Based on a sample of 6,700 Canadian systems, Table 3 suggests that the price of the systems themselves to the end-user (all components taken together – heat pump units, loop and labour) also increased over 2007-2010 by an average of 20% for horizontal loops and 9% for vertical loops. Here again, we observe that there was no benefit to the final customer from higher sales volumes, suggesting that a significant portion of all financial assistance dollars were absorbed by stakeholders in the supply chain.

If we assume demand for GSHP systems is elastic, a small price increase should imply a major reduction in customer demand. We have observed exactly this in Canada in recent years, and it implies that the market is likely characterized – in the presence of subsidies – by free ridership and a high level of opportunism. As soon as the subsidy is gone, the quantity demanded should fall sharply as free riders have been satisfied. Many years will pass before a next generation of potential buyers is ready to enter the market, therefore.

All factors indicate that after four years of financial assistance programs, customers are faced with higher prices in real dollar terms. Increased national sales over the period clearly did not help address the high first cost barrier. Also, if higher demand is reflected in rising marginal production costs, then the economic benefits accruing to the consumer are declining and their simple pay-back periods, all other things being equal, will actually lengthen. This means that GSHP will likely prove a tough sell for years to come.

#### **4 LACK OF AWARENESS, DEMAND FOR GSHP AND CONSUMER BEHAVIOUR**

As indicated in Table 1, lack of awareness is still considered to be an important barrier. With close to 1 million units installed in North America however, we cannot concur that lack of awareness is still a major barrier. We are not talking here about a few sparse installations across the continent. We are talking about one million homes: one million customers who each decided to buy such a system. This means that at least ten million other potential customers are perfectly aware of the technology but for specific reasons, have decided not to purchase one. High first cost as discussed earlier is likely one good reason why they haven't done so.

While high first cost appears to be a solidly established barrier, lack of awareness rests on much less credible grounds. In many of the studies we looked at, the methodology leading to the conclusions is often nebulous. References to the thinking of "a very credible source" or to the opinion of industry experts that were "informally surveyed by the author" leave the reader with doubts. In essence, if the same people are always surveyed by the different authors and other authors are just quoting the others, or worse, their own previous work, chances are that we will end up with a very narrow view of the industry and its barriers. This phenomenon – availability heuristics and availability cascades – has been discussed at length in policy literature (Kuran and Sunstein 1999).

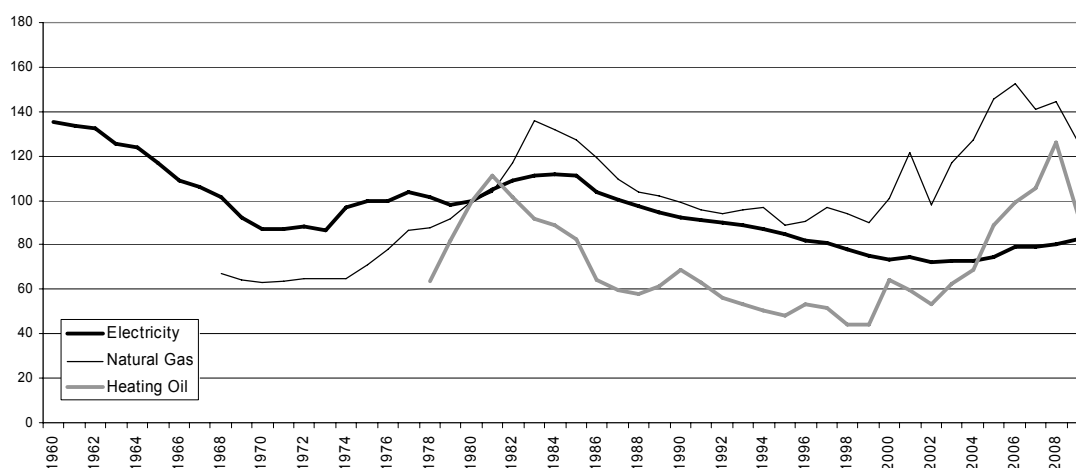
We therefore suggest looking at the lack of awareness from a different angle. Why not look at the industry's own lack of awareness and understanding of the consumer decision making process? Maybe this could help qualify what is meant exactly by lack of awareness. In fact, we believe a closer look at the customer decision-making process will help illuminate the role of subsidies, tax credits and other financial assistance programs.

Decision-making for major durable goods such as cars, homes and heating systems is highly dependent on income. When buying a heating system, the customer's expectation on energy savings reflects both variable costs of alternative energy sources as well as the capital cost of the system itself. In heating systems, there is an important wealth effect that enters into the equation, and the relative price of GSHP systems compared to alternative systems (mainly oil and gas furnaces but also electric baseboards or central electric units) will definitely direct if not dominate a customer's decision.

Indeed, in the existing residential sector, fuel switching is not something that happens overnight. The type of energy used for heating our homes directly depends on the heating system within the home. In the retrofit market, we need to understand that heating system replacement depends strongly on capital stock turnover. Dallaire (1997) made a very convincing demonstration to that effect and added that relative energy prices will have very little effect if the consumer is not able to afford to switch heating system before the end of a system's useful life. Here again, the income effect will play an important role in limiting choice of heating equipment, regardless of energy prices.

Understanding consumer behaviour also implies understanding a number of factors related to energy pricing. There is not a unique GSHP market in North America but a multitude of regional and often local markets, each with their own paradigms. Selling a GSHP to a customer who's paying the lowest electricity price on the continent is not the same as selling a GSHP system to a customer with subsidized residential natural gas prices. Customers facing the highest electricity rate on the continent but able to access lower priced natural gas will likely not switch to GSHP. The high first cost barrier takes a different perspective depending on the market; the presumed lack of customer awareness could be pure and simple lack of interest because GSHP cost will never be recovered over the owner's lifetime.

It has been argued by Wade (2003) that “long-run price responses occur through changes in the capital stock of energy-consuming equipment installed in buildings.” This essentially means that changes in capital stock will depend on long term relative energy prices. What is often perceived as lack of awareness could simply be the reflection of stable relative energy prices in the long term. Real energy prices for heating our homes have not been skyrocketing over the past 30 years. In fact, they remained fairly stable with some hikes in times of crisis; prices in real dollar terms have actually for long periods.



Source : U.S. Energy Information Administration

**Figure 3: Real Residential Energy Prices – United States (1980 = 100)**

In Figure 3, while we see that prices sometimes vary significantly in the short term, they tend to come back to their long term equilibrium over time. In 2009, natural gas and oil prices for example were back to their 1983 and 1981 levels respectively with mainly lower prices for the most part of the 25 years in between. Electricity prices have been slowly and regularly going down and they are significantly lower in 2009 – in real terms – than in 1960. And while relative prices show some movement upwards in short time periods, particularly between 2002 to 2008, prices now seem to be returning to their longer term equilibrium.

Considering the information in Figure 4 in contrast to Figure 1 and Figure 3, we note that the increased interest for ground source heat pumps in the past 6 or 7 years may well be another short term reaction to rising fossil fuel prices. While we all hope that the French history of the 1980s will not repeat itself, this is a scenario that should not be rejected. However, this hypothesis appears logical in light of the results obtained by Wade (2003). Wade found that long-run cross-price elasticity for electricity and natural gas in the residential sector was 0.13, 0.01 for electricity and distillate fuel, and 0.05 for natural gas and distillate fuel. It would therefore take a major exogenous factor such as a major break with long term conventional energy prices to break the current market equilibrium for heating systems.

While real energy prices were stable or even declined, real disposable income increased steadily over the past decades and so did income disparity as shown in Figure 5 and Figure 6. The share of energy spending for heating and cooling our homes declined as a proportion of real disposable income overall, and especially so for those in the top income tiers. Rising energy price is always less of a concern for higher income customers. For lower income individuals, assuming that energy bills represent a higher share of their disposable income, chances are that they will never be able to afford GSHP as a class. Considering this income effect, we deduce that financial assistance programs in recent years benefited a high proportion of free riders from the population strata with the highest disposable income.

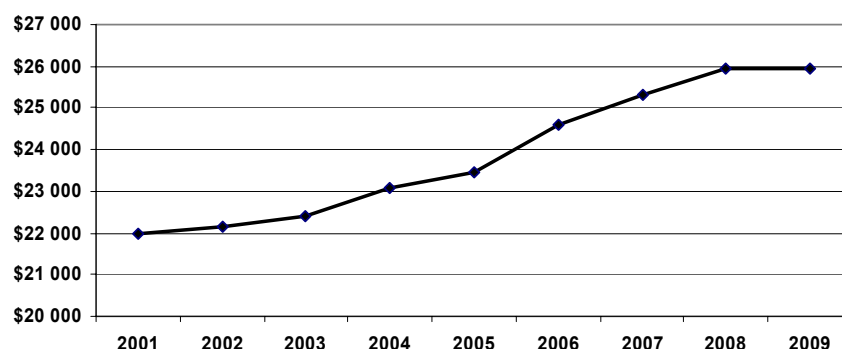




Source: U.S. Energy Information Administration

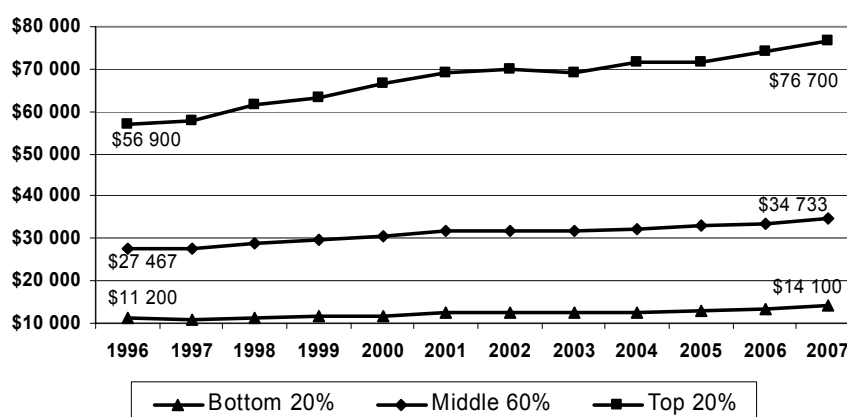
**Figure 4: Crude Oil – Weekly Canadian Par Spot Prices FOB**

Note that this discussion has specifically not mentioned the achievement of a higher unit COPs. The effort to reach a higher heat pump appliance efficiency is not meaningful if the system performance is at stake (Hénault 2011), and may be counterproductive from a market point of view. Because heat pump price off the manufacturer's loading dock represents less than 10% of the system price, we conclude that there are better targets in the value chain for cost reduction.



Source: Institut de la statistique du Québec

**Figure 5: Real Personal Disposable Income Per Capita**



Source: Institut de la statistique du Québec

**Figure 6 : Average Family-Adjusted After-Tax Income, by Income Group  
Canada 1996-2007 (2007 Constant Dollars)**

Finally we have noticed that historically very little attention is given to energy prices in existing literature discussing GSHP markets. We think this is a serious weakness in our industry's ability to understand its markets. Energy prices and relative energy prices in particular provide keys to the difficulties that industry has had in expanding its market share. We suggest more work should be done in this area in order to obtain a deeper and more systematic understanding of the consumer decision making process.

## 5 MISSING INGREDIENTS

Confidence in our ability to move markets forward does not necessarily coincide with the market's confidence in our ability to do so. This is reflected in the contrasting Canadian market results from the periods 1995 – 2005, and 2005 – 2010, and the contrasting GSHP industry development strategies at work during those periods.

The North American GSHP industry has sent seriously mixed messages to customers in the past decades. First, many of us try to sell customers a highly-priced durable good which we claim provides greater comfort or has other quality virtues. On the other hand, many tell customers that sizing, designing and installing this high quality, expensive system does not require a highly qualified technician. Some industry players also try to convince customers and colleagues that everyone can become an industry professional within 24 classroom hours, regardless of background. Some assert that 24 classroom hours is enough time to learn about geology, ground water protection, safe handling of refrigerants, 220 Volt electrical wiring, pipe fusion, flushing and purging, and receive a fully valid accreditation.

Manufacturer and distributor training was used for years as a recruitment tool to build dealer networks. While valuable to train potential dealers on the technical specificities of a manufacturer's heat pump models, this has little to do with educating a workforce. We are not aware of any industry where long-term development and growth was based solely on industry training: we are unaware of plumbers or electricians (or car mechanics or any trades-person) trained only by their product suppliers and then allowed to work directly.

In the CGC market transformation process, we have tried to address this discrepancy in strategic fit: high-quality, more expensive and innovative products such as GSHP systems cannot be sold with a simple training approach or a less development industry infrastructure.

CGC have built eight (8) original training courses, raising the amount of training required, have added a separate accreditation process consisting of documentation and experience verification, and created another to document and certify systems. Further Canada's industry association is working with governments and members to build and implement a trade framework which makes sense for our industry over the medium and long terms.

Further, CGC has transferred its training courses to a group of 17 Canadian trade colleges, helping create long-term industry infrastructure. Matriculated full-time students usually now learn through two courses of 45 hours each, spread over a full semester as part of their extant trades programs. Some college partners have pushed the initiative even further by creating a GSHP technologist program.

Finally, we must note another structural concern in the North American industry's approach. Classic economics – illustrated by the famous example of Mattel's Barbie Doll production process – dictate that commodities involving low-skill work will be most efficiently produced in countries with a labour-cost advantage. As noted elsewhere at length, "...the key to the United States' success in the green technology sector is provision of the economic, regulatory, and legal support for the development and implementation of new green technologies....[T]here are still many regulatory and legal barriers that are holding back the

development of the market....” (Wolak 2011) This holds true for Canada as well, although labour costs are lower. We have concluded from our work with governments and standards bodies that in fact a major barrier for GSHP in North America is lack of efficient and effective codes, standards, regulatory and legal mechanisms.

## 6 CONCLUSION

We have shown above that the GSHP industry is faced with extremely rigid prices reflecting supply chain organisation. Points of friction and built-in economic inefficiencies are and will remain a major barrier to the growth of the industry.

‘First cost’ as a barrier is an unclear concept to the authors, as is ‘lack of awareness’. A major weakness of barrier analysis thus far may be due to availability heuristics.

Without major exogenous shocks – such as a medium and long term price rise in real-dollar relative energy prices, or a major change in the structure of the supply chain – system prices are likely to remain far too high for the average North American residential customer. We suggest the industry will benefit by addressing this systematic issue directly, and also by focusing on larger-scale projects and markets. This latter strategy means that work will be (rightly) limited to a core of licensed trades-people and professional engineers.

Based on Canadian industry results from the period 2005 – 2010, the authors have further concluded that to transform the Canadian GSHP market we must continue to re-examine and transform our approach in three areas:

1. educating the labour force,
2. building industry infrastructure for the long term, including
  - a. continuing to develop the quality program through public educational and institutional integration, leading toward an eventual trades approach, and
  - b. improving codes and standards for the long term, and
3. rendering our industry’s message more consistent for industry’s future partners and customers.

## 7 REFERENCES

Ally, M. 2006. “Ground Source Heat Pumps in the USA.” DOE Space Conditioning, Refrigeration & Water Heating Program, U.S. Department of Energy. Presentation to the IEA Heat Pump Meeting 2006, Linz, Austria, May 11-12, 2006.

CGC, 2004. “GeoExchange Annual Planning Session.” Canadian GeoExchange Coalition, Montréal, October 25/26, 2004.

Caneta, 2004. “Market, Economic, and Barrier Analysis for Ground Source Heat Pumps in Canada, US, and Europe.” Prepared by Caneta Research for Natural Resources Canada, October 15, 2004.

Clayton Christensen, and Michael Raynor, 2003. “The Innovator’s Solution: creating and sustaining successful growth.” Harvard Business School Publishing, Boston MA USA.

Dallaire, C. 1997. “Une analyse des mesures thermiques et économiques de la consommation d’énergie pour le Québec et l’Ontario, 1984-1994.” Mémoire présenté à la

Faculté des études supérieures de l'Université Laval pour l'obtention du grade de maîtrise ès arts. Université Laval, mars 1997.

Goetzler, W., R. Zogg, H. Lisle, J. Burgos, 2009. "Ground-Source Heat Pumps: Overview of Market Status, Barriers to Adoption, and Options for Overcoming Barriers." Navigant Consulting, Final Report submitted to: U.S. Department of Energy, February 3, 2009.

Gupta, R., R. Irving, 2008. "Assessing the potential of ground source heat pumps to provide low-carbon heating and cooling in UK dwellings in a changing climate." Proceedings of conference: Air Conditioning and the Low Carbon Cooling Challenge, Cumberland Lodge, Windsor, UK, 27-29 July, 2008.

Hugues, P. J., 2008. "Geothermal (Ground-Source) Heat Pumps : Market Status, Barriers to Adoption, and Actions to Overcome Barriers." Oak Ridge National Laboratory ORNL/TM-2008/232, December 2008.

Jaudin, F., J. Ransquin. 2010. "Investigations into GSHP development in France." Proceedings World Geothermal Congress 2010. Bali, Indonesia, 25-29 April, 2010.

Kuran, Timur and Cass R. Sunstein 1999. "Availability Cascades and Risk Regulation," Stanford Law Review, Vol 51, pp.683 761.

Le Feuvre, P. 2007. "An Investigation into Ground Source Heat Pump Technology, its UK Market and Best Practice in System Design." MSc Thesis, University of Strathclyde. September 2007.

Le Feuvre, P., C. St John Cox, 2009. "Ground source heating and cooling pumps – state of play and future trends." The Environment Agency, Bristol, November 2009.

Liu, X., 2010. "Assessment of National Benefits from Retrofitting Existing Single-Family Homes with Ground Source Heat Pump Systems." Resources for the Future, Washington, September 2010.

Marbek, 1999. "Ground Source Heat Pump Market Development Strategy – Executive Summary." Marbek Resources Consultants, Report Prepared for: Natural Resources Canada, March 31, 1999.

NHBC, 2007. "Ground source heat pump systems – Benefits, drivers and barriers in residential developments." NHBC Foundation, October 2007.

Wade, S. H., 2003 "Price Responsiveness in the AEO2009 NEMS Residential and Commercial Buildings Sector Models." Energy Information Agency, 12 p.

Wolak, Frank A. 2010 "Regulatory Barriers to Lowering the Carbon Content of Energy Services." Stanford University / Ewing Marion Kauffman Foundation, pub. 8 p.