CENTRAL SOLAR HEATING PLANTS WITH SEASONAL STORAGE FOR RESIDENTIAL APPLICATIONS IN CANADA:
A CASE STUDY OF THE DRAKE LANDING SOLAR COMMUNITY

by

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Abstract

In Canada, 20% of greenhouse gas (GHG) emissions result from burning fossil fuels to heat homes, buildings, and water. Solar thermal technologies convert the sun’s energy into emission-free heat. The Drake Landing Solar Community (DLSC) in Okotoks, Alberta uses a Central Solar Heating Plant (CSHP) with Seasonal Storage to achieve an astounding annual reduction of 89% in fossil fuel consumption and more than 5 tonnes in GHG emissions per home.

This thesis examines: (1) the role for solar thermal technologies in Canada; and (2) what social, economical, and environmental factors are critical to the implementation and ultimate success of the DLSC. The former was examined through a literature review and the latter through a qualitative case study. Data was collected from published articles, media reports, conference proceedings, and in-person interviews in Okotoks.

International markets have shown strong solar thermal growth, yet Canada lags significantly despite its powerful solar resources and readily available technology. Europe has demonstrated that strong policies with ambitious targets have a critical role in the implementation of solar technologies. A review of recent public opinion polls demonstrates Canadians value the environment and would favour such policy developments.

The case study sought to understand the roles and motivations of the municipality, home builder group, and homeowners. The municipality exhibited tremendous leadership when it embarked on a path towards sustainability that included controlled growth based on ecological limitations and investment in solar thermal technology for municipal buildings. The Federation of Canadian Municipalities was instrumental in exposing Okotoks and the home builder group to the CSHP successes in Europe. The flexibility and innovation of the home
builder group provided conventionally-styled homes, which were able to seamlessly incorporate the technologies of the DLSC.

For the homeowners, critical components of the success of the project included: a means to participate in environmental change, increased community cohesion due to aligned values; and price stability for their heating costs. Additionally, all of the homeowners interviewed stated that they would be willing to pay extra to support the technology, which indicates that future projects may require less subsidization.
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Chapter 1
Introduction

The past two hundred years of modern economic activity has led to unprecedented burgeoning economies and technological advances (Sachs, 2005). The soaring increases in personal income provide the opportunity for the world’s wealthiest citizens to enjoy all of life’s modern conveniences. This would have been unimaginable to even the parents of our eldest citizens in Canada, who experienced trying times of famine, economic hardships, and war. However, these conveniences have a tremendous associated cost; they are all products of an economy centred on the consumption of fossil fuels. These fuels were deposited in the earth millennia ago and are rapidly being extracted and consumed for their energy, leaving behind a blanket of gaseous byproducts which are unequivocally heating the earth’s climate. The consequences of global warming present a “true planetary emergency”, the most challenging crisis that humanity has ever known (Gore, 2006).

Heating individual houses accounts for a large proportion of fossil fuel related emissions in Canada. Our climate is extremely diverse, with temperatures exceeding +30 and -30 °C in our southern-most inhabited towns and cities. To provide heating for these homes in the coldest months, many homeowners are reliant on enormous quantities of fossil fuels. With our extremely low population density, there is ample room for our citizens and sprawling housing developments surround our city centres. Many of these developments consist of single family, detached homes, each with its own fossil fuel-based heating system.

This thesis examines an alternative to the status-quo; the use of the sun’s energy to meet the heating demands of a community of detached homes in southern Canada. Chapter 1 will provide ample background on global warming, the Canadian context, and the roles of solar
thermal technology. In Chapter 2, the findings of the most relevant literature will be discussed, providing insights into the perceptions of global warming in Canada, municipal sustainability, and the role of policy in the market growth of solar thermal technologies. The case study of the Drake Landing Solar Community (DLSC) will also be introduced in Chapter 2, with analysis of the project’s economics. In Chapter 3, the methods used for the qualitative case study will be discussed. This will be followed by my results and discussions of the qualitative case study in Chapter 4, providing insights into the local factors that were present to make the DLSC a success. Finally, Chapter 5 will present the conclusions of the qualitative case study along with recommendations for future research.

1.1 Global Warming and the Canadian Contribution

1.1.1 The Age of Industrialization

The modern economy of the industrialized world is entirely dependent on fossil fuel consumption to power technology. We can now produce, sell, and consume commodities at a rate never before seen. But to understand our current situation and all the implicit addictions to fossil fuels, we must analyze the origins of modern technology at the dawn of the Industrial Revolution.

The pre-industrial age consisted of primarily agrarian lifestyles, with society consisting of very few rich and many poor citizens around the world (Sachs, 2005). In the middle of the 18th century, coal emerged as the primary fuel source to provide power for great mechanical inventions, such as the steam engine. Before coal, mechanical advantage was powered by unpredictable and comparatively weak natural systems, such as water or wind. Coal offered the
potential to drastically increase productivities of machines to manufacture goods for less cost. This was the beginnings of the Industrial Revolution and the start of the material age.

As these mechanical devices were extremely expensive, production progressed to a centralized system where large factories took advantage of economies-of-scale to produce more and more goods and lower costs. The centralization of work within factories shifted the employment from distributed rural production to large complexes nestled in the outskirts of the world’s largest cities.

England was one of the first countries to benefit from the Industrial Revolution and its city of Manchester is a good example of its effects (Sachs, 2005). Production from the textile and metal factories brought unprecedented wealth to employees. This was the first time in modern human civilization that a societal middle class was formed. But this all came at a cost with devastating amounts of harmful pollution from the coal combustion. Coal was also used as a primary heating source for homes, further contributing to the pollution.

The pollution from industry and home heating formed dark canopies over the large cities, leading to localized acid rain, extreme ecological damage, and detrimental to the health of the citizens. The effects of Industrialization habits stretched far into the 20th century, with the London Fog Disaster in December of 1952. More than four thousand citizens of London died due to respiratory-related illnesses from being acutely exposed to a wave of hazardous airborne byproducts from manufacturing (Thorsheim, 2004).

Canada experienced a similar path to industrialization in the late 19th and early 20th century. Although the country is extremely vast, it is open to both the Pacific and Atlantic Oceans for transportation of goods by water. Additionally, the construction of the Canadian National Railways in the early 20th century provided means to transport goods by land. Major
manufacturing industries were established on the Great Lakes in the centre of the country. Like the above example of England, the move to centralized industry in Canada also brought about wealth and tremendous ecological damage.

### 1.1.2 Global Warming

The 20th century continued to evolve from the Industrial Revolution, with advances in science and technology to produce increasingly more efficient fuels. Gasoline, diesel fuel, and natural gas revolutionized the way the world produces usable energy. The world now has access to highly efficient electricity production, manufacturing, transportation, and heating and cooling of buildings. While these fuels are more efficient and have significantly fewer particulate emissions than coal, they continue to produce carbon dioxide ($CO_2$), carbon monoxide, nitrous oxides, and sulfur dioxides. These byproducts have local and global implications.

The gases released in fuel combustion migrate to the upper ranges of the earth’s atmosphere. The sun’s rays can penetrate this layer of gaseous matter and continue to the earth’s surface. This gaseous envelope contains the sun’s heat and warms the earth. This is a natural process and is essential for stable temperatures for life to exist on earth (The David Suzuki Foundation, 2008). With the tremendous levels of anthropogenic emissions however, the temperature of the earth’s land and water are increasing.

This process is commonly referred to as Global Warming and the resulting effects are known as Climate Change. Due to the lay interpretation of this phenomenon, these two terms will be used interchangeably in this dissertation and defined as the increasing temperatures of the earth’s air, water, and land resulting from anthropogenic emissions. While many gases combine to cause global warming, $CO_2$ is by far the most abundant gas and widely used as the metric. The result of anthropogenic fossil fuel emissions since the industrial revolution is a
radiative force on the earth of $+2.30 \text{ W/m}^2$, resulting in a 1-3 °C temperature increase globally (IPCC, 2007a).

In 1988, the World Meteorological Organization and the United Nations Environment Programme under the United Nations Framework Convention on Climate Change formed the Intergovernmental Panel on Climate Change (IPCC). The intent of the IPCC is to evaluate the risk of human induced climate change.

The IPCC has produced four assessment reports in 1990, 1995, 2001, and 2007 respectively. Each report reviews the collective scientific knowledge of the status of climate change, what effects have and may happen due to global warming, and what policy actions must be taken to avoid negative consequences. The reports are widely trusted in academia and government, but are often challenged by industry and industrial lobbyists. The latest report in 2007 states clearly that the scientific warnings unequivocally show global warming is occurring and it is very likely due to anthropogenic activities (IPCC, 2007a):

"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."

There is currently more CO$_2$ in the atmosphere then in the last 10,000 years, with an increase in the latter part of the 19th century and a sharp increase in the middle of the 20th century (as shown in Figure 1-1). These two peaks correspond well with the advent of the Industrial Revolution, the end of World War II, and increases in fossil fuel consumption. What remains less clear is the rate at which this CO$_2$ will cause increasing radiative forces on the earth.
It is estimated that an additional 50-75% of these CO₂ emissions have been absorbed in the earth’s vast oceans or in brown clouds of smog in the atmosphere and their effects have not yet been seen. This is an alarming discovery because of the significant impacts on global temperatures, sea levels, and receding snow cover (Figure 1-2).

The effects of global warming will no doubt be dire and perhaps beyond the comprehension of conservative science. The fourth assessment by the IPCC predicts the global emissions of greenhouse gases (GHGs) will continue to increase by 1.8 to 4.0 °C by the end of the 21st century, depending on many factors including primarily changes in global use of fossil fuels (IPCC, 2007a). The IPCC predicts with “high confidence” that there will be significant changes in wind patterns, precipitation, and sea-ice patterns. The result of this will have huge implications to our planet (Figure 1-3).
Figure 1-2. Observed global changes in (a) average surface temperature, (b) average sea levels from tide data (blue) and satellite data (red), and (c) snow cover. The shaded area represent the band of estimated uncertainty in the observations (IPCC, 2007a).
The paradox of climate change is clear: the modern economy has made industrialized nations prosperous by destroying the world’s natural environments. Resolving the ill-effects of climate change, as indicated in Figure 1-3, is the challenge that we must now face (Gore, 2006).

In 2006, Sir Nicholas Stern, the Head of the Government Economic Service released the first economic review of the implications of climate change. The conclusion of this review was simple,
“...the benefits of strong and early action far outweigh the economic cost of no action (Stern, 2006).”

This review was a warning for the leaders of the world including policy makers and heads of the global economy. Stern was very aware of the effects of climate change, including millions of hungry people, droughts, and coastal flooding. The review reveals the real tragedy of global warming:

“The most vulnerable – the poorest countries and populations – will suffer earliest and most, even though they contributed least to the causes of climate change (Stern, 2006).”

This is echoed by former US Vice President Al Gore who stated that the citizens of the wealthy nations have a responsibility to help the poor who will be most affected by the climate change crisis:

“... it’s time to take a hard, honest look at our role in this escalating disaster. We helped manufacture the suffering in Africa, and we have a moral obligation to try to fix it (Gore, 2005).”

The brilliance of the Stern Review is that he was able to take the findings of the IPCC and translates them into common economic terms and opportunities. He stated that the world is set to lose between 5 and 20% of the global GDP each and every year due to global warming. What will it take to prevent this? Stern (2006) predicted a meager 1% of the global GDP per year. It seems the old adage of “an ounce of preventions is worth a pound of cure” holds true today. Perhaps the most inspiring message to leaders of our economy is:

“The world does not need to choose between averting climate change and promoting growth and development. Changes in energy technology and in the structure of economies have created opportunities to decouple growth from greenhouse gas emissions (Stern, 2006).”
As stated previously, it is very unlikely that the leaders of the economy will take heed to Stern’s warnings. In 1997, the international Framework Convention on Climate Change developed the Kyoto protocol, proposing voluntary targets for countries to address climate change. Its primary purpose is to mitigate the effects of global warming by ensuring reductions in GHG emissions. The protocol calls for a first reduction to 6% below 1990 emission levels by 2012 and an 80% reduction by 2050. There are 161 nations who have committed to this international accord, including Canada (Environment Canada, 2006a).

1.1.3 Canadian Emissions

In 2005, Canada emitted 747 megatonnes (Mt) of CO\textsubscript{2} equivalent GHGs (Environment Canada, 2006a). This represents more than 9% of the 7.9 gigatonnes (Gt) of CO\textsubscript{2} emitted globally (Environment Canada, 2006b). To achieve the first target of the Kyoto protocol, Canada can emit no more than 6% below 1990 emission levels. This equates to 563 Mt of CO\textsubscript{2} equivalent GHGs, requiring more than a 32% reduction from 2005 levels by 2012 (Figure 1-4). While Canada is obliged under international law to meet the Kyoto commitments, the current federal government refuses to take measures to achieve these goals and has been subject to much international criticism. The National Round Table on Energy and the Environment (NRTEE) has made its own targets for GHG emissions to be 60-70% less than 2006 levels by 2050 (NRTEE, 2007). This is substantially less aggressive than the Kyoto target of 80% of 1990 levels by 2050. GHG emissions have increased more than 25% in Canada since 1990.
To fully appreciate Canadian emissions, it is necessary to analyze the GHG emissions in further detail by emitting sources (Figure 1-5). Energy use by the residential and commercial sectors accounts for 29% of the total Canadian GHG emissions in 2005 (Environment Canada, 2006b). Further stratification of the data shows that the majority of this energy is used to provide space and water heating, totally one fifth of all Canadian GHG emissions. While this is to be expected due to our cold climate, it also shows the potential that exists to lessen our emissions in the heating sector alone.
1.2 Solar Thermal Heating General Overview

“The most promising solar technologies in the short-term are those that capture the heat of the sun’s rays to heat indoor space or water (The David Suzuki Foundation, 2007).”

At this point, it should be clear that Canadians are reliant on fossil fuels and have key role in global warming and its devastating effects. It is also clear that GHG emissions are significant for residential space and water heating demands. Fortunately, the sun’s energy can be collected and converted to thermal heat to meet much of these demands through the application of solar technology. With approximately 1,000 W of energy per square meter, the sun’s energy is entirely free of GHG emissions and completely renewable (IEA, 2005a). The components of solar technology used to harvest this energy have embodied energy and associated GHG emissions from their manufacturing but these can be offset through years of
reliable, emission-free energy generation. Methods to utilize the sun’s energy are in two forms: passive and active.

Passive solar energy systems involve no additional energy or machinery to collect the solar energy. An example of a passive solar energy system is a building design where the building is oriented to absorb the sun’s rays. When optimized, this passive solar design can provide heating in the winter months, aid in ventilation and cooling in the summer, and provide daylight for interior lighting. All of these benefits reduce the demand for electricity and ultimately fossil fuels (IEA, 2005a).

Active solar energy systems require additional resources to utilize solar energy (IEA, 2005a). These systems use engineered collectors to harness and transfer the sun’s heat to a storage capacity and provide useful heat in the forms of space heating, domestic hot water (DHW) heating, pool heating, and low temperature commercial processes such as crop drying. The technologies explored in this thesis are district and residential solar hot water heating system to meet DHW and space heating demands (see Section 1.3).

1.2.1 Solar Domestic Hot Water Heating

There are two types of active solar thermal heating technologies that will be discussed in this dissertation. The first provides domestic hot water heating for a single residence. The second is a communal, district active solar thermal system that provides space heating to a collection of detached residences; this will be introduced in the subsequent section, 1.2.2.

Individual residences have the option to install reliable and commercially available technology to capture the sun’s energy and heat their domestic hot water. There are two common types of collectors: flat-plate and evacuated tube collectors. The homes in the case
The flat-plate solar domestic hot water system consists of 4 components: the solar collectors to gather the sun’s energy; an energy pack to control the circulation of heat transfer fluid, an auxiliary water storage tank, and primary hot water heating tank (Figure 1-6). The systems are completely compatible with standard Canadian housing plumbing and can be installed during the house construction phase or easily retrofitted.

The flat-plate collectors can be combined in series or parallel configurations to capture the required amount of energy, depending on the heating demands of the application. Typically, the solar collectors are mounted on the exterior of the building with a strong southern exposure for maximum solar gain. The efficient collectors transfer the gathered solar energy into the heat transfer fluid, which is a glycol-water solution in the specific case of the EnerWorks Inc. system.
(EnerWorks Inc., 2007a). The thermal fluid is transferred down to the energy pack where the collected thermal energy is transferred to the water stored in the auxiliary storage tank via a heat-exchanger. The auxiliary tank is connected to the primary water heating tank of the residence. If there is not enough solar energy to meet the demands of the house, the main water heater will supply the additional required energy. The entire flat-plate solar thermal system acts essentially as a pre-heater to the existing main water heater system.

Most solar domestic hot water (SDHW) systems are extremely reliable and have been proven to provide approximately 50% of the hot water demands annually across Canada (Figure 1-7). This reduction in GHG emissions has been shown to be 1 tonne of GHG equivalent for every 2 panel system installed.

Figure 1-7. Canadian domestic hot water requirements met with a 2 panel flat-plate solar thermal system (Enerworks Inc., 2007b).
1.2.2 Central Solar Heating Plants

The second type of active solar thermal energy system relevant to this dissertation is Central Solar Heating Plants (CSHP). A CSHP differs from the individual solar DHW system described above in the collection and storage of the solar thermal energy. Where the individual DHW systems collect thermal energy to displaced individual home hot water demands, the CSHP uses large quantities of connected solar collectors and combines the captured thermal energy in one large centralized storage system. The key benefit of a CSHP is the ability to store the collected solar energy in large quantities during the summer months and extract it for space heating requirements in the winter months.

Foreseeing the demand for solar energy capture and usage, the International Energy Agency (IEA) established the Solar Heating and Cooling Programme (SHC) in 1977. The SHC programme is designed to encourage international collaboration of solar thermal applications, from the R&D phases to commercialization as well as policy development to increase market penetration (IEA, 2007a). The IEA developed a subtask to further the development of CSHP: Task 7 - Central Solar Heating Plants with Seasonal Storage (IEA, 2007b). By 1988, the subtask was completed by European participants: Sweden, Germany, Denmark, Austria, Switzerland, the Netherlands, and Finland. The long-term goal of the SHC programme is to provide 10-15% reduction of the primary energy consumption of OECD countries by 2025 (IEA, 2007a).

1.3 The Drake Landing Solar Community

The Drake Landing Solar Community (DLSC) is a group of 52 homes within the town of Okotoks, Alberta. Okotoks is located 23 km south of Calgary, the centre of economic activity supporting the Alberta oil sands development (Calgary Economic Development, 2008). The town of Okotoks is a prominent leader in municipal environmental initiatives in Canada. The main
driving force centres on limiting the population to the ecological capacity of the Sheep River watershed. This will be explored in much more detail in the Literature Review, Section 2.2 Municipal Sustainability.

The homes of the DLSC were designed with a goal to provide 90% of its space heating demands and 50% of its water heating through solar energy. This is a first in many respects: it is the greatest solar fraction (percent of heating demand met with solar energy) in the world to date; it is the first CSHP in North America; it will reduce heating loads by more than 5 tonnes of GHG emissions per year per home (Figure 1-8). These ambitious goals are met with three initiatives: individual flat-plate solar systems to provide domestic hot water heating; a communal CSHP to provide space heating; and extremely energy efficient R-2000 building designs. The total energy savings per home is projected to be 111 GJ per year. This equates to an annual savings of $954 when compared to a 90% high-efficiency natural gas system.¹.

Each home utilizes a two panel EnerWorks Inc. system that functions as described in 1.2.1. The collectors are mounted flush to the roof on the south side of the homes. When the homes require hot water for its domestic purposes, the collected solar energy is transferred into the primary water heating tank. If the water temperature is not high enough to satisfy the DHW needs, additional heat is provided by means of a high efficiency natural gas boiler in the primary heating tank.

The homes are also built to the R-2000 Standard, a protocol with numerous technical requirements, as described by Natural Resources Canada (NRCan), to provide extraordinary building energy efficiency. Homes that are built to the R-2000 standard achieve approximately a 30% reduction in energy consumption when compared to non-R-2000 building construction.

¹ This calculation assumes an energy content of 0.05 GJ/m³ and purchase price of $0.43/m³ for natural gas.
This is achieved primarily through improved insulation, minimizing air leaks around doors and windows, and using high efficiency heating systems such as solar thermal or high efficiency natural gas furnaces (NRCan, 2007b).

**Figure 1-8.** The anticipated reduction of greenhouse gas emissions from space and water heating in the Drake Landing Solar Community versus a typical Canadian house (DLSC, 2007).

### 1.3.1 The DLSC Central Solar Heating Plant

The 52 homes of the DLSC were constructed as shown in Figure 1-9. All of the housing lots have a home at the street side of the lot with a separate garage at the back portion of the lot. To provide sufficient space heating, it was determined that 798 flat-plate collectors would be required. The garages are all uniform in design with connected roofs. This was designed to provide sufficient space to mount all of the required collectors.
The 798 panels (2,293 m²) were connected in four distinct groups, corresponding to the four rows of garages (Figure 1-10). Like the individual 2 collector systems on the homes, the larger groups of panels allow a water-glycol solution to be heated with the captured energy from the sun. The heated fluid is returned from the 4 groups of panels and enters the Energy Centre. The Energy Centre is where all the controls of the system are located. There are also 2 short term buffer vessels (480 m³) which dampen fluxes of energy. The fluid is then transferred from the buffering vessels to a borehole thermal energy storage (BTES) field, located next to the Energy Centre (Sibbitt et al., 2007).
The BTES consists of 144 vertical boreholes, each having a depth of 37 m. Each borehole has polyethylene plumbing lines which extend to the bottom and then form a U shape, returning to the surface. The boreholes were grouted with a highly thermally conductive material. The matrix of 144 boreholes covers an area about 35 m in diameter and is topped with insulating material and then graded for public use.

During the warmer months of the year, the system will primarily be charging the BTES field. In the colder months, each home will draw energy from the BTES field into their homes. Each home is outfitted with a specifically designed high efficiency forced-air furnace that extracts heat from the returned fluid. The BTES is expected to take 3 years of this cycling of charging and depleting before it reaches its steady state and is predicted to provide in excess of
90% of the space heating demands of the homes (Sibbitt et al., 2007). In times when the energy demand of the homes exceeds that which can be supplied from the CSHP, there are two natural gas burners to supply the additional required heat. Early results show the first group of collectors to be commissioned is performing better than anticipated and demonstrates great promise for the entire system (Sibbitt et al., 2007).
Chapter 2
Literature Review

2.1 Canadian Perceptions of the Environment and Global Warming

The Drake Landing Solar Community offers a tangible demonstration of a central solar heating plant and a means to significantly lower emissions from Canadian homes but to what extent will Canadians be interested in such an initiative? To date, the peer-reviewed literature is completely void of Canadian perceptions of the environment, global warming, or the associated risks. While the full extent of this discussion lies far outside the scope of this dissertation, this section will use public opinion polling data to portray a broad overview of the current Canadian perceptions and risks of the global warming and the environment.

In Canada, the health care system is a universal public system, meaning all Canadian citizens have equal rights of access to appropriate health care. The system is funded primarily under provincial jurisdiction but there is an overarching federal system involved in its operation. Recently, the health care system has failed to meet the expectations of Canadians and as such has become the center of political concern.

In 2004 for example, 35 per cent of Canadians rank “health care/health care system” as the highest priority for federal policies (n=1,641, p=0.05)\(^2\). In strong contrast, the same study showed that only 2 per cent of the respondents believed the environment deserved the same priority. In 2007 however, a swift change in public opinion occurred when the environment became the second place priority for Canadians\(^3\). A second poll released in January of 2007 from

\(^3\) See Ipsos Reid (2007), Appendix F, study 10.
Decima showed that the environment became the “No. 1 issue for Canadians”, leading health care, the military mission in Afghanistan, and the economy (n=1,800, p=0.05)\(^4\).

Two studies by Angus Reid Strategies showed in March of 2007 that one third of Canadians “believe that climate change is the most important issue facing humanity today” with 77 per cent of Canadians believing “global warming is real”\(^5\). To translate this recent surge in concern for the environment from the national to the provincial level, the same studies show the province of Quebec is the most concerned and Alberta is the least, with 83 and 69 per cent believing in global warming respectively. This is important to this dissertation since one of the goals of this research is to juxtapose the ambitious environmental goals of the Drake Landing Solar Community with the resistance of Albertans to demand progressive environmental change.

Alberta has a long history of desiring autonomy from federal politics and subscribes to the neo-conservative free-market economics. In the northern part of the province, the development of the “oil sands” project has lead to a boom in the provincial economy with tremendous environmental devastation. The wealth from this project has allowed the province of Alberta to eliminate its debt. Alberta is the first province to do so and now has removed its provincial sales tax. To further exemplify the province’s new abundance of wealth, the provincial government has issued “Prosperity Bonus” cheques of $400 to nearly every Alberta citizens because of its financial surplus in January 2007. In fact, in 2007 the Alberta province posted the largest surplus ever at $8.7 billion dollars, due primarily to revenues from oil royalties (CBC, 2006).

\(^4\) See Decima (2007), Appendix F, study 15.
\(^5\) See Angus Reid Strategies (2007), Appendix F, studies 11 and 12.
Alberta is the largest emitter of GHG’s in Canada and as demonstrated in the public opinion polls, also the least concerned about global warming⁶. In light of this however, 96 per cent of Albertans believe that “individuals need to take an active role” in combating climate change⁶. It is also worthy to note that 65 per cent believe that the “government should take responsibility” (n=1000, p=0.05)⁷. It appears that the province is somewhat divided when it comes to taking action against climate change, between those who prefer an autonomous and individual approach and those who believe the government should provide leadership. These circumstances will become important later in this thesis when discussing the motivations of homeowners to purchase a home in the Drake Landing Solar Community.

2.2 Municipal Sustainability

2.2.1 Sustainability and Sustainable Development

The term sustainable development was brought to popularity with the release of the Brundtland Commission’s report “Our Common Future” by the World Commission on Environment and Development (WCED) in 1987 (Brundtland et al., 1987)⁸. The commission defined world sustainable development as a means to “meet the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland et al., 1987). While this definition set the framework for defining sustainability, it leaves the term “sustainable development” open to much interpretation.

The United Nations Conference on Environment and Development (UNCED) held what is commonly known as the “Earth Summit” in Rio de Janeiro, Brazil in 1992. This conference

⁶ See Angus Reid Strategies (2007), Appendix F, studies 11 and 12.
brought together 108 heads of states and attempted to define further sustainable development. The resultant document, Agenda 21, put forth 27 principles required to achieve sustainable development, the first being “Human beings are at the centre of concerns for sustainable development” (UN, 1992). These principles attempted to turn the theory of sustainable development into practice. The Earth Summit also produced the United Nations Framework Convention on Climate Change, which was the basis for the still to come Kyoto Protocol and Intergovernmental Panel on Climate Change (see introduction for details involving the Kyoto Protocol).

Since these two ground-breaking documents, there has been much scholarly debate as to the meaning of sustainability and sustainable development. Through the debate however a clear definition emerged: sustainability is defined as benefiting the environment, the economy, and society. Where neoclassical economics fail to appropriately value externalities, sustainable development seeks an optimum where there is a maximization of benefits to the environment and society as well as economy. The interdependencies of the three pillars of sustainability is often demonstrated as a visual model, where sustainable emerges as the confluence of the environmental, economic, and social factors (Figure 2-1).

Figure 2-1. Widely accepted visual model of sustainable development, highlighting the convergence of the environment, society, and economy (Parkins, 2000).
Municipal planning and development must follow these same principles if they are to achieve sustainability. More specifically, municipal planning must ensure the: efficient use of land, minimization of natural resource consumption, and maximization of social networking between citizens and local governments (Roseland, 1998).

Infrastructure Canada developed a framework to assess sustainability of Canadian municipalities. The framework, presented in a report entitled “The Path Towards Sustainability”, states there are eight criteria for municipal sustainability (Infrastructure Canada, 2006). A sustainable municipality must:

- be future-oriented and cognizant of ecological limits;
- support local economic development that is mindful of ecological developments;
- integrate the three dimensions of sustainability;
- consider the regional context;
- promote a livable and accessible built form;
- encourage a place-based economy that considers a community’s unique characteristics;
- incorporate principles of ecological design and ecological infrastructure; and
- support cultural sustainability.

2.2.2 The Town of Okotoks and Municipal Development

The town of Okotoks was established in the earth 20th century and until recently, has been a town of autonomy, preserving the unique lifestyle of living in the plains of southern Alberta. However, with the increasing economic development of the oil sands, Calgary has been steadily growing in population and land size. This has increased the pressure on Okotoks to become, in effect, a commuting town to support Calgary. The town of Okotoks itself has grown 13% each year between 2001 and 2006, claiming the title of the second fastest growing municipality in Canada (Okotoks, 2006a). Fortunately, the municipal government of Okotoks
foresaw this growth and demands for housing and put forth the Municipal Development Plan (MDP) in 1998.

“… this Municipal Development Plan will conduct long range planning, such that at a build-out population of 25,000 to 30,000 residents, a harmonious balance is achieved between economic opportunity, social conscience, and environmental stewardship (Okotoks, 1998).”

The broad aim of this plan is to manage growth in manner that “preserves the enviable lifestyle” citizens have come to appreciate about their town (Okotoks, 1998). The foundation for this plan is the Sheep River watershed, which flows elegantly through the downtown core. An assessment of the Sheep River estimated that the watershed can support the water demands of between 25-30,000 residents (Okotoks, 1998). The town has decided that this will represent the upper limit of allowable population.

The MDP focuses on four key areas to approach sustainability: Land Use/Urban Design; Transportation Systems; Open Space/Urban Forest; Regional Partnerships and Planning (Okotoks, 1998). From these categories the plan sets forth more specific goals such as reducing reliance on vehicles by planning for more mixed-use, higher density housing projects, eco-efficiency, recycling, and water conservation. The plan was formulated in a holistic manner such that the ecological, economic, and social considerations of the next 10-20 years were captured (Okotoks, 1998). The MDP represents the beginnings of “Sustainable Okotoks”; a vision that remains today.

Since the development of the MDP, the town of Okotoks has implemented many services to improve energy efficiency, water conservation, and waste diversion from landfills. The town also successfully installed solar thermal projects on five municipal buildings by the end of 2006. These included the recreation centre, Murray and Piper Arenas, recycling centre, and operations centre.
2.2.3 Citizen Support for Sustainable Vision

The town of Okotoks has earned wide acclaim for their efforts for sustainable planning and development, but were the MDP and the commitments to sustainability representative of the people within Okotoks? Fortunately, the town of Okotoks has also been a leader in the use of social data to guide its decision making process.

In 1998, a community survey (n=375) demonstrated that 75 percent of the citizens agreed with the cap on the population and 80 per cent believed this cap should be based upon the ecological limits of the Sheep River watershed (Okotoks, 1998). To further demonstrate the citizen commitment to sustainable development, an overwhelming 83 percent replied that “the Town should refuse” any development which does not follow the four sustainable development categories listed previously (Okotoks, 1998).

In 2006, another survey was conducted by Banister Research and Consulting Inc. to assess the community satisfaction to date. This survey was done one year prior to municipal elections to hold the council accountable and to set direction for the next council members’ term. The survey (n=1,465) showed that 90 per cent of citizens were very or somewhat aware of the activities the town was engaged in to be a sustainable community (Okotoks, 2006). As illustrated in Figure 2-2, respondents recognized five key areas as important to sustainability.

The advances towards a Sustainable Okotoks are very representative of the people within the town and should serve as an example of achievement for similar municipalities.
2.3 The Not-In-My-Backyard Effect on Renewable Energy Projects

The promise of clean and renewable energy has prompted many countries to heavily invest in renewable energy technology and develop aggressive policies to increase the market penetration. However, a critical barrier that has not been significantly addressed is the localized social acceptance of renewable energy project implementation (Wüstenhagen, Wolsink, & Bürer, 2007).

Traditional energy production involves centralized systems which generate the energy in a centralized location and transmit the energy to the end-users. Centralized production of energy enjoys the benefits of economies-of-scale and highly efficient equipment and processes to provide energy at low costs. Renewable energy, in contrast, changes this model: multiple generation sources produce energy and transmit this energy from different points in the distribution system. Increasing the number of generation sources inherently increases the
number of stakeholders in the decision-making process. This process may include but is not limited to municipal planners, citizens, and project developers (Bell, Gray, & Haggett, 2005).

Wind power has emerged as the prominent source of decentralized production of energy and has experienced significant social opposition to project development. The existence of this opposition has been widely acknowledged but there is little known about the root of the social opposition and a complete ignorance of the significance of its role in project completion. For example, it has been estimated that only a quarter of the wind power projects proposed in the UK have been commissioned. This is in sharp contradiction to the overwhelming general support by the public, where 85% support wind power (Bell et al., 2005). Clearly, the social opposition is a large barrier to market development.

An oft used and widely criticized explanation for this social opposition is the existence of the not-in-my-backyard (NIMBY) effect. This effect postulates that while people have a general approval for renewable energy production, they are not willing to bear the costs of production in their immediate vicinity (Bell et al., 2005). If the production occurs elsewhere, these individuals will make use of the clean energy while forcing others to bear the production costs of the energy (Bell et al., 2005). This explanation is criticized because it oversimplifies the motives of the opponents to renewable energy development. NIMBY-ism may in fact be a legitimate response to a renewable energy project development if the citizens of the community are expected to bear a disproportionally high share of the costs but receive disproportionally low shares of the benefits. This is often the case with wind projects because the projects are often located in rural, isolated areas where the power will be generated but then is exported to more dense regions where the electricity will be consumed.
Bell et al. (2005) suggest that the low success rates of wind power projects in the UK are the result of a much broader, more complex issue than the NIMBY-ism effect alone. Bell et al. (2005) expanded NIMBY-ism to define the root of this problem as a “social gap”. The social gap is the result of three explanations: the “democratic deficit”, the “qualified support”, and the “self-interest” explanation. It is important for the reader to realize that the intent of this section is not to suggest the reasons for the social gap are not legitimate; in fact these options may be the only means of social action. Only by fully understanding the root causes of the social gap, can we expect sustainable increases in decentralized renewable energy generation.

The first explanation, the” democratic deficit”, suggests that while the public has shown consistently in opinion polls to be in favour of renewable energy projects, a small minority of people have the ability to stop the project at the planning and implementation phases (Bell et al., 2005). It is postulated that this is a result of poor planning processes, where an external developer plans a project and then puts forth this plan to the public. It is then open to “community engagement” where the public can participate (Bell et al., 2005). This sets up a “decide-announce-defend” process where people participating are likely to solely bring criticism (Wolsink, 2000). In contrast, small renewable energy projects have been shown to have far better support, especially if the local citizens are to benefit financially from the projects’ success and are involved during the planning stages (Burton & Hubacek, 2007).

Understanding the social gap as part of a “qualified support” explanation attempts to seek reasons for individuals, who have high approval rates of renewable energy, rejecting particular renewable energy projects (Bell et al., 2005). This explanation does well to suggest there are “general limits” to which renewable energy projects can be implemented without indirect or direct negative consequences to the local environment or social situations (Bell et al., 2005).
The “self-interest” explanation suggests that individuals are not willing to sacrifice their private goods to benefit public goods (Bell et al., 2005). For example, in the specific case of wind energy, people are not willing to have wind developments “spoil” their view (a private loss) to produce electricity from clean and renewable sources (a gain in public goods). This is very close to the widely-accepted definition of the NIMBY effect.

Perhaps a fourth explanation that is lacking in Bell’s review is when a community is expected to incur disproportionate local losses to generate the electricity for external users. This is the case for a significant amount of the rural wind farms being planned in Ontario. The production of electricity by wind power is not a neutral event; there are significant changes to the local ecological, aesthetic, and social conditions of the community. Since the largest consumers are often in urban developments, the power is generated in the rural community and the bulk of which is sent to external users. The people of the rural community are forced to bear a disproportionate amount of localized impacts for the benefits they will gain.

The aforementioned explanations of the social gap expand the NIMBY-ism concept. If a strong distributed renewable energy generation system is to be developed, citizens, planners, policy advisors, and project developers should completely understand and appreciate the explanations of the social gap. Strong community involvement at the beginning stages is the key to successful project implementation.

2.3.1 Solar versus Wind Power Siting Issues

All wind power technologies cause significant impacts to their surroundings, particularly visual and noise related (Burton & Hubacek, 2007). Large-scale wind applications have similar issues but also synergistic effects if implemented in a multi-turbine manner. These effects may
have direct and indirect effects on wildlife (fish, migratory birds), landscapes, and humans (Burton & Hubacek, 2007).

In contrast to wind technologies, residential or commercial solar technology is a relatively benign source of electricity generation. There are no moving parts and solar panels can be mounted in a manner that blends in with or augments a building’s exterior. Innovations in Germany have lead to a complete roof design using solar panels as the exterior surface. These are assembled at a manufacturing plant and delivered to the site as a single unit, thus lessening the work required to install the panels. Additionally, there are no air emissions or noise issues, both serious concerns of any energy production.

Industrial-scale installations of solar collectors can have many of the same siting issues as large wind installations. The collectors are arranged in a horizontal matrix, often spanning several acres of land to satisfy the required amount of exposure to sunlight. The land below the installations will become unusable for agriculture purposes and could have significant impacts on the local ecology. Industrial-scale installations are outside the scope of this dissertation.

In a qualitative study conducted by Burton and Hubacek (2007), participants in the UK were interviewed and asked to rate energy production technologies on a scale from 0 (very poor) to 100 (excellent). The participants scored each technology based on these criteria: generation capacity, lifespan, carbon emissions, noise, impact upon the natural environment, and social effects. Weighting was applied to each category, based on consultation with energy professionals and interviewees, and an index score was determined for each technology listed (Figure 2-3).

There are two extremely important conclusions that can be drawn from this research. Firstly, solar PV has the highest index for public approval. Since solar thermal panels are very
similar in nature to solar PV panels, these findings suggest a high level of social acceptance for the panels used in the Drake Landing Solar Community. Secondly, the technologies that have the highest approval scores are those which are utilizing renewable sources, are small-scale in design, and decentralized. Again, this knowledge is directly applicable to the CSHP in Okotoks.

![Bar chart showing individual perceptions of renewable energy producing technologies.](image)

**Figure 2-3.** Individual perceptions of renewable energy producing technologies, with a higher value indicating a more favourable social response (Burton & Hubacek, 2007).

### 2.4 Solar Markets and Potential for Penetration

#### 2.4.1 Potential for Solar Thermal Energy Utilization

The sun’s radiation impacts the earth’s surface and water systems with approximately 1 kilowatt (kW) of power for every square meter (Philibert, 2005). Theoretically, if all of this energy were harvested, the International Energy Agency (IEA) has estimated it would equal 173,000 terrawatts (TW) of energy. The IEA has also predicted the total primary energy supply for the world in the year 2030 to be 21.8 TW, or 8,000 times less than the available solar energy (Philibert, 2005). Mankind’s complete primary energy could be captured in theoretical terms by
covering 0.6% of the landmass with solar energy collection technologies operating at 10% efficiency (Philbert, 2005).

There are many limitations to this theoretical supply including solar distribution on the earth’s surface and intermittent supply of sunlight (Philbert, 2005). In addition to these limitations there are technical and economic considerations that dictate the amount of energy that can be harnessed. Solar energy is typically utilized in two main forms, as heat or converted to electricity. The focus of this research is the use of solar energy to provide domestic hot water and space heating demands (please see introduction for more details on active solar thermal energy systems).

In reality, solar energy does not impact the earth at a uniform rate and varies widely without regard to political boundaries. The bulk of the radiation intercepts the earth between 30 degrees north and 30 degrees south latitude (Philibert, 2005). While Canada is outside this ideal band, there is still a significant amount of solar radiation along the country’s southern and most populated border. The average annual solar radiation in this region of Canada is estimated to be 1.31 megawatt-hours of power (MWh)/m² (NRCan, 1984). As will be discussed in the subsequent market analysis, Canada has ample solar resources when compared to countries such as Germany, which is the current solar energy leader (Figure 2-4).

### 2.4.2 Market Penetration

The global solar thermal industry can be classified into 3 groups: air, glazed, and unglazed collectors. Air collectors are most widely used for industrial preheating for space heating systems. In this context, glazed collectors include both glazed flat-plate and evacuated tube systems that are used to supply energy for domestic hot water and/or space heating.
Unglazed collectors are most widely used for pool heating as their initial costs are much lower than glazed collectors. By the end of 2005, there was an installed capacity of 159 million m$^2$ of solar collectors, capable of generating 111 gigawatts of solar thermal energy (GW$_{th}$) in 45 reporting countries (Weiss, Bergmann, & Faninger, 2007). The world market is primarily composed of glazed collectors, with a 44:56 ratio of glazed flat-plate and evacuated tube collectors (Figure 2-5). China is the world leader with over 47% of the market share, primarily focusing on evacuated tube technology (Weiss et al., 2007).

In contrast, the Canadian market has seen little growth with a total of 576 megawatts of solar thermal energy (MW$_{th}$) or 0.822 million m$^2$ of collector capacity installed (Weiss et al., 2007). As shown in Figure 2-6, the primary market penetration has been in unglazed solar collectors, which total more than 78% of the Canadian market share (Weiss et al., 2007).
The most active segment of the global solar thermal industry is in glazed panels. China and Taiwan have experienced growth rates of 22% between 1999-2005 (Weiss et al., 2007). While the growth rate for installed glazed panels in Canada in 2005 was 130%, this is a result of the small installed capacity (Figure 2-7). According to market research conducted by the
Canadian Solar Industries Association (CanSIA), the market is expecting strong growth rates to continue in 2006 and 2007 with an average expectation of 60% growth (SAIC, 2006).

**Figure 2-7.** Canadian solar thermal system sales by technology type (SAIC, 2006).

### 2.4.3 Potential for Greenhouse Gas Reductions via Solar Thermal Heating

As stated in the introduction, solar thermal energies have a large potential to replace fossil fuels to heat our homes and water. On a global scale, the installed glazed and unglazed collectors have a capacity of 111 GWth in 2005 (Weiss et al., 2007). Assuming a nominal efficiency of 7%, the capacity will yield 66 terrawatt-hour (TWh) of power, equivalent to consuming 10.7 billion liters of oil and avoiding nearly 30 million tonnes of CO$_2$ annually (Weiss et al., 2007). In Canada, there was an installed capacity of 506.2 MW$_{th}$ from glazed and unglazed collectors by the end of 2005 (Weiss et al., 2007). Using the same assumptions as the Weiss et al. (2007), this equates to an oil savings of 28.7 million liters of oil and a reduction of 78.4 thousand tons of CO$_2$ per year. When dispersed over Canada’s population of more than 32 million, this equates to a 2.4 tonnes of CO$_2$ reduction per 1,000 inhabitants.
A review of the world solar industry reveals Canada significantly lags the world market (Table 2-1). Upon analyzing the top collector yields by economic region, Europe is the logical next market target from Canada’s current penetration rate because of the similarities in climates, GDP, and exposure to sun radiation. What would be the impact on GHG emissions if Canada increased its capacity to match the European levels of 7.2 tonnes of CO$_2$ reduction per 1,000 inhabitants?

<table>
<thead>
<tr>
<th>Table 2-1. Global solar thermal yields and greenhouse gas reductions per citizen. Canada significantly lags the world penetration rates (Weiss et al., 2007).</th>
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<tr>
<td><strong>Country</strong></td>
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<tr>
<td>----------------</td>
</tr>
<tr>
<td>China + Taiwan</td>
</tr>
<tr>
<td>Europe</td>
</tr>
<tr>
<td>Japan</td>
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<tr>
<td>Australia + New Zealand</td>
</tr>
<tr>
<td>Canada</td>
</tr>
</tbody>
</table>

To reach the European target of 7.2 tonnes of CO$_2$ reduction per 1,000 inhabitants, Canada would have to increase its glazed capacity nearly 11-fold. This new capacity would reduce a total of 232 kilotonnes of emissions, but this is only 0.23% of the total 100 megatonnes of emissions produced in Canada from space and water heating in 2004 (Environment Canada, 2006b). Although meeting the current European market penetration level would not reach the necessary climate change objectives, it would represent a huge shift in the market. The new capacity is equivalent to installing 290,000 2-panel EnerWorks Inc. systems.

What would the solar industry be if it were used to reach the Kyoto-equivalent targets applied to space and water heating? In 1990, space and water heating accounted for 86 MT of emissions. The Kyoto-equivalent targets would be 81 and 48 Mt reduction in GHG emissions by 2012 and 2050 respectively (Figure 2-8). To meet these targets, the solar thermal industry in
Canada would have to increase its capacity by more than 300 fold, requiring a revolution in the technology and applications.

![Figure 2-8. Historical Canadian greenhouse gas emissions for water and space heating in the residential and commercial sectors, with projected reductions required to meet Kyoto-equivalent targets at years 2012 and 2050 (NRCan, 2006).](image)

### 2.5 Policies for Market Growth

As demonstrated in the previous section, Canadians must radically change the way they provide space heat and DHW demands from oil based to solar thermal technologies. To achieve this seemingly insurmountable goal, one can look to the success of market strategies utilized by Europe.
2.5.1 Europe Thermal Solar Markets

What are the key factors driving the European solar thermal market growth? To begin answering this question, it is necessary to analyze the role of individual countries in stimulating market growth (Figure 2-9). Clearly Germany (DE) has the majority market share with 50% of all European Capacity. Austria (AT) is commonly viewed as the leader because it has the second largest market share and the second largest capacity per capita, representing the most advanced solar thermal market in Europe.

![Figure 2-9. Summary of the 2006 European Union solar thermal market shares. Legend: DE=Germany, AT=Austria, GR=Greece, FR=France, IT=Italy, ES=Spain, CY=Cyprus, UK=United Kingdom; CH= Czech Republic (ESTIF, 2007).](image)

The European Solar Thermal Industry Federation (ESTIF) demonstrates strong confidence in its market growth, boasting a two-fold increase in the EU market in 2006-2007 and expects this growth to continue (ESTIF, 2007). At the end of 2006, the European market grew by 2.1 GW\(_{th}\) capacity, reaching a total of 13.5 GW\(_{th}\) in capacity. Comparing this to the Canadian operational capacity of 0.50 GW\(_{th}\), it is clear that there is much to learn from the European strategies. It
should be noted that while Europe has significantly better market penetration than Canada, this is lead by few dominant countries. According to the 2007 release of the “Solar Thermal Action Plan for Europe”, there are 7 strategies to maximize solar thermal growth: set ambitious targets; raise awareness; provide adequate training; research and development; financial incentives; provide regulations; and showcase successful demonstration projects (ESTIF, 2007). These strategies are listed with no order except for the first: set ambitious targets. Setting ambitious targets is the principle strategy for a long-term, self-sustaining solar thermal industry in Europe. The remaining six strategies are interdependent but rely on these targets to be set by policy and decision makers.

2.5.2 European Policies and Growth Targets

The White Paper for Renewable Energy was released as a ground breaking proposal to promote the use of renewable energies in Europe (European Commission, 1997). The ambitious targets established therein were the foundation for the often praised EEG, the Renewable Energy Sources Act in 2004 (EEG, 2004). The EEG led to an explosion in wind and solar electric market growth in Germany and was adopted by several other European countries. The EEG was the first to provide policies designed to give priority to renewable energy. This was accomplished with the use of a feed-in tariff, where decentralized generation of renewable electricity could be sold to the electricity distribution network. This system is much more successful than the quota-based systems that were developed in other European countries. The quota-based system relies on a quota to be determined by the policy makers and a free-market pricing system of renewable energy certificates to be sold to producers of electricity. There are a number of reasons why the quota-based system has failed in comparison to the feed-in tariff.
system, but this is only applicable to electricity generation and thus, outside the scope of this research.

Along with electricity generation, the White Paper set forth goals to increase the solar thermal market share. In 1990, the report recommended at target of 100 million m$^2$ (58.8 GW$_{th}$) of solar thermal capacity by 2010. In the decade since the completion of the White Paper, much progress has been made in the 7 key focus areas allowing the ESTIF to set a more ambitious target, far surpassing the White Papers initial response (Table 2).

The minimal target set forth by ESTIF was based upon imposing a similar market penetration of Austria on the remainder of the EU. Austria has an impressive capacity of 199 kilowatt of solar thermal energy (kW$_{th}$) per 1,000 capita. If the entire EU were to reach this level, a capacity of 11.2 GW$_{th}$ would be required. To accomplish this target, market would have to grow 16% annually averaged over all 27 EU countries from 2005 to 2020. While Germany, Austria, and Greece have far exceeded this growth rate, great advances in policy would be needed to implement such widespread growth (ESTIF, 2007).

<table>
<thead>
<tr>
<th></th>
<th>Capacity in operation (GW$_{th}$)</th>
<th>kW$_{th}$ per 1,000 capita</th>
</tr>
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<tbody>
<tr>
<td>Actual Market 1990</td>
<td>2.2</td>
<td>5</td>
</tr>
<tr>
<td>Actual Market 2005</td>
<td>11.2</td>
<td>24</td>
</tr>
<tr>
<td>White Paper - Target 2010</td>
<td>59</td>
<td>133</td>
</tr>
<tr>
<td>ESTIF - Minimal target 2020</td>
<td>91</td>
<td>199</td>
</tr>
<tr>
<td>ESTIF - Ambitious target 2020</td>
<td>320</td>
<td>700</td>
</tr>
<tr>
<td>ESTIF - Long term potential</td>
<td>1,200</td>
<td>2,600</td>
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</tbody>
</table>

The more ambitious target and the long-term potential are further removed from the industrial reality but set a clear direction. The ambitious target of 320 GW$_{th}$ by 2020 would be
1m² of collector for every citizen in the EU. The long term potential would be realized with large scale residential space and water heating (ESTIF, 2007).

The most conclusive evidence of support for solar thermal market growth in Europe came during the summit of EU Heads of State in March 2007 when it was unanimously agreed to nearly triple the renewable energy use to a binding target of 20% by 2020, including solar heating and cooling (ESTIF 2007). The Europe Commission is now working to put forth a Directive reflecting these targets that will be adopted by the European Parliament and Council.

2.5.3 Canadian Policies

The 2007 federal government has developed its eco-ACTION action plan to reduce greenhouse gases and air pollution. The plan, released in April 2007, has three arms encompassing all sectors of Canadian emissions: eco-ENERGY, eco-AGRICULTURE, and eco-TRANSPORTATION (NRCan, 2007c). While this plan has been heavily criticized for its intensity-based rather than absolute targets for GHG emission reductions, it represents the current vision of the Canadian federal politics and therefore deserves further interpretation.

The eco-ENERGY Renewable Heat and Energy program is relevant to this thesis for its solar thermal heating funding. The total funding for the program is $1.5 B until 2011, with a plan to use $36 M for solar thermal heating specifically. The funds are to serve two functions: 1) provide a financial rebate of 25% for commercial, industrial, and institutional installations and 2) establish a pilot program to assist utilities, local governments, NGOs and buyer cooperatives to install systems on at least 200 homes by 2010 (ECOACTION, 2007a).

The federal funding for solar thermal technologies is also augmented by provincial funding which depends on the specific provincial jurisdiction (Appendix A). In Ontario, for example, provincial incentives will match the 25% of initial capital costs offered by the federal
Renewable Heat and Energy program for commercial solar thermal systems. Additionally, the federal eco-ENERGY Retrofit for Homes program also offers grants to individual homeowners for up to $5,000 in energy efficiency upgrades. Solar domestic hot water systems for homes are eligible for $500 federal grants under this program and some provinces like Ontario will match this price for a total of $1,000.

2.5.4 Canadian Certified Equipment and Installers

A significant barrier in the Canadian market is the lack of Canadian certified solar hot water equipment and installers. The federal government has approved numerous domestic and imported solar hot water collectors that are eligible for the financial incentives described above. However, to ensure integrity in the Canadian solar domestic hot water market, NRCan is embarking on a task to certify 12 packaged solar hot water systems by 2011 that will be performance tested and Canadian Standards Approved (CSA) (ECOACTION, 2007b). In addition to the equipment certification, the Canadian Solar Industries Association (CanSIA) has certification programs available to installers (CanSIA, 2008). These two measures provide the foundation for strong growth in equipment and installers while maintaining integrity in the installations.

2.5.5 Canadian Solar Thermal Targets

While the Canadian SHW market place is expected to grow, there exists a large void in firm targets to which effective policies should guide the marketplace. The federal government has not embraced solar thermal technologies as a significant contributor to combat GHG emissions. In the report entitled, “Getting to 2050: Canada’s transition to a low-emission future”, solar thermal heating is not mentioned. This document is the outcome of detailed research and analysis of the National Round Table on Energy and the Environment (NRTEE, 2007). The report predicts natural gas price increases of 50% from 2007 prices by 2050, and this
will encourage the marketplace to upgrade to greater energy efficient products by means of the eco-ENERGY incentives listed above.

It is extremely disappointing for the federal government to under utilize efficient building design or passive and active solar technologies which have been proven to have a large role in reducing the total amount of energy consumed by homes. Contrary to the lack of federal targets, CanSIA has put forth a progressive document highlighting the benefits of solar to provide heat, economic gains, and job creation opportunities.

CanSIA predicts the solar industry could provide 25 million MW of power to the Canadian markets by 2025 if their recommendations were followed (CanSIA, 2004). The outcome of the CanSIA plan would be $30-40 B in economic activity, 180-280 thousand jobs related to the solar industry, and 15-30 million tonnes of greenhouse gas reductions (CanSIA, 2004). Solar thermal systems would contribute more than 45% to these growth goals, with an additional 2.4 and 6 million residential and commercial SHW systems to be installed. Germany has experienced a similar market transformation since the creation of its EEG plan. With the manufacturing sectors losing jobs in central Canada, a transformation of new solar related jobs and economic activity should not be overlooked by the federal government.

There are several recommendations for policy improvements to achieve these goals and perhaps the most important and fundamental is long-term, sustained support for the industry. Like the ESTIF, CanSIA suggests the immature markets are due to the intermittence of federal policy support (CanSIA, 2004). In addition to the lack of support, financial mechanisms have not been developed to provide low-interest loans for purchasers. Similar to the advanced feed-in tariffs for solar electricity, the opportunity to sell collected thermal energy to utilities has not yet been explored. The report also strongly recommends the government should lead-by-example
by: a) committing to purchase 20% of its heating requirements from solar hot water systems and b) installing solar hot water systems on all new government owned buildings.

2.6 Central Solar Heating Plant Economics

2.6.1 European Experiences

In 1993, the Solarthermie 2000 programme was initiated in Germany for a period of 10 years (Mangold, Schmidt, & Lottner, 2003) and other European countries began to invest in R&D and commercialization of solar thermal technologies (Schmidt, Mangold, & Müller-Steinhagen, 2004 and Heller, 2000). A large arm of this direction was to develop “solar assisted district heating” projects with the aim to increase economic effectiveness through project implementation (Schmidt et al. 2004). By the 2004, there were 55 large scale central solar heating plants (CSHPs) in Europe, ranging from 500-2700 m$^2$ of collector area size, concentrated mostly in Germany, Austria, Denmark, and Sweden (Table 3).

The relatively mature CSHP market in Europe provides guidelines on the economics of various design considerations. Figure 2-10 shows the investment costs for the heat storage of the ten largest CSHPs in Europe, categorized by storage type. It is important to note that regardless of the type of heat storage, the CSHPs follow economies-of-scale curves well.
Table 2-3. A list of the largest central solar heating plants in Europe and Canada (Schimdt et al. 2004, Sibbitt et al. 2006)

<table>
<thead>
<tr>
<th>Plant, country</th>
<th>Year of initial operation</th>
<th>Collector area (m²)</th>
<th>Collector supplier</th>
<th>System type with storage capacity</th>
<th>Load size (GWh per annum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marstal, Denmark</td>
<td>1996</td>
<td>18,300</td>
<td>Arcon; Denmark</td>
<td>DS: 2,100 m³ water tank + 4,000 m³ sand-water + 10,000 water pit</td>
<td>28</td>
</tr>
<tr>
<td>Kungalv, Sweden</td>
<td>2000</td>
<td>10,000</td>
<td>Arcon, Denmark</td>
<td>DS: 1,000 m³ water tank</td>
<td>90</td>
</tr>
<tr>
<td>Nykvarn, Sweden</td>
<td>1985</td>
<td>7,500</td>
<td>TeknoTerm, Sweden; Arcon, Denmark</td>
<td>DS: 1,500 m³ water tank</td>
<td>30</td>
</tr>
<tr>
<td>Falkenberg, Sweden</td>
<td>1989</td>
<td>5,500</td>
<td>TeknoTerm, Sweden; Arcon, Denmark</td>
<td>DS: 1,100 m³ water tank</td>
<td>30</td>
</tr>
<tr>
<td>Neckarsulm, Germany</td>
<td>1999</td>
<td>5,044</td>
<td>Arcon, Denmark; Paradigma, SET; Wagner, Germany; Sonnenkraft; Austria</td>
<td>SS: 63,400 m³ duct heat store</td>
<td>1.7</td>
</tr>
<tr>
<td>Aeroskopin, Denmark</td>
<td>1998</td>
<td>4,900</td>
<td>Arcon, Denmark</td>
<td>DS: 1,200 m³ water tank</td>
<td>13</td>
</tr>
<tr>
<td>Rise, Denmark</td>
<td>2001</td>
<td>3,575</td>
<td>Marstal VVS, Denmark</td>
<td>SS: 4,000 m³ water tank</td>
<td>3.7</td>
</tr>
<tr>
<td>Friedrichshafen, Germany</td>
<td>1996</td>
<td>3,500</td>
<td>Arcon, Denmark; Paradigma, SET; Wagner, Germany</td>
<td>SS: 12,000 m³ water-filled concrete tank</td>
<td>2.4</td>
</tr>
<tr>
<td>Ry, Denmark</td>
<td>1990</td>
<td>3,025</td>
<td>Arcon, Denmark</td>
<td>Directly connected to district heating</td>
<td>32</td>
</tr>
<tr>
<td>Hamburg, Germany</td>
<td>1996</td>
<td>3,000</td>
<td>Wagner, Germany</td>
<td>SS: 4,500 m³ water-filled concrete tank</td>
<td>1.6</td>
</tr>
<tr>
<td>Okotoks, Canada</td>
<td>2006</td>
<td>2,293</td>
<td>EnerWorks, Canada</td>
<td>SS: 35,000 m³ BTES field</td>
<td>0.53</td>
</tr>
</tbody>
</table>

9 DS: Diurnal heat storage, SS: Seasonal heat storage
Figure 12. Investment costs (€) of heat stores of the ten largest central solar heating plants in Europe. The two curves represent symbolic economies-of-scale (Schmidt et al., 2004).
2.7 Drake Landing Funding

The Drake Landing Solar Community is funded by three subsidization sources: the Government of Alberta, the Government of Canada, and the Federation of Canadian Municipalities (Table 4).

<table>
<thead>
<tr>
<th>Funding Source and Program</th>
<th>Funding Amount ($CDN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government of Canada (via NRCan and Technology Early Action Measures program)</td>
<td>2,600,000</td>
</tr>
<tr>
<td>Federation of Canadian Municipalities (via the Green Municipal Funds)</td>
<td>2,900,000</td>
</tr>
<tr>
<td>Government of Alberta (via the Innovation Program)</td>
<td>1,125,000</td>
</tr>
<tr>
<td><strong>Total Funding</strong></td>
<td><strong>$6,625,000</strong></td>
</tr>
</tbody>
</table>

2.8 Central Solar Heating Plant Economic Analysis

The CSHP in Neckarsulm, Germany utilizes duct seasonal storage technology, which consists of vertical ducts in the ground similar to the BTES technology used in the DLSC described previously. The Neckarsulm plant was constructed as a pilot study in 1997 with 760 m$^2$ of collectors and 4,300 m$^3$ of storage volume (Energie-Cities, 2001). The plant was later expanded to 20,200 and 63,400 m$^3$ in 1998 and 2001 respectively (Mangold et al., 2003). The Neckarsulm plant was one of Germany’s first CSHP and was designed to be a demonstration plant under the Solarthermie 2000 program and it is logical to expect that this plant would involve similar first-time struggles as experienced in the DLSC project. It is therefore a good reference against which the economics of the DLSC plant can be compared (Table 5).
Table 2-5. System comparison of the Neckarsulm and Drake Landing central solar heating plants (Sibbitt et al., 2006 and Mangold et al., 2003).

<table>
<thead>
<tr>
<th>Funding Source and Program</th>
<th>Neckarsulm Phase I (1997-99)</th>
<th>Drake Landing Solar Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat plate collector area (m²)</td>
<td>2,637</td>
<td>2,293</td>
</tr>
<tr>
<td>Duct heat storage (m³)</td>
<td>20,200</td>
<td>35,000</td>
</tr>
<tr>
<td>Heat Demand (MWh/a)</td>
<td>1,663</td>
<td>527</td>
</tr>
<tr>
<td>Solar Fraction (% of total demand)</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>Heat Delivered (MWh/a)</td>
<td>832</td>
<td>486</td>
</tr>
<tr>
<td>Cost of System ($M CDN, 2007 dollars)</td>
<td>2.68</td>
<td>6.63</td>
</tr>
</tbody>
</table>

The first phase of the Neckarsulm CSHP had a total system cost of 1.5 M Euros (Mangold et al., 2003). Using the published consumer price index and exchange rates, this would equal roughly $2.68 M Canadian in 2007 dollars (see Appendix F for detailed calculations and assumptions).

While the DLSC utilizes many of the same systems as the Neckarsulm project, there are many features that make it unique and may begin to address the nearly 3-fold increase in initial costs. The DLSC is designed to provide the highest solar fraction of CSHPs to date, expected to achieve greater than 90% of the required space heating demand. This achievement caused an enormous increase in system costs when compared to similarly sized plants that achieve much lower solar fractions. Additionally, during construction of the BTES field, the town of Okotoks received 100-year record levels of flooding, causing considerable setbacks. Since this is the first project of its kind in North America, there were also considerable technical difficulties with
equipment and sourcing. It is estimated that the total costs of the flood and equipment difficulties increased the project cost by $1.2 M CDN (Western Wheel, 2006).
Chapter 3
Qualitative Research Methods

3.1 Introduction

The first two chapters provide the reader with the Canadian context for global warming and the potential for solar heating to reduce GHG emissions. The Drake Landing Solar Community is the first chance to observe a central solar heating plant in Canada. The central aim of this research is to understand the local factors which contributed to the success of the DLSC project. More specifically, who were the key actors in the project, what were the motivations for their participation, and how critical is their involvement to the success of the project?

In the case of DLSC, there are considerable involvements and partnerships at work. While the project is centrally orchestrated through the Natural Resources Canada, there are key contributors at a more local level. The municipality of Okotoks certainly is involved through its drive for sustainability. There must also be a house builder who is willing to take on new and innovative projects; in this case, the builder is Sterling Homes. However, to complete the project, there must be people willing to purchase the new homes. These three actors formed the boundary of scope for this case study, but by no means are intended to diminish the involvement of the other partners involved in the project that were not analyzed.

Many conditions exist which makes the DLSC unique: DLSC is the first CSHP within North America; it is also capable of the highest solar fraction to date of CSHPs globally, a showcase of Canadian technical excellence and execution; it is located in a suburb community south of Calgary, which is the epicenter for oil and gas production in Canada, arguably the most urgent and largest source of environmental devastation in Canada; Calgary and Okotoks are
experiencing some of the largest growth rates in the nation and must balance this with sound urban planning. These are but a few examples of the factors which lead to the rich and incredibly complex situation of the DLSC. This research examines the community as a case-study for which we have no perspective, offering insights into the specifics of the DLSC local actors and their motivations. These insights are not known in the Canadian context and are required to promote future CSHP developments.

3.2 Central Purpose

The purpose of this case study was to provide an early investigation designed to discover, describe, and understand the motivations of the critical local actors in the success of the DLSC. The scope is limited to three groups of actors: the homeowners, the house builder, and the municipality. The central thrust of this case study is the exploration of the homeowners’ motives for purchasing a home in the DLSC, to what extent CSHP factored into their decision making, and if the community members have formed a community that is somehow different from other Canadian suburb communities. The exploration of the municipality and house builder will probe the leadership and underlying reasons for their involvement and support for the DLSC project. It is only with the confluence of motives by these actors that the DLSC project becomes a reality.

3.3 Research Questions

Creswell (1998) suggests sound qualitative research is guided by a central question, subquestions which further disseminate this over-arching quest, and more procedural topical questions to specifically answer the central question. The researcher is to pose central questions
which may be non-directional and open-ended (Creswell, 1998). In the tradition of case study inquiry, the researcher’s subquestions should explore questions of “how” and “what” versus “why” while the purpose of the topical questions is to provide a rich description, analysis, and lessons learned from the case (Creswell, 1998).

The central question of this research is “What is the social response to the Drake Landing Solar Community, a collection of 52 suburban homes that utilize a collective central solar heating plant for space heating and individual solar domestic hot water systems?”. Subsequent questions are:

- What is the current status of the DLSC?
- What reasons do homeowners offer for purchasing a home in DLSC?
- How critical were economic realities in their decision?
- How did the town come to support the DLSC and were there unique conditions present to influence the acceptance and success of the project?
- How did the home builder become involved in the project and what were their motivations?
- What risks were the homeowner’s exposed to during the project and to what extent were these risks mitigated?

Topical questions that provide procedural direction for the research are:

- How can one summarize the status of the DLSC and the community members therein?
- What themes of social drivers emerge from speaking to homeowners, town officials, and the housing builder?
- How would I interpret these themes in the context of solar technology in Alberta and Canada as a whole?

3.4 Data Collection

In order to satisfy the central aim of this research, it was essential that I visit Okotoks and the DLSC. In October of 2007, I spent one week in the Calgary and Okotoks areas. Being in Okotoks gave me a firsthand appreciation for the complexity of the research quest including the present social, historical, economical, and political realities. The success of this site visit was dependent on gaining access to individuals involved in the project and their protection under strict research ethical guidelines. This section explores the methods used to achieve this end.

The main source of data for this research comes from discussions with key actors involved in the project and who are located in the Okotoks region. This involved speaking to town officials, homeowners, and project developers. The majority of the discussions were facilitated in a structured but open-ended interviews (described in more detail later) with homeowners in their homes. Other data flows from conversations had while visiting the technical facilities of the CSHP, a schedule meeting and interview with the town municipal manager in the Okotoks town hall. One conversation occurred during a leisurely dog walk with a homeowner. Creswell (1998) stresses that a good case study utilizes several sources of information, be they interviews, participant observation, or audio and visual materials.

Access to the homeowners was accomplished by delivering research flyers to each house in the DLSC. This flyer included a coversheet, letter of information, and a list of the interview questions (Appendices B, C, and D). The flyers were delivered in person by going to
each home early in my visit. If the homeowner was available during my visit, I would give them a flyer and ask if they wished to participate in my research study. If they did, we would move into the interview process. If they wished not to participate, I would leave them with a flyer and ask them to contact me if they had a more convenient time. If the home owner was not home, I would leave a flyer in their door.

The interview was typically a 30-45 minute process in which I asked a total of 14 questions to each participant. The interviews were done at the convenience of the participant and at the location of their choice. For the homeowners, this was often in their homes, into which they graciously welcomed me. The questions were categorically posed in 4 sections: background of the participant, followed by environmental, social, and economic considerations affecting the individual participant’s decision making process and motives. At the end of the interview, there was time for any additional questions or thoughts that the participants would like to add. For a complete list of questions and the information sheet provided to the participants, please see Appendix D.

Paramount to this study was the ethical protection of the participants. In accordance with the School of Graduate Studies, I submitted my proposed research for ethical approval with the General Research Ethics Board at Queen’s University. The nature of this research posed minimal risk to the participants and was given official ethics approval to conduct the research as per the conditions of the submission (Appendix G). Critical to the ethics permission was to protect the anonymity of the participants and a secure means to protect the collected data. Prior to each interview, the participant signed a consent form to give permission for the use of collected data in my research.
3.5 Data Analysis

Creswell (1998) suggests that the main purpose of the case study analysis is to provide a detailed description of the case and its setting as the data was collected. In this way, the outcomes of the analysis may provide naturalistic generalizations for application by the reader (Creswell, 1998).

The categorical aggregation analysis method (Creswell, 1998) was used in this case study. The interview data was transcribed and four broad categories were established: environmental, social, economical, and technological. Within these categories, the data was further collapsed into four major themes: environmental motivations of homeowners, community cohesion, economic realities, and leadership roles of the municipality and homeowners.

3.6 Verification

Any analysis, either qualitative or quantitative, requires extensive verification so that the results are deemed meaningful and may be applied to the field of study. Stake (1995) describes the process of verification in qualitative case studies in terms of a single question, “Do we have it right?”. This case study was verified by three means: triangulation; clarifying researcher bias, and a rich, thick description of the case (Creswell, 1998).

In triangulation, the data is verified by making use of all sources of data and many respondents who add insights into the emerging themes (Creswell, 1998). In this case study, the homeowners were all asked the same questions and the data was recorded in the form of audio...
material and field notes. Generalizations on the major themes were formed and disputed based on the many perspectives of the participants.

The outcomes of this case study are only valid under the conditions at the time of research. The role of the researcher is to relay the participants’ insights but inevitably the researcher’s own biases became intertwined in the analysis (Creswell, 1998). The introduction and literature review serve to provide insight into my own biases so that the reader may factor them into the conclusions of the research.

The third method of verification was a “rich, thick description” of the case study (Creswell, 1998). The findings of the case study serve to tell the story of the participants and provides the results with as much depth as possible, substantiated with the respondents own words where possible. In this way, a reader may decide if the findings have transferability to another area of research.
Chapter 4
Case Study Results

4.1 Introduction

This section will describe the results of the qualitative study conducted during my site visit at Okotoks. The data consisted of eleven interviews, nine of which were homeowners, resulting in more than 7.5 hours of recorded interviews and associated field notes. From the analysis, four themes emerged: environmental motivations of homeowners, community cohesion, economic realities, and leadership roles of the municipality and homeowners. The confidentiality of the participants is required at all times as per the Graduate Research Ethics Board requirements on my research study. It is for this reason that individual responses will remain anonymous (unless otherwise permitted and referenced) and their responses will be identified in quotations in the following results of the case study.

While the subsequent results of the case study were verified within the scope of the study, further generalizations drawn from this research must take into account the low response rate of the homeowners when applying to another population. There are 52 homes in the DLSC and only 9 homes responded to the research flyers. One explanation for the low response rate is that not all of the homes were occupied at the time of research. The research was also conducted in a relatively short time frame of 5 days in which I was onsite for only a few hours each day, thus giving limited chances for participation.
4.2 Environmental Motivations of Homeowners

The first part of the interview was designed to provide insights into the environmental motivations present during the participant’s decision making processes. It is clear that these participants were not forced into partaking in this project and have many other options for housing in the Calgary region. So how then are 52 homes purchased and occupied by individuals who want to be early adopters in this new technology? This central purpose proved to be complex and varied depending on the participant involved. What follows are the explorations of the environmental motivations of the homeowners.

4.2.1 Environmental Crisis and Response

Emerging early in the data analysis process was a call-and-response theme of an imminent environmental crisis and the lack of an adequate response, either personally or as a social collective. In the case of the homeowners, many felt like the local and global economies are growing too quickly and lacked “future thought”. Without this future thought and planning, resources are consumed far too quickly and the citizens of the DLSC need only to look to their own oil sands exploitation in the north of Alberta.

One participant suggested that Albertans, as a people, “have a very strong connection to the land”, alluding to a sense of place and suggesting this is a call for an environmental response. Perhaps this was best illustrated by an anecdote involving one of the homeowners’ parent, whom she openly labeled as being unconcerned about the environment or environmentalism as it is commonly defined. En route to a fishing lodge destination, her father crossed over “Fort Mac”, referring to Fort MacMurray which is the support town for the Athabasca oil and tar sands project. Upon seeing the vast open pit mines and such
overwhelming devastation to the land, her father “began to cry” for the loss of the natural environment.

The homeowners had varied methods for gauging the environmental crisis. In some cases, it was measured by the localized effects of snowfall changes or urban smog, while it was global warming and its globalized effects which were of concern for others. One participant was concerned about the local smog accumulation over the Calgary city centre. He asks, “... never mind global warming, do you really want to live in that?”. The awareness of an environmental crisis was always closely followed with a sense of accountability for their individual part in either perpetuating the crisis or changing its direction. As one interview simply asks, “What will be left for our children?”, it is clear that individuals believe they have a key role to play. The action that each homeowner is willing to take was equally as varied. Some foresee the need for “easy changes”, such as low flow faucets and recycling. Others were much more adamant that larger changes were needed and insisted they would “go down kicking and screaming” to make sure they change the path leading to the current environmental crisis.

The solar hot water technology was the primary reason for some to move to the DLSC. One respondent suggested that the technology resonated so clearly with her husband that moving here was the only option available. She enthusiastically reports that the technology “really represented who he was”, implying the need for a large role in the response to the environmental crisis. Another owner said, “There’s nothing else going on in Canada” and was delighted for the opportunity to partake in the adoption of this new technology. For others, economics, small house size, and proximity to family were strong factors in the decision making process and the solar technology was an “added bonus”. These latter factors will be discussed in
greater detail in the subsequent sections. It is important to note that even though the solar hot
water technology was not the pivotal factor for all in their decision to move to DLSC, it was
never viewed as a negative addition to the homes.

4.2.2 Definitions and Implications of Sustainability

Since it was clear that respondents believed an environmental crisis was approaching, I
wanted to expand this thought further: how do the homeowners define sustainability and how
does this align with the vision of sustainability to which the town of Okotoks subscribes?

The definitions for sustainability were very diverse and highlight the issue of poorly
defined language and its role within the environmental movement. Definitions of sustainability
included: becoming more self-sufficient in resources and energy; minimizing environmental
impact; energy efficiency; reducing consumption; and supporting local economies. Although the
definitions for sustainability were quite varied, it was clear that sustainability had a time factor
associated with it. It can be generalized that to all who had responded, sustainability means
using resources in a manner in which the utilization could continue indefinitely.

This ambiguity in the term “sustainability” has an extremely dangerous potential to lead
to green-washing but this was clearly not the case here with the very well informed residents of
the DLSC. With respect to Okotoks, most residents were familiar with its vision to hold a
population cap based on the carrying capacity of the Sheep River watershed. Okotoks was also
viewed favourably for its solar hot water applications on municipal buildings and its good
recycling program. However, everyone agreed that neither the DLSC nor Okotoks are
sustainable. One participant is quick to point out that although the energy consumption of the
DLSC is significantly reduced via the solar hot water and R-2000 building construction, they still have a gas fireplace which consumes exhaustible natural gas. Another person points out that most of the residents in DLSC commute to Calgary for employment and must consume enormous quantities of fossil fuels in their automobiles. Indeed, it would be very interesting for future research to compare the total GHG emissions of citizens living in the DLSC with those living in the Calgary city core that can walk, bike, or use mass-transit to arrive at their work, recreation, or shopping destinations.

In all cases, this is not a defeatist perspective but rather an optimistic acknowledgment that there so many ways to continue the journey towards sustainability. As one homeowner phrased it, DLSC and Okotoks are just the “tip of the iceberg”. The citizens of the DLSC are actively suggesting further improvements towards sustainability to the town and the community developers including options for community gardening, municipal composting, xeriscape (low water) landscaping methods, and high-efficiency appliances.

4.2.3 Role of Traditional Heating in Canada

An interesting part of the discussion centred on how residential space and water heating contribute to residential GHG emissions. Some could quote the suggested 5 tonnes of GHG reduction per home that is predicted by the DLSC developers. Others intuitively understand that heating is a large part of residential energy consumption in Canada. In all cases however, when asked to suggest a percentage of residential energy consumption that comes from space and hot water heating, the estimation was from 30 to more than 50% of GHG’s. This is actually remarkably low compared to the actual data of 82% (Environment Canada, 2006b). To clarify the question for one respondent, I described home energy consumptions as emissions resulting
from heating, hot water, and appliance usage. Confused, he suggested that he doesn’t “think appliances produce GHG’s”. He then quickly made the connection to the fuels that are combusted to make electricity for his appliances and the resulting GHG emissions. It is telling of the current understanding of GHG emissions as being directly linked to fossil fuel combustion. When energy is consumed in a secondary form, such as electricity, is not clear to everyone that this also contributes to global warming. It is therefore, conceivable that people who wish to respond to the environmental crisis will readily see the role solar thermal technologies can play to directly displace GHG emitting energy sources.

4.3 Community Cohesion

The structured interviews were designed to extract information about the social dynamics within the DLSC. Although there was an entire set of questions related to this topic, most respondents were extremely excited to express their satisfaction with the community cohesion earlier on in the interview process. This section will deal with the evidence to support the increased community cohesion and provide insights into the underlying reasons for this phenomenon.

4.3.1 Evidence of Increased Community Cohesion

The DLSC was developed in two discrete sets of homes: in early 2006, the first 26 homes on Drake Landing Court were occupied and beginning in 2007, the second row of the remaining 26 homes on Drake Landing Lane was occupied (see Figure 4-1 for clarity).
This is important for two reasons. Firstly, the first occupants were generally more excited about the solar technology and were keen to become early adopters. Evidence to support this claim is discussed in the preceding section theme of “Environmental Motivation”. The second reason is that the first occupants have had more time to adjust to their new community and begin forming a community network.

Overwhelmingly, the participants in the first group of homes emphatically expressed their content with their neighbors and their community. One respondent stated that “everybody
is tight on this street” and another suggests “we all just get along really well”, implying that the community cohesion and bonds between neighbors are ever-present and formidable. This increased cohesion was echoed by all participants in the first groups and most in the second group. A second-group participant suggested that “60-70% of people in DLSC are extremely nice and friendly” and that this is very different and favourable when compared to his previous experiences in different communities in the Calgary region. An interesting point of interpretation was the speed in which these connections were made. Most respondents were extremely surprised and pleased with the rate at which they have met the people in the DLSC. One participant in the first group claims he has “never got to know neighbors this fast”, comparing the DLSC to other communities in Alberta and British Columbia. Another in the first group suggests she had a “quick connection with [her] neighbors right away”.

4.3.2 Reasons for Increased Community Cohesion

There are several reasons why the community cohesion is increased in the DLSC. The first and perhaps most obvious reason is the shared environmental concern or alignment of environmental core values. As suggested in the proceeding section, all participants believe there is an environmental crisis either approaching or present and there is a need for action. Respondents suggest that this common ground provides an immediate starting point for conversation and beginning to build strong community networks.

Another member of the first group insists that there are issues of urban design at work in the DLSC and points to the location of the garages at the rear of the lots. Most of the homeowners park their cars in front of their houses and this provides an “increase in interaction
with the neighbors” because they have more opportunities for chance encounters while leaving their homes. In contrast, a member of the first group adamantly states that she believes it’s not the design of the DLSC that promotes community cohesion but rather it’s the roles of the specific individuals in the community. She suggests that it takes like-mindedness in an open environment where there are leaders who push the extremities of the group and allow others to “shyly attend”. The result gives people an experience in which “cross-pollination” can occur to stimulate ideas, action, and increase community cohesion.

Another dimension of the increased community cohesion is the bonding experience that comes from being early adopters in the solar technology. As one interviewee states, “People are really fascinated and excited to live in a project like this”. There have been numerous media events in the DLSC including the Weather Network, The National on CBC, The Current on CBC Radio One, and a group of cyclists who used the DLSC as a backdrop for their documentary, highlighting the destruction of the oil sands. This attention reaffirms to the homeowners that they are embarking on something out-of-the-ordinary and that is in a very favourable environmental and social light.

4.3.3 Social Dynamics Divide

It is important to note however that not all in the second group felt that there was a stronger sense of community or community cohesion present. One homeowner suggested that while the community spirit is “pretty good”; there is a definite divide between the people in the more established first group of homes and those of the second group. Perhaps a portion of this separation is due to the fact that at the time of my field visit, there were still some homes that were not sold yet on the second row. One participant invited me into his home for an interview
and obviously still settling into his new home. His living room was full of moving boxes and there was unfinished landscaping in the yard. In contrast, the first groups of homes were very settled and had made elaborate rock gardens and pathways lining the entrances to their homes.

I believe there is a deeper interpretation in the divide between the social dynamics of the first homes and the second. The divide exists primarily because of the deeper understanding of and passion to advance sustainability amongst the first group. All of the participants in the first group were extremely ambitious in their definition of sustainability and how the DLSC and Okotoks could fit into sustainability. Respondents subscribe to a deeper ecological sense of what sustainability means suggesting “everything is part of the whole” and that the social and environmental issues were more pressing and needed immediate action both on a personal and community-scale level. One person in the first group of homes says that the DLSC community enables residents to “borrow each other’s wheelbarrows, ideas, and muscles”. The first group was also very vocal in their drive to push the developers towards ideas of community gardening and the potential for a car-free front lane. It appears the first group of homeowners came here with an overarching purpose: to embrace sustainability in a suburban environment.

4.4 Economic Realities

A key element in the success of the DLSC is the role of economics. There are many dynamics at play including: the subsidization of the new technology by means of federal, provincial, and municipal incentives; the impact of the Calgary real-estate boom; the formation of a micro-utility to manage the heating costs by Atco Gas; and the willingness of people to pay
for the new technology. The results of this study offer an opportunity to learn what the homeowners know of the economic dynamics and what role they had in their decision to become a member of the DLSC.

4.4.1 Funding of Project

During the interview, I asked each participant what they knew of how this project was subsidized in an open and non-leading manner, allowing the participant to fully disclose all information they had regarding funding. At a high level, all of the respondents understood that the project was heavily subsidized by various government actors. This generality holds true for all interviews. The variability arises when describing who these actors are and specifically to what extent they have contributed to the project. Most of the participants understood that a combination of federal and provincial funds was used, however none knew of the involvement of the Federation of Canadian Municipalities (FCM). This contribution is indeed the largest of the three contributors at $2.9M CDN, or more than half of the total funding. This funding was made available via the Green Municipalities Fund. In fact, it was the FCM that has been instrumental in the adoption of solar hot water technology by Okotoks and this will be discussed later in the “Leadership” theme.

When asked about the funding for the project, most of the homeowners were quick to quote a number based on funding per house. An equal number of people claimed the funding was $40K and $100K per house. The original funding of the project totaled $5.5 M and a straight division across 52 homes equates to slightly more than $109 K per house. However, with setbacks reported in Chapter 2, the project cost is now estimated at $6.6 M, or more than $127
K per house. One participant believed the funding was equal between federal and provincial, with each contributing $7M for a total of $14M.

The source of their information remains unclear since the participants seem to have absorbed it via their own individual interactions with the project to date. It can be concluded that there is great ambiguity in the true cost of the solar technology and how this project was subsidized.

4.4.2 Willingness to pay for technology

It was clear that regardless of the exact amount of subsidization used in the project, the homeowners understood this technology was new and expensive. The ever-present questions in the literature regarding renewable energy technology adoption are what is the cost of technology and what are people willing to pay?

Before answering these questions, it is important to first frame the real-estate market in the Okotoks region. The homes in the DLSC were designed to be entry-level homes, classed mostly for their small floor space of between 1,396 and 1,653 square feet, and priced competitively in the Calgary region real-estate market. These homes were planned for people who in the traditional sense wanted fewer rooms at a lower market price, such as first time home buyers, couples starting a family, or retired individuals. The houses were priced to be competitive with the local real-estate market. One of the residents in the first group of homes stated that the market price for the homes in early 2006 was between $239-256K. They stated that the same house in late 2007 had a market price of around $420K. This enormous increase in home prices led to a large price differential between the first and second group of homes. This
must be factored into understanding what homeowners are willing to pay as some have already paid substantially more than others. It is therefore logical to group the responses into on the first and second homeowners.

For this analysis, I will assume a baseline of $250K for homes purchased in the first group, based on the average of the interview data described above. In interview with a second group home owner, it was stated that their purchase price was $386K so this will be the assumed purchase price of all second group homes. This assumption is valid only in the context of converting crude estimations of willingness-to-pay from percentage of purchase price to dollar amounts. Future research would do well to obtain actual real-estate prices for the homes of all respondents. The resultant data is shown in Figure 4-2.

When analyzing this quantitative data, it’s imperative to remember that this is a qualitative study and that any kind of statistical analysis and subsequent conclusions are not valid due to the serious limitations in the small sample size. What can be drawn from these data however, are two very important qualitative conclusions. The first and most important is that people are willing to pay above market prices to support this new technology. The second and less concrete conclusion is that people who purchased their homes at a higher market value are generally willing to pay less for the technology.
The conclusion that people are willing to pay for technology has enormous potential for market and policy applications. During the literature review process, data indicating what people would be willing to pay to support CSHP technologies were complete absent. The range of responses is clearly less than the true cost of $127 K per house but this need not be discouraging. People are willing to support an environmental technology that has the potential to reduce large amounts of carbon from the atmosphere and have made this decision independently from traditional real-estate market forces. As seen in the European experience with CSHP, economies of scale have a large effect on lowering the cost to homeowners (Chapter 2, Figure 21). With larger projects, the price per home will reduce and this research finds that homeowners are willing to provide much of the funding, effectively reducing the need for subsidies.
The latter conclusion can be seen in the trends in Figure 4-2. This phenomenon is logical since the people have purchased the homes at a higher market value and they have less ability for economic support. A confounding and very important factor in this analysis is the overwhelming sense that the first group of homeowners had a much more in-depth and impassioned environmental motivation than the second group. This could also be a large factor in the disparate data groupings. These two factors, higher purchase price and weakened environmental motivation, cannot and should not be separated in this analysis due to the nature of this qualitative study and the lack of supporting data. To properly decouple these confounding factors, a rigorous and proper statistical quantitative study should be performed in which the data in Figure 4-2 accurately reflects the variability in the purchase price of homes and willingness to pay for the technology.

4.4.3 Motivations for willingness to pay

It is clear that the people are willing to pay to support the cost of the DLSC homes and their technology. As discussed in the literature review, Canadian and Albertan citizens are by no means altruistic. A large percentage of Canadians believe there is an environmental crisis but there has only been speculation as to what extent people will make personal choices to support their concerns. How then can the homeowners’ willingness to pay be explained? The interviews yielded many insights into this phenomenon.

Many of the homeowners were very excited to have homes that were built to the R-2000 standard. This ensures a highly efficient building envelope, minimizing the demand for heating and cooling. It was important to many of the homeowners in terms of cost savings for their space heating. But a secondary reason why the R-2000 standard was important to
homeowners was because it ensured high quality housing construction. With the burgeoning real-estate market in Calgary, there are many reports of poor house construction due to the severe shortage in skilled and experienced tradespeople. To build a home to R-2000 standards requires unique certification which helps to ensure a smaller and more reliable subset of eligible tradespeople for the house construction. The homeowners are willing to pay extra to support this increase in housing construction quality which adds “additional confidence”.

The people of DLSC who are driven by environmental motivations have a “vested interest” in the success of the solar project. As one respondent said he would be “upset if the system fails or ... if someone jeopardized it”. When asked why he would be willing to pay more, he stated he was glad to advance the technology “to bring down the price for others”. This sentiment was echoed by other homeowners and demonstrates their desire to have more CSHPs to help combat the environmental crisis. Early adopters are needed for CSHP and again, as shown with the European experiences, the costs have lessened drastically with increasing scale and experience of plant construction.

The homeowners were also very pragmatic. Realizing that fuel prices are escalating to unprecedented high prices at increasing rates, they were all very pleased to secure their heating demands for 5 years under the agreement with Atco Gas, an Alberta based natural gas distribution company (ATCOGas, 2008). As stated in the introduction, the CSHP is expected to take 5 years to commission and reach the steady-state thermal conditions required to provide 90% or greater of the space heating demands of the homes. During this 5 year period, ATCO Gas is managing the energy centre as a utility company and fixes the heating costs to the
homeowners at $60 per month for five years. People were very excited to have the 5 year fixed heating costs foreseeing the ever-rising prices of natural gas.

If the DLSC project meets its requirements at the end of the 5 years, ATCO Gas has the option to take over the utility for the long term. If however the project fails to meet its project objectives, the homeowners bear no risk because Atco Gas will replace the special hot water furnace with a traditional high efficiency natural gas furnace. This mitigation of risk was a key element for the homeowners.

4.5 Leadership Roles of the Municipality and House Builder

The preceding sections explored the remarkable social dynamics involved in the acceptance of solar technology by the residents of Drake Landing. In addition to their continued support, the project also needs to have support by the municipality and the home builder. This section will outline specifically the leadership roles of these two key actors.

4.5.1 The Town of Okotoks

“Citizens a) have a right to manage their destiny and b) desire to have a vision about what that community will be” - Rick Quail, Municipal Manager, Town of Okotoks

The town of Okotoks is experiencing many firsts amongst other Canadian municipalities. It is one of a few satellite towns to support the burgeoning commercial success of Calgary, so close that many of its citizens depend on a steady commute to and from the Calgary city limits for employment. It is the second fastest growing town in Canada, with a population soaring by
over 13% annually between 2001 and 2006 (Blackstone Commercial, 2007). The result is a town with an estimated 19,352 population base in 2006 and showing no signs of slowing down. The Deerfoot Trail highway was extended to the community in late 2003, providing for a smooth commute to the Calgary city limits in less than 30 minutes as experienced during my visit. So how then does a town council control this growth? Or perhaps more importantly, why does a municipal government want to impede what can conveniently be viewed as progressive growth? The answers to these questions are complex and largely point to a town council that is exceptionally forward thinking and who show incredible leadership skills. The following are the results and interpretations of my interview with Rick Quail, the municipal manager for the town of Okotoks.

As outlined in the literature review, the process to limit growth or pursue smart growth began during the 1990’s when the population of Okotoks began to increase to support Calgary’s economy. The town of Okotoks was caught between supporting this growth by essentially becoming a “bedroom community” or retaining its small-town charm and having a uniqueness and purpose of its own. Mr. Quail states that the starting point in a smart-growth strategy is for the town to “manage its own destiny”. This includes an acknowledgement of the human and ecological limitations of the water supply based on the Sheep River that meanders through the downtown core. It was projected that the watershed of the Sheep River could support no more than 25-30,000 people. Acknowledging this ecological limitation was the footing upon which Okotoks began its journey into smart growth and led to the eventual placement of the Drake Landing Solar Community.
In the middle of the 1990’s, the town embarked on its new smart-growth strategy. To do this, they realized that they needed to reorganize and ensure that their organization was capable of the formidable challenges ahead. Mr. Quail recalls that the municipality recognized that it need to be “innovative and risk taking”, leading to a new organization structure consisting of 22 business centres with 5 supporting managers. The ultimate structure of the municipality was to be a “customer service” provider for the citizens of Okotoks.

The involvement of citizens was essential to any strategy of smart growth. When asked how the town sought this involvement, Mr. Quail suggests plainly that you “go out to the citizens and ask”. Through public meetings, community surveys, and “community based social marketing”, the town officials were able compile a projection of the town in 20 years (see the literature review for more details of this social marketing data). This included several iterations of vetting the town’s direction with the citizens. Mr. Quail said that elaborate “visualizations were made”, including a virtual helicopter ride through the proposed town under the new vision. This process involves “continuously revisiting the premises, the foundation” of the plan, for without this sound foundation any strategy is sure to fail. Mr. Quail states that the important part is to stay transparent to the citizens and “be sure they know all about the vision” in the process.

The proposed vision of Okotoks is a town with autonomy. It is a town which strives to live within the ecological limitations of the Sheep River watershed through what Mr. Quail states as “constant innovations” in landscaping practices, retrofits of infrastructure, and tracking of water distribution. It is a town that provides an ambitious goal of reaching a diversity mix of 20:80 commercial to residential land-use from its current state of 10:90, effectively providing
gainful employment for its citizens within its own town boundaries. It is a town that sees lessening its environmental impact as not limited to water-use issues but a town that achieves significant economic, environmental, and social benefits by utilizing reliable, energy efficiency technologies. The pursuit of technologies is the path which eventually led the town to the Drake Landing Solar Community.

In the mid-1990’s, Mr. Quail explains the energy market went through deregulation and had important impacts on Okotoks. The first is that the town stipulated a certified renewable energy minimum for electricity consumption. As of early 2007, 80 per cent of the electricity delivered to the town is generated through certifiable renewable means. In addition, the town earned a $90 K rebate for energy efficiency initiatives under the market deregulation. The $90 K was allocated to an eco-efficiency fund and provided seed-money for energy efficiency projects in the town. What happened next highlights the brilliance of their foresight: with the energy savings from the initial energy efficiency upgrades, the council did not dole out the savings to the citizens but ordered that they be returned to the eco-efficiency fund. This revolving fund was then used to seed more energy efficiency initiatives and perpetuates itself through the subsequent savings in energy. This is the financial mechanism by which the town was able to purchase its solar hot water pool heating system for the Aquatic Centre, the solar hot water ice surfacing system on the hockey arenas, and the solar air space heating system for the municipal operations centre. Mr. Quail insists the foresight to reinvest the funds into a revolving fund system was paramount in their success with these and many more energy efficiency initiatives.

In the early 2000’s, the Federation of Canadian Municipalities invited Mr. Quail and other town officials from across Canada to visit international sites that had successfully utilized
renewable energy and energy efficiency technologies. In 2002, Mr. Quail travelled to Denmark and in 2003, he visited the Netherlands. It was during this time that he became aware of the abundant potential for solar hot water technology to be used at a municipal level. He witnessed firsthand “the real potential” in energy consumption savings and the direct environmental impact through the offsetting of fossil fuel combustion with “municipal district cogeneration plants”. Upon his return to Canada, Mr. Quail and the town officials embarked on an ambitious task to outfit to apply his learnings to the town of Okotoks.

Simultaneously, Natural Resources Canada in partnership with SAIC Canada was seeking to begin a demonstration plant of CSHP technology. The southern portion of Alberta has some of the highest solar resource availability in Canada. Okotoks was already well on its mission to become a sustainable municipality and had several successful solar technology applications. The leadership and vision of Okotoks were completely in support of innovation and sustainable development and thus the project was conceived: a central solar heating plant with seasonal storage; the first CSHP in North America; the highest achievable solar fraction in the world, and a reduction of more than 5 tonnes of GHG emissions for each house it supports. When the town was approached and asked, “Will you partake?” the council leapt at the chance, Mr. Quail recalls. It was a perfect fit.

4.5.2 The Sterling Group Home Builder

The town of Okotoks involved United Communities, a prominent Calgary based real-estate development company to design what would later become the Drake Landing Solar Community. United Communities solicited interest from builders for the new and innovative project. The “only one to respond” was the Sterling Group, a significant builder in Western
Canada, in operation for more than 50 years, building between 4 and 5 hundred homes per year (The Sterling Group, 2008). The DLSC project was given to Special Projects Manager, Keith Paget, with whom I had the pleasure to speak during my visit to Okotoks. The exceptional commitment to innovation, flexibility, and leadership of The Sterling Group at the local level was essential for the project’s success.

In May of 2003, Mr. Paget initiated the feasibility studies of the DLSC, a group of homes committed to environmental sustainability through individual and community-level applications of solar technology. There were two phases to this research. The first was a visit to explore successful CSHPs in Sweden, Denmark, and Germany in 2003. To Mr. Paget, it was evident that the technology was reliable and ready for application in Canada. Simultaneously, social market data was collected at The Sterling Group of home building projects around the Calgary region. In an exit survey, homeowners were asked if they would like to be involved in an “environmentally designed community”. The responses suggested that a significant percentage of people were indeed interested. Mr. Paget also shared similar recent social research which shows a significant increase in people who are interested in environmentally designed community but the details cannot be discussed in this dissertation due to the confidential nature of this market data.

Armed with the data suggesting a desire for this type of home from buyers and the success stories of European CSHP’s, Mr. Paget and the project’s partners began to design the homes for the DLSC. At this point, the market conditions suggested that there could be a collapse and that “the starter market was more likely to succeed”. In terms of the Calgary region’s real-estate market, this translates to houses that were around 1,500 square feet in livable space. The technical specifications of the heating demand of the 52 homes suggested 800
solar panels were required. Mr. Paget states that the solution to this became the separate garages that were connected with “breezeways”, providing sufficient surface area for the 800 solar collector panels.

A complication to the solution was that “most [customers] in this market wouldn’t pay for the garage”. Fortunately, the funding for this project covered the additional capital cost to make the garages more energy efficient, have better frost-resistant foundations, add breezeways to connect the garages, and atypical sloped roofs for optimum orientation to the sun (It was determined more cost effective to mount the panels flat to the roof and have the roof angled than to use a racking solution for the panels.). The end result is the “customer pays $5K for the garage”.

Another critical decision in the design phase was to make the homes “comparable to conventional homes”. To Mr. Paget, this was the most important design consideration and took priority over the solar technology, utilizing R-2000 or the Alberta Built Green standards. When it came to the ability to sell DLSC homes, Mr. Paget doesn’t speculate to the factors in the buyer’s decision making process, but rather suggests the market had grown to such an extent that many more homes “easily could have been sold”. As explored in the “Environmental Motivations” theme, some of the residents had apprehensions about moving into a home with new untested features such as solar heating and low flow faucets. Mr. Paget insists that during the design phase, the solar technology was also “made easy for homeowners”, imply that little intervention would be needed. The culmination of these design features was a home that was marketable to a broad range of customers, offering many environmentally-friendly services at no burden to the owner.
The Sterling Group has had experiences with the Alberta Built Green (ABG) program previous to the DLSC. Mr. Paget explained that the ABG program leads to an energy efficient building, which at a gold level has minimal impact to construction costs. Additionally, builders who use the ABG program receive a financial incentive to do so. When the DLSC project required the homes to be built to the more stringent standards of R-2000, the leap was much smaller than if the homes had to be designed without the ABG gold standard.

Mr. Paget explains that The Sterling Group has a philosophy which delivers a resounding message: “Do the right thing”. In case of the DLSC, The Sterling Group realized the need for a builder who was willing to work within partnerships to implement this cutting-edge project. Mr. Quail employed his leadership at the municipal level with commitment to their collective vision for a sustainable Okotoks. Mr. Paget and the Sterling Group seized the opportunity to become involved in the DLSC project from an implementation perspective and was a critical piece of the confluence of factors necessary to make the Drake Landing Solar Community a reality.
Chapter 5
Conclusions and Future Recommendations

The choice of this dissertation was made to serve as a bridge, spanning the gap between my training and understanding as an engineer and the social and environmental implications of technology. The DLSC is a world-leading example of technological excellence and innovation, but before it can be replicated, it must be understood if a community like the DLSC is the right thing. Indeed, it will lead to enormous GHG emission reductions for the homes in the subdivision, but is it the right thing for the people of Okotoks? Is it the best use of the technology? Does it fit within the values of Canadians or what sustainability means in Canada? To begin answering this question, the complex social and environmental underpinnings of the DLSC were analyzed with a keen eye to historical, political, and cultural factors. Once this first quest was satisfied, the second objective was to understand the factors required to implement more communities like the DLSC. This section will outline the conclusions and future recommendations of research, drawn from the literature review and case study of the DLSC.

5.1 Literature Review

The literature review was designed to explore global warming and how solar heating technologies could be part of the solution. All of the peer-reviewed literature shows, without dispute, that the earth’s climate is indeed warming and this is very likely due to anthropogenic GHG emissions. It is clear that these emissions must be reduced to mitigate catastrophic changes to the earth’s climate. Solar thermal technologies are reliable and immediately available to capture the sun’s heat for domestic hot water and space heating. In the case of the DLSC, each home will reduce their GHG emissions by more than 5 tonnes every year. This great
reduction in emissions is due to the use of the central solar heating plant (CSHP), residential solar hot water appliances, and energy-efficient R-2000 house construction.

Recent public opinion polls demonstrate that Canadians are very concerned with the effects of global warming, in fact, valuing this above all other policy issues including the economy, health care, and the war in Afghanistan. This is a clear and power shift in the values of Canadians in recent years. To add more pieces to the puzzle, the province of Alberta and the home of the DLSC, is the largest emitter of GHG’s in Canada due to its energy intensive production of the oil tar sands. According to public opinion polls, Alberta is also the least likely in Canada to believe in global warming.

In the midst of this complex situation emerges Okotoks, a beaming example of municipal sustainability. Realizing the enormous economic boom in the Calgary region and subsequent housing growth required to support this boom, Okotoks took the innovative approach to manage its own destiny. It is the first municipality in Canada to limit its growth based on the carrying capacity of its ecological resources; in the case of Okotoks, the Sheep River can provide for no more than 25-30,000 citizens. In addition to living within the constraints of the local watershed, the municipality is also striving for greater energy efficiency, shifting the focus from burning fossil fuels to utilizing renewable energy, including active solar heating.

Renewable energy often involves utilizing a distributed energy generation model where energy is produced close to the end user. In the case of solar heating, this often happens with many installations of collectors placed on the exterior of buildings that require the energy. This
is a tremendous shift in production, requiring more facilities to produce the energy and more decision making processes to ensure the local citizenry are satisfied. While large wind and solar production plants must often contend with NIMBY-ism, solar hot water on a small-scale has been shown to have a much higher rate of acceptance.

Canada is fortunate to have a tremendous solar resource, comparable to countries in Europe who have become world leaders in the use of solar technologies. Unfortunately, at the present time, Canada has capitalized very little of this market potential, mostly with low heat, unglazed pool heaters. The unglazed market is, without question, reducing GHG emissions in Canada, but the largest potential lies within the glazed collectors. Europe has made better use of the glazed technology and has led to a reduction of 7.2 kg GHG emissions for every one of its citizens. Canada significantly lags Europe and would have to increase its solar heating penetration 11 fold to match the same levels of emission reductions on a per capita basis. However, this would still be well short of reaching the required emission reductions under the Kyoto treaty. To satisfy this, a 300 fold increase would be required. In other words, a complete revolution of how we utilize solar heating technologies. Of course there is a tremendous role for other renewable energy fuel sources (such as biomass) for heating, which would reduce fossil fuel consumption and lessen the burden on solar to meet the GHG emission reduction targets.

A review of effective market policies in Europe highlights some of the reasons for the lagging solar thermal market in Canada. The largest shortcoming in energy policy comes from the complete lack of solar thermal targets on either the federal or provincial level. Beginning with the UK’s white paper and continuing with the German EEG energy policy document, European countries have been extremely clear about how much of their energy is required to
come from solar energy. This is the foundation upon which all the market penetration is built in Europe. Canada would do well to set forth its own targets to effectively stimulate the market. Fortunately, the Canadian Solar Industries Association (CanSIA) has provided target documents, is providing sound training for installers, and is ensuring the technology follows strict regulations under the Canadian Safety Association certifications. Incentives are also available in Canada for individual homeowners. The federal government is very active in supporting the R&D and commercialization of solar thermal technologies through the Natural Science and Engineering Research Council of Canada (NSERC) and Natural Resources Canada.

Europe has also had vast experience and success with CSHP; by the end of 2004, there were more than 55 large-scale CSHPs installed, ranging from 500-2,000 m² in collector surface area. Their experiences clearly show that regardless of technology used for the construction of the CSHP, economies-of-scale principles are present with larger plants becoming much more cost effective.

5.2 Case Study Results
The results of the qualitative research conducted in the DLSC are the first academic insights into the social drivers of the key actors. The results are divided into two parts: the views and opinions of expressed by the homeowners; and the leadership required by the municipality and the home builder.

5.2.1 Homeowners
An overwhelming theme from the respondents was a call-and-response to the imminent environmental crisis. Although the homeowners had varied ways to gauge the state of the
environment, all clearly stated that the current rate of production and consumption in the DLSC and throughout Canada is not sustainable and lacked future thought. The DLSC provided a way for the homeowners to make a tangible difference, by using less fossil fuel to heat their homes. My hypothesis upon beginning this research was that Albertans would be less accepting of an environmental project because of their oil-based economy. However, being acutely aware of the destruction in the oil sands made the respondents more aware of the urgent need for a change in behavior and they had motivation to undergo environmental action.

Sustainability was a key part of the research. In particular, I was interested to understand what sustainability meant to the homeowner in the context of their day-to-day lives, the community of Okotoks, or the country. The definitions of sustainability were varied, all having to do with lessening impact on the environment. One dimension that remained steady was a time component, with all the respondents understanding that sustainable actions must be able to be continued indefinitely. They all agreed that Okotoks was not sustainable but the municipality and the DLSC community had embarked on a path towards sustainability. When asked about the role of traditional heating in GHG emissions, few understood the real impacts of traditional fossil fuel-based heating and subsequently the large role that solar heating will have on their environmental impacts. It became clear that homeowners may be more apt to appreciate solar thermal technology for its direct link to fossil fuel replacement. An interesting area of future research would be to compare the total GHG emissions of citizens living in the DLSC with those living in the Calgary city core that can walk, bike, or use mass-transit to arrive at their work, recreation, or shopping destinations.
Community cohesion was another theme in the responses, with most stating that the DLSC had increased community cohesion compared to their previous places of residence. There were several possible reasons put forth to understand this phenomenon including alignment of environmental core values, open design of properties, shared excitement and enthusiasm of using this new technology. The DLSC community is definitely divided into two separate groups, with the first row of homes being occupied a year ahead of the second. While this of course gave the first group more time to become accustomed to each other, there is a deeper divide between the two groups due to the sense of sustainability. The first group overwhelmingly subscribed to a much deeper sense of sustainability and was much more aggressive with their action to combat the environmental crisis, hence becoming early adopters in the CSHP technology. Conversely, some of the second group came to DLSC for environmental reasons but for most, the attractive market price of the homes was the primary reason.

The last theme explored with the homeowners was the economic reality of the project. All of the respondents understood that the project was heavily subsidized but none were aware of the actual funding partners and their respective contributions. In all cases, the Federation of Canadian Municipalities (FCM) was not recognized, but this organization is the largest funding partner, providing 45% of the total project funding. In addition, the FCM also was pivotal in showcasing the role of district heating and solar thermal technologies to the municipality and home builder. The effects that this awareness had on the implementation of sustainable practices, use of renewable energy technologies, and a change in mindsets cannot be understated.
The straight cost of the CSHP shared equally over the 52 homes is approximately $127K CDN. It is imperative to understand what, if any, of this amount would be paid for by the homeowners to support the technology. It was very clear that all respondents would have paid an additional fee above the market price for their home to support the CSHP. The amount varied from $10-80K CDN. Less clear are the reasons for the separation in the data between the first and second group of homeowners. It appears that the second group is willing to pay less for the technology, but great caution must be applied when trying to draw reasons for this. This research was done as a qualitative study and as such, the data is not statistically significant due to the small sample size. It is recommended that a proper quantitative study be designed and conducted to understand the true underlying reasons for this discrepancy. Additionally, acquiring the actual real-estate prices for all of the homes would add depth to the quantitative study.

However, using the qualitative results of this study, there were two emerging reasons for the second group willing to pay less for the technology. The first is the second group had a significantly higher purchase price of their homes than the first group, thus having less freedom financially to pay above this price. The second and equally important is the aforementioned weakened state of environmental motivation of the second group when compared to the first group. Again, the root of this effect can only be determined by future quantitative research.

The reasons for paying more for the technology were not superficial or altruistic. Of course, many stated that this was a means to respond to the environmental crisis. In addition, many appreciated the benefits of increased energy efficiency through R-2000 home construction. The residents were also tied to the success of the project and would like to see
additional CSHP’s be developed. Their willingness to pay was in faith that it would help lower the costs of the technology so that others may enjoy the same benefits in future installations of CSHP’s in Canada. Another large motivation was the fixed price of heating via the CSHP for a five year term. In a time of escalating fuel prices, this stability was very much welcomed.

5.2.2 Leadership

It became clear that this project required a willing group of homeowners to purchase and experiment with the CSHP technology but in addition to this, there needed to be strong leadership on behalf of the municipality and home builder.

In the mid 1990’s, the municipality of Okotoks had a choice: become a bedroom community for booming Calgary or maintain its own autonomy. The interview with municipal manager Rick Quail highlighted that it takes strong leadership, willingness to innovate, and creative problem solving to achieve the latter. “Manage our own destiny” was a phrase that anchored my discussions with Rick. Okotoks understood its watershed constraints and limited its growth to 25-30K citizens based on the supply capacity of the Sheep River. In addition to water conservation programs, the municipality also has best-in-class programs for recycling, encouraging growth of local economies, and energy efficiency.

The town of Okotoks developed an eco-efficiency fund, to which Rick credits the success of the DLSC. The fund is mandated to be a revolving fund so that any savings accrued from energy efficiency projects will need to be directed to the fund, and in turn foster new energy-efficiency projects. This fund sparked the solar thermal projects for the aquatic centre, hockey arena, and municipal buildings. Through this, the municipal became aware of the benefits of
solar thermal technology. The FCM showed the municipal the potential for district solar thermal heating plants and when approached by NRCan to partake in the DLSC, the municipality leapt at the chance; it was a perfect fit for the goals of the citizens and the vision for a sustainable Okotoks.

The final piece explored in this case study was the role of the home builder. Much credit must be given to Keith Paget and the Sterling Group for the willingness to embark on such an ambitious and innovated project as the DLSC. When first approached on the idea, Keith first went to Europe to see CSHP in action, with the support of the FCM. Upon returning to Canada, social market data was collected around the Calgary to understand the market for homes using solar thermal and environmentally friendly technology. The data suggested that there was adequate interest and Sterling began to design the homes. It was imperative that the homes be small and no different in appearance nor functionality when compared to other homes in the surrounding area. These two points were key to the project’s success, perhaps more so than Keith could have imagined. The former was decided based on trends in the real-estate market, but the small footprint of the homes in the DLSC was attractive to the environmentally-minded homeowners. The latter was important when appealing to people who wanted to be less involved with the technology or were apprehensive of the role in their lifestyles. The solar heating functions just as a standard forced-air furnace would with a thermostat in the main living space; to the end-user, there is no extra effort required. As outlined in the homeowner’s motivations, the ease-of-use and aesthetic “normalcy” of the homes was a critical factor in the homeowner’s decision to buy and live in the DLSC.
5.3 Concluding Remarks

This concludes the investigation into the Drake Landing Solar Community. The results of this research showcase Canadian technical innovation, the willingness of Canadians to lessen their environmental impact, and a market ready and willing to pay for solar thermal technology. The DLSC is being heralded around the globe as beacon of hope for environmental change. Solar technologies have the potential to revolutionize our economy while producing fewer emissions. Perpetuating our reliance on fossil fuels to heat our water and homes will, without a doubt, rob future generations of all nature that is rightfully theirs. The sun is here, abundant, and strong and the technology exists to capture it to heat our homes and water. Now we must make it happen.
References


### Appendix A

**Canadian Solar Hot Water Incentives**

Appendix A, Table 1. A survey of the provincial and federal incentives for residential solar thermal technologies.

<table>
<thead>
<tr>
<th>Province</th>
<th>Incentives Available</th>
<th>Province</th>
<th>Federal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberta</td>
<td>0</td>
<td></td>
<td>$500</td>
</tr>
<tr>
<td>British Columbia</td>
<td>PST Exemption</td>
<td>$500</td>
<td></td>
</tr>
<tr>
<td>Manitoba</td>
<td>0</td>
<td></td>
<td>$500</td>
</tr>
<tr>
<td>New Brunswick</td>
<td>$500</td>
<td></td>
<td>$500</td>
</tr>
<tr>
<td>Newfoundland and Labrador</td>
<td>0</td>
<td></td>
<td>$500</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>PST/GST Exemption</td>
<td></td>
<td>$500</td>
</tr>
<tr>
<td>Northwest Territories</td>
<td>$500</td>
<td></td>
<td>$500</td>
</tr>
<tr>
<td>Nunavut</td>
<td>0</td>
<td></td>
<td>$500</td>
</tr>
<tr>
<td>Ontario</td>
<td>$500 &amp; PST Rebate</td>
<td></td>
<td>$500</td>
</tr>
<tr>
<td>Prince Edward Island</td>
<td>PST Exemption</td>
<td></td>
<td>$500</td>
</tr>
<tr>
<td>Quebec</td>
<td>0</td>
<td></td>
<td>$500</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>$1,000</td>
<td></td>
<td>$500</td>
</tr>
<tr>
<td>Yukon</td>
<td>$500</td>
<td></td>
<td>$500</td>
</tr>
</tbody>
</table>

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11 All incentives are for single residential installations and in Canadian dollars. Subsidies may be subject to a home energy audit as stipulated in the federal ecoENERGY initiative. The terms PST and GST refer to Provincial Sales Tax and General & Service Tax respectively.
Appendix B
Letter of Information

Participant Name: ____________________________

The aim of this research is to understand the social conditions necessary for the successful implementation of a district solar hot water heating. The Drake Landing Solar Community has been chosen, as its innovation and implementation is the first of its kind in North America. The research consists of interviews in which the participant will be asked to state their opinion on questions related to the topic under study.

The interviews will be between 30-45 minutes in duration and will consist of a series of questions to guide the dialog (please see enclosed “Interview Guide”). There will be no follow-up studies. The interview will be conducted in person with participant and the researcher at the participant’s convenience.

There are no known physical, psychological, economic or social risks involved with the participation in the research. Participation in the research project is completely voluntary and participants are free to withdraw at any point of time during the research for any reason they may deem fit. There is no compulsion for participants to answer a question/questions that they are not comfortable with and the participant may withdraw from the interview at anytime simply by notifying the interviewer.

The interviews will be taped for detailed analysis at a later time. Confidentiality is paramount: the electronic audio file will be kept on password-protected computer and all hard-copies will be stored in a locked filing system with sole access to the researcher only. The individual data will be compiled with other interviews and the results will not reveal the identity of the individual interviewed. If it becomes necessary to quote some information, I will seek your written consent prior to doing so.

The results of this research will be part of a larger Master’s thesis and submitted to Queen’s University. Should it be deemed appropriate, some or all of this research may be published in peer-reviewed journals. The academic community and any other person interested in it shall have access to it through Queen’s University.

There is no remuneration provided for participating in this research.

Should you have additional questions or concerns, the researcher may be reached via telephone at: 613-888-0927 or via email at 7jmw1@qlink.queensu.ca or my supervisor Dr. S. J. Harrison at 613-533-2588 or harrison@me.queensu.ca. Additionally you may contact the Chair of the General Research Ethics Board at Queen’s University, Kingston, Canada, Stephen Leighton, tel. 613-533-6000 ext. 74579, email chair.greb@queensu.ca, regarding any complaints or queries with respect to the research.
Appendix C

Letter of Consent

Researcher: Jason Wamboldt
Master's of Environmental Studies Candidate,
School of Environmental Studies
Queen's University, Kingston, Ontario

Project Title: The Use of District Solar Hot Water Systems to Heat Canadian Housing Developments

1. Name of Participant:

2. I have read the Letter of Information and have had all questions regarding it answered to my satisfaction.

3. I am aware of the aims of this research project titled ‘The Use of District Solar Hot Water Systems to Heat Canadian Housing Developments’ and the nature and extent of my involvement in the same and have consented to the use of a tape-recorder to record my interview.

4. I am aware that I can contact the researcher, Jason Wamboldt at 613-888-0927 or 7jmw1@qlink.queensu.ca or his supervisor, Dr. S.J. Harrison at 613-533-2588 or harrison@me.queensu.ca, or the Chair of the General Research Ethics Board at Queen’s University, Kingston, Canada, Stephen Leighton, tel. 613-533-6000 ext. 74579, email chair.greb@queensu.ca, regarding any complaints or queries with respect to the research.

5. I am aware that my participation is completely voluntary and that I am free to withdraw from the research at any point of time.

6. I am assured that the researcher shall protect the confidentiality of my identity by not using my name or any other identifying information in the research and keeping the raw data safely in a bank locker.

Choose and initial one of the following:

_________ I hereby give explicit consent to the researcher to quote in an unattributed fashion in this research.

_________ I prohibit the researcher from quoting in an unattributed fashion in this research.

Name: ____________________ Date: ________________

Signature: ____________________
Appendix D

Interview Questions and Thematic Guide

Introduction

1) How long have you been a part of the Drake Landing Solar Community and what is your involvement?
2) If you are a newcomer to the DLSC, when did you move to the DLSC and what were your reasons for doing so?
3) What is your academic/professional background?

Environment

4) Do you have formal experience with environmental issues? Do you have previous experiences with renewable technology?
5) What does sustainability mean to you?
6) What do you know of the vision the Town of Okotoks has for sustainability?
7) What impact do you think heating Canadian homes on global warming? How does solar hot water heating fit into this picture?
8) What additional environmentally friendly activities are you involved with in Okotoks, either individually or as a community (e.g. municipal composting, community gardens, individual solar PV panels, etc.)?

Social Conditions

9) Why did you choose to live in the DLSC instead of Calgary or its neighboring towns? What type of people do you think made a similar chose to yours?
10) How participatory is the solar hot water technology (e.g. Do you need to monitor it and make changes?)? How important was this in making your decision to move here.
11) Do you think the DLSC is a more closely-knit community because of the interest in the solar hot water system (i.e. bringing together like-minded people)? Are the more or fewer community events than in your previous home community?

Economic Considerations

12) What is your understanding of how this project is funded?
13) How much would you be willing to pay extra to have the DLSC solar hot water technology in a new home (e.g. % of mortgage, $ value)?

Other Questions

14) Do you have any ideas/concerns that could be used to improve a future community that uses district solar hot water heating?
Appendix E

GREB Ethics Permission

Appendix E, Figure 1. Approval of General Research Ethics Board to conduct the qualitative case study.
Appendix F

Public Opinion Polls – Online Media Search

Appendix F, Table 1. A survey of contemporary public opinion polls used to assess current perceptions of the Canadian public and their perceptions of the environment and perception of risks.

<table>
<thead>
<tr>
<th>Study</th>
<th>Organization</th>
<th>Polling Dates</th>
<th>Key Findings</th>
<th>Sample Size (n)</th>
<th>Certainty</th>
<th>Reference</th>
</tr>
</thead>
</table>
| 1     | Ekos Research Associates      | May 27-29, 2002     | “67% [Canadians] support Kyoto, 19% oppose”  
“Klein has warned that a ratified Kyoto accord will hurt both Alberta’s economy and that of the entire country....Still, among Albertans surveyed, 54 per cent said they support ratification.” | 1,217           | +/- 2.8%, p=0.05 | http://www.cbc.ca/canada/story/2002/06/09/kyoto_poll020609.html |
| 2     | Environics Research Group     | June 27-28, 2004    | Most important voting issue, riding: Kings-Hants, Nova Scotia:  
- 44% Health care/health care system  
- 1% Environment/pollution | 500             | +/- 4.5%, p=0.05 | http://www.cbc.ca/canadavotes2004/thepolls/electiondaypoll.html#khome|
| 3     | Environics Research Group     | June 27-28, 2004    | Most important voting issue, riding: Outremont, Quebec:  
- 35% Health care/health care system  
- 3% Environment/pollution | 500             | +/- 4.5%, p=0.05 | http://www.cbc.ca/canadavotes2004/thepolls/electiondaypoll.html#you |
<table>
<thead>
<tr>
<th>#</th>
<th>Environics Research Group</th>
<th>Date</th>
<th>Most important voting issue, riding: Oshawa, Ontario:</th>
</tr>
</thead>
</table>
| 4  | Environics Research Group | June 27-28, 2004 | - 50% Health care/health care system  
                  |             | - 2% Environment/pollution                              |
|    |                          |            | [500 +/- 4.5%, p=0.05]      |
|    |                          |            | [http://www.cbc.ca/canadavotes2004/thepolls/electiondaypoll.html#os] |
| 5  | Environics Research Group | June 27-28, 2004 | Most important voting issue, riding: Etobicoke-Lakeshore, Ontario: |
|    |                          |            | - 36% Health care/health care system  
                  |             | - 3% Environment/pollution                              |
|    |                          |            | [500 +/- 4.5%, p=0.05]      |
|    |                          |            | [http://www.cbc.ca/canadavotes2004/thepolls/electiondaypoll.html#el] |
| 6  | Environics Research Group | June 27-28, 2004 | Most important voting issue, riding: Burnaby-Douglas, Ontario: |
|    |                          |            | - 41% Health care/health care system  
                  |             | - 3% Environment/pollution                              |
|    |                          |            | [500 +/- 4.5%, p=0.05]      |
|    |                          |            | [http://www.cbc.ca/canadavotes2004/thepolls/electiondaypoll.html#bd] |
| 7  | Environics Research Group | Nov. 2-6, 2006 | “71 per cent said the federal Conservatives’ proposed clean air plan is not tough enough in dealing with environmental issues.”  
                  |             | “But 13 per cent said the environment was the top issue [2nd behind health care at 16%], up from just four per cent during the election”.  
                  |             | “… during the 1990s, the environment, as an important issue, hovered around five per cent, mostly because of the recession. But with the subject continuously in the media, that figure rose to 10 per cent about five months ago.”  
|    |                          |            | [2,005 +/- 2%, p=0.05]  
<table>
<thead>
<tr>
<th>No.</th>
<th>Group Name</th>
<th>Date</th>
<th>Summary</th>
<th>Sample Size</th>
<th>Margin of Error</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Environics Research Group</td>
<td>Nov. 21-25, 2006</td>
<td>“... most important issue facing the country [in 2004]....”</td>
<td>1,641</td>
<td>+/-2.5%, p=0.05</td>
<td><a href="http://www.cbc.ca/canadavotes2006/analysiscommentary/poll.html">http://www.cbc.ca/canadavotes2006/analysiscommentary/poll.html</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 35% Health care/health care system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 6% Economy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 2% Environment/pollution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Environment Canada's Public Opinion Research Group</td>
<td>Dec. 8-30, 2006</td>
<td>“… factors [Canadians] believe determine environmental policy”</td>
<td>2,045</td>
<td>+/-2.2%, p=0.05</td>
<td><a href="http://www.cbc.ca/cp/national/070407/n040719A.html">http://www.cbc.ca/cp/national/070407/n040719A.html</a></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>- 38 per cent thought industry was the most influential</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>- 18% Canadian public</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>- 13% Environmental groups</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 13% international organization</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>- 10% who thought science was</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“93 per cent - place high importance on being environmentally friendly consumers. Most say they would be willing to pay five or ten per cent more for environmentally friendly products, only nine per cent say they would pay nothing more”.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Ipsos Reid</td>
<td>Jan. 25, 2007</td>
<td>“… environment has jumped in recent weeks from its normal eighth or ninth spot on the list of people's concerns to second (behind health).”</td>
<td></td>
<td></td>
<td><a href="http://www.cbc.ca/canada/toronto/story/2007/01/24/torenvironment.html">http://www.cbc.ca/canada/toronto/story/2007/01/24/torenvironment.html</a></td>
</tr>
</tbody>
</table>
| 11 | Angus Reid Strategies | March 2007 | “... one-third of Canadians think climate change is the most important issue facing humanity today.”

“... people in Quebec are most concerned about the environment and are willing to do something about it, while Albertans are the least green-minded.”

“... well-educated and wealthy Canadians are the most reluctant to change their behaviour to help the environment.”

“[Canadians] weren't interested in driving more fuel-efficient cars or lowering the thermostat in their homes.” | 3,500 | +/- 1.9%, p=0.05 | http://www.cbc.ca/cp/national/070321/n032140A.html |
| 12 | Angus Reid Strategies | Mar. 6-19, 2007 | “... almost four in five Canadians — 77 per cent — are convinced global warming is real.”
“In Alberta, 69 per cent of respondents said they believed in global warming, while in Quebec, the number soared to 83 per cent.”
“Fifty-seven per cent of Quebecers polled said they are promoting better behaviour toward the environment, while only 36 per cent of Albertans said they are doing the same.”
Number 1 issue to Canadians:
- 30% global warming #1 issue
- 31% health care
“Almost half — 47 per cent — believe climate change will affect their lives and those of future generations, while 42 per cent think it will not significantly affect their lives, but will have an impact on the lives of future generations, the poll suggested.” | 3,600 | +/- 1.6%, p=0.05 | http://www.cbc.ca/technology/story/2007/03/22/environment-poll.html |
| 13 | Canadian Medical Association | June 19-29, 2007 | “About 27 per cent of Canadians believe they have environment-related illnesses such as asthma and allergies.” | 1,001 | +/- 3.2%, p=0.05 | http://www.cbc.ca/canada/story/2007/08/19/cma-reportcard.html |
| 14 | Ipsos-Reid | July, 2007 | “Ninety-one per cent of Canadians believe they should do their part to help fight global warming, even if they have to pay more to do it. ...But they are less likely to expect their governments to shoulder responsibility for fixing environmental problems at 72 per cent.”

“Of all Canadians, Albertans, at 96 per cent, feel strongest that individuals need to take an active role in helping the environment, the poll suggests. However, they were also least likely, at 65 per cent, to believe the government should take responsibility for environment issues.”

“... nearly one-quarter [of Canadians] don’t believe global warming is proven.”

“About 90 per cent are willing to spend extra for energy-efficient light bulbs, 89 per cent willing to spend more on their next big purchases. Seventy per cent say they’re willing to pay more for environmentally friendly cleaning products, and 40 per cent say they're likely to buy a hybrid that runs on fossil fuel and electricity as a next car; 61 per cent of those surveyed are willing to pay extra to avoid heavily packaged goods.” |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000</td>
<td>+/- 3.1%, p=0.05.</td>
<td><a href="http://www.cbc.ca/consumer/story/2007/07/04/enviro-survey.html">http://www.cbc.ca/consumer/story/2007/07/04/enviro-survey.html</a></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>15</th>
<th>Decima</th>
<th>Dec-Jan 2007</th>
<th>“… the environment is the No. 1 issue for Canadians ... ahead of health care, the military mission in Afghanistan and the economy.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,800</td>
<td></td>
<td><a href="http://www.cbc.ca/canada/story/2007/01/04/cabinet-shuffle.html">http://www.cbc.ca/canada/story/2007/01/04/cabinet-shuffle.html</a></td>
<td></td>
</tr>
</tbody>
</table>
Appendix G
Economic Conversions

Appendix G, Table 1. Consumer price indexes for Germany from 1995 to 2007.

<table>
<thead>
<tr>
<th>Year</th>
<th>Consumer Price Index, 2000=100&lt;sup&gt;12&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>93.9315</td>
</tr>
<tr>
<td>1996</td>
<td>95.28904</td>
</tr>
<tr>
<td>1997</td>
<td>97.10509</td>
</tr>
<tr>
<td>1998</td>
<td>98.01312</td>
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<td>1999</td>
<td>98.57053</td>
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<td>100</td>
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<td>2001</td>
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<td>2002</td>
<td>103.4074</td>
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<tr>
<td>2005</td>
<td>107.8846</td>
</tr>
<tr>
<td>2006</td>
<td>109.5837</td>
</tr>
<tr>
<td>2007</td>
<td>112.0921</td>
</tr>
</tbody>
</table>

Appendix G, Table 2. Currency exchange calculations for the capital cost of Neckarsulm in 2007 Canadian dollars.

Cost of solar system  
(Million Euros, 1997) 1.5

Price Index Change. 1997-2007  
(2000=100) 15.0

Cost of solar system  
(Million Euros, 2007) 1.7

Exchange Rate<sup>13</sup>  
1.00 EUR = 1.55219 CAD

Cost of solar system  
(Million CAD, 2007) 2.7


<sup>13</sup> Currency exchange rate, data extracted on 2008/05/13, available from http://www.xe.com/ucc/convert.cgi.