

Solar Colwood: An Evaluation of the Effectiveness of the Solar Colwood Program in Reducing Greenhouse Gases

Ra Consulting (Team 7)

Parneet Gandhi, Sarah Harrison, Giovanna Heron, Dylan Mair, Jeff Van Andel

Royal Roads University

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1.0 Executive Summary

This report presents the findings of Ra Consulting's investigation of the effectiveness of the Solar Colwood program to contribute to the City of Colwood's carbon neutrality goals. The purpose of the research was to analyse the contribution that Solar Colwood-supported home energy improvements have made to reducing corporate emissions for the City of Colwood as part of their carbon neutrality commitment. The factors that affect the ability of the Solar Colwood program to encourage the adoption of solar hot water heaters and ductless split heat pumps by Colwood residents were also examined. These factors will ultimately affect the extent to which Solar Colwood reduces greenhouse gas emissions. It was found that with full participation in the Solar Colwood program (120 ductless split heat pumps and 880 solar hot water heater installations) the ductless split heat pumps and solar hot water heaters would have reductions of 17.83 and 54.29 tonnes of CO₂e, respectively. This accounts for roughly a 0.1% reduction of the community wide greenhouse gas emissions for the City of Colwood, and will balance roughly 15% of corporate emissions. Further research related to this report identified that residents with ductless split heat pumps and solar hot water heater installations were pleased with the ability of these systems to reduce their energy use, and decrease their utility costs. A number of barriers were also identified which related to energy consumption behaviour, administration, public relations and rebate retrieval. The report concludes by mentioning that the estimated reductions for the solar hot water heaters and ductless split heat pumps have shown to have considerable impacts on balancing corporate emissions, however, are not capable of solely balancing these emissions. Several recommendations were made which Ra Consulting feels will contribute to improvement of the Solar Colwood program, some of which include incorporating more quantifiable technologies, targeting energy consumption behaviour, compiling a more accessible billing information database, and providing more transparent communication for Colwood residents including future participants of the Solar Colwood program.

2.0 Introduction

This introduction covers the scope of this research project, the research questions and methods.

2.1 Project Scope

The scope of this project was to monitor the current success of Solar Colwood in meeting program objectives of carbon neutrality and reduction of greenhouse gas emissions by 33% by the year 2020. The barriers associated with installation that may limit the success of the Solar Colwood program were identified as well as recommendations for overcoming these barriers and increasing the uptake of solar hot water heaters and ductless split heat pumps throughout the City of Colwood.

There are numerous of limitations to the scope of this project. The Solar Colwood program is new, and will take years before the City of Colwood can truly monitor energy and emissions savings. While this report seeks to show greenhouse gas reduction thus far, the goals of the program have not yet been met in terms of uptake of the technology. Therefore, this report does not truly monitor the success of the project, but provides indicators of success and reflects what may be seen in the future.

2.2 Research Questions

The following research questions were identified as a means of investigating the primary question of this research project:

1. To what degree have Solar Colwood-supported ductless split heat pump and solar hot water heater installations contributed to the City of Colwood's carbon neutrality commitment?
2. What barriers may be preventing those interested in the Solar Colwood program from actually installing the solar hot water heaters and ductless split heat pumps, and how can these be overcome?

2.3 Methods

To answer the research questions, the following methods were employed: Utility bills were collected and analysed from Solar Colwood participants. These participants also answered a structured questionnaire regarding home energy consumption behaviors and provided feedback on their satisfaction with the Solar Colwood program.

2.3.1 Ductless Split Heat Pump and Solar Hot Water Monetary Savings and Energy/GHG reductions

In order to obtain information regarding GHG reductions from the ductless split heat pumps and solar hot water heaters supported by the Solar Colwood program, Ra consulting collected utility bills from participants of the Solar Colwood program with ductless split heat pumps installed, as well as gained access to the sharepoint database developed by the Royal Roads Office of Sustainability. The Sharepoint Database provides the data from utility bills for participants with solar hot water heaters installed in their household.

To determine energy reductions from participants with ductless split heat pumps, letters were sent to participants, including an endorsed letter by the Mayor of Colwood. This letter asked participants to e-mail or mail their energy usage amounts after installation of their ductless split heat pumps as well as

asked them to provide their utility bill for the same billing period in the preceding year. This allowed for a better estimate of energy reductions and monetary savings from the newly installed ductless split heat pumps to be determined. The energy reductions and monetary savings for participants with solar hot water heaters were determined using the information provided on the RRU Office of Sustainability's sharepoint database. All energy reductions shown in this report were recorded as kWh.

Greenhouse Gas Reductions from the ductless split heat pumps and solar hot water heaters were reported as tonnes of CO₂e and determined by multiplying energy reductions by the emission factors provided by the Community Energy and Emissions Inventory Technical Methods and Guidance Manual. For 2011 the emission factor for electricity provided by BC Hydro was determined to be 24.666 tonnes of CO₂e per kWh. All data collected regarding monetary savings, energy reductions, and GHG reductions were reported on an excel spreadsheet.

2.3.2 Projected Greenhouse Gas Reductions

Average daily usage was calculated for each bill by dividing the usage (kWh) by the number of days that the bill covered. This made the data easier to use for comparison purposes. Average yearly energy savings (kWh) were then calculated by subtracting the average daily usage for the post-installation bill from the average daily usage calculated for the pre-installation bill, and then multiplying it by 365.

From all the bills received for a particular technology, an average was taken of calculated yearly savings per homeowner and converted to tonnes CO₂e. This average yearly GHG reduction was then extrapolated to predict the energy savings that would be achieved by the installation of 60 ductless split heat pumps and 30 solar hot water heaters (approximately the current number of installations) as well as by the installation of 120 ductless split heat pumps and 880 solar hot water heaters (Solar Colwood goal). The projected reductions in one year were compared to the corporate emissions outlined by the City of Colwood in order to determine the extent to which the Solar Colwood supported ductless split heat pumps and solar hot water heaters would be contributing to the city's goal of becoming carbon neutral by 2012. These numbers were then compared to community wide emissions as outlined in the 2007 community energy and emissions inventory for the city in order to determine the extent to which the ductless split heat pumps and solar hot water heaters would be contributing to the city's goal of reducing community wide emissions by 33% by the year 2020.

2.3.3 Email Questionnaire

An email survey was sent on June 19 2012 asking participants with ductless split heat pumps to answer several questions (as seen in Appendix I) about their satisfaction with the project and the number of residents in the houses that have the systems installed. The email also included a reminder about sending billing information to Ra Consulting and several other questions regarding the program.

2.3.4 Limitations

A number of limitations to the methods outlined have been identified. First, the amount of data that were collected has been minimal and cannot be considered large enough to determine the extent to which the systems are contributing to carbon neutrality as well as their ability to help reduce community wide emissions by 33% by the year 2020. This problem arose because data was provided on a voluntary

basis, and some homeowners apparently were not comfortable providing their energy consumption information. Second, without a yearlong data collection period one cannot define the true capability of both the ductless split heat pumps and solar hot water heaters at reducing emissions over a one year time period. Third, there are a number of variables related to homeowner behaviour as well as the households themselves that could be contributing to inaccurate results. Such variables could include the energy consumption behaviours, the number of individuals living in the home, the number of other energy efficiency upgrades aside from ductless split heat pumps and solar hot water heaters, etc. Finally, a more thorough data collection period is necessary in order to accurately monitor the success of the Solar Colwood program. As it stands now, Ra Consulting will be able to provide an estimate of the projected reductions that the Solar Colwood program may have; however, it will be difficult to make statements with confidence due to the limited data the team has been able to collect.

3.0 Literature Review

The following literature review provides a contextual background which relates to carbon neutrality in British Columbia and outlines findings from an ongoing study that is being conducted by Dr. Chris Ling that pertains to social diffusion and barriers which relate to the Solar Colwood program. The characteristics of Colwood residents as they relate to the potential participation in household energy savings initiatives are also outlined.

3.1 Background

The City of Colwood became a signatory to the *British Columbia Climate Action Charter* in 2008 (City of Colwood, 2010). This charter constitutes a voluntary agreement for Colwood to become carbon neutral in its operations by 2012 (City of Colwood, 2010; Union of BC Municipalities, 2007). To achieve Carbon neutrality, the City of Colwood must account for their corporate emissions from the daily operations of the City (eg. Building heating, vehicle fleets, water works,). (Green Communities Committee [GCC], 2011). In 2011, corporate emissions throughout the City of Colwood amounted to 487 tonnes of CO₂ equivalents (City of Colwood, 2012a).

The Green Communities Committee (2011), a joint venture between the Union of British Columbia Municipalities and the provincial government, has developed a four-step method for communities to achieve carbon neutrality: measure, reduce, balance/offset, and report. Measurement of greenhouse gases can be achieved very simply by keeping track of the consumption data (ie. fuel usage, electrical bills, etc.). The data can then be converted to a measure of GHG emissions, usually tonnes CO₂ equivalents. It is very important that communities understand what services need to be included when calculating their corporate emissions; traditional town services, and the equipment/infrastructure that support them are to be included. However, airports, staff travel, waste processing, and a few other sectors are excluded from a community's corporate emissions. When traditional town services are performed by a third-party contractor, the emissions are still required to be included as part of the town's corporate emissions. Several hundred computer programs exist to help communities log and calculate their emissions (eg. SMARTTool) (GCC, 2012).

After GHG emissions have been measured for a community, the next step is for the community to minimize their corporate emissions, usually through building and fleet upgrades. The reduction step not only decreases a community's emissions (which in turn reduces the extent at which the community must balance/offset its emissions), but also reduces the amount of money a community must spend for energy consumption, saving tax dollars. (GCC, 2011)

The balance/offset step is the focus of Solar Colwood. Balancing and offsetting focuses on reducing GHG emissions from sources that do not fall under the community's corporate emissions. This can be done by investing in local clean energy projects, such as Solar Colwood, or by purchasing carbon offsets from a credible provider. (GCC, 2011)

Investment in local clean energy projects can occur in one of two ways. A community can choose from a variety of projects that are supported by the Green Communities Committee. These projects include: retrofitting buildings to make them more energy efficient and/or drawing energy from sources that emit fewer greenhouse gases, installing solar hot water heaters, promoting home composting, and investing in low-emission vehicles. The second option is to invest in a project that doesn't fall under one of the preceding categories, but still results in a GHG emission reduction. Unlike with the Green Communities Committee supported projects, this second option requires a more intensive planning stage, along with validation from a third party of professionals. (GCC, 2011)

Solar Colwood is a combination of the Green Communities Committee supported projects. The project primarily focuses on promoting the installation of solar hot water heaters, which they have ambitiously set an installation goal of 880 units. Solar Colwood also supports incentives for homeowners wishing to install ductless split heat pumps, thereby retrofitting their homes with energy-saving technology. In addition, Solar Colwood is investing in level 2 electric vehicle charging stations, an investment in low-emission vehicles. (City of Colwood, 2011)

The final step for communities to achieve carbon neutrality is reporting. Here, local governments publicly report on their gross corporate emissions for the year as well as their emissions reductions through balancing and offsetting (GCC, 2011).

In addition to the City of Colwood's carbon neutrality goal, the province of BC has set a GHG reduction goal of 33% from 2007 levels by 2020 for province-wide emissions ("Bill 44", 2007). The City of Colwood has incorporated this goal into their community plan, and has set per capita GHG reduction goals (see Table 1) that are in line with the province's goals yet embrace population growth projections for the city (City of Colwood, 2008). Carbon neutrality aside, the Solar Colwood program represents a progressive plan that supports both of these provincial and community GHG reduction goals.

The following table identifies the reduction targets that the City of Colwood has set for its community by the years 2020, 2030, and 2050:

Table 1: The City of Colwood’s greenhouse gas emission and energy use reduction targets. Source: City of Colwood, 2008

Target Criteria	Target Year		
	2020	2030	2050
Per Capita GHG emissions reduction from 2007 levels	50%	75%	93%
Total GHG emissions reduction from 2007 levels	33%	49%	80%
Per Capita Energy reduction from 2007 levels	38%	56%	70%
Total Energy reduction from 2007 levels	14%	22%	12%

In order to assist communities to fulfill their greenhouse gas reduction targets, the province of BC has developed Community Energy and Emission Inventories reports (Province of BC, 2012a). These reports incorporate the consumption of greenhouse gas emissions from activities that occur in communities in on-road transportation, buildings and solid waste (Province of BC, 2012a). They are meant to assist local governments in meeting their climate action charter commitment, as well as develop strategies for emission reductions and target specific sectors (Province of BC, 2012a). These reports initially reported on emissions for 2007; however, on June 20, 2012, the 2007 CEEI reports were replaced by the draft 2010 CEEI reports (Province of BC, 2012a). In 2007, the community wide emissions for the City of Colwood were determined to be 57, 919 tonnes of CO₂e based on the 2007 CEEI report (Province of BC, 2012b). Community wide emissions for the 2010 CEEI draft report indicates that emissions have increased to a total of 66, 318 tonnes of CO₂e (Province of BC, 2012b).

3.2 Homeowners Survey

Near the end of 2011, a survey was conducted by Dr. Chris Ling as a means of obtaining information for his ongoing research project, *Understanding the Public Uptake and Acceptance of a Municipal Green Energy Incentive Program*. The survey was meant to review the City of Colwood’s Solar Colwood program in regards to home energy use and awareness of energy efficiency throughout residents of the municipality. A considerable amount of useful information is contained in the results of this survey and has been used in this report as a means of identifying some of the current barriers the program is facing. (Ling, unpublished survey results, 2011-12)

The first barrier identified in the results from Dr. Ling’s research was the time in which residents have lived in their homes. The survey indicated that the majority of Colwood residents have lived in their homes for less than ten years. In fact, 27.75% of the residents have only lived in their current household for less than five years. This information suggests that residents of Colwood may not feel settled in their current household to commit to installing energy efficiency upgrades such as ductless split heat pumps and solar hot water heaters supported by the Solar Colwood program. The cost for these systems may

be too high for homeowners to commit to installing these systems when they are unsure if they will live in their home long enough to see payback. (Ling, unpublished survey results, 2011-12)

Another barrier identified using these results was the fact that only a small portion of the survey group were concerned about their utility bills. This will be problematic for the program since a positive attitude toward energy consumption is necessary for the city to reach their carbon neutrality commitment, as well as reduce community wide emissions by 33% by the year 2020. Only 11% of the residents in the sample surveyed were “very concerned” over their utility bills. As much as 36 % of the residents indicated that they were only moderately concerned with their utility bills, and 17% indicated that they had little concern. If this attitude towards energy consumption continues, the city could have difficulties reaching their emission reduction targets. (Ling, unpublished survey results, 2011-12)

The information provided by Dr. Ling also indicated that 61.24% of the residents of Colwood use electricity as the source of heating for their home. With this in mind, the city might not notice as significant a reduction in emissions as they may have expected. This is because the emissions from the use of other sources of energy such as natural gas or heating oil are considerably higher than those that result from the use of electricity (BC Ministry of the Environment, 2010). Therefore, if the majority of individuals who install these systems displace electric with electric, they may save energy but their reduction in GHG emissions would be considerably lower. (Ling, unpublished survey results, 2011-12)

Lastly, this information has also indicated that there is currently little awareness regarding the Solar Colwood program. In fact, 38% of the residents that were surveyed indicated that they were “not at all” aware of the Solar Colwood program. (Ling, unpublished survey results, 2011-12)

3.3 Focus Groups: Early Adopters, Solar BC “solar innovator” group

A number of focus groups were conducted by Dr. Chris Ling in continuation of his ongoing research project “Understanding the Public Uptake and Acceptance of a Municipal Green Energy Incentive Program”. Two of the focus groups that were reviewed for this report included the Solar Colwood Early Adopters group, and a Solar BC “solar innovators” focus group.

3.3.1 Solar Colwood Early Adopters group

The early adopters focus group was conducted with residents that were among the first to implement solar hot water heaters and ductless split heat pumps to their homes. The participants’ responses in this report will assist Solar Colwood in identifying barriers associated with uptake of the technology, as well as to discover possible solutions to these barriers. This information will also aid in showing the homeowners’ priorities for energy efficiency upgrades and energy use, and how satisfied they are with the technology after installation.

One of the participants invested in a solar hot water heater because of the rising cost of energy. When they went to solar, their children were so excited that they told their friends. The participant mentioned that they thought they would not have to decrease their water consumption and their children mentioned they could probably shower longer. The participant also mentioned that during some months such as December when there is no sun, there is very little savings from the solar hot water heaters (Ling, unpublished transcript of focus group, 2011 - 12).

Residents also identified that they incurred other costs with installation that the program does not mention. These costs included hiring an electrician if wires had to be moved; hiring a repairman and/or drywaller to fix holes made in walls, ceilings, or roofs; or hiring a plumber to accommodate a storage tank. The residents of this focus group also identified other problems that arise with installation including the way the finished product looked, the installers' lack of experience as some were apprentices, and having to change the area that was first designated as the spot for installation. This proved to be a problem for some homeowners, and meant having to pay for cleanup or waiting longer for installation. Another problem with installation was limited space to install tanks, which was thought to increase the cost of installation. For one participant, it meant buying a new washing machine and dryer for the small space in their laundry room (Ling, unpublished transcript of focus group, 2011 - 12).

Most of the participants heard about the program through word of mouth from city councilors such as Judith Cullington. Other participants mentioned that there was an advertisement in the *Goldstream News Gazette*. Another mentioned talking about the system with J. Scott, the program coordinator for Solar Colwood. Similar to other focus groups, a problem came up regarding which solar hot water heaters were the best to install. There are flat panels and tubes, and some problems with tubes can mean that on a snowy day there has to be physical removal of snow from the tubes so that frost does not form. This should be discussed with homeowners before installation (Ling, unpublished transcript of focus group, 2011 - 12).

Some of the residents indicated that their reasoning behind adopting the technology was related to the ability to obtain sustainable energy practices for future generations. Another participant mentioned that the cash incentives were a big selling point. Reducing carbon emissions and increasing the value of the home was also mentioned to be a considerable incentive for this technology as well as getting off the grid and paying less for energy was also a large factor (Ling, unpublished transcript of focus group, 2011 - 12).

Residents of this focus group also indicated that the installation resulted in increased attention to the technology as neighbours and visitors began asking questions about the technology. However, participants mentioned that through consultation with other residents, they would not be interested in implementing the technology if it were to take too much time to decide and install the appropriate solar hot water system (Ling, unpublished transcript of focus group, 2011 - 12).

All of the participants of this focus group mentioned that installing the system got them thinking about sustainability, particularly related to energy savings and carbon footprint reduction. They mentioned that they looked at using rainwater to flush their toilets, using greywater for their gardens, and other home energy upgrades. One participant mentioned that they saw the addition of the solar hot water heaters as a value added to the house even if they did plan on moving in the future. In this case, staying in the home for a short period of time was not a deterrent to getting the technology installed (Ling, unpublished transcript of focus group, 2011 - 12).

Some of the barriers they encountered or thought were possible were: condominium owners not allowing renters or owners to add solar hot water heaters to their units; the cost of the technology (and

other incurred costs); other priorities such as fixing something else on their home, as well as paying for tuition and vacations. Participants mentioned that there should also be good incentives for seniors to adopt the technology; and that loans should be available if someone does not have the money upfront. The final barrier they identified was related to the difficulty in obtaining information as the process in getting the system installed can be rather research intensive. (Ling, unpublished transcript of focus group, 2011 - 12).

3.3.2 Solar BC “Solar Innovators” focus group

The results of this focus group provided particularly interesting information regarding the barriers surrounding solar hot water heater installation. It seems that the recurring problem with installation of the solar hot water heaters is space. Participants of this focus group identified that they were pleased with their installation but space was the biggest problem throughout the installation process (Ling, unpublished transcript of focus group, 2011 - 12).

Some participants of the Solar BC group identified reasons they installed their system. One individual stated that he was retiring and was no longer interested in paying a high utility bill. Others felt it was simply “the right thing to do”. It seems that people who have installed the system were interested mostly in reducing their carbon footprint and living sustainably rather than saving money on their utility bills (Ling, unpublished transcript of focus group, 2011 - 12).

This group identified the importance of incentives on installing the solar hot water heaters. An individual who had his system installed in 2009 indicated that it was an easy decision because there were numerous incentives for installation such as BC’s Live Smart program, there were also federal incentives at the time which saved him a considerable amount of money. This individual also stated that a ten year payback period was certainly better than 20, as he intends on being in the house for at least 20 years. When participants were asked about the extent to which incentives triggered their installation, one individual indicated that they probably wouldn’t have installed their system if federal and provincial incentives did not exist at the time. Another individual stated that he would have thought about it for a lot longer were the incentives not present (Ling, unpublished transcript of focus group, 2011 - 12).

The topic of resale of homes was addressed in terms of the impact of solar hot water heaters surrounding their ability to sell their home in the future. Participants indicated that there may be problems with aesthetics, and the ability to resell the home can vary depending on how the buyer views green technology/sustainable initiatives. It was interesting to note that none of the participants of this focus group had the intention of selling their home, so the issue of resale, and whether the system was increasing the homes was not one of their concerning when deciding to install the system (Ling, unpublished transcript of focus group, 2011 - 12).

3.4 Characteristics of Colwood Residents as they Relate to Potential Participation in Household Energy Savings Initiatives

After summarizing the information given by participants in the focus groups, a particular barrier that was identified through homeowner responses was the cost of the technology. It was thought that possibly household income was an issue and so a decision was made to analyze income and

demographics for the City of Colwood through census data. The city councillors and mayor would like to see the technology (solar hot water heaters & ductless split heat pumps) implemented in 1,000 homes. The census data will help in showing how feasible this may be, and whether income or other areas of demographics may be barriers to uptake of the technology.

The income ranges for those employed taken from census data collected by Statistics Canada in 2006 showed that the average income for both males and females before taxes was \$44,071, and 45% of those employed made over \$30,000 per annum. The average cost of a home was \$415,643, and the average yearly cost for home improvements was \$1,200. For owner occupied dwellings, this represented up to 20% of the household income (for 30% of households) and about 19% of the household income (for up to 99% of households). This information also indicated that only 15% of the residents of Colwood rent their homes. (BC Stats, 2010)

While there is a significant amount of household income already being spent on major improvements, the annual income in Colwood is greater than that of the City of Victoria and the unemployment rate is only 5% (Statistics Canada, 2006). For participants to indicate that the cost of the technology is such a large deterrent for solar hot water heater installation, a lot of their income must be going towards cost of living (bills, mortgage, etc.) or family support. Seniors (65 years +) make up 11% of the population of Colwood, of which 65% live with their families. Also, children account for 33% of the population and even include individuals up to 25 years of age who still live at home. If most of these homes are supporting seniors or children, then it may mean a limitation on the income set aside for home improvements, with priority placed on paying for elderly care, child care or student tuition. (BC Stats, 2010)

Another problem that could arise when participants complete home energy assessments would be the age of their homes. As addressed by one survey respondent, a homeowner may use the Solar Colwood program to get an energy assessment, but may not be able to implement ductless split heat pump technology. This would appear as if they were not a part of the Solar Colwood program as they would need heat pumps that include ducts. About 55% of the homes in Colwood are over 30 years old, while just over 80% of homes are over 20 years old (Statistics Canada, 2006).

In general, it is believed that given the annual income of the residents of Colwood that the city will be able to meet their target of 1,000 units installed. From further census analysis it is thought that income within households may be differed to other living costs or to supporting families. In general the reason for slow uptake and energy assessment inquiries may be due most importantly to social diffusion barriers. The rate of uptake in future years may also be affected by the demographic transition of the population from income earners to retirees.

4.0 Results

This section presents the results regarding the effectiveness of the Solar Colwood program in reducing GHG emissions. Findings regarding energy savings, greenhouse gas reductions and monetary savings through Solar Colwood supported ductless split heat pumps and solar hot water heater installations,

early adopter feedback, and an email questionnaire are presented. The information provides a number of findings that are important in answering the research questions of this report.

4.1 Solar Colwood Participant Greenhouse Gas Reductions

The data obtained from residents with ductless split heat pumps installed show an average monthly reduction of 495 kWh, while the residents of solar hot water heaters show an average monthly reduction of 206 kWh. Following the methods outlined for calculating GHG emissions in the *Community Energy and Emissions Inventory Technical Methods and Guidance Document* (BC Ministry of the Environment, 2010), the average yearly GHG reductions per homeowner was found to be 0.1486 tonnes CO₂e for residents with ductless split heat pumps installed and 0.06169 tonnes CO₂e for residents with solar hot water heaters. This makes the ductless split heat pumps a better choice for reducing GHG emissions.

Table 2 below presents the average daily energy savings observed when comparing post-installation bills to pre-installation bills (from the same season in the previous year) for 9 homeowners who had ductless split heat pumps installed in their homes. The estimated average yearly reductions for each household are also presented.

Table 2: Average daily energy savings observed when comparing post-installation bills to pre-installation bills (from the same season in the previous year) for 9 homeowners who had ductless split heat pumps installed on their homes. Average daily energy savings were extrapolated to a period of 1 year (365 days) and the median, standard deviation, and range are listed on a per year basis.

Average 30 day Reduction (kWh)	495
Number of Sets of Bills Analysed	19
Estimated Average Yearly Reduction (kWh)	6023
Yearly Standard Deviation (kWh)	12141
Yearly Median (kWh)	2011
Yearly Range (kWh)	-11460 to 30837

Table 3 presents the yearly GHG reductions using the average energy savings observed for ductless split heat pumps shown in table 2. These results are presented on a per homeowner, per 60 homeowners (approximately the number of participants as of June 26, 2012), and per 120 homeowner (Solar Colwood installations target) basis.

Table 3: Yearly GHG reductions calculated based on the average energy savings observed for ductless split heat pump adopters (see table 2), presented on per homeowner, per 60 homeowners (approximately the number of participants as of 26 June 2012), and per 120 homeowners (Solar Colwood goal) bases.

Average yearly GHG reductions per homeowner (tonnes CO ₂ e)	0.1486
Average yearly GHG reductions per 60 homeowners (tonnes CO ₂ e)	8.914
Average yearly GHG reductions per 120 homeowners (tonnes CO ₂ e)	17.83

Table 4 below presents average daily energy savings observed when comparing post-installation bills to pre-installation bills (from the same season in the previous year) for 3 homeowners who had solar hot water heaters installed in their homes and use electricity as their water heating source. The estimated average yearly reduction is also presented.

Table 4: Average daily energy savings observed when comparing post-installation bills to pre-installation bills (from the same season in the previous year) for 3 homeowners who had solar hot water heating installed on their homes and use electricity as their water heating source. Average daily energy savings were extrapolated to a period of 1 year (365 days) and the median, standard deviation, and range are listed on a per year basis.

Average 30 day Reduction (kWh)	206
Number of Sets of Bills Analysed	3
Estimated Average Yearly Reduction (kWh)	2501
Yearly Standard Deviation (kWh)	611
Yearly Median (kWh)	2272
Yearly Range (kWh)	2037 to 3194

Table 5 below presents the yearly GHG reductions calculated based on the average energy savings observed for solar hot water heater adopters who use electricity as their water heating source (see table 4), presented on a per homeowner, per 30 homeowners (approximately the number of participants as of 26 June 2012), and per 880 homeowners (Solar Colwood goal) basis. It should be noted that the ductless split heat pumps had a much greater impact on reducing emissions in comparison to the solar hot water heater.

Table 5: Yearly GHG reductions calculated based on the average energy savings observed for solar hot water heating adopters who use electricity as their water heating source (see table 4), presented on per homeowner, per 30 homeowners (approximately the number of participants as of 26 June 2012), and per 880 homeowners (Solar Colwood goal) bases.

Average yearly GHG reductions per homeowner (tonnes CO ₂ e)	0.06169
Average yearly GHG reductions per 30 homeowners (tonnes CO ₂ e)	1.851
Average yearly GHG reductions per 880 homeowners (tonnes CO ₂ e)	54.29

Table 6 below presents the average observed percent energy reductions observed when comparing pre-installation to post-installation bills (same season in different years) for 19 sets of bills collected from 9 homeowners with ductless split heat pumps installed, 3 sets of bills collected from 3 homeowners with solar hot water heaters installed, and 4 sets of bills collected from 3 homeowners with both technologies installed. Percent energy reductions were calculated by correcting bills to 30 day periods.

Table 6: Average observed percent energy reductions observed when comparing pre-installation to post-installation bills (same season in different years) for 19 sets of bills collected from 9 homeowners with ductless split heat pumps installed, 3 sets of bills collected from 3 homeowners with solar hot water heaters installed, and 4 sets of bills collected from 3 homeowners with both technologies installed. Percent energy reductions were calculated by correcting bills to 30 day periods.

Energy-reducing technology installed	Average percent energy reduction per billing set analysed (Pre-installation compared to post-installation)
Ductless split heat pump	11%
Solar hot water heating	10%
Both ductless split heat pump and solar hot water heating	39%

Table 7 shows the predicted GHG reductions from Solar Colwood supported ductless split heat pumps and solar hot water heaters at current uptake and full participation and the predicted remaining corporate emissions and offset costs.

Table 7: Predicted GHG reductions from Solar Colwood supported ductless split heat pumps and solar hot water heaters at current uptake and full participation and the predicted remaining corporate emissions and offset costs.

	GHG reduction (tonnes CO ₂ e)	Predicted remaining corporate emissions after balancing (based on 2011 corporate emissions = 487 tonnes CO ₂ e) (tonnes CO ₂ e)	Predicted offset cost (based on an offset cost of \$25/tonne CO ₂ e)
Predicted GHG reduction for 2012 (60 ductless split heat pumps and 30 solar hot water heaters) (tonnes CO ₂ e)	10.77	476	\$11,900
Predicted GHG reduction with full participation (120 ductless split heat pumps and 880 solar hot water heaters) (tonnes CO ₂ e)	72.12	415	\$10,375

4.2 Monetary Savings

Table 7 and 8 below present the monetary savings on a monthly basis calculated using current step one, and step two electricity rates provided by BC Hydro for homeowners with ductless split heat pumps and solar hot water heaters, respectively. The results shown are presented on a per homeowners basis. The households that have repeating numbers or letters indicate different billing periods.

The savings for ductless split heat pumps in table 7 and the solar hot water heater savings in table 8 were calculated based on values provided by BC hydro and are set up to show savings based on the average kWh used/30 days pre and post installation billing periods. The rates being charged for step one and step two are 0.063 dollars/kWh and 0.088 dollars/kWh, respectively (BC Hydro, 2012b). Step one threshold is 1350kWh (BC Hydro, 2012b). Once over that threshold, the homeowners will be charged according to step 2 rates (.088 dollars/kWh) (BC Hydro, 2012b).

Most homeowners have a billing cycle every two months. As mentioned above the total for step one will be 1350 kWh for one billing period, however, there are some homeowners that have a monthly billing cycle. The step one threshold is adjusted accordingly. BC Hydro gives the step 1 threshold at 22.1918 kWh per day (BC Hydro, 2012b). For example, if the billing cycle was four days, the step one threshold would be: 22.1918 kWh /day x 4 days = 88.77 kWh. All monetary reductions range for billing periods between December to the end of April.

Note the variability in energy savings between households. This is likely attributed to differences in consumption behavior as well as whether households had other home energy improvements (eg. improved insulation).

Table 8: Monetary savings on a monthly basis calculated based on current step one, and step two electricity rates provided by BC Hydro for homeowners with ductless split heat pumps. Results are presented on a per homeowner, per 30 day basis.

Household 1	\$61.11
Household 3	-\$82.71
Household 3	-\$33.60
Household 3	\$175.87
Household 4	\$122.22
Household 5	\$21.86
Household 5	\$14.48
Household 6	\$112.12
Household 7	\$0.52
Household 8	\$11.42
Household 9	-\$49.35
Household 9	\$22.57
Household 9	-\$16.50
Household 9	\$141.71
Household 10	-\$39.78
Household 10	-\$46.27
Household 10	-\$14.57
Household 10	\$84.37
Household 10	\$140.56

Table 9: Monetary savings on a monthly basis calculated based on current step one, and step two electricity rates provided by BC Hydro for homeowners with solar hot water heaters. Results are presented on a per homeowners basis. Note*: Homeowners with a star indicate they have both solar hot water heater and ductless split heat pump systems installed

Homeowner A	\$16.32
Homeowner B	\$14.66
Homeowner G	\$23.00
Homeowner C*	\$162.95
Homeowner D*	\$122.22
Homeowner E*	\$44.17
Homeowner E*	\$59.88

4.3 Feedback from Adopters of the Ductless Split Heat Pump System

The feedback obtained from adopters of the ductless split heat pumps indicated that electricity consumption has been considerably reduced in homes. This was the case particularly by Homeowners 1, 2, 3, and 6. The homeowners have also indicated that they feel the installation has made their home much more comfortable.

Homeowner 2 indicated that although his energy consumption has decreased, taxes and electricity rates continue to increase. As a result, the monetary savings following installation have been minimal. However, the homeowner stated that the heating effects are immediate and come without a high cost, a large benefit to installing the system. Homeowner 4 indicated that although his energy consumption has been reduced it could likely be attributed to the number of other installments he has had on his home such as air sealing, attic insulation, and an outer door replacement. This individual also has a solar hot water heater attached to his home. Homeowner 5 indicated that they were extremely impressed with the system and would recommend it to anyone.

An interesting finding was seen by homeowner 7. Following installation, the energy consumption of this individual increased considerably. The individual indicated that before they installed the system they were heating their living and dining room with base board heaters which were extremely inefficient so they would often turn them off at night. However, after installing the ductless split heat pumps, the individual stated that the heat pump was capable of keeping the room warm, and they could leave it running over night without a significant increase in their energy use in comparison to the baseboard heaters they previously used. As a result, it was found that this homeowner was using more energy following the installation of the system.

The general consensus based on the feedback received from adopters of the ductless split heat pumps indicated that the systems have in fact had an impact on decreasing energy consumption. Homeowners have also indicated that they are extremely pleased with the systems not only based on their ability to reduce energy use, but keep their home comfortable over the winter months.

4.4 Email Questionnaire

The email questionnaire that was sent to early adopters of the ductless split heat pump technology throughout the City of Colwood resulted in minimal feedback from residents. Of the 54 adopters of the technology, only four of them were willing to complete the survey questions. However, the homeowners that did complete this survey provided some useful information related to the research and objectives contained in the scope of this project.

Homeowner 4 indicated that two people live in their home. They also mentioned that they have had many other improvements to their home which include solar hot water heater, improved attic insulation and air sealing, and replaced one of their doors to meet energy star requirements. In terms of their energy consumption behaviours they stated that since installing the system they have tried to use less water and turn off the heat in the evening. The homeowner then shared their opinion on green technology and indicated that they feel it is “ok”, but great when money is saved. The homeowner then shared their source of knowledge in the program and stated that they heard of the program through

receiving a pamphlet in the mail, as well as through communication with J. Scott. This homeowner also felt that the Solar Colwood program was exceptional and should certainly be continued. They then mentioned that the energy guide rating of their home went from 72 to 84 following installation, and that they feel the ductless split heat pump has made their home much more efficient. The homeowner did however question why it is that when they do save energy, that energy costs from BC Hydro immediately increase to minimize savings.

Homeowner 5 indicated that 2 people live in their home. Other home energy improvements that this individual has made included installing a new window to reduce air drafts from entering their home. This individual also indicated that following installation they have not made any changes to their energy consumption behaviour. They then mentioned that they have not encountered any barriers with the ductless split heat pump they have installed. In terms of where the individual heard about the program, they indicated that advertising was their source of knowledge regarding Solar Colwood, however, they feel that the program needs to advertise a bit more. In terms of the program, the individual mentioned they feel it is excellent and that adopting green technology has made them feel very good.

Homeowner 7 indicated that there are 2 people living in their home. They also mentioned that they have not had any further improvement to their home as it is only 5 years old and the insulation and windows conform to current building standards. In terms of the energy consumption behaviours, the homeowner indicated that the only changes to their behaviour were in the winter months when they shut off their baseboard heating in the rooms where the pumps were installed. The homeowners also indicated that the heat pump provides comfort, and the ability to get air conditioning along with substantial rebates made the decision of installing the pump considerably easier. After asking where they heard of the program they indicated that ads in the local paper were the source of their knowledge. This homeowner then shared their opinion on the program mentioning that they think the program is great and that it stimulates people into increasing the efficiency of their homes, as well as provides work for local businesses. The homeowner mentioned though that they did not see a considerable reduction in their energy use, and the main reason for installing the system was to increase the comfort of their home. One barrier the homeowner mentioned was the difficulty in receiving their rebate following installation of the heat pump. They mentioned that it took them 8 months to get the federal rebate and 11 months to get their BC Hydro rebate back and that this could discourage many people from entering into such a program.

Homeowner C indicated that 12 people lived in their home, and that they have both solar hot water heater and ductless split heat pumps installed in their home. Other energy improvement to the individual's home included a new washer, stove, and dishwasher all of which met energy star requirements. In terms of their energy consumption behaviours following installation, the homeowner mentioned that they are actively conserving water. Some of the behaviours they took on to conserve water included having shorter showers, waiting until later in the day to shower, or running the dishwasher on sunnier days. They also mentioned that they have a clothes line for drying their clothes, which would be contributing to lower energy consumption. In terms of barriers that went along with installation the homeowner indicated that dealing with contractors was not an easy task. The homeowner also mentioned that the technology is expensive. In terms of their source of knowledge

about the Solar Colwood program, the homeowner indicated that they heard about the program through the Solar Colwood website. The individual feels that the Solar Colwood program is great, saying “who doesn’t love free money”, and that the program is forward thinking and innovative. In terms of any negative feedback, the homeowner mentioned that the program has issues with public relations and could use some work at the administrative level.

Another homeowner indicated that he was certainly happy with the Solar Colwood program, but he could not provide data that would be representative of the technology. He also indicated that the ductless split heat pump was one of many energy renovations he has done over the winter/spring. He then stated that there has been no insulation in their attic since the installations, and the windows have been replaced. As a result there were periods of big drafts, and attic hatches were left open.

Another homeowner provided some feedback but was not willing to provide any of his personal information. However, he did mention that the savings are substantial and that he is reducing his energy consumption. This homeowner also mentioned that he had a considerable amount of difficulty obtaining the rebates from Solar Colwood following the installation of his ductless split heat pump. The homeowner also mentioned that he feels there are currently some administrative issues. In order to avoid some of the problems this homeowner faced he recommended the program hire a trades person who understands the technologies they are working with.

5.0 Discussion

The following section analyses the results of this report, relating to observed energy reductions and their impact at reaching the communities energy reduction targets. This discussion section also includes an analysis of the written testimonies provided by participating homeowners, a comparison of the literature review transcripts and the structured questionnaire, and the current limitations to the Solar Colwood program are identified.

5.1 Observed Energy Reductions

Due to a lack of data, there is a degree of uncertainty surrounding the results. For example, the only billing data that was analysed was from months between December and June. This fails to take into account the true yearly savings for each homeowner, which can vary significantly from season to season. With ductless split heat pumps, use is minimal in the summer months when required heating energy is lower (assuming the heat pumps are not used for cooling). In the case of the solar hot water heaters, warm summer weather drastically increases the temperature to which the units can heat water. The sample size is also fairly low, and likely is composed strictly of homeowners with a keen interest in energy savings. Thus, one would expect that respondents would be experiencing higher energy savings based purely from their enthusiasm for energy efficiency.

Of the three bills that were analysed for solar hot water heater participants, all homeowners were using electricity as an energy source for water heating. Due to the low level of GHG emissions associated with electricity in British Columbia, the impact of solar hot water heaters may be much different than what this report has estimated. This is because natural gas and heating oil release higher amounts of GHG

emissions than electricity, and therefore a solar hot water heater running in conjunction with a fossil fuel-powered water heating system would result in a higher GHG reduction than it would with an electric water heater.

If the installation goals of Solar Colwood are met (120 ductless split heat pumps and 880 solar hot water heaters), a significant GHG reduction would result, allowing for the city to balance a fair portion of its corporate emissions. However, these reductions would still not be enough to completely balance corporate emissions (assuming corporate emissions are similar to 2011 values). In terms of cost efficiency, providing substantial grants to homeowners for very minimal emission reductions is far more costly than if the city were to balance its corporate emissions purely from the purchase of offsets. Although, offsets represent emission reductions that occur outside the community, while the Solar Colwood program allows the city to invest locally to facilitate its balancing requirements for carbon neutrality. Therefore, it is somewhat justifiable to spend more money to attempt to balance emissions locally, but perhaps Colwood should carefully consider providing grants for technologies that result in greater emission reductions than the technologies currently supported.

The average percent energy use reduction by household by billing period was around 10% for households with either solar hot water heating or a ductless split heat pump installed. For households with both technologies installed, average percent reduction in energy use was 39%. These represent major energy savings for each household, meaning that home energy improvements can have a large impact on per capita energy usage. However, with the data obtained by Ra Consulting, it is hard to estimate exactly what those per capita savings are, because it would require knowledge of the entire energy budgets of each person in each household, a fair portion of which is dependent on an individual's daily transportation methods. Nevertheless, the energy use reductions seen by the installation of solar hot water heaters and ductless split heat pumps are substantial, and the though the technologies alone may not be able to bring Colwood to fully achieve its per capita energy reduction goals, the reductions observed represent a big step in the right direction.

5.1.1 The effects of observed energy reductions on balancing corporate emissions as well as contributing towards community energy reduction goals

Assuming that 60 ductless split heat pump adoptees and 30 solar hot water heating adoptees (approximately current numbers) have these technologies installed and are using them year-round with the same average energy savings observed in this report, approximately 10.765 tonnes CO₂e will be reduced throughout these households. At an offset price of \$25/tonne CO₂e, the city avoids buying \$269.13 worth of carbon offsets. When considering that Colwood provides a minimum \$500 grant to each individual homeowner (City of Colwood, 2012b), the cost of purchasing offsets would be far less than the cost of providing these grants. However, when an offset is purchased, money leaves the community to pay the offset provider. Solar Colwood grants, on the other hand, represent a local investment, and furthermore, reductions represent progress towards the GHG reductions specified in the *Official Community Plan* (see table 1) (City of Colwood, 2010).

5.2 Monetary Savings

Based on the lack of data received regarding monetary savings for both the ductless split heat pumps and solar hot water heaters, one cannot make a definitive statement with regards to the savings that these systems are actually capable of; however, of the ten households that responded with data regarding energy consumption following the installation of their ductless split heat pump, there appears to be a considerable amount of savings through most of the billing periods. Homeowners have seen savings as significant as \$175.87 over 30 days. This suggests that Colwood residents could show interest in adopting this technology in the future. However, there are instances where homeowners have actually used more electricity and no savings were found. It is possible for this to be attributed to individual energy consumption behaviours, or the number of people in the home during that period could fluctuate. There are also a number of other variables to consider with respect to energy consumption. These could include the fact that each household will have a number of unique characteristics that could cause different amounts in savings. Individuals could also have more efficient insulation in their homes or have other energy efficient upgrades that assist in reducing energy costs. Despite the number of variables to consider the information surrounding monetary savings for homeowners with ductless split heat pumps suggests that residents of Colwood will begin to see these systems as an investment that comes with great incentive.

The data regarding energy consumption for the solar hot water heaters that was received from the RRU Office of Sustainability also shows savings as a result of their installation. As mentioned earlier, the capabilities of these systems are not entirely shown considering a yearlong data collection period has not been accomplished and the savings from summer months have not been accounted for. When viewing the monetary savings for homeowners who have had both ductless split heat pumps and solar hot water heater installed one can see the capability of these systems at increasing monetary savings when they are both working together. Having both systems installed can be very expensive for some homeowners but the results show a significant difference in savings when comparing households that have both systems installed to those that only have the solar hot water heaters. Homeowners C, E, and D shown in table 8 show the monetary savings for these homeowners and it is evident that they are having considerably higher savings than the rest of the homeowners with solar hot water heaters. The monetary savings for homeowners with installed solar hot water heaters is assumed to be understated based on the reporting period that has been established. With this in mind, it would be no surprise to see the uptake of these systems increase when Colwood residents notice the energy reductions you can see with this system over summer months.

5.3 Analysis of Written Testimonies Provided by Participating Homeowners

The feedback provided by residents with ductless split heat pumps has provided useful results pertaining to the effectiveness of the ductless split heat pumps and solar hot water heaters at instilling success in the Solar Colwood program. The homeowners with ductless split heat pumps indicated that they were extremely satisfied with the system. This was evident considering the number of individuals who noticed their homes were much more comfortable throughout winter months. It was also mentioned by a particular homeowner that the heating effects are immediate and come without a high cost. Homeowners also stated that they noticed considerable reductions in their energy bills.

Furthermore, homeowners mentioned they feel the program can be effective in an economic sense by providing work for local businesses. The positive feedback provided by several of the homeowner's suggests that the program has had some considerable success in terms of pleasing its participants and reducing energy consumption since its inception in 2011.

In relation to the second research question, the information provided from homeowners has allowed for a number of barriers to be identified. The first major barrier identified is the energy consumption behaviours of the homeowners. A particular instance relates to one homeowner who indicated that because of the added comfort provided by the ductless split heat pumps, they no longer turn their heat off at night. This resulted in increased energy consumption in their billing period which could prove to be a problem for the program if other homeowners take on similar behaviours. Another barrier which was identified surrounds the difficulty some of the homeowners have had receiving their rebates following installation of their systems. A particular homeowner indicated that it required 8 months to receive their federal rebate and 11 months to receive their BC Hydro rebate. Given the difficulty this individual faced, this could prove to be a problem for the Solar Colwood program. In order for Solar Colwood to increase uptake this will need to be addressed as it is expected that the grants are such a huge incentive for uptake.

Another barrier that has been identified appears to originate at the administrative level. This was found as a result of a particular homeowner who indicated that he felt the individuals involved in the management of the program did not communicate their knowledge effectively. Another individual mentioned that the program has some issues that need to be worked out with respect to public relations. This could be a problem with respect to uptake, especially if these individuals were to go around telling others throughout the community of their negative experiences.

One Solar Colwood participant mentioned that they were not planning on using their ductless split heat pump, for which they received a grant, to do any home heating at all. Instead, they intended on continuing to use their existing heating system, and employing their heat pump only for cooling purposes. In the case of this homeowner, the installation of a heat pump will result in no energy use reductions at all, instead energy used by the home will likely increase, contrary to the intentions of the Solar Colwood program. For this homeowner, Colwood has essentially helped them to purchase an air conditioner.

Homeowners have also mentioned that they have had issues with BC Hydro in that whenever they start to save money, their rates tend to increase. This is an issue for the homeowners because despite the fact that they are reducing their energy consumption their savings are minimized which can be disappointing for homeowners who have installed the system.

After receiving feedback from some of the participants in this program, it does appear that the majority of those with the ductless split heat pumps and solar hot water heaters are pleased with the results they are seeing with respect to reduced energy consumption and comfort in their home. This information suggests that there will be continued success for the Solar Colwood program, particularly if word gets out about the ability of these systems to reduce energy and save the homeowner some money. Aside

from the benefits, it has become evident that there are issues regarding energy consumption behaviours of homeowners, rebate retrieval, as well as issues surrounding administrative/public relations.

5.4 Comparison of the Feedback and Questionnaire Responses to the Transcripts of Focus Groups

The homeowners' responses from the structured questionnaire sent out by Ra Consulting showed a correlation in responses to those seen in the unpublished transcripts provided by Dr. Ling in early 2012. As mentioned earlier, the homeowners feel there was a decrease in energy consumption, and that their homes were heated much more evenly and were found to be more comfortable. The results from the structured questionnaire also showed that behaviour was not skewed towards conserving energy after adopting these greener technologies. While some respondents did try to use less energy, others were not as concerned with conserving energy use, and stated that they used more energy by leaving their ductless split heat pump running all night or showering more often. Furthermore, in Dr. Ling's survey results only 11% of residents were very concerned with their utility bills, which would explain the reasoning behind the poor energy consumption behaviours of some of the residents and the increased (Ling, unpublished survey results, 2011-12). This variability in outlook and behaviour was also portrayed in transcripts provided by Dr. Ling which confirms the likelihood that energy consumption behaviour in Solar Colwood participants is an issue.

One homeowner mentioned that when they saved energy, BC Hydro's rates immediately increased, which minimizes savings. This was an unexpected finding, and an unpleasant surprise to homeowners. It was expected that there would have been more monetary savings seen after implementing the technology, however the savings were minimal. Variability in electrical rates can be misleading to potential ductless split heat pumps and solar hot water heater adopters and convince them that their technology will save them more money than it does.

In table 6 the average percent energy reduction per billing set showed that ductless split heat pumps saved on average about the same amount of energy as solar hot water heaters. Ductless split heat pumps reduced energy use by 11% while solar hot water heaters reduced energy use by 10%. It was also shown that installing the two systems together reduced energy use by an average of 39%. This is in contrast to what was expected from ideas suggested from respondents in Dr. Ling's transcripts, as solar hot water heaters were expected to reduce more energy. Monetary savings in Table 9 also show that homeowners with both systems installed save more than homeowners with only one of the two technologies installed. This was expected as homeowners did express that other upgrades to their home was completed in order to further reduce energy consumption.

6.0 Conclusions

The limitations to the Solar Colwood project that have been identified are not extensive, and are outlined as they relate to carbon neutrality and the future success of the program.

While conducting this monitoring project, the federal grants portion of the Solar Colwood program which was expected to end on March 31, 2012 ended two months early. This meant that homeowners

would not have rebates to cover up to \$1,250 for solar hot water heaters and \$500 for ductless split heat pumps. While the City of Colwood has decided to cover the portion for solar hot water heaters, they will not be covering the \$500 for ductless split heat pumps. This is a setback to the program, as people will have to pay more upfront for the ductless split heat pumps which could deter them from installing the technology.

Another limitation to the program and to uptake of the technology was the fact that home energy assessors were not recommending solar hot water heaters to homeowners or were not recommending the types of heat pumps that are covered by rebates. This could stem from a variety of reasons. By not recommending solar hot water heaters, contractors may be looking at other home energy technologies that are more cost effective. From a previous lifecycle assessment report it was calculated that solar hot water heaters could have a payback period of ten years (Davidson, Eikenaar, Fonteyne, Girard, & Leong, 2011). This makes it hard for homeowners to experience short term savings, in relation to the amount invested. There are other energy efficient upgrades that can save money in a shorter time period such as improved home insulation, insulating windows and doors, or using more energy efficient devices which are typically more ideal for a homeowner looking to reduce energy consumption. On Southern Vancouver Island the amount of sunlight received annually is also lower than necessary to see high annual energy savings for solar hot water heaters (which was also factored into the long payback period) (Davidson et al, 2011). For ductless split heat pumps, the problem arises with the age of the homes in Colwood. Older homes use furnaces and because the homes contain ducts, and would be retrofitted with a standard heat pump opposed to a ductless split heat pump. If energy audits are conducted on these homes through the Solar Colwood program and recommendations are made to install heat pumps with ducts, homeowners will not be able to access the grants provided by Solar Colwood and would not contribute to balancing corporate emissions.

There has been slow uptake of solar hot water heaters for the program. While solar hot water heaters are not the main focus of this report, it is a key area in the Solar Colwood program, and was hoped to bring the most energy savings for the program. Ductless split heat pumps have had better uptake, but will not show as much greenhouse gas reductions since most homes are already using electricity for heating. This slow uptake of the technology will affect not only our results for this project but also the carbon neutrality goals for the Solar Colwood program. If uptake does not increase as was hoped by the program implementers, then it is not likely that this program will be able to balance corporate emissions to become carbon neutral. This is an issue that must be (and is being) addressed by the program representatives, and recommendations will be made as to how to improve uptake of the technology.

The BC Climate Action Toolkit set up by the Provincial Government outlines project plans for carbon neutrality for local governments. The ductless split heat pump project would fall under the Project Profiles Option 1B: Project Profile Energy Efficient Building Retrofits and Fuel Switching. Within this project profile, it is stated that in order for the system to be most effective, it should: “cause fuel switching from a high carbon energy source [e.g., light oil] to a low carbon energy source [e.g., electricity]” (Province of BC. 2012c). As most homes in Colwood are heated by electricity there would be no real switch from energy source. The electricity provided by BC Hydro is also considered to be quite clean energy. For these heat pumps to be able to assist in reducing energy emissions there would be

more reliance on homeowners to reduce their overall use of electricity and heating. This is less tangible to measure as it is dependent on human values and behaviour, and would also depend on weather fluctuations, such as prolonged cold weather that would cause increase in usage for ductless split heat pumps.

As outlined in this report, the consensus appears to be that many of the participants of the Solar Colwood program are pleased with their ductless split heat pumps and solar hot water heaters. There was also found to be an average of around 10% reduction of overall energy use in houses with one system installed and 39% reduction of overall energy use in houses with both systems installed. Greenhouse gas reductions have proven difficult to quantify due to variability in home energy efficiency and energy use behaviour among participants. Most of the estimated reductions were seen over the winter months, while sunlight was not a particularly common occurrence. This means that as the summer months approach greater savings for homeowners with installed solar hot water heaters can expect even higher reductions to their energy usage. From the research done by Ra Consulting it is believed that the Solar Colwood supported ductless split heat pumps and solar hot water heaters will not solely reach the cities goal of reaching carbon neutrality by 2012. However, the estimated reductions for the solar hot water heaters and ductless split heat pumps have shown to have considerable impacts on balancing corporate emissions.

7.0 Recommendations

The following recommendations have been established in order to improve the future success of the Solar Colwood program.

7.1 Increase Uptake/Social Awareness

Currently uptake targets for the implementation of ductless split heat pumps and solar hot water heaters have not been met and it was identified that one issue was lack of awareness. Public education of not only the Solar Colwood program, but also the City of Colwood's carbon neutrality goals should be of a main priority if uptake targets are to be met. If the residents of Colwood understand the goals and feel as though they are a part of them, it is believed they will be more inclined to participate, which could lead to further uptake of the two outlined systems. Another suggestion is that when potential participants are inquiring about the project they be made aware of the reductions seen by current participants, as well as the participants' overall happiness with their systems.

It is known by Ra Consulting that Solar Colwood has participated in several festivities in an attempt to increase public awareness; however, this does not seem to have been particularly effective. Perhaps running an awareness program of the Solar Colwood project and Colwood's carbon neutrality goals at the primary/middle schools in the area would help to increase awareness and further uptake targets.

7.2 Barriers to Social Diffusion

While the main purpose of this report did not focus on social diffusion it did identify some barriers, using unpublished information obtained from Dr. Chris Ling's concurrent studies and data obtained from emailed questionnaires sent out by Ra Consulting. One identified barrier, which was briefly discussed

above, was energy consumption behaviours of the homeowners. If participants are not conservative with their energy use they will end up consuming more energy, which could be a problem for the program. Another issue that was identified was the difficulty that some homeowners had receiving their rebates. The grants available for the installation of the solar hot water heaters and ductless split heat pumps are considerable and are a key factor to uptake. The 8 to 11 month waiting period for the grants, that were experienced by some participants, have the potential to cause the homeowner financial stress, along with the construction costs to install the systems. This could lead to bad press for the program. Ra Consulting is unsure as to whether homeowners were initially told about the potential long wait period for grants and extra construction costs, but if not this should be explained with transparency when potential participants are inquiring about the program.

Overall it was found by Ra Consulting's questionnaire and the unpublished questionnaire provided by Dr. Chris Ling that homeowners were pleased with their installed systems and felt their homes were heated more evenly as well as felt much more comfortable in the space. While beyond the scope of this project, one factor that needs further research is to determine if the lower than expected monetary savings are due to systems that do not function as manufacturers state, slight fluctuations in BC Hydro's rates and/or a general lack of energy conservation on the homeowners part (Ling, 2012).

7.3 Change Behaviour of Colwood Residents

One of the biggest issues with any program of this nature is changing the behaviours of the individuals, not only those participating but those that live within the community. One key recommendation is to educate and engage the community of Colwood surrounding this issue. In the responses received from the emailed survey by Ra Consulting it was found that most participants of the Solar Colwood program did not change their energy use behaviour, in fact, in some circumstances they increased their energy use. This is of concern when considering the success of the Solar Colwood program and Colwood's overall goals for carbon neutrality. The most effective way to reduce consumption is thought to involve encouraging the public. This could be done through programs or household "competitions" which could cause reductions in energy as well as increase energy consciousness. This would be an extremely proactive approach to reaching Colwood's carbon neutrality goals by 2012. An example of technology which would increase energy awareness would be the "Smart Home Systems" technology, which shows energy usage of individual households. This system allows for individuals to turn on and off electrical systems from smartphones or other electronic portable devices. It also shows daily, weekly and monthly averages for the household energy use as well as, daily "real time" uses. This could easily be turned in to a "friendly" competition either within the household or on a larger community scale. It would also allow residents to visually see the energy consumption for certain electronics and other household appliances (washer/dryer/dishwasher/shower), which could encourage homeowners to reduce their use of these energy guzzling electronics and appliances.

7.4 Accessible Billing Information

More accessible billing information would be extremely beneficial in determining the success of the Solar Colwood program. It was identified by Ra Consulting that obtaining billing information containing energy usage for the participants with installed ductless split heat pumps was a time consuming and

difficult venture. Although originally the participants signed documentation allowing their billing information to be released by BC Hydro to the Solar Colwood program, due to privacy issues, BC Hydro was unable to provide any billing data. This meant that participants had to be contacted individually and asked to provide energy usage data on their own time. This was met with enthusiasm by some and unwillingness by others. Several emails were received from participants with the ductless split heat pumps stating that they were unimpressed by the program and did not wish to participate and that they had already been contacted by a group at Royal Roads. Ra Consulting was unaware of this fact, which highlights the need for better communication between research groups, so as not to waste time collecting the same data and to limit the annoyance to the participants of the program.

It is suggested that future participants are made aware of the importance of providing energy usage information, as this is a main factor in calculating the overall tonnes of CO₂e that the program has reduced. There is even the opportunity to start an energy usage collection program, where participants can regularly provide/update their energy usage per billing period. An interactive website or database between individual participants, research groups and Solar Colwood management would be extremely beneficial to the program.

7.5 Improved Technologies

One issue with the current program, which was brought to the attention of Ra Consulting, after a consultation with members from the Climate Action Secretariat, was that the Solar Colwood program is not replacing a more polluting energy source, since both the previous systems and the newly installed systems both use electricity. This means that overall reductions seen by the program will be considerably lower than if a more polluting energy source was to be displaced, such as coal power, oil, or natural gas. This means that even if all the targets were met for installations of both outlined systems (880 solar hot water heaters, and 120 ductless split heat pumps) the estimated CO₂e would not be enough to balance Colwood's corporate emissions alone. If, however, an alternate energy source were to be displaced it could greatly increase the reductions in CO₂e that the program could provide.

It is recommended that residences with oil furnaces be identified and made aware of various other technologies that could be implemented that would not only reduce greenhouse gas emissions but also save the homeowner money in the long term. Although this is outside the realm of the Solar Colwood project it would aid the City of Colwood in achieving its carbon neutrality goals. Also, due to the lack of sunlight that is experienced in the Colwood area annually, solar hot water heaters may not have been the best technology chosen to reduce greenhouse gas emissions. It was identified that in many cases it can be extremely difficult to quantify various other changes that the city may take to reduce overall emissions, such as adding bike lanes or sidewalks, and that the Solar Colwood program does serve its purpose as a quantifiable entity.

If Solar Colwood addresses these recommendations it is expected that the uptake of solar hot water heaters and ductless split heat pumps will improve and the program will become a larger contributor to carbon neutrality for the City of Colwood. Fulfilling their uptake goals will lead to significant GHG

reductions that can be used to balance corporate emissions, however, current program participation is minimal and therefore, current GHG reductions are minor.

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Appendix I: Email Responses to Questionnaire Sent to Ductless Split Heat Pump Participants

Email #1: Emailed questionnaire sent out June 26, 2012

Response received June 26, 2012:

1. My Ductless split heat pump was installed in December 2011.
2. Two people live in my Home.
3. Yes:
 1. Solar hot water heating was installed in December as well.
 2. Attic insulation upgraded from R12 to R50 plus air sealing performed.
 3. Replaced one outside door to meet Energy Star ratings.
4. Yes: We try to use less water and Heat turned off in the evening hours.
5. We experienced no barriers leading to installation.
6. Green technology is OK and Great when money is saved.
7. My Initial knowledge of Solar Colwood was received via a pamphlet in the mail, then thoroughly briefed by Coordinator, J. Scott.
8. I believe the Solar Colwood program is exceptional and should be continued.
9. My energy guide rating, after my improvements at (Question 3), went from 72 to 84. That is efficient!!
 - The only thing I question is, when we save energy, why do energy costs from BC Hydro immediately increase to minimize savings?

Email #2: Emailed questionnaire sent out June 26, 2012

Response received June 27, 2012:

The following answers are in sequence to your questions:

- installed July, 2011
- 2 people live in the home
- no further improvements- the home is only 5 years old and the insulation, windows conform to current building standards.
- the only changes were in the winter when we shut off the baseboard heating in the two rooms where the heat pump heads were installed. The heat pump provided a more even and comfortable heating.
- no barriers were encountered leading up to installation
- we did it more for comfort than anything else. The ability to get air conditioning along with substantial rebates made the decision easy.
- ads in the local paper then going online.
- I think it is a great program. It stimulates people into upgrading their homes and provides work for local business. While in our case it was basically for comfort and we did not save much on energy costs, I am sure there were many older homes where substantial savings were realized.

- it is unfortunate that the rebates from the other levels of government were cancelled. A note on this however, it took us 8 months to get the federal rebate and 11 months to get the BC Hydro rebate. This was much too long and, if typical, would discourage many people for entering into such a program again.

Email #3: Emailed questionnaire sent out on June 19, 2012

Response received June 20, 2012

I do not wish to share personal information, but I will say this, the saving in energy cost is substantial , I also had nothing but a hard time getting my money from solar Colwood . [redacted] [management] does not have a clue about what ... doing, they should of hired a trades person, someone who understands the system.

Email # 4: Emailed questionnaire sent out June 19, 2012

Response received June 19, 2012:

My system was installed Nov 23, 2011.

12 people live in my home.

I installed a solar hot water system and hrv around the same time. Also recently bought new energy star washer, stove, and dishwasher. We are actively conserving water. Short showers etc. Also waiting if possible until later in the day, on sunny days, to shower and run the dishwasher to take advantage of free hot water. We also have a clothes line for drying clothes.

Dealing with contractors isn't the easiest to do in the best of circumstances. The technology is expensive thus a daunting endeavor.a leap of faith was needed. It's important for me to do what I can. To be a role model to my kids and support an emerging industry.

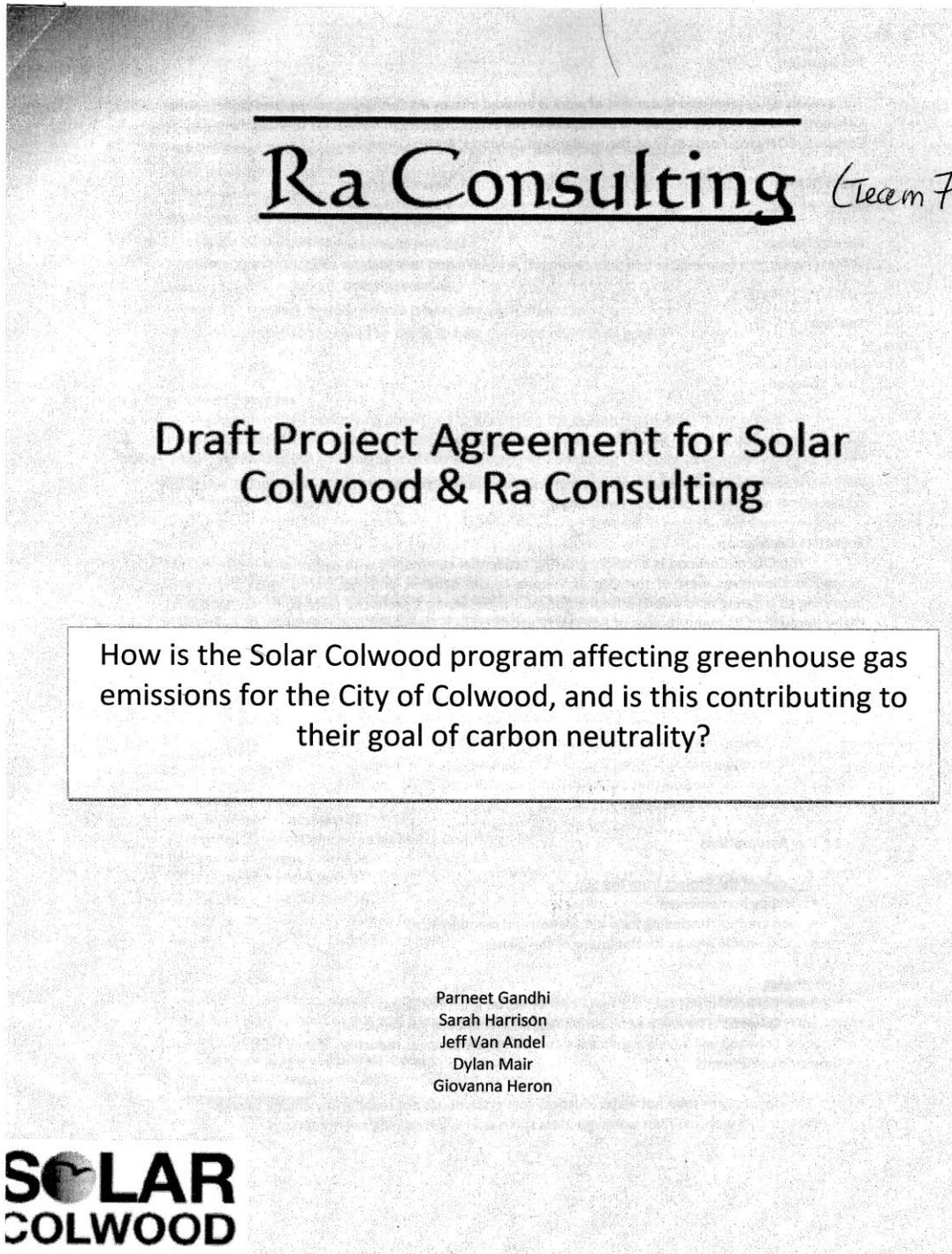
I heard about the program through the city of colwood's pathetic attempt at a website. I love the solar colwood program. Who doesn't love free money. It's forward thinking and innovative. Kinks to work out and pr work to be done but overall a passing grade.

Appendix II: Summary of Collected Bill Data and Energy Reduction Calculations

	Homeowner	Before					After					Savings?	Average savings/30d	Average savings/365d	% reduction (30d)		
		Usage (kWh)	Billing Start Date	Billing End Date	No. of Days	Average usage/day	Average Usage/30d	Usage (kWh)	Billing Start Date	Billing End Date	No. of Days					Average usage/day	Average Usage/30d
Duct less Split Heat Pump	1	4907	05-Jan-11	03-Mar-11	57	86.0877193	2582.631579	3586	04-Jan-12	01-Mar-12	57	62.9122807	1887.368421	Saving	695.2631579	8459.035088	26.92%
	3	2002	07-Jan-11	04-Feb-11	28	71.5	2145	2984	05-Jan-12	03-Feb-12	29	102.8965517	3086.896552	No Saving	-	-	-
	3	2142	05-Mar-11	05-Apr-11	31	69.09677419	2072.903226	2292	06-Mar-12	03-Apr-12	28	81.85714286	2455.714286	No Saving	-	-	-
	3	3687	05-Feb-11	04-Mar-11	27	136.5555556	4096.666667	2094	04-Feb-12	05-Mar-12	30	69.8	2094	Saving	2002.666667	24365.77778	48.89%
	4	6585	07-Jan-11	04-Mar-11	56	117.5892857	3527.678571	4272	05-Jan-12	05-Mar-12	60	71.2	2136	Saving	1391.678571	16932.08929	39.45%
	5	3394	05-Apr-11	03-Jun-11	59	57.52542373	1725.762712	2906	03-Apr-12	01-Jun-12	59	49.25423729	1477.627119	Saving	248.1355932	3018.983051	14.38%
	5	6116	04-Feb-11	04-Apr-11	59	103.6610169	3109.830508	5791	03-Feb-12	02-Apr-12	59	98.15254237	2944.576271	Saving	165.2542373	2010.59322	5.31%
	6	2814	07-Jan-11	03-Feb-11	27	104.2222222	3126.666667	1665	06-Jan-12	02-Feb-12	27	61.66666667	1850	Saving	1276.666667	15532.77778	40.83%
	7	3987	04-Mar-11	03-May-11	60	66.45	1993.5	3976	02-Mar-12	01-May-12	60	66.26666667	1988	Saving	5.5	66.91666667	0.28%
	8	3451	04-Feb-11	04-Apr-11	59	58.49152542	1754.745763	3249	03-Feb-12	03-Apr-12	60	54.15	1624.5	Saving	130.2457627	1584.65678	7.42%
	9	3961	06-Jan-11	04-Feb-11	29	136.5862069	4097.586207	4660	04-Jan-12	03-Feb-12	30	155.3333333	4660	No Saving	-	-	-
	9	6274	04-Feb-11	07-Mar-11	31	202.3870968	6071.612903	3655	03-Feb-12	05-Mar-12	31	117.9032258	3537.096774	Saving	2534.516129	30836.6129	41.74%
	9	3692	07-Mar-11	05-Apr-11	29	127.3103448	3819.310345	3873	05-Mar-12	03-Apr-12	29	133.5517241	4006.551724	No Saving	-	-	-
	9	4188	5-Apr-11	05-May-11	30	139.6	4188	2488	03-Apr-12	02-May-12	29	85.79310345	2573.793103	Saving	1614.206897	19639.51724	38.54%
	10	2763	4-Dec-10	06-Jan-11	33	83.72727273	2511.818182	3261	03-Dec-11	05-Jan-12	33	98.81818182	2964.545455	No Saving	-	-	-
	10	2088	4-Feb-11	07-Mar-11	31	67.35483871	2020.645161	2633	03-Feb-12	05-Mar-12	31	84.93548387	2548.064516	No Saving	-	-	-
10	1584	5-Apr-11	05-May-11	30	52.8	1584	1750	03-Apr-12	03-May-12	30	58.33333333	1750	No Saving	-	-	-	
10	3184	7-Jan-11	03-Feb-11	27	117.9259259	3537.77778	2319	06-Jan-12	02-Feb-12	27	85.88888889	2576.666667	Saving	961.1111111	11693.51852	27.17%	
10	2997	8-Mar-11	04-Apr-11	27	111	3330	1556	06-Mar-12	02-Apr-12	27	57.62962963	1728.888889	Saving	1601.1111111	19480.18519	48.08%	
Solar Hot Water Heating	A	2796	3-Dec-10	03-Feb-11	62	45.09677419	1352.903226	2410	02-Dec-11	02-Feb-12	62	38.87096774	1166.129032	Saving	186.7741935	2272.419355	13.81%
	B	6124	3-Dec-10	03-Feb-11	62	98.77419355	2963.225806	5778	02-Dec-11	02-Feb-12	62	93.19354839	2795.806452	Saving	167.4193548	2036.935484	5.65%
	G	4850	03-Feb-11	04-Apr-11	60	80.83333333	2425	4325	02-Feb-12	02-Apr-12	60	72.08333333	2162.5	Saving	262.5	3193.75	10.82%
Both Tech	C	4189	5-Apr-11	05-May-11	30	139.6333333	4189	2488	03-Apr-12	05-May-12	32	77.75	2332.5	Saving	1856.5	22587.41667	44.32%

no- logie s				11					12	12							
	D	6585	07- Jan-11	04- Mar-11	56	117.589 2857	3527.67 8571	4272	05- Jan-12	05- Mar-12	60	71.2	2136	Savi ng	1391. 67857 1	16932.0 8929	39.45 %
	E	1592	04- Apr-11	05- May-11	31	51.3548 3871	1540.64 5161	1072	02- Apr-12	03- May-12	31	34.5806 4516	1037.41 9355	Savi ng	503.2 25806 5	6122.58 0645	32.66 %
	E	1664	05- May-11	03- Jun-11	29	57.3793 1034	1721.37 931	1004	03- May-12	01- Jun-12	29	34.6206 8966	1038.62 069	Savi ng	682.7 58620 7	8306.89 6552	39.66 %

Appendix III: Draft Project Agreement for Solar Colwood & Ra Consulting



Introduction

This project agreement and statement of work is entered into by Ra Consulting and by the Project sponsor, Solar Colwood. This Agreement is made in pursuance of the Project described herein, for services owned by Solar Colwood, BC Hydro, Fortis BC, and the residents of Colwood, British Columbia.

Team Name:

Ra Consulting

Faculty Advisor:

Leslie King

Team Members:

Parneet Gandhi
Sarah Harrison
Dylan Mair
Jeff Van Andel
Giovanna Heron

Sponsor:

Chris Ling
Solar Colwood

Research Question

How is the Solar Colwood program affecting greenhouse gas emissions for the City of Colwood, and is this contributing to their goal of carbon neutrality?

1. Project Description

The City of Colwood is a rapidly growing residential community with exceptional heritage landmarks. It is located 10 kilometres west of the City of Victoria in the dynamic and fast paced West Shore. From a noble beginning to a daring leap into the future, Colwood is becoming a preferred place to live in Southern Vancouver Island because of its many choices of housing types; its close proximity to commercial areas and large selection of retail shopping options.

With over 16,000 residents and 6,000+ homes, the City of Colwood has embarked on a groundbreaking project to bring renewable solar energy as a communal project in attempts to lower greenhouse gas emissions, allow residents to get off the grid, and save on energy consumption. Colwood's ambitious target of lowering greenhouse gas emissions by 50% by 2020 has an initial target of retrofitting 1,000 homes with solar thermals, ductless split pumps, and other energy efficient retrofits.

Ra Consulting has appointed with the task of assessing whether the Solar Colwood project has so far met its goals in relation to the goals set out by the sponsors for the project, but also in relation to carbon neutrality and reducing greenhouse gas emissions.

1.1 Key Assumptions

Main Goals of the Project from the Sponsor

- Happy homeowners
- Job creation (including local installation and maintenance)
- Sustainable energy for the future of the planet

Hypotheses

H₀: Solar Colwood is not having a significant effect on greenhouse gas reduction

H₁: Solar Colwood is having a significant effect on greenhouse gas reduction

H₂: Solar Colwood will have a significant effect on greenhouse gas reduction, if they reach their goal of one thousand participants

H₀: Participants with solar hot water/ductless split systems are not reaping any energy savings

H₁: Participants with solar hot water/ductless split systems are reaping energy savings

1.2 Other Project Questions to be Addressed

- Has the action to date had an impact on energy usage, pertaining to participants?
- Have there been reductions in energy use so far?
- Is there an actual reduction of GHGs?
- What gaps exist from the previous reports?
- What gaps exist in terms of research findings?
- Are there any restrictions on data that cause flaws in the monitoring and reporting of the program's success?
- What is the payback period, if there is one, and what affects this?
- What recommendations could be made to help Colwood meet their goals?

1.3 Underlying Objectives

Ra Consulting has identified underlying objectives to answering the research question, those objectives are: Using the previous baseline as a starting point; identify gaps in current monitoring methods used to track energy usage; evaluating the effectiveness of installed systems; comparing the gains in energies received from the Colwood project to other similar programs; and determine carbon neutrality benefits of SHW/ductless split technology based on actual data.

1.4 Methods

- Gather raw data from participants' energy bills
- Develop a reporting Excel spreadsheet based on the BC carbon neutrality workbook
- Telephone survey to assess social diffusion, happiness, awareness
- Compare the effects of Solar Colwood to the effects of investing in carbon trusts

1.5 Analytical Methods to be Used

- Telephone survey for Colwood residents
- Compare bills before and after installation of solar heaters/ductless split heat pumps.

2. BACKGROUND AND INITIAL OBLIGATIONS

2.1 Milestone Deliverables

- Ethical Review – February 28
- First presentation - Completed by March 2nd
- Compilation of data – April 24
- Second presentation- June 3rd
- Third presentation- August 15
- Survey Results - Currently waiting for results
- Begin writing draft report- Mid third quarter

2.2 Deliverables to Sponsor

Ra Consulting will need to come to an agreement with the sponsor to determine what their expectations are and meet these expectations to the best of our ability. Some examples of expectations would be:

- Timely responses
- A professional and useful final report
- Professional interactions with Solar Colwood participants
- Happy homeowners
- Job creation and economic development
- Sustainability

2.3 Ethical Review

- Yes, we will need to contact and extract data from Colwood residents (potentially BC Hydro and Fortis) regarding their energy usage, in the form of energy bills.
- We will visit T'Souke First Nation to get a sense of the effectiveness of their solar program.
- Possible telephone survey

2.4 Communication Plan for Sponsor & Faculty Advisor

Meet every two weeks with Chris Ling and Leslie King

2.5 Deliverables to Department

- What is expected in our major project outline as per the schedule of activities
- Ethical Review

2.6 Expectations of Sponsor

Any data that the City of Colwood has regarding the project should be provided to us when necessary and when in agreement with ethical standards. This could include:

- The number of participants
- Census data (demographics, population)
- Timely responses to emails, voicemails, etc.
- Clear outline of what their objectives are
- Energy use data and survey data

3.0 BUDGET

3.1 Identify Expected Budget Areas

- Travel to T'Souke to see their solar program
- Travel to households
- Document acquisition

Appendix 2

Major Project Timeline

Quarter Two

Draft Terms of Reference

January 10 (Week 2) – February 8 (Week 6)

Final Terms of Reference

February 14 (Week 7) – February 29 (Week 8)

Ethical Review

February 7 (Week 6) – March 6 (Week 10)

Annotated Table of Contents

February 7 (Week 6) – March 7 (Week 10)

Major Project Presentation Number 1 – Outline Project, Methodology, and Goals

February 14 (Week 7) – March 9 (Week 10)

Quarter Three

Initial research – Contact Residents, Develop monitoring strategy, Interview Contractors

March 27 (Week 1) – April 10 (Week 3)

Team Interim Report

April 17 (Week 4) – May 30 (Week 10)

Begin Writing Draft Final Report

May 15 (Week 8)

Major Project Presentation Number 2

May 15 (Week 8) – June 8 (Week 11)

Quarter Four

Finish Writing Draft Final Report

June 19 (Week 1) – July 11th (Week 4)

Corrected Final Report

July 23 (Week 6) – August 8 (Week 8)

Appendix IV: Written homeowner testimonies

July 10, 2012

Dear Sir or Madam:

Re Success of the Solar Colwood Program

As requested, you will find previous and current billings of B.C. Hydro.

Our heat pump was installed Feb 29, 2012.

Since then we have been very impressed with the solar system and would recommend it to anyone.

Hope the enclosed information is what you have requested.

Sincerely

Re: Heat Pump Installation

As you can see from the enclosed hydro bills from 2011 and 2012 our bill has gone up. This is most evident in the March billing which is \$100 higher in 2012.

We attribute this to usage of the heating option of the heat pump vs. using baseboard heating last year. One of the rooms with a unit is a living/dining room with a vaulted ceiling approximately 25' high. This room was always difficult to heat evenly. With the baseboard heating we turned down the heat at night and generally kept this room cooler using the gas fireplace as a backup.

The heat pump has kept this area much more comfortable and we have not turned down the temperature at night. The heat is constant without any cool spots. The master bedroom has the other unit and it also heated with the heat pump vs. baseboard units.

Overall we are very happy with the heat pump, especially having the cooling feature during the few times it is required in this area.

Royal Roads University
26 April, 2012

Ref: Your letter dated 20 April, 2012

Subject: Meter readings and Home energy status as requested.

As of January 2012, I have had several changes affecting my energy footprint:

1. Ductless split heat pump installed.
2. Solar water heating installed.
3. Outer door replaced which meets Energy Star requirements.
4. Attick insulation increased from R12 to R50.
5. Air sealing throughout my house, professionally done.

The end result was and EnergyGuide evaluation improvement from 70 to 84.

My Electricity was read monthly in 2011 and bymonthly in 2012 as follows:

				<u>Billing</u>
<u>2011</u>	Jan 7 to Feb 4	29 days	2964kwh	Step1 @ \$.06270
	Feb 5 to Mar 4	28 days	3621kwh	Step2 @ \$.08780
			<u>Total 57 days 6585kwh</u>	
<u>2012</u>	Jan 5 to Mar 5		<u>Total 61 days 4272kwh</u>	Step1 @ \$.06670 Step2 @ \$.09620

I am extremely pleased with the results to date of my recent Home improvements. The insulation upgrade and Heat pump addition were immediate factors in lower energy use. The rates were increased across the board for this 2012 billing period and I am told a 6% increase is again in the wind.

Make all the changes you want, the Hydro increases eat up ALL your savings, therefore personal comfort is more a factor then any increase in savings we will ever see.

Hello Everyone!

Here are some bills as you have requested.

I could send more as the months progress - but I feel the next few would not reflect just the heat pump - as we have recently changed all the pot light bulbs - in the house to compact fluorescent - so that may have an affect as well. (I hope.)

The heat pump - I feel has reduced the electricity consumption plus the house is ^{much!} more comfortable!!

Thanks for your work.

HERE ARE THE
REQUESTED COPIES OF OUR
HYDRO BILL BEFORE + AFTER
INSTALLING DUCTLESS
HEAT PUMPS. THERE IS
CERTAINLY A SAVINGS ON
OUR HYDRO BILL.

FURTHERMORE WE FIND
OUR HOME IS SO MUCH
MORE COMFORTABLE (WARMER)
DURING WINTER MONTHS
WITH THE PUMPS

HOPE THIS HELPS