Royal Roads University

Solar Colwood Final Report

2015

To: City of Colwood
From: Nancy Wilkin, Director, Office of Sustainability, RRU
Subject: RRU Solar Colwood Monitoring Program Findings
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Introduction

This report details the findings of the Royal Roads University Solar Colwood Monitoring Program. This monitoring program was part of the larger partnership between the university and the City of Colwood. Royal Roads University (RRU) and the City of Colwood (City) continue to maintain a strong collaborative working relationship. The Memorandum of Understanding (MOU) between RRU and the City, signed in 2009, celebrates and further develops this professional and community connection, leading to successful community based projects, such as the Solar Colwood program. The Solar Colwood program models the purpose of the MOU in partnering on sustainability initiatives and to be global leaders in environmental sustainability.

Partnership

The Solar Colwood program originally began as a three-year community-based sustainability project funded by Natural Resources Canada's (NRCAN) Clean Energy Fund but was extended into a fourth year. At the commencement of Solar Colwood, RRU and the City signed a project partnership Agreement, where RRU agreed to provide representation for the duration of the program through RRU's Office of Sustainability. The Office of Sustainability agreed to participate on the Solar Colwood partnership team, and to provide leadership in helping make the program a success, especially through research and community relations. As a result of this partnership, both RRU and the City are actively participating in creating a 'green' learning laboratory in our vibrant community.

RRU has reached its milestones that meet with the Agreement guidelines set out in the partnership agreement for the Solar Colwood program (January 2011 to March 2015). This report serves as both the 2014 year-end report for the university's participation in the program as well as the final report for the Office of Sustainability's monitoring program.

Office of Sustainability

The Office of Sustainability's (OS) main objective is to support RRU's Sustainability Plan. Within the guidelines of this plan, the OS strives to foster sustainable community relations and support sustainability research projects, both of which are addressed in our Solar Colwood partnership Agreement with the City.

During the four years of the Solar Colwood program, the OS was responsible for conducting the RRU Solar Colwood Monitoring Program, provided guidance for seven student-led applied learning projects and carried out an independent interdisciplinary research study with the School of Environment and

Sustainability and the School of Business. In 2014, RRU further supported the Solar Colwood program through the following actions:

- Attended monthly partnership meetings
- Participated in Solar Colwood community events
- Supported the program internally, with the program partners, and within the local community
- Provided support, guidance, and feedback in the City's ongoing development of the Solar Colwood program, including in the program extension request to NRCAN
- Ensured that RRU and the City meet the privacy measures (as related to the Solar Colwood program) outlined in the BC Freedom of Information and Protection of Privacy Act (FOIPPA)[1];
- Offered assistance as required

Solar Colwood Monitoring Program

This leading-edge research measured energy use and greenhouse gas emissions saved by Solar Colwood participants at a household level.

Timeline

Our monitoring program evolved in both scope and methodology program over its duration; this evolution mirrors that of the Solar Colwood program itself over the same period. In year one this program focused entirely on households that had installed solar hot water systems (SHW). A municipal election occurred in 2012 that saw a slow-down on the marketing of the Solar Colwood program as it had become the target of a small but very vocal group of dissenters within the community. In year two, the study was expanded to include all the energy saving technologies promoted through the Solar Colwood program, thus capturing a more representative sample of participants' energy saving actions in the Solar Colwood program. Year two also saw City Green Solutions take over as the project delivery team and major changes the BC Freedom of Information and Protection of Privacy Act (FOIPPA); the latter of which required the OS to significantly change its approach to connecting with participants of the Solar Colwood program. Year three saw high uptake of the incentives for ductless split heat pumps and slower adoption of the solar systems. Year four saw the program expanded to offer incentives for solar thermal hot water systems to all of the municipalities within the Capital Regional District (CRD).

[1] For information on the BC Freedom of Information and Protection of Privacy Act visit: http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/96165_00

Purpose

The purpose of RRU Solar Colwood Monitoring program was to measure the changes in household energy use and greenhouse gas emissions (GHG) by homeowners and businesses that installed a solar hot water (SHW) system, ductless split heat pump(s), electric vehicle charging station infrastructure (EV or photo-voltaic PV4EV) and/or other significant energy saving retrofit technologies as part of the Solar Colwood program. Participation in the monitoring program by Solar Colwood community members was voluntary. All information collected from the participating households was stored on secure Royal Roads University servers and all personal information was managed in compliance of the *BC Freedom of Information and Protection of Privacy Act* (FOIPPA).

Methodology

The methodology of the monitoring program begins with recruitment of voluntary participants from the Solar Colwood community. Since sharing of personal information between the City of Colwood and RRU is prohibited through FOIPPA, RRU is unable to collect the names, residential addresses, email addresses, and telephone numbers of the Solar Colwood community members directly from the Solar Colwood Delivery Team.

Data Collection

In order to approach the FOIPPA requirements with respect to research participant recruitment and data collection, RRU has innovatively responded in the following ways:

- Developed an online survey that allows potential participants to give their informed consent to RRU. This survey allows RRU to collect household demographic and personal information in compliance with FOIPPA. The online survey link is initially electronically delivered by the Solar Colwood Delivery Team to every new and existing Solar Colwood community member.
- Presented the preliminary findings of the monitoring program at special Solar Colwood events, such as home tours, community events, and social celebrations.
- Provided the opportunity for Solar Colwood community members to reconsider participation during solar system check-ups conducted by the Solar Colwood Delivery Team. An informed consent form was offered to allow for the transfer of personal contact information from the Solar Colwood Delivery Team to RRU.
- Provided ongoing customer service via email, telephone, or in person to existing participants in order to maintain participant retention.

- Offered multiple formats for participants to complete the monitoring survey: online, by email, by telephone, or in person.
- Offered multiple formats to submit utility billing information: by email, by mail, or in person.
- Ensured participants that data collected is secure and kept confidential as per the requirements of FOIPPA and the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans* (TCPS) of the Canadian Federal government.

Following the completion of the monitoring survey, Solar Colwood participants submit their utility bills for analysis.

Data Analysis

This program uses a direct comparison of the participant's utility bills from at least one year before and at least one year after the installation of energy saving technologies as part of the Solar Colwood program. Energy consumption data from both periods (before and after) was normalized for solar insolation and heating degree days, as appropriate, prior to comparison in order to minimize the influence of weather on changes in energy use experienced by participants.

WEATHER NORMALIZATION

Solar insolation is a measure of the amount of solar radiation available in a given location and can directly affect the amount of energy, from conventional sources, that is required to heat water. The presence of higher levels of solar radiation translates into a lower demand for other energy sources than times of lower radiation levels. Heating degree days (HDD) is a measure of effect of ambient temperature on the heating requirements within a building. As the ambient temperature drops, more energy is required to maintain a given temperature in a building; lower heating degree day values are indicative of a warmer period of time. Without normalization, changes in these weather metrics could influence the magnitude of energy use changes observed through utility billing information alone.

Solar Insolation and heating degree day data was collected from the School-based Weather Station for Greater Victoria[2]. Data collection on this network of weather stations is managed in collaboration with the School of Earth and Ocean Sciences at the University of Victoria. Data from the Happy Valley, Sangster and Wishart elementary school weather stations was used for our analysis in order to provide

[2] Greater Victoria School-based Weather Station Network; http://www.victoriaweather.ca/; Accessed March 31, 2015.

the most specific weather information given the locations of the homes studied. Solar insolation and heating degree data from these stations is provided in Appendix A.

Specific normalization factors for both solar insolation and heating degree days were generated for each of the participating households using weather data from the closest weather station for the specific timing of their pre- and post- installation periods. A sample of the weather normalization calculations using heating degree day data for the period of November 2010 to October 2011 from the Happy Valley Elementary weather station is presented in Equation 1 below:

$$\frac{Long\ Term\ Annual\ Average\ Sum}{Specific\ Period\ Sum} \times Average\ daily\ energy\ consumption = Normalized\ energy\ consumption$$

$$\frac{2995.5\ HDD}{3024.1\ HDD} \times \frac{127.5kWh}{day} = 126.3kWh/day$$

Equation 1 – Sample weather normalization calculation

The effect of weather on energy consumption is illustrated in Equation 1 above – lower ambient temperatures in this period have resulted in higher heating requirements (3024.1 HDD vs. 2995.5 HDD long term) which in turn have resulted in slightly higher energy consumption (127.5 kWh vs. 126.3 kWh normalized).

Solar insolation normalization was conducted on the energy consumption of those households that installed a solar thermal hot water system (SHW); while, heating degree days normalization was performed on those households that installed a ductless split heat pump (DSHP). A combined factor was applied to the energy consumption of households which had installed both a SHW and DSHP.

GREENHOUSE GAS EMISSIONS REDUCTIONS

Changes in greenhouse gas emissions by households as a result of energy consumption were calculated by applying emissions factors of 2.8 kg CO_2 e and 49.75 kg CO_2 e for electricity supplied by BC Hydro and natural gas from Fortis BC[3] used by participating households in the period before installation, one year after installation and since the installation of energy efficiency technologies through the Solar Colwood program. These values were then compared directly to calculate the percentage of emissions reduction

[3] 2014 BC Best Practices Methodology for Quantifying Greenhouse Gas Emissions; Victoria BC; Ministry of Environment, December 2014; http://www2.gov.bc.ca/gov/DownloadAsset?assetId=6DF9D0E1E46D4DC28F96E190AF4D7783&filename=2014_bc_best_practices_methodology_for_quantifying_greenhouse_gas_emissions.pdf; Accessed March 31, 2015.

between these periods. In Equation 2, a sample of the calculation of the greenhouse gas emissions associated with natural gas consumption is presented.

$$Normalized\ Average\ Daily\ Energy\ Consumption\ \left({}^{GJ}/_{Day}\right) \times Emissions\ Factor\ \left({}^{kg\ CO_2e}/_{GJ}\right) = Associated\ Emissions\ \left({}^{kg\ CO_2e}/_{Day}\right)$$

$$0.158\ {}^{GJ}/_{Day} \times 49.75\ {}^{kg\ CO_2e}/_{GJ} = 7.86\ {}^{kg\ CO_2e}/_{Day}$$

Equation 2 - Sample calculation for the conversion of energy consumption to greenhouse gas emissions

Limitations

Our data collection methodology was chosen to maximize the ease with which homeowners could participate. The main assumption of our method is that changes in energy use, reflected in utility billing information, is the result from the installation of more efficient water and space heating technologies. This methodology does not account for any energy savings that may be the result of a change in behavior, such as energy conservation practices, or any changes in energy use that may be the result of the installation of devices or appliances that consume additional energy within the home not part of the Solar Colwood program.

Results and Discussion

In this section the results from our homeowner survey, energy consumption monitoring program and greenhouse gas emissions calculations are discussed.

Table 1 - The levels of participation of homeowners in the aspects of the RRU Solar Colwood Monitoring Program.

No. of Participants	Description of Participant Status
8	Full participation (survey & complete utility bill submission)
5	Partial participation (partial bill submission)
13	Complete survey participation (includes 10 participants from Colwood and 3 from the CRD)
11	No participation (no response)
32	Discontinued participation at various stages of program
8	Anonymous participation (online survey only)

As shown in Table 1 above, there were several levels of participation by homeowners in the aspects of our monitoring program; ranging from no participation to full participation throughout the four year program. Twelve homeowners provided at least one year of utility data before and after installation and eight households supplied billing data for the extent of our program (at least two years of data after installation). Of the eight households with full participation, six used BC Hydro's myHydro website[4] to provide our research team with direct access to their utility billing data. The importance of this direct link to billing data to the success of our project cannot be overstated.

Also of note here are the 32 households that dropped out at the various stages of the program. This group includes any household that responded to our correspondence but did not supply our team with any utility billing information. A change in the way in which our team was allowed to interact with these homeowners was a major factor in the loss of many participants. There were several such changes over the course of the program, most important being changes to the BC Freedom of Information and Protection of Privacy Act (FOIPPA)[5] but also changes to the Solar Colwood delivery team and the various other research projects that were in competition for the attention of Solar Colwood homeowners.

As our results show, a core group of households maintained full participation throughout the program. These households were contacted directly by our team under the rules of contact set out at the outset of the program. The result of this direct contact was that lasting personal relationships were formed. After the changes to FOIPPA, our office had to reconnect with homeowners through convoluted process in order to have them re-give their informed consent for participation. Under these rules of contact, more effort was required from homeowners in order to participate. The result was the loss of some participants and lower levels of participation moving forward.

Survey Results

The majority of the monitoring program participants are homeowners who have installed a SHW system, exclusively or combined with other retrofits. This group is made of mainly the early adopters of the program. The high level of participation from this group is likely a product of their eagerness to participate coupled with the freedom with which our research team had in approaching them initially.

[4] BC Hydro - myHydro Website: https://www.bchydro.com/sso/UI/Login?realm=bchps&goto=https%3A%2F%2Fwww.bchydro.com%3A443%2FBCHCustomerPortal%2Fweb%2Flogin.html; Accessed March 31, 2015.

Additional retrofits include DSHP, EV charging station, EV4PV charging station, and/or specific LiveSmart BC program approved energy saving technologies.

A total of 49 responses were collected from our online surveys and the complete list of responses, minus any personal information, is provided in Appendix B. The majority of complete responses were received by individuals that had installed a solar thermal hot water system or a ductless split heat pump; with only 8% (3 of 37) the respondents had installed both systems in their homes. Figure 1 provides a breakdown of the energy efficiency actions performed by homeowners that responded to our surveys.

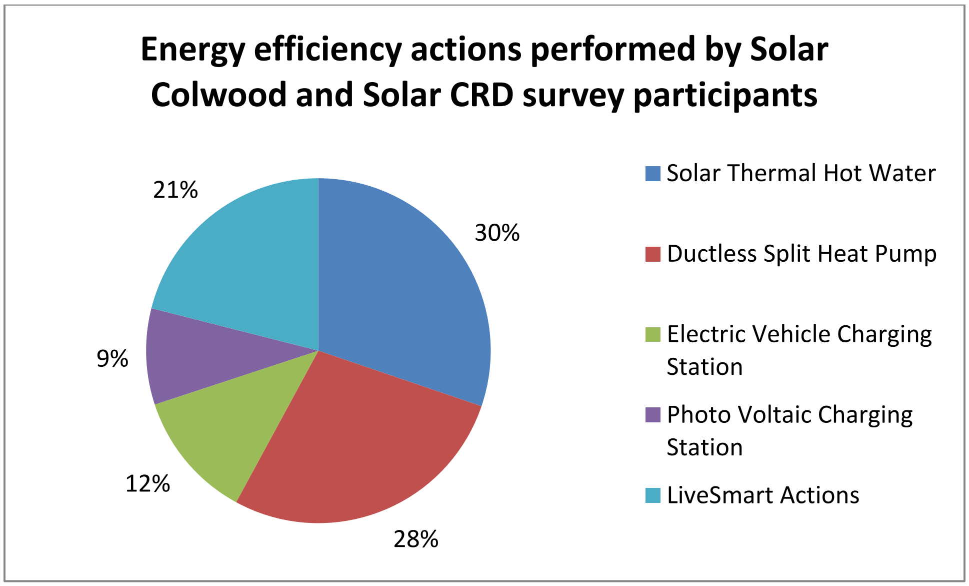

Figure 1 – A breakdown of the energy efficiency actions reported by survey respondents.

In the LiveSmart Actions category, the installation of insulation (13%) and electric thermostats (13%) were the two actions completed most often; followed by the installation of bathroom fans (10%) and an air source heat pump (10%). A complete list of the LiveSmart actions completed by survey respondents is presented in Appendix B as part of the survey results.

The relatively high level of participation in our surveys did not translate directly into participation in the utility bill submission process. While there are likely several reasons for this discrepancy, it is likely that the one-time only nature of survey participation was seen as more convenient and required less effort than committing to the practice of bill submission.

Energy Consumption Monitoring

Our monitoring program collected data from 12 of the 39 households (30.7%) that installed a solar thermal hot water system as part of the Solar Colwood program and 8 of 39 (20.5%) homes provided data for at least two years after installation. After comparing the normalized values for energy consumption from one year before and after the installation of energy efficiency technologies through participation in the Solar Colwood program, we found that ***all of the households in our study group experienced a reduction in energy consumption over this period.***

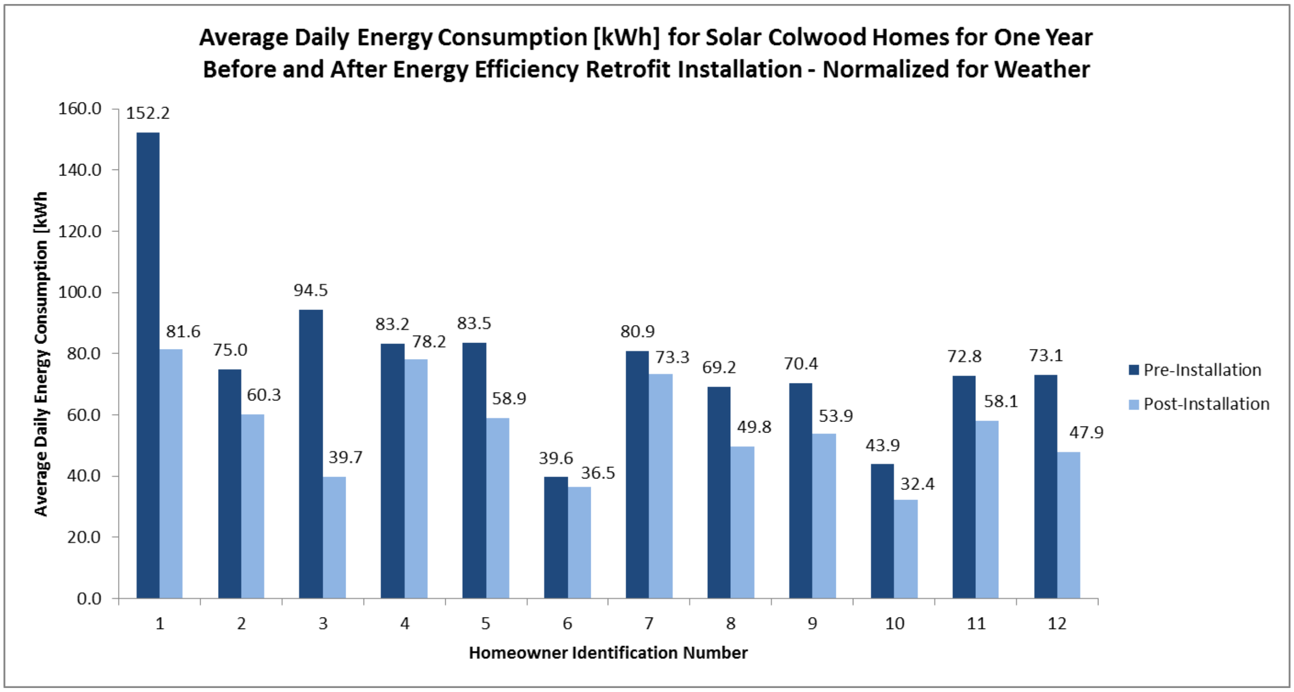

Figure 2 – A comparison of the average daily energy consumption in the households in our study group before and after the installation of energy efficient technologies through the Solar Colwood program.

Figure 2 shows the variability of the energy use reductions experienced. Households 4, 6 and 7 experienced reductions of 6%, 8% and 9% respectively; while households 1 and 3 reduced their energy consumption by 46% and 58% respectively. The difference in energy reductions experienced by these 5 households can likely be explained away by the presence of other energy efficiency improvements made in the homes that experienced the greater reductions. For example, Households 1 & 3 both installed solar hot water systems, ductless split heat pumps and upgraded attic and interior wall insulation. We can also see that households using higher levels of energy prior to installation had higher reductions after installation. It is possible that lower energy consumption patterns prior to installation were the product of a concerted effort on the part of homeowners and left fewer opportunities for further reductions. On average, households experienced a 26% reduction in energy consumption in the first year after the installation of energy efficiency retrofits. Households that continued to supply our team with utility data for at least two years after installation were found to have reduced energy consumption by an average of 37% since installation.

The fact that these values are lower than our preliminary findings is mainly due to the inclusion of more households, (12 here vs. 9 in our preliminary findings) and to a lesser extent, a product of different normalization factors. Our preliminary results were based on the energy changes experienced by households that were earlier adopters of the Solar Colwood program. This group is generally characterised by their high level of interest in energy efficiency as well as the extent to which they have embraced the energy efficiency options made available to them through the Solar Colwood program. Basing our preliminary findings on their data likely skewed the results towards higher levels of energy reductions. The core group of early adopters continued to supply our team with data, while other households dropped out of the monitoring program over time; two houses were sold, one household simply stopped responding to our requests for information and one participant cited a bad experience with an installer as the reason for dropping out. Figure 3 below shows the changes in energy use for the eight households that maintained full participation for the extent of the program.

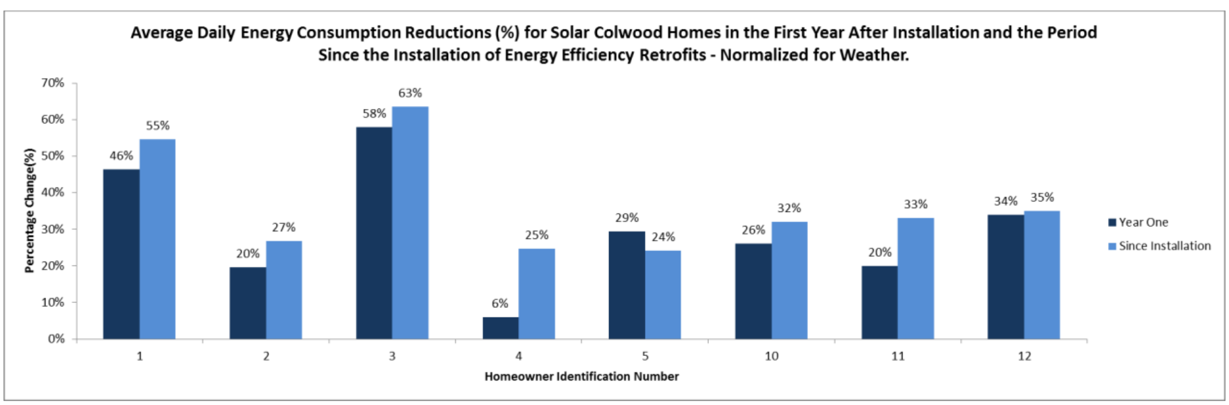

Figure 3- The energy consumption reductions between Year One (after installation) and the period since the installation of energy efficiency technologies (including year one).

With the exception of Household 5, participating households experienced further reductions in energy consumption following the first year after installation. This result speaks the influence that conservation behaviour can have on energy consumption - with the technology already in place; most households were able to achieve a further reduction in their energy consumption. Household 4, for example, experienced 19% lower energy consumption in the period following their first year with their solar hot water system in place; this result is likely due to a conscious effort to reduce energy consumption.

Greenhouse Gas Emissions Reductions

Since greenhouse gas emissions are directly related to energy consumption, it is no surprise that ***all of the households in our study group experienced a reduction in greenhouse gas emissions produced as a result of energy consumption over the study period.*** Based on the changes in both electricity and natural gas, we found that households had reduced GHG emissions by an average of 37% after the first year. Households that continued to provide us with data over the entire study period were found to have reduced emissions by 43% since installation. The difference in average energy consumption and GHG emission reductions is a product of the different emissions factors for natural gas and electricity; based on the BC Government estimations, natural gas produces 17.77 times more GHG emissions per unit energy than electricity. This difference in emissions intensity is very clearly in the results displayed in Figure 4 below.

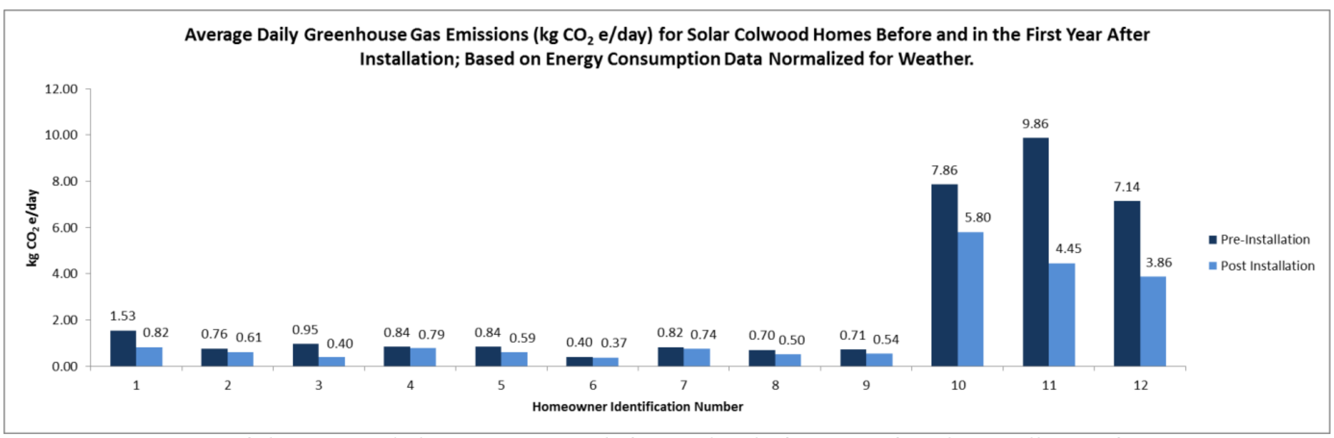

Figure 4 - A comparison of the average daily GHG emissions before and in the first year after the installation of energy saving technologies.

Households 10, 11 and 12 used natural gas in their homes and the effect of this practice on their daily GHG emissions is obvious. For example, despite using less than half of the daily energy of Household 1 (81.583 kWh vs 32.41 kWh, 58.14 kWh, and 47.90 kWh for Households 10, 11 and 12 respectively), these households produced 7, 5.4 and 4.7 times the GHG emissions of Household 1.

These findings clearly demonstrate the utility of such an incentive program as a tool for reducing greenhouse gas emissions at the household level and, by extension, community level.

Recommendations

The following recommendations are based on the experience gained over the course of this four year program and are offered to any community considering creating a similar program.

- Establish and maintain a consistent method of contacting potential program participants, one that is built upon establishing personal relationships between the research team and the study subjects.
- Work with local utility providers to improve the ease with which homeowners can share their consumption data.

Conclusions

The findings of our four year monitoring program demonstrate that homeowners who installed solar thermal hot water and/or ductless split heat pumps through the Solar Colwood incentive program reduced their energy consumption and greenhouse gas emissions by an average of 26% and 37% respectively in the first year after installation. For the period after installation until December 2014 (including the first year) energy consumption was down 37% and GHG emissions 43% compared to pre-installation values. As expected, homeowners that installed both systems demonstrated greater reductions in energy consumption. Based on these findings, it is clear that the use of financial incentive programs by municipal or regional governments to inspire homeowners to install energy efficient technologies can translate into meaningful reductions in energy consumption and GHG emissions at the community level.

Appendix A – Weather Data

Happy Valley Elementary Heating Degree Days 2006-2013 (degrees Celsius)

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average
January	-	-	477.7	476.5	342.5	346.7	455.4	451.3	399.9	421.4286
February	-	-	390	406.5	312.8	426.1	371.6	353.7	420.5	383.0286
March	-	-	414	440.1	345.3	364	395.9	353.3	262.3	367.8429
April	-	-	348.7	290.5	287.9	343.5	271.1	281.1	251.7	296.3571
May	-	39	191.2	198	232.8	233.5	204.9	156.7	126.4	191.9286
June	-	123.4	158	81.7	134	117.5	146.2	80.5	82.9	114.4
July	-	28	61.5	29.7	52.8	66.8	50.3	4.6	20.2	40.84286
August	-	44.8	54.4	47.9	58.1	35.4	33.1	17.7	8.9	36.5
September	-	146.1	114.1	103.9	125.6	77.1	92.7	93.1	56	94.64286
October	-	292.7	282.8	253.9	254.4	200.4	251.7	270.3	167.9	240.2
November	-	390	309.9	349.4	399.8	399	338.2	358.4	356.2	358.7
December	-	456.6	517.5	500.4	413.3	444.8	416.2	470	385.4	449.6571
Annual Total	0	1520.6	3319.8	3178.5	2959.3	3054.8	3027.3	2890.7	2538.3	
Annual Average Total for Period*		2995.529								* Does not include 2006 or 2007

Happy Valley Elementary Solar Insolation 2007 - 2013 (W/m²)

Year	2007	2008	2009	2010	2011	2012	2013	2014	Average*
January	-	37.03839	41.9596774	29.918	32.9923077	30.38323	35.97613	37.94548387	35.1733158
February	-	61.18828	77.2392857	67.24185	58.9557143	59.12103	53.76429	62.6825	62.8847068
March	-	106.5903	114.952903	122.8177	100.897419	113.1132	123.6213	109.7496667	113.106081
April	-	198.792	212.123333	174.845	179.718333	174.131	181.5397	185.772	186.703048
May	-	234.3074	253.301935	218.9384	223.700968	248.9442	232.9619	249.8670968	237.431705
June	247.014	269.79	290.216333	273.3683	263.891	237.2513	268.9777	289.0303333	270.360714
July	248.545806	283.6852	289.948387	310.0287	269.230323	273.5974	331.7123	285.8467742	292.007012
August	227.669355	207.8563	238.790645	240.0129	228.751647	243.3119	212.0316	230.5064516	228.751647
September	163.032333	177.3633	167.397667	136.2933	165.245667	189.8757	137.9063	169.8233333	163.415048
October	83.7967742	78.67516	87.1725	87.13645	68.9958333	76.98903	99.74323	74.37451613	81.8695315
November	48.194	39.00767	36.3393333	35.78967	38.724	39.80633	40.27567	48.832	39.8249524
December	30.236	26.75065	31.4058065	27.00355	28.5596774	21.61806	28.38161	29.33774194	27.5795853
Annual Total	-	1721.045	1840.84781	1723.394	1659.66289	1708.142	1746.892	1773.767898	

Annual Average* for Period	1739.107	* Does not include 2007

Sangster Elementary Heating Degree Days 2006-2013 (degrees Celsius)

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average
January	84	454.6	462.1	460.1	151	429	458.4	434	386.8	368.8889
February	368.5	348.4	376.1	391.9	275.2	426.8	373	341.9	406.8	367.6222
March	357.5	341.4	403.4	427.3	329.6	367	397.1	196.3	326.4	349.5556
April	262.3	282.6	338.5	286.2	278.3	343.8	272.2	266.4	234.9	285.0222
May	170	191.7	188.4	191.2	222.8	237.1	208.6	148.4	109.7	185.3222
June	71.1	118.3	147.4	68.5	127.7	114.6	150.3	65.1	65.7	103.1889
July	26.2	24.4	51.6	26.7	55.9	65.4	46.3	11	14.3	35.75556
August	40.7	40.6	54.4	40	55.1	35.825	34.4	15.8	5.6	35.825
September	98	141.6	108.4	87.4	124.6	62.3	99.7	89	50.2	95.68889
October	250.6	270.6	275.4	251.8	244.4	265.8	235.5	256.8	160.4	245.7
November	372.4	370	304.9	339.6	391.1	384.4	330.2	336.1	313.1	349.0889
December	399.1	440.7	505.2	478.5	411.7	440	420.2	451.7	443.3875	443.3875
Annual Total	2500.4	3024.9	3215.8	3049.2	2667.4	3172.025	3025.9	2612.5	2517.288	
Annual Average*	2865.046									

Sangster Elementary Solar Insolation 2007 - 2014 (W/m²)

Year	2007	2008	2009	2010	2011	2012	2013	2014	Average
January	38.67871	39.51097	41.63742	24.5592857	32.04968	29.11065	34.08548	34.6012903	34.27918
February	63.9975	67.17517	79.05	75.3784	63.32786	61.57207	57.845	68.0421429	67.04852
March	106.16	105.7926	119.3258	129.006774	97.90742	113.9639	137.2056	115.95871	115.6651
April	185.0857	203.8463	209.4803	174.106667	179.7097	178.8427	181.702	180.887	186.7075
May	274.0442	233.2987	252.2	217.283548	225.0477	245.6094	234.2855	231.91129	239.21
June	265.1163	270.2007	284.243	265.981667	263.8677	231.5423	267.0807	286.02	266.7565
July	261.5161	273.0655	284.2119	301.899032	253.6719	266.2448	309.1965	275.497419	278.1629
August	229.8052	211.5433	248.5287	238.278065	225.6182	224.2639	201.1297	225.778387	225.6182
September	152.9321	162.3448	158.0018	138.739667	133.14	176.899	129.4167	161.200345	151.5843
October	86.18733	80.68032	86.07097	94.0003226	89.44613	79.30677	98.148	77.1090323	86.36861
November	47.35633	39.79567	37.001	36.3973333	44.0969	35.44567	42.06	52.5768966	41.84122
December	26.88806	26.83677	33.29581	27.9764516	28.23516	23.21	26.76871	27.60157	27.60157
Annual Total	1737.768	1714.091	1833.047	1723.60721	1636.118	1666.011	1718.924	1737.18408	
Period Average*	1720.844								

Wishart Elementary Heating Degree Days 2006-2013 (degrees Celsius)

Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	Average
January	408.8	454.1	460.3	286.8	338.7	424.4	455.1	449.5	401.5	408.80
February	105.6	347	375.1	361.6	308.8	425.8	372.4	354.1	421.3	341.30
March	356.2	337.7	399.3	426.4	327.9	362	392.8	353.8	344.2	366.70
April	260.4	278.9	283.3	278.6	273.4	337.9	266.7	277.1	246.9	278.13
May	165.9	186.3	180.5	183.2	216.2	229.5	201.1	154.6	116.3	181.51
June	72.9	110.8	143.2	50.7	119.8	106.8	141.8	71.9	75.4	99.26
July	31.3	19.1	43.8	0	44.4	58.2	40.3	12.5	18.1	29.74
August	37.9	36.7	47.8	38.7	50	28.5	25.5	33.95	6.5	33.95
September	96.3	139.9	104.3	94	116.8	80.6	94	93	60.3	97.69
October	256.7	276.4	270.9	250.5	241.9	263.9	206.8	257.8	172.6	244.17
November	372	370	294.6	335.1	385.7	394.1	318.2	346	352.4	352.01
December	422	437.4	501.9	479.2	406.4	441.8	414.9	434.2	384	435.76
Annual	2586	2994.3	3105	2784.8	2830	3153.5	2929.6	2838.45	2599.5	
Annual Average	2869.02									

Daily average solar insolation by month for Wishart Elementary 2007 - 2014 (W/m²)

Year	2007	2008	2009	2010	2011	2012	2013	2014	Average
January	33.3267742	38.263548	32.752	33.6974194	33.98581	31.1229	35.03839	36.72613	34.36412
February	59.5553571	61.137931	75.84	65.4160714	63.41071	59.20138	56.74393	67.04786	63.54415
March	97.6196774	102.29806	115.1058	122.781935	100.6758	110.1884	119.2139	110.7148	109.8248
April	173.508667	206.18885	205.8973	168.329667	175.7347	171.2277	179.8383	186.005	183.3413
May	257.293548	228.16548	246.3894	214.771935	219.7458	238.7597	229.8929	244.0516	234.8838
June	250.979	259.81367	269.2831	263.026667	258.1973	226.3547	262.747	281.815	259.0271
July	249.723871	269.96806	305.85	300.071613	255.2839	255.6865	306.7477	276.5561	277.486
August	211.465161	203.345	230.5632	231.593548	221.6413	231.2394	221.6413	221.6413	221.6413
September	140.186	166.466	156.124	134.278	152.65	174.414	123.8715	156.012	150.5002
October	77.3893548	80.29	82.76968	87.3964516	84.24968	74.64032	93.33387	73.58097	81.70629
November	44.545	40.382667	38.31	38.7913333	43.51833	41.53233	43.10833	50.47867	42.58333
December	26.5254839	29.183548	34.65516	29.5032258	30.64677	24.46484	29.50258	31.14065	29.45278
Annual Total	1622.11789	1685.5028	1793.54	1689.65787	1639.74	1638.832	1701.68	1735.77	
Annual Average for Period		1688.355							

Appendix B – Survey Results

To view either file, simply click on the icon above and the embedded document will open within Word.

Please note that all responses containing personal information have been removed from the results of both surveys.

Solar Colwood Survey Results

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Solar Colwood & Solar CRD Survey Results

Royal_Roads_University_Solar_Colwood_a