Photo: Solshare, http://www.solshare.ca/category/alternative-

Evaluating Site Suitability for Community Solar Energy

Collaboration with the Sunshine Coast Community Solar Association

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Executive Summary:

The following is a report to the SCCSA (Sunshine Coast Community Solar Association), which primarily explores the options for a potential 20kW-sized community owned solar array on the Sunshine Coast. Through a partnership with a third-party project called Solshare, the SCCSA would be able to quickly initiate community solar projects on the Sunshine Coast without having to set up an independent co-operative. This would provide Sunshine Coast residents with an opportunity to invest in community solar energy and earn monetary returns without having to install their own rooftop solar array. This array could potentially be hosted by one of three properties in the Sunshine Coast: The Summerhill Fine Homes Inc. warehouse, the proposed Sechelt Operations Centre, and the proposed Rockwood Oceans Stories retirement home. The community of the sunshine coast has the desire to obtain independent energy, and stems from environmental sustainability reasons as well as the privacy concern over BC Hydro's new smart meters.

With BC Hydro providing some of the lowest electricity rates in Canada and many buildings in the province having unsuitable orientation or shading conditions, implementing solar energy on the Sunshine Coast is a challenge. To determine whether a SCCSA community solar array would be feasible for the respective building owners to host on their building, we used SAM (Systems Advisor Model), a renewable energy management software to predict the amount of available solar energy throughout the year for each site. Then using Excel, we compared the cost for the building owner of using BC Hydro energy instead of leasing energy from the SCCSA array.

We recommend that the SCCSA approach owners of buildings paying BC Hydro's residential electricity rates. Out of the three buildings that we looked at for this project, the Rockwood Ocean Stories retirement development, is the only building site which would offer favorable economic returns and savings if the building owner were to host the 20kW community solar array. This is because BC Hydro residential rates are significantly cheaper than their general service commercial rates, and would become cheaper than the SCCSA electricity rates in a relatively short amount of time. These rates led to a payback period of 15 years for the Rockwood Ocean Stories site, which is within the possible project lifetime for the SCCSA. To contrast this, the site paying the largest general service rate, the Sechelt Operations Centre, had a payback period of 66 years, which is not even within the Solar Panels' lifetime and is therefore financially infeasible from the perspective of the building owner. Therefore, we recommend SCCSA to only approach residential owners, except if commercial building owners have a

strong desire to have on-site solar and are willing to accept economic losses for hosting the community solar array.

We also did a survey of literature and some first-hand research to evaluate the geothermal energy as a direct alternative to installing a SCCSA Solar Array. Due to the local geology and the conditions at the three respective sites, installing geothermal heating would be extremely challenging for the respective building owners, and certainly more challenging than installing a solar array.

SECTION 1: BACKGROUND

1.1 Project Context:

The SCCSA (Sunshine Coast Community Solar Association) is a non-profit organization that seeks to educate the Sunshine Coast community on the benefits of renewable energy and energy conservation. The SCCSA also provides support to residents of the Sunshine Coast by providing them with financial and logistic support in utilizing solar energy. This includes organizing bulk buys of solar photovoltaic (PV) panels, hosting workshops on how to perform solar assessments, and collaborating with partners in the Sunshine Coast community to explore the possibilities for rooftop PV arrays to interested building owners.

While market prices on solar PV have been dropping and so allowing for more homeowners and businesses to invest in solar PV technology, many Sunshine Coast residents face substantial roadblocks that deter them from investing in a solar PV system. Solar still requires a substantial initial investment for the purchase and installation of PV panels. B.C. has some of the lowest net metering rates in North America due to the hydro based electricity, creating adverse market conditions to advance solar in B.C. Many homes and buildings have unsuitable orientation and shading conditions for rooftop solar, which renders a significant proportion of homeowners and business owners unable to invest in renewable solar energy systems. Such factors have combined to limit solar development throughout BC. as well as in the Sunshine Coast, where many residents have a keen interest in investing in environmentally friendly renewable energy systems that are independent from the BC Hydro grid.

The SCCSA has been exploring opportunities for community solar development on the Sunshine Coast. These community-owned solar projects would provide these residents a chance to invest in a larger installation on the Sunshine Coast and earn financial returns, while they support clean energy in their community. The SCCSA intends to partner with Solshare Energy, a co-operative controlled corporation with the goal of growing community-based renewable electricity generation in BC. Solshare focuses on providing BC communities the chance to invest in community solar arrays, which act as an alternative power grid in which different property owners share the same solar power source. A partnership with Solshare would allow the SCCSA to quickly initiate community solar projects on the Sunshine Coast without having to set up an independent co-operative, while also supporting the

Solshare program on the Sunshine Coast by locating interested building owners and gathering sufficient investments from the community (Heartwood Solutions Consulting, 2017).

Solshare's model for community solar energy relies on community investments and building owners who are willing to initially pay a premium for their electricity (Solshare Offering Memorandum, 2016). Under this model, Solshare leases the solar system to the building owners without any upfront costs. The building owners don't have to pay for the panels and their installation, but instead they initially pay a premium price for the electricity generated by these panels. They are initially paying a premium because BC Hydro's electricity rates are cheaper than the electricity rate that is initially charged by the SCCSA. However, over time, the building owner recoups and saves on that initial cost as BC Hydro's electricity rates increase each year and eventually surpasses the electricity rate charged by the SCCSA, which increases by no more than half of BC Hydro's rate of increase. The Solshare leases are typically 10 years in duration, with option to renew the 10-year lease at the end of the lease period. If renewed, the building owner will continue payments following the rate structure of the previous lease. If the owner chooses not to renew the rate, the array gets moved to another location, and the owner of this new building will pay a new rate, likely adapted from the BC Hydro rate at that time. A Solshare project has a minimum capital cost of around $70,000 (Heartwood Solutions Consulting, 2017), which is to be financed through community investments. The community investors, who essentially funded the project and paid for the upfront cost of the solar system and its installation receive annual dividends on their investments. In this way, Solshare's community solar model offers an opportunity for building owners to save money on their electricity while supporting the community members and residents who are unable to invest in their own solar system by offering them moderate monetary returns for investments into a community solar array.

The SCCSA are currently considering three building developments on the Sunshine Coast that are interested in working through the SCCSA to install a rooftop solar PV system. The three buildings under consideration are the following: The Sechelt Operations Centre, which is still in the development and planning stages; Summerhill Fines Homes Inc. in Gibsons, which has already been built; and Rockwood Ocean Stories, a senior residence home that is still in the development and planning stages. These buildings were chosen due to their favorable locations as well as rooftop orientations and dimensions, which make them ideal candidates for hosting a community solar array on the Sunshine Coast.

Figure 1

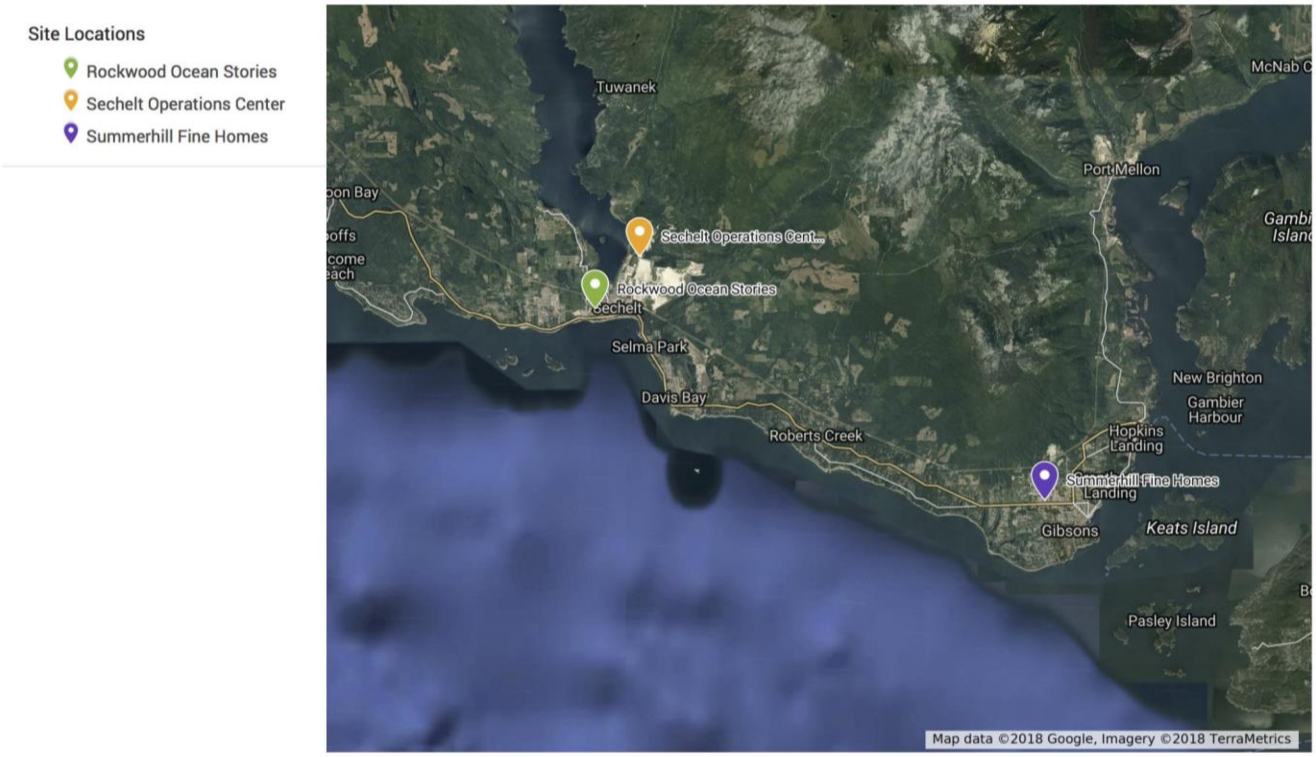


Figure 1: The specific locations of the three building sites for the proposed SCCSA community solar array on the Sunshine Coast, B.C.

1.2 Research Objectives and Goals:

In order to support the SCCSA's effort to expand community solar energy on the Sunshine Coast, we explored how feasible it would be for these buildings to host a 20kW community solar array. This involved modeling the solar energy production on each of the three sites and then conducting a cost analysis to determine whether grid-supplied energy from BC Hydro or a leased 20kW solar array from the SCCSA is the most cost-effective energy option for the building owner. The financial cost analysis was done from the perspective of the building owner, thus the results in this report are meant to be presented to the building owners to help them weigh the alternatives of hosting a community solar array through the SCCSA, owning and maintaining their own PV system, or being supplied electricity through the conventional BC Hydro grid. Additionally, through research and site visits, this project also explores opportunities for geothermal energy development on the Sunshine Coast from the building owner's perspective.

This report assesses the project's research objectives, which are as follows:

1. Model the favourability of installing a 20kW community owned solar array compared to conventional grid electricity supply from BC Hydro.
2. Compare the costs of hosting a SCCSA community grid against the costs of owning your own solar array.
3. Explore the opportunities for geothermal energy development on the Sunshine Coast.

SECTION 2: SOLAR ANALYSIS

2.1 Introduction to Solar Analysis:

The purpose of our solar analysis is to evaluate the three building sites for PV viability and to provide an estimated payback assessment for a 20kW SCCSA-leased system. By modeling the annual energy production and financial implications of hosting a 20kW SCCSA community solar array, we were able to outline the costs and benefits associated with different energy options for the building owners. We compared the costs and benefits of hosting a 20kW SCCSA array, owning your own 20kW array, as well as having your electricity supplied from BC Hydro. This was done by determining the positive net cash and the payback period of the BC Hydro and SCCSA rate, which are defined as follows:

Positive net cash point (or inflection point): The point in time when the annual payments for the SCCSA solar array becomes cheaper than the annual payments for the same amount of electricity supplied from BC Hydro.

Payback period: The point in time when the building owner has recouped the costs of paying the initial premium for the solar energy and the leased array generates revenue in the form of net positive savings for the building owner.

2.2 Methods:

Annual solar production has been modeled in the System Advisor Model (SAM) software. This software was developed by the NREL (National Renewable Energies Laboratory) in the United States, and it allows for performance and financial modelling of renewable energy systems, including solar arrays. Estimates and calculations made in SAM were based on site-specific shading measurements, made using a Solar Pathfinder tool. We used the Solar Pathfinder tool to estimate the spatial distribution of sunlight at the building sites throughout the year and to determine whether physical obstructions might be impacting solar PV effectiveness.

On January 26th, 2018, we visited all three sites on the Sunshine Coast to take measurements with the Solar Pathfinder in order to provide us with estimates for the effects of shading at each site. Despite the fact that shading effects will only diminish PV production if shadows are cast on the rooftop solar modules, we had to take our shading measurements at ground level because two of the three buildings have not been built yet. For this reason, our shading measurements are conservative estimates which are likely to overestimate the effects of shading on solar PV production. Nonetheless, we are assuming our shading measurements are representative of the three buildings despite the fact that two of the them have not yet reached construction stage.

In order to make sure the outputs of our SAM models were accurate, we modeled a 5.98 kW rooftop solar array in SAM that is owned and maintained by SCCSA board member Gerry Pageau in Gibsons. Gerry provided us with monthly energy production data for the year of 2015, which we compared to SAM's annual energy production estimates for a PV system of the exact same size. Our SAM model provides a slight underestimation during the summer months and an overestimation during the winter months. However, SAM's estimates for total annual energy produced were off by less than one percent. For this reason, we are assuming that our solar production estimates made in SAM are representative of the actual electricity production from a 20kW solar array on the Sunshine Coast.

Gerry's Annual Production	SAM's annual production estimates
7,425 kWh	7,416 kWh

Modeling the solar energy production in SAM required us to make the following assumptions across all model runs:

- The type of solar panel and inverter module that the system will use:
  LG Electronics LG320N1C-G4 paired with Hoymiles Converter Technology MI-250. The LG Electronics module is the module that was used for the most recent Solshare project and is thus a representative system to use in our model. The Hoymiles inverter is a common inverter and is thus representative of an inverter that would be used for this project.
- An array size of 20 kWdc.
- DC to AC ratio of 0.75.

- Tilt of panels was modeled at 40 degrees. This amount of tilt was chosen because it is a middle ground between the optimum fixed tilt values for panels located at 49 degrees latitude during the summer (~20 degrees) and winter (~60 degrees).
- Azimuth of the panels is 180 degrees, directly south-facing panels.
- The shading measurements taken at the site are representative of the shading that will be at the building when it is built. This may mean that our results are underestimations of annual solar energy production because the amount of shading experienced at the ground level (where our shading measurements were taken) would be higher than the amount of shading experienced at the rooftop level (where the solar arrays will be installed).

Subsequent financial calculations were based on the annual solar energy production estimates for the 20kW array at each site. Calculations were made to estimate the corresponding electricity bills that the building owner would have to pay the SCCSA for the amount of power produced by the array as well as the electricity bill for the same amount of power provided by BC Hydro. General assumptions include:

- Solar energy production by the panel does not decline each year. Solar PV production for the 20kW array stays constant through time and do not degrade. Because B.C's climate is relatively mild and cold, losses due to degradation are not as large of a concern, as they will be subject to less damage.
- Panel lifetime is determined by Lombardo, 2014 and considered to be 25 years at this point the panels will be producing approximately 80% of their day one power production.
- BC Hydro rates increase by 3% each year.
- SCCSA rates start at $0.14/kWh and increase by 1.5% each year (no more than half of BC Hydro's rate of increase).
- Inflation rates have not been included explicitly in our financial calculations. However, our financial calculations are based on an assumed BC Hydro annual 3% increase for their electricity prices, which is done partially to combat inflation (BC Hydro, n.d.).
- All the energy produced by these panels is consumed by the building before electricity from the grid comes on.

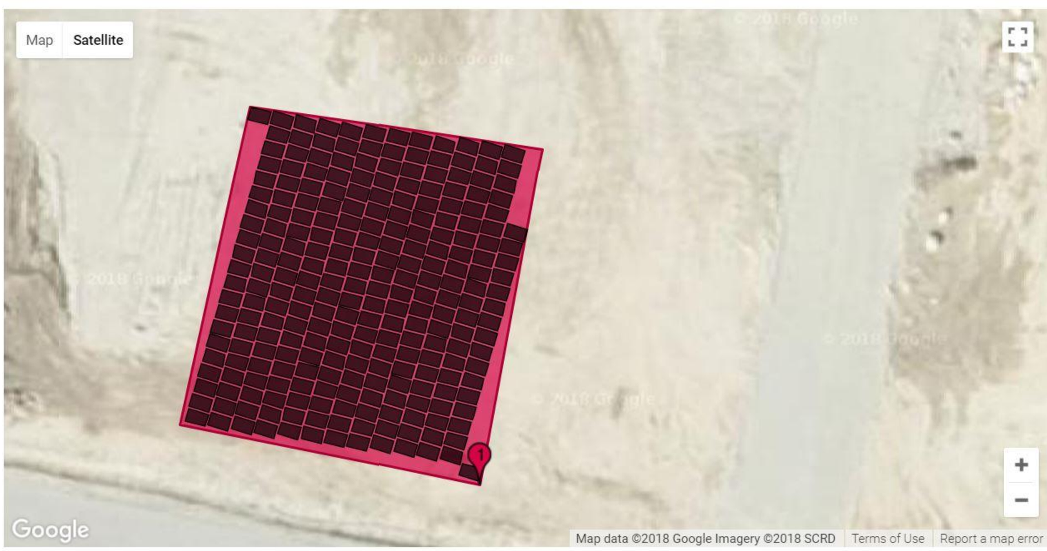
With these assumptions, using Microsoft Excel, we graphed the predicted SCCSA PV and BC Hydro electricity payments into the future in order to find the positive net cash point and the payback period for a 20kW SCCSA array at each building site.

2.3 Results, Sechelt Operations Centre:

Introduction:

The Sechelt Operations Centre is a new development that will house public works and parks staff and equipment. The building itself is currently in the preliminary design and permitting phase of development. The site is located at 5400 Dusty Road in Sechelt, BC, and occupies approximately 20,509m^2 of space. In the building plans issued for review on August 2nd, 2017, the proposed building footprint is approximately 860m^2, with a “green roof” and a designated strip for solar panels. The total building area is estimated at 2,685m^2, which includes work bays, a dedicated sign-making area, a workshop, office space, a training area and lunchrooms.

Based on the building plans for the Sechelt Operations Centre dated August 2nd, 2017, the roof can accommodate 200 panels after building slopes and roof obstructions are taken into account. This would amount to a roughly 64 kW sized array.



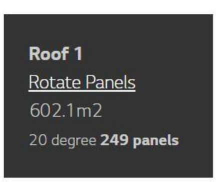


Fig 2.3.1 Rough current design of the upper roof on the Schelt Operations Centre and the numbers of panels it could accommodate. Despite the fact that we are modeling a 20kW solar array, the Sechelt Operations Centre has a roof area that is large enough for an over 60kW solar array.

Solar production:

Metric	Value
System nameplate DC rating (kW)	19.85
Annual energy (year 1)	23,841 kWh
Capacity factor (year 1)	13.7%
Energy yield (year 1)	1,201 kWh/kW
Performance ratio (year 1)	0.83

In the first year of operation, the modeled 20kW system produces annual energy of 23,841 kWh.

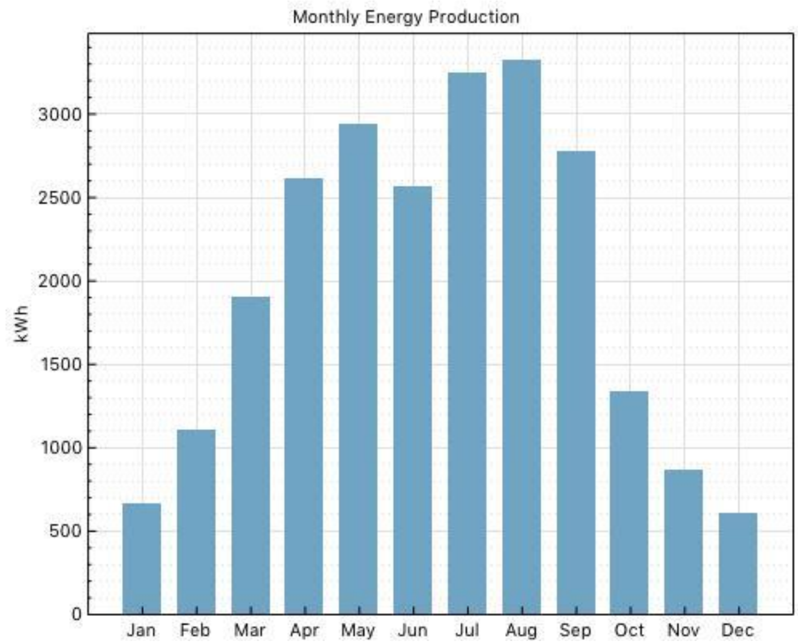


Figure 2.3.2 Monthly Energy Production for a 20kW array on the Sechelt Operations Centre. A graphical representation of how solar energy production varies through the year. As expected, solar energy production is highest in the summer and lowest in the winter. Solar energy production from the 20kW array will provide a small proportion of the building's energy demands in the winter.

System losses:

System losses have been modeled as follows:

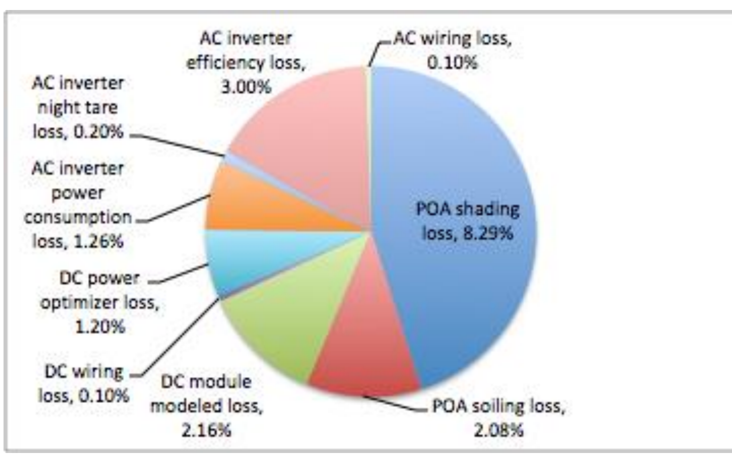


Fig 2.3.3 Modelled losses for a 20kW solar array on the Sechelt Operations Centre. Shading is the most dominant source of energy loss, but may be an overestimation due to the nature of our shading measurements. Optimizer losses, wiring losses and efficiency losses are likely to be relatively small in value, but may vary from system to system.

Financial outlook:

If the Sechelt Operations Centre building owners were to lease a 20kW system from the SCCSA, they would not have to pay for the upfront costs for the equipment and installation. They would instead be paying the SCCSA for the electricity generated by the solar panels at an initial rate of $0.14/kWh. We compared the costs associated with SCCSA electricity payments to payments that the building owners would have to pay BC Hydro for the exact same amount of electricity. To do this, we assumed that this building will be billed under BC Hydro's large general service rate once the building is operational. BC Hydro's large general service rates include:

- A basic charge at $0.24290/day
- An energy charge of $0.055/kWh
- A demand charge of $11.21/kW
- 5% rate rider tax.
- 5% GST
- 3% rate of increase each year.

The Sechelt Operations Centre is a relatively large development, and will likely have a large electricity demand for the proposed buildings. Our financial calculations thus assume that this 20kW system will only provide a portion of the building's power demand. For that reason, the building owners will be paying this daily basic charge regardless of whether or not the building chooses to lease the system from the SCCSA. Thus the basic charge does not need to be included in our financial calculations.

Year of Lease	SCCSA Lease Payment	BC Hydro Payment	Difference in Payments	Net Positive Cash
1	$3,162	$1,751	-$1,411	-$1,411
2	$3,209	$1,804	-$1,406	-$2,816
3	$3,257	$1,858	-$1,400	-$4,216

4	$3,306	$1,913	-$1,393	-$5,609
5	$3,356	$1,971	-$1,385	-$6,994
6	$3,406	$2,030	-$1,376	-$8,370
7	$3,457	$2,091	-$1,366	-$9,736
8	$3,509	$2,154	-$1,355	-$11,092
9	$3,562	$2,218	-$1,344	-$12,435
10	$3,615	$2,285	-$1,330	-$13,766
41	$6145.60	$6210.88	$65.29	-$41,711.43

Table 2.3.1 Calculated electricity payments for the energy produced by a 20kW array under a potential SCCSA lease and under BC Hydro's large general service rates. Total net savings represents the accumulation of the differences in energy payments through time. The first 10 years are shown along with the year at which payback has been reached and savings are being earned for the building owner.

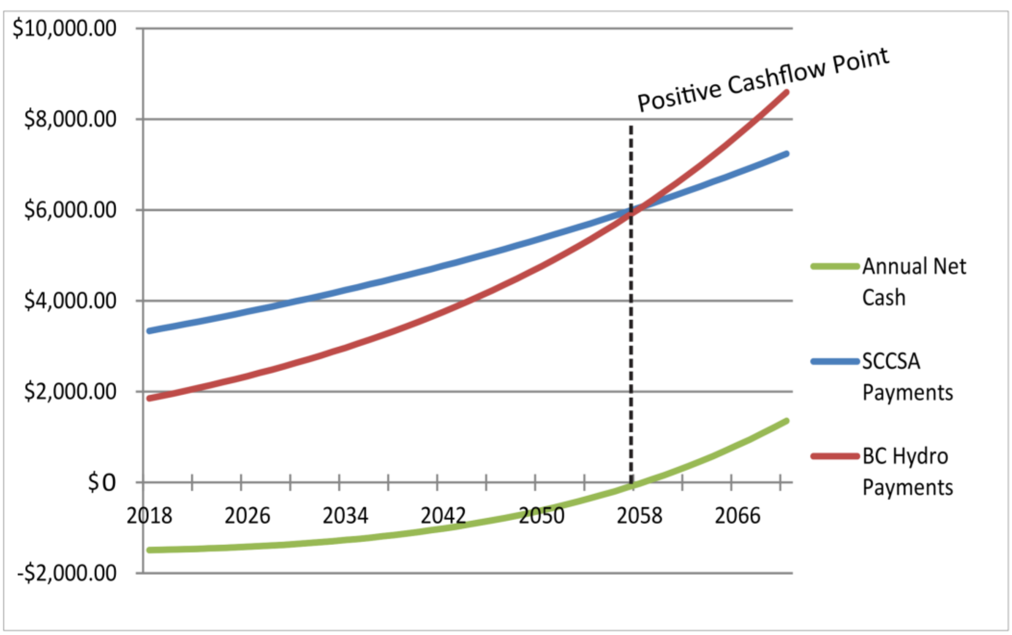


Fig 2.3.4 Overview of financial calculations and financial returns for a 20kW solar array installed on the Sechelt Operations Centre and leased from the SCCSA. The positive cashflow point is the inflection point, or the year at

which the SCCSA payments becomes cheaper than BC Hydro payments. Based on our calculations, the positive cashflow point occurs at around 2058. For that reason, leasing a 20kW solar array from the SCCSA does not offer the Sechelt Operations Centre building owners with favorable economic returns.

Discussion:

Assuming that the proposed Sechelt Operations Centre will be billed under BC Hydro's large general service rate, the building owners/developers will not reap any savings in the foreseeable future by hosting a 20kW community solar array. Under the assumption that BC Hydro and SCCSA rates will increase by 3% and 1.5% each year, respectively, it would take approximately 41 years of leasing this 20kW array system for the SCCSA payments to become cheaper than the corresponding BC Hydro payments. The payback time for the 20kW SCCSA array would be approximately 66 years. This is primarily because of the comparatively low energy rates charged under BC Hydro's large general service rate. If the Sechelt Operations Centre instead falls under BC Hydro's medium general service rate (annual peak demand between 35 and 150 kW and uses less than 550,000 kWh per year) then the inflection point becomes 20 years and the payback period is 36 years.

These results indicate that under the Solshare model, hosting a 20kW community solar array on the proposed Sechelt Operations Centre would not provide any economic returns or savings for the building owner during the SCCSA lease period or during the 25-year lifetime of the PV array. These findings are largely due to the relatively low electricity rate charged under BC Hydro's large general service rate. It's worth noting that in a 2016 report for the Sechelt Operations Centre, PBX Engineering Ltd. found the payback period for a 8.75kW PV system on the proposed Sechelt Operations Centre to be 56 years. While their report does not consider the solar array under the Solshare model for community solar and also does not assume any increase in BC Hydro's electricity rates, their general findings are similar to what we have found, which is that the payback period for a rooftop solar array on the proposed Sechelt Operations Centre would not generate any savings for the building owner.

2.4 Results, Summerhill Fine Homes Inc.:

Introduction:

Summerhill Fine Homes Inc. is a developer specialized in building green buildings and homes on the Sunshine Coast. The building is a warehouse that is shared by 3 different businesses. Summerhill Fine Homes rents out approximately ⅓ of the building. The warehouse is already constructed, and located at 675 Industrial Way, Gibsons BC.

Based on satellite imagery. This roof has roughly enough space for 200 panels at maximum capacity, as shown in the figure below. Hosting this many panels would generate about 60kW.

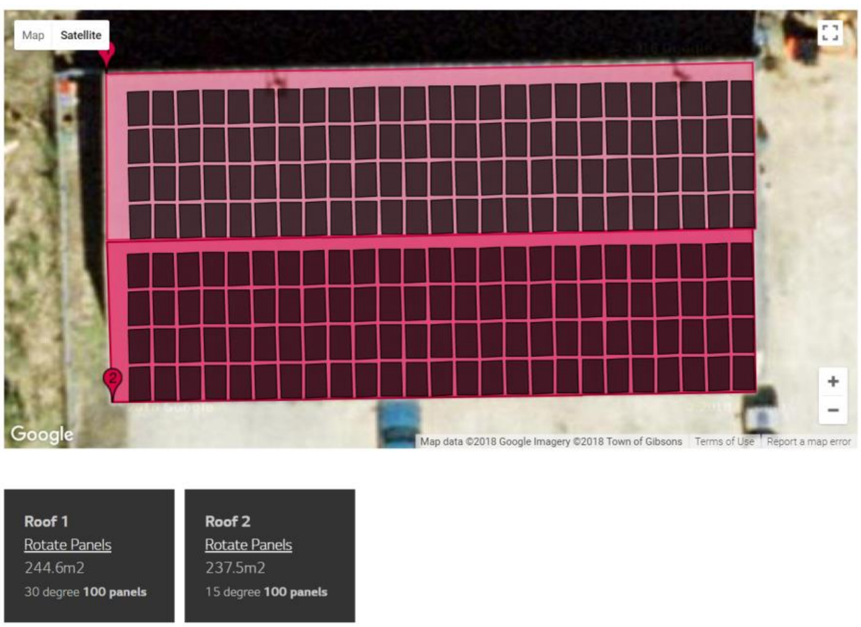


Fig 2.4.1 Image of the roof of the Summerhill Fine Homes warehouse with an estimation of how many panels it could host. Despite the fact that we are modeling a 20kW solar array, the building used by Summerhill Fine Homes has a roof area that is large enough for an over 60kW solar array.

Solar production:

Metric	Value
System nameplate DC rating (kW)	19.85
Annual energy (year 1)	26,033 kWh
Capacity factor (year 1)	15.0%
Energy yield (year 1)	1,311 kWh/kW
Performance ratio (year 1)	0.90

In the first year of operation, the modeled 20kW system produces annual energy of 26,033 kWh.

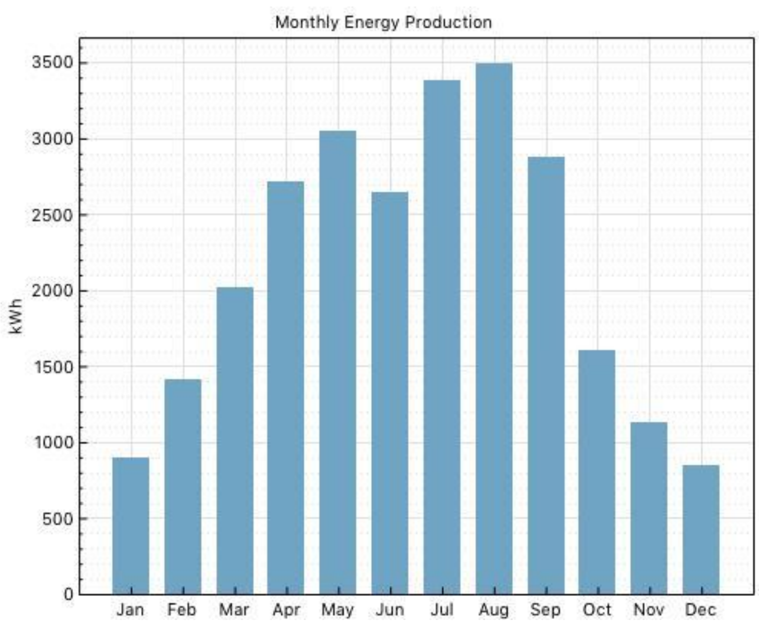


Fig 2.4.2 Modelled energy production for a 20kW array on the roof of the Summerhill Fine Homes warehouse. A graphical representation of how solar energy production varies through the year. As expected, solar production is highest in the summer and lowest in the winter. Peak solar production occurs in the month of August, with a monthly solar production value of around 3500 kWh.

System losses:

There are no structures around the building that would cast a shadow on the modeled rooftop array. Shading losses were taken to be 0%

System losses were modeled as follows:

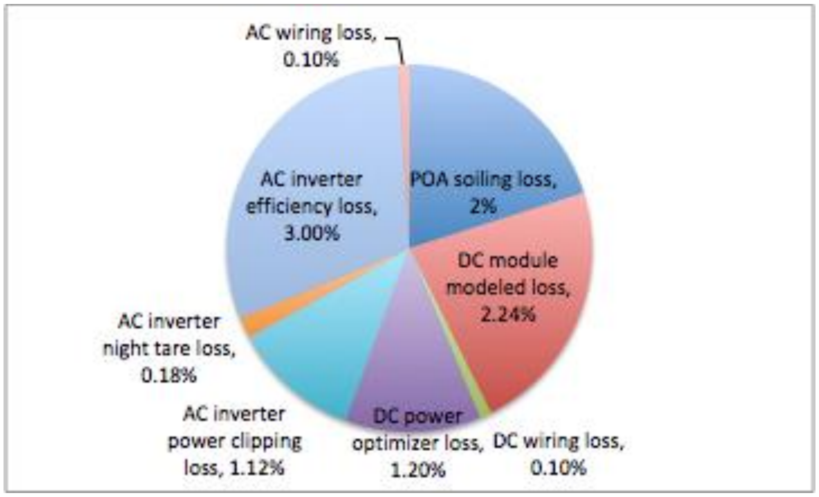


Fig 2.4.3 Modelled losses for 20kW array on the roof of the Summerhill Fine Homes Warehouse. There are no structures or trees which cast shadows over the building, thus there are no losses due to shading. Optimizer losses, wiring losses and efficiency losses are likely to be relatively small in value, but may vary from system to system.

Financial outlook:

If the Summerhill Fine Homes Inc. building owners were to lease this 20kW system from the SCCSA, they would not have to pay for the upfront costs for the equipment and installation. They would instead be paying the SCCSA for the electricity generated by the solar panels at an initial electricity rate of $0.14/kWh. We compared the costs associated with SCCSA electricity payments to payments that the building owners would have to pay BC Hydro for the exact same amount of electricity. To do this, we assumed that this building will be billed under BC Hydro's medium general service rate. BC Hydro's medium general service rates include:

- An energy charge of $0.088/kWh
- A demand charge of $4.92/kW
- 5% rate rider tax.
- 5% GST.
- 3% rate of increase each year.

Our financial calculations assume that this 20kW system will only provide a portion of the building's power demand. For that reason the building owners will be paying this daily basic charge regardless of whether or not the building chooses to lease the system from the SCCSA. Thus the basic charge does not need to be included in our financial calculations.

Year of Lease	SCCSA Lease Payment	BC Hydro Payment	Difference in Payments	Total Net Savings
1	$3,247.74	$2,422.82	-$824.91	-$824.91
2	$3,296.45	$2,495.51	-$800.95	-$1,625.86
3	$3,345.90	$2,570.37	-$775.53	-$2,401.39
4	$3,396.09	$2,570.37	-$748.61	-$3,149.99
5	$3,447.03	$2,726.91	-$720.12	-$3,870.12
6	$3,498.73	$2,808.71	-$690.02	-$4,560.14
7	$3,551.21	$2,892.97	-$658.24	-$5,218.38
8	$3,604.48	$2,979.76	-$624.72	-$5,843.10
9	$3,658.55	$3,069.16	-$589.39	-$6,432.49
10	$3,713.43	$3,161.23	-$552.20	-$6,984.69
36	$6,229.28	$7,880.27	$1,650.99	$1,388.87

Table 2.4.1 Calculated electricity payments for the energy produced by a 20kW array under a potential SCCSA lease and under BC Hydro's medium general service rates. Total net savings represents the accumulation of the differences in energy payments through time. The first 10 years are shown along with the year at which payback has been reached and savings are being earned for the building owner.

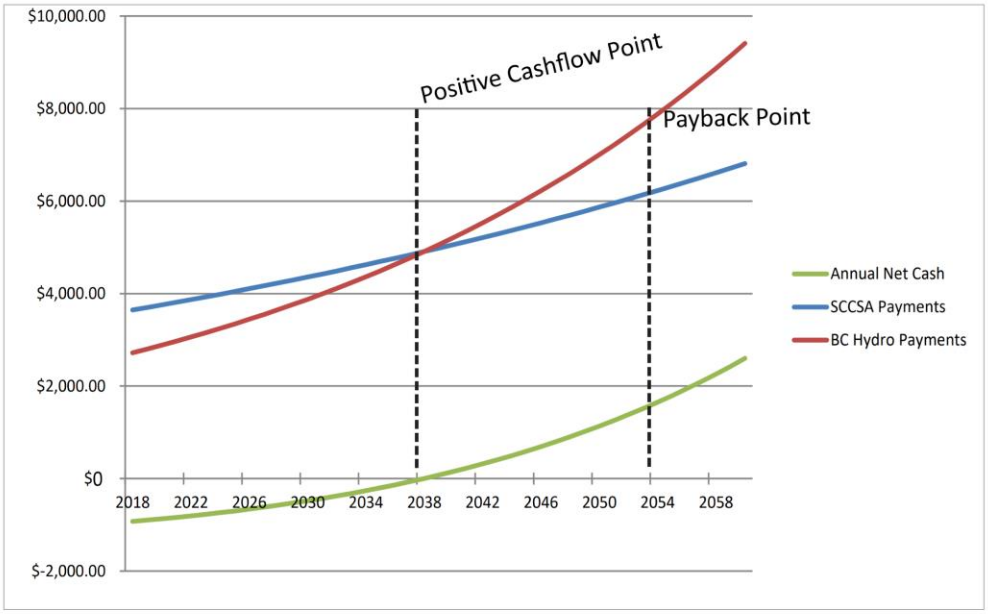


Fig 2.4.4 Overview of the financial calculations and returns for a 20kW solar array leased from the SCCSA and installed on the Summerhill Fine Homes building. The positive cashflow point is the inflection point, or the year at which the SCCSA payments become cheaper than the BC Hydro payments. Based on our calculations, the positive cashflow point occurs at around 2038. The payback point for the leased array will occur after 36 years of leasing the array. For this reason, leasing a 20kW solar array from the SCCSA does not offer the Summerhill Fine Homes building owners with favorable economic returns.

Discussion:

With BC Hydro and SCCSA rates increasing by 3% and 1.5% every year, it would take approximately 20 years of leasing this 20kW array system for the SCCSA payments to become cheaper than the corresponding BC Hydro payments. The payback period is 36 years. By the time this project reaches positive cashflow, both the SCCSA lease period and the panel lifetime will have elapsed. Thus it is unlikely that leasing an array from the SCCSA will reap any savings for the building owners. This is primarily due to the effect of BC Hydro's relatively low commercial energy rates on the inflection point and payback period associated with hosting a 20kW array from the SCCSA.

2.5 Results, Rockwood Ocean Stories:

Intro:

Rockwood Ocean Stories is an independent supportive living and assisted living centre currently in the development stages of building. At the time of our site visit (January 26th, 2018), the lot on which the buildings will be built on has not been cleared. We are assuming that this development will be paying BC Hydro’s residential electricity rates, which makes the project of interest to the SCCSA.

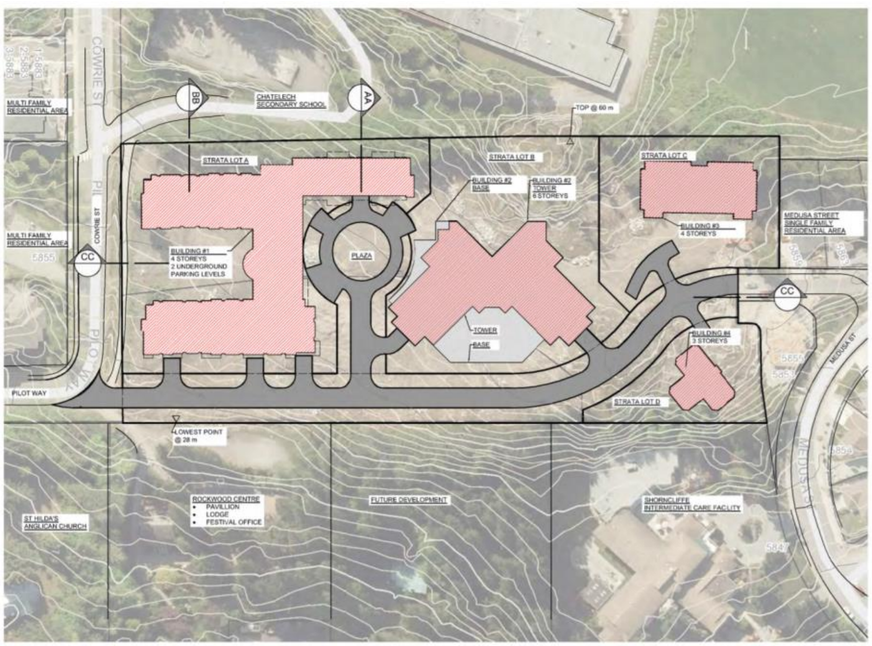


Fig 2.5.1 Site plan for the proposed Rockwood Ocean Stories retirement community, taken from the 2015 conceptual site plan. Shading measurements were taken at the approximate location of building #1.

Solar Production:

Metric	Value
System nameplate DC rating (kW)	19.85
Annual energy (year 1)	23,674 kWh
Capacity factor (year 1)	13.6%

Energy yield (year 1)	1,192 kWh/kW
Performance ratio (year 1)	0.82

In the first year of operation, the modeled 20kW system produces annual energy of 23,674 kWh.

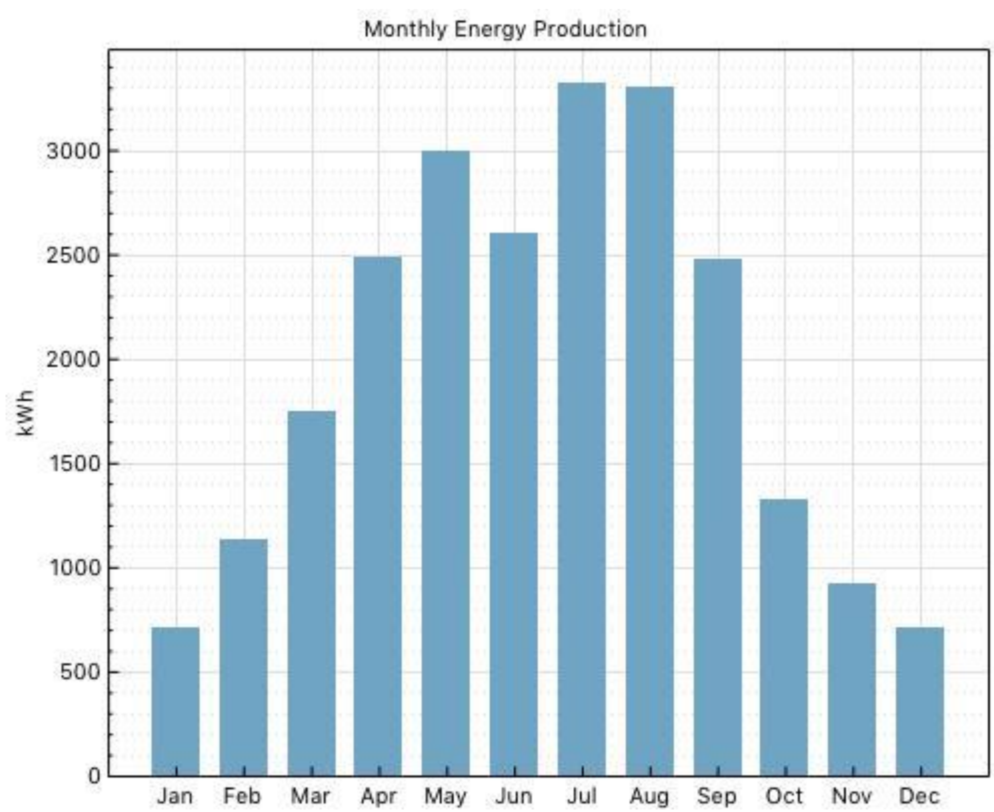


Fig 2.5.2 Modelled Energy Production for a 20kW array on the Rockwood Ocean Stories Retirement Community development. A graphical representation of how solar energy production varies through the year. Solar production is highest during the month of July, with a monthly solar production value of around 3300 kWh.

System Losses:

System losses have been modeled as follows:

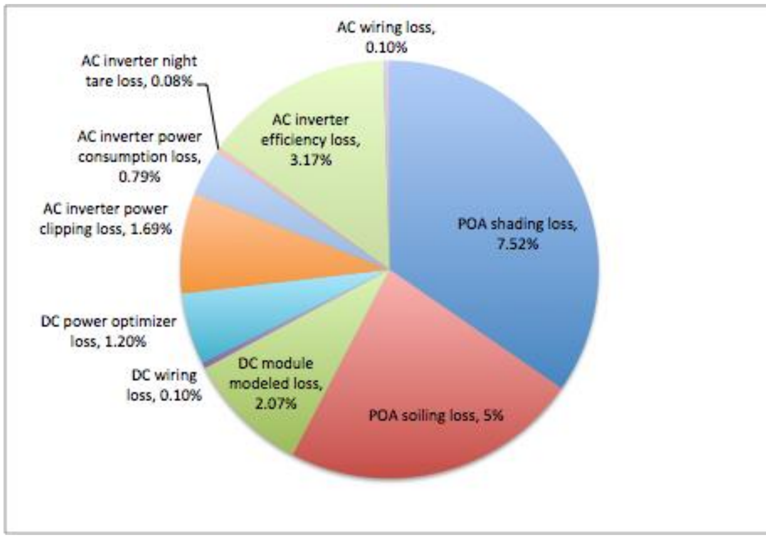


Fig 2.5.3 Modelled losses for a 20kW array on the Rockwood Ocean Stories Retirement Community development. Shading is the most dominant source of energy loss, but may be an overestimation due to the nature of our shading measurements and the final location for the 20kW array. Optimizer losses, wiring losses and efficiency losses are likely to be relatively small in value, but may vary from system to system.

Financial Outlook:

If the developers of the Rockwood Ocean Stories retirement complex were to lease this 20kW system from the SCCSA, they would not have to pay for the upfront costs for the equipment and installation. They would instead be paying the SCCSA for the electricity generated by the solar panels at an initial electricity rate of $0.14/kWh. We compared the costs associated with SCCSA electricity payments to payments that the building owners would have to pay BC Hydro for the exact same amount of electricity. To do this, we assumed that this building will be billed under BC Hydro's residential rates. BC Hydro's residential rates include:

- Basic charge of $0.1899/day
- Step 1 energy charge (first 1350kWh in the 2-month billing period) of $0.0858/kWh
- Step 2 energy charge (all net-metered energy beyond 1350kWh in the 2-month billing period) of $0.1287/kWh.
- 5% rate rider tax.

- 5% GST.
- 3% rate of increase each year.

Year of Lease	SCCSA Lease Payment	BC Hydro Payment	Difference in Payments	Total Net Savings
1	$3,314.35	$2976.02	-$338.32	-338.32
2	$3,364.06	$3065.30	-$298.76	-$637.08
3	$3,414.52	$3157.26	-$257.26	-$894.34
4	$3,465.74	$3251.98	-$213.76	-$1,108.10
5	$3,517.73	$3,349.54	-$168.19	-$1,276.28
6	$3,570.49	$3,450.03	-$120.47	-$1,396.75
7	$3,624.05	$3,553.53	-$70.52	-$1,467.27
8	$3,678.41	$3,660.13	-$18.28	$1,485.55
9	$3,733.59	$3,769.94	$36.35	$1,449.20
10	$3,789.59	$3,883.03	$93.45	$1,355.75
15	$4,501.50	$4,082.46	$419.04	$60.42

Table 2.5.1 Calculated electricity payments for the energy produced by a 20kW array under a potential SCCSA lease and under BC Hydro's residential rates. Total net savings represents the accumulation of the differences in energy payments through time. The first 10 years are shown along with the year at which payback has been reached and savings are being earned for the building owner.

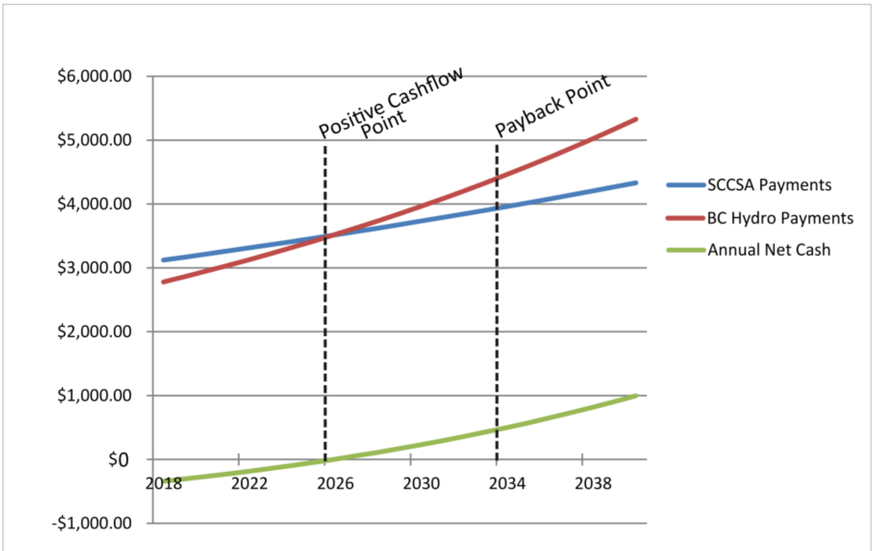


Fig 2.5.4 Overview of the financial calculations and returns for a 20kW solar array leased from the SCCSA and installed on the Rockwood Ocean Stories development. The positive cashflow point is the inflection point, or the year at which the SCCSA payments become cheaper than the BC Hydro payments. Based on our calculations, the positive cashflow point occurs at around 2026, or after 8 years of leasing the array. The payback point for the leased array will occur around 2036, or after 15 years of leasing the system. Due to the relatively short payback period, leasing a 20kW system from the SCCSA could potentially generate energy savings and revenue for the Rockwood Ocean Stories building owners.

Discussion:

Assuming that the complex is billed at BC Hydro's residential rate, our analysis reveals that the Rockwood Ocean Stories development is the most viable option to host a 20kW community solar array. If we assume that the energy generated by the 20kW array would be billed under BC Hydro's 2 step residential electricity charges (i.e. the first 1350 kWh charged at $0.0858/kWh and all excess energy billed at $0.1287/kWh), then the positive net cash point would occur at approximately 8 years and the payback time would be at approximately 15 years. However, if we assume that the energy generated by the 20kW array is billed under the second step of BC Hydro's 2 step residential electricity charges (i.e. all energy billed at $0.1287/kWh), then all payments to the SCCSA would be cheaper than the corresponding payments to BC Hydro.

Our results show that for the Rockwood Ocean Stories developers/building owners, hosting a SCCSA 20kW community represents a financially viable energy option which has the potential to generate savings on the amount of energy produced by the PV array. Typical Solshare leases are 10 years in length, with the option to extend the lease another 10 years after the initial lease expires. Our analysis shows that if the Rockwood Ocean Stories developers were to lease a 20kW system for 20 years, the PV system could generate them around $3,327.03 in savings on their electricity bill by the end of the lease period relative to what they would be charged by BC Hydro during that 20-year lease period.

2.6 Conclusions:

The significance of BC Hydro rates:

A significant portion of the financial viability of this project depends heavily on the BC Hydro rate increases. These in turn depend on many unpredictable factors such as which party holds power in the province, new hydro projects such as the Site C Dam, etc. For our project we chose to keep a constant BC Hydro rate increase of 3% per year; however, there is no guarantee that it will remain this way. Historically there has been a trend of increasing BC hydro rates, mostly to compensate for inflation (BC Hydro Revenue Requirement Application 2006). Even now, without the decision by the BC Utility Council to freeze electricity rates for the next 6 months, electricity rates were on course to increase by 3% for this year and the following one. Not assuming any rate increases in the coming years would be a poor choice. Additionally, Solshare models its project's financial viability by assuming a 3% rise in BC Hydro's rates each year and that their own rates will increase by 1.5% each year (half of the BC Hydro increase).

With that in mind, it is quite safe to assume that rates will continue to increase into the future and that the 3% rate increase is a conservative estimate. The SCCSA needs to be aware of the provincial government's plans to change BC Hydro's rates and understand that it has a huge impact on financial viability for the building owner as well as the size of future savings that will result from hosting a community solar array.

SCCSA vs. private ownership:

There is also the possibility for the building owner to purchase their own array instead of opting for the community owned model. For the building owner that would mean that they buy the panels, pay for their installation as well as any maintenance and upkeep costs. Additionally, this means that the building owners do not pay for the electricity generated by the solar panels once they have been installed. A significant obstacle to this is the large capital cost of installing and maintaining your own array. The installation of a 20kW array by itself is estimated to cost about $52,000, not including maintenance costs. Obtaining an array that uses the SCCSA leasing agreement would offset the operations and potential maintenance costs, which are all covered in the lease agreement. Panel maintenance is generally a minor concern due to the durability of modern solar panels. However, it may become a concern as the project increases in age. Owning your own 20kW solar array would become cheaper than leasing a 20kW array from the SCCSA after approximately 13 years. This is assuming rate charged for the generated electricity under the SCCSA lease starts at $0.14/kWh and increases at 1.5% each year. This essentially means that relative to the payments that would be made to the SCCSA for a 20kW PV array, the building owner would generate savings after 13 years if he/she decides to pay for the $52,000 upfront cost for the panels and installation. This also highlights the fact that for a building owner who has the desire to have a PV array on his/her rooftop but doesn't have enough funds to pay for the upfront cost, a lease agreement with the SCCSA or Solshare represents a realistic option to host a PV system.

2.7 Recommendations:

Our analysis and site specific results have revealed that building sites that are billed under BC Hydro's residential rate category are the most favorable for hosting a community solar array under Solshare's business model. A residential site hosting a 20 kW sized system will either be saving money on energy bills immediately, or saving money after approximately 8 years of energy payments to the SCCSA, depending on which step the energy produced by the solar panels would be billed under BC Hydro's two-step residential rate system.

Installing an array on a building site that pays commercial BC Hydro electricity rates would not be financially favorable to the building owner. SCCSA will not be able to approach these building owners and offer favorable economic returns. The Sechelt Operations Centre has an over 41 year period of time before the inflection point, which is longer than the advertised lifetime of the solar panel that was used for our analysis. Summerhill Fine Homes Inc. in Gibsons has a 20 year period until inflection and 35 years until payback. The SCCSA should only approach commercial buildings owners if they have a strong desire to host solar panels such as support for local community groups, independence from provincial power providers, personal incentive for green power commitments, and/or a lack of extra capital to spend on the purchase, installation, operation and maintenance of solar panels on their own.

Our results show that the SCCSA should focus on targeting residential buildings for any future community solar arrays on the Sunshine Coast. The Rockwood Ocean Stories development represents the most financially viable option for the building owners out of all three sites that were analyzed in our report. For this reason, the SCCSA should focus on communicating with the Rockwood Ocean Stories building owners about their interests in hosting a community solar array. The SCCSA should also determine what BC Hydro rate structure the Rockwood ocean Stories development would fall under.

SECTION 3: GEOTHERMAL EVALUATION

3.1 Geothermal & Geo-exchange Systems:

As part of the broader goal of promoting the use of renewable energy on the Sunshine Coast, the SCCSA asked our team to investigate the potential of geothermal power in the area as a possible alternative energy source. Geothermal energy is derived from underground sources of heat, which produce temperature gradients in the subsurface. These gradients are used to heat the solution in the geothermal system and pumped to heat exchangers connected to the system. The two most common geothermal systems are hydrothermal and enhanced geothermal systems (EGS). However, recently low-temperature geothermal systems have become increasingly popular. These systems make use of underground heating to create a convective circulation system where a fluid of water is heating while it passes through the underground, before coming back to the surface and powering turbines or providing direct heat. EGS circulates water in the same way as hydrothermal systems in order to produce energy/heating. EGS development occurs where permeability is absent from the geothermal system at hand. However, systems that utilize fractures in the rocks underground must first be artificially engineered in order to tap into the heat source underground. Our initial research revealed that there is geothermal potential on the Sunshine Coast. In a study on British Columbia's geothermal resource, The Canadian Geothermal Association revealed that there is moderate potential for high energy geothermal development around the Sunshine Coast Regional District (CanGEA, 2014).

A different style of geothermal usage is ground-coupled heat pumps and borehole heat exchangers (BHX). They provide direct use heat, called geo-exchange systems (GXS's). While these systems still rely on a fluid being heated in underground pipes and brought back up to the surface, they generally operate at smaller depths (about 100m deep) and don't require deep convective systems. These geothermal heat-exchange (GHX) systems also don't require the conventionally large temperature gradients to exist, making them more accessible to areas without sources of groundwater or a fault system.

Generally speaking, a GXS is made up of an underground pipe loop, a heat pump and the distribution system. The GXS circulates the heat-transferring fluid through the loop and to the heat pump located inside the building. The heat pump extracts the heat and distributes it throughout the building. The fluid is then pumped back into the ground where it is able to draw more heat from the surrounding soil. During summer, the heat pump is used to transfer heat from the building into the ground. Although the heat pumps require electricity to operate, they use it very efficiently, extracting 2 – 4 times as much heat as the input electricity. Heat pumps can be used in many other similar situations, where a low temperature source of heat is available.

These systems are often referred to as closed loop systems because the fluid continues to circulate through the system's pipes. Another type of GXS are open loop systems, in which water is pumped from a water body directly through the heat pump. The heat pump extracts the heat and returns the water to its source. GXS's are constructed as either horizontal loop systems or vertical loop systems which require holes to be drilled into the earth.

3.2 Background Research and Site Visit:

In the last decade, ground-coupled heat pump systems have become more popular and recently, the B.C. town of Gibsons, located in the southern region of the Sunshine Coast, has developed a district geothermal utility in order to supplement their recent population growth. The geothermal systems will provide heating for residential and commercial developments within a 110-acre parcel of land. Horizontal GHX system were chosen due to the high costs incurred by vertical GHX systems as well as the potential environmental impacts to Gibsons' groundwater source of water caused by the drilling of vertical boreholes. Geothermal energy capacity was determined by excavating test pits in order to determine the soil conditions and thermal conductivity (Lohrenz, 2011).

During our visit to the Gibsons community geothermal facility we learned that the whole region is underlain by glacial till a few metres into the ground. Due to how difficult it is to dig through glacial till, it limits the types of geothermal systems that can be installed to only horizontal loops. Horizontal loops require shallow trenches for the heat exchange pipes, which take up large amounts of space.

Additionally, multiple horizontal ground heat exchange projects on the Sunshine Coast have been developed. These projects differ in scale and most notably include the Gibsons District Energy Utility and the Chapman Creek Hatchery. The Chapman Creek Hatchery in Sechelt boasts a unique system in which a 5kW micro hydropower system provides the energy required for the heat pumps in a 20kW geothermal heating system for the facility's heating needs. This project highlights the fact that small-scale solar projects could be paired with geothermal ground heating systems in order to provide the electricity required to run the heat pumps. However, the only way of determining whether or not any site will be able to sustain a geothermal heat exchange is to do test excavations that test the soil's thermal conductivity properties.

3.3 Conclusions:

Each of the three sites will experience significant difficulties should they try to incorporate a horizontal GHX systems due to a lack of open space. Vertical GHX systems are also non-viable because the Sunshine Coast community is situated on top of glacial till, which creates an unstable foundation.

- The Summerhill Fine Homes warehouse is located in the middle of an urban area, and surrounded by concrete, complicating the process of installing the heat exchanger. This area is also surrounded by other developments, which further restricts geothermal energy development in that case.
- The Sechelt Operations Centre does not have enough space to host a horizontal ground heat exchanger on the building lot. However, there appears to be a large vacant lot directly across Dusty Road that would be sufficiently sized to host a horizontal ground heat exchanger for the Operations Centre. To pursue geothermal development at this site, significant changes would have to be made to the development plans as the open lot across Dusty Road would have to be acquired.
- The lot on which the Rockwood Ocean Stories development will be built on does not appear to have enough space to fit a horizontal ground heat exchange field of sufficient size to provide heat for the whole facility. Making space for one would require significant alterations to the building plans.

3.4 Recommendations:

For the three building sites addressed in this project, geothermal energy development is either not a viable option as a source of heat energy or large changes in the development plans would have to be made in order to install horizontal ground heat exchange system. In the case of Summerhill Fine Homes it would be impossible to incorporate a geothermal system due to the location having no open ground to dig the required trenches. We therefore suggest that the SCCSA compare their model to these geothermal solutions, which emphasizes the practicality of solar.

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Elias (Eli) Braunstein: An environmental sciences student from San Francisco finishing his 5th year of undergraduate study at UBC. Passionate about the utilization of renewable energy systems as well as our efforts to respond and adapt to the challenges posed by climate change. Eli primarily assisted with the solar modeling in SAM, financial calculations and geothermal research.

Pierre: 4th year environmental sciences student from Jakarta, Indonesia. His interests lie primarily in the practical applications of science, which is what drew him to this project. Pierre worked on the SAM models, some financial models, report writing, and poster design for this project.

Frank Fan: I'm an environmental science major and statistics minor student from Richmond, BC. I am in my third year at UBC after spending a year in Co-op work-terms. I'm passionate about energy conservation in buildings and data analysis to predict environmental trends. I hope to attend graduate school in statistics and then work in Environment Canada. My beneficial skills in working on this project are Excel, Python, and R for data analysis. I bring in data analytics, complex report formatting, and poster construction and design into the project.

Timothy (Tim) Roth: Environmental sciences major, in the "Land, Air and Water" subset of the program. From Calgary on a five year school term for this program. He enjoys working with GIS software, Excel programming in VBA, Server/Database technology software and hardware systems. He hope to integrate environmental sciences with those interests and work with a resources company (either mining or oil sands related) in an monitoring, policy, or mitigation programs to help companies develop and adapt to more sustainable practices in an increasingly environmentally conscious world. Designed and built the poster in illustrator with Pierre, made the early on precedence diagrams, various solar panel figures, field measurements and helping the team edit the various report versions.

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