Identification and Preliminary Analysis of Potential Solar Photovoltaic (PV) Sites in the Corporate Portfolio

Capital Regional District (CRD)

Prepared for

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McLoughlin Point Wastewater Treatment Plant, Victoria, BC

Disclaimer

This report was produced as part of the UBC Sustainability Scholars Program, a partnership between the University of British Columbia and various local governments and organizations in support of providing graduate students with opportunities to do applied research on projects that advance sustainability and climate action across the region.

This project was conducted under the mentorship of the CRD staff. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of the CRD or the University of British Columbia.

Cover photo sourced from –
https://acecbcawards.com/2022-awards/2022-municipal-civil-infrastructure/mcloughlin-point-wastewater-treatment-plant/

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Glossary of Terms

kWh	kilowatt-hour – is a unit of electrical energy measurement that represents the amount of energy consumed or produced by a power of one kilowatt over the duration of one hour.
kWp	kilowatt-peak – is a unit of measurement that represents the maximum electrical power output of a solar photovoltaic (PV) system under standard test conditions.
Specific Yield	Solar PV specific yield is a measure of the efficiency and performance of a solar PV system. It represents the amount of electrical energy (in kilowatt-hours, kWh) that is expected to be generated per unit of installed solar PV capacity (in kilowatt-peak, kWp) over a year. This calculation includes factors such as geographical location, solar irradiance, PV technology, system orientation and tilt, shading, overall system efficiency, and maintenance – considered in accordance with industry benchmarks and best practices. Unit of measurement – kWh/kWp/year.
Area required (footprint) per kWp – rooftop solar PV	Area required per kWp of installed PV capacity is calculated using PV modules with current commercially available power class (550-600Wp rated each) and includes inter-row spacing as well as necessary offsets from edges and shading objects.
Electrical Energy Import	Electrical energy import refers to the consumption of energy from the utility grid (BC Hydro).
Electrical Energy Export	Electrical energy export refers to supplying excess energy generated by the solar PV system back to the grid.
Near-field & Far-field shadow	Near-field shadowing refers to the shadowing effects caused by objects that are close to the solar array, such as services equipment, trees, adjacent buildings etc. Far-field shadowing occurs due to objects that are at a greater distance from the solar array, such as distant buildings, mountains, or large structures on the horizon. The effect of far-field shadows is generally broader and more dispersed, covering a larger area compared to the more concentrated and localized impact of near-field shadows.

Inter-row shadow	Inter-row shadow in solar PV refers to the shading that happens when one row of solar modules casts a shadow on the row behind it. This typically occurs when the rows are spaced too closely or positioned at an angle where the front row blocks sunlight from reaching the modules in the rear row. This effect is most pronounced during early morning or late afternoon when the sun is lower on the horizon.
Global Horizontal Irradiance (GHI)	GHI is the total amount of solar radiation received by a horizontal surface on the Earth's surface. It includes both direct sunlight (direct normal irradiance) and diffuse sunlight (scattered from the atmosphere) that strikes the surface from all angles. GHI is a key parameter in solar energy assessments, as it helps determine the potential solar energy available at a specific location for photovoltaic (PV) systems and other solar technologies.
Plane Of Array Irradiance (POA)	POA refers to the amount of solar radiation incident on the surface of a solar module or array that is oriented at a specific angle. Unlike GHI, which measures radiation on a flat, horizontal surface, POA considers the tilt and orientation of the solar module or array. This measurement is crucial for accurately assessing the energy production potential of a solar PV system, as it directly affects the amount of sunlight the modules receive.

Executive Summary

This report presents the comprehensive feasibility analysis conducted on over 400 corporate sites within the Capital Regional District (CRD) portfolio and various sites in nearby improvement districts to identify potential sites for solar photovoltaic (PV) installations. Using various industry-leading tools and benchmarks (refer to section – Methodology), the study shortlisted 32 sites based on annual electrical energy consumption and solar PV energy generation potential, and subsequently, a final 10 sites were selected for detailed analysis. The analysis included hourly energy generation versus consumption comparison, geo-tagged 3D solar PV design, installed capacity estimation and shadow analysis.

The final selection of 10 sites represents the highest energy consumers and top candidates for solar PV installation. This forms the primary recommendation for prioritizing future financial analysis and investments in distributed solar PV integration at these sites – refer to Table 1.

Table 1: Top 10 sites for solar PV integration[2]

Site Name	Address	Annual Energy Consumption (kWh)	Estimated PV Capacity (kWp)	Estimated Area Required (m^2)	Annual PV Energy Generation (kWh)	Annual PV Generation/ Consumption (%)
McLoughlin Point Wastewater Treatment Plant	337 Victoria View Rd	10,663,018	171	1,154	190,442	2%
Panorama Recreation Centre	1885 Forest Park Dr	3,062,753	1,186	7,709	1,266,223	41%
Macaulay Point Pump Station	330 View Point Rd	2,348,842	40	280	45,817	2%
Saanich Peninsula Wastewater Treatment Plant	9055 Mainwaring Rd	2,002,971	133	931	148,820	7%
Rainbow Road Aquatic Centre	262 Rainbow Rd	1,086,420	147	956	144,877	13%
CRD Headquarters (Fisgard)	625 Fisgard St	1,012,386	89	623	97,274	10%
SEAPARC Recreation Centre	2168 Phillips Rd	840,997	98	662	93,557	11%
Greenglade Community Centre	2151 Lannon Way	624,516	233	1,515	250,397	40%
Integrated Water Services Headquarters	479 Island Hwy	343,717	271	1,762	292,329	85%
Mayne Island Fire Hall	513 Felix Jack Rd	6,274[1]	123	800	131,127	-

Cumulatively, the top 10 sites have the potential of installing approximately 2.5 MWp of rooftop solar PV capacity that would generate 2,661 MWh annually. This presents the CRD with an opportunity to offset operational utility expenses and enhance energy resiliency with minimal impact on the BC Hydro grid.

[1] Annual energy consumption data for Galiano Fire Hall was used due to unavailability of data for Mayne Island.
[2] Arranged in descending order based on annual energy consumption (considering 2023 data).

Key Takeaways & Next Steps

The key takeaways from the technical analysis and data summarized in Table 1, are as follows –

- The wastewater treatment plants (WWTP), and recreation/community centres have relatively higher energy consumption.
- McLoughlin Point WWTP has the highest energy consumption and would require more than just rooftop solar PV (limited due to on-roof services and available shade-free space). Other installation types such as ground-mounted (solar car park canopy) or floating solar PV could be considered to meet energy consumption.
- Recreation/community centres have relatively higher potential to integrate cost-effective rooftop solar PV installations atop existing metal-sheet roof structures[3], capable of meeting up to 40% of annual energy consumption.
- Panorama Recreation Center and IWS headquarters boast the highest potential to integrate solar PV, meeting up to 41% and 85% of annual energy consumption[4] respectively.
- Pumping stations, pressure control stations and fire halls have relatively lower potential to consider rooftop PV installations due to limited shade-free space available.
- All sites apart from Macaulay Pumping Station can accommodate approximately 90 kWp solar PV installations.

The future work would involve conducting an in-depth study to fully understand the available electrical service capacity (spare feeders) at the identified sites. This is required to determine the feasibility of installing solar PV systems without necessitating significant electrical upgrades and/or downsizing PV capacity based on available electrical capacity. Additionally, a financial feasibility analysis will be necessary to evaluate the capital expenditures (CAPEX) and operational expenditures (OPEX) associated with the solar PV systems and any required electrical infrastructure upgrades. This analysis will also need to factor in potential incentives from BC Hydro, ensuring that the proposed installations are not only technically feasible but also economically viable. This comprehensive approach will provide the business case to equip the CRD to make informed decisions on the integration of solar PV at the selected sites.

Background

In 2021, the CRD renewed its Climate Action Strategy, emphasizing its role as a leader in climate action over the next five years. As part of Goal 4 (Low-Carbon and Resilient Buildings and Infrastructure), the CRD committed to evaluating the business case for installing renewable power at corporate sites, including water and wastewater locations. This project is a critical step towards achieving the CRD's 2030 target of a 45% reduction in greenhouse gas (GHG) emissions and the 2050 target of net-zero emissions. By identifying and implementing solar PV opportunities, the CRD aims to offset operational utility expenses and increase building resiliency.

[3] Subject to the structural dead load design and withstand capability.
[4] Subject to the assessment of electrical upgrades required to integrate solar PV systems.

Objective

The primary objectives of this project were –

- To identify and prioritize CRD facilities for potential solar PV installations.
- To understand the feasibility and impact of renewable power installations based on physical location and electrical capacity.
- To provide detailed analysis and recommendations for the top 10 sites, ensuring that the CRD is well-positioned to pursue solar PV opportunities that support its climate action goals.

Scope

The scope of technical feasibility analysis delivered includes –

- Reviewing site data, mapping (location, shade-free usable area) and ranking sites based on annual electrical energy consumption.
- Estimation of solar PV irradiation, specific yield, area required and energy generation potential using design simulation for the shortlisted 32 sites.
- Hourly interval electrical energy consumption versus PV generation comparison, geo-tagged 3D solar PV designs, installed capacity estimation and shadow analysis for the top 10 sites.

Methodology

The methodology adopted for the technical feasibility analysis is summarized in Table 2.

Table 2: Methodology for technical feasibility analysis

Step & Scope	Deliverables	Software Tools utilized
Step 1 – Estimation of average solar PV specific yield and typical area required per kWp of installed PV capacity	Using industry-leading softwares and benchmarks, the average specific yield for the Capital region (BC) and typical area required per kWp of installed PV capacity (rooftop installations) were estimated. Average solar PV specific yield: 1,065 kWh/kWp/year Typical area required (footprint): ~6.5 m^2 per kWp installed	SolarGIS Prospect, City of Victoria Solar Rooftop, Helioscope
Step 2 – Reviewing, mapping and ranking sites (400+ sites)	The list of sites shared by the CRD based on data from BC Hydro and PUMA [5] software was reviewed. Key details included name, location, meter number, building type and annual electrical energy consumption (kWh) for the year 2023. The sites were mapped and viewed to estimate available shade-free area for solar PV installation. The sites were ranked based on historical data of annual energy consumption. The master sheet is attached in Appendices.	Microsoft Excel, CRD Regional Map, Google Earth

[5] Prism Utility Monitoring & Analysis is a web-based energy management and GHG accounting tool.

Step 3 – Preliminary design simulation and PV capacity estimation (shortlisted 32 sites)	Using simulation softwares, the preliminary design and PV capacity were estimated for a selection of 32 shortlisted sites with the highest potential for solar PV integration. A comparison of the results from the design softwares for one site in Victoria was conducted to validate the estimates.	City of Victoria Solar Rooftop, Helioscope
Step 4 – Detailed analysis of PV design and electrical data (top 10 sites)	A further detailed analysis including geo-tagged 3D PV design, final installed capacity, shadow analysis, hourly interval electrical energy consumption versus generation and energy import/export was conducted for a final selection of 10 sites (out of shortlisted 32). A site visit was conducted to some of the top 10 sites for dimensions measurement, design fine-tuning and electrical data verification.	Microsoft Excel, Helioscope
Step 5 – Final Report & Documentation	The entire process and results from the technical feasibility analysis are compiled into this report and a set of reference documents. A project presentation is scheduled for the CRD management.	Microsoft Word, Excel & PowerPoint

The suite of software tools utilized for the technical feasibility is depicted in Figure 1.

Figure 1: Suite of software tools used for the analysis

The sites under assessment within the CRD corporate portfolio are spread across the Capital Regional District in British Columbia – map depicted in Figure 2.

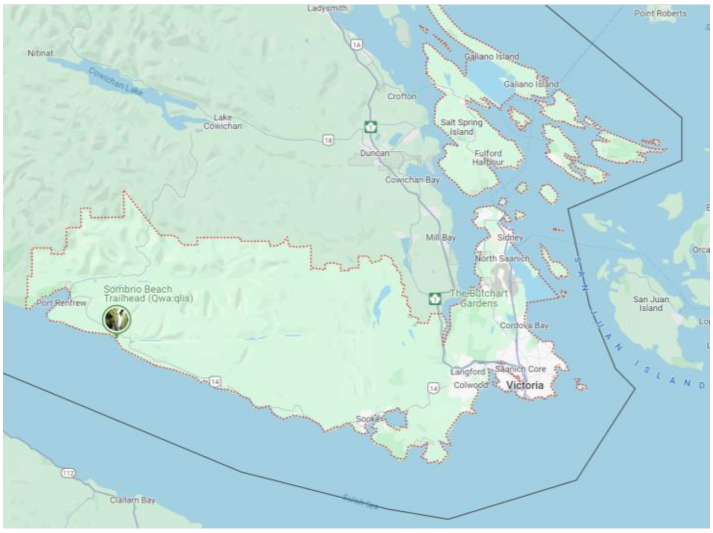


Figure 2: Map of the Capital Region District (CRD) in British Columbia

For the solar PV specific yield estimation, SolarGIS Prospect software is used to produce high-quality simulation-based solar PV output data map[6] for various locations in the Capital region, as depicted in Figure 3. Victoria boasts the highest potential with a specific yield of approx. 1,373 kWh/kWp/year, while the average for the region is estimated at 1,065 kWh/kWp/year.

Figure 3: Specific Yield estimates[7] for various locations in the Capital Regional District.

The CRD Regional Map tool and Google Earth were utilized to view satellite imagery and estimate the available shade-free space for solar PV installation. The sites were tagged on Google Earth as depicted in Figure 4.

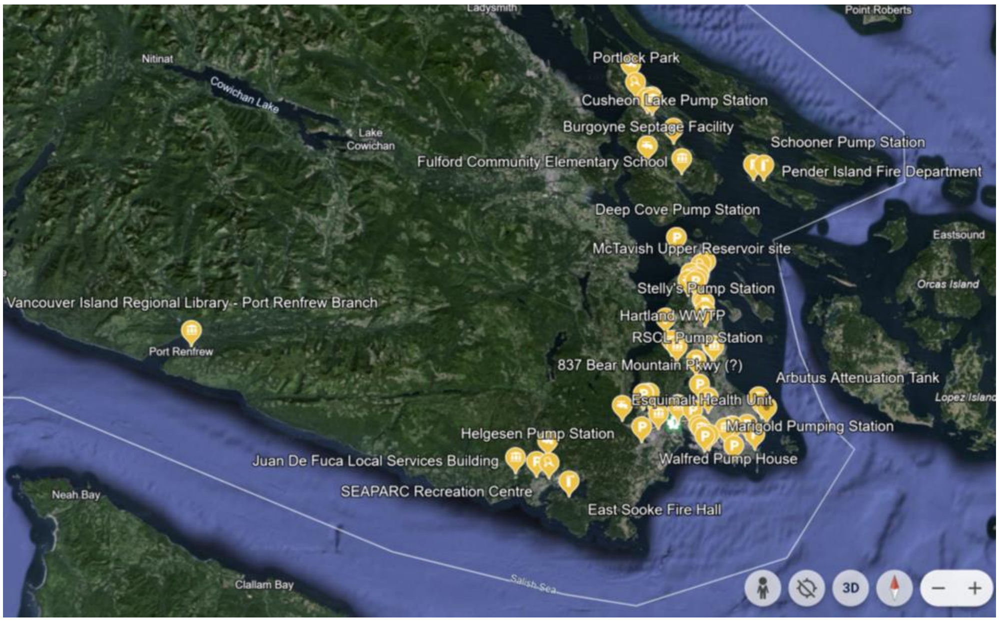


Figure 4: Snippet of the CRD sites viewed, mapped and tagged on Google Earth

[6] SolarGIS Prospect software's technical specifications and calculation methods

[7] Solar PV potential map and specific yield estimates generated in SolarGIS Prospect software.

For verification purposes, the specific yield and area required per kWp of rooftop solar PV installation were also generated using City of Victoria Solar Rooftop Calculator (refer to Figure 5) and compared with the estimates from SolarGIS and Helioscope. The estimates were found comparable and the comparison for the CRD HQ (Fisgard) is presented in Table 3.

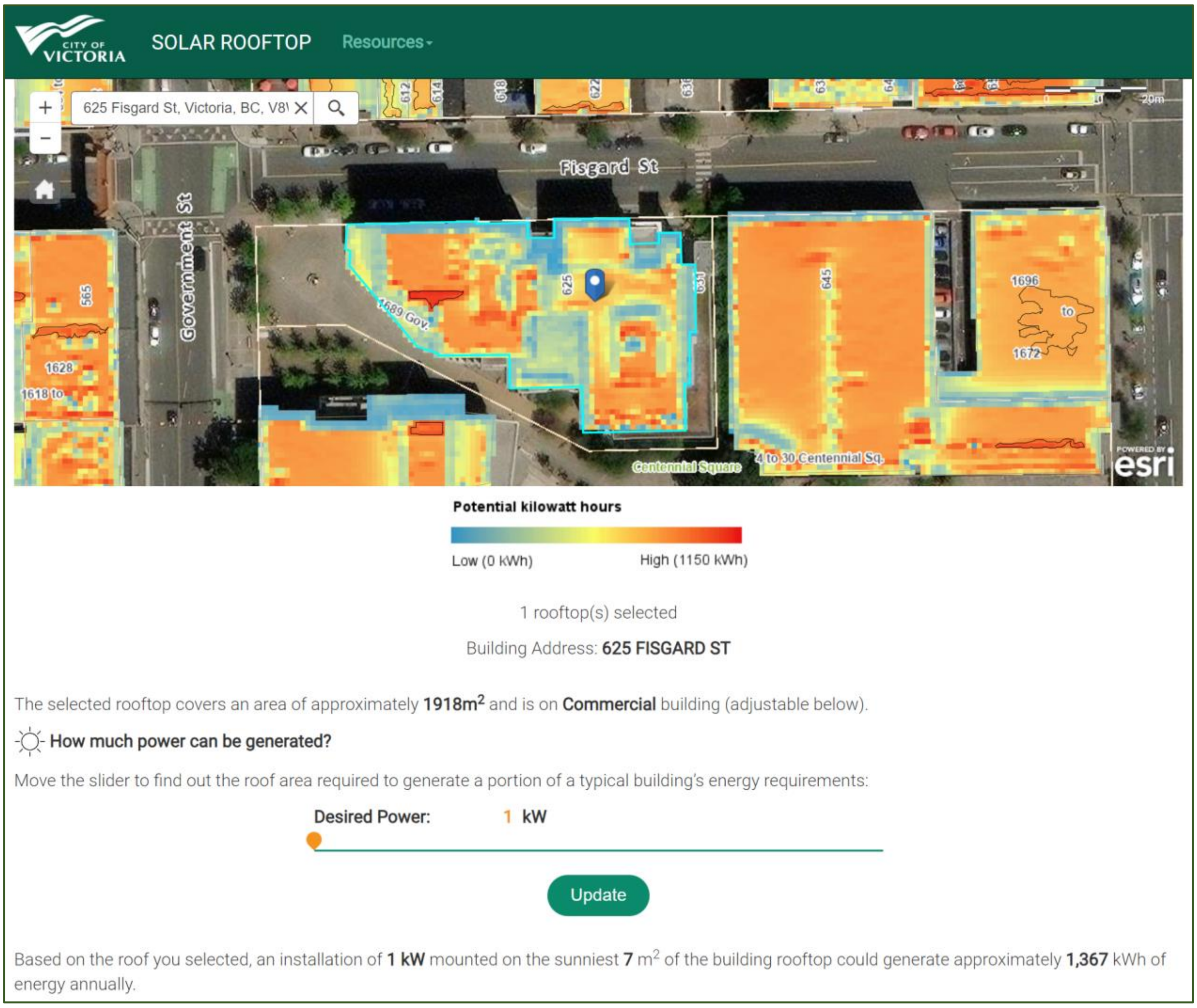


Figure 5: Solar PV specific yield and area required per kWp[8] installed atop CRD HQ

Table 3: Comparison of Specific Yield & Area required per kWp estimates

Parameter	Value	Source/Software Tool	Site
Solar PV Specific Yield	1,373 kWh/kWp/year	SolarGIS Prospect	CRD HQ (Fisgard)
Solar PV Specific Yield	1,367 kWh/kWp/year	City of Victoria Solar Rooftop	
Area required per kWp	6.5 m^2	Helioscope	
Area required per kWp	7 m^2	City of Victoria Solar Rooftop	

[8] Estimates generated using the City of Victoria Solar Rooftop calculator tool.

The various solar PV installation types[9] considered to design solar PV systems atop the selected sites are flush-mounted, elevated, and ballast-mounted; as illustrated in Figure 6, Figure 7 and Figure 8 respectively.

Figure 6: Depiction of flush-mounted installation on tilted metal-sheet roof

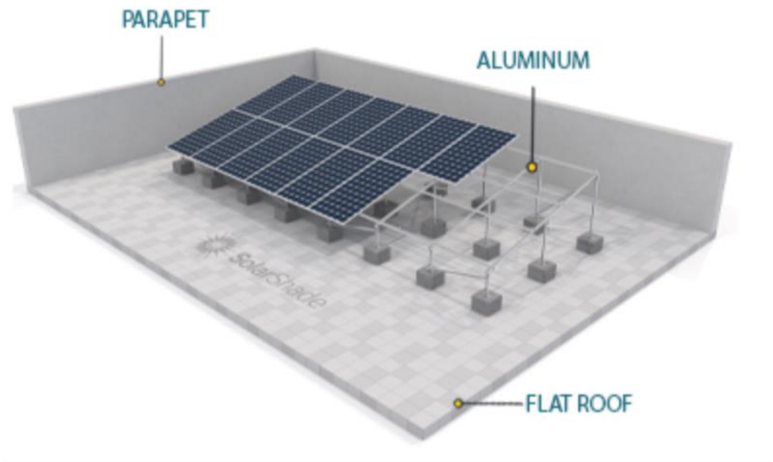


Figure 7: Depiction of elevated installation on flat roof

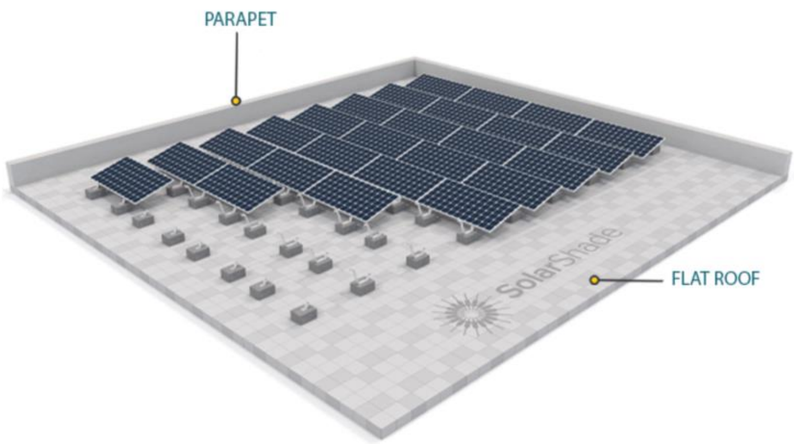


Figure 8: Depiction of flush-mounted (ballasted) installation on flat roof

[9] Reference images for solar PV installation types taken from https://solarshade.ae/

Top 10 Sites – PV Design & Electrical Data Analysis

This section details the solar PV design and electrical data analysis for the final selection of top 10 sites.

McLoughlin Point WWTP

The award-winning McLoughlin Point WWTP has the highest energy consumption within the CRD corporate portfolio. Despite the deployment of leading sustainability measures through the selection of efficient equipment and processes, such as effluent heat recovery, green roofing, EV charging stations, LED and solar-tube lighting, effluent water reuse, and power monitoring, the facility still requires significant energy. Implementing on-site solar PV installations can further reduce energy consumption and costs, enhance sustainability, and improve the overall energy efficiency of the plant. The rooftop solar PV system is designed optimally on the obstruction- and shade-free spaces atop the rooftop as depicted in Figure 9.

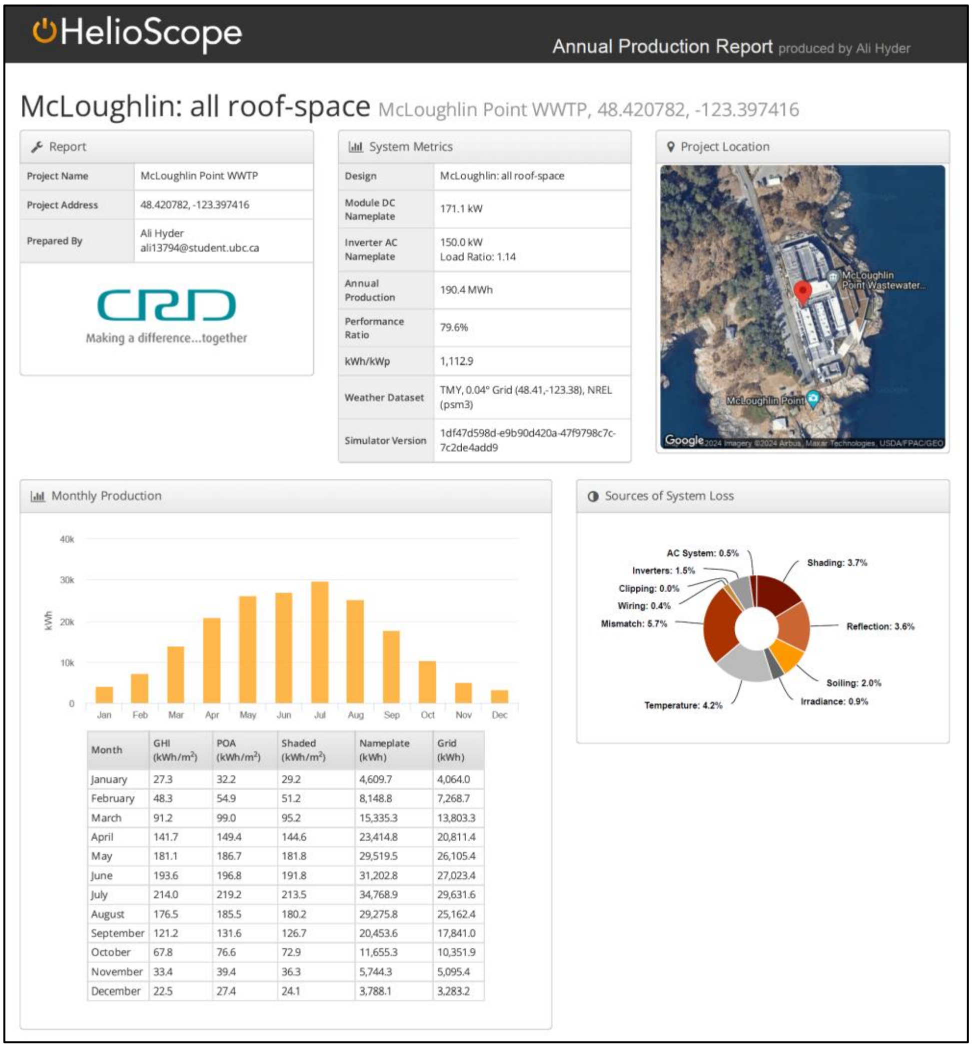
An alternative, smaller design installed only on the existing rooftop cable-ladders has also been designed to be assessed later as a cost-effective pilot project using existing mounting structures. The details of both PV designs are listed in Table 4.

Figure 9: Rooftop solar PV system designed atop McLoughlin Point WWTP

Table 4: Rooftop solar PV system details (McLoughlin WWTP)

Design	Installation Type	Solar PV DC Capacity (kWp)	Solar PV AC Capacity (kW)	Annual Energy Generation (kWh)	PV Specific Yield (kWh/kWp/year)
Design 1 – All roof-space	Elevated and ballasted (flat roof)	171.1	150	190,442	1,113
Design 2 – Rooftop cable-ladders only	Flush-mounted on cable-ladder structure	22.9	20	24,709	1,079

A snippet of the design simulation report generated in Helioscope is shown in Figure 10 and the complete reports are attached in Appendices. Further, shadow analysis was also simulated to ensure an optimally shade-free (inter-row, near- and far-field) design during the solar hours as illustrated in Figure 11.


HelioScope Annual Production Report produced by Ali Hyder

McLoughlin: all roof-space McLoughlin Point WWTP, 48.420782, -123.397416

Report

Project Name	McLoughlin Point WWTP
Project Address	48.420782, -123.397416
Prepared By	Ali Hyder ali13794@student.ubc.ca

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System Metrics

Design	McLoughlin: all roof-space
Module DC Nameplate	171.1 kW
Inverter AC Nameplate	150.0 kW Load Ratio: 1.14
Annual Production	190.4 MWh
Performance Ratio	79.6%
kWh/kWp	1,112.9
Weather Dataset	TMY, 0.04° Grid (48.41,-123.38), NREL (psm3)
Simulator Version	1df47d598d-e9b90d420a-47f9798c7c-7c2de4add9

Project Location

Monthly Production

Month	GHI (kWh/m^2)	POA (kWh/m^2)	Shaded (kWh/m^2)	Nameplate (kWh)	Grid (kWh)
January	27.3	32.2	29.2	4,609.7	4,064.0
February	48.3	54.9	51.2	8,148.8	7,268.7
March	91.2	99.0	95.2	15,335.3	13,803.3
April	141.7	149.4	144.6	23,414.8	20,811.4
May	181.1	186.7	181.8	29,519.5	26,105.4
June	193.6	196.8	191.8	31,202.8	27,023.4
July	214.0	219.2	213.5	34,768.9	29,631.6
August	176.5	185.5	180.2	29,275.8	25,162.4
September	121.2	131.6	126.7	20,453.6	17,841.0
October	67.8	76.6	72.9	11,655.3	10,351.9
November	33.4	39.4	36.3	5,744.3	5,095.4
December	22.5	27.4	24.1	3,788.1	3,283.2

Sources of System Loss

Figure 10: Snippet of rooftop solar PV design simulation report (McLoughlin WWTP)

Figure 11: Solar PV system shading heatmap (McLoughlin WWTP)

Furthermore, the hourly interval electrical energy consumption versus generation and energy import/export analysis was conducted (attached in Appendices). The monthly summary is listed in Table 5.

Table 5: Monthly summary of energy consumption and PV generation (McLoughlin WWTP)

Month	2023 Consumption (kWh)	Estimated Solar Generation (kWh)	Solar Generation/Consumption (%)
January	957,121	4,064	0.42%
February	890,735	7,269	0.82%
March	973,433	13,803	1.42%
April	927,433	20,811	2.24%
May	900,642	26,105	2.90%
June	835,672	27,023	3.23%
July	836,707	29,632	3.54%
August	856,355	25,162	2.94%
September	784,596	17,841	2.27%
October	874,538	10,352	1.18%
November	860,072	5,095	0.59%
December	965,715	3,283	0.34%
Annual	10,663,018	190,442	1.8%

Table 5 shows that the designed rooftop solar PV system is capable of meeting only up to 2% of annual energy consumption.

Thus, the McLoughlin Point WWTP having the highest energy consumption would require more than just rooftop solar PV which is constrained due to on-roof services and limited shade-free space. Other installation types such as ground-mounted solar car park structures or floating solar PV systems (suitable for sites at shoreline) could be considered to meet energy consumption.

Panorama Recreation Centre

The Panorama Recreation Centre is a strategic site with the highest potential to install a rooftop solar PV system due to its large metal-sheet roofs[10], capable of considerably meeting the increasing energy consumption envisaged with future expansion plans.

The rooftop solar PV system is designed optimally on the obstruction- and shade-free spaces atop the metal-sheet roofs as depicted in Figure 12.

An alternative, smaller design installed only on the south-west roofs has also been designed considering the existing electrical capacity available[11] (340kW) at the facility and without requiring any electrical upgrades. The details of both PV designs are listed in Table 7.

[10] Subject to the structural dead load design and withstand capability as well as the assessment of electrical upgrades required to integrate solar PV systems.
[11] Previous electrical study conducted by AES Engineering Ltd. (File Reference – 0123.0442).

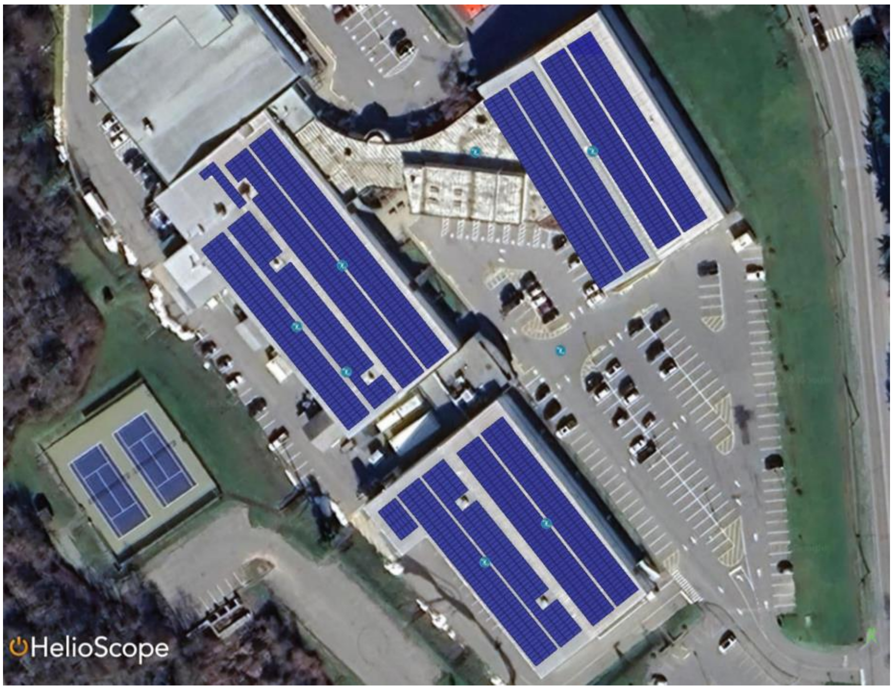
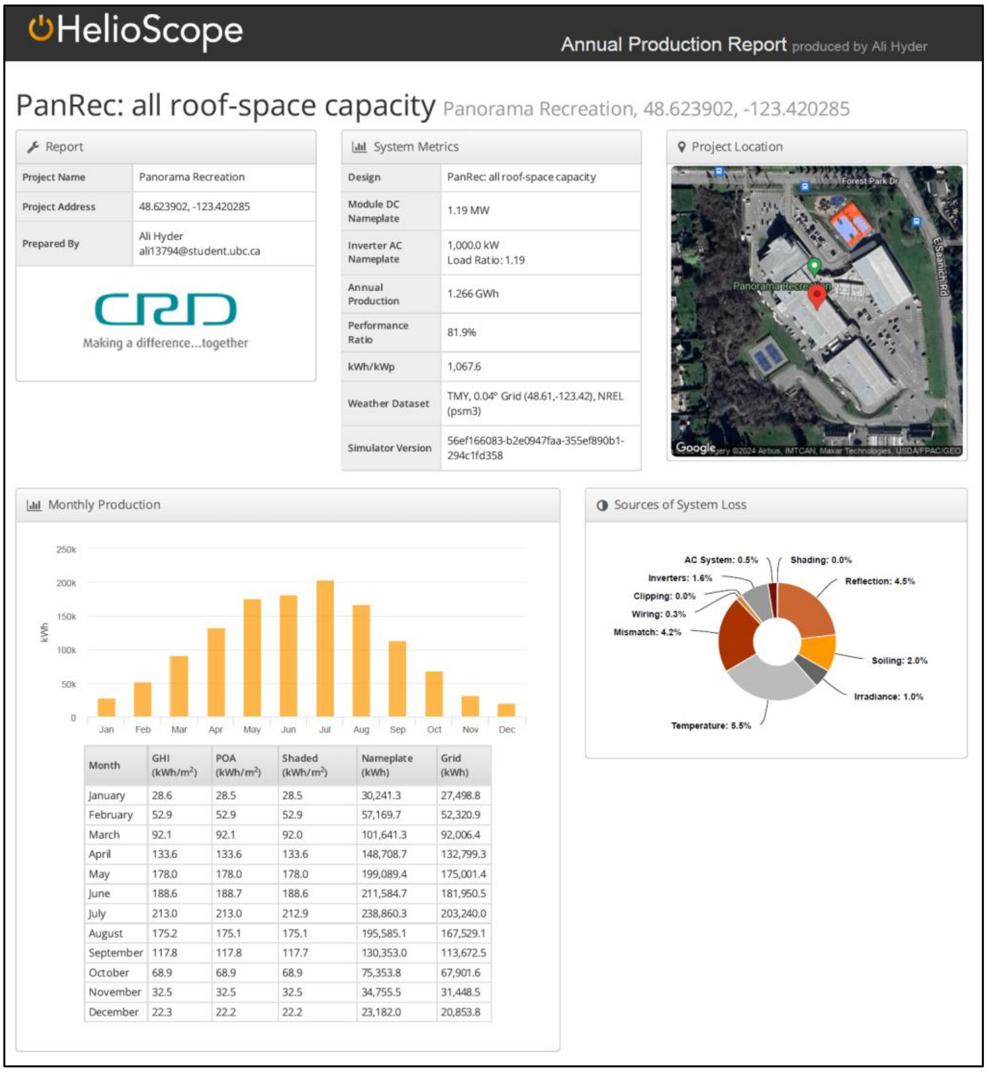


Figure 12: Rooftop solar PV system designed atop Panorama Recreation Centre

Table 6: Rooftop solar PV system details (Panorama Recreation)

Design	Installation Type	Solar PV DC Capacity (kWp)	Solar PV AC Capacity (kW)	Annual Energy Generation (kWh)	PV Specific Yield (kWh/kWp/year)
Design 1 – All roof-space	Flush-mounted (metal-sheet roof)	1,186.1	1,000	1,266,223	1,068
Design 2 – Electrical limit	Flush-mounted (metal-sheet roof)	389.4	375	423,340	1,087

A snippet of the design simulation report generated in Helioscope is shown in Figure 13 and the complete reports are attached in Appendices. Further, shadow analysis was also simulated to ensure an optimally shade-free (inter-row, near- and far-field) design during the solar hours as illustrated in Figure 14.



HelioScope Annual Production Report produced by Ali Hyder

PanRec: all roof-space capacity Panorama Recreation, 48.623902, -123.420285

Report

Project Name	Panorama Recreation
Project Address	48.623902, -123.420285
Prepared By	Ali Hyder ali13794@student.ubc.ca

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System Metrics

Design	PanRec: all roof-space capacity
Module DC Nameplate	1.19 MW
Inverter AC Nameplate	1,000.0 kW Load Ratio: 1.19
Annual Production	1.266 GWh
Performance Ratio	81.9%
kWh/kWp	1,067.6
Weather Dataset	TMY, 0.04° Grid (48.61,-123.42), NREL (psm3)
Simulator Version	56ef166083-b2e0947faa-355ef890b1-294c1fd358

Project Location

Monthly Production

Sources of System Loss

Month	GHI (kWh/m²)	POA (kWh/m²)	Shaded (kWh/m²)	Nameplate (kWh)	Grid (kWh)
January	28.6	28.5	28.5	30,241.3	27,498.8
February	52.9	52.9	52.9	57,169.7	52,320.9
March	92.1	92.1	92.0	101,641.3	92,006.4
April	133.6	133.6	133.6	148,708.7	132,799.3
May	178.0	178.0	178.0	199,089.4	175,001.4
June	188.6	188.7	188.6	211,584.7	181,950.5
July	213.0	213.0	212.9	238,860.3	203,240.0
August	175.2	175.1	175.1	195,585.1	167,529.1
September	117.8	117.8	117.7	130,353.0	113,672.5
October	68.9	68.9	68.9	75,353.8	67,901.6
November	32.5	32.5	32.5	34,755.5	31,448.5
December	22.3	22.2	22.2	23,182.0	20,853.8

Figure 13: Snippet of rooftop solar PV design simulation report (Panorama Recreation)

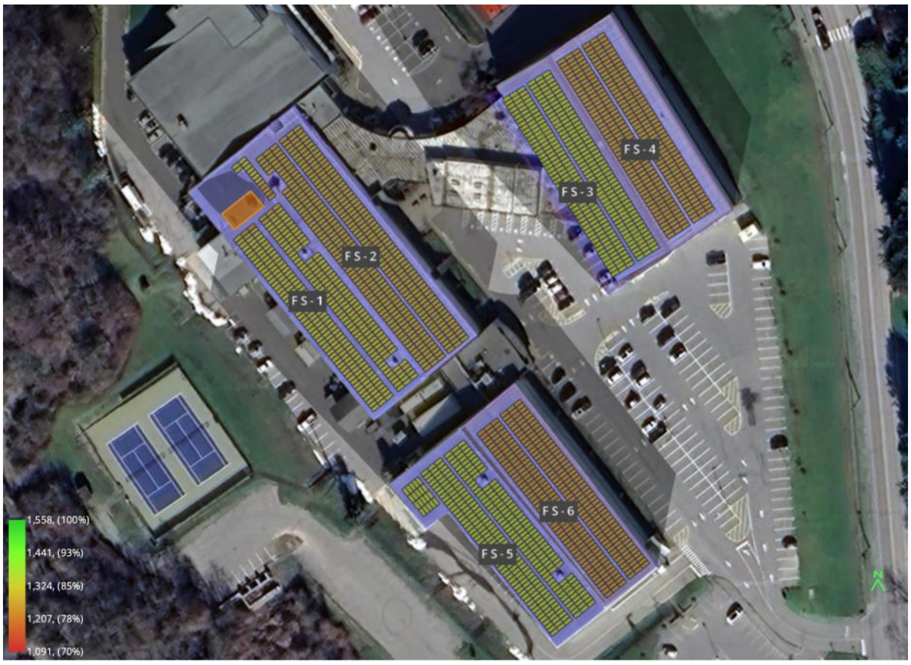


Figure 14: Solar PV system shading heatmap (Panorama Recreation)

Furthermore, the hourly interval electrical energy consumption versus generation and energy import/export analysis was conducted (attached in Appendices). The monthly summary is listed in Table 7.

Table 7: Monthly summary of energy consumption and PV generation (Panorama Recreation)

Month	2023 Consumption (kWh)	Estimated Solar Generation (kWh)	Solar Generation/Consumption (%)
January	288,006	27,499	10%
February	259,449	52,321	20%
March	279,738	92,006	33%
April	210,260	132,799	63%
May	183,260	175,001	95%
June	161,795	181,951	112%
July	213,027	203,240	95%
August	311,538	167,529	54%
September	275,624	113,673	41%
October	297,271	67,902	23%
November	288,805	31,449	11%
December	293,979	20,854	7%
Annual	3,062,753	1,266,223	41%

Table 7 shows that the designed rooftop solar PV system is capable of significantly meeting the overall annual energy consumption (up to 41%) and approximately 100% during summer months, considering the whole roof-space capacity design option.

Thus, the Panorama Recreation Centre has the highest potential for rooftop solar PV installations atop its metal-sheet roofs. However, integrating the full roof-space capacity would require significant electrical infrastructure upgrades. Therefore, the design option based on available electrical capacity can be considered as a viable alternative to integrate solar PV without necessitating extensive electrical system upgrades.

Macaulay Point Pump Station

The rooftop solar PV system is designed optimally on the obstruction- and shade-free space atop the tilted concrete roof of Macaulay Point Pump Station as depicted in Figure 15.

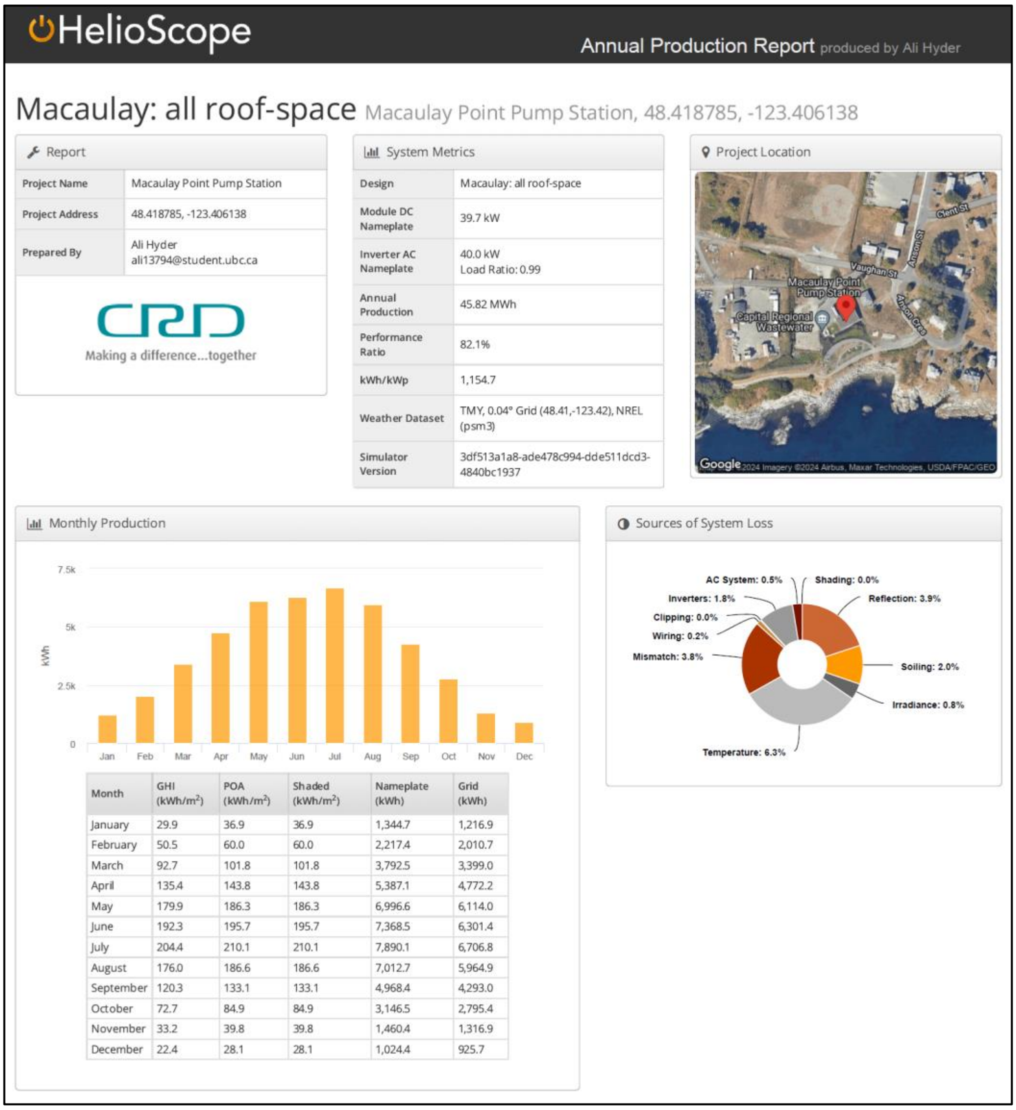
Figure 15: Rooftop solar PV system designed atop Macaulay Point Pump Station

The details of the rooftop solar PV design are listed in Table 8.

Table 8: Rooftop solar PV system details (Macaulay Pump Station)

Design	Installation Type	Solar PV DC Capacity (kWp)	Solar PV AC Capacity (kW)	Annual Energy Generation (kWh)	PV Specific Yield (kWh/kWp/year)
All roof-space	Flush-mounted (tilted concrete roof)	39.7	40	45,817	1,155

A snippet of the design simulation report generated in Helioscope is shown in Figure 16 and the complete reports are attached in Appendices. Further, shadow analysis was also simulated to ensure an optimally shade-free (inter-row, near- and far-field) design during the solar hours as illustrated in Figure 17.



Month	GHI (kWh/m²)	POA (kWh/m²)	Shaded (kWh/m²)	Nameplate (kWh)	Grid (kWh)
January	29.9	36.9	36.9	1,344.7	1,216.9
February	50.5	60.0	60.0	2,217.4	2,010.7
March	92.7	101.8	101.8	3,792.5	3,399.0
April	135.4	143.8	143.8	5,387.1	4,772.2
May	179.9	186.3	186.3	6,996.6	6,114.0
June	192.3	195.7	195.7	7,368.5	6,301.4
July	204.4	210.1	210.1	7,890.1	6,706.8
August	176.0	186.6	186.6	7,012.7	5,964.9
September	120.3	133.1	133.1	4,968.4	4,293.0
October	72.7	84.9	84.9	3,146.5	2,795.4
November	33.2	39.8	39.8	1,460.4	1,316.9
December	22.4	28.1	28.1	1,024.4	925.7

Figure 16: Snippet of rooftop solar PV design simulation report (Macaulay Pump Station)

Figure 17: Solar PV system shading heatmap (Macaulay Pump Station)

Furthermore, the hourly interval electrical energy consumption versus generation and energy import/export analysis was conducted (attached in Appendices). The monthly summary is listed in Table 9.

Table 9: Monthly summary of energy consumption and PV generation (Macaulay Pump Station)

Month	2023 Consumption (kWh)	Estimated Solar Generation (kWh)	Solar Generation/Consumption (%)
January	270,845	1,217	0.45%
February	245,973	2,011	0.82%
March	257,956	3,399	1.32%
April	224,198	4,772	2.13%
May	155,697	6,114	3.93%
June	143,075	6,301	4.40%
July	135,577	6,707	4.95%
August	129,490	5,965	4.61%
September	131,368	4,293	3.27%
October	162,242	2,795	1.72%
November	218,174	1,317	0.60%
December	274,248	926	0.34%
Annual	2,348,842	45,817	1.95%

Table 9 shows that the designed rooftop solar PV system is capable of meeting only up to 2% of annual energy consumption.

Thus, the Macaulay Point Pump Station, despite its high energy consumption has limited potential for rooftop solar PV due to its small roof footprint, which is typical of pumping and pressure control stations. To meet its energy needs, alternative installation types such as ground-mounted solar car park structures or floating solar PV systems (suitable for sites at shoreline) could be considered.

Saanich Peninsula WWTP

The rooftop solar PV system is designed optimally on the obstruction- and shade-free spaces atop the flat roofs of Saanich Peninsula WWTP as depicted in Figure 18.

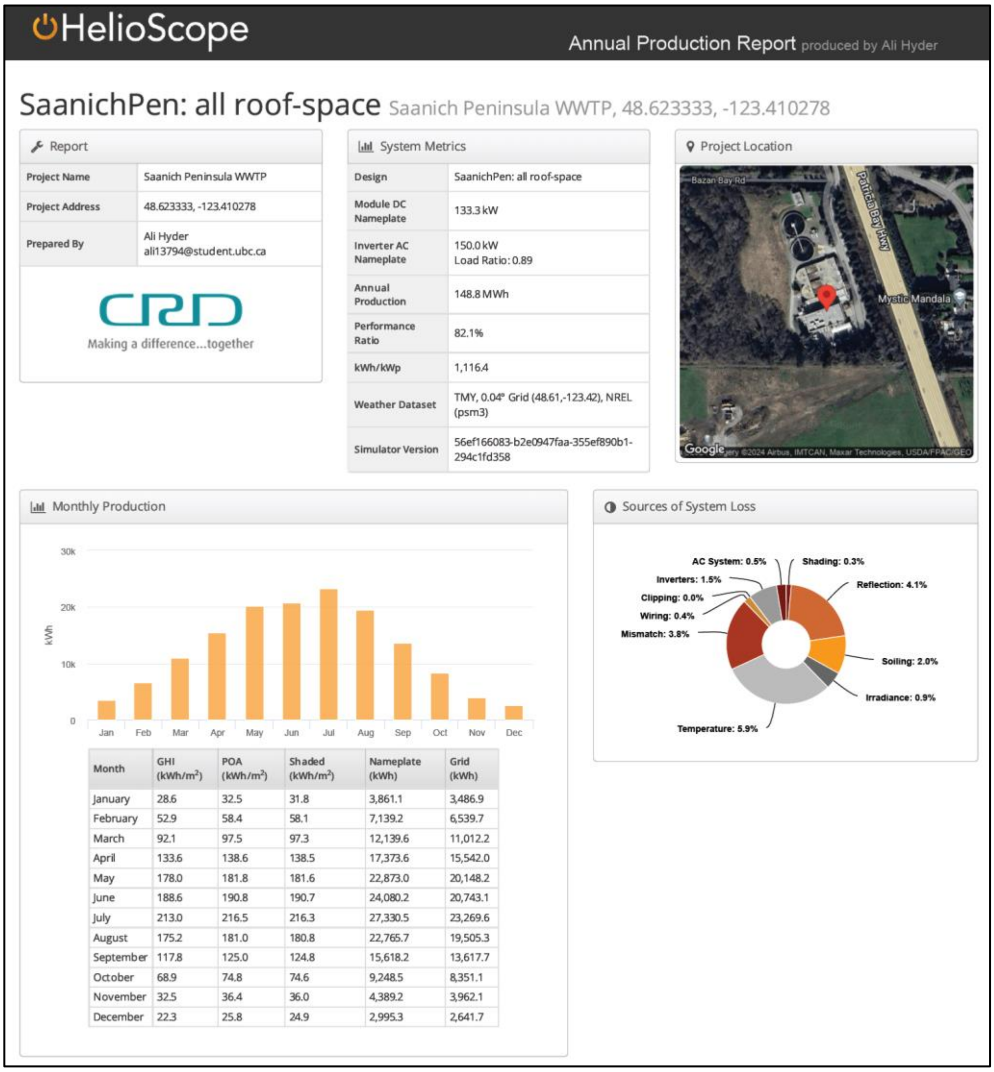
Figure 18: Rooftop solar PV system designed atop Saanich Peninsula WWTP

The details of the rooftop solar PV design are listed in Table 10.

Table 10: Rooftop solar PV system details (Saanich Peninsula WWTP)

Design	Installation Type	Solar PV DC Capacity (kWp)	Solar PV AC Capacity (kW)	Annual Energy Generation (kWh)	PV Specific Yield (kWh/kWp/year)
All roof-space	Elevated (flat roof)	133.3	120	148,820	1,116

A snippet of the design simulation report generated in Helioscope is shown in Figure 19 and the complete reports are attached in Appendices. Further, shadow analysis was also simulated to ensure an optimally shade-free (inter-row, near- and far-field) design during the solar hours as illustrated in Figure 20.



HelioScope Annual Production Report produced by Ali Hyder

SaanichPen: all roof-space Saanich Peninsula WWTP, 48.623333, -123.410278

Report

Project Name	Saanich Peninsula WWTP
Project Address	48.623333, -123.410278
Prepared By	Ali Hyder ali13794@student.ubc.ca

Making a difference...together

System Metrics

Design	SaanichPen: all roof-space
Module DC Nameplate	133.3 kW
Inverter AC Nameplate	150.0 kW Load Ratio: 0.89
Annual Production	148.8 MWh
Performance Ratio	82.1%
kWh/kWp	1,116.4
Weather Dataset	TMY, 0.04° Grid (48.61,-123.42), NREL (psm3)
Simulator Version	56ef166083-b2e0947faa-355ef890b1-294c1fd358

Project Location

Monthly Production

Month	GHI (kWh/m^2)	POA (kWh/m^2)	Shaded (kWh/m^2)	Nameplate (kWh)	Grid (kWh)
January	28.6	32.5	31.8	3,861.1	3,486.9
February	52.9	58.4	58.1	7,139.2	6,539.7
March	92.1	97.5	97.3	12,139.6	11,012.2
April	133.6	138.6	138.5	17,373.6	15,542.0
May	178.0	181.8	181.6	22,873.0	20,148.2
June	188.6	190.8	190.7	24,080.2	20,743.1
July	213.0	216.5	216.3	27,330.5	23,269.6
August	175.2	181.0	180.8	22,765.7	19,505.3
September	117.8	125.0	124.8	15,618.2	13,617.7
October	68.9	74.8	74.6	9,248.5	8,351.1
November	32.5	36.4	36.0	4,389.2	3,962.1
December	22.3	25.8	24.9	2,995.3	2,641.7

Sources of System Loss

Figure 19: Snippet of rooftop solar PV design simulation report (Saanich Peninsula WWTP)

Figure 20: Solar PV system shading heatmap (Saanich Peninsula WWTP)

Furthermore, the hourly interval electrical energy consumption versus generation and energy import/export analysis was conducted (attached in Appendices). The monthly summary is listed in Table 11.

Table 11: Monthly summary of energy consumption and PV generation (Saanich Peninsula WWTP)

Month	2023 Consumption (kWh)	Estimated Solar Generation (kWh)	Solar Generation/Consumption (%)
January	178,384	3,487	2%
February	157,947	6,540	4%
March	182,524	11,012	6%
April	180,393	15,542	9%
May	174,071	20,148	12%
June	150,895	20,743	14%
July	159,840	23,270	15%
August	161,938	19,505	12%
September	153,583	13,618	9%
October	146,996	8,351	6%
November	172,800	3,962	2%
December	183,600	2,642	1%
Annual	2,002,971	148,820	7%

Table 11 shows that the designed rooftop solar PV system is capable of meeting only up to 7% of annual energy consumption.

Thus, the Saanich Peninsula WWTP, despite its high energy consumption has limited potential for rooftop solar PV due to extensive on-roof services and equipment. To meet its energy needs, alternative installation types such as ground-mounted solar car park structures could be considered.

Rainbow Road Aquatic Centre

The rooftop solar PV system is designed optimally on the obstruction- and shade-free spaces atop the metal-sheet roofs of Rainbow Road Aquatic Centre as depicted in Figure 21.

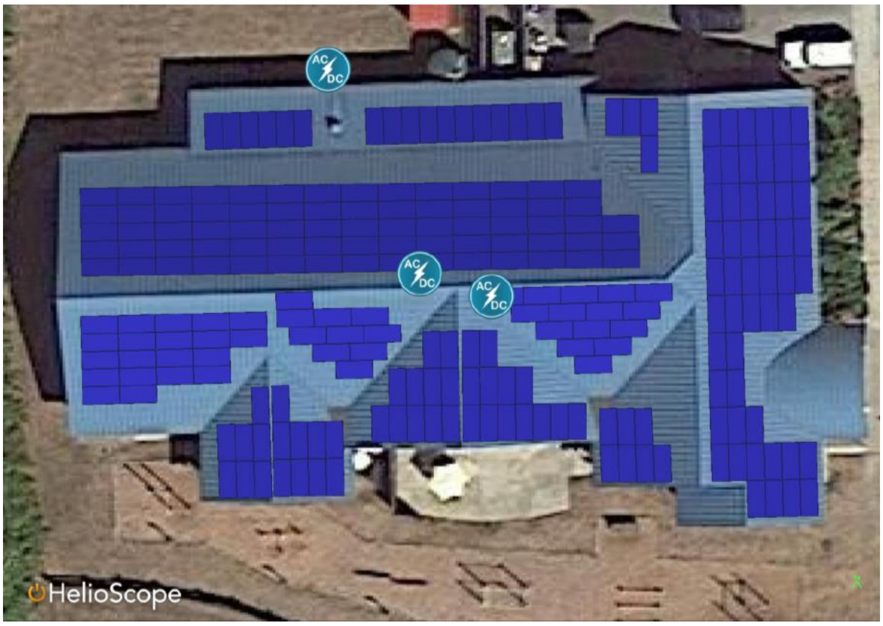


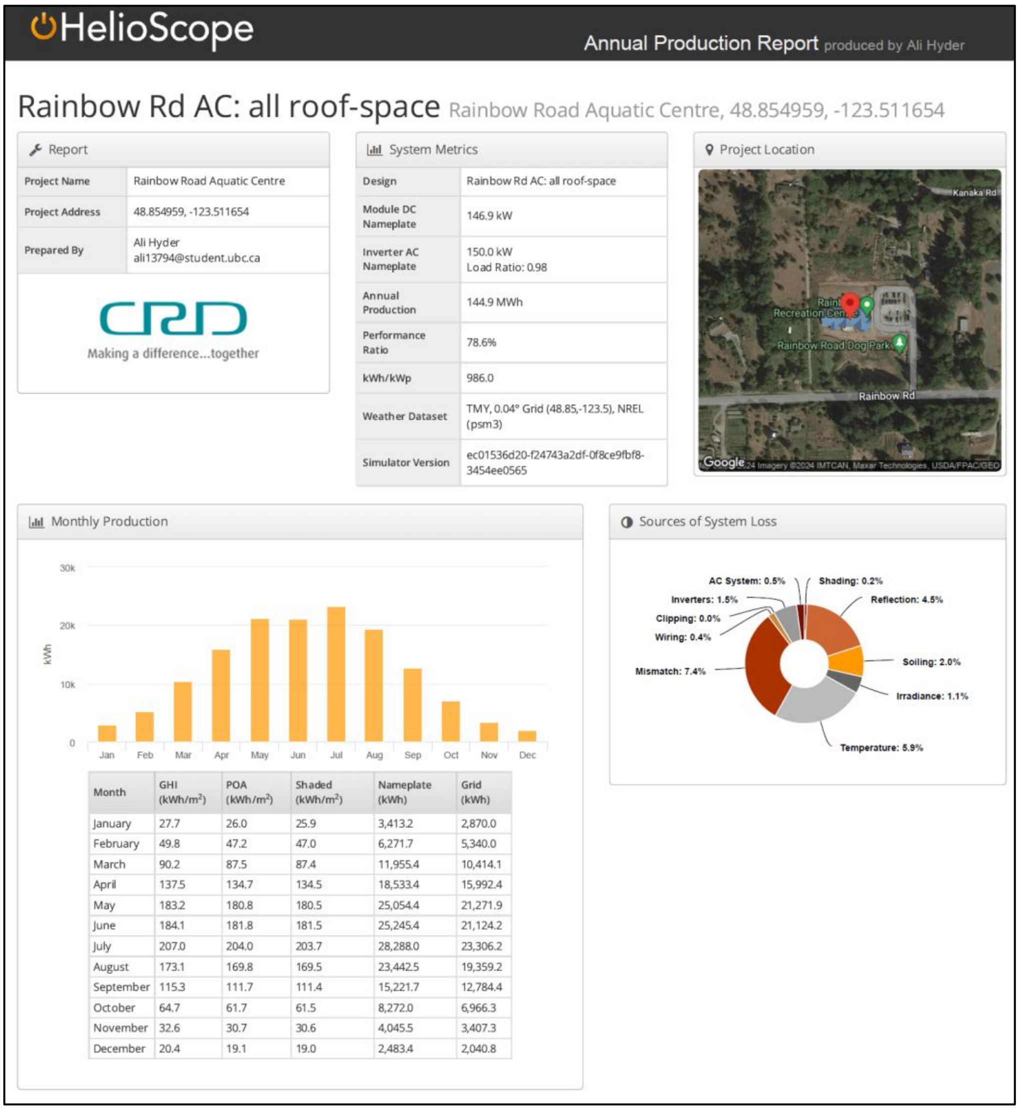
Figure 21: Rooftop solar PV system designed atop Rainbow Road Aquatic Centre

The details of the rooftop solar PV design are listed in Table 12.

Table 12: Rooftop solar PV system details (Rainbow Road AC)

Design	Installation Type	Solar PV DC Capacity (kWp)	Solar PV AC Capacity (kW)	Annual Energy Generation (kWh)	PV Specific Yield (kWh/kWp/year)
All roof-space	Flush-mounted (metal-sheet roof)	146.9	120	144,877	986

A snippet of the design simulation report generated in Helioscope is shown in Figure 22 and the complete reports are attached in Appendices. Further, shadow analysis was also simulated to ensure an optimally shade-free (inter-row, near- and far-field) design during the solar hours as illustrated in Figure 23. The solar PV specific yield is below average at the location and even lower on the north-facing side of the roofs.



Month	GHI (kWh/m²)	POA (kWh/m²)	Shaded (kWh/m²)	Nameplate (kWh)	Grid (kWh)
January	27.7	26.0	25.9	3,413.2	2,870.0
February	49.8	47.2	47.0	6,271.7	5,340.0
March	90.2	87.5	87.4	11,955.4	10,414.1
April	137.5	134.7	134.5	18,533.4	15,992.4
May	183.2	180.8	180.5	25,054.4	21,271.9
June	184.1	181.8	181.5	25,245.4	21,124.2
July	207.0	204.0	203.7	28,288.0	23,306.2
August	173.1	169.8	169.5	23,442.5	19,359.2
September	115.3	111.7	111.4	15,221.7	12,784.4
October	64.7	61.7	61.5	8,272.0	6,966.3
November	32.6	30.7	30.6	4,045.5	3,407.3
December	20.4	19.1	19.0	2,483.4	2,040.8

Figure 22: Snippet of rooftop solar PV design simulation report (Rainbow Road AC)

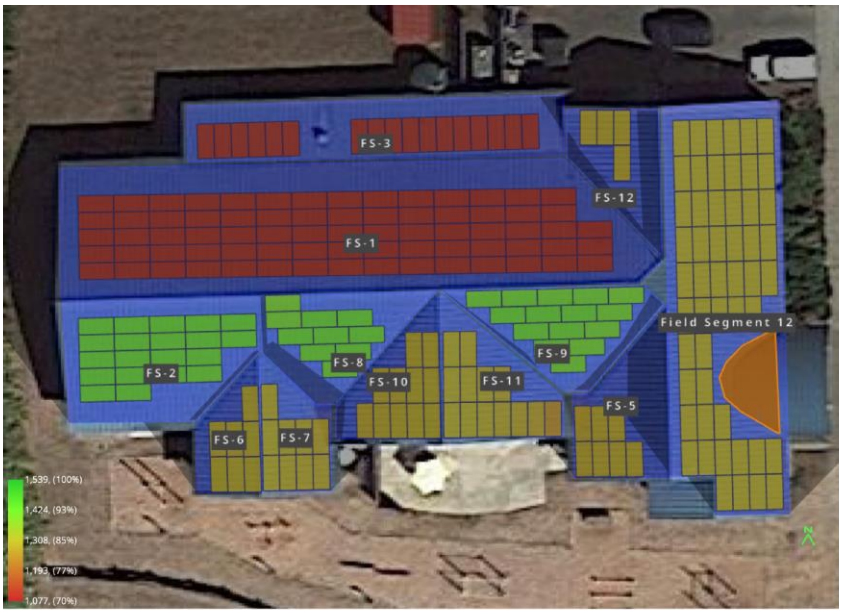


Figure 23: Solar PV system shading heatmap (Rainbow Road AC)

Furthermore, the hourly interval electrical energy consumption versus generation and energy import/export analysis was conducted (attached in Appendices). The monthly summary is listed in Table 13.

Table 13: Monthly summary of energy consumption and PV generation (Rainbow Road AC)

Month	2023 Consumption (kWh)	Estimated Solar Generation (kWh)	Solar Generation/Consumption (%)
Jan	116,299	2,870	2%
Feb	98,541	5,340	5%
Mar	100,129	10,414	10%
Apr	52,072	15,992	31%
May	89,702	21,272	24%
Jun	84,748	21,124	25%
Jul	87,070	23,306	27%
Aug	87,535	19,359	22%
Sep	90,214	12,784	14%
Oct	104,225	6,966	7%
Nov	107,158	3,407	3%
Dec	68,730	2,041	3%
Annual	1,086,420	144,877	13%

Table 13 shows that the designed rooftop solar PV system is capable of meeting up to 13% of annual energy consumption.

Thus, the Rainbow Road Aquatic Centre has reasonable potential for rooftop solar PV, despite challenges such as multiple roof orientations and below-average PV specific yield.

CRD HQ (Fisgard)

Considering its high energy use and prime downtown location, the CRD HQ is a key corporate site for potential solar PV integration. The rooftop solar PV system is designed optimally on the obstruction- and shade-free spaces atop the flat roofs as depicted in Figure 24.

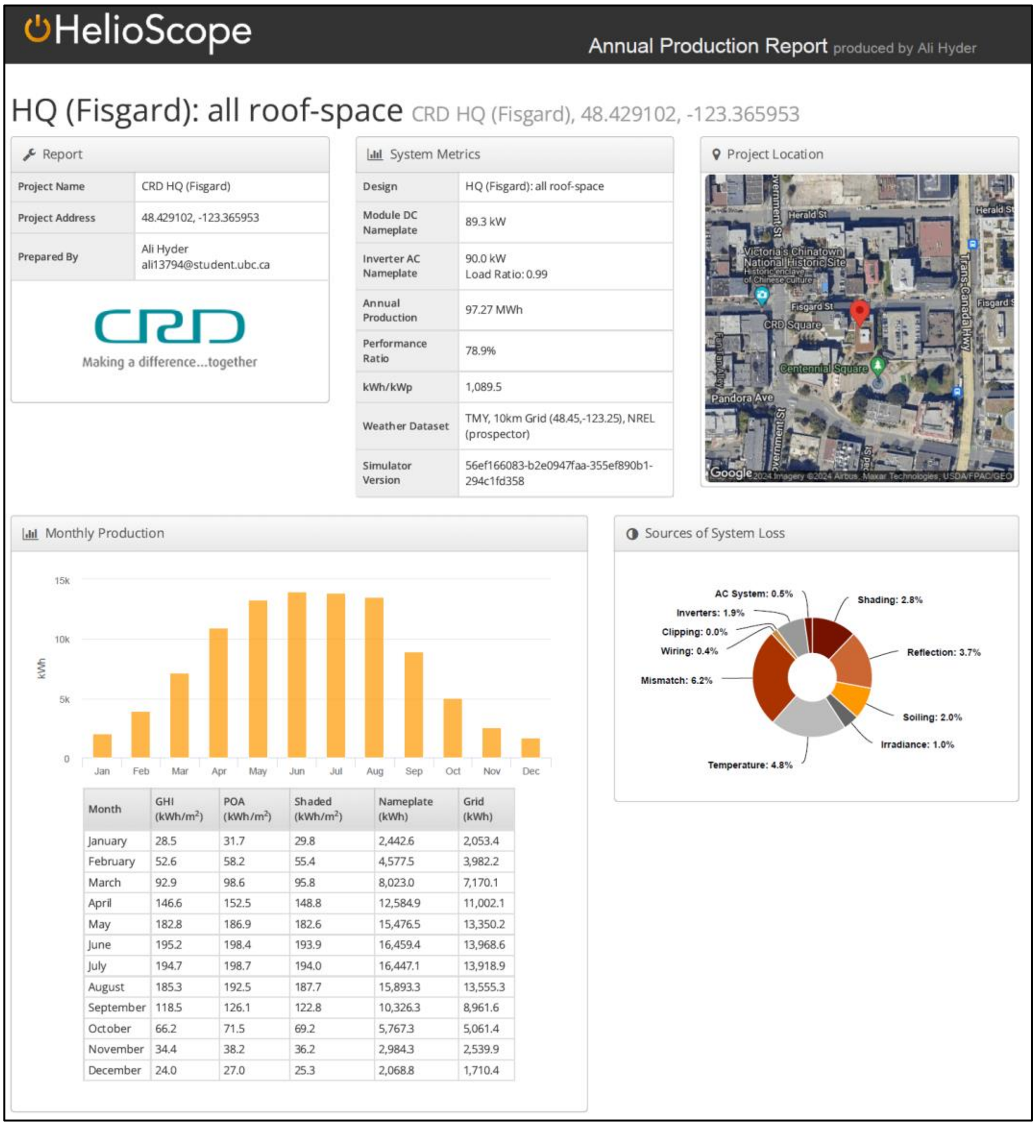
Figure 24: Rooftop solar PV system designed atop CRD HQ

The details of the rooftop solar PV design are listed in Table 14.

Table 14: Rooftop solar PV system details (CRD HQ)

Design	Installation Type	Solar PV DC Capacity (kWp)	Solar PV AC Capacity (kW)	Annual Energy Generation (kWh)	PV Specific Yield (kWh/kWp/year)
All roof-space	Elevated (flat roof)	89.3	90	97,274	1,090

A snippet of the design simulation report generated in Helioscope is shown in Figure 25 and the complete reports are attached in Appendices. Further, shadow analysis was also simulated to ensure an optimally shade-free (inter-row, near- and far-field) design during the solar hours as illustrated in Figure 26.


HelioScope | Annual Production Report produced by Ali Hyder

HQ (Fisgard): all roof-space CRD HQ (Fisgard), 48.429102, -123.365953

Report

Project Name	CRD HQ (Fisgard)
Project Address	48.429102, -123.365953
Prepared By	Ali Hyder ali13794@student.ubc.ca

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System Metrics

Design	HQ (Fisgard): all roof-space
Module DC Nameplate	89.3 kW
Inverter AC Nameplate	90.0 kW Load Ratio: 0.99
Annual Production	97.27 MWh
Performance Ratio	78.9%
kWh/kWp	1,089.5
Weather Dataset	TMY, 10km Grid (48.45,-123.25), NREL (prospector)
Simulator Version	56ef166083-b2e0947faa-355ef890b1-294c1fd358

Project Location

Monthly Production

Month	GHI (kWh/m²)	POA (kWh/m²)	Shaded (kWh/m²)	Nameplate (kWh)	Grid (kWh)
January	28.5	31.7	29.8	2,442.6	2,053.4
February	52.6	58.2	55.4	4,577.5	3,982.2
March	92.9	98.6	95.8	8,023.0	7,170.1
April	146.6	152.5	148.8	12,584.9	11,002.1
May	182.8	186.9	182.6	15,476.5	13,350.2
June	195.2	198.4	193.9	16,459.4	13,968.6
July	194.7	198.7	194.0	16,447.1	13,918.9
August	185.3	192.5	187.7	15,893.3	13,555.3
September	118.5	126.1	122.8	10,326.3	8,961.6
October	66.2	71.5	69.2	5,767.3	5,061.4
November	34.4	38.2	36.2	2,984.3	2,539.9
December	24.0	27.0	25.3	2,068.8	1,710.4

Sources of System Loss

Figure 25: Snippet of rooftop solar PV design simulation report (CRD HQ)

Figure 26: Solar PV system shading heatmap (CRD HQ)

Furthermore, the hourly interval electrical energy consumption versus generation and energy import/export analysis was conducted (attached in Appendices). The monthly summary is listed in Table 15.

Table 15: Monthly summary of energy consumption and PV generation (CRD HQ)

Month	2023 Consumption (kWh)	Estimated Solar Generation (kWh)	Solar Generation/Consumption (%)
January	92,266	2,053	2%
February	79,942	3,982	5%
March	89,683	7,170	8%
April	81,393	11,002	14%
May	92,568	13,350	14%
June	81,964	13,969	17%
July	88,630	13,919	16%
August	93,076	13,555	15%
September	80,901	8,962	11%
October	77,045	5,061	7%
November	79,405	2,540	3%
December	75,512	1,710	2%
Annual	1,012,386	97,274	10%

Table 15 shows that the designed rooftop solar PV system is capable of meeting up to 10% of annual energy consumption.

Thus, the CRD HQ has reasonable potential for rooftop solar PV, and given its prime location, it is an excellent candidate for future solar PV integration.

SEAPARC Recreation Centre

The rooftop solar PV system is designed optimally on the obstruction- and shade-free spaces atop the flat roof of SEAPARC Recreation Centre as depicted in Figure 27. The large metal-sheet roofs have been purposely left out as they have been deemed structurally incapable for solar PV integration by the CRD.

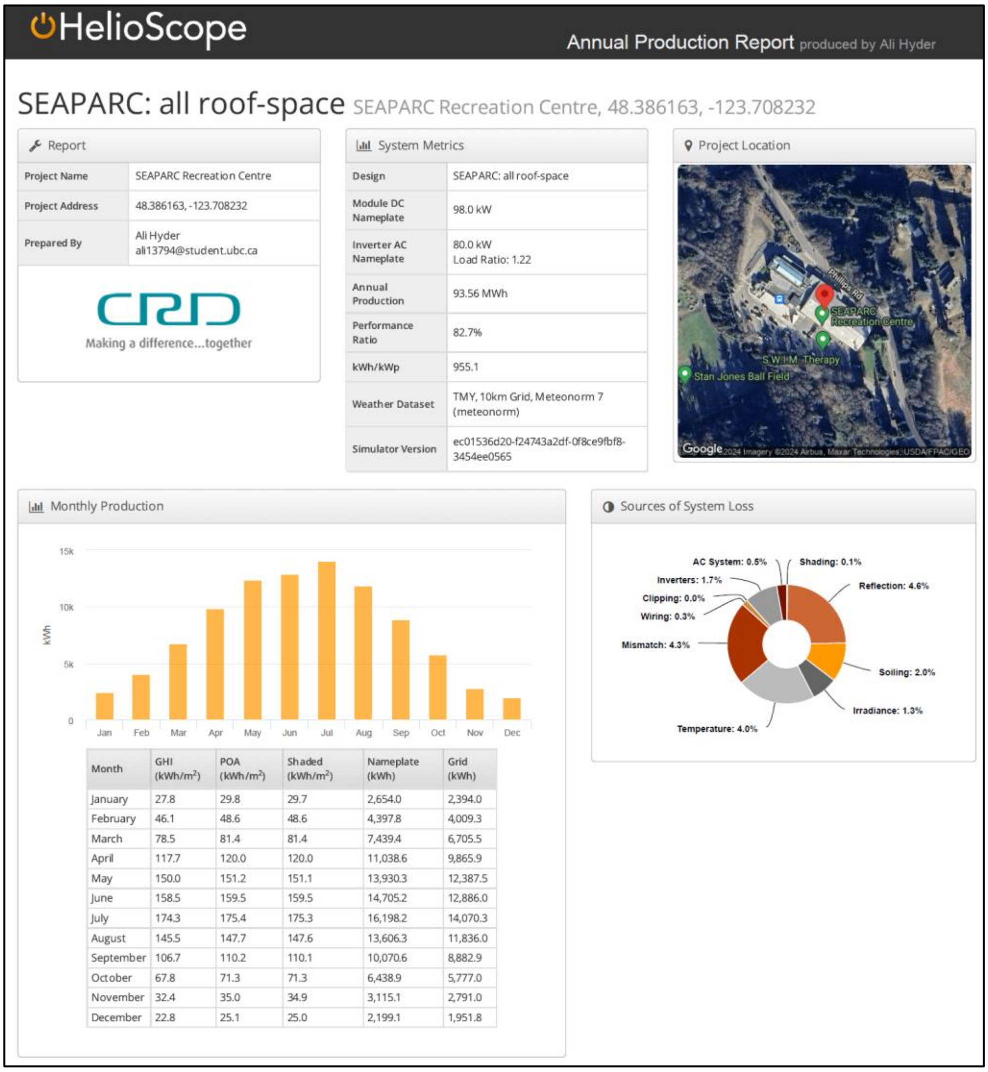
Figure 27: Rooftop solar PV system designed atop SEAPARC Recreation Centre

The details of the rooftop solar PV design are listed in Table 16.

Table 16: Rooftop solar PV system details (SEAPARC)

Design	Installation Type	Solar PV DC Capacity (kWp)	Solar PV AC Capacity (kW)	Annual Energy Generation (kWh)	PV Specific Yield (kWh/kWp/year)
All roof-space	Elevated (flat roof) + Flush-mounted (metal-sheet roof)	98	80	93,557	955

A snippet of the design simulation report generated in Helioscope is shown in Figure 28 and the complete reports are attached in Appendices. Further, shadow analysis was also simulated to ensure an optimally shade-free (inter-row, near- and far-field) design during the solar hours as illustrated in Figure 29. The solar PV specific yield is below average at the location and even lower on the north-facing side of the roofs.



Month	GHI (kWh/m²)	POA (kWh/m²)	Shaded (kWh/m²)	Nameplate (kWh)	Grid (kWh)
January	27.8	29.8	29.7	2,654.0	2,394.0
February	46.1	48.6	48.6	4,397.8	4,009.3
March	78.5	81.4	81.4	7,439.4	6,705.5
April	117.7	120.0	120.0	11,038.6	9,865.9
May	150.0	151.2	151.1	13,930.3	12,387.5
June	158.5	159.5	159.5	14,705.2	12,886.0
July	174.3	175.4	175.3	16,198.2	14,070.3
August	145.5	147.7	147.6	13,606.3	11,836.0
September	106.7	110.2	110.1	10,070.6	8,882.9
October	67.8	71.3	71.3	6,438.9	5,777.0
November	32.4	35.0	34.9	3,115.1	2,791.0
December	22.8	25.1	25.0	2,199.1	1,951.8

Figure 28: Snippet of rooftop solar PV design simulation report (SEAPARC)

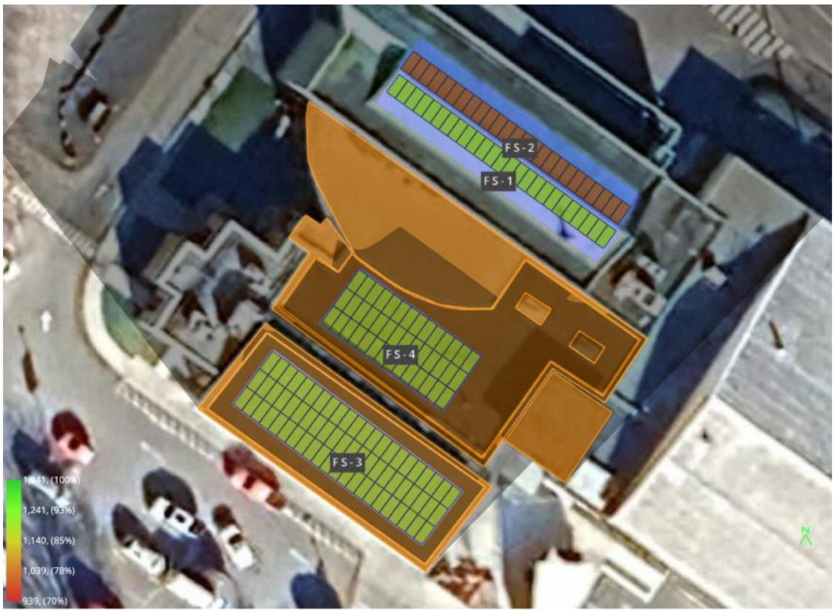


Figure 29: Solar PV system shading heatmap (SEAPARC)

Furthermore, the hourly interval electrical energy consumption versus generation and energy import/export analysis was conducted (attached in Appendices). The monthly summary is listed in Table 17.

Table 17: Monthly summary of energy consumption and PV generation (SEAPARC)

Month	2023 Consumption (kWh)	Estimated Solar Generation (kWh)	Solar Generation/Consumption (%)
January	79,303	2,394	3%
February	68,505	4,009	6%
March	55,529	6,706	12%
April	71,736	9,866	14%
May	72,831	12,388	17%
June	54,138	12,886	24%
July	72,836	14,070	19%
August	72,814	11,836	16%
September	71,891	8,883	12%
October	71,901	5,777	8%
November	72,480	2,791	4%
December	77,034	1,952	3%
Annual	840,997	93,557	11%

Table 17 shows that the designed rooftop solar PV system is capable of meeting up to 11% of annual energy consumption.

Thus, the SEAPARC Recreation Centre has reasonable potential for rooftop solar PV, despite challenges such as the exclusion of large metal-sheet roofs, the need for multiple installation-types and below-average PV specific yield.

Greenglade Community Centre

The Greenglade Community Centre has a high potential to install a rooftop solar PV system due to its large metal-sheet roofs [12], capable of considerably meeting annual energy consumption.

The rooftop solar PV system is designed optimally on the obstruction- and shade-free spaces atop the metal-sheet roofs as depicted in Figure 30.

An alternative, smaller design installed only on the new roof extension has also been designed considering the structural design and load bearing capability of the new roofs, without necessitating any structural upgrades. The details of both PV designs are listed in Table 18.

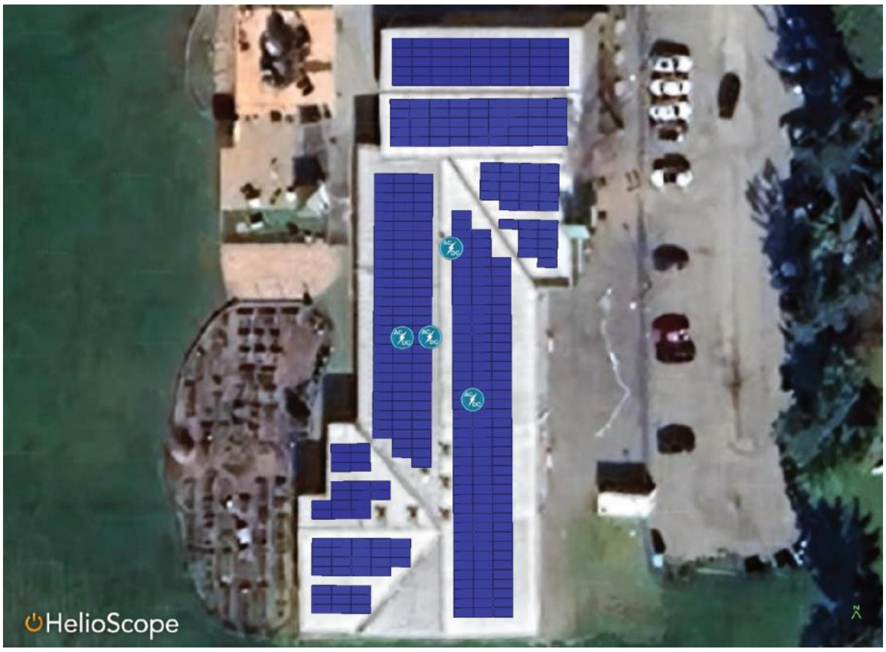


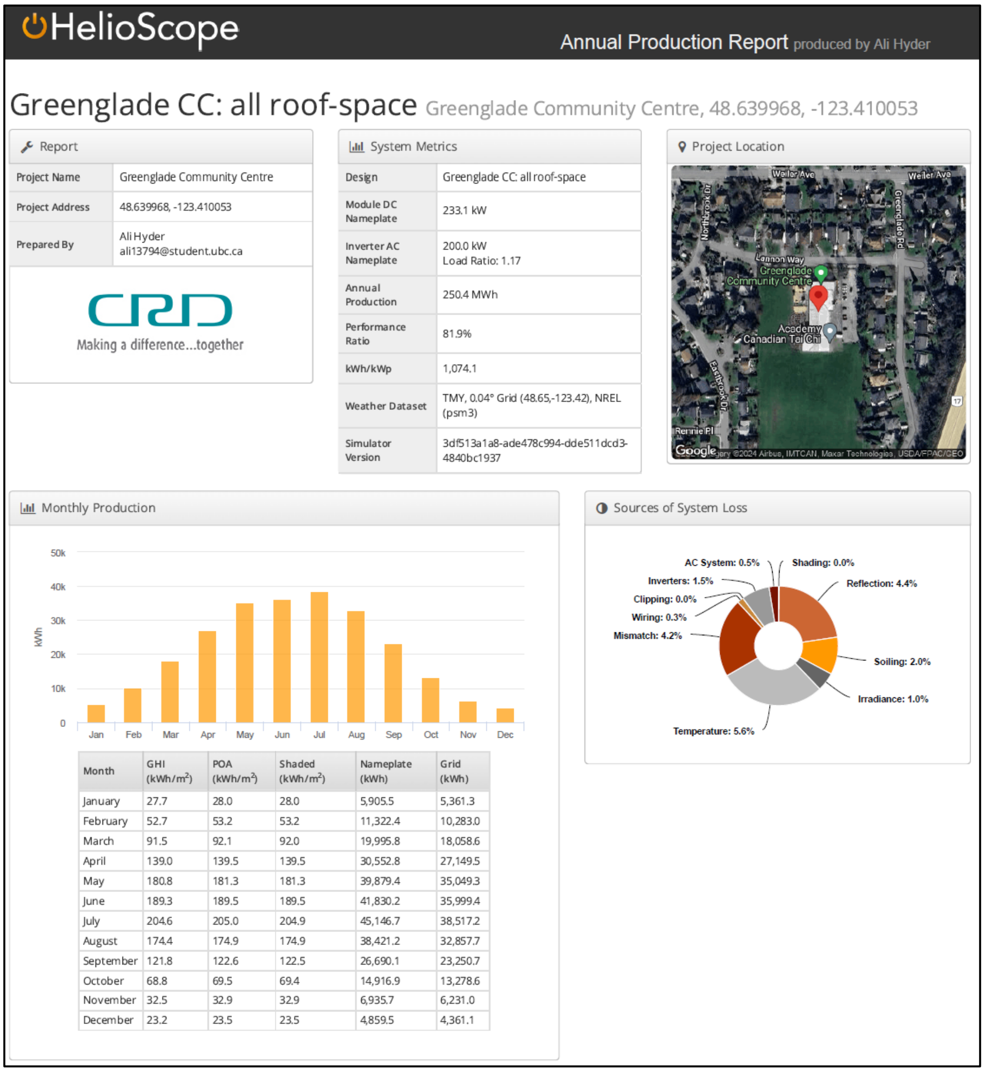
Figure 30: Rooftop solar PV system designed atop Greenglade Community Centre

Table 18: Rooftop solar PV system details (Greenglade CC)

Design	Installation Type	Solar PV DC Capacity (kWp)	Solar PV AC Capacity (kW)	Annual Energy Generation (kWh)	PV Specific Yield (kWh/kWp/year)
Design 1 – All roof-space	Flush-mounted (metal-sheet roof)	233.1	200	250,397	1,074
Design 2 – New roof extension only	Flush-mounted (metal-sheet roof)	78.7	80	83,107	1,056

A snippet of the design simulation report generated in Helioscope is shown in Figure 31 and the complete reports are attached in Appendices. Further, shadow analysis was also simulated to ensure an optimally shade-free (inter-row, near- and far-field) design during the solar hours as illustrated in Figure 32.

[12] Subject to the structural dead load design and withstand capability as well as the assessment of electrical upgrades required to integrate solar PV systems.


HelioScope Annual Production Report produced by Ali Hyder

Greenglade CC: all roof-space Greenglade Community Centre, 48.639968, -123.410053

Report

Project Name	Greenglade Community Centre
Project Address	48.639968, -123.410053
Prepared By	Ali Hyder ali13794@student.ubc.ca

CRD Making a difference...together

System Metrics

Design	Greenglade CC: all roof-space
Module DC Nameplate	233.1 kW
Inverter AC Nameplate	200.0 kW Load Ratio: 1.17
Annual Production	250.4 MWh
Performance Ratio	81.9%
kWh/kWp	1,074.1
Weather Dataset	TMY, 0.04° Grid (48.65,-123.42), NREL (psm3)
Simulator Version	3df513a1a8-ade478c994-dde511dcd3-4840bc1937

Project Location

Monthly Production

Month	GHI (kWh/m^2)	POA (kWh/m^2)	Shaded (kWh/m^2)	Nameplate (kWh)	Grid (kWh)
January	27.7	28.0	28.0	5,905.5	5,361.3
February	52.7	53.2	53.2	11,322.4	10,283.0
March	91.5	92.1	92.0	19,995.8	18,058.6
April	139.0	139.5	139.5	30,552.8	27,149.5
May	180.8	181.3	181.3	39,879.4	35,049.3
June	189.3	189.5	189.5	41,830.2	35,999.4
July	204.6	205.0	204.9	45,146.7	38,517.2
August	174.4	174.9	174.9	38,421.2	32,857.7
September	121.8	122.6	122.5	26,690.1	23,250.7
October	68.8	69.5	69.4	14,916.9	13,278.6
November	32.5	32.9	32.9	6,935.7	6,231.0
December	23.2	23.5	23.5	4,859.5	4,361.1

Sources of System Loss

Figure 31: Snippet of rooftop solar PV design simulation report (Greenglade CC)

Figure 32: Solar PV system shading heatmap (Greenglade CC)

Furthermore, the hourly interval electrical energy consumption versus generation and energy import/export analysis was conducted (attached in Appendices). The monthly summary is listed in Table 19.

Table 19: Monthly summary of energy consumption and PV generation (Greenglade CC)

Month	2023 Consumption (kWh)	Estimated Solar Generation (kWh)	Solar Generation/Consumption (%)
January	86,436	5,361	6%
February	84,981	10,283	12%
March	80,525	18,059	22%
April	66,163	27,150	41%
May	32,592	35,049	108%
June	28,348	35,999	127%
July	19,033	38,517	202%
August	18,241	32,858	180%
September	24,512	23,251	95%
October	45,863	13,279	29%
November	68,642	6,231	9%
December	69,182	4,361	6%
Annual	624,516	250,397	40%

Table 19 shows that the designed rooftop solar PV system is capable of significantly meeting the overall annual energy consumption (up to 40%) and between 100-200% during summer months, considering the whole roof-space capacity design option.

Thus, the Greenglade Community Centre has high potential for rooftop solar PV installations on its metal-sheet roof. However, utilizing the full roof space would require significant electrical infrastructure upgrades and possibly structural enhancements as well. Therefore, the design option based on the new roof extension is a viable alternative, allowing for solar PV integration without extensive electrical and structural upgrades.

Integrated Water Services HQ

The Integrated Water Services (IWS) HQ has significant potential to install a rooftop solar PV system due to its large metal-sheet roofs[13], capable of considerably meeting the increasing energy consumption (approaching 100% service capacity) with the charging requirement of growing electrical vehicles fleet parked on-premises.

The rooftop solar PV system is designed optimally on the obstruction- and shade-free spaces atop the metal-sheet roofs as depicted in Figure 33.

The details of the rooftop solar PV design are listed in Table 20.

[13] Subject to the structural dead load design and withstand capability as well as the assessment of electrical upgrades required to integrate solar PV systems.

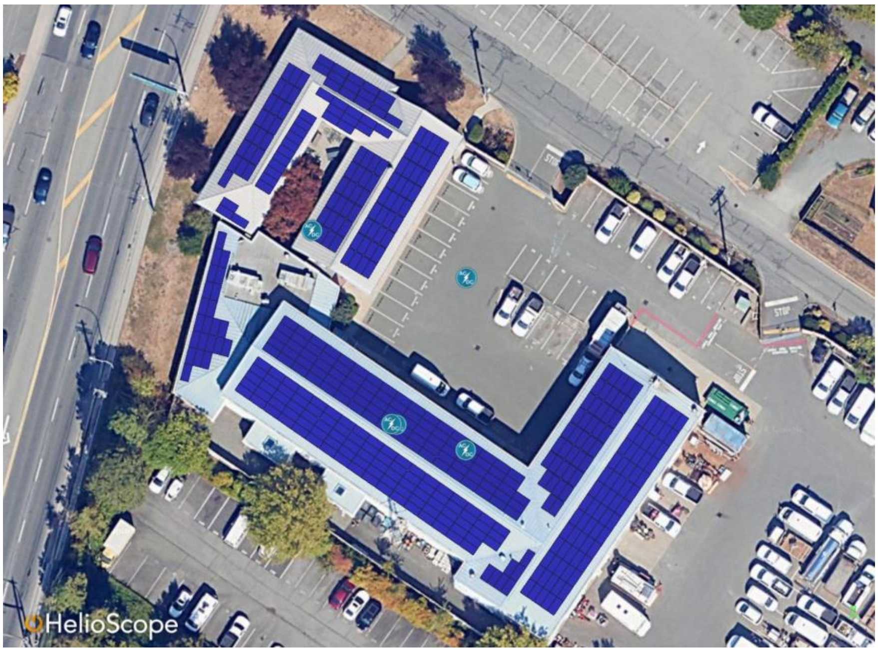
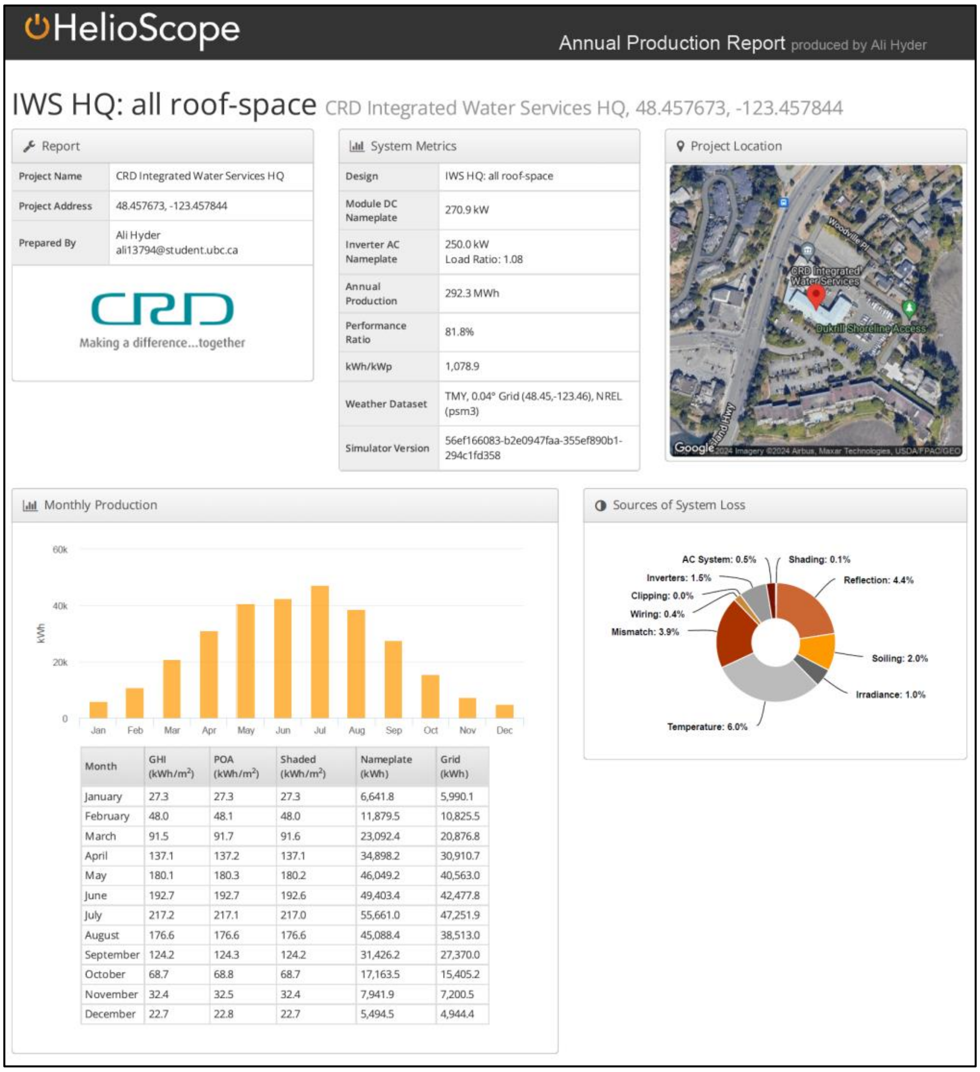


Figure 33: Rooftop solar PV system designed atop IWS HQ

Table 20: Rooftop solar PV system details (IWS HQ)

Design	Installation Type	Solar PV DC Capacity (kWp)	Solar PV AC Capacity (kW)	Annual Energy Generation (kWh)	PV Specific Yield (kWh/kWp/year)
Design 1 – All roof-space	Flush-mounted (metal-sheet roof)	270.9	250	292,329	1,079

A snippet of the design simulation report generated in Helioscope is shown in Figure 34 and the complete reports are attached in Appendices. Further, shadow analysis was also simulated to ensure an optimally shade-free (inter-row, near- and far-field) design during the solar hours as illustrated in Figure 35.



HelioScope — Annual Production Report produced by Ali Hyder

IWS HQ: all roof-space CRD Integrated Water Services HQ, 48.457673, -123.457844

Report

Project Name	CRD Integrated Water Services HQ
Project Address	48.457673, -123.457844
Prepared By	Ali Hyder ali13794@student.ubc.ca

CRD Making a difference...together

System Metrics

Design	IWS HQ: all roof-space
Module DC Nameplate	270.9 kW
Inverter AC Nameplate	250.0 kW Load Ratio: 1.08
Annual Production	292.3 MWh
Performance Ratio	81.8%
kWh/kWp	1,078.9
Weather Dataset	TMY, 0.04° Grid (48.45,-123.46), NREL (psm3)
Simulator Version	56ef166083-b2e0947faa-355ef890b1-294c1fd358

Project Location

Monthly Production

Month	GHI (kWh/m^2)	POA (kWh/m^2)	Shaded (kWh/m^2)	Nameplate (kWh)	Grid (kWh)
January	27.3	27.3	27.3	6,641.8	5,990.1
February	48.0	48.1	48.0	11,879.5	10,825.5
March	91.5	91.7	91.6	23,092.4	20,876.8
April	137.1	137.2	137.1	34,898.2	30,910.7
May	180.1	180.3	180.2	46,049.2	40,563.0
June	192.7	192.7	192.6	49,403.4	42,477.8
July	217.2	217.1	217.0	55,661.0	47,251.9
August	176.6	176.6	176.6	45,088.4	38,513.0
September	124.2	124.3	124.2	31,426.2	27,370.0
October	68.7	68.8	68.7	17,163.5	15,405.2
November	32.4	32.5	32.4	7,941.9	7,200.5
December	22.7	22.8	22.7	5,494.5	4,944.4

Sources of System Loss

Figure 34: Snippet of rooftop solar PV design simulation report (IWS HQ)

Figure 35: Solar PV system shading heatmap (IWS HQ)

Furthermore, the hourly interval electrical energy consumption versus generation and energy import/export analysis was conducted (attached in Appendices). The monthly summary is listed in Table 21.

Table 21: Monthly summary of energy consumption and PV generation (IWS HQ)

Month	2023 Consumption (kWh)	Estimated Solar Generation (kWh)	Solar Generation/Consumption (%)
Jan	34,808	5,990	17%
Feb	30,696	10,826	35%
Mar	32,875	20,877	64%
Apr	28,062	30,911	110%
May	28,153	40,563	144%
Jun	25,202	42,478	169%
Jul	25,101	47,252	188%
Aug	25,811	38,513	149%
Sep	22,203	27,370	123%
Oct	26,875	15,405	57%
Nov	31,642	7,201	23%
Dec	32,289	4,944	15%
Annual	343,717	292,329	85%

Table 21 shows that the designed rooftop solar PV system is capable of significantly meeting the overall annual energy consumption (up to 85%) and between 150-200% during summer months.

Thus, the IWS HQ presents a high potential for rooftop solar PV installations on its metal-sheet roofs. However, utilizing the full roof space would require significant electrical infrastructure upgrades and possibly structural enhancements as well. Therefore, it is advisable to consider a final capacity or installation type that minimizes the need for extensive electrical and structural upgrades while providing additional benefits, such as a solar PV car park.

Mayne Island Fire Hall

The rooftop solar PV system is designed optimally on the obstruction- and shade-free spaces atop the newly constructed metal-sheet roofs of Mayne Island Fire Hall, depicted in Figure 36.

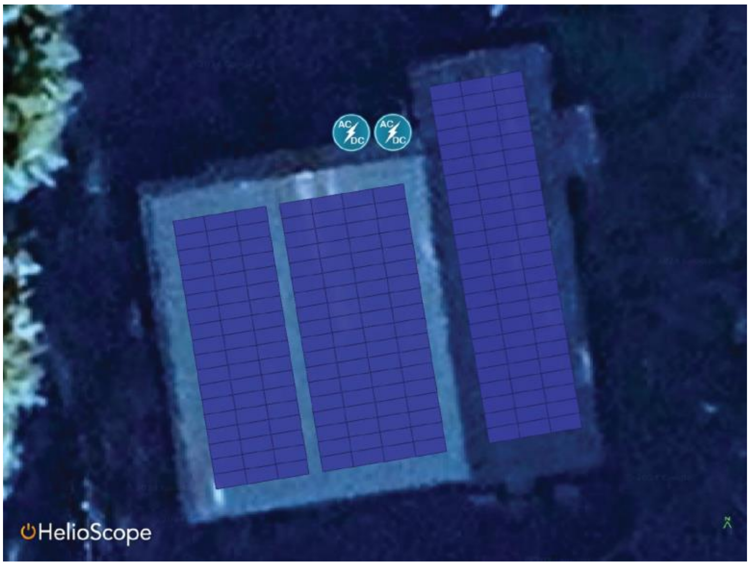


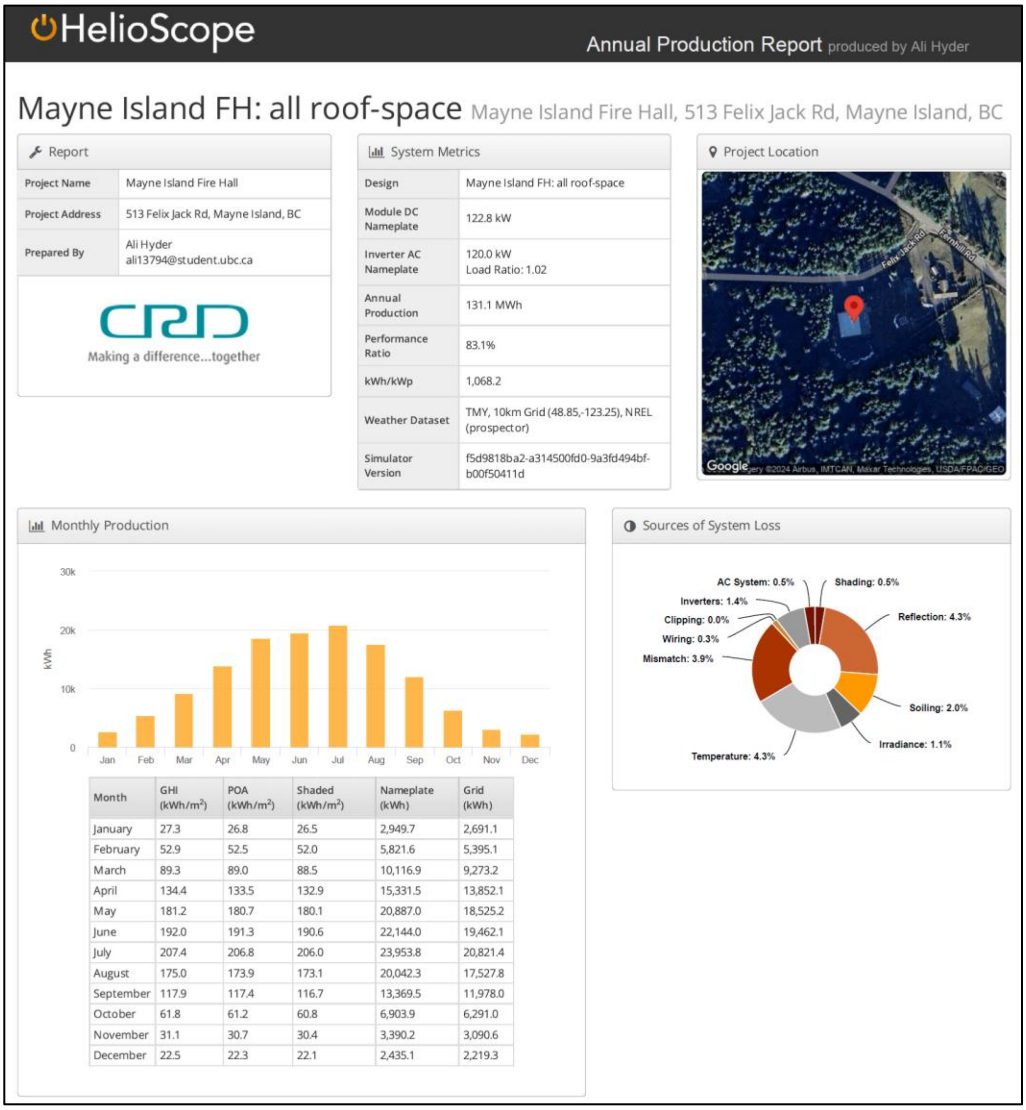
Figure 36: Rooftop solar PV system designed atop Mayne Island Fire Hall

The details of the rooftop solar PV design are listed in Table 22.

Table 22: Rooftop solar PV system details (Mayne Island FH)

Design	Installation Type	Solar PV DC Capacity (kWp)	Solar PV AC Capacity (kW)	Annual Energy Generation (kWh)	PV Specific Yield (kWh/kWp/year)
All roof-space	Flush-mounted (metal-sheet roof)	122.8	120	131,127	1,068

A snippet of the design simulation report generated in Helioscope is shown in Figure 37 and the complete reports are attached in Appendices. Further, shadow analysis was also simulated to ensure an optimally shade-free (inter-row, near- and far-field) design during the solar hours as illustrated in Figure 38.



Month	GHI (kWh/m²)	POA (kWh/m²)	Shaded (kWh/m²)	Nameplate (kWh)	Grid (kWh)
January	27.3	26.8	26.5	2,949.7	2,691.1
February	52.9	52.5	52.0	5,821.6	5,395.1
March	89.3	89.0	88.5	10,116.9	9,273.2
April	134.4	133.5	132.9	15,331.5	13,852.1
May	181.2	180.7	180.1	20,887.0	18,525.2
June	192.0	191.3	190.6	22,144.0	19,462.1
July	207.4	206.8	206.0	23,953.8	20,821.4
August	175.0	173.9	173.1	20,042.3	17,527.8
September	117.9	117.4	116.7	13,369.5	11,978.0
October	61.8	61.2	60.8	6,903.9	6,291.0
November	31.1	30.7	30.4	3,390.2	3,090.6
December	22.5	22.3	22.1	2,435.1	2,219.3

Figure 37: Snippet of rooftop solar PV design simulation report (Mayne Island FH)

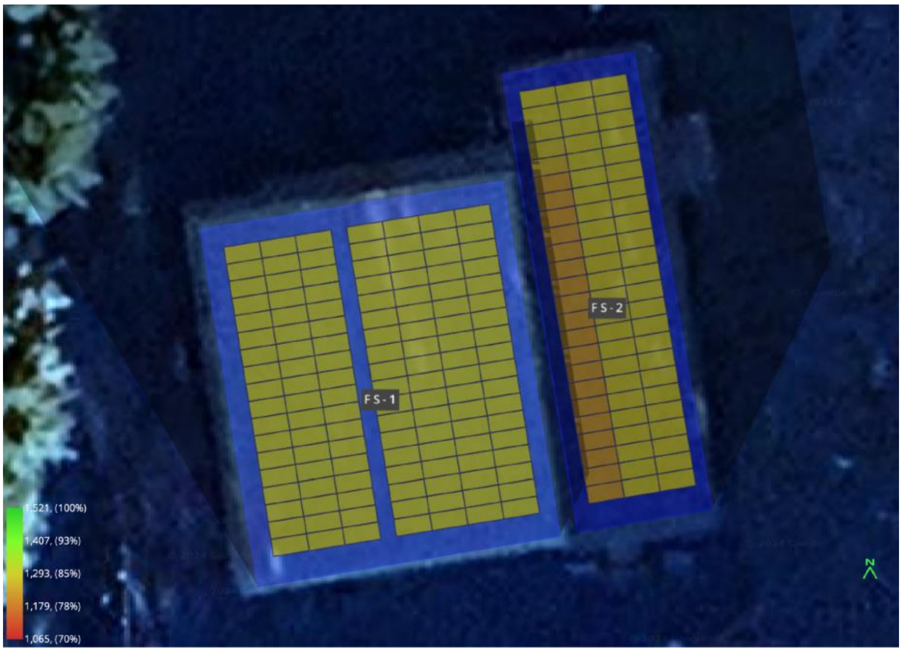


Figure 38: Solar PV system shading heatmap (Mayne Island FH)

Furthermore, the hourly interval electrical energy consumption[14] versus generation and energy import/export analysis was conducted (attached in Appendices). The monthly summary is listed in Table 23.

Table 23: Monthly summary of energy consumption and PV generation (Mayne Island FH)

Month	2023 Consumption (kWh)	Estimated Solar Generation (kWh)	Solar Generation/Consumption (%)
January	1,014	2,691	265%
February	714	5,395	756%
March	866	9,273	1071%
April	515	13,852	2689%
May	497	18,525	3727%
June	510	19,462	3818%
July	627	20,821	3321%
August	137	17,528	12783%
September	123	11,978	9750%
October	124	6,291	5075%
November	364	3,091	848%
December	782	2,219	284%
Annual	6,274	131,127	2090%

Table 23 shows that the designed rooftop solar PV system can meet and surpass the annual energy consumption.

Thus, the Mayne Island Fire Hall shows significant potential for rooftop solar PV installations on its newly constructed metal-sheet roofs. However, to refine the energy analysis, it is essential to obtain the site's annual energy consumption data to accurately estimate the solar PV energy offset potential.

[14] Annual energy consumption data for Galiano Fire Hall was used due to unavailability of data for Mayne Island.

Conclusion

In conclusion, the final selection of 10 sites represents the highest energy consumers and top candidates for solar PV installations. This forms the primary recommendation for prioritizing future financial analysis and investments in distributed solar PV integration at these sites. Cumulatively, the top 10 sites have the potential of installing approximately 2.5 MWp of rooftop solar PV capacity that would generate 2,661 MWh annually – refer to Table 24.

Table 24: Cumulative PV capacity and energy generation potential (top 10 sites)

Site Name	Address	Estimated PV Capacity (kWp)	Annual PV Energy Generation (kWh)
McLoughlin Point Wastewater Treatment Plant	337 Victoria View Rd	171	190,442
Panorama Recreation Centre	1885 Forest Park Dr	1,186	1,266,223
Macaulay Point Pump Station	330 View Point Rd	40	45,817
Saanich Peninsula Wastewater Treatment Plant	9055 Mainwaring Rd	133	148,820
Rainbow Road Aquatic Centre	262 Rainbow Rd	147	144,877
CRD Headquarters (Fisgard)	625 Fisgard St	89	97,274
SEAPARC Recreation Centre	2168 Phillips Rd	98	93,557
Greenglade Community Centre	2151 Lannon Way	233	250,397
Integrated Water Services (IWS) Headquarters	479 Island Hwy	271	292,329
Mayne Island Fire Hall	513 Felix Jack Rd	123	131,127
Cumulative PV Capacity & Energy Generation Potential		2.5 MWp	2,661 MWh

Recommendations

The closing recommendations for the top 10 sites are summarized below –

- The McLoughlin Point WWTP having the highest energy consumption would require more than just rooftop solar PV which is constrained due to on-roof services and limited shade-free space. Other installation types such as ground-mounted solar car park structures or floating solar PV systems (suitable for sites at shoreline) could be considered to meet energy consumption.
- The Panorama Recreation Centre has the highest potential for rooftop solar PV installations atop its metal-sheet roofs. However, integrating the full roof-space capacity would require significant electrical infrastructure upgrades. Therefore, the design option

based on available electrical capacity can be considered as a viable alternative to integrate solar PV without necessitating extensive electrical system upgrades.

- The Macaulay Point Pump Station, despite its high energy consumption has limited potential for rooftop solar PV due to its small roof footprint, which is typical of pumping and pressure control stations. To meet its energy needs, alternative installation types such as ground-mounted solar car park structures or floating solar PV systems (suitable for sites at shoreline) could be considered.
- The Saanich Peninsula WWTP, despite its high energy consumption has limited potential for rooftop solar PV due to extensive on-roof services and equipment. To meet its energy needs, alternative installation types such as ground-mounted solar car park structures could be considered.
- The Rainbow Road Aquatic Centre has reasonable potential for rooftop solar PV, despite challenges such as multiple roof orientations and below-average PV specific yield.
- The CRD HQ has reasonable potential for rooftop solar PV, and given its prime location, it is an excellent candidate for future solar PV integration.
- The SEAPARC Recreation Centre has reasonable potential for rooftop solar PV, despite challenges such as the exclusion of large metal-sheet roofs, the need for multiple installation-types and below-average PV specific yield.
- The Greenglade Community Centre has high potential for rooftop solar PV installations on its metal-sheet roof. However, utilizing the full roof space would require significant electrical infrastructure upgrades and possibly structural enhancements as well. Therefore, the design option based on the new roof extension is a viable alternative, allowing for solar PV integration without extensive electrical and structural upgrades.
- The IWS HQ presents a high potential for rooftop solar PV installations on its metal-sheet roofs. However, utilizing the full roof space would require significant electrical infrastructure upgrades and possibly structural enhancements as well. Therefore, it is advisable to consider a final capacity or installation type that minimizes the need for extensive electrical and structural upgrades while providing additional benefits, such as a solar PV car park.
- The Mayne Island Fire Hall shows significant potential for rooftop solar PV installations on its newly constructed metal-sheet roofs. However, to refine the energy analysis, it is essential to obtain the site's annual energy consumption data to accurately estimate the solar PV energy offset potential.

Future Work

Future work would involve an in-depth study to assess the available electrical service capacity (spare feeders) at the identified sites. This is crucial to determine the feasibility of installing solar PV systems without significant electrical upgrades or the need to downsize PV capacity accordingly. Additionally, a financial feasibility analysis will evaluate the capital expenditures (CAPEX) and operational expenditures (OPEX) for the solar PV systems and necessary electrical upgrades, considering potential incentives from BC Hydro. This comprehensive analysis will ensure the proposed installations are both technically feasible and economically viable, providing the CRD with a solid business case and equip them to make informed decisions on the integration of solar PV at the selected sites.

Acknowledgement

The author expresses sincere gratitude to the project mentor, Keegan Hardy, for his unwavering support and guidance throughout this project. Appreciation is also extended to the entire Climate Action Team at the CRD for their hospitality during site visits. Special thanks to Georgia Donohue for her efforts in data collation and support during the site visits.

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Finally, the author expresses deep gratitude to Karen Taylor, the UBC Sustainability Scholars program, and the project sponsor, BC Hydro, for providing this valuable opportunity to work with the CRD in advancing sustainability and clean energy initiatives.

Appendices

The appendices are tabulated in Table 25 and the files have been shared with the CRD along with this report.

Table 25: Table of Appendices

Appendix	File/Folder Name & Contents
Appendix 1	Master Sheet – Summary of CRD sites' data and selection for solar PV integration
Appendix 2	PV Design & Electrical Data Analysis (McLoughlin Point WWTP) – • Helioscope simulation and shade analysis reports • Energy consumption versus generation analysis (monthly and hourly)
Appendix 3	PV Design & Electrical Data Analysis (Panorama Recreation Centre) – • Helioscope simulation and shade analysis reports • Energy consumption versus generation analysis (monthly and hourly)
Appendix 4	PV Design & Electrical Data Analysis (Macaulay Pump Station) – • Helioscope simulation and shade analysis reports • Energy consumption versus generation analysis (monthly and hourly)
Appendix 5	PV Design & Electrical Data Analysis (Saanich Peninsula WWTP) – • Helioscope simulation and shade analysis reports • Energy consumption versus generation analysis (monthly and hourly)
Appendix 6	PV Design & Electrical Data Analysis (Rainbow Road Aquatic Centre) – • Helioscope simulation and shade analysis reports • Energy consumption versus generation analysis (monthly and hourly)
Appendix 7	PV Design & Electrical Data Analysis (CRD HQ) – • Helioscope simulation and shade analysis reports • Energy consumption versus generation analysis (monthly and hourly)
Appendix 8	PV Design & Electrical Data Analysis (SEAPARC Recreation Centre) – • Helioscope simulation and shade analysis reports • Energy consumption versus generation analysis (monthly and hourly)
Appendix 9	PV Design & Electrical Data Analysis (Greenglade Community Centre) – • Helioscope simulation and shade analysis reports • Energy consumption versus generation analysis (monthly and hourly)
Appendix 10	PV Design & Electrical Data Analysis (IWS HQ) – • Helioscope simulation and shade analysis reports • Energy consumption versus generation analysis (monthly and hourly)
Appendix 11	PV Design & Electrical Data Analysis (Mayne Island Fire Hall) – • Helioscope simulation and shade analysis reports • Energy consumption versus generation analysis (monthly and hourly)

Panorama Recreation Centre, North Saanich, BC