City of Salmon Arm Solar PV Feasibility Review for City Hall, Fire Hall No. 3, and the Art Centre

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1. Executive Summary

Subject to professional structural review, demonstration rooftop solar PV systems (4 – 10 kWp) installations are feasible for City Hall, Fire Hall No. 3, and the Art Centre.

Very Good to Excellent solar PV performance can be expected from all three sites with Fire Hall No. 3 having more shading constraints than the others.

In all cases electrical infrastructure will either directly accommodate demonstration systems (City Hall) or can be made to with minor modifications (Fire Hall No. 3 and Art Centre).

City Hall offers more unconstrained roof space and opportunity for future expansion than the other buildings. However, the solar PV business case is more attractive for Fire Hall and Art Centre buildings due to their higher electrical energy rate; BC Hydro Small General Service Rate ($0.1139/kWh) versus Large General Service Rate ($0.0606/kWh) for City Hall.

The Art Centre will have the largest annual electrical grid consumption reduction impacts through demonstration PV system installation; 26% – 53% annual reduction versus 13% – 33% for Fire Hall No. 3 and 0.8% – 2.0% for City Hall. The Art Centre may also be the most operationally conducive building for public information sessions, visits, and tours potentially associated with a demonstration system installation.

Summarized findings for each building are provided below with more details given in sections 2.7, 3.7, and 4.7.

<u>City Hall</u>

Rooftop space would easily accommodate a 4 – 10 kWp rooftop demonstration system whose key metrics would include:

- BC Hydro grid energy consumption reduction by 0.8% – 2.0%
- Before tax annual electrical energy cost savings of $281 - $703 (at 2019 rates)
- Before tax (GST only) estimated installation costs of $10,600 - $24,000

Key metrics for an ultimate City Hall 108kWp rooftop solar PV system include:

- BC Hydro grid energy consumption reduction by 22%
- Before tax annual electrical energy cost savings of $7972 (at 2019 rates)
- Before tax (GST only) estimated installation costs of $221,400

Solar patio canopy and parking shelter options would also be viable though at considerably higher cost per watt than roof mounting.

Fire Hall No. 3

Rooftop array placement is constrained by obstacles and shading but a 4 – 10 kWp demonstration system could be accommodated with some care. Projected key metrics would include:

- BC Hydro grid energy consumption reduction by 13% – 33%
- After-tax annual electrical energy cost savings of $583 - $1415 (at 2019 rates)
- Before tax (GST only) estimated installation costs of $11,130 - $24,480

Projected key metrics for an ultimate 19.2 kWp rooftop solar PV system include:

- BC Hydro grid energy consumption reduction by 62%
- Before tax annual electrical energy cost savings of $2664 (at 2019 rates)
- Before tax (GST only) estimated installation costs of $45,120

Art Centre

Rooftop array placement is somewhat constrained by physical obstacles and shading but a 4 – 10 kWp demonstration system can be accommodated. Projected key metrics include:

- BC Hydro grid energy consumption reduction by 26% – 53%
- After tax annual electrical energy cost savings of $708 - $1416 (at 2019 rates)
- Before tax (GST only) estimated installation costs of $13,260 - $24,480

Projected key metrics for an ultimate 19.8 kWp capacity adding a solar parking shelter:

- BC Hydro grid energy consumption reduced to Net-Zero
- After tax annual electrical energy cost savings of $2747 (at 2019 rates)
- Before tax (GST only) estimated installation costs of $62,880

In all three cases projected installation costs assume roof structures can accommodate ballasted racking systems. Should professional structural review find otherwise, installed costs using mechanically attached racking will be somewhat higher.

2. Salmon Arm City Hall

City Hall is located at 500, 2 Avenue NE shown in Figure 1. The large roof space has good potential for solar arrays in various locations. Solar canopies over 2nd floor outdoor patios, or a solar parking shelter in the south parking lot could be other solar PV options to consider. More details are given below.

Figure 1: Salmon Arm City Hall and Law Courts Building

2.1 City Hall Solar Photography

Solar photography was done with the Solmetric SunEye 210 at various strategic locations of the roof, patio areas and parking lot as shown in. Figure 2.

Good solar PV performance depends on arrays being as shade free as possible to maximize direct (unshaded) solar irradiation. Solar access score, is the percentage of available direct solar irradiation expected to strike the location during a specific time period after accounting for external shade caused by trees, mountains, or man-made structures. The Solmetric SunEye calculates solar access on a monthly basis, then deduces annualized, Summer (May-Oct), and Winter (Nov-Apr) scores.

Figure 2: City Hall Building Solar Photography Sites

Solar access results for each City Hall location are summarized in Table 1. The very high annual solar access scores (96%-99%) suggest excellent solar PV performance for all the roof locations considered. For the parking lot locations 1 and 2, solar access is reduced due to shading by nearby trees and lamp standards. Further details are provided below.

Location	Annual	Summer	Winter
Upper North Roof	99%	100%	96%
West Location 1	96%	99%	92%
West Location 2	99%	99%	99%
South Location 1 & 2	98%	99%	97%
South West	99%	100%	98%
Patio Location 1 & 2	95%	96%	94%
Parking Lot Location 1 & 2	80%	89%	61%

Table 1: City Hall Solar Access Results

2.1.1 City Hall – Upper North Roof

Figure 3 shows the upper north roof section.

Figure 3: City Hall Upper North Roof

Figure 4 shows the charts for the annual sun paths, monthly solar access and shading obstruction elevation vs. azimuth for the Upper North roof section.

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading = 176°**
GPS Location: Latitude=50.70074°N -- Longitude=119.27884°W
Solar Access: Annual: 99% -- Summer (May-Oct): 100% -- Winter (Nov-Apr): 96%

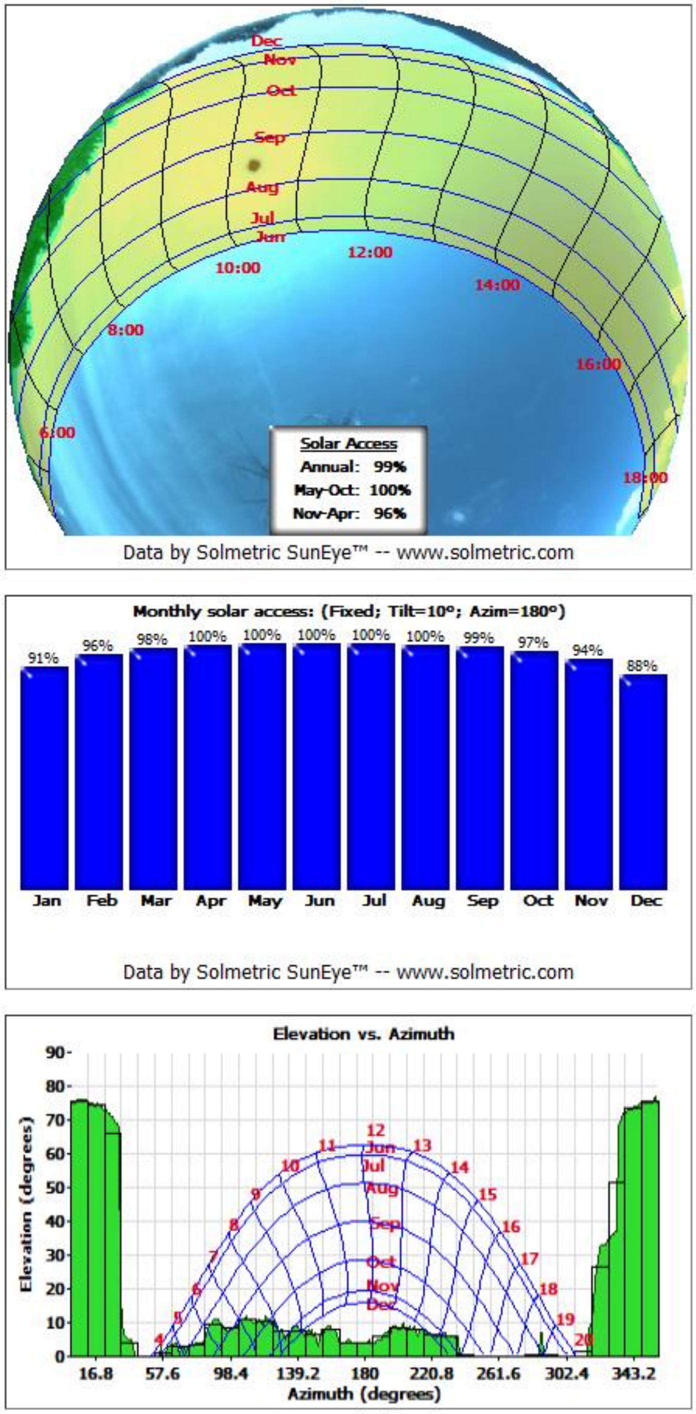


Figure 4: City Hall Upper North Roof Solar Access

2.1.2 City Hall – West Location 1

Figure 5 shows the charts for the annual sun paths, monthly solar access and shading obstruction elevation vs. azimuth.

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=178°**
GPS Location: Latitude=50.70060°N -- Longitude=119.27905°W
Solar Access: Annual: 96% -- Summer (May-Oct): 99% -- Winter (Nov-Apr): 92%

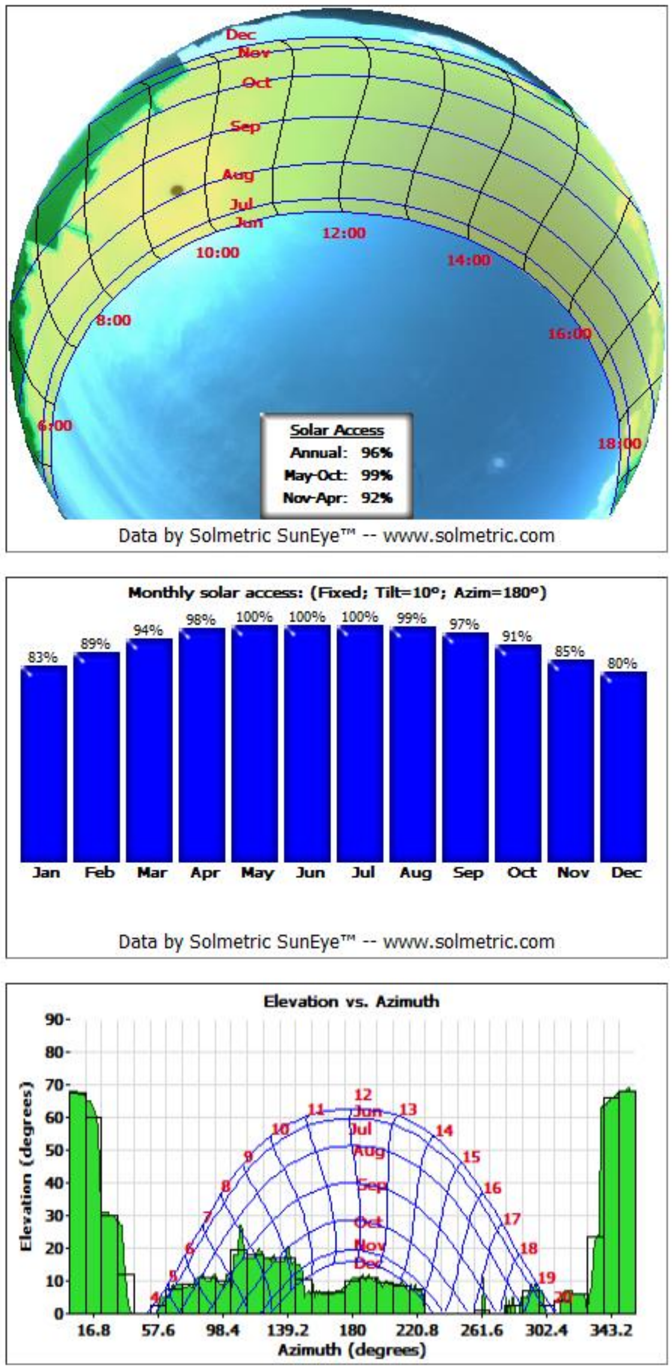


Figure 5: City Hall West Roof Location 1 Solar Access

2.1.3 City Hall – West Location 2

Figure 6 shows the charts for the annual sun paths, monthly solar access and shading obstruction elevation vs. azimuth.

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=174°**
GPS Location: Latitude=50.70072°N -- Longitude=119.27904°W
Solar Access: Annual: 99% -- Summer (May-Oct): 99% -- Winter (Nov-Apr): 99%

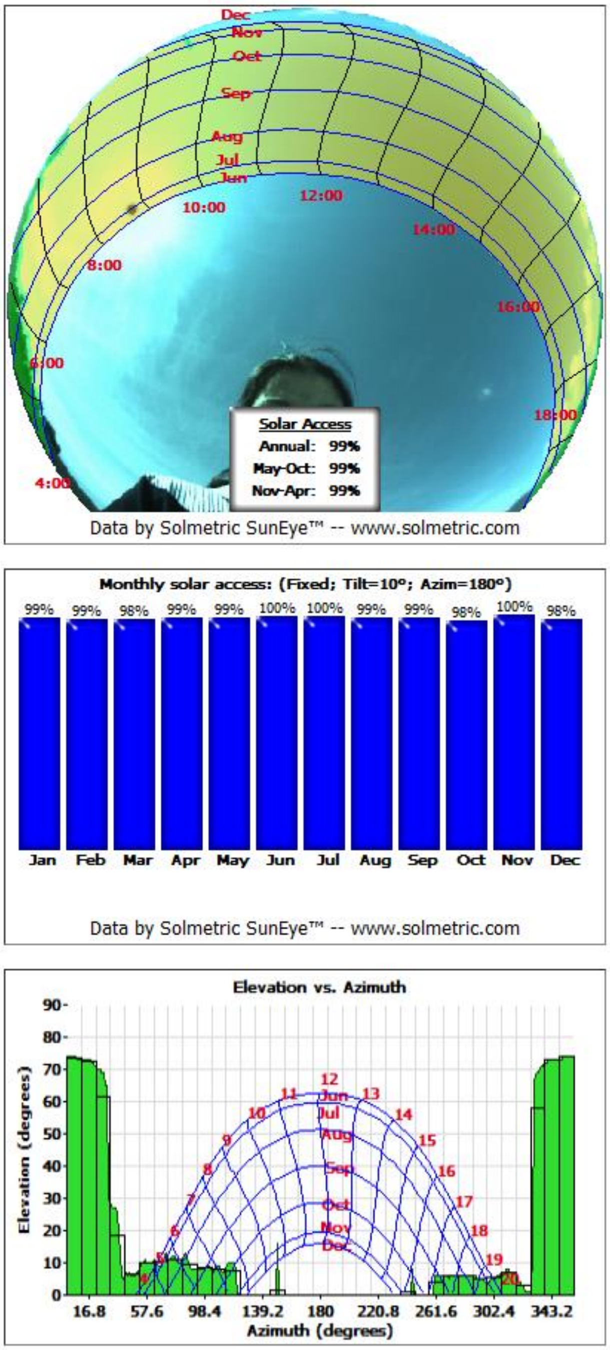


Figure 6: City Hall West Roof Location 2 Solar Access:

2.1.4 City Hall – South Location 1 & 2

Figure 7 shows the charts for the annual sun paths, monthly solar access and shading obstruction elevation vs. azimuth.

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=181°**
GPS Location: Latitude=50.70048°N -- Longitude=119.27894°W
Solar Access: Annual: 98% -- Summer (May-Oct): 99% -- Winter (Nov-Apr): 97%

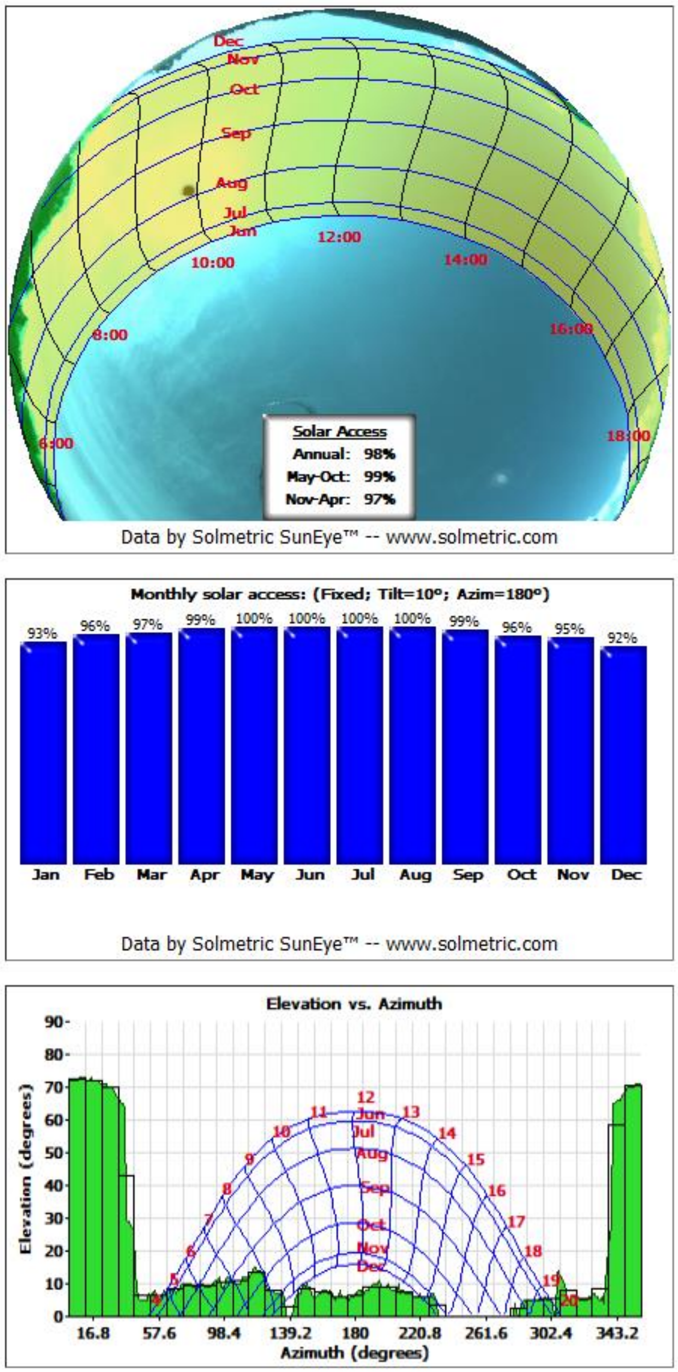


Figure 7: City Hall South Roof Solar Access

2.1.5 City Hall – South West

Figure 8 shows the charts for the annual sun paths, monthly solar access and shading obstruction elevation vs. azimuth.

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=181°**
GPS Location: Latitude=50.70048°N -- Longitude=119.27926°W
Solar Access: Annual: 99% -- Summer (May-Oct): 100% -- Winter (Nov-Apr): 98%

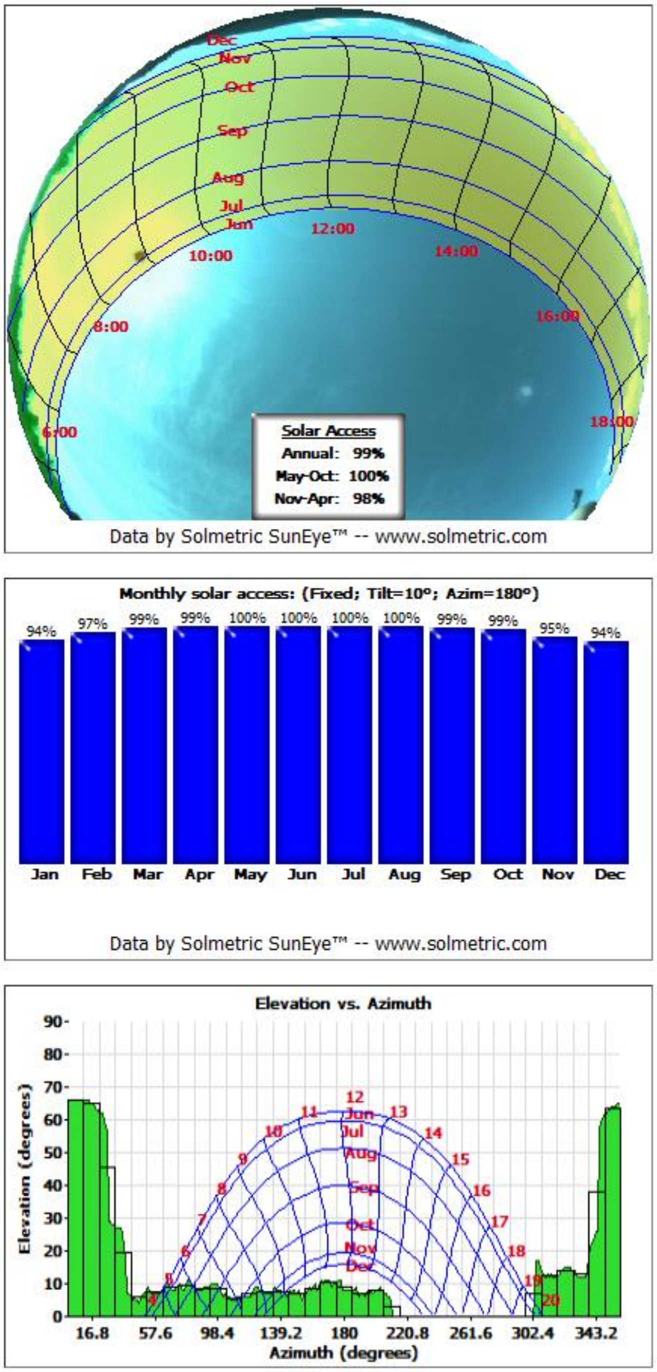


Figure 8: City Hall South West Roof Solar Access

2.1.6 City Hall – Patio Location 1 & 2

Figure 9 shows the charts for the annual sun paths, monthly solar access and shading obstruction elevation vs. azimuth.

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=176°**
GPS Location: Latitude=50.70038°N -- Longitude=119.27910°W
Solar Access: Annual: 95% -- Summer (May-Oct): 96% -- Winter (Nov-Apr): 94%

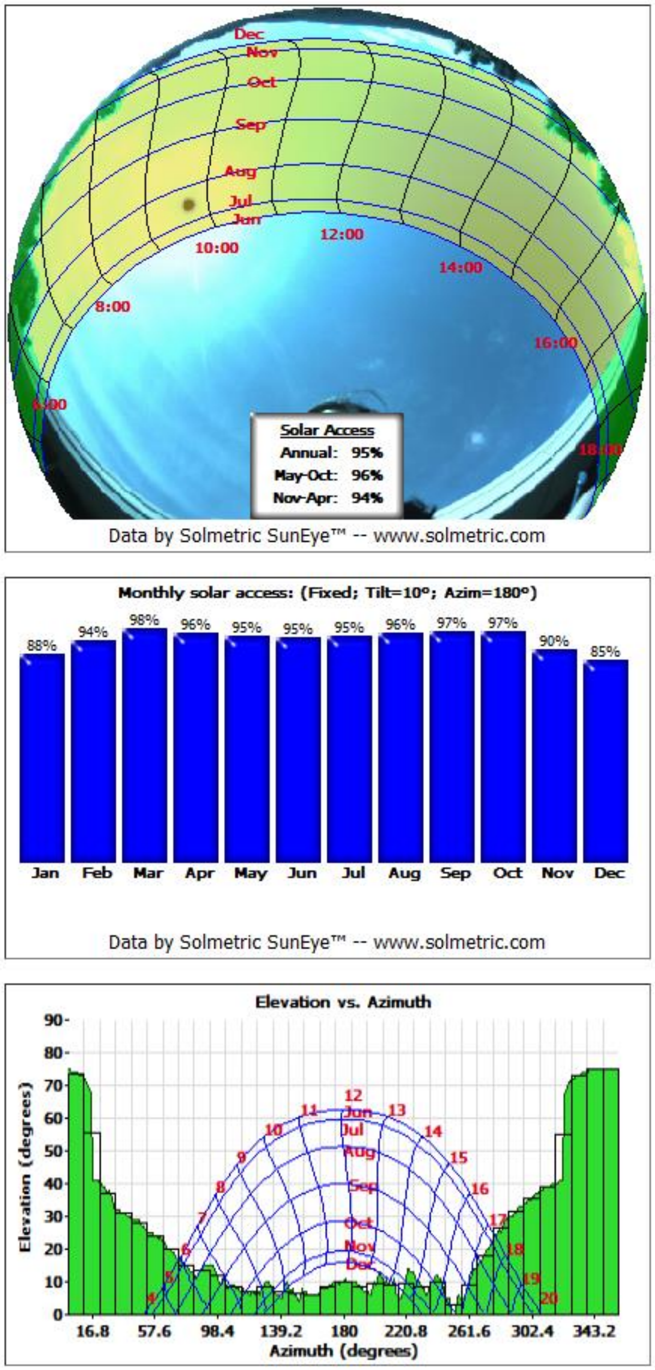


Figure 9: City Hall Patio Solar Access

2.1.7 City Hall – Parking Lot Location 1 & 2

Figure 10 shows the charts for the annual sun paths, monthly solar access and shading obstruction elevation vs. azimuth. Solar access scores are significantly reduced by existing trees and lamp standards.

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=183°**
GPS Location: Latitude=50.70002°N -- Longitude=119.27898°W
Solar Access: Annual: 80% -- Summer (May-Oct): 89% -- Winter (Nov-Apr): 61%

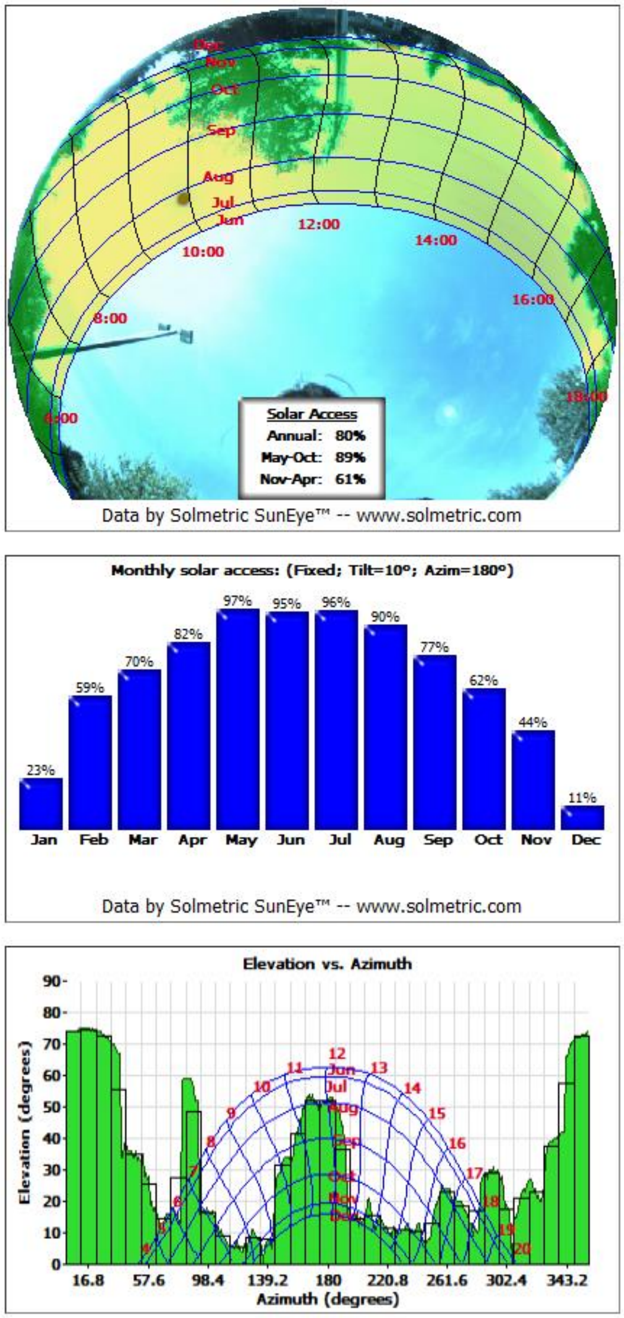


Figure 10: City Hall Parking Lot Solar Access

If a solar parking shelter were considered, we would advise the relocation of trees and lamp standards to reduce shading impacts. Figure 11 shows the significantly improved solar access scores for this location if shading by trees and lamp standards could be reduced.

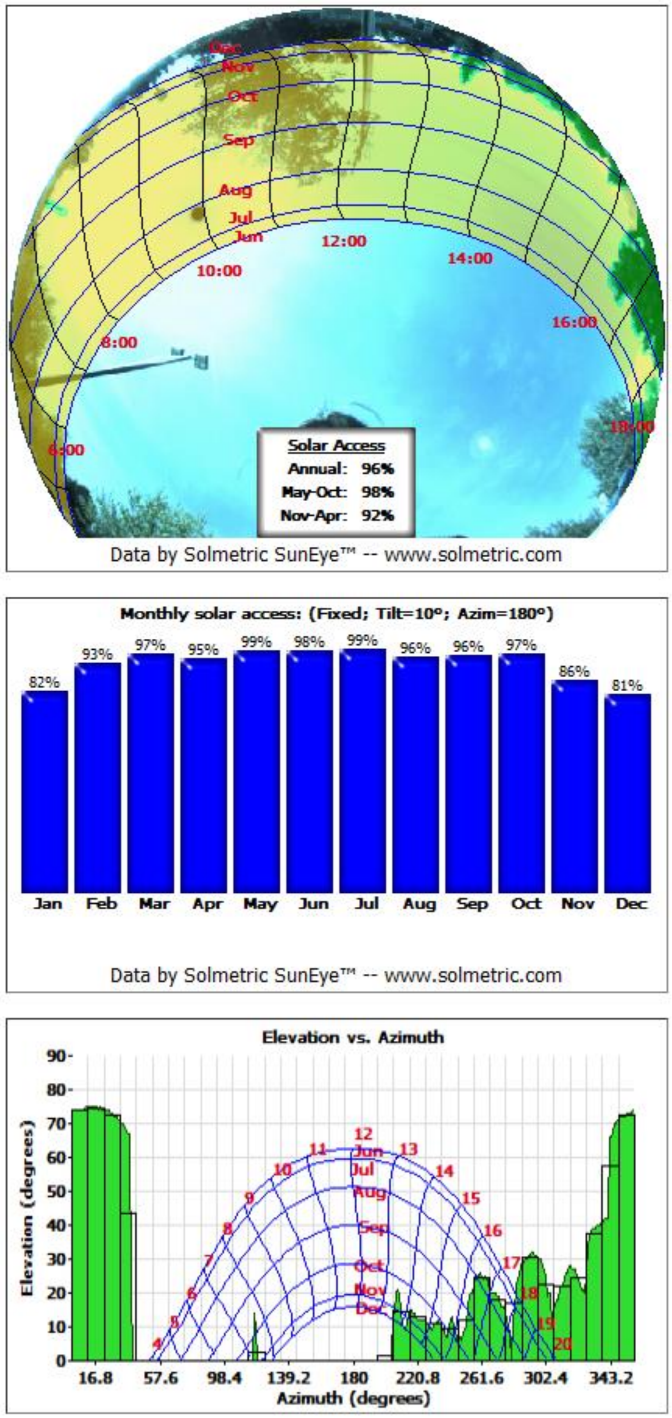


Figure 11: City Hall Parking Lot Solar Access with Shading Obstacles Removed

2.2 City Hall Array Placement, Sizing, and Mounting Options

The City Hall roof is extensive and will allow for varied PV array sizes and placement options as further described below. We have also considered patio solar canopy and solar parking shelter options which may be of interest in the future.

2.2.1 Roof Mounting Options and Considerations

The City Hall roof is extensive and will allow for varied PV array sizes and placement options. As shown in Figure 12, the majority of the roof is flat with two sections sloped at 5°; still considered flat for solar racking purposes. The surface of the roof is finished with an SBS torch-on membrane.

Figure 12: City Hall Roof Sections

Retrofitting solar PV to flat roofs is most easily done with ballasted racking systems provided the roof structure can safely manage the additional load. Ballasted racking secures arrays to the roof with carefully engineered concrete block ballast placement to meet site wind and seismic load requirements. Advantages of ballasted racking include ease of installation and minimizing roof membrane penetrations. Appendix A shows some examples of solar PV installations using ballasted racking.

A professional structural review would be needed to confirm targeted city hall roof sections can manage the impacts of solar arrays and proposed ballasted racking designs.

We considered maximum solar PV array sizes and placements suitable for the city hall roof while respecting roof edge safety and mechanical equipment maintenance clearances. As shown in Figure 13, our measurements and rooftop models suggest in the order of 296 solar PV modules (72 cell or 144 split cell types) could be accommodated. Figure 14 further breaks down PV capacity by roof section assuming the use of 365W solar modules.

We suggest sections 3 or 4 for initial installation of a small demonstration PV system. These are nearest the roof hatch and most safely accessed if installation tours were a consideration. Careful installation planning would allow ease of future expansion if desired. Subject to structural review, City Hall roof has sufficient PV array space to meet the current BC Hydro Net-Metering program limit of 100 kW_{AC} capacity. However, building electrical distribution equipment will limit this to 90 kW_{AC} as discussed in section 2.3.

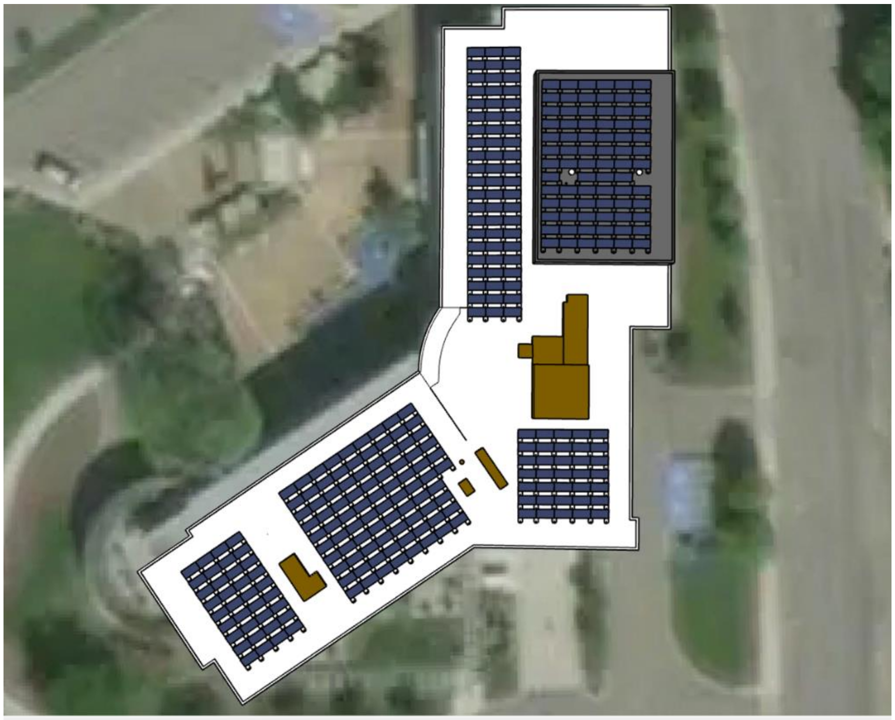
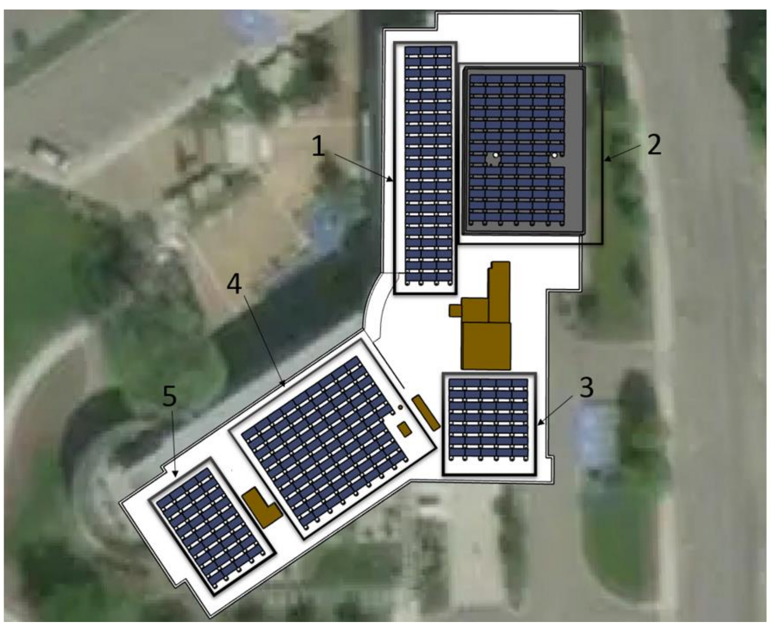


Figure 13: City Hall Roof – Maximum Solar PV Array Placement



Section #	# of Solar Panels	Total power (kWp)
1	63	23
2	76	27.7
3	35	12.8
4	86	31.4
5	36	13.1
TOTAL	296	108

Figure 14: City Hall Roof-top Breakdown of Solar PV Array Capacities

2.2.2 Patio Canopy and Parking Shelter Solar PV Options and Considerations

Alternatives to roof mounting for future consideration would be 2nd level patio canopies, and ground level parking shelters. Figure 15 and Figure 16 show the 2nd Level West and South patio locations while Figure 17 provides some examples of solar PV patio awning installations. Solar photography results previously shown in Figure 9 confirm the patio areas have excellent solar access scores.

Figure 15: Level 2 West Patio

Figure 16: Level 2 South Patio Areas

Parking lots on the south side of the building could be considered for solar parking shelters in the future provided shading were mitigated to improve solar access as shown in Figure 11. EV charging stations are frequently installed concurrently with solar parking structures to allow harvesting vehicle fuel from the sun. Figure 18 shows the City Hall south parking areas along with an example solar PV parking structure.

Example array layouts for 19.5 kWp total solar patio canopy capacity and a 20 kWp solar parking shelter are shown in Figure *19*.

Figure 17: Solar Patio Awning Examples

Figure 18: City Hall South Parking Area and a Solar Parking Shelter Example

Figure 19: Example 19.5 kWp Solar Canopy and 20 kWp Parking Shelter Capacities

2.3 City Hall Solar Electrical Review

The electrical single-line drawing provided us for City Hall is included in Appendix B. BC Hydro grid supply enters the MDC (main distribution centre 1600A, 120/208V, 3P) in the mail electrical room 004, on the parkade level. The MDC supplies two sub-distribution centres (600A, 120/208V, 3P) SDC1 and SDC2 respectively in electrical rooms 138 (level 1) and 226 (level 2). SDC1 powers level 1 sub-panels 1A through 1G (excepting 1C) while SDC2 powers level 2 sub-panels 2A through 2F (excepting 2B).

Electrical rooms 004, 138, and 226 are directly aligned over/below each other with supply cable routing vertically through electrical room floor slabs as shown in Figure 20. While we were not able to enter it, the rooftop mechanical penthouse also appears to be aligned over room 226 below. Vertical alignment of rooms 004, 138, 226, and mechanical penthouse will simplify future solar PV cabling to the rooftop, though some floor slab coring may be required if existing cores cannot be utilized.

Figure 20: Electrical Cable Ceiling Slab Cores – Main Electrical Room 004

An emergency backup generator, auto-transfer switch, and emergency distribution panel have been added, but are not shown on the single-line. Based on our inspection, it appears supply has been reconfigured for sub-panels 2B and 1C to keep them powered via generator emergency panel during BC Hydro outages. Panels backed up by emergency generator should be avoided as a solar PV points-of-connection as grid-dependent solar PV inverters are not intended for parallel operation with emergency generation.

Based on panel locations, bus capacities, CEC Section 64 requirements, and cable access to rooftop arrays, we recommend distribution panels MDC (room 004), SDC1 (room 138), sub-panel 1A (room 138), or SDC2 (room 226) as suitable points-of-connection to the grid for solar PV generation. These allow maximum grid-connected solar PV generation up to 90 kWAC using MDC, 32.4 kWAC using SDC1 or SDC2, or 18 kWAC using sub-panel 1A as summarized in Table *2*.

Figure 21: MDC - Room 004 – Spare Breaker Positions

Figure 22: SDC1 (Room 138) and SDC2 (Room 226) Spare Breaker Positions

Solar PV Point-of-Connection	Rated Bus Capacity (Amps)	Grid Supply CB (Amps)	Max Solar PV CB (Amps)	Max Solar PV Generation kWAC
MDC - 004	1600	1600	250	90
SDC1 - 138	600	600	90	32.4
SDC2 - 226	600	600	90	32.4
SP 1A - 138	225	200	50	18

Table 2: Points-of-Connection and Associated Maximum Allowable Solar Generation

The BC Hydro Net-Metering program requires a single point-of-connection for on-site grid-connected generation. Sub-panel 1A would provide sufficient capacity for a 4-10 kWp demonstration project presently under consideration. However, given the extensive roof space and alternate PV options, the MDC would be a more advisable point-of-connection if providing for simplified future expansion is important to the City.

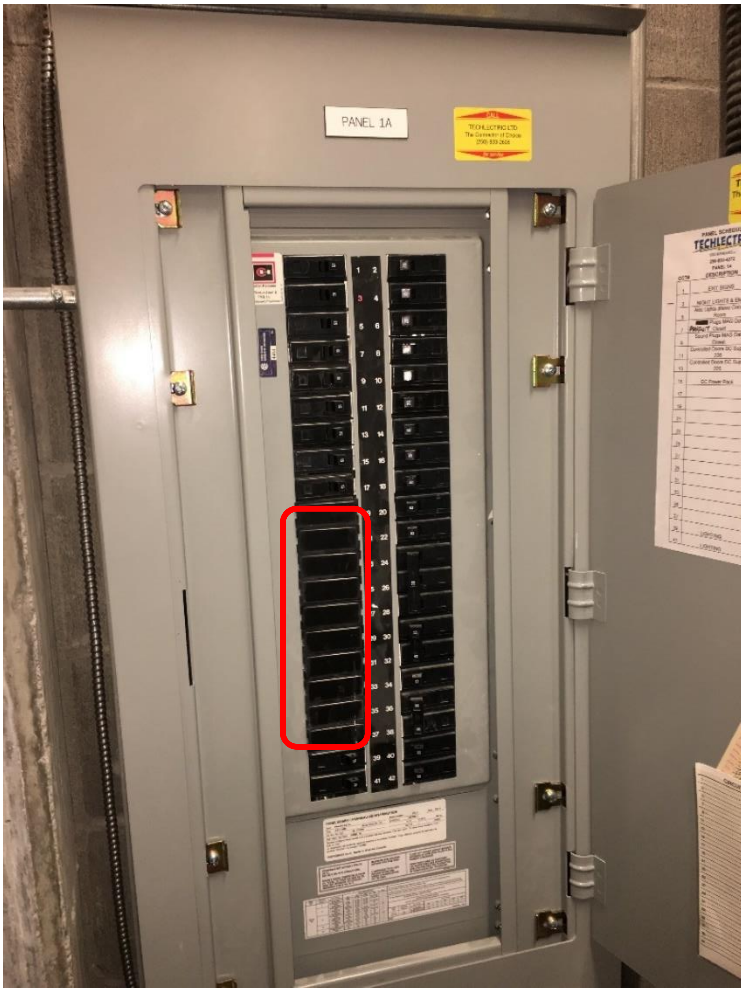


Figure 23: Sub-Panel 1A (Room 138) Spare Breaker Positions

2.4 City Hall Electrical Consumption and Demand

BC Hydro service is under the 1600 Large General Service (LGS) rate. Along with the basic energy charge there is also a demand charge corresponding to monthly peak demand (15-min sliding window). Power factor surcharges also apply if power factor drops below 90%. Rate 1600 energy and peak demand charges are $0.0606/kWh and $12.34/kW respectively at the time of writing. We were provided City Hall 2018 monthly consumption and peak demand for which are shown in Table 3 and Table 4.

Annual electrical consumption for the building was approximately 574,560 kWh. Based on the 2019 LGS rates City Hall annual electrical energy cost is about $34,818.

Month	Consumption (kWh)	Consumption Charges	Consumption Charges with GST
January	54,240	$3,287	$3,451
February	50,880	$3,083	$3237
March	45,600	$2,763	$2,902
April	40,800	$2,472	$2,596
May	46,560	$2,822	$2,963
June	44,160	$2,676	$2,810
July	52,800	$3,200	$3,360
August	47,520	$2,880	$3,024
September	48,960	$2,967	$3,115
October	41,040	$2,487	$2,611
November	47,760	$2,894	$3,039
December	54,240	$3,287	$3,451
TOTAL	**574,560**	**$34,818**	**$36,559**

Table 3: City Hall 2018 Monthly Consumption

Monthly demand peaks are in the range 53 – 156 kW with resulting demand charges $654 - $1925. Highest demand peaks were May through Aug due to space cooling.

Month – Date - Year	Peak Demand (kW)	Demand Charges	Charges with GST
February 21, 2018	122	$1505	$1,581
March 13, 2018	109	$1345	$1,412
May 7, 2018	117	$1444	$1,516
May 24, 2018	137	$1691	$1,775
June 20, 2018	149	$1839	$1,931
July 30, 2018	156	$1925	$2,021
August 9, 2018	154	$1900	$1,995
September 27, 2018	55	$679	$713
October 23, 2018	107	$1320	$1,386
December 3, 2018	53	$654	$687

Table 4: City Hall 2018 (February - December) Peak Demand

2.5 City Hall Solar PV Harvests and Energy/Demand Impacts

Based on solar access measurements and local insolation levels (NRCAN Municipal Insolation database), south facing City Hall roof sections could be conservatively expected to harvest in the order of 1160 kWh/year for each 1 kWp of solar PV installed.

Projected solar energy harvests per year, 2019 value of these harvests, and BC Hydro consumption reduction for the building are summarized in
Table 5 for solar PV system sizes discussed in section 2.2 and shown in Figure 14. Note that value of harvested solar PV energy will increase with any future BC Hydro rate increases.

Location & PV System Size	Energy Harvest (kWh/yr)	Energy Savings ($/yr) at 2019 Rates + GST	BC Hydro Consumption Reduction
North Roof - Section 1 (23 kWp)	26,680	$1698	5%
North Roof - Section 2 (27.7 kWp)	32,132	$2045	6%
South Roof – Section 3 (12.8 kWp)	14,848	$945	3%
South Roof – Section 4 (31.4 kWp)	36,424	$2318	6%
South Roof – Section 5 (36 kWp)	41,760	$2657	7%
MDC Limit – (108 kWp/90 kWAC)	125,280	$7972	22%

Table 5: City Hall Solar Harvests, Energy Savings and Consumption Impacts

Building peak demand and associated charges are significant May-Sep; months during which solar PV works best at our latitude. These are almost certainly due to space cooling load which tends to peak late afternoon, while solar PV generation tends to peak mid day. Particularly with a larger PV system, solar might assist in shaving late afternoon cooling demand peaks; further increasing savings. For example, peak shaving of 10 kW monthly May-Sep would save an additional $648 (after tax) annually.

Since BC Hydro metering logs date but not time-of-day of monthly demand peaks, solar PV related peak shaving benefits cannot be predicted with confidence. Intentional peak shaving with PV systems requires battery storage be incorporated to allow intentional dispatching of stored solar energy in real time as demand peaks occur.

2.6 City Hall Solar PV Installations Budget Costing

Approximate installed budget costing for selected City Hall PV systems is summarized in
Table 6. Note that solar PV systems are PST exempt in BC.

PV System Size and Location	Budget Installation Cost (Excluding Taxes)
Rooftop 4 kWp Demonstration System	$10,600 ($2.65/Watt)
Rooftop 10 kWp Demonstration System	$24,000 ($2.40/Watt)
Rooftop 36 kWp	$82,800 ($2.30/Watt)
Rooftop 108 kWp	$221,400 ($2.05/Watt)
Patio Canopy 9 kWp Demonstration System	$31,500 ($3.50/Watt)
Patio Canopies 19.5 kWp	$67,275 ($3.45/Watt)
Parking Shelter 20 kWp	$75,000 ($3.75/Watt)

Table 6: Approximate Installed Costing for Selected City Hall Solar PV Systems

2.7 City Hall Solar PV Feasibility Conclusions

Rooftop array locations will provide excellent performance, initially hosting a smaller demonstration system while ultimately accommodating about 108 kWp PV maximum capacity in the future. With the BC Hydro LGS Rate 1600 applying, energy is valued at $0.0606/kWh; much less than SGS Rate 1300 ($0.1139/kWh) in force for Fire Hall No. 3 and the Art Centre.

Projected key metrics for a 4 – 10 kWp rooftop demonstration solar PV system include:

- BC Hydro grid energy consumption reduction by 0.8% – 2.0%
- Before tax annual electrical energy cost savings of $281 - $703 (at 2019 rates)
- Before tax (GST only) estimated installation costs of $10,600 - $24,000

Projected key metrics for an ultimate 108kWp rooftop solar PV system include:

- BC Hydro grid energy consumption reduction by 22%
- Before tax annual electrical energy cost savings of $7972 (at 2019 rates)
- Before tax (GST only) estimated installation costs of $221,400

Solar patio canopy and parking shelter options would also be viable as discussed; though at considerably higher cost per watt than roof mounting.

Building electrical infrastructure has capacity to accommodate a 4 – 10 kWp demonstration system using sub-panel 1A (room 138) as the point-of-connection to the grid. In support of simplified future expansion, using MDC (room 004) as the point-of-connection accommodates initial small demonstration systems through to a future ultimate 108kWp rooftop capacity. Projected costs assume roof structures can accommodate the additional deadload associated with ballasted racking systems. A professional structural review is required to verify whether a ballasted racking strategy would be acceptable.

3. Fire Hall No.3

Salmon Arms Fire Hall No.3 is located at 141 Ross Street NE shown in Figure 24. The two flat roof sections have many obstacles (vents, mechanical equipment, antennas, etc) that will restrict placement of solar PV and create undesirable shading. However, solar installation would still be possible in the less congested and more shade-free areas of the roof. More details are given below.

Figure 24: Fire Hall No.3 Building

3.1 Fire hall Solar Photography

We performed solar photography with the Solmetric SunEye 210 at rooftop locations shown in Figure 25 judged to be suitable for solar PV array placement. Significant seasonal variation occurs at North Locations 1 and 2 because of shading by the hose tower roof access structure. Further details are discussed in the next sections. The solar access results are summarized in Table 7.

Location	Annual	Summer	Winter
North Location 1	96%	99%	89%
North Location 2	85%	93%	69%
North Location 3	93%	96%	86%
North Location 4	98%	99%	95%
South	99%	99%	98%

Table 7: Fire Hall No.3 Solar Access Results

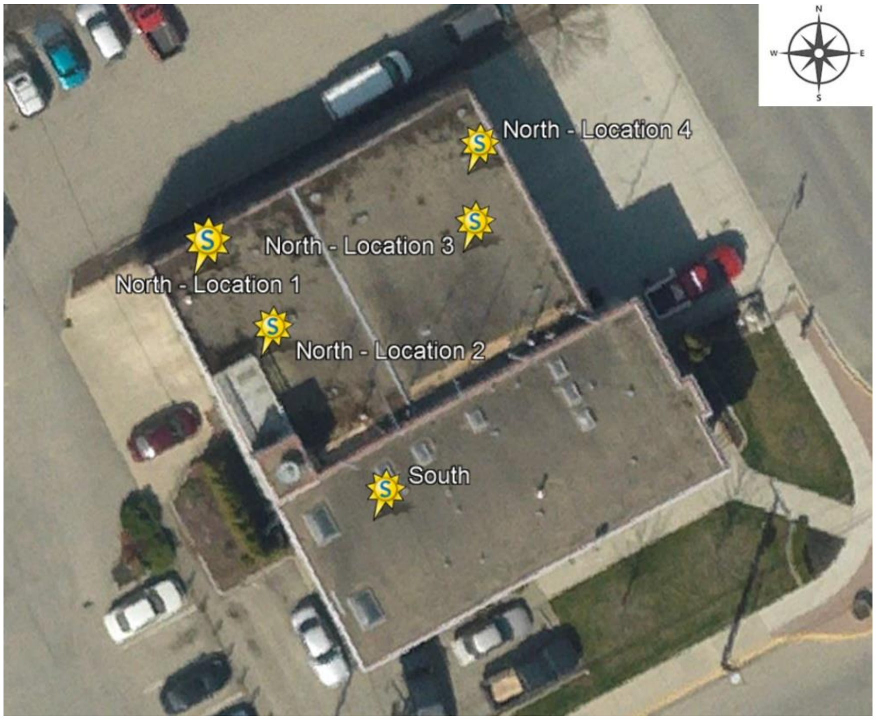


Figure 25: Fire Hall No.3 Building Solar Photography Sites

3.1.1 Fire Hall No.3 – North Location 1

Figure 26 shows the charts for the annual sun paths, monthly solar access and shading obstruction elevation vs. azimuth. Reduction in winter solar access score is due to the shading caused by the nearby roof access and antennas.

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=180°**
GPS Location: Latitude=50.70092°N -- Longitude=119.28090°W
Solar Access: Annual: 96% -- Summer (May-Oct): 99% -- Winter (Nov-Apr): 89%

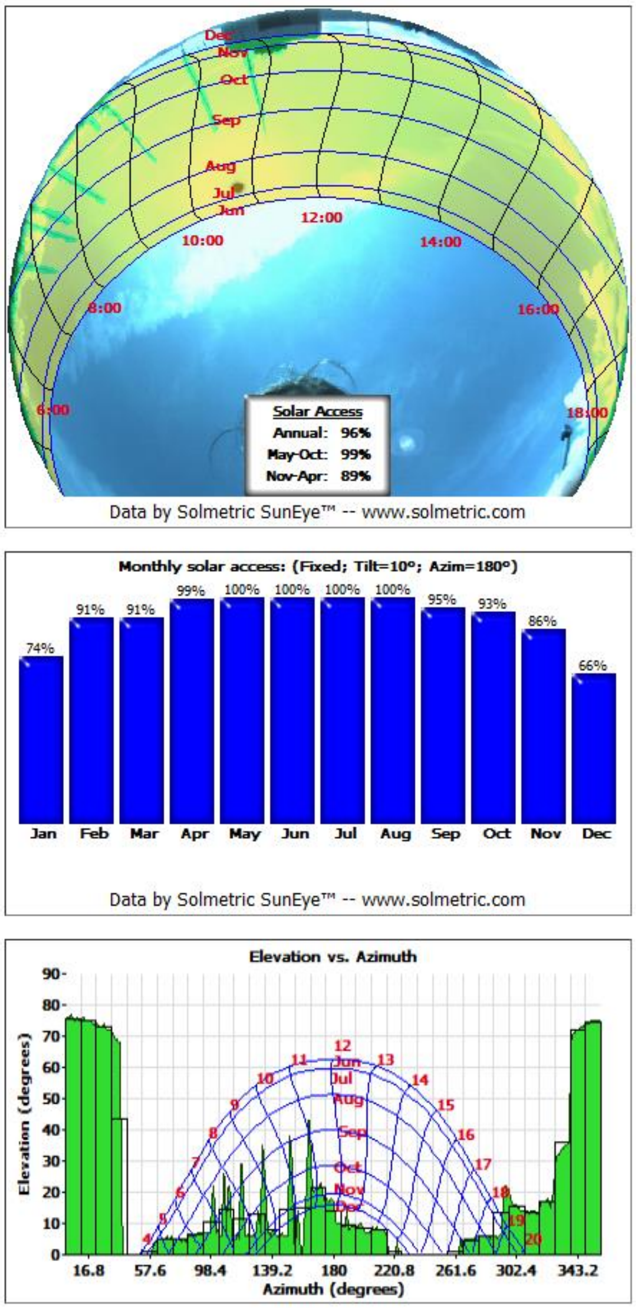


Figure 26: Fire Hall No.3 North Roof Location 1 Solar Access

3.1.2 Fire Hall No.3 – North Location 2

Figure 27 shows the charts for the annual sun paths, monthly solar access and shading obstruction elevation vs. azimuth. Comparing to North Location 1, annual scores are significantly reduced due to winter shading from the roof access structure. We consider this an undesirable solar PV location.

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=181°**
GPS Location: Latitude=50.70088°N -- Longitude=119.28084°W
Solar Access: Annual: 85% -- Summer (May-Oct): 93% -- Winter (Nov-Apr): 69%

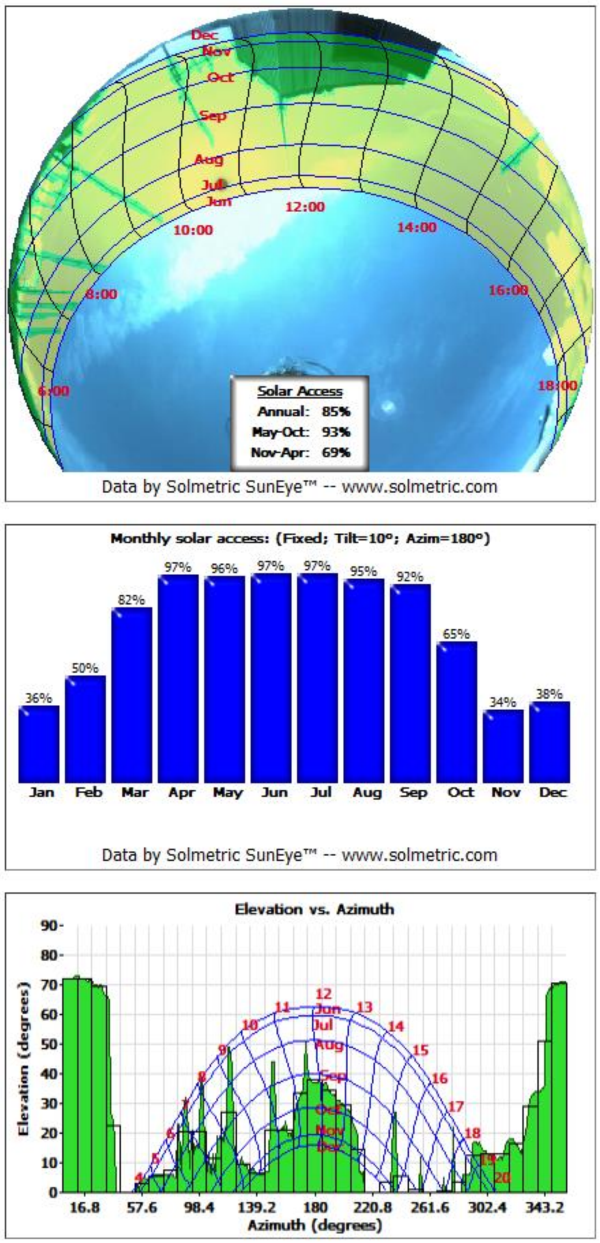


Figure 27: Fire Hall No.3 North Roof Location 2 Solar Access

3.1.3 Fire Hall No.3 – North Location 3

Figure 28 shows the charts for the annual sun paths, monthly solar access and shading obstruction elevation vs. azimuth. Winter solar access score is reduced by nearby antennas; though annual score remains very good.

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=179°**
GPS Location: Latitude=50.70094°N -- Longitude=119.28068°W
Solar Access: Annual: 93% -- Summer (May-Oct): 96% -- Winter (Nov-Apr): 86%

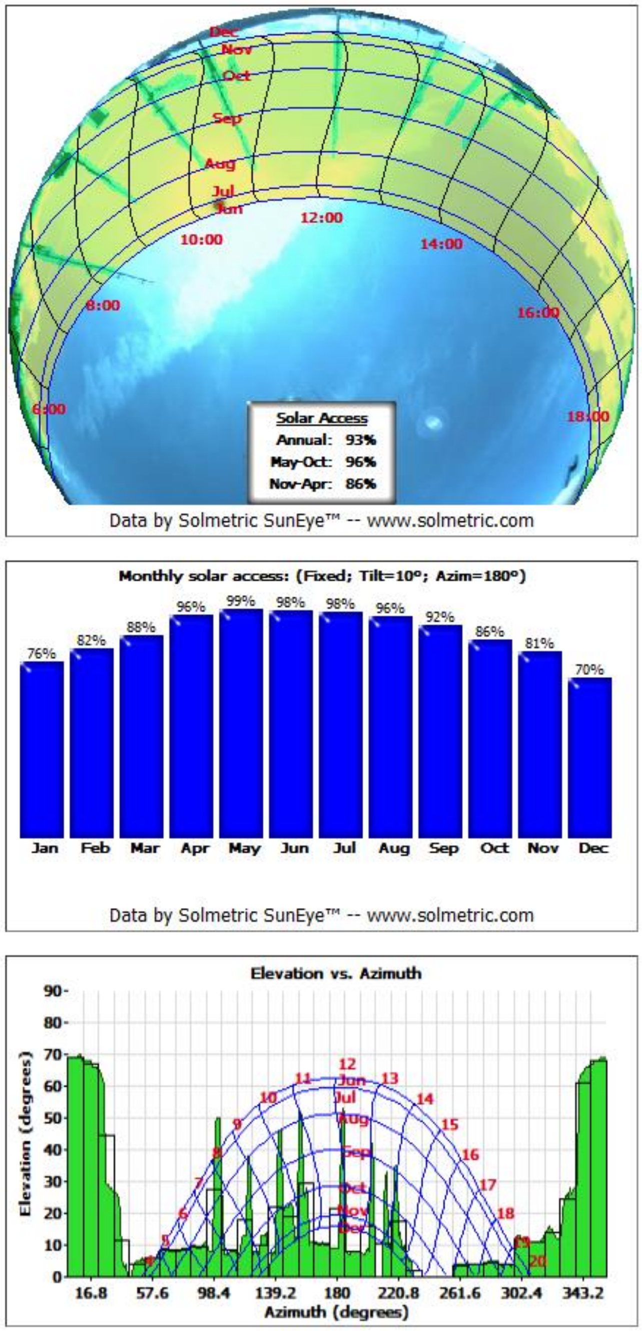


Figure 28: Fire Hall No.3 North Roof Location 3 Solar Access

3.1.4 Fire Hall No. 3 – North Location 4

Figure 29 shows the charts for the annual sun paths, monthly solar access and shading obstruction elevation vs. azimuth. Comparing to North Location 3 , scores are improved by increasing distance to nearby antennas; thus reducing their shading impact.

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=178°**
GPS Location: Latitude=50.70098°N -- Longitude=119.28068°W
Solar Access: Annual: 98% -- Summer (May-Oct): 99% -- Winter (Nov-Apr): 95%

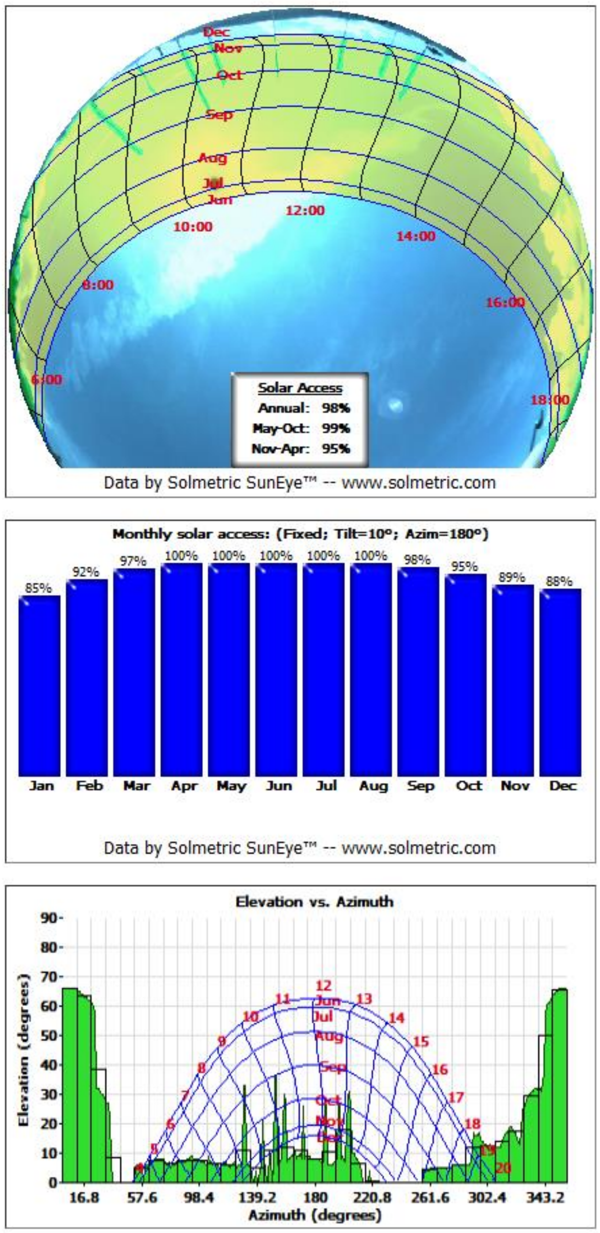


Figure 29: Fire Hall No.3 North Roof Location 4 Solar Access

3.1.5 Fire Hall No. 3 – South

Figure 30 shows the charts for the annual sun paths, monthly solar access and shading obstruction elevation vs. azimuth. While scores are excellent, array space is limited.

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=182°**
GPS Location: Latitude=50.70080°N -- Longitude=119.28074°W
Solar Access: Annual: 99% -- Summer (May-Oct): 99% -- Winter (Nov-Apr): 98%

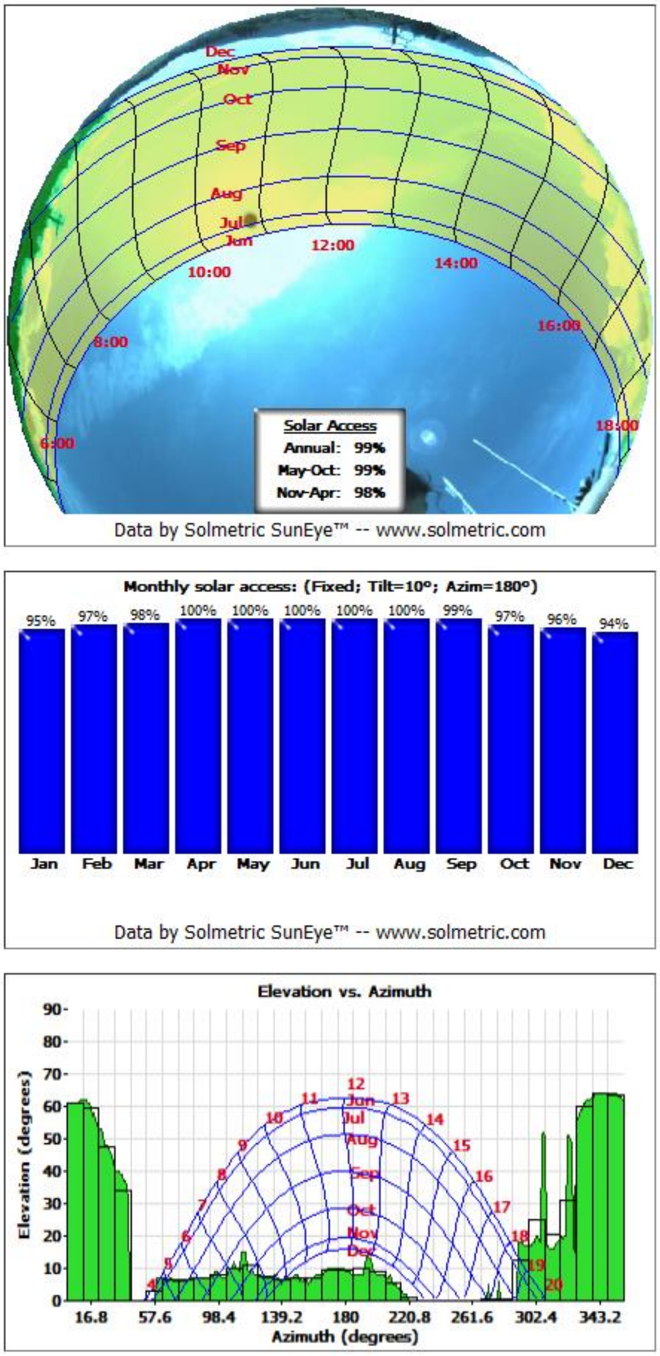


Figure 30: Fire Hall No.3 South Roof Solar Access

3.2 Fire Hall No.3 Array Placement, Sizing, and Mounting Options

Fire Hall No.3 has significant roof obstacles that will limit solar array placement; some of which also cause noteworthy shading. The south roof has excellent shading scores but considerably more constrained placement options than the north roof.

Figure 31 shows north roof obstructions which include antennas, roof access and vents. Solar photography shows north locations 3 and 4 to be the best placement choice for demonstration systems 4 – 10 kWp. Usable south roof space limits system size to in the order of 3.6 kWp.

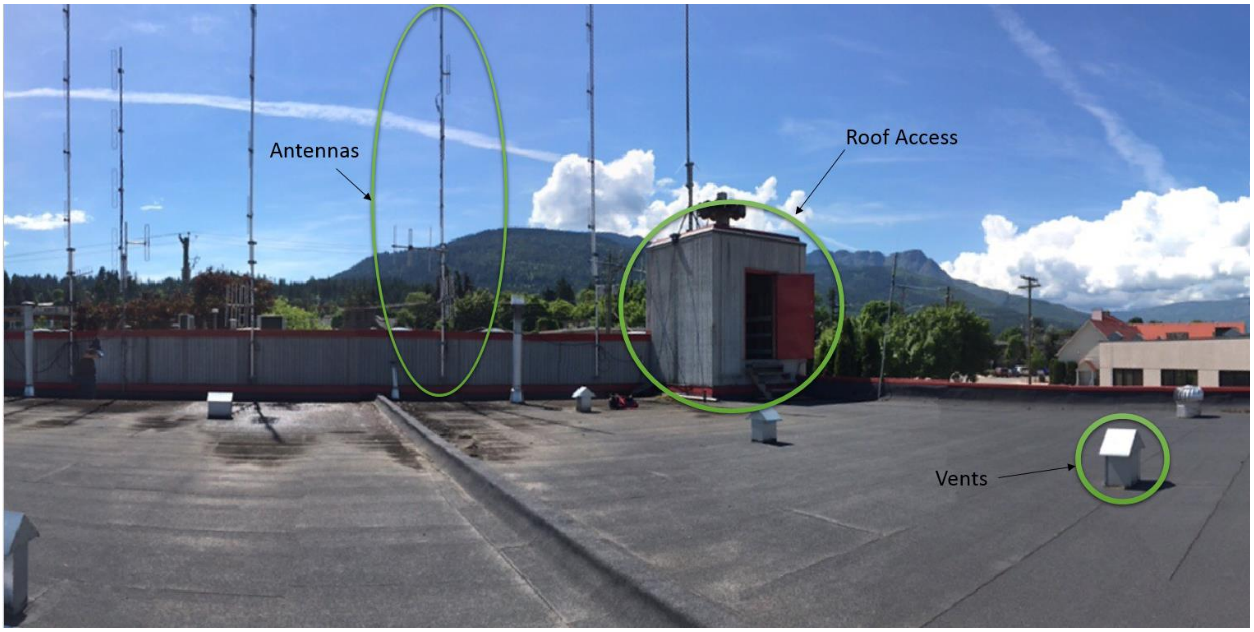


Figure 31: Fire Hall No.3 North Roof Obstructions

Figure 32 shows obstructions which include skylights, vents, and heat exchangers that significantly limit PV array placement and size on the south roof.

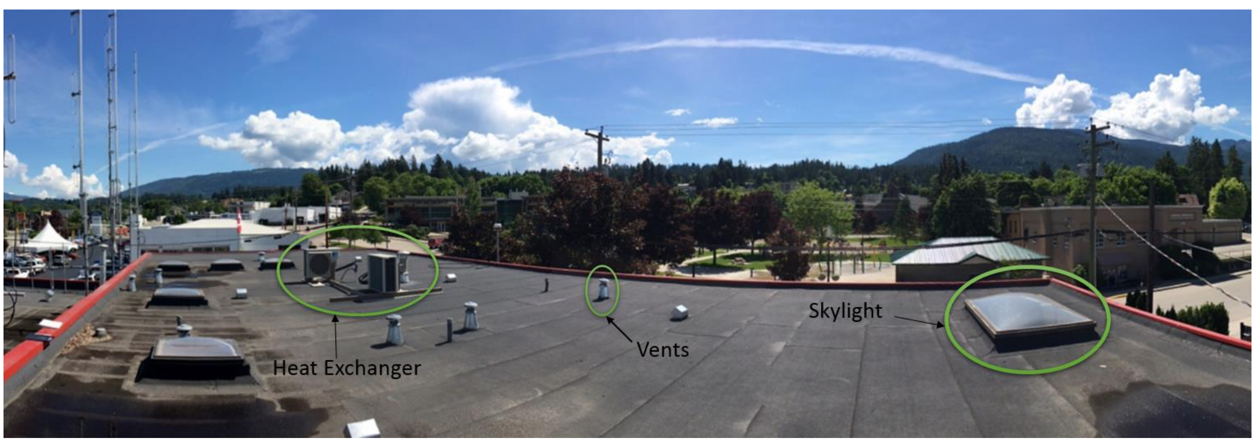
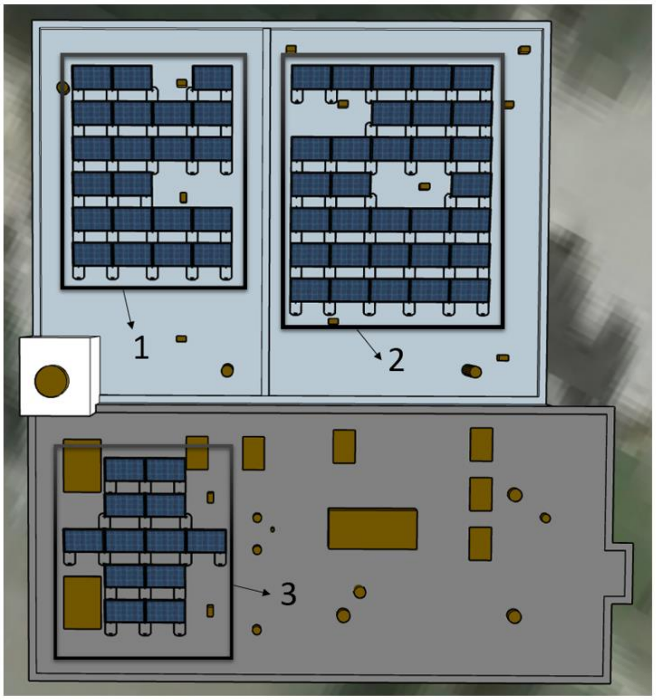


Figure 32: Fire Hall No.3 South Roof Obstructions

The roofs are flat and finished with SBS torch on material which is significantly older in appearance than city hall. Retrofitting solar PV to Fire Hall No. 3 would be most easily done with ballasted racking provided the roof structure can safely manage the additional load. See Appendix A for examples of solar PV installations using ballasted racking.

Based on our site measurements and approximate rooftop models, the fire hall roof can accommodate about 64 solar PV modules (60 cell type) in 3 sub-array sections as shown in Figure 33. Array power capacities are based on 300 W solar modules.



Section #	# of Solar Panels	Total Power (KWp)
1	21	6.3
2	31	9.3
3	12	3.6
TOTAL	64	19.2

Figure 33: Fire Hall No.3 Rooftop Solar PV Array Placements and Capacities

Due to shading constraints, section 1 will be the least desirable. For demonstration systems 4 – 10 kWp we suggest section 2 as the best starting option, keeping modules as far north of the antennas as possible to minimize shading impacts. Expansion into sections 1 and 3 could be considered in future for up to 19.2 kWp ultimate capacity.

3.3 Fire Hall No.3 Solar Electrical Review

Electrical drawings were not available. An approximate electrical single line drawing based on our inspection is shown in Figure *34*.

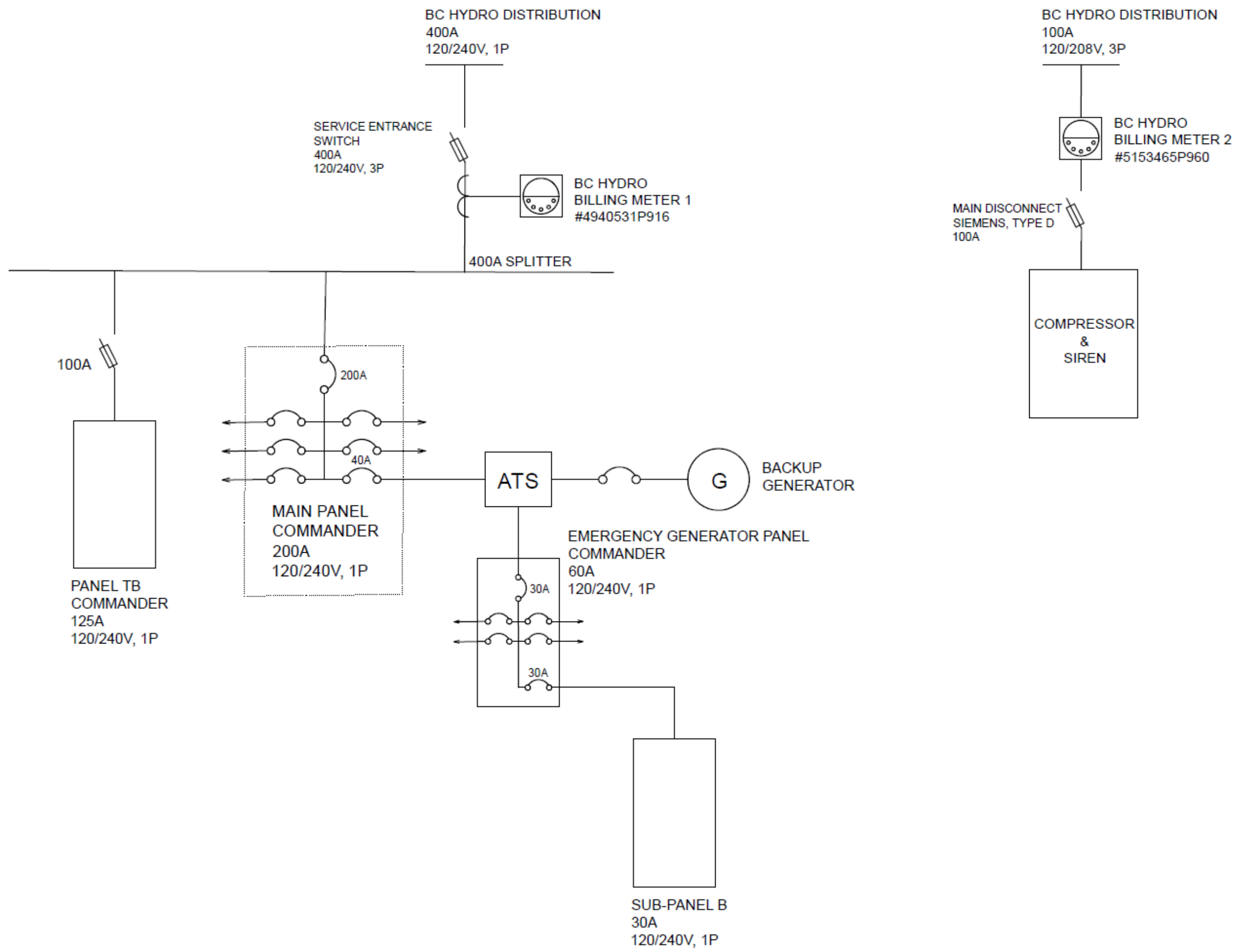


Figure 34: Fire Hall No. 3 Approximate Electrical Single Line Diagram

The building is supplied by two separate BC Hydro services. The main service is 120/240VAC, single phase, 400A via meter 1; supplying the main panel located in the electrical room and the truck bay panel (TB) as shown in Figure *35*. The 2nd service via BC Hydro meter 2, is 120/208VAC, 3-phase, 100A and supplies compressor and siren systems as shown in Figure *36*.

Table 8 summarizes locations and meter serial numbers for each of the billing meters.

BC Hydro Meter	Location	Serial Number
1	Main electrical room	4940531P916
2	Truck bay for compressor and siren	5153465P960

Table 8: Fire Hall BC Hydro Meter Information

An Automatic Transfer Switch (ATS) in the main electrical room maintains supply to the Emergency Panel via an outdoor backup generator in the case of BC Hydro outages. The Emergency Panel should be avoided as a solar PV point-of-connection as grid-dependent solar PV inverters are not intended for parallel operation with backup generation.

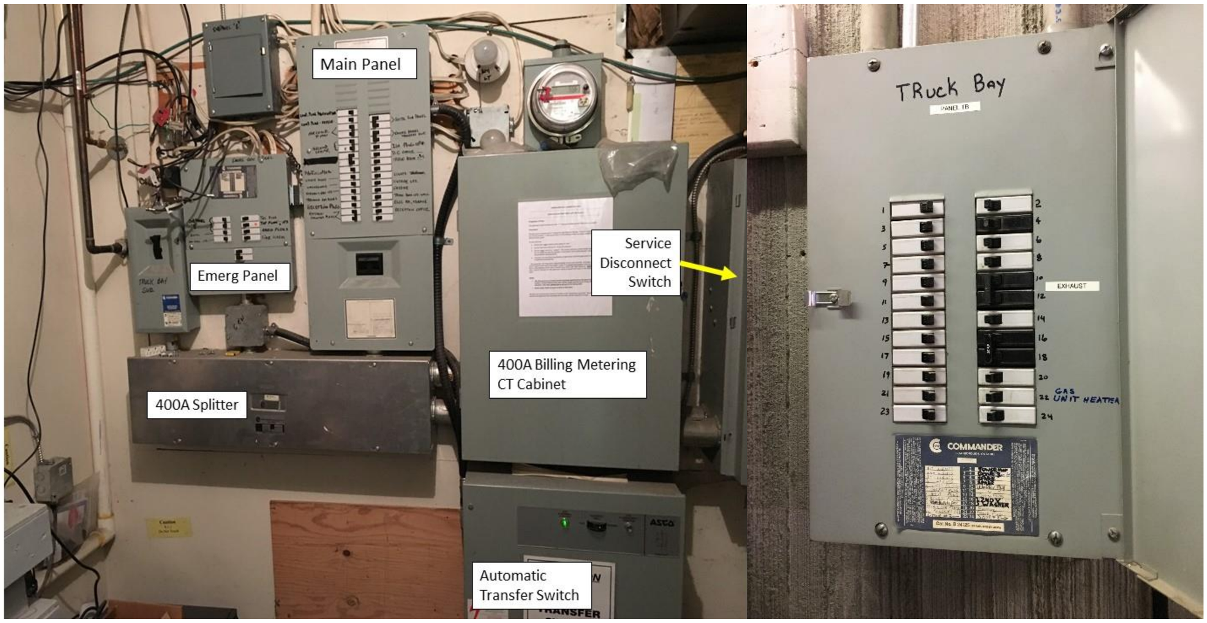


Figure 35: Fire Hall Single Phase Main Service and Sub-Panel TB

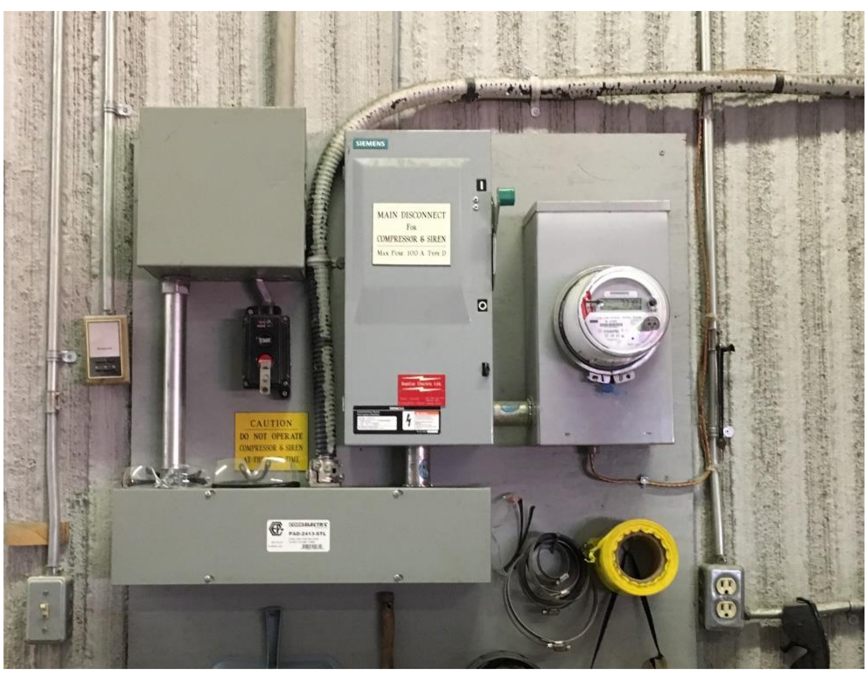


Figure 36: Fire Hall 3-Phase Service

Only the single-phase service is acceptable as a solar PV point-of-connection under the BC Hydro Net-Metering program as the 3-phase service is much too lightly loaded. Based on panel locations, bus capacities, CEC Section 64 requirements, and cable access to rooftop arrays, the 400 Amp splitter in the main electrical room is presently the most viable point-of-connection for a demonstration system 4 -10 kWp or a future ultimate 19.2 kWp system. By upgrading to a 200 Amp version, panel TB in the truck bay could also be suitable for a demonstration system. Cable routing to the rooftop would be simplified if the hose tower could be used for this purpose.

3.4 Fire Hall No.3 Electrical Consumption

BC Hydro provides single-phase service (via meter 1 #4940531P916) and 3-phase service (via meter 2 #5153465P960) to the building under the Small General Service (SGS) Rate 1300; energy charges of $0.1139/kWh at time of writing.

We were provided monthly consumption information for 2018 which is shown in Table 9 for meter 1 and Table 10 for meter 2. Meter 1 electrical consumption was approximately 36,060 kWh in 2018; a $4,107 cost before taxes at present rates. Meter 2 consumption was on the other hand only 305 kWh in 2018; a $34 cost before taxes.

Bi-Monthly	Consumption (kWh)	Consumption Charges	Consumption Charges with GST
January	6,780	$722	$811
March	5,760	$656	$689
May	5,460	$622	$653
July	6,060	$690	$725
September	6,360	$724	$761
November	5,640	$642	$675
TOTAL	36,060	$4107	$4313

Table 9: Fire Hall 2018 Monthly Consumption for Meter 1

Bi-Monthly	Consumption (kWh)	Consumption Charges	Consumption Charges with GST
January	55	$6.26	$6.58
March	44	$5.01	$5.26
May	41	$4.67	$4.90
July	76	$8.66	$9.09
September	47	$5.35	$5.62
November	42	$4.78	$5.02
TOTAL	305	$34.74	$36.48

Table 10: Fire Hall 2018 Monthly Consumption for Meter 2

3.5 Fire Hall No.3 Solar PV Harvests and Energy Impacts

Based on solar access measurements and local insolation levels, south facing Fire Hall roof sections could be conservatively expected to harvest in the order of 1160 kWh/year for each 1 kWp of solar PV installed.

Projected solar energy harvests per year, present value of these harvests, and the impacts on BC Hydro consumption for the single-phase service (meter 1) are summarized in Table 11 for example demonstration systems (4 – 10 kWp) using roof sections discussed in section 3.2 (Figure 33). Note that the value of harvested solar PV energy will increase with BC Hydro rate increases.

Location & PV System Size	Energy Harvest (kWh/yr)	Energy Savings ($/yr) at 2019 Rates + GST	BC Hydro Consumption Reduction - Meter 1
North Roof - Section 2 (4.2 kWp)	4,872	$583	13%
North Roof - Section 2 (9.3 kWp)	10,788	$1290	30%
North Roof – Section 2 and 1 Partial (10.2 kWp)	11,832	$1415	33%
Maximum Rooftop 19.2 kWp	22,272	$2664	62%

Table 11: Fire Hall Solar Harvests, Energy Savings and Consumption Impacts

3.6 Fire Hall No.3 Solar PV Installations Budget Costing

Approximate installed budget costing for example Fire Hall No. 3 PV demonstration systems 4 – 10 kWp systems and ultimate capacity is summarized in Table 12. Note that solar PV systems are PST exempt in BC.

PV System Size and Location	Budget Installation Cost (Excluding Taxes)
North Roof - Section 2 (4.2 kWp)	$11,130 ($2.65/Watt)
North Roof - Section 2 (9.3 kWp)	$22,320 ($2.40/Watt)
North Roof – Section 2 and 1 Partial (10.2 kWp)	$24,480 ($2.40/Watt)
Maximum Rooftop 19.2 kWp	$45,120 ($2.35/Watt)

Table 12: Approximate Installed Costing for Selected Fire Hall No. 3 Solar PV Systems

3.7 Fire Hall No.3 Solar PV Feasibility Conclusions

Rooftop array placement choice is quite constrained by physical obstacles (south roof in particular) and shading in the case of the north roof. None-the-less well performing demonstration systems (4 – 10 kWp) could be accommodated on the north roof using section 2 first followed by northmost portions of section 1. Future expansion up to 19.2 kWp would be possible using all available roof sections. With the BC Hydro SGS Rate 1300 applying, energy is valued at $0.1139/kWh; making the business case for solar PV more attractive than city hall.

Projected key metrics for a 4.2 – 10.2 kWp rooftop demonstration solar PV system include:

- BC Hydro grid energy consumption reduction by 13% – 33%
- After-tax annual electrical energy cost savings of $583 - $1415 (at 2019 rates)
- Before tax (GST only) estimated installation costs of $11,130 - $24,480

Projected key metrics for an ultimate 19.2 kWp rooftop solar PV system include:

- BC Hydro grid energy consumption reduction by 62%
- Before tax annual electrical energy cost savings of $2664 (at 2019 rates)
- Before tax (GST only) estimated installation costs of $45,120

Building electrical infrastructure has capacity to accommodate a 4.2 – 10.2 kWp demonstration system on the single-phase service (meter 1) using the 400A splitter in the main electrical room as the point-of-connection to the grid. Sub-panel TB could alternately be used if first upgraded to 200A bus capacity. Either point-of-connection would be suitable for future expansion to the maximum roof 19.2 kWp configuration.

Projected costs assume roof structures can accommodate the additional deadload associated with ballasted racking systems. A professional structural review is required to verify whether a ballasted racking strategy would be acceptable.

4. Arts Centre

Salmon Arm Arts centre is located at 70 Hudson Avenue NE shown in Figure 37. The roof has various obstacles restricting array placement but a demonstration solar PV installation 4 – 10 kWp will still be possible in the less congested areas. The Arts centre also has nearby trees, buildings and chimney causing some shading that will need to be carefully considered in the installation. More details are given below.

Figure 37: Arts Centre Building

4.1 Art Centre Solar Photography

Solar photography was done with the Solmetric SunEye 210 on various locations of the roof shown in Figure 38 where we felt array placement could be feasible.

The solar access results for each location are summarized in Table 13. Most locations have excellent solar access scores other than South Roof Location 1 which is significantly shaded by a deciduous tree along the south-west side of the building. Further details on solar access and shading obstructions are given in the next sections.

Figure 38: Arts Centre Building Solar Photography Sites

Location	Annual	Summer	Winter
North Location 1	96%	97%	92%
North Location 2	97%	99%	92%
South Location 1	86%	94%	68%
South Location 2	95%	99%	86%

Table 13: Arts Centre Solar Access Results

4.1.1 Art Centre – North Location 1

Figure 39 shows the charts for the annual sun paths, monthly solar access and shading obstruction elevation vs. azimuth.

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=185°**
GPS Location: Latitude=50.70066°N -- Longitude=119.28426°W
Solar Access: Annual: 96% -- Summer (May-Oct): 97% -- Winter (Nov-Apr): 92%

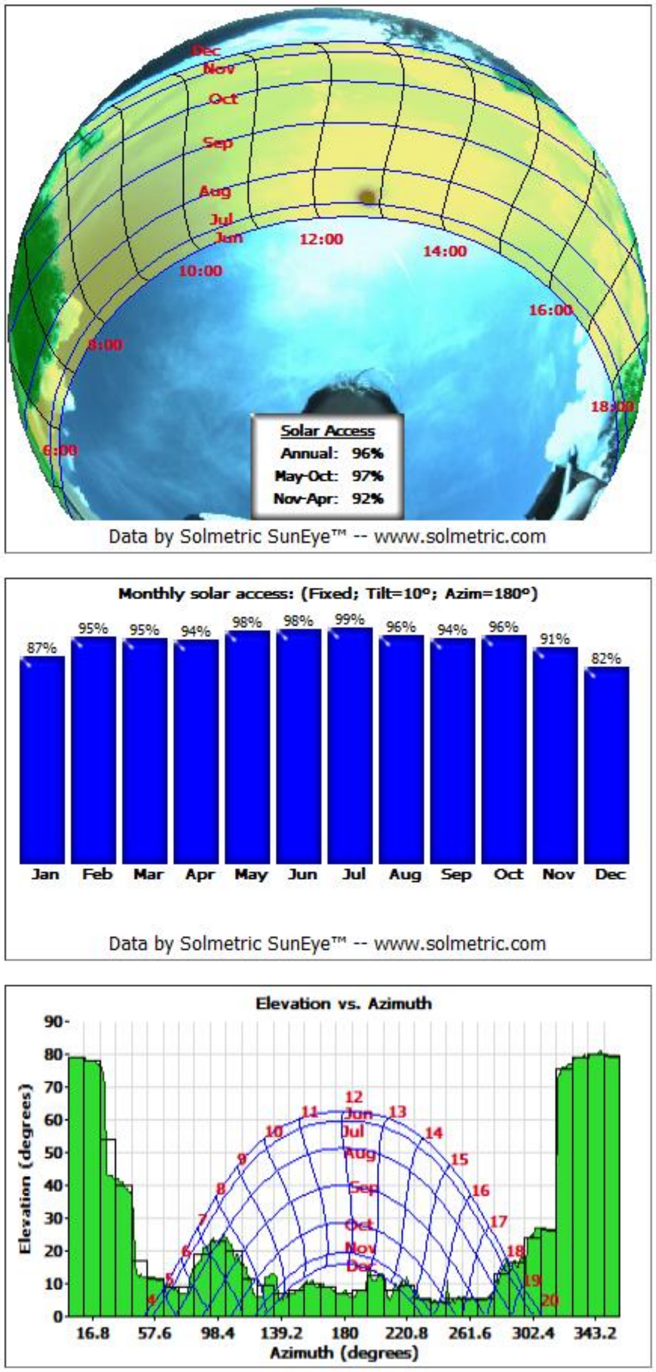


Figure 39: Art Centre North Roof Location 1 Solar Access

4.1.2 Art centre – North Location 2

Figure 40 shows the charts for the annual sun paths, monthly solar access and shading obstruction elevation vs. azimuth.

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=187°**
GPS Location: Latitude=50.70070°N -- Longitude=119.28428°W
Solar Access: Annual: 97% -- Summer (May-Oct): 99% -- Winter (Nov-Apr): 92%

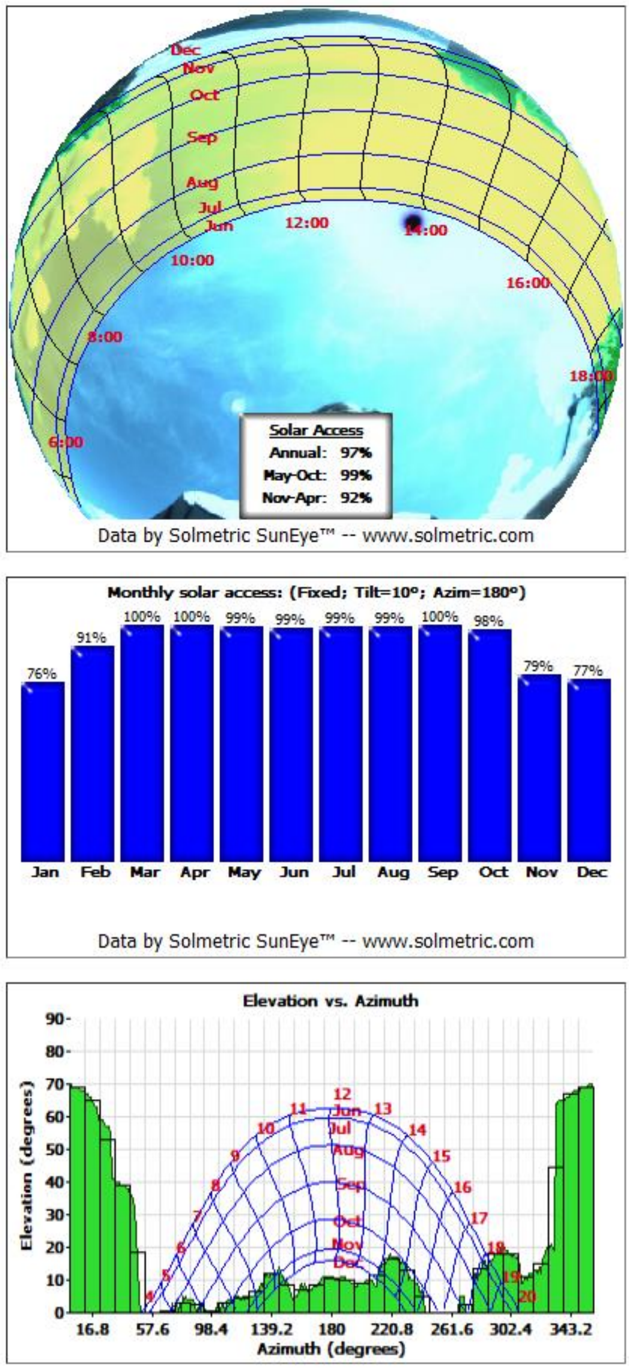


Figure 40: Art Centre North Roof Location 2

4.1.3 Art Centre – South Location 1

Figure 41 shows the charts for the annual sun paths, monthly solar access and shading obstruction elevation vs. azimuth. Significant shading by the deciduous tree directly southwest presently reduces solar access scores.

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=175°**
GPS Location: Latitude=50.70060°N -- Longitude=119.28432°W
Solar Access: Annual: 86% -- Summer (May-Oct): 94% -- Winter (Nov-Apr): 68%

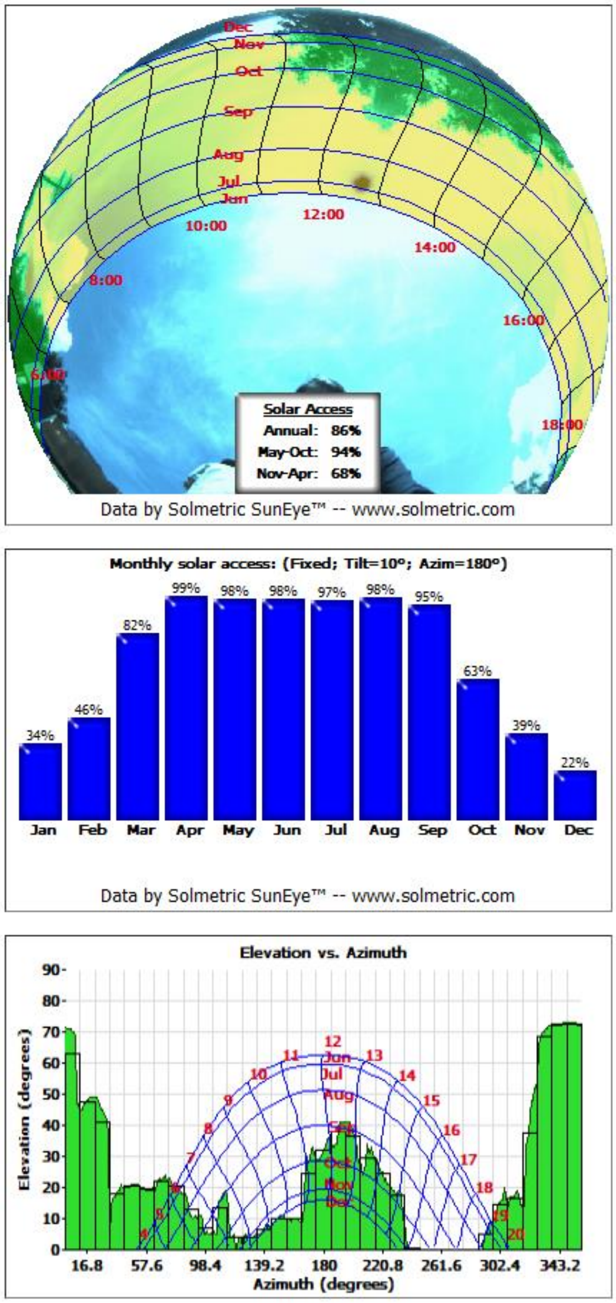


Figure 41: Art Centre South Roof Location 1 Solar Access

Selective topping or removal of the shade tree is possible, would dramatically improve solar access scores for South Location 1 as shown in Figure 42.

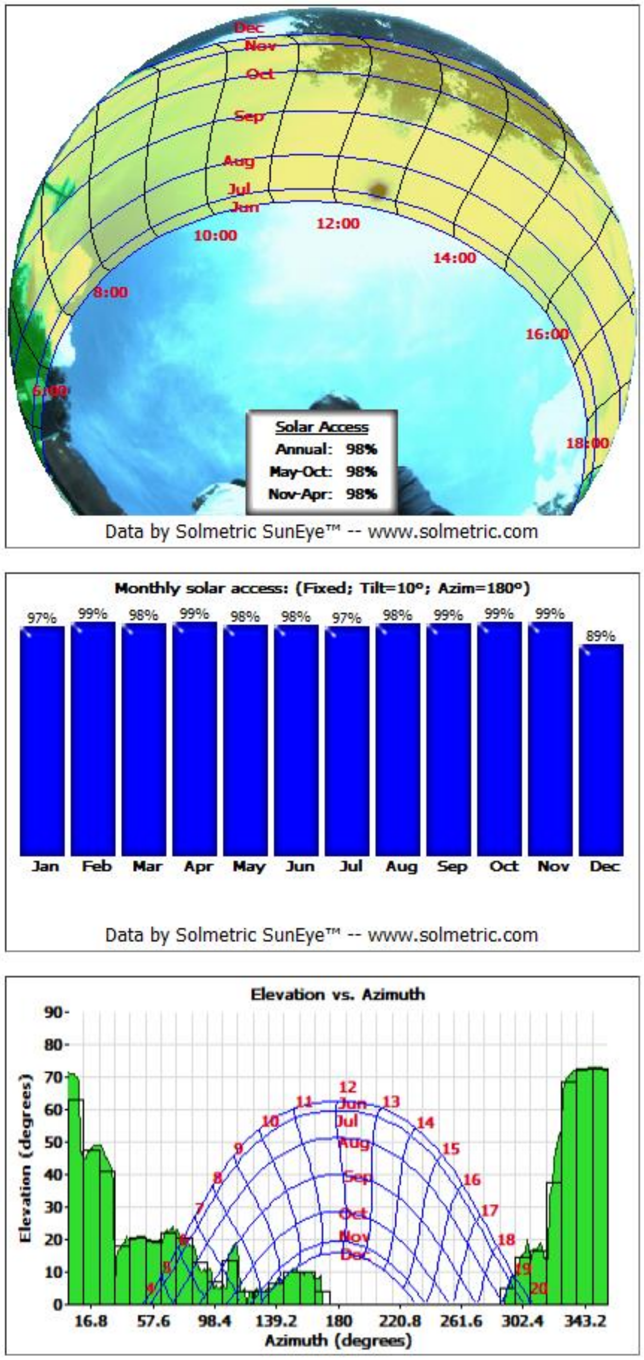


Figure 42: Art Centre South Roof Location 1 with Tree Shading Removed

4.1.4 Art Centre – South Location 2

shows the charts for the annual sun paths, monthly solar access and shading obstruction elevation vs. azimuth. The building to the south-west reduces solar access during the winter months, but a very good 95% annual score still results.

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=177°**
GPS Location: Latitude=50.70060°N -- Longitude=119.28439°W
Solar Access: Annual: 95% -- Summer (May-Oct): 99% -- Winter (Nov-Apr): 86%

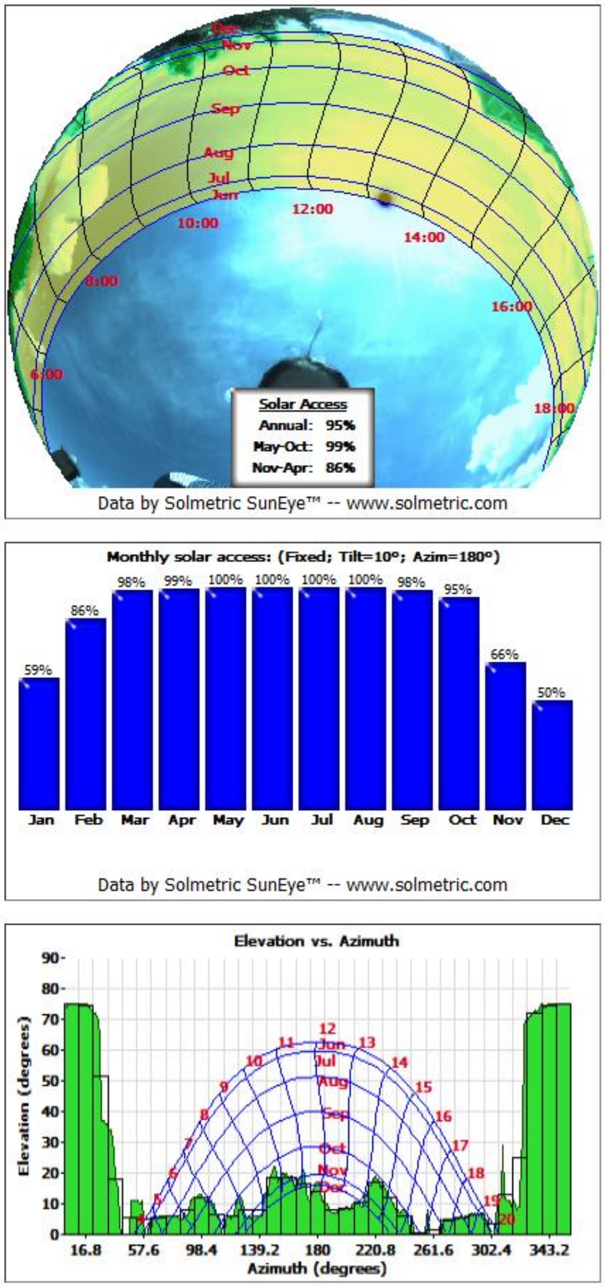


Figure 43: Art Centre South Roof Location 2 Solar Access

4.2 Art Centre Array Placement, Sizing, and Mounting Options

Both north and south roof sections have obstacles solar array placement will need to be designed around. Figure 44 shows the north roof section with key obstructions including air handler and roof access hatch. Small roof drains may be worked around.

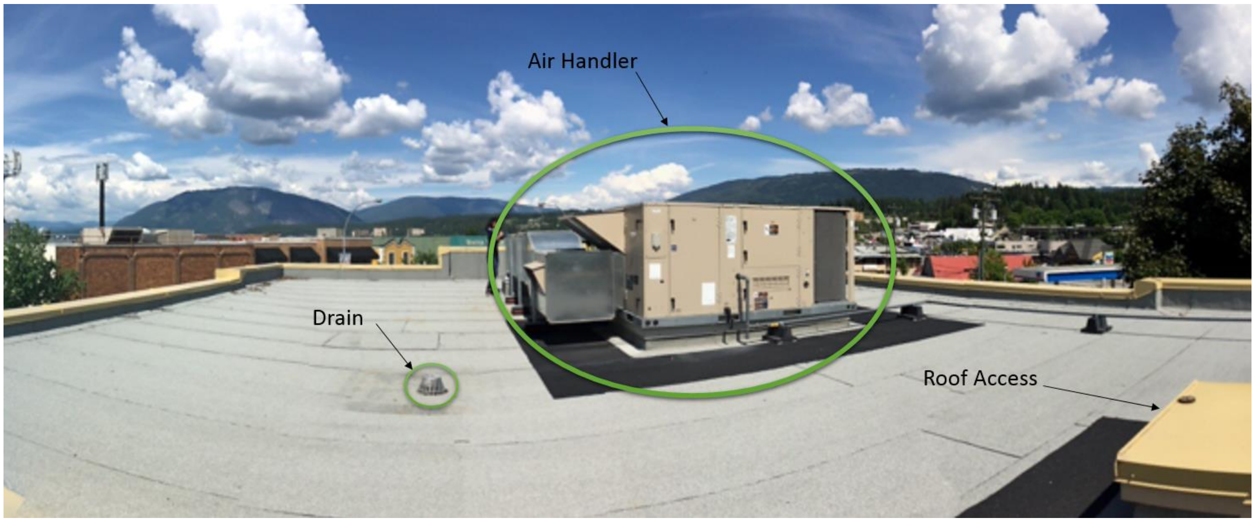


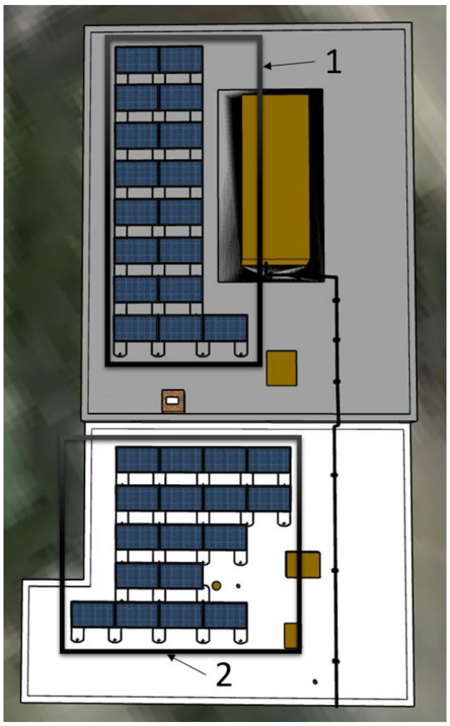
Figure 44: Art Centre North Roof Obstructions

Figure 45 shows the tree and building which cause south roof shading as discussed in the previous section. The chimney would also cause undesirable shading if north roof solar modules were placed too close to it.

Figure 45: Art Centre South West Roof Shading Obstructions

Both north and south roofs are finished with SBS torch on membrane, with the north roof apparently having been replaced quite recently. Retrofitting solar PV to the Art Centre roof tops would be most easily done with ballasted racking provided the roof structure can safely manage the additional load. See Appendix A for examples of solar PV installations using ballasted racking.

The maximum solar PV array capacity we feel could fit the Arts Centre roof respecting maintenance clearances and shading constraints is shown in Figure 46, along with sub-array capacities based on 300W 60 cell solar modules.



Section #	# of Solar Panels	Total Power (KWp)
1	17	5.1
2	17	5.1
TOTAL	34	10.2

Figure 46: Arts Centre Breakdown of Solar PV Array

Another option to consider is a solar parking shelter (9.6 kWp shown) at the south wall as in Figure 47, which could be free standing or partially supported by the building. The parking shelter could be associated with an EV charging station if desired. Removal of the tree presently shading the south roof would be necessary.

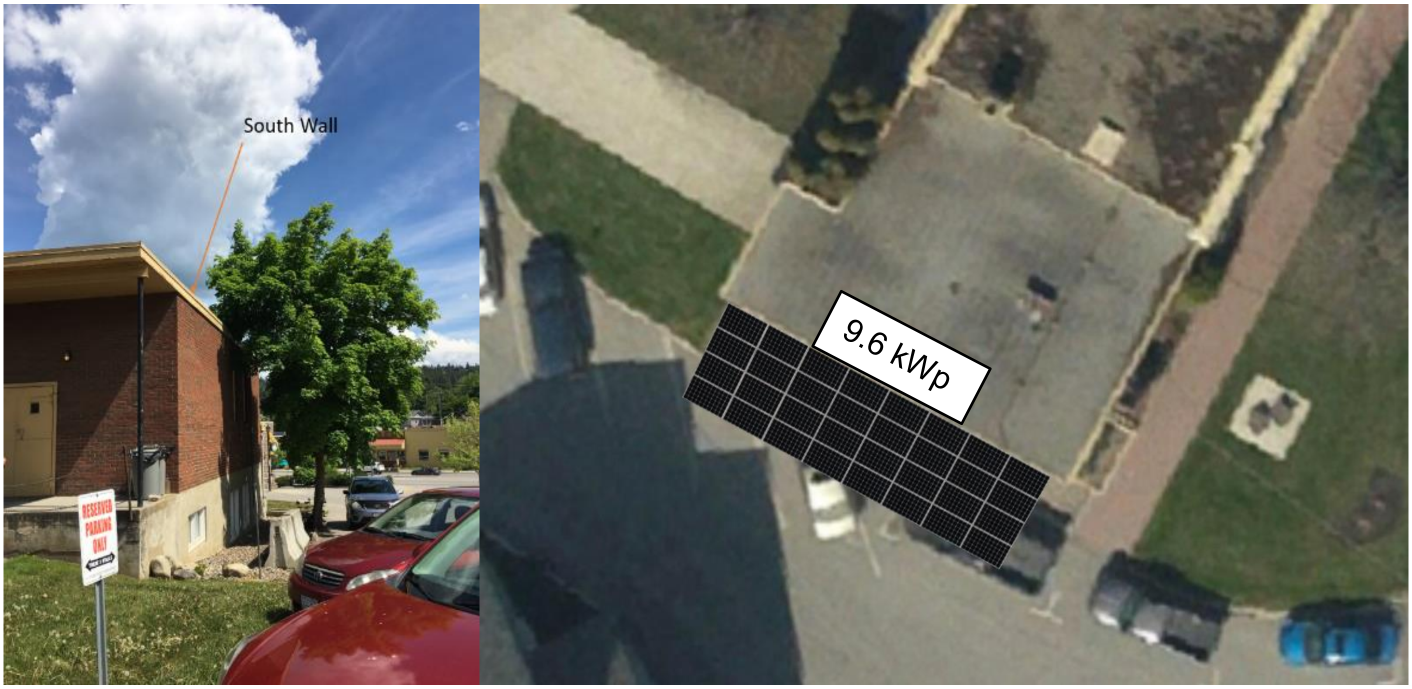


Figure 47: Art Centre South Wall Solar Parking Shelter Concept

4.3 Art Centre Solar Electrical Review

Electrical drawings were not available. By inspection we deduced the electrical single line in . The building has a 120/208V, 3-phase, 200A main service from BC Hydro. Supply is distributed through the building using a 200A Siemens main panel located in a downstairs closet, which also sub-feeds panel A on the upper floor.

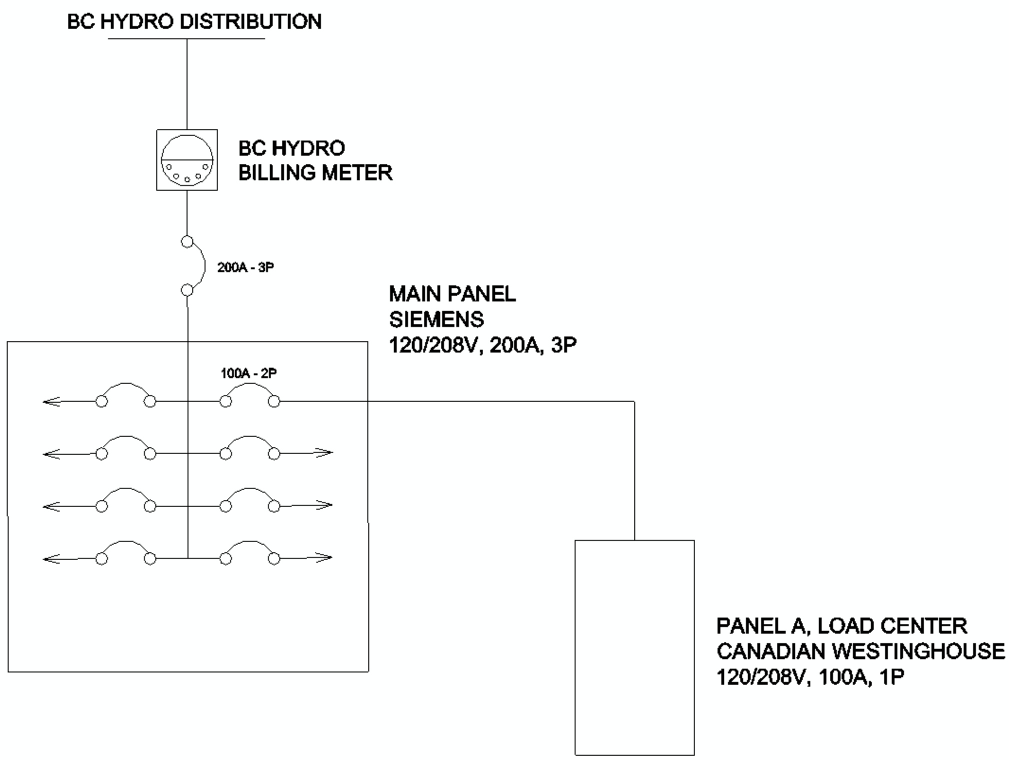


Figure 48: Arts Centre Electrical Single Line

As shown in Figure *49*, both panels are full with no additional circuit breaker space. To provide a CEC Section 64 compliant solar PV point-of-connection to the grid we would recommend one of the following minor service modifications:

- If PV systems larger than 10 kWAC will never be installed, space for a 30 A – 3P solar PV breaker must be created in the main panel; by combining circuits, using piggy-back breakers, or replacing the panel.

- To allow for possible future PV systems capacity exceeding 10kWAC, a 400 A service splitter could be added, into which the solar PV system would connect.

Figure 49: Art Centre Main and Sub Panels – No Spare Breaker Positions

4.4 Art Centre Electrical Consumption

BC Hydro provides service to the building under the Small General Service (SGS) Rate 1300. We were provided the monthly consumption information for 2018 shown in Table 14. Annual electrical consumption for the building was approximately 22,334 kWh in 2018. At the time of writing Rate 1300 electrical energy charge is $0.1173 per kWh so annual consumption has a value of $2,620 before tax.

Month - 2018	Consumption (kWh)
January	1,553
February	1,830
March	1,753
April	1,828
May	1,855
June	1,894
July	2,543
August	2,128
September	1,569
October	2,125
November	1,762
December	1,404
TOTAL	22,334

Table 14: Arts Centre 2018 Monthly Consumption

4.5 Art Centre Solar PV Harvests and Energy Impacts

Based on solar access measurements and local insolation levels, south facing Art Centre roof sections could be conservatively expected to harvest in the order of 1160 kWh/year for each 1 kWp of solar PV installed if roof shading with careful placement.

Projected solar energy harvests per year, present value of these harvests, and the impacts on BC Hydro consumption for the building are summarized in Table 15 for the solar PV System sizes discussed in section 4.2. Note that the value of harvested solar PV energy will increase with BC Hydro rate increases.

Location & PV System Size	Energy Harvest (kWh/yr)	Energy Savings ($/yr) at 2019 Rates + GST	BC Hydro Consumption Reduction
North Roof - Section 1 (5.1 kWp)	5,916	$708	26%
South Roof - Section 2 (5.1 kWp)	5,916	$708	26%
Both Roofs (10.2 kWp)	11,832	$1,416	53%
Parking Shelter (9.6 kWp)	11,136	$1,332	52%
Roofs and Parking Shelter (19.8 kWp)	22,968	$2747	103%

Table 15: Arts Centre Solar Harvests, Energy Savings and Consumption Impacts

North and south rooftop systems together with the example solar parking shelter would result in Net-Zero electrical energy use based on 2018 consumption figures.

4.6 Art Centre Solar PV Installations Budget Costing

Approximate installed budget costing for example Art Centre demonstration systems 4 – 10 kWp systems and ultimate capacity is summarized in Table 16Table 12. Note that solar PV systems are PST exempt in BC.

PV System Size and Location	Budget Installation Cost (Excluding Taxes)
North Roof - Section 1 (5.1 kWp)	$13,260 ($2.60/Watt)
South Roof - Section 2 (5.1 kWp)	$13,260 ($2.60/Watt)
Both Roofs (10.2 kWp)	$24,480 ($2.40/Watt)
Parking Shelter (9.6 kWp)	$38,400 ($3.90/Watt)
Roofs and Parking Shelter (19.8 kWp)	$62,880 ($3.18/Watt)

Table 16: Approximate Installed Costing for Selected Art Centre Solar PV Systems

4.7 Art Centre Solar PV Feasibility Conclusions

Rooftop array placement is somewhat constrained by physical obstacles and shading but well performing demonstration systems (4 – 10 kWp) could be accommodated using one of or both north and south roof sections. The north roof membrane is much newer making it a better choice over the south roof for systems up to 5.1 kWp. Up to 10.2 kWp could be accommodated using both north and south roof, and up to 19.8 kWp using a solar parking shelter on the south wall of the building. With the BC Hydro SGS Rate 1300 applying, energy is valued at $0.1139/kWh; making the business case for solar PV more attractive than city hall.

Projected key metrics for a 4.2 – 10.2 kWp rooftop demonstration solar PV system include:

- BC Hydro grid energy consumption reduction by 26% – 53%
- After tax annual electrical energy cost savings of $708 - $1416 (at 2019 rates)
- Before tax (GST only) estimated installation costs of $13,260 - $24,480

Projected key metrics for an ultimate 19.8 kWp capacity with a solar parking shelter:

- BC Hydro grid energy consumption reduced to Net-Zero
- After tax annual electrical energy cost savings of $2747 (at 2019 rates)
- Before tax (GST only) estimated installation costs of $62,880

Reconfiguration or upsizing of the main panel will be required to accommodate a 4.2 – 10.2 kWp demonstration system, or addition of a 400 A service splitter if expansion beyond 10.2 kWp is desired.

Projected costs assume roof structures can accommodate the additional deadload associated with ballasted racking systems. A professional structural review is required to verify whether a ballasted racking strategy would be acceptable.

5. Professional Structural Review

Incorporating building rooftop solar PV has structural and electrical impacts which must be carefully considered. While we have assessed and advised on solar electrical impacts in this report, a professional structural review is required to confirm acceptability for solar PV rooftop solutions proponents might propose.

For these existing buildings, ballasted racking would deploy quickly, and minimize membrane penetrations required for securing PV systems to the rooftop. Depending on site wind and seismic loads as well as array geometry and size, ballasted racking could add 2 – 8 psf (or more) deadload under PV array footprints over solely mechanically attached racking. Mechanically attached racking reduces deadload but can require extensive effort to properly anchor to the roof structure along with significant membrane cutting/repair. A mixture of ballasting with sparse mechanical anchoring can provide a compromise when use of one method solely is not possible.

Professional structural assessment in advance will confirm rooftop PV system installation viability, and provide clear structural constraints to which future solar PV installations will need to comply.

We estimate structural review cost ranges to be as follows assuming inspections can be completed for the three buildings in a single trip by local (Thompson-Okanagan) service provider:

- **City Hall:** $2500 - $3500 (Likely less if original structural drawings available).
- **Fire Hall No. 3:** $1500 - $2500
- **Art Centre:** $1500 - $2500

6. On-Going Solar PV Systems Maintenance Costs

While grid-connected solar PV system maintenance requirements are generally minimal, we suggest the following routines and costs be kept in mind.

a) **Routine Equipment Monitoring** – (Estimated 6 hrs/year). Once monthly web-based system monitoring checks to confirm on-going normal operation of solar modules and inverter(s).

b) **Module Soiling Checks and Cleaning** – (Estimated 6 hrs/year). Bi-annual inspection and simple cleaning with water hose as required. Dust, bird droppings, and other soiling reduces solar module energy production. In our climate regular rainfall is usually sufficient to keep major soiling at bay. Some owners have found rinsing panels with a water hose and sponge (for stubborn soiling) to be helpful; eg. in Mar and again in Aug. Others choose to rinse panels only if routine web monitoring suggests a soiling problem with particular solar modules.

c) **Racking Inspection** – (Estimated 1 hr/year). Ballasted racking vendors recommend ballast placements be inspected once per year to ensure ballast blocks have not shifted out of place due to expansion/contraction, seismic activity, etc.

d) **Inverter Replacement** – (Once per system life cycle). Solar PV module life is typically assumed to be 30 years though systems can last much longer. Conventional wisdom suggests budgeting for one inverter replacement during the lifetime of the solar modules. Extended inverter warranties out to 25 years are increasing available making inverter replacement budgeting less of a concern. A string inverter replacement for 4 – 10 kWp demonstration systems would presently be in the order of $2500 - $4000. Costs would vary if micro-inverters were used versus a string inverter.

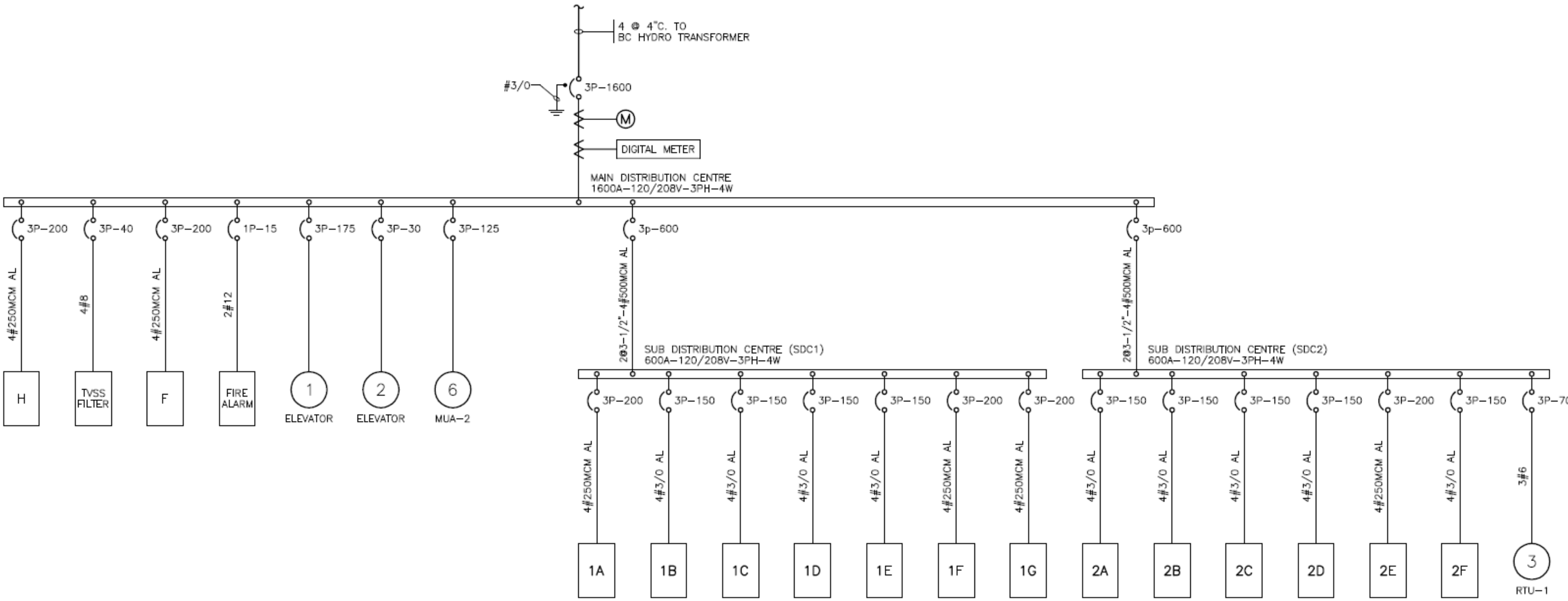
Appendix A: Ballasted Racking Installation Examples

6.4 kWp Array using Ballasted Racking – Britannia Mine Museum, Britannia BC

10.2 kWp Array using Ballasted Racking – Thompson Rivers University, Kamloops BC

24.5 kWp Array using Ballasted Racking – Nicola Valley Institute of Technology, Merritt BC

Appendix B: City Hall Electrical Single Line Drawing



SINGLE LINE DIAGRAM
NTS