ROOFTOP SOLAR IN CANMORE

A Neighbourhood by Neighbourhood Analysis

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PIONEER CONSULT

Executive Summary

As climate commitments continue to drive policy decisions around the world, Canmore must explore alternative energy sources to remain both economically competitive and environmentally conscious. The following report is a theoretical analysis of rooftop solar applicability in Canmore, on a neighbourhood by neighbourhood basis. The two goals of the study were to determine the total electric potential of rooftop solar in Canmore, and to generate Suitability Maps that highlight how the solar potential changes throughout neighbourhoods in the town. The unique terrain surrounding Canmore was considered, as well as each neighbourhood's building types. The data are shown as a relative ranking in the Suitability Maps, and the numerical values are all presented in Appendix A.

Suitability Maps:
Neighbourhood Suitability - Measures the capacity factor (solar resource potential) of each neighbourhood's **location within the town.**
Building Suitability - Measures the **percentage of total rooftop area that could be utilized** for solar arrays.
Net Energy Production - The **absolute maximum** amount of energy a neighbourhood can generate. Since this is not levelized based on rooftop areas larger neighbourhoods typically have a larger net energy production potential.
Overall Suitability - A ranking **of how well each neighbourhood is designed** for solar taking into account the neighbourhood and building suitability.
Residential Energy Offset - Measures **what percentage of their own electricity residential buildings can offset** per neighbourhood.

Results: If solar was adopted across every possible rooftop in Canmore, the electricity generation would be **42,181 MWh/yr,** which is equivalent to **taking 8,600 cars[2] off the road (40,072 tonnesCO_2).** The **residential sector** would, on average, be able to offset **64% of their own electricity usage.** Institutional and commercial buildings do not follow a regular pattern of electricity use, and averages were not be used to analyze those sectors. The commercial and institutional buildings offer the largest open roof spaces, therefore offering the largest possible solar systems, which in turn will reduce project costs[7]. Because of these reduced costs on large buildings, **an individual analysis of the largest buildings is recommended**.

The analysis presented some interesting, and unexpected results. Most striking was the effect of rooftop geometry compared to the effect of location within the valley. It was expected to see the sunny eastern side of the valley significantly out-perform the shady western side, when in fact, **the rooftop geometry ended up having 4.3 times more impact than the location.** This reinforces the notion that new development presents a **one-time opportunity** to harness solar energy efficiently. These opportunities can be capitalized on via an **update to the architectural guidelines that includes open roof space with southern exposure.** If done correctly, new architectural guidelines can make it easier and cheaper for residents in Canmore to adopt solar, without sacrificing aesthetics.

In this analysis, **26 neighbourhoods out of the 36 reviewed were primarily composed of residential buildings**, showing that rooftop solar adoption in Canmore relies heavily on the willingness of homeowners to install solar arrays. As 75% of building area is zoned for residential-use, the citizens of Canmore truly have the ability to make a difference in the sustainability of their neighbourhoods.

Ultimately, the conclusion is that the most efficient way to utilize rooftop solar energy in Canmore is to **design rooftops to accommodate solar arrays, prior to breaking ground on a new build.** For existing buildings, the roof design has significantly more impact than location within the valley.

Disclaimer:

The following study is **not** intended to be used to evaluate an individual residential, commercial, or municipal project, as the results presented are intended for high-level policy decisions and based on neighbourhood averages. Each potential site requires an individual assessment by a local professional.

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1.0 - Introduction

Due to the high level of interest in solar energy from the residents of Canmore (see Appendix B) there is value in the town exploring the potential of rooftop solar energy and determining the neighbourhoods best suited for solar arrays. Rooftop solar is an attractive option for renewable electricity in Canmore due to the lack of available space within the municipality. Knowing the potential of rooftop solar in Canmore will provide the municipality with a tool that will help to achieve the goals of The Environmental Sustainability Action Plan (ESAP).

The current GHG emissions associated with Alberta's electricity grid are approximately 950gCO2eq/kWh[13], the highest in Canada. Given that the average **residential** building in Alberta consumes approximately 5.2kWh/ft^2[1], Canmore's total **residential electricity consumption** is estimated to be 50,856MWh/year. The associated electricity generation emissions are 48,312tonnes CO2eq/year. Solar electricity has no generation emissions and as a result could significantly reduce the municipality's total emissions. Larger building types (institutional and commercial) do not follow regular energy use profiles, and so average values do not apply to Canmore's industrial and commercial district. Accurate energy data on Canmore's commercial and institutional buildings was not available, though there are many options for tracking this type of data, such as third-party energy-tracking services.

One of the largest deterrents in solar energy adoption is the installation costs and associated high payback periods. To minimize the payback period and maximize the return on investment it is important to install solar arrays in the areas with the highest solar potential. In pursuit of this, this study provides a relative ranking of neighbourhoods in Canmore based on their solar suitability. This will provide the municipality with information on how they can target their investment, subsidies, and education programs to maximize the emissions offset by solar arrays. An overall rooftop production potential has also been provided to allow the town to assess the potential impact of investing in solar generation. Interestingly the percentage difference between the neighbourhood with the highest average capacity factor, Silvertip Stonecreek, and the lowest average capacity factor, Peaks of Grassi, is only 11.4%. This demonstrates that the impact of mountain shading may not be as significant as one would think. When comparing the maximum capacity factors at an ideal azimuth (typically 180 degrees) in each neighbourhood the percentage difference increases to 17.3%.

2.0 - Background

Alberta's electrical grid relies on carbon intensive generation sources such as coal and natural gas, resulting in a grid with greenhouse gas emission intensity 5 times the national average[3]. To reduce the greenhouse gas intensity, cleaner generation sources must be added to the generation mix. Southern Alberta has some of the highest solar irradiance (watts/m^2 from the sun) levels in North America, making it an attractive location for solar generation. Solar generation has lifecycle emissions over 30 times less than coal, and 10 times less than natural gas[4]. The combination of high solar potential and low emissions makes solar generation an attractive option for low-carbon electricity generation.

Solar electricity generation can be classified as either utility scale (large) or microgeneration (small). Municipalities are generally concerned with microgeneration, particularly rooftop generation, to increase the utility of already occupied space. This generation is usually tied into the electrical grid so that in times of excess supply, the electricity is exported to the grid and made available to all consumers. The producer is then given a credit on their electricity bill for electricity added to the grid. Conversely, in times of low supply, the grid can supplement the production of the solar array, removing the need for battery storage. Adding large, variable amounts of electricity to the grid could create complications for the grid operators. However, since Alberta has a large interconnected grid, the impact of a single municipality on the overall generation and consumption within the province is negligible. As a result, the variable nature of grid connected solar systems is mitigated and the overall impact to the Alberta grid is minimal. The downside to an individual producing electricity and exporting to the grid instead of consuming it locally is that the transmission and distribution charges associated with electricity use are not avoided. It is within provincial law that Albertans can install only enough microgeneration to cover their own consumption. Annual production cannot exceed annual consumption[5].

2.1 - Solar Installation Incentives

With available subsidies (seen in Table 2.1) and rapidly decreasing costs, solar energy is becoming increasingly affordable. Although Alberta's electricity prices are currently among the lowest in the world, uncertainty surrounding the future of the electricity market following the retirement of the coal facilities could increase the economic viability of solar energy and provide a buffer against rising electricity rates. Additionally, the town of Canmore offered eight solar subsidies with a value of $1250 each in 2018 to further incentivize rooftop solar in the municipality. As can be seen in Appendix B, knowledge of both the provincial and municipal incentives in Canmore is low. A potential use of this study is to target education/information campaigns toward citizens living in areas with high solar suitability.

Table 2.1: Existing Solar Subsidies as of September 2018:

	Residential	Commercial
Provincial Maximum Incentives	The lesser of $10 000, or 30% of eligible system costs	The lesser of $500 000, or 25% of eligible system costs
Municipal Incentives	Eight subsidies of $1250, given based on lottery after application	

3.0 - Methods

Our theoretical model of Canmore's rooftop solar energy includes two main sets of factors: Application (building suitability) and Capacity (neighbourhood suitability). The Capacity Factor methodology has been verified with existing solar arrays in Canmore. It was found to be quite accurate with a cumulative error of 1.04%, as shown in Table 3.1. The Application Factor is mainly a function of roof design and varies greatly based on the style of construction. Neighbourhoods with high Application Factors represent construction styles that favour solar arrays.

Important Assumptions:

1) Roofs were assumed to have an equal likelihood of facing any direction and trend areas were used for any significant group of roofs that clearly did not follow this assumption.
2) Any roof area that could not contain at least 6 panels was assumed to not have any panels due to economic constraints[6].
3) Assumed standard 5.25 x 3.3ft, 280W panel[6]: REC 280W, this is the panel most commonly used by Skyfire Energy.
4) Average roof tilt is assumed to be 27 degrees based on the recommendation of the Bow Valley Builders and Development Association. This assumption was validated by the solar array installation data provided by KCP Energy. Setting these variables allows the measurement of variation based on location (see section 3.2).

Relevant Definitions:

- Insolation: The amount of solar radiation that reaches the earth's surface. The available insolation determines how much output a solar panel will produce throughout the day.
- Azimuth: The horizontal direction, in degrees, the panel faces. 0/360 degrees represents a panel facing due north and 180 degrees represents a panel facing due south.
- Tilt: The vertical orientation of the panel. 0 degrees would represent a flat panel and 90 degrees would represent a vertical panel.
- Application Factor: Application Factors are applied to reduce the amount of total rooftop area to an area suitable for PV panel installation. This is a measure of usable rooftop area (also referred to as 'Building Suitability' in this report).
- Capacity Factor: The Capacity Factor converts the installed power of a solar array into electricity generation. It represents the actual electricity production as a percentage of the theoretical maximum production over a given time period. For the purposes of this report the Capacity Factor is an annualized value providing the average electricity generation potential throughout the course of the year. The Capacity Factor takes into account the amount of electricity generation for the amount of solar insolation at a given location, tilt, and azimuth. Capacity Factor is also referred to as 'Neighbourhood Suitability' in this report.
- Trends: A trend in a neighbourhood is defined as any set of buildings that *do not* follow the assumption that all roof planes are equally likely to face all directions. Identifying trends in neighbourhoods allows this report's analysis to account for regular, repeating construction types

(condos, low income housing, storage units, etc.) without abandoning our assumptions for average neighbourhoods.

Table 3.1: Theoretical Production vs. Actual Production

Site Name	**Latitude**	**Longitude**	**Array Size (kW)**	**Average Actual Production (kWh)**	**Prediction using Theoretical Model (kWh)**	**% Difference**
9 Street	51.090226	-115.36414	6.24	4456.9	4556.4	-0.55%
9 Street	51.0901393	-115.36478	5.46	5182.5	5044.5	0.67%
11 Street	51.0914229	-115.36543	8.58	9756.6	9019.3	1.96%
Larch Place	51.1034273	-115.37806	3.66	3269.8	3745.3	-3.39%
Cougar Point Road	51.088754	-115.33867	4.77	4764.4	4874.5	-0.57%
Coyote Way	51.0863092	-115.32892	4.42	4808.5	4577.8	1.23%
Lady Macdonald Crescent	51.084064	-115.32795	3.66	4190.6	3556.25	4.09%
Larch Avenue	51.1001695	-115.37237	4.24	3507.2	4202.7	-4.51%
Miskow Close	51.057621	-115.32824	6.71	6866.0	5718.3	4.56%
2nd Street	51.0837466	-115.35954	4.88	5285.9	5023	1.28%
Moraine Road	51.0808404	-115.32722	3.71	4509.1	3983.4	3.10%
Overall:				**56597.5**	**54301.45**	**1.04%**

3.1 - Building Suitability Methodology (Application Factor)

To calculate the amount of area in Canmore that is available for rooftop solar, the percentage of usable roof area was determined in each neighbourhood. This was done by applying the Application Factors listed below to an appropriate number of homes, determined based on the size of the neighbourhood, and averaging the result. The overall confidence interval is 6.5% for the Application Factor results. For neighbourhoods with trend areas, additional sample buildings that mirrored the trend were averaged separately. The trend areas were then calculated as a percentage of the total neighbourhood area and a weighted average was used to determine the overall neighbourhood Application Factor. The overall Application Factor ranking by neighbourhood can be seen in Figure 4.2, in the Results section. The Application Factor values can be found in Appendix A, separated by neighbourhood. The following factors were applied to their neighbourhood's total area, resulting in a realistic area available for rooftop solar.

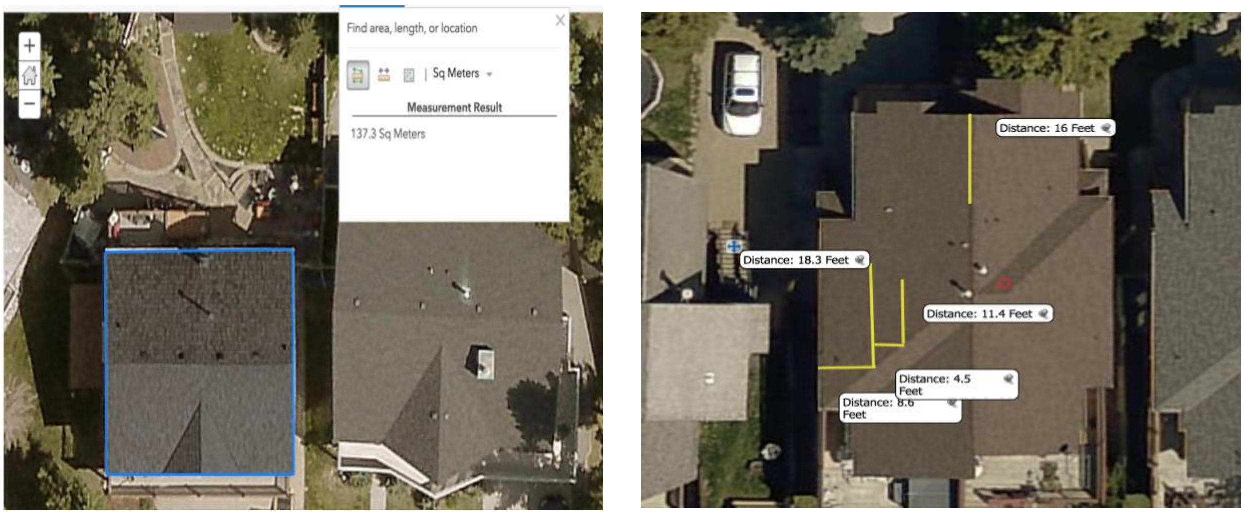
Application Factors Considered:

Obstacles - This factor represents the amount of usable roof area accounting for areas that are already in use for chimneys, HVAC systems, and geometry. CONNECTExplore software (provided by the town of Canmore) was used for sample building roof measurements, and steps are outlined below. Obstacle factor methodology was verified when possible by visually inspecting existing arrays and comparing the actual number of panels to the expected number of panels for the building. There were no significant discrepancies.

Step 1 - Determine the total roof area of a sample building by using the CONNECTExplore 'area' tool.

Step 2 - Determine the length and width of any roof plane on the sample building roof using the CONNECTExplore 'distance' tool, a sample is shown below in Figure 3.1

Figure 3.1: Steps 1 and 2 in Obstacle Factor determination



Step 3 - Calculate the maximum number of standard 5.25 x 3.3ft panels that could be placed in each open space, either by placing them on a vertical or horizontal orientation. If the maximum number of panels was less than 6, assume no panels would be placed in this area as systems less than 1.5kW (6x280W panels) are not economic.

Step 4 - Add up the number of panels for all the areas on the sample building and convert to area by multiplying by the area of a standard 5.25 x 3.3ft, 280W panel.

Step 5 - Divide the maximum panel area by the total roof area to calculate the overall obstacle factor for the sample building.

Step 6 - Repeat steps 1-5 for an appropriate number of sample buildings and calculate the average value. Do the same for each trend.

Shading - The shading value was kept consistent at 63%[6], meaning that 37% of roof area is not fit for solar due to excess shading from objects such as trees or other buildings. This value is from a 2016 NREL report[6] that found the solar potential in the US by using LIDAR data for buildings in 128 US cities (approximately 23% of all US buildings). Any area that had an isolation level less than 80% of the maximum insolation in that area was considered unfit for solar due to shading. The Canmore specific shading value may differ slightly, but this was beyond the scope of the project.

Structural Applicability - This factor takes into account the ability of the building to support the additional load of the solar panels. A value of 95% (5% unsuitable) was chosen for residential buildings and 85% (15% unsuitable) was chosen for larger commercial and institutional buildings. These numbers are based on consultation with Skyfire Energy and KCP, two of the leading solar installers in the province of Alberta. The material used in the construction of each building type plays a role in the difference between factors.

Array Type – This factor accounts for the unusable roof area from panel spacing and self-shading. There are two types of arrays that were considered, open rack and fixed mount. Open rack panels are used on flat rooftops, to increase the tilt. Fixed mount panels are installed directly onto the roof plane. Open rack panels cast a larger shadow than fixed mounted panels, resulting in less usable roof space. The values of 98% (2% unusable) for fixed mounted and 70% (30% unusable) for open rack were taken from the same NREL report referenced in the 'Shading' section.

3.2 - Neighbourhood Suitability Methodology (Capacity Factor)

Once the total usable rooftop area for solar installations was found through section 3.1, the next step was to calculate the output of the solar arrays in Canmore based on their locations in the town. A combination of data from existing solar arrays in Canmore, the software SolarGIS, and available literature was used. The overall Capacity Factor ranking by neighbourhood can be seen in Figure 4.1, in the Results section. The Capacity Factor values can be found in Appendix A, separated by neighbourhood. Steps in the analysis are outlined below.

Step 1 - SolarGIS data points were taken at an average interval of 250 meters around the perimeter of each neighbourhood. The 250m interval was chosen to match the resolution of the SolarGIS software. The average number of data points considered per neighbourhood was 13.

Step 2 - SolarGIS software was used to view the annual solar insolation for each of the 473 data points within the town of Canmore.

- To ensure consistency across all measurements, an azimuth angle of 180 degrees and a tilt angle of 27 degrees were assumed. The 27 degree tilt was recommended by the Bow Valley Builders and Development Association as an average tilt for houses in Canmore. This was validated as the average tilt of the reference arrays provided by KCP energy was 27 degrees.
- For each point, the total available solar insolation was considered as well as the percentage reduced by terrain shading (mountains) and percentage reduced by angular reflectivity.

Step 3 - To account for the assumption that all roof planes are equally likely to face all directions, data points at 12 different azimuth angles (0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330) were taken in the center of each neighbourhood and the output was calculated using SolarGIS data. This shows the variation in output as the panels face different directions. For the purposes of our results the average of the output at each of the 12 different azimuth angles was used as the average output for each neighbourhood.

Step 4 - Data was exported from SolarGIS and system losses of 12%[7] were applied, taking into account: soiling, shading, mismatch, wiring, connections, degradation, slight inaccuracies in the accuracy of manufacturer panel rating and system availability.

- Inverter losses of 4%[7] were applied for the conversion of DC to AC electricity.
- Snow losses were calculated using the NAIT reference array data for Edmonton[8] and the difference in precipitation between Canmore and Edmonton. This was completed by multiplying the annual losses due to snow of 4.04% at a 27 degree tilt in Edmonton by the difference between Edmonton and Canmore precipitation between November and March (assumed as months with snow). The resulting annual snow losses in Canmore were 7.57%.

3.3 - Theoretical Model Process and Data Used

To compare the results of Building and Neighbourhood suitability the data was combined and analyzed on a neighbourhood by neighbourhood basis. The following procedure outlines how the overall model of the town was designed and includes information on the data inputs for this process.

Modelling Process:

1) Total Roof Area: To calculate the total roof area the total building area was used as well as the assumption that the average building roof was tilted at an angle of 27 degrees. The roof area was broken down by neighbourhood and by building classification (residential, commercial, industrial, institutional, recreational, and other).
2) Usable Roof Area: To calculate the total available space on each rooftop that could be used for solar energy, the total roof area was multiplied by the Building Suitability (Application Factor) to give a usable roof area for solar energy in each neighbourhood.
3) Installed Power: The usable roof area was divided by the area requirements for a single solar panel and then multiplied by the rated capacity of the assumed solar panel to give an installed power value in Watts.
4) Electricity Output: The installed power was converted to annual electricity production using the Capacity Factor and the assumption that each panel is equally likely to be facing any direction (north, south, east, west). The installed power was multiplied by the capacity factor and the number of hours in the year to provide the annual electricity production in kWh. The individual Capacity and Application Factors for each neighbourhood were used and the results were summed to calculate the solar potential for the entire town.
5) Overall Solar Suitability: The output per meter squared of building area combines the Capacity and Application Factors to show which neighbourhoods have the highest output potential per meter squared of building area. This should not be confused with efficiency of a panel installed in a given location which is represented by Capacity factor.
6) Average Array Size: The average residential array size was calculated using the total residential building area in each neighbourhood divided by the number of residential structures in the neighbourhood. Using the roof angle assumption and applicable Application Factors the average array size was calculated.
7) Percentage of Residential Electricity Offset: The percentage of residential electricity usage that could be offset by maximizing the solar installations on residential buildings in each neighbourhood. This was calculated by multiplying the average residential array size in each neighbourhood by the number of residential structures and then using the Capacity Factor to calculate the electricity production. The percentage offset was based on the Energy Efficiency Alberta guidepost that each single detached home uses, on average, 5.2kWh/ft2 of building area[1].

Data sources include:

CONNECTExplore software: Used for the calculation of the Application Factor (building suitability) and analysis of individual buildings suitability for solar.
SolarGIS: Used to provide solar insolation data for locations across Canmore and show the variation of available solar energy across the town and how it varies with azimuth angle.
Edmonton Snow Loading study & Canmore Weather Data: Used to estimate the impact of losses due to snow in the town of Canmore. This data is open-sourced.
PVWatts: NREL database used for system and inverter losses.
Building footprint area data (Canmore): Used to estimate total rooftop area available in the town of Canmore.
Building usage/class/neighbourhood data (Canmore): Used to categorize the results into building usage, neighbourhood, building class data.
KCP Energy output from existing arrays: Used to validate our model by comparing the output of our model to existing solar arrays in Canmore.

4.0 – Results

The results of this study are presented in five Suitability Maps and two other figures. Together, these visuals show the variation in solar-applicability across the town. It is important to note that all the Suitability Maps are ranked relative to the town's maximum. To see just how much each neighbourhood varies, a breakdown is shown in Appendix A.

To generate the Suitability Maps, Google's Fusion Tables were used. These tables allow the reader of this study to interact with the Suitability Maps (if an electronic copy is available), simply follow the appropriate link, select the maps tab, and select a neighbourhood to see the exact ranking. The shapes and lengths represent neighbourhood boundaries as described by KML data provided via the town of Canmore.

Figure 4.1 – Neighbourhood Suitability Map
Figure 4.2 – Building Suitability Map
Figure 4.3 – Net Energy Production (Production Potential/ Overall Output)
Figure 4.4 – Overall Suitability
Figure 4.5 – Residential Energy Offset

Figure 4.0: Neighbourhood Reference Map

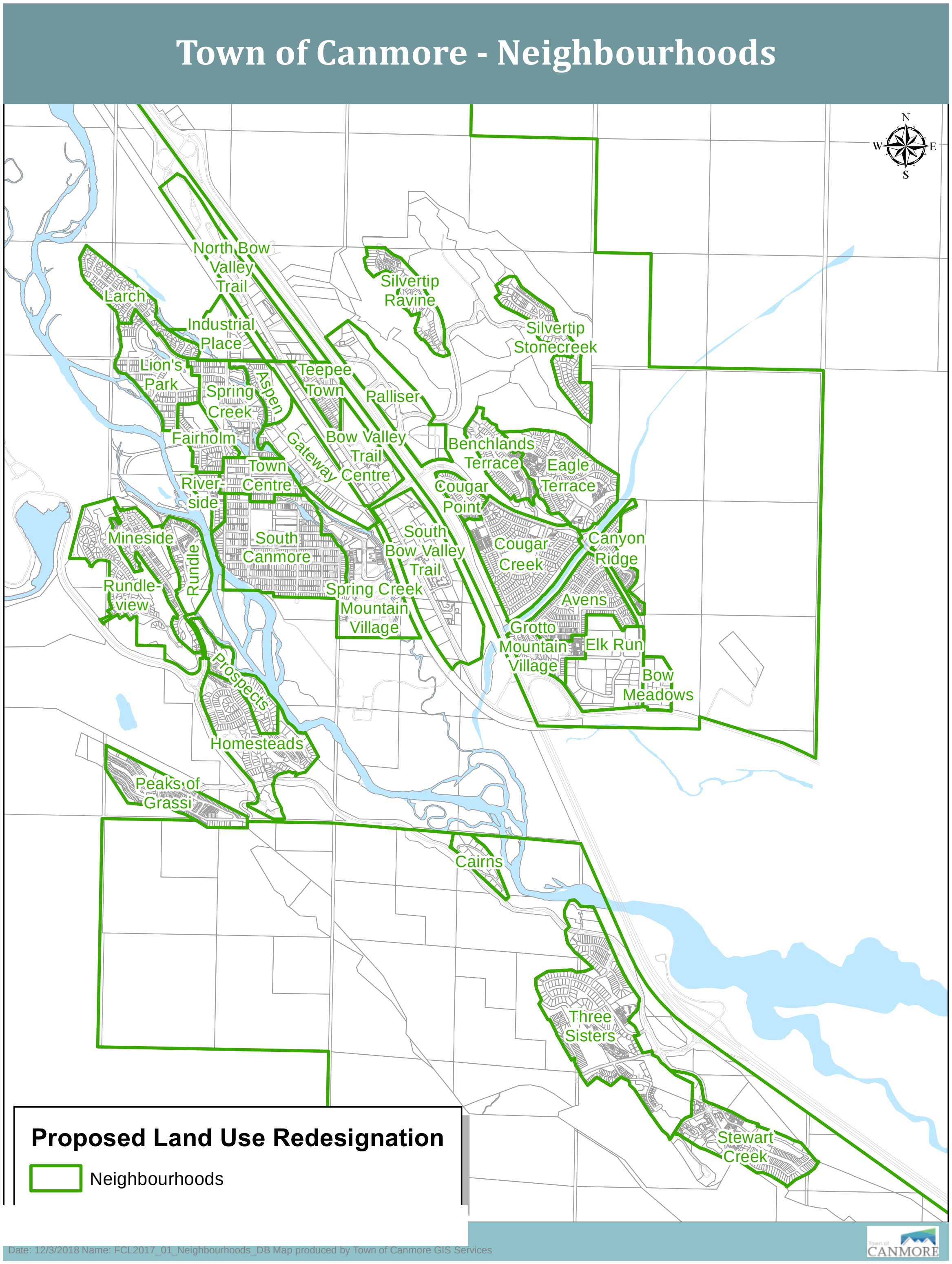
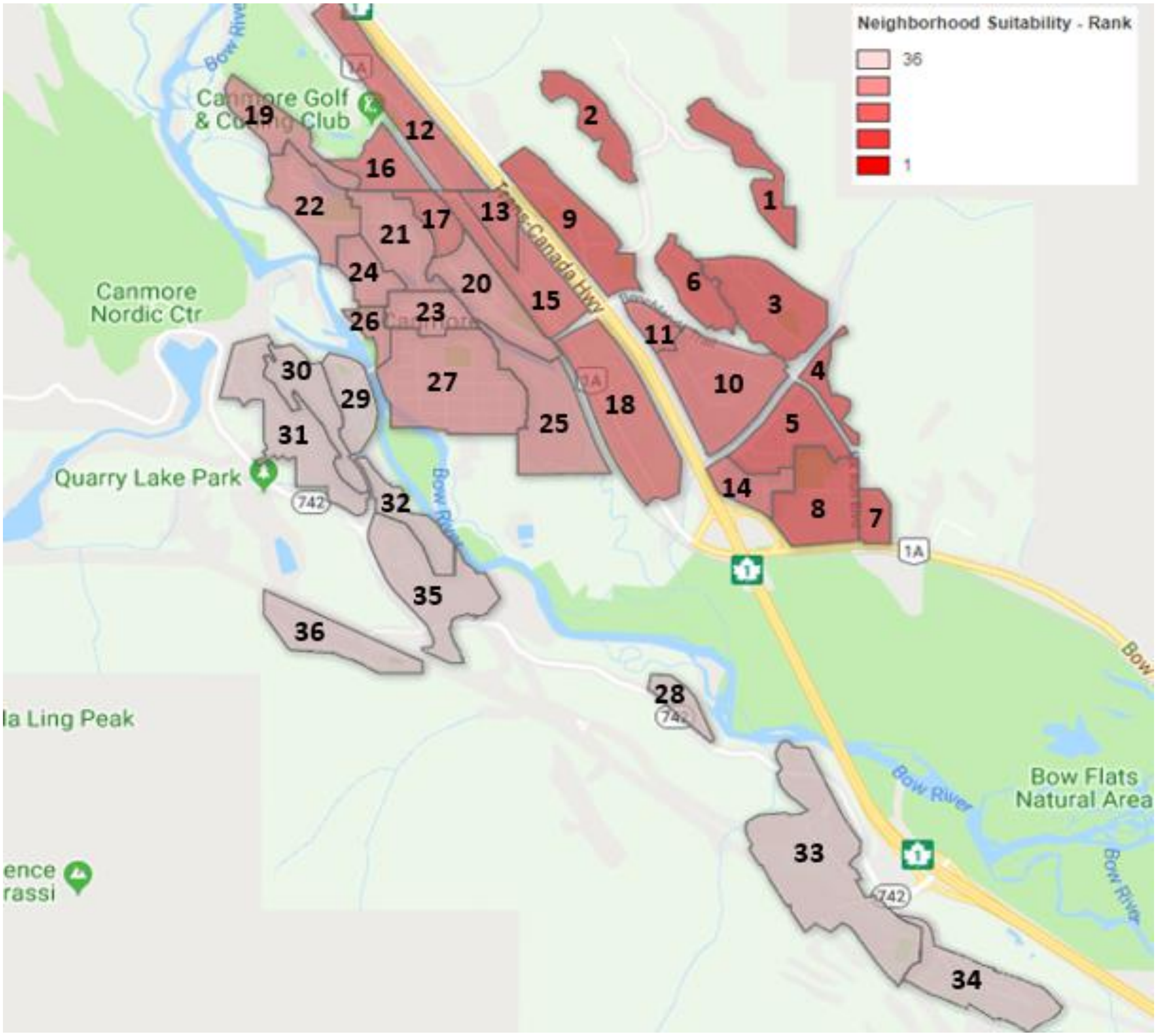


Figure 4.1 – Neighbourhood Suitability Map (Capacity Factor)

The Neighbourhood Suitability map shows the capacity factor of each neighbourhood. The capacity factor is representative of the percentage of time a solar panel on a roof in the neighbourhood would be producing at its maximum rated output. The higher the capacity factor, the more solar irradiation (sunlight) is available in the neighbourhood over the course of the year, which increases the efficiency of rooftop solar installations. This map can show where the highest natural potential for solar is within the town, however this does not necessarily correlate to the areas with the highest available usable rooftop area for solar. The neighbourhood of Silvertip Stonecreek is the most suitable location for solar, with a Capacity factor of 13.18% at a 180 degree azimuth. Peaks of Grassi is the least suitable with a Capacity factor of 11.08% at a 180 degree azimuth. A complete neighbourhood breakdown can be found in Appendix A. It can be seen from Figure 4.1 that neighbourhoods in the northeast tend to have better solar production potential, gradually becoming less suitable the farther southwest they are. This is due to the unique shading provided to Canmore from the surrounding mountains. The northeast section of the town receives more hours of sunlight than the southwest portion. This does not mean that the southwestern neighbourhoods are necessarily bad for solar. Southern Alberta has a higher solar insolation (W/m^2) than the capital cities in Germany and China[9], the countries with the most installed solar capacity worldwide. Even the worst neighbourhoods in Canmore have a relatively high potential.


Neighborhood Suitability - Rank
36
1
Canmore Golf & Curling Club
Canmore Nordic Ctr
Quarry Lake Park
Trans-Canada Hwy
Bow River
Bow Flats Natural Area
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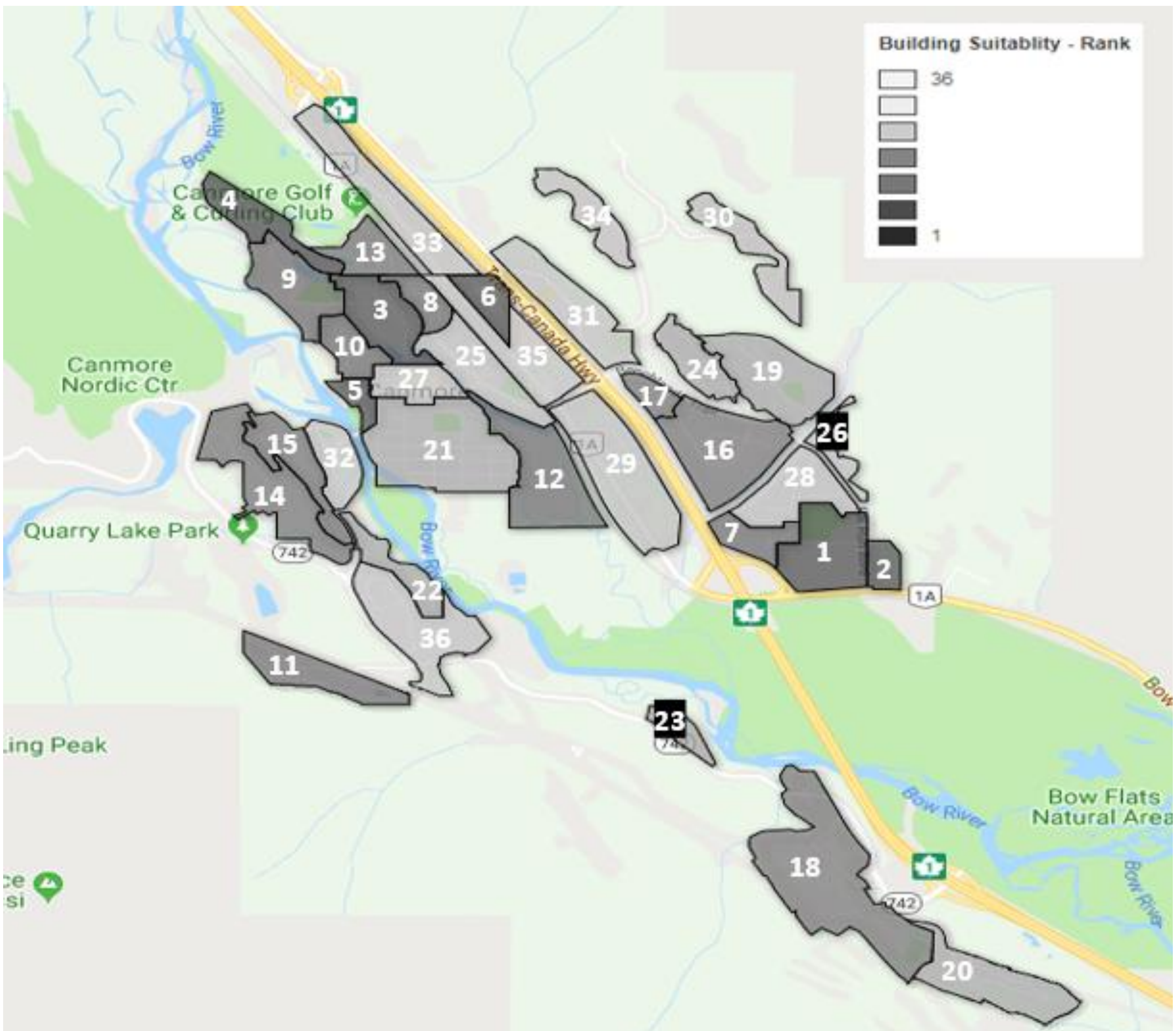
Community	Value/Rank	Maximum Community Capacity Factor (180 Degrees)	Average Community Capacity Factor (Cumulative)
Aspen	Value	12.65%	9.67%
Aspen	Rank	17	18
Avens	Value	12.88%	9.77%
Avens	Rank	5	6
Benchlands Terrace	Value	12.87%	9.76%
Benchlands Terrace	Rank	6	7
Bow Meadows	Value	12.87%	9.75%
Bow Meadows	Rank	7	8
Bow Valley Trail Centre	Value	12.71%	9.73%
Bow Valley Trail Centre	Rank	15	13
Cairns	Value	12.15%	9.48%
Cairns	Rank	28	28
Canyon Ridge	Value	12.96%	9.77%
Canyon Ridge	Rank	4	5
Cougar Creek	Value	12.83%	9.73%
Cougar Creek	Rank	9	12
Cougar Point	Value	12.80%	9.74%
Cougar Point	Rank	12	10
Eagle Terrace	Value	13.02%	9.80%
Eagle Terrace	Rank	3	3
Elk Run	Value	12.84%	9.78%
Elk Run	Rank	8	4
Fairholm	Value	12.48%	9.62%
Fairholm	Rank	25	23
Gateway	Value	12.61%	9.67%
Gateway	Rank	20	17
Grotto Mountain Village	Value	12.75%	9.72%
Grotto Mountain Village	Rank	13	15
Homesteads	Value	11.78%	9.24%
Homesteads	Rank	34	35
Industrial Place	Value	12.69%	9.66%
Industrial Place	Rank	16	21
Larch	Value	12.63%	9.66%
Larch	Rank	19	20
Lion's Park	Value	12.54%	9.61%
Lion's Park	Rank	22	24
Mineside	Value	12.04%	9.39%
Mineside	Rank	30	30
North Bow Valley Trail	Value	12.81%	9.72%
North Bow Valley Trail	Rank	11	14
Paliser	Value	12.82%	9.75%
Paliser	Rank	10	9
Peaks of Grassi	Value	11.08%	8.85%
Peaks of Grassi	Rank	36	36
Prospects	Value	11.93%	9.34%
Prospects	Rank	32	32
Riverside	Value	12.36%	9.56%
Riverside	Rank	27	26
Rundle	Value	12.13%	9.44%
Rundle	Rank	29	29
Rundleview	Value	11.96%	9.34%
Rundleview	Rank	31	33
Silver Tip Ravine	Value	13.02%	9.84%
Silver Tip Ravine	Rank	2	2
Silvertip Stonecreek	Value	13.18%	9.91%
Silvertip Stonecreek	Rank	1	1
South Bow Valley Trail	Value	12.63%	9.69%
South Bow Valley Trail	Rank	18	16
South Canmore	Value	12.38%	9.55%
South Canmore	Rank	26	27
Spring Creek	Value	12.59%	9.67%
Spring Creek	Rank	21	19
Spring Creek Mountain Village	Value	12.49%	9.60%
Spring Creek Mountain Village	Rank	24	25
Stewart Creek	Value	11.69%	9.34%
Stewart Creek	Rank	35	34
Teepee Town	Value	12.75%	9.73%
Teepee Town	Rank	14	11
Three Sisters	Value	11.78%	9.36%
Three Sisters	Rank	33	31
Town Centre	Value	12.49%	9.63%
Town Centre	Rank	23	22
Canmore Overall	Value	12.51%	9.61%

Figure 4.2 – Building Suitability Map (Application Factor)

The Building Suitability map shows the application factor of each of the neighbourhoods. The application factor represents the percentage of the overall rooftop area that is suitable for solar installations. Neighbourhoods with higher application factors have larger unobstructed rooftop area that could be used for solar installations increasing the output potential of the neighbourhood. The neighbourhood of Elk Run has the highest ratio of roof area available for solar compared to total roof area, with an Application Factor of 45.74%. Homesteads has the lowest Application Factor with only 8.97% of roof area being usable for solar production. A complete neighbourhood breakdown can be found in Appendix A. Neighbourhoods with a high percentage of institutional/industrial buildings tend to have a better ranking due to a higher 'Obstacles' factor (less obstacles in the way). The large, open roof spaces allow for larger groups of panels while many residential homes have open areas too small to fit at least 6 panels on. There are however, many unique factors involved in calculating the Application Factor which results in the lack of trend, as seen in Figure 4.2.



Community	Value/Rank	Application Factor
Aspen	Value	30.87%
Aspen	Rank	8
Avens	Value	18.01%
Avens	Rank	28
Benchlands Terrace	Value	19.33%
Benchlands Terrace	Rank	24
Bow Meadows	Value	41.04%
Bow Meadows	Rank	2
Bow Valley Trail Centre	Value	10.71%
Bow Valley Trail Centre	Rank	35
Cairns	Value	19.36%
Cairns	Rank	23
Canyon Ridge	Value	18.36%
Canyon Ridge	Rank	26
Cougar Creek	Value	24.68%
Cougar Creek	Rank	16
Cougar Point	Value	21.14%
Cougar Point	Rank	17
Eagle Terrace	Value	20.39%
Eagle Terrace	Rank	19
Elk Run	Value	45.74%
Elk Run	Rank	1
Fairholm	Value	28.31%
Fairholm	Rank	10
Gateway	Value	19.20%
Gateway	Rank	25
Grotto Mountain Village	Value	31.88%
Grotto Mountain Village	Rank	7
Homesteads	Value	8.97%
Homesteads	Rank	36
Industrial Place	Value	26.25%
Industrial Place	Rank	13
Larch	Value	34.24%
Larch	Rank	4
Lion's Park	Value	29.00%
Lion's Park	Rank	9
Mineside	Value	24.92%
Mineside	Rank	15
North Bow Valley Trail	Value	13.14%
North Bow Valley Trail	Rank	33
Paliser	Value	14.44%
Paliser	Rank	31
Peaks of Grassi	Value	27.79%
Peaks of Grassi	Rank	11
Prospects	Value	19.72%
Prospects	Rank	22
Riverside	Value	33.43%
Riverside	Rank	5
Rundle	Value	13.84%
Rundle	Rank	32
Rundleview	Value	25.01%
Rundleview	Rank	14
Silver Tip Ravine	Value	12.96%
Silver Tip Ravine	Rank	34
Silvertip Stonecreek	Value	15.88%
Silvertip Stonecreek	Rank	30
South Bow Valley Trail	Value	15.94%
South Bow Valley Trail	Rank	29
South Canmore	Value	19.90%
South Canmore	Rank	21
Spring Creek	Value	34.51%
Spring Creek	Rank	3
Spring Creek Mountain Village	Value	26.36%
Spring Creek Mountain Village	Rank	12
Stewart Creek	Value	20.01%
Stewart Creek	Rank	20
Teepee Town	Value	32.03%
Teepee Town	Rank	6
Three Sisters	Value	20.94%
Three Sisters	Rank	18
Town Centre	Value	18.05%
Town Centre	Rank	27
Canmore Overall	Value	23.23%

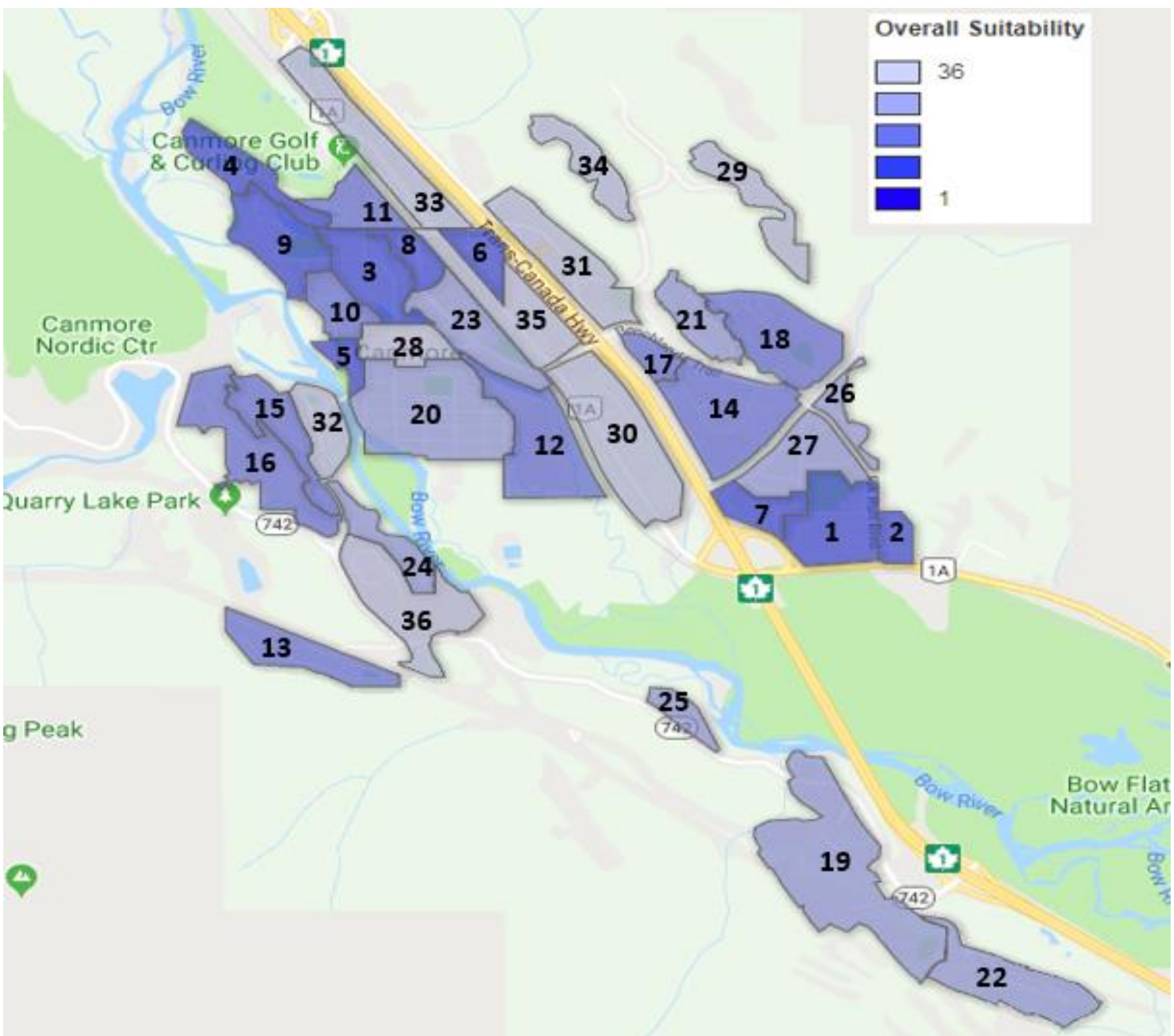
Figure 4.3 – Net Solar Energy Production Potential (Total Output)

With 100% adoption of solar on all rooftops that meet criteria (outlined in section 3.1)**, the total solar energy production potential for the town of Canmore is 42,181 MWh/yr, offsetting 40,072 tonnesCO2eq/yr.** It should be noted that the net solar energy production is significantly impacted by the size of each neighbourhood. This should not be confused with a metric showing the quality of each neighbourhood for solar energy production. It is meant to show a snapshot of the total electricity each neighbourhood could produce if solar arrays were maximized on all existing structures. This is a combination of the Building and Neighbourhood Suitability maps above. Assuming that residential homes in Canmore consume the same amount of electricity per square foot as an average Alberta home, each neighbourhood could offset an average of 64% of its own residential electricity use with rooftop solar generation. The neighbourhood potential output rank can be seen in Figure 4.3. The neighbourhoods with the highest and lowest production potential respectively are Three Sisters (3,339 MWh/yr) and Cairns (171 MWh/yr). A complete neighbourhood breakdown can be found in Appendix A.

Community	Value/Rank	Total Output (MWh/year)
Aspen	Value	872.07
Aspen	Rank	24
Avens	Value	1650.80
Avens	Rank	7
Benchlands Terrace	Value	747.51
Benchlands Terrace	Rank	25
Bow Meadows	Value	889.54
Bow Meadows	Rank	22
Bow Valley Trail Centre	Value	611.24
Bow Valley Trail Centre	Rank	27
Cairns	Value	171.40
Cairns	Rank	36
Canyon Ridge	Value	446.05
Canyon Ridge	Rank	34
Cougar Creek	Value	2746.53
Cougar Creek	Rank	3
Cougar Point	Value	562.13
Cougar Point	Rank	28
Eagle Terrace	Value	1990.72
Eagle Terrace	Rank	5
Elk Run	Value	2062.87
Elk Run	Rank	4
Fairholm	Value	1258.57
Fairholm	Rank	12
Gateway	Value	1428.47
Gateway	Rank	10
Grotto Mountain Village	Value	1085.53
Grotto Mountain Village	Rank	15
Homesteads	Value	707.02
Homesteads	Rank	26
Industrial Place	Value	873.10
Industrial Place	Rank	23
Larch	Value	1415.46
Larch	Rank	11
Lion's Park	Value	1245.05
Lion's Park	Rank	13
Mineside	Value	1028.08
Mineside	Rank	18
North Bow Valley Trail	Value	470.08
North Bow Valley Trail	Rank	32
Paliser	Value	242.96
Paliser	Rank	35
Peaks of Grassi	Value	1646.52
Peaks of Grassi	Rank	8
Prospects	Value	449.09
Prospects	Rank	33
Riverside	Value	560.40
Riverside	Rank	29
Rundle	Value	484.47
Rundle	Rank	30
Rundleview	Value	1038.77
Rundleview	Rank	17
Silver Tip Ravine	Value	478.63
Silver Tip Ravine	Rank	31
Silvertip Stonecreek	Value	937.31
Silvertip Stonecreek	Rank	20
South Bow Valley Trail	Value	1567.27
South Bow Valley Trail	Rank	9
South Canmore	Value	3235.02
South Canmore	Rank	2
Spring Creek	Value	1219.75
Spring Creek	Rank	14
Spring Creek Mountain Village	Value	1735.46
Spring Creek Mountain Village	Rank	6
Stewart Creek	Value	922.81
Stewart Creek	Rank	21
Teepee Town	Value	993.94
Teepee Town	Rank	19
Three Sisters	Value	3338.53
Three Sisters	Rank	1
Town Centre	Value	1067.93
Town Centre	Rank	16
Canmore Overall	Value	42181.07

Figure 4.4 – Overall Suitability (Combined Capacity/Application Factors)

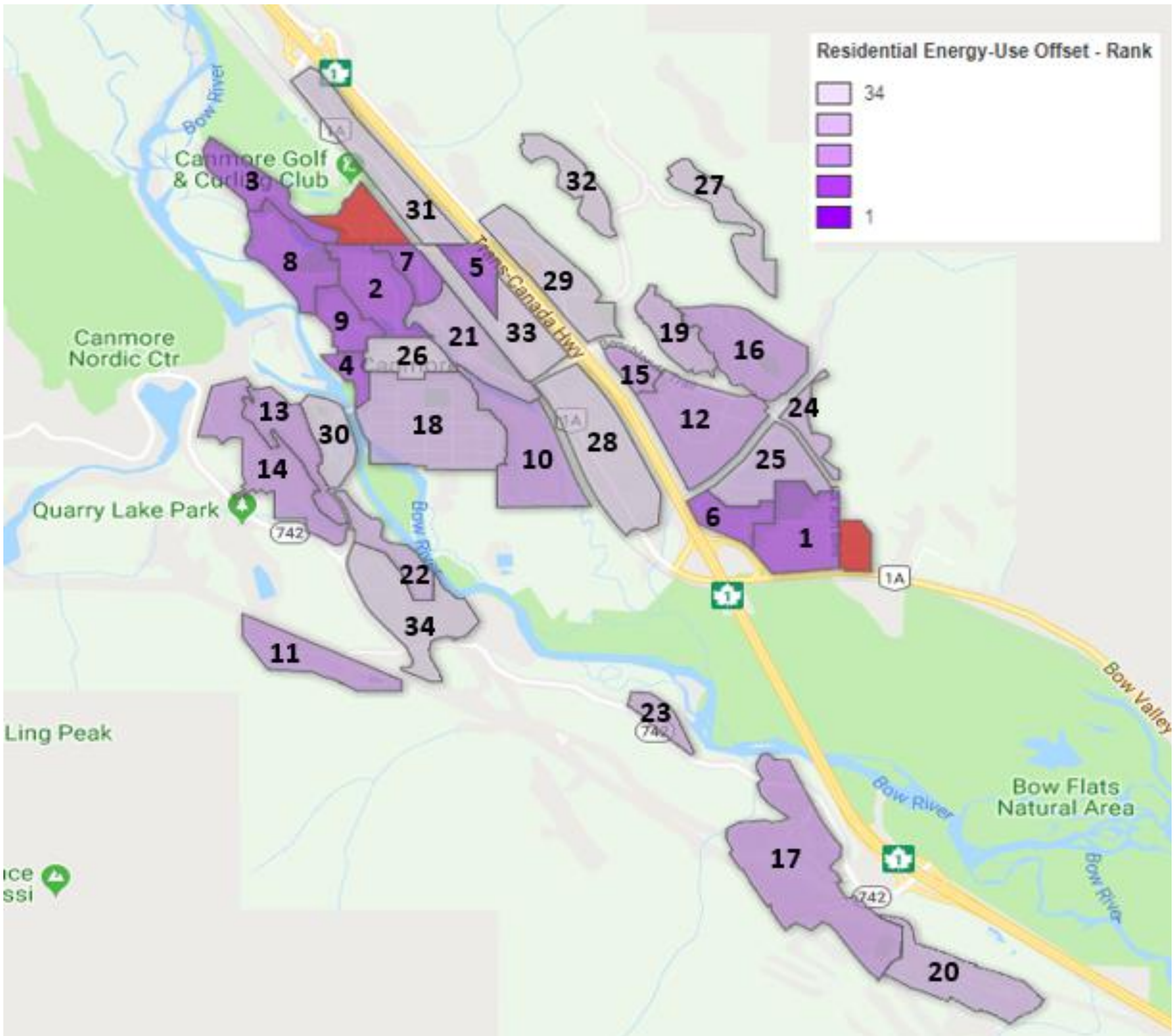
The overall suitability combines the capacity and application factors. It calculates the total electricity output (kWh) per m^2 of rooftop area. It takes into account both the number of panels that could be placed on a rooftop given the application factor guidelines and multiples that by the average capacity factor of the installed panels. It does not take into account the size of a neighbourhood, just the average overall quality of a rooftop for solar energy. Figure 4.4 shows the neighbourhood ranking for solar generation per unit of roof area. This differs from overall potential in that it allows neighbourhoods to be compared in a levelized way, factoring both Building and Neighbourhood suitability. Elk Run has 73.75 kWh/m^2/yr, the highest neighbourhood levelized potential output. Homesteads has the lowest levelized potential output with 13.66 kWh/m^2/yr. A complete neighbourhood breakdown can be found in Appendix A. **Canmore's overall solar potential per unit of roof area is 36.80 kWh/m^2/yr.** The Overall Suitability Map closely mirrors the Building Suitability Map, suggesting that building type has a greater impact on existing neighbourhoods than location within the valley.



Community	Value/Rank	Overall Suitability (kWh/m2/year)
Aspen	Value	49.21
Aspen	Rank	8
Avens	Value	29.00
Avens	Rank	27
Benchlands Terrace	Value	31.08
Benchlands Terrace	Rank	21
Bow Meadows	Value	65.94
Bow Meadows	Rank	2
Bow Valley Trail Centre	Value	17.17
Bow Valley Trail Centre	Rank	35
Cairns	Value	30.25
Cairns	Rank	25
Canyon Ridge	Value	29.57
Canyon Ridge	Rank	26
Cougar Creek	Value	39.57
Cougar Creek	Rank	14
Cougar Point	Value	33.95
Cougar Point	Rank	17
Eagle Terrace	Value	32.95
Eagle Terrace	Rank	18
Elk Run	Value	73.75
Elk Run	Rank	1
Fairholm	Value	44.89
Fairholm	Rank	10
Gateway	Value	30.61
Gateway	Rank	23
Grotto Mountain Village	Value	51.09
Grotto Mountain Village	Rank	7
Homesteads	Value	13.66
Homesteads	Rank	36
Industrial Place	Value	41.79
Industrial Place	Rank	11
Larch	Value	54.54
Larch	Rank	4
Lion's Park	Value	45.92
Lion's Park	Rank	9
Mineside	Value	38.56
Mineside	Rank	15
North Bow Valley Trail	Value	21.06
North Bow Valley Trail	Rank	33
Paliser	Value	23.20
Paliser	Rank	31
Peaks of Grassi	Value	40.52
Peaks of Grassi	Rank	13
Prospects	Value	30.38
Prospects	Rank	24
Riverside	Value	52.68
Riverside	Rank	5
Rundle	Value	21.53
Rundle	Rank	32
Rundleview	Value	38.49
Rundleview	Rank	16
Silver Tip Ravine	Value	21.02
Silver Tip Ravine	Rank	34
Silvertip Stonecreek	Value	25.95
Silvertip Stonecreek	Rank	29
South Bow Valley Trail	Value	25.46
South Bow Valley Trail	Rank	30
South Canmore	Value	31.31
South Canmore	Rank	20
Spring Creek	Value	55.01
Spring Creek	Rank	3
Spring Creek Mountain Village	Value	41.71
Spring Creek Mountain Village	Rank	12
Stewart Creek	Value	30.79
Stewart Creek	Rank	22
Teepee Town	Value	51.37
Teepee Town	Rank	6
Three Sisters	Value	32.29
Three Sisters	Rank	19
Town Centre	Value	28.65
Town Centre	Rank	28
Canmore Overall	Value	36.80

Figure 4.5 – Residential Energy Offset

Figure 4.5 represents a ranking of each neighbourhoods ability to offset their own **residential** electricity usage (areas in red have no residential). This potential would only be realized if solar panels were installed on all available residential rooftop area that met the criteria of the application factors. The neighbourhood of Elk Run has the greatest residential electricity offset and Homesteads has the least offset. A complete neighbourhood breakdown can be found in Appendix A.



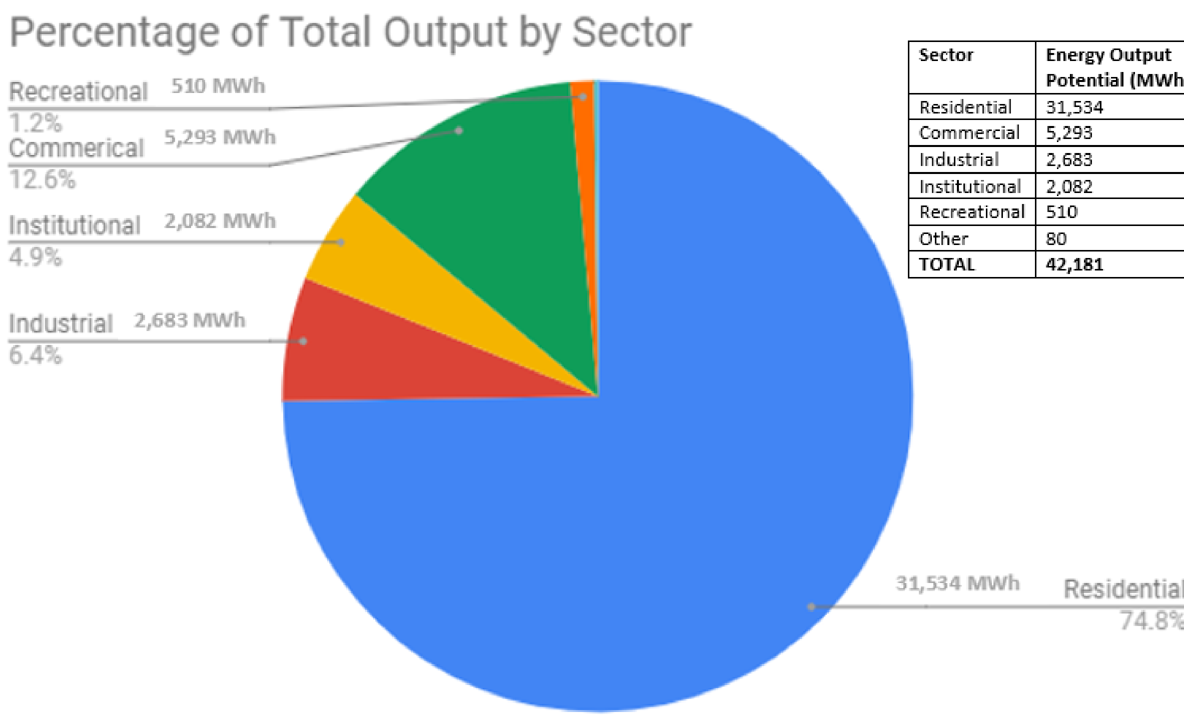
Community	Value/Rank	Residential % Energy Offset
Aspen	Value	87.93%
Aspen	Rank	7
Avens	Value	51.80%
Avens	Rank	25
Benchlands Terrace	Value	55.53%
Benchlands Terrace	Rank	19
Bow Meadows	Value	
Bow Meadows	Rank	
Bow Valley Trail Centre	Value	30.68%
Bow Valley Trail Centre	Rank	33
Cairns	Value	54.04%
Cairns	Rank	23
Canyon Ridge	Value	52.83%
Canyon Ridge	Rank	24
Cougar Creek	Value	70.70%
Cougar Creek	Rank	12
Cougar Point	Value	60.65%
Cougar Point	Rank	15
Eagle Terrace	Value	58.88%
Eagle Terrace	Rank	16
Elk Run	Value	131.76%
Elk Run	Rank	1
Fairholm	Value	80.20%
Fairholm	Rank	9
Gateway	Value	54.69%
Gateway	Rank	21
Grotto Mountain Village	Value	91.29%
Grotto Mountain Village	Rank	6
Homesteads	Value	24.41%
Homesteads	Rank	34
Industrial Place	Value	
Industrial Place	Rank	
Larch	Value	97.44%
Larch	Rank	3
Lion's Park	Value	82.04%
Lion's Park	Rank	8
Mineside	Value	68.90%
Mineside	Rank	13
North Bow Valley Trail	Value	37.63%
North Bow Valley Trail	Rank	31
Paliser	Value	41.44%
Paliser	Rank	29
Peaks of Grassi	Value	72.40%
Peaks of Grassi	Rank	11
Prospects	Value	54.27%
Prospects	Rank	22
Riverside	Value	94.12%
Riverside	Rank	4
Rundle	Value	38.46%
Rundle	Rank	30
Rundleview	Value	68.78%
Rundleview	Rank	14
Silver Tip Ravine	Value	37.56%
Silver Tip Ravine	Rank	32
Silvertip Stonecreek	Value	46.37%
Silvertip Stonecreek	Rank	27
South Bow Valley Trail	Value	45.49%
South Bow Valley Trail	Rank	28
South Canmore	Value	55.94%
South Canmore	Rank	18
Spring Creek	Value	98.29%
Spring Creek	Rank	2
Spring Creek Mountain Village	Value	74.52%
Spring Creek Mountain Village	Rank	10
Stewart Creek	Value	55.02%
Stewart Creek	Rank	20
Teepee Town	Value	91.79%
Teepee Town	Rank	5
Three Sisters	Value	57.70%
Three Sisters	Rank	17
Town Centre	Value	51.19%
Town Centre	Rank	26
Canmore Overall	Value	63.96%

Notes on Figure 4.5 – Residential Energy Offset

- The Residential Offset and Building Suitability Maps are similar, however they do vary slightly. The differences arise from the variation in Neighbourhood Suitability across the town.
- There is a wide range in the number of residential buildings in each neighbourhood. Bow Valley Trail Centre, Cairns, Elk Run, Gateway, north Bow Valley Trail, Palliser, and South Bow Valley Trail all have less than 20 residential buildings which could skew the results for these neighbourhoods due to the smaller sample size. Details on the building classification per neighbourhood can be found in Appendix A.

4.6 - Potential Output by Sector

The total potential output by sector can be seen in Figure 4.6. Residential buildings represent the largest production potential (74.8%), mainly due to the large amount of residential roof area compared to other sectors.



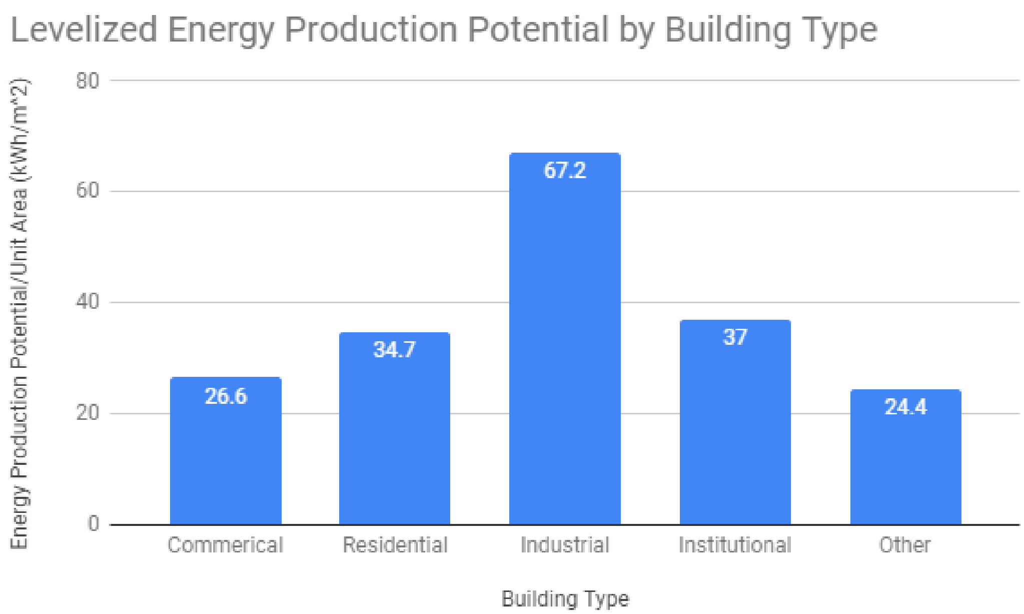
Sector	Energy Output Potential (MWh/yr)
Residential	31,534
Commercial	5,293
Industrial	2,683
Institutional	2,082
Recreational	510
Other	80
TOTAL	**42,181**

Figure 4.6 – Percentage of Total Output by Sector

4.7 - Levelized Energy Production

It can be seen from Figure 4.7 that industrial buildings (typically large, with flat rooftops) tend to be the best suited for rooftop solar. As noted in the Building Suitability results (figure 4.2), this is largely due to the significantly higher percentage of usable roof area per industrial building when compared to other building types.

Figure 4.7 – Levelized Energy Production Potential by Building Type



5.0 – Discussion on Trends from the Results

5.1 - Direction of the Panels (Azimuth)

Due to Canmore's location in the Rocky Mountains, there is a significant impact on the amount of solar energy available across different azimuth angles and in different neighbourhoods. In a location with no mountains, it could be expected that the east and west sides of a house would be equally suitable for solar, but in Canmore the east side of a house (azimuths 60-150 degrees) provides an average of 5% more production than the west side of a house (azimuth 210-300 degrees). This effect is more pronounced in the southwest portion of the valley. Silvertip Stonecreek, on the north side of the valley, sees virtually no difference between east and west azimuths, whereas Peaks of Grassi sees a difference greater than 10%. This result is expected due to the proximity to the mountains in the southwest side of the valley.

5.2 - Effect of Azimuth in Canmore on Levelized Cost of Electricity

Calculation Assumptions:

Array Size: 3kW
Solar Installation Cost: 2$/watt
Solar lifespan: 25 years
Interest Rates: 3% annually
Fixed operational maintenance costs: 50$/year
Capacity Factor (Canmore wide average at 180 degrees) = 12.50%
Tilt: 27 degrees

If this array were installed at an azimuth of 180 degrees, facing due south on the average Canmore home, the Levelized Cost of Electricity (LCOE) would be 0.12$/kWh. If the homeowner decided to expand the array and, for the same installation cost, installed another identical array at an azimuth of 270 degrees, the LCOE for the new array would be 0.16$/kWh and the cumulative LCOE would be 0.14$/kWh. If the same owner installed a third array at an azimuth of 0 degrees, facing due north, the LCOE for the third array would be 0.23$/kWh and the cumulative LCOE would jump to 0.17$/kWh.

This scenario demonstrates the change in production associated with changing azimuth angles and its impact on the cost of the electricity produced. What it does not consider is the fact that the average installation cost of the array would likely decrease as the size of the array increased. This is due to the fixed costs associated with the installation. In order to make an informed decision on how to maximize the return on solar investments, the fixed costs (electrical disconnects, permitting, engineering) and variable costs (materials, installation labour) associated with a solar installation would need to be confirmed with local solar installers. This would help determine the cutoff azimuth angle at which point it was no longer economically efficient to install more panels on the remaining faces of the roof.

The tilt angle also plays a role, however most homeowners do not have the option to change the roof tilt of their home. The optimal tilt angle in Canmore ranges from approximately 30 degrees near the south side of the valley to approximately 45 degrees on the north side of the valley based on SolarGIS optimization. Another consideration with the tilt of a solar array is how it impacts the production change with azimuth angle and snow loading. As the tilt increases, the variation in production with each change in azimuth angle also increases. For snow loading, the higher the tilt angle the less impact snow loading has on the performance of the solar array.

5.3 - Location Within the Bow Valley (Terrain Shading)

A difference in production can also be seen in the difference between the north and south neighbourhoods in Canmore. The most extreme differences between the maximum and minimum solar potential are between 10% and 15%, with the north side being more favourable. Figure 4.1 shows that neighbourhood suitability trends upward toward the northeast. The most extreme difference between maximum capacity factors was 13.18% in Silvertip Stonecreek at 180 degree azimuth compared to 11.08% at 180 degree azimuth in the Peaks of Grassi neighbourhood.

5.4 - Offsetting Residential Energy Consumption

The Residential Electricity Offset results show that on average, each neighbourhood could be offsetting, on average, 64% of its own residential electricity use, and that there is significant variation throughout the different neighbourhoods. Excluding neighbourhoods with less than 20 residential buildings, the average offset ranges from 38% to 97%. This is mainly a correlation to the building suitability factor in each neighbourhood. If buildings were designed in a way to optimize usable rooftop area for solar arrays it would not be unreasonable to design homes that had net zero electricity requirements.

5.5 - A Closer Look at Silvertip Stonecreek

Far and away, the largest contrast in this study is the effect of building suitability. The most suitable location of all the neighbourhoods, Silvertip Stonecreek, ranks 29th in overall suitability due to the low amount of space on each building that is available for solar. Silvertip Stonecreek represents a missed opportunity for solar energy, which once again highlights the effect that building design has on the amount of energy that can be captured. To further show the importance of building suitability it should be noted that the top 3 neighbourhoods in terms of residential electricity offset all ranked in the bottom half of the neighbourhood suitability at 19, 20, and 26 respectively.

5.6 - Designing with Solar in Mind

A key takeaway from these results is the impact of designing homes and neighbourhoods with solar in mind. Consider the fact that the building suitability percentage varies from 45.74% in Elk Run to 8.97% in Homesteads. Elk run would have 5 times the usable roof area that Homesteads has for the same building footprint area. For comparison, the difference in Capacity Factor between the top and bottom neighbourhoods is only 1.18 times, which has a much less significant impact when it comes to the overall solar production potential of the town. **The maximum change in application factor between neighbourhoods has 4.3 times the impact of the maximum change in capacity factor across all Canmore neighbourhoods.** If solar were considered at the design phase, both the building suitability and Capacity Factor could be maximized in order to provide the most productive and efficient solar array possible for the development location. In addition, the install costs are reduced when the roof is designed for an array. A significant portion of the installation cost is the engineering, permitting, and electrical installation which could be managed much more efficiently at the design stage rather than as retrofits to existing construction.

5.7 - Theoretical Model vs. Actual Implementation

These results are presented under the scenario where solar panels are to be installed on all available roof planes in Canmore that are not shaded, regardless of the direction that they are facing. In reality, this would not be practical. Even though the difference between the maximum Capacity Factor for each neighbourhood facing due south (Canmore-wide average of 12.5%) and the Capacity Factor considering all directions equally (Canmore-wide average of 9.6%) may not seem large, it has a significant impact on the LCOE, as shown in section 5.2.

6.0 - Recommendations

6.1 - Recommendation on how this report should be used

Neighbourhood Suitability:

The Suitability Map in figure 4.1 shows the effect of the mountain shading based on location within the valley. The ranking of neighbourhood suitability takes into account just how much sunlight can be captured in each neighbourhood. While there is significant variability across the town, the Neighbourhood Suitability has a smaller impact than the Building Suitability. **This result should be used to determine the location of solar-specific projects** such as neighbourhood arrays or municipal buildings incorporating solar in the design phase.

Building Suitability:

This result is an assessment of just how much space in each neighbourhood is available for solar. The building suitability (figure 4.2) **should not be provided to the public as an estimation of their individual home suitability**, only as an estimate of the average of available space in their entire neighbourhood. The building suitability result becomes increasingly accurate for neighbourhoods where regular construction patterns emerge, such as neighbourhoods dominated by hotels or condo-complexes. The data are therefore presentable to those governing organizations, as certain condos/hotels had enough suitable area to alter the average for their entire neighbourhood. **As a large area of available space leads to higher electricity production, new solar investment should favour projects in these neighbourhoods.**

Net Energy Production:

As a representation of total potential, this result shows which neighbourhoods can produce the most energy if solar installations are included on every suitable rooftop. While this would not be economic in practice, it does allow us to see the upper bound of what is possible through rooftop solar. This result should be used primarily to provide context to policy makers and **should not** be used to determine where to invest in solar arrays.

Overall Suitability:

Overall Suitability (output per meter squared) ranks the neighbourhood's design for solar generation. New net zero neighbourhoods can be designed in the most economically and environmentally efficient manner through a set of new development guidelines based on results of this report.

Residential Energy-Use Offset:

The results for this Suitability Map (figure 4.5) should be considered in the context ESAP, especially with regards to the 2020 Neighbourhood goal to reduce CO_2 emissions to 2007 levels. If the overall goal is to have a net zero town, then each neighbourhood's ability to offset its own emissions (trend toward net zero) should be considered when designing new neighbourhoods.

6.2 - Recommended Courses of Action

6.21 - Analysis of top buildings and/or municipal buildings

The 25 buildings with the largest area represent 10% of the overall building area in the town. An individual solar-assessment of these buildings is recommended since they represent such a large portion of potential solar generation capacity. In general, the larger the array size, the cheaper it becomes. Incorporating arrays on the largest buildings will be an economic rooftop solar option. A list of the top 25 buildings in terms of building area is included below.

BuildingClass	BuildingUse	Neighbourhood	LandUseDistrictDescription	Area (m2)
Recreational	Recreation Centre/Ice Arena	Industrial Place	URBAN RESERVE DISTRICT	7738.834204
Institutional	Nursing Home	Fairholm	RESIDENTIAL SINGLE FAMILY-DETACHED DISTRICT	7408.372465
Commercial	Commercial - Service/Retail/Office	Gateway	GATEWAY COMMERCIAL DISTRICT	5042.866195
Commercial	Commercial - Service/Retail/Office	Gateway	GATEWAY COMMERCIAL DISTRICT	5499.507372
Institutional	Other Institutional	Bow Valley Trail Centre	PUBLIC USE DISTRICT	5559.840296
Residential	Townhouse/Apartment/Walk Up - R3	Three Sisters	RESIDENTIAL COMPREHENSIVE MULTIPLE UNIT DISTRICT	3182.307403
Residential	Apartments-Elevators - R5	Spring Creek Mountain Village	SPRING CREEK MOUNTAIN VILLAGE COMPREHENSIVE RESIDENTIAL DIRECT CONTROL DISTRICT	3034.122269
Institutional	School	Industrial Place	CANMORE COLLEGIATE SCHOOL DIRECT CONTROL DISTRICT	7884.7481
Institutional	School	Three Sisters	PUBLIC USE DISTRICT	4131.249309
Commercial	Hotel/Visitor Accommodation	Bow Valley Trail Centre	BOW VALLEY TRAIL CENTRAL DISTRICT	5142.920241
Commercial	Hotel/Visitor Accommodation	South Bow Valley Trail	BOW VALLEY TRAIL GENERAL DISTRICT	4451.48482
Commercial	Mixed Use - Residential with Visitor Accommodation	South Bow Valley Trail	BOW VALLEY TRAIL GENERAL DISTRICT	3549.000627
Commercial	Mixed Use - Residential with Visitor Accommodation	South Bow Valley Trail	BOW VALLEY TRAIL GENERAL DISTRICT	3994.053517
Commercial	Hotel/Visitor Accommodation	South Bow Valley Trail	BOW VALLEY TRAIL GENERAL DISTRICT	3164.145299
Institutional	School	South Canmore	PUBLIC USE DISTRICT	5159.315061
Commercial	Hotel/Visitor Accommodation	Homesteads	COMMERCIAL RESORT DISTRICT	4341.603702
Institutional	School	Cougar Creek	PUBLIC USE DISTRICT	5051.766313
Commercial	Unknown	Gateway	GATEWAY COMMERCIAL DISTRICT WITH AUTOMOTIVE USES	4415.248619
Recreational	Recreation Centre/Library/Pool	Gateway	MULTIPLEX DISTRICT	5182.454266
Commercial	Mixed Use - Residential with Visitor Accommodation	Bow Valley Trail Centre	BOW VALLEY TRAIL CENTRAL DISTRICT	4854.26711
Commercial	Hotel/Visitor Accommodation	Spring Creek Mountain Village	SPRING CREEK MOUNTAIN VILLAGE VISITOR ACCOMODATION DIRECT CONTROL DISTRICT	3897.009859
Residential	Apartments-Elevators - R5	Spring Creek Mountain Village	SPRING CREEK MOUNTAIN VILLAGE COMPREHENSIVE RESIDENTIAL DIRECT CONTROL DISTRICT	3844.586673
Commercial	Hotel/Visitor Accommodation	South Bow Valley Trail	BOW VALLEY TRAIL GENERAL DISTRICT	3422.575925
Commercial	Hotel/Visitor Accommodation	South Bow Valley Trail	BOW VALLEY TRAIL GENERAL DISTRICT	3328.917298
Commercial	Hotel/Visitor Accommodation	South Bow Valley Trail	BOW VALLEY TRAIL GENERAL DISTRICT	3349.700923

6.22 - Re-organize Distribution Structure for Subsidies

The current payment structure for solar subsidies in Canmore could be revised to maximize GHG reductions per dollar spent. To maximize emissions offset per dollar spent it is recommended to focus solar incentives based on the Neighbourhood Suitability rankings. In these neighbourhoods, large south facing, obstruction free roof areas are optimal for solar installations. Neighbourhood specific recommendations for solar installation criteria, including optimal array size and azimuth angle cutoff criteria, can be calculated with more information on installation costs.

6.23 – Update Architectural Guidelines

The results show there are two major factors determining a new development's solar potential: building suitability, and location. As Canmore grows, so does the available area for rooftop solar. To maximize the future solar potential of the town of Canmore, a set of specific guidelines or incentives for the design-phase considerations of solar energy in new neighbourhoods can be developed. Design for net zero electricity homes and neighbourhoods that maximize solar efficiency would help align Canmore's goals of neighbourhood growth and minimizing environmental impact.

6.24 - Sustainability and Neighbourhood Engagement

Energy literacy tends to be overestimated by policy makers, and citizens tend not to trust governments on energy matters[10]. As shown in Appendix B, the citizens of Canmore care greatly about reducing their greenhouse gas emissions and tend to be interested in solar, however they typically have limited knowledge on solar technology and available incentives. Installing a solar array is a significant investment decision, and **unbiased public information campaigns** to provide more information on the benefits and drawbacks of solar energy are recommended. While this report provides information on the potential and applicability of rooftop solar in Canmore, a package containing information on the costs, installation, operation, decommissioning, and FAQ would be beneficial to those considering installing an array. Additionally, this public information approach can be applied to other sustainability and efficiency initiatives including reducing energy use, solar thermal heating, new windows, LED lighting, thermostats, and no-draft doors. This will provide residents the information and confidence they need to make informed investment decisions.

6.25 – Create a Competitive Drive

Two large-scale field experiments have shown that **providing residents with feedback** on their own electricity and natural gas usage, with a focus on peer-to-peer benchmarking, **can reduce energy consumption at a low cost to the neighbourhood itself[11]**. Given the amount of energy-use data recorded electronically, this feedback will become increasingly easy to distribute through third party data-tracking services. Canmore itself has an online tracker dedicated to the solar array at the Civic Center using this exact type of service[12]. Creating an atmosphere where the citizens are engaged and educated by actively comparing their energy usage to their peers will lead to a natural, sustainable reduction in GHG emissions with a low capital investment. Additionally, the town would have access to energy data for most of the buildings, allowing for more accurate reporting on multiple building types.

6.26 – Adoption of the PACE program

A noteworthy program, one that the public is not widely informed of, is the soon to be implemented PACE (Property Assessed Clean Energy) program. It is a financing option for residential or commercial institutions that allows clean energy adopters to install renewable energy systems for no money down and repay the debt through property taxes. PACE offers system owners a way to avoid the high upfront costs associated with solar installation. The PACE program involves the private funding of a solar array (or other energy project), paid back via property taxes. The idea behind PACE is to **create an environment where citizens are financially benefiting from their solar array from day one**, instead of having to wait lengthy payback periods. It is hoped that this program will be implemented by the province in 2019 and subsequently approved by municipalities individually.

7.0 - Conclusion

The town of Canmore is known for its natural beauty and highly active lifestyle. Implementing renewable energy production is an important step for the town as it seeks to retain the pristine environment, while adding resiliency to the grid in emergencies. Rooftop solar is a particularly effective generation source in any municipality, as it better utilizes otherwise occupied space and minimizes any increase in the town's footprint. In the case of Canmore, rooftop solar could have a significant impact on the town's carbon emissions. The 2 main goals of this report were:

1) Quantify the total rooftop solar potential in Canmore using our model combined with the town's data.
2) Generate a 'solar Suitability Map' of the town showing the neighbourhoods with relative high, medium, and low solar potential.

In reference to the first goal, a complete adoption of solar on all eligible rooftops would result in **42,181 MWh/yr of production**, with the **residential sector being able to offset an average of 64%** of its own energy usage on a neighbourhood by neighbourhood basis. The Alberta electricity generation mix is uniquely carbon intensive due to a heavy reliance on fossil fuels (950gCO2eq/kWh). This means that reductions in electricity required from will have a large effect on the amount of carbon emitted, resulting in an emissions reduction of 40,072 tonnes of CO2eq/yr for the town, **an equivalent of 8,600 cars removed from the road.**

For the design of **new neighbourhoods**, a set of solar development guidelines could be easily added to the existing architectural guidelines based on the results of this report. These guides would allow for the design of net-zero neighbourhoods in the most environmentally responsible and economically sustainable way.

For **existing buildings**, the best investment opportunities for solar would be found by first identifying the neighbourhoods with a high solar resource (Neighbourhood Suitability Map) and then looking for large, south-facing, unobstructed roof areas. Neighbourhood specific recommendations for solar installation criteria including optimal array size and azimuth angle cutoff criteria can be calculated with more information on installation costs.

8.0 - References

Listed in order of appearance, in IEEE style.

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Appendix A: Overall Results and Neighbourhood Summaries

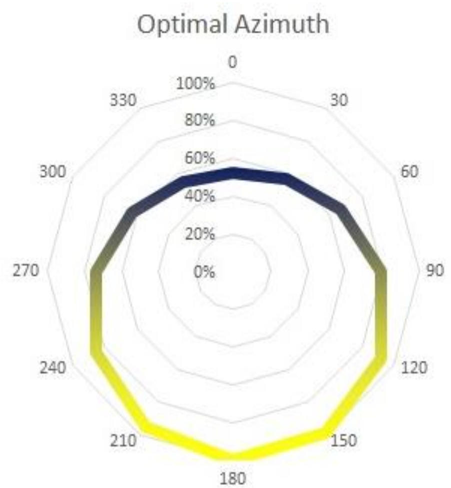
Canmore's Overall Results:

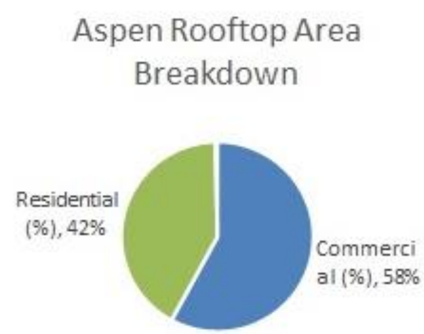
Parameter	Value
Application Factor (Building Suitability)	23.23%
Maximum Neighbourhood Capacity Factor (Neighbourhood Suitability – Panel Facing south)	12.51%
Average Neighbourhood Capacity Factor (Neighbourhood Suitability – Cumulative total of Panels Facing all Directions)	9.61%
Total Building Area (m2)	1217034.11
Total Roof Area (m2)	1365909.31
Total Array Size (kW) possible in Canmore	50212.74
Net Potential Output (MWh/year)	42181.07
Canmore's Overall Suitability (kWh/m2/year)	36.80
Average Residential Array Size (kW)	10.99
Residential % Energy Offset	63.96%

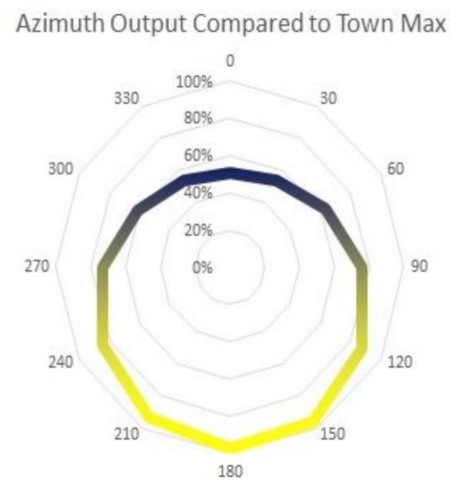
Breakdown by Sector	Annual Output (MWh/Year)	Percentage of Total Output
Residential	31533.83551	74.76%
Industrial	2682.733874	6.36%
Institutional	2081.602538	4.93%
Commercial	5293.01127	12.55%
Recreational	509.8588913	1.21%
Other	80.02932676	0.19%
Total	42181.07141	

Aspen

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**30.87%**	**12.65%**	**9.67%**	**17720.21**	**19887.86**	**1029.37**	**872.07**	**49.21**	**5.97**	**87.93%**
Rank	**8**	**17**	**18**				**24**	**8**	**24**	**7**

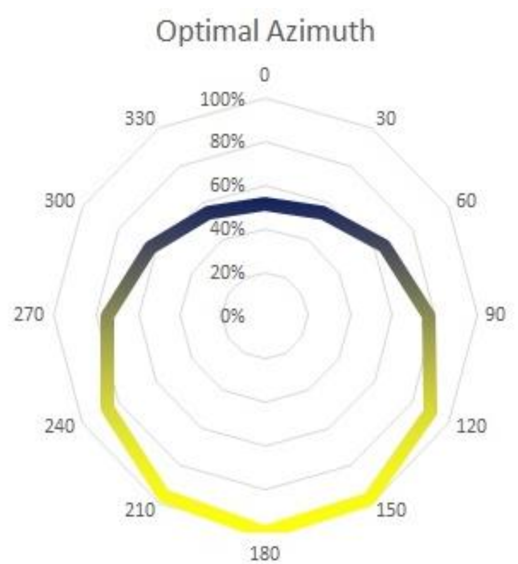


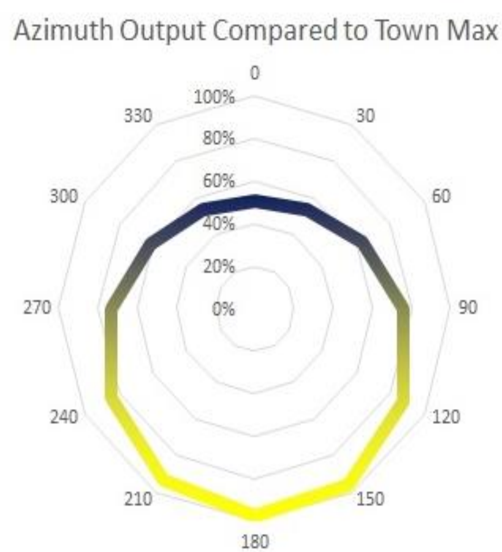




Avens

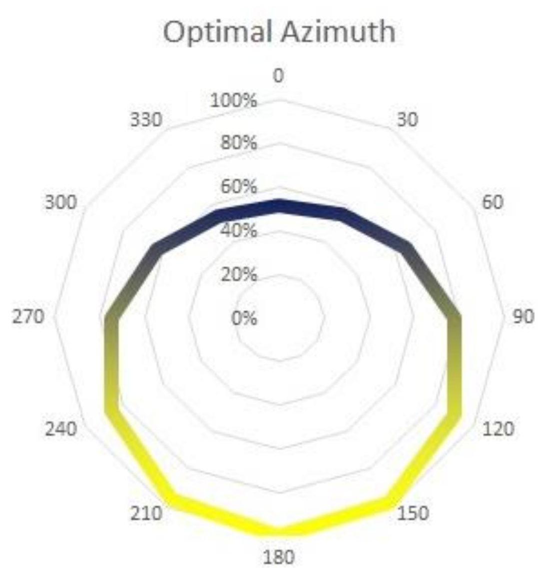
Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**18.01%**	**12.88%**	**9.77%**	**56932.78**	**63897.15**	**1929.49**	**1650.80**	**29.00**	**3.87**	**51.80%**
Rank	**28**	**5**	**6**				**7**	**27**	**30**	**25**

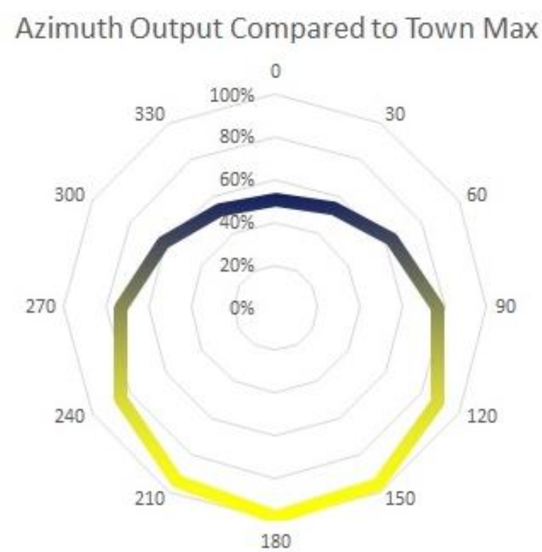




Benchlands Terrace

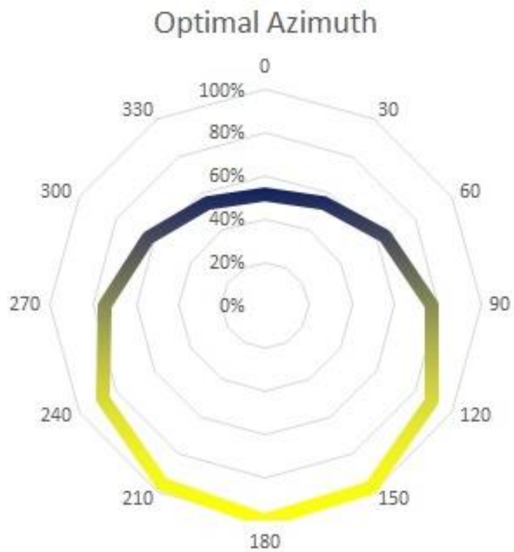
Value/Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**19.33%**	**12.87%**	**9.76%**	**24048.42**	**26990.17**	**874.75**	**747.51**	**31.08**	**7.41**	**55.53%**
Rank	**24**	**6**	**7**				**25**	**21**	**15**	**19**

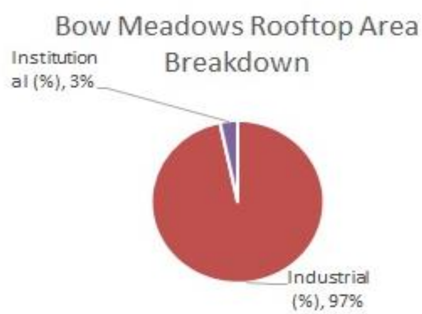


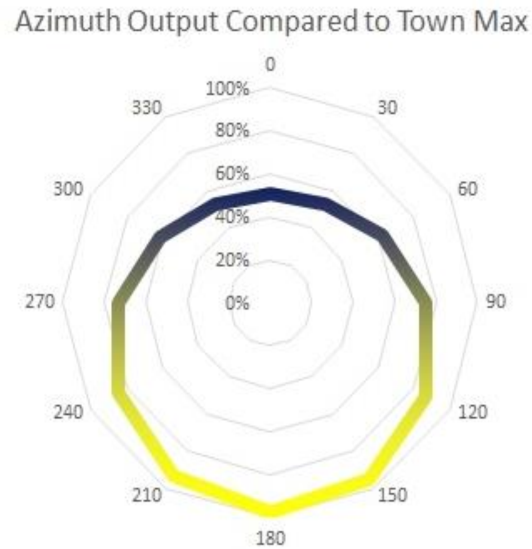


Bow Meadows

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)
Value	**41.04%**	**12.87%**	**9.75%**	**13489.95**	**15140.12**	**1041.80**	**889.54**	**65.94**	**N/A - No Residential**
Rank	**2**	**7**	**8**				**22**	**2**	**N/A**

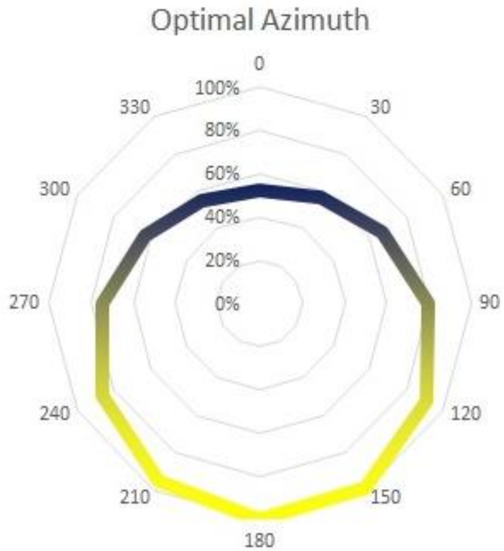


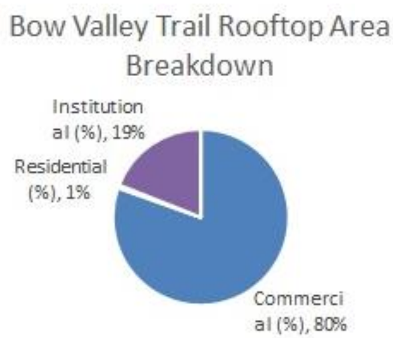


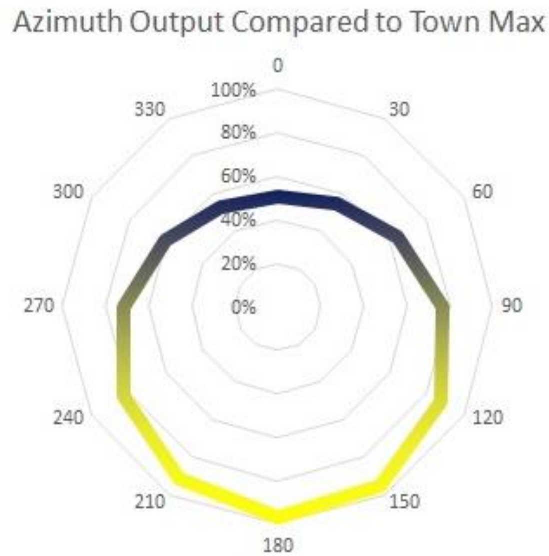


Bow Valley Trail Centre

Value /Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**10.71%**	**12.71%**	**9.73%**	**35596.94**	**39951.38**	**717.41**	**611.24**	**17.17**	**0.98**	**30.68%**
Rank	**35**	**15**	**13**				**27**	**35**	**34**	**33**

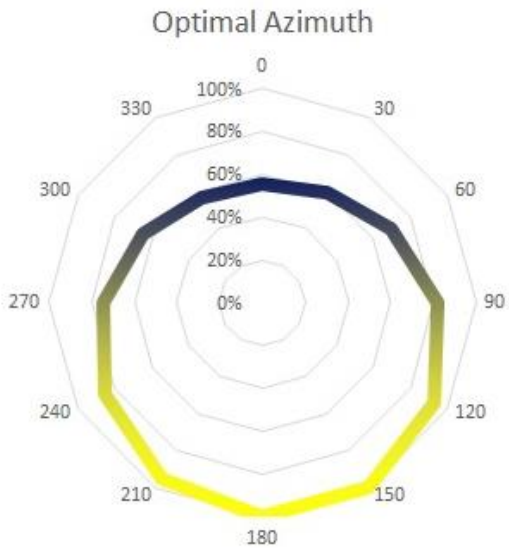


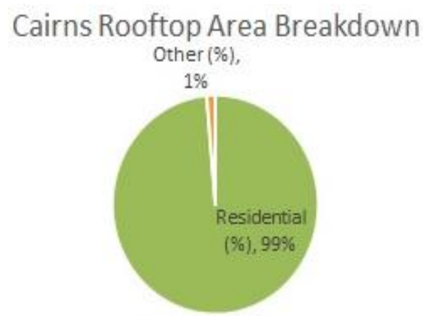


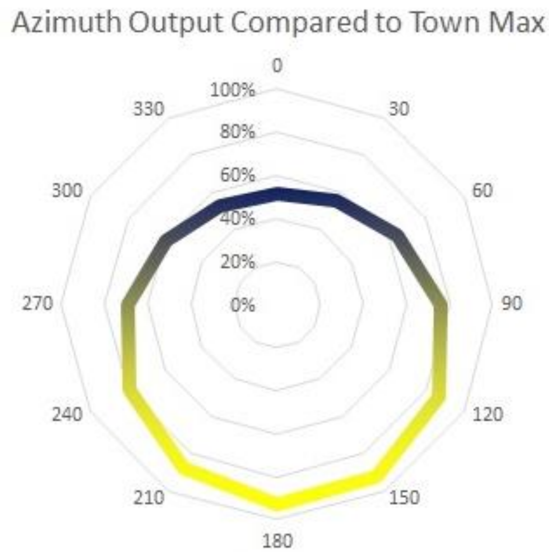


Cairns

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**19.36%**	**12.15%**	**9.48%**	**5666.32**	**6359.46**	**206.43**	**171.40**	**30.25**	**13.58**	**54.04%**
Rank	**23**	**28**	**28**				**36**	**25**	**6**	**23**

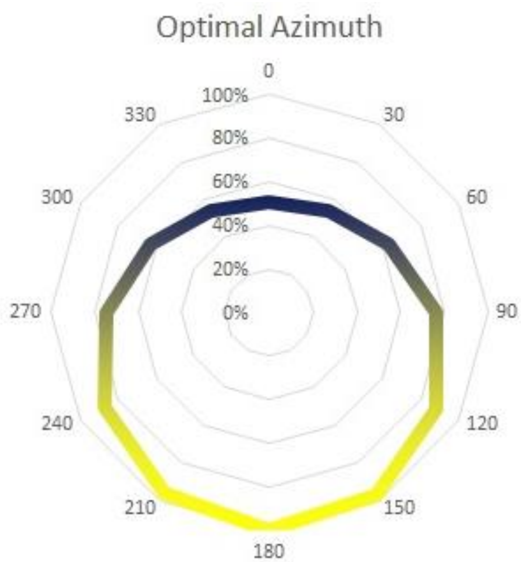


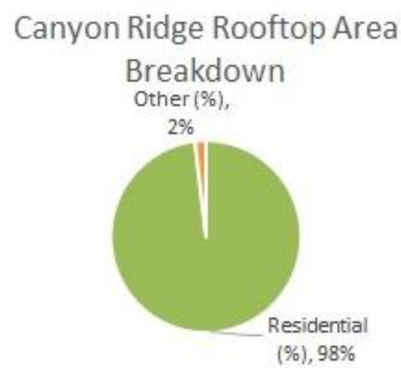


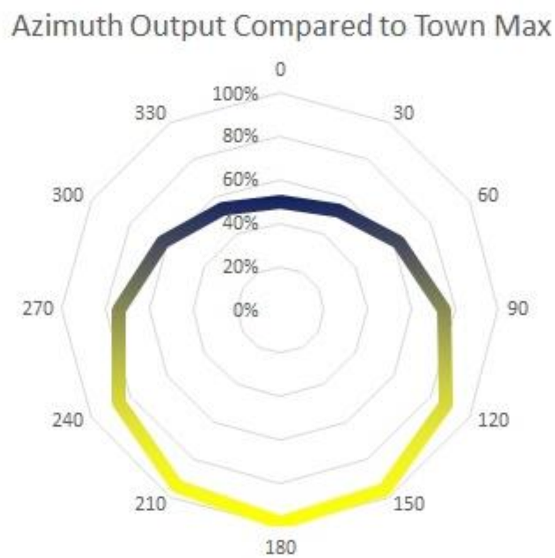


Canyon Ridge

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**18.36%**	**12.96%**	**9.77%**	**15083.50**	**16928.61**	**521.13**	**446.05**	**29.57**	**7.63**	**52.83%**
Rank	**26**	**4**	**5**				**34**	**26**	**14**	**24**

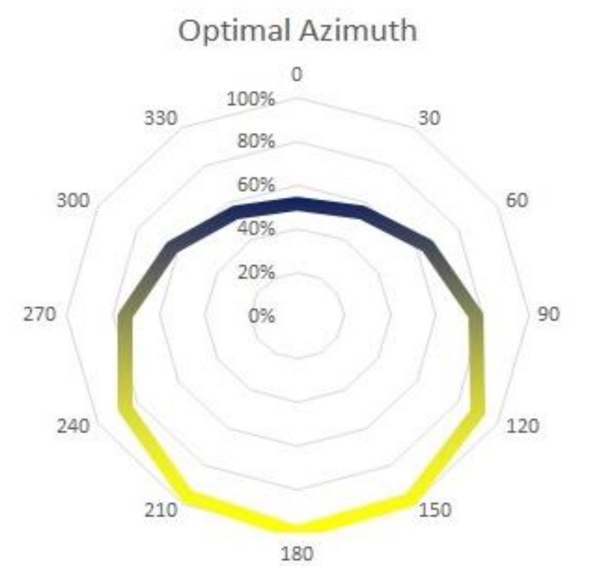


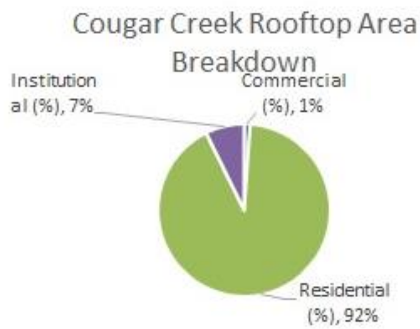


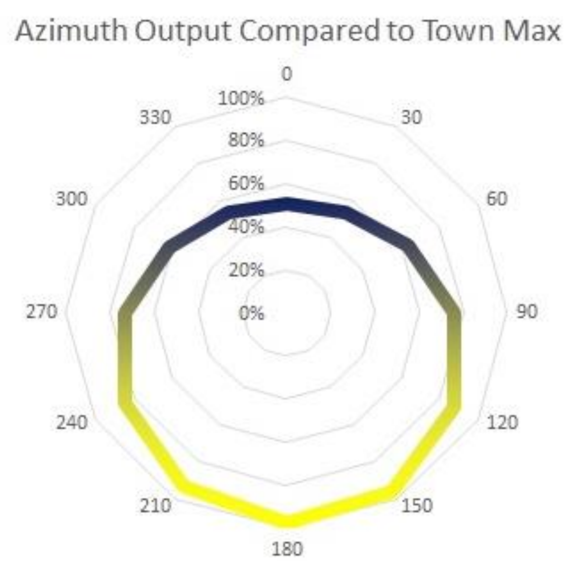


Cougar Creek

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**24.68%**	**12.83%**	**9.73%**	**69407.34**	**77897.68**	**3223.43**	**2746.53**	**39.57**	**6.15**	**70.70%**
Rank	**16**	**9**	**12**				**3**	**14**	**22**	**12**

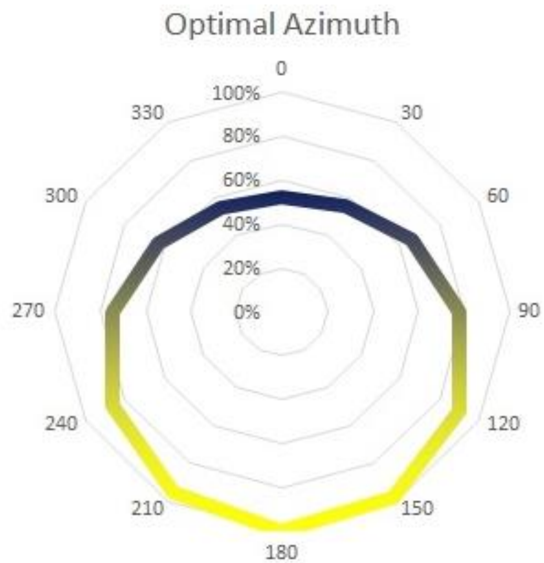


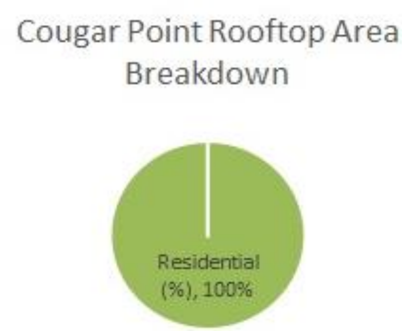


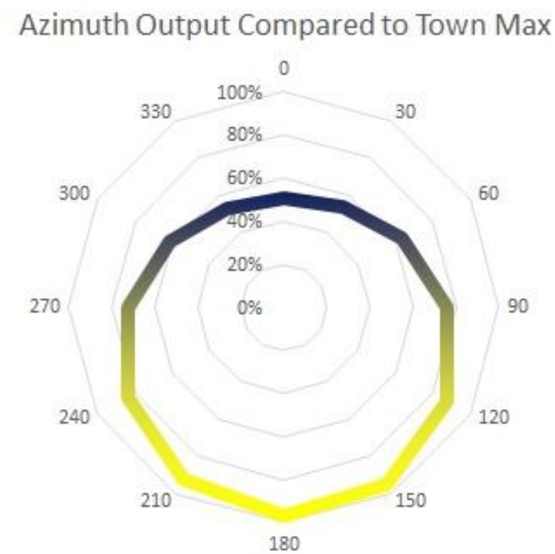


Cougar Point

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**21.14%**	**12.80%**	**9.74%**	**16559.31**	**18584.95**	**658.74**	**562.13**	**33.95**	**6.16**	**60.65%**
Rank	**17**	**12**	**10**				**28**	**17**	**21**	**15**

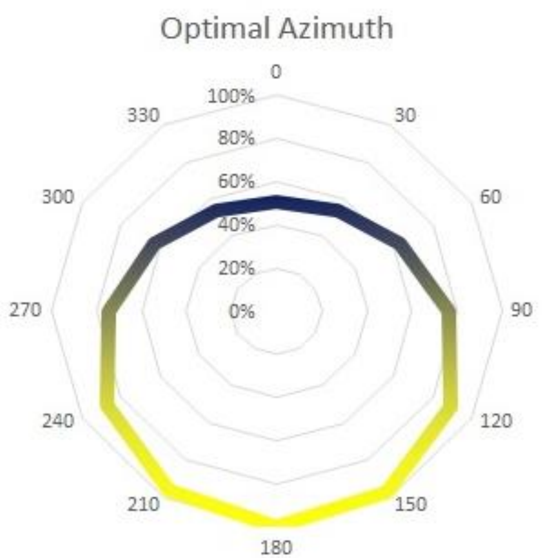


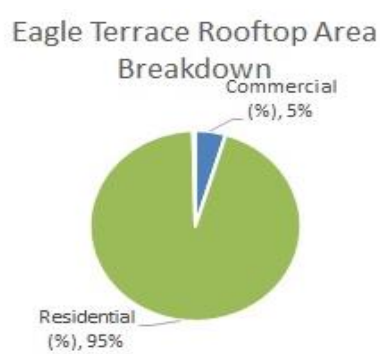


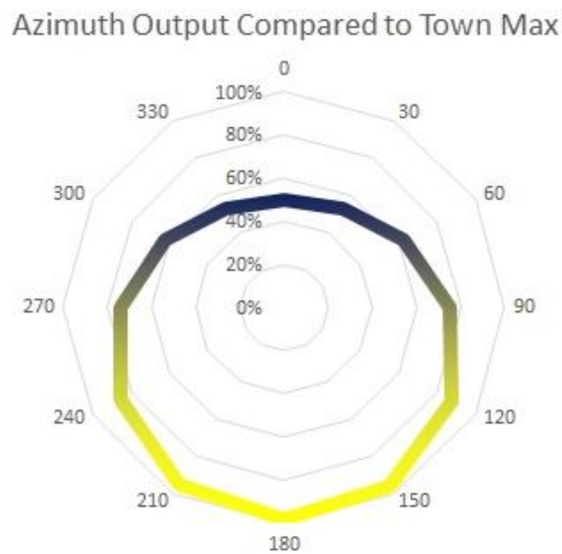


Eagle Terrace

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**20.39%**	**13.02%**	**9.80%**	**60409.04**	**67798.65**	**2317.86**	**1990.72**	**32.95**	**8.28**	**58.88%**
Rank	**19**	**3**	**3**				**5**	**18**	**11**	**16**

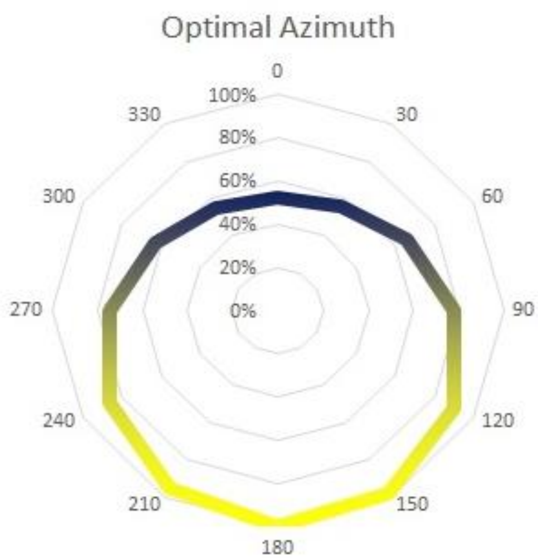


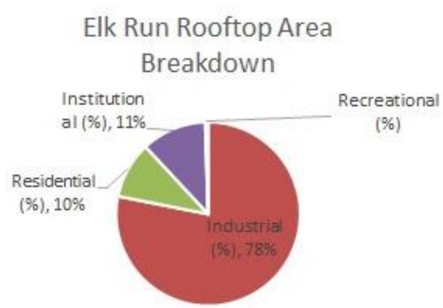


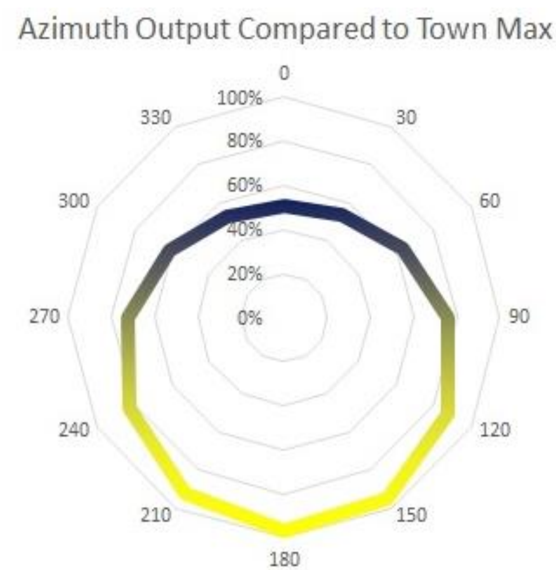


Elk Run

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**45.74%**	**12.84%**	**9.78%**	**27972.73**	**31394.52**	**2407.68**	**2062.87**	**73.75**	**79.99**	**131.76%**
Rank	**1**	**8**	**4**				**4**	**1**	**1**	**1**

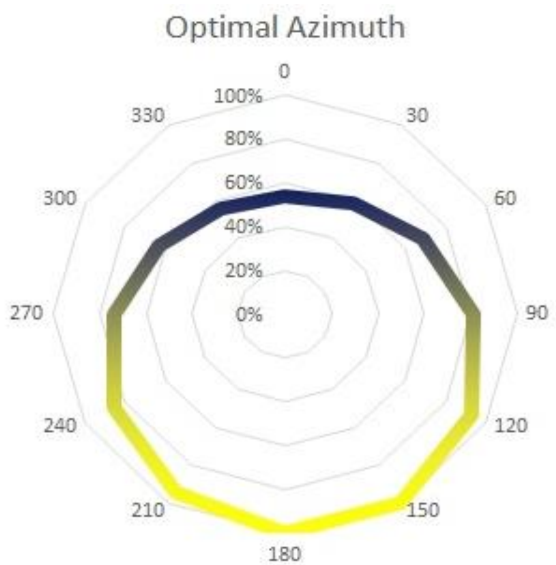


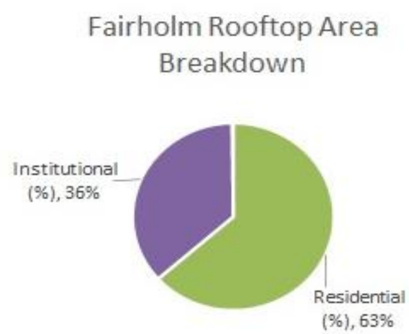


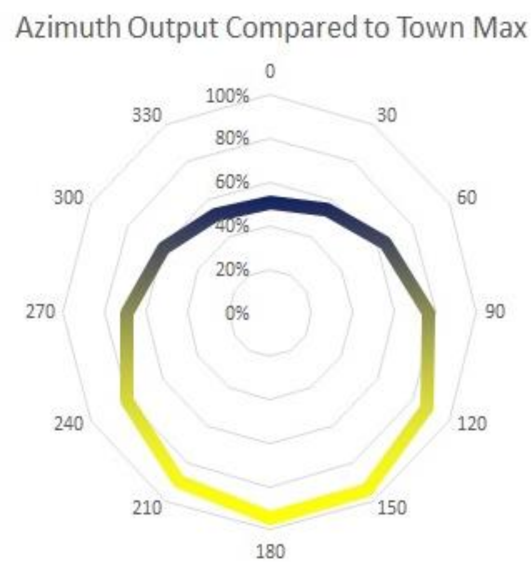


Fairholm

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**28.31%**	**12.48%**	**9.62%**	**28038.74**	**31468.61**	**1493.71**	**1258.57**	**44.89**	**5.21**	**80.20%**
Rank	**10**	**25**	**23**				**12**	**10**	**29**	**9**



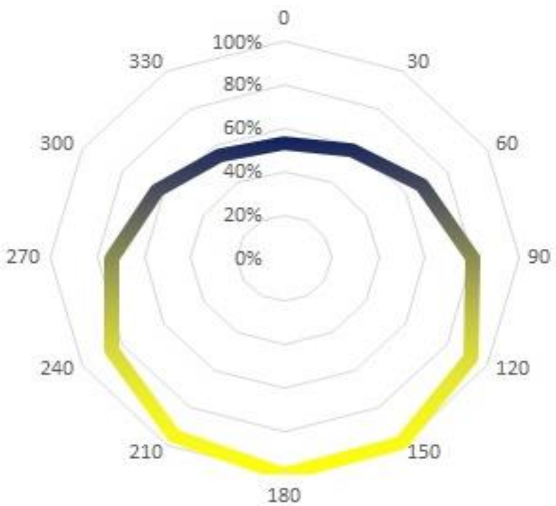




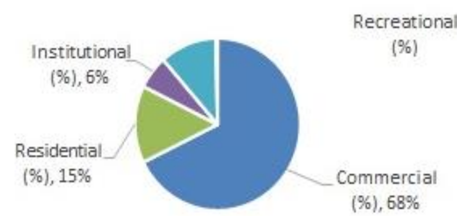
Gateway

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**19.20%**	**12.61%**	**9.67%**	**46667.63**	**52376.31**	**1686.10**	**1428.47**	**30.61**	**22.25**	**54.69%**
Rank	**25**	**20**	**17**				**10**	**23**	**4**	**21**

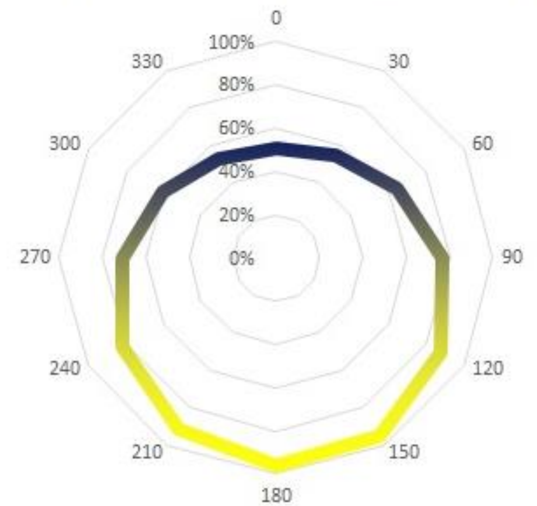
Optimal Azimuth



Gateway Rooftop Area Breakdown

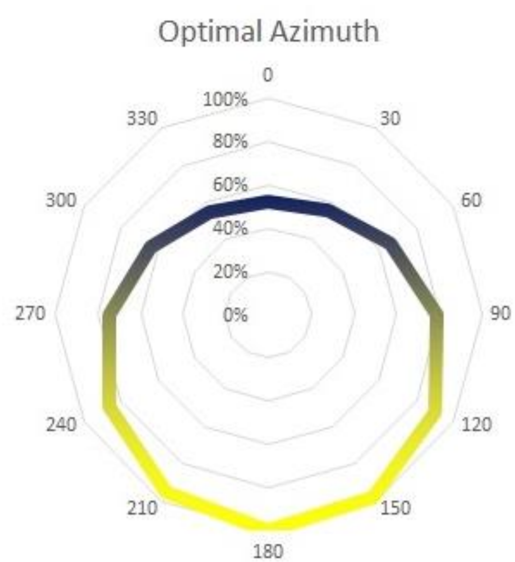


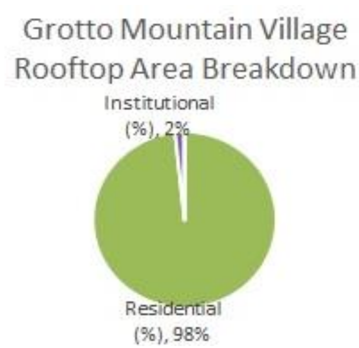
Azimuth Output Compared to Town Max

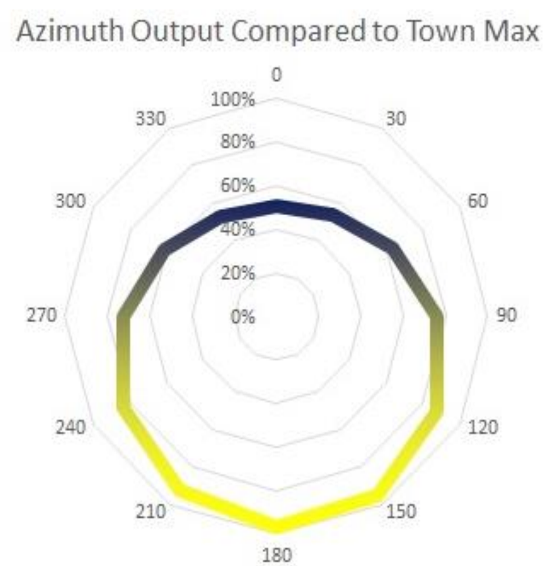


Grotto Mountain Village

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**31.88%**	**12.75%**	**9.72%**	**21245.93**	**23844.86**	**1274.56**	**1085.53**	**51.09**	**5.80**	**91.29%**
Rank	**7**	**13**	**15**				**15**	**7**	**25**	**6**

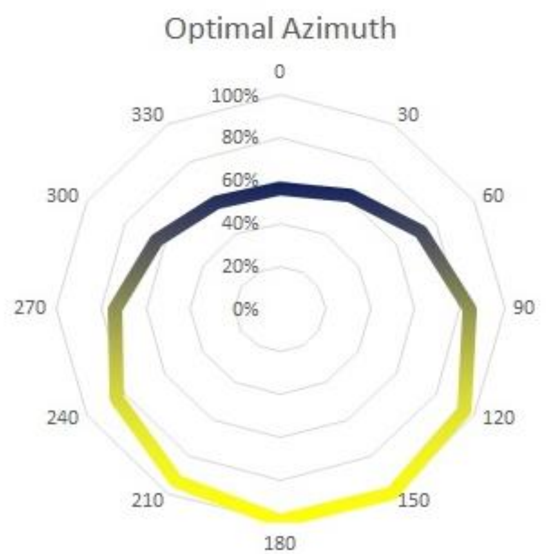


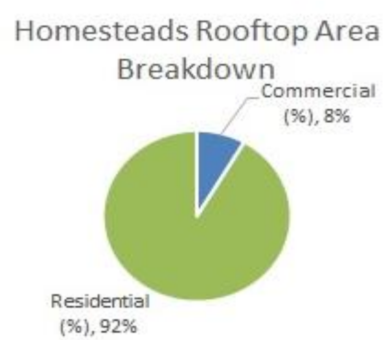


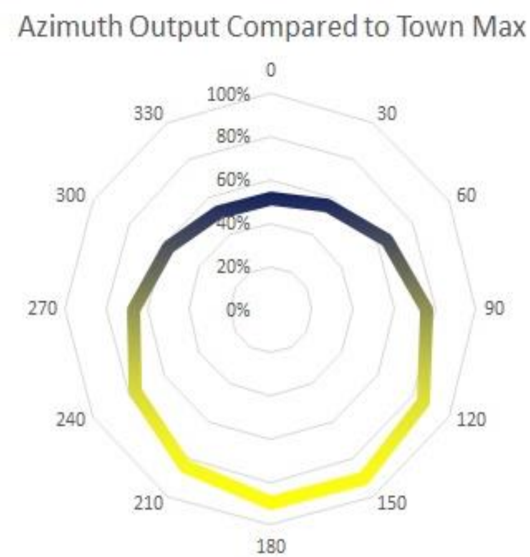


Homesteads

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**8.97%**	**11.78%**	**9.24%**	**51742.22**	**58071.65**	**873.38**	**707.02**	**13.66**	**3.40**	**24.41%**
Rank	**36**	**34**	**35**				**26**	**36**	**32**	**34**

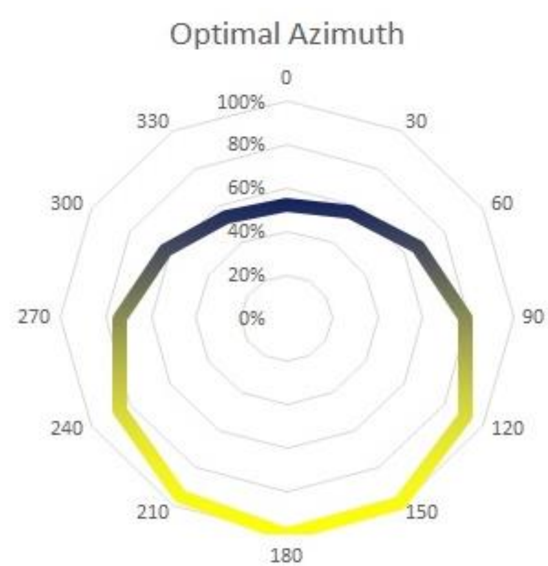


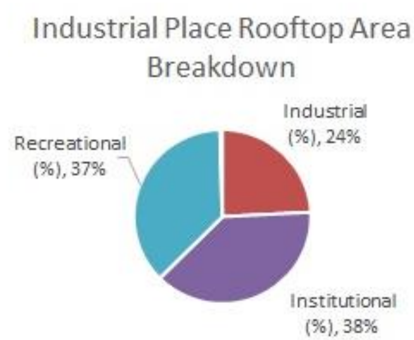


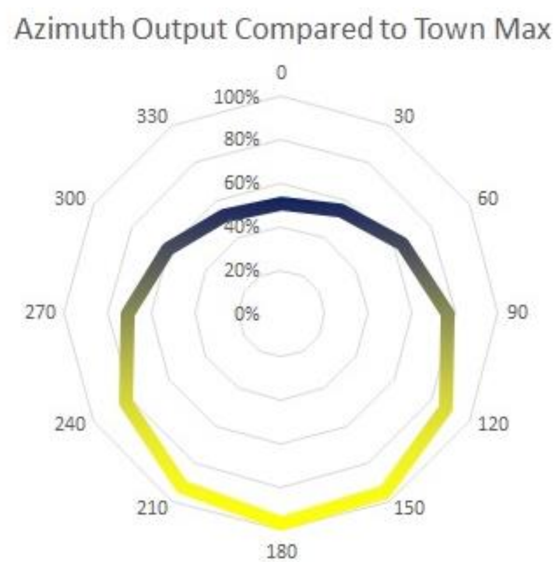


Industrial Place

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)
Value	**26.25%**	**12.69%**	**9.66%**	**20894.24**	**23450.15**	**1032.10**	**873.10**	**41.79**	**N/A - No Residential**
Rank	**13**	**16**	**21**				**23**	**11**	**N/A**

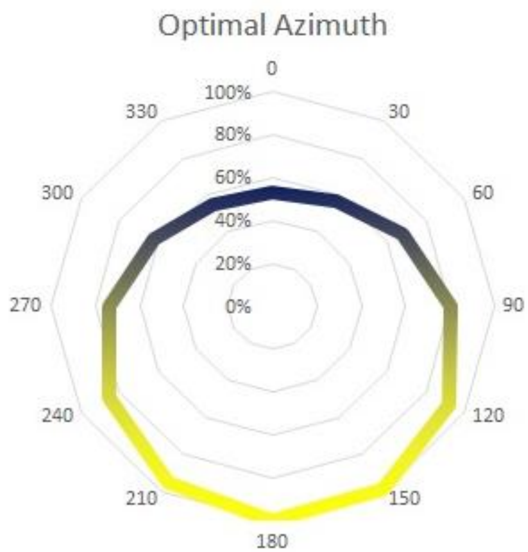


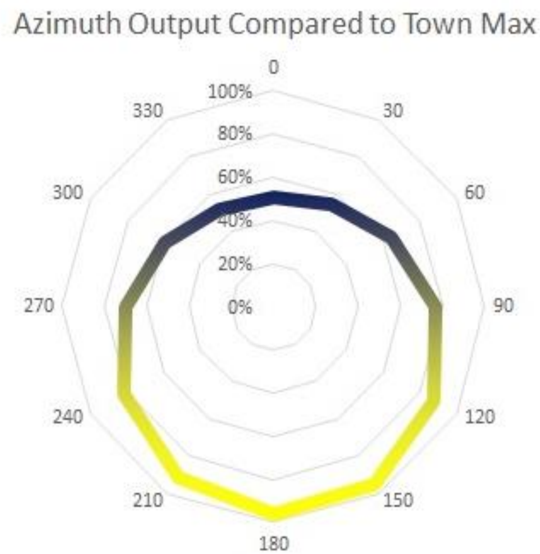




Larch

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**34.24%**	**12.63%**	**9.66%**	**25953.11**	**29127.85**	**1672.21**	**1415.46**	**54.54**	**6.69**	**97.44%**
Rank	**4**	**19**	**20**				**11**	**4**	**19**	**3**

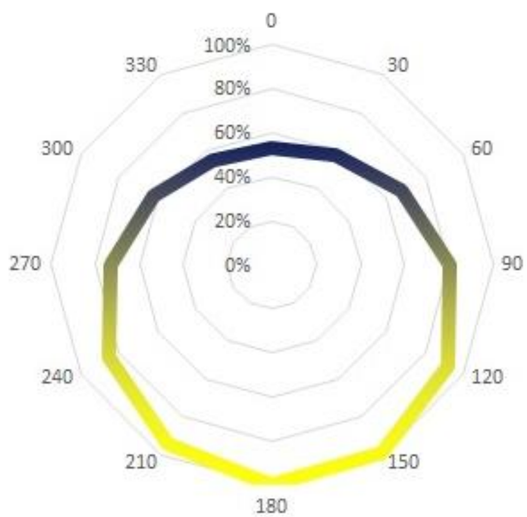




Lion's Park

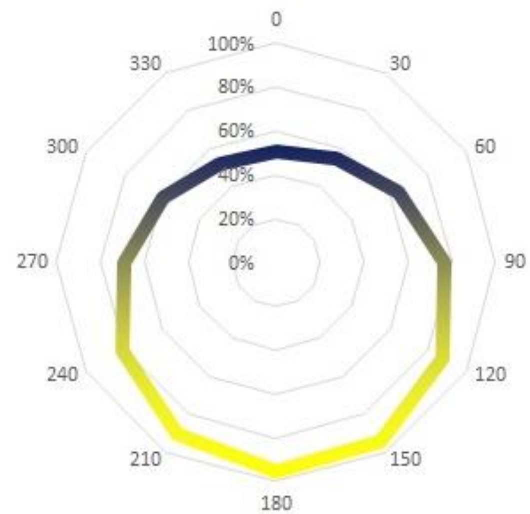
Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**29.00%**	**12.54%**	**9.61%**	**27116.21**	**30433.23**	**1479.77**	**1245.05**	**45.92**	**6.80**	**82.04%**
Rank	**9**	**22**	**24**				**13**	**9**	**17**	**8**

Optimal Azimuth



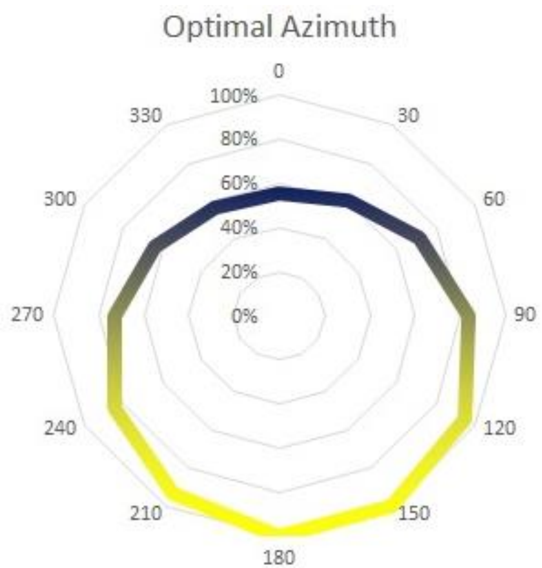
Lion's Park Rooftop Area Breakdown

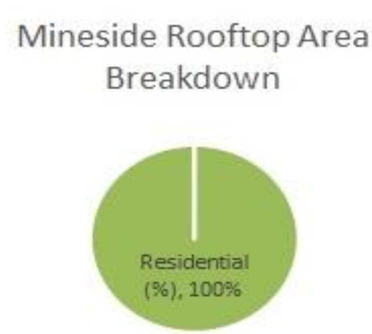
Azimuth Output Compared to Town Max

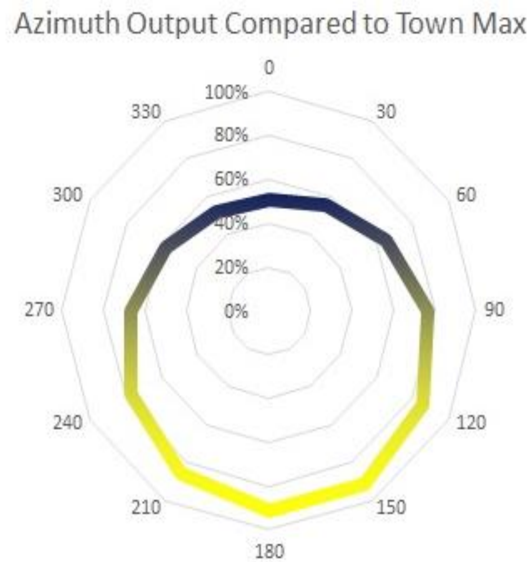


Mineside

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**24.92%**	**12.04%**	**9.39%**	**26659.48**	**29920.63**	**1250.16**	**1028.08**	**38.56**	**5.23**	**68.90%**
Rank	**15**	**30**	**30**				**18**	**15**	**28**	**13**

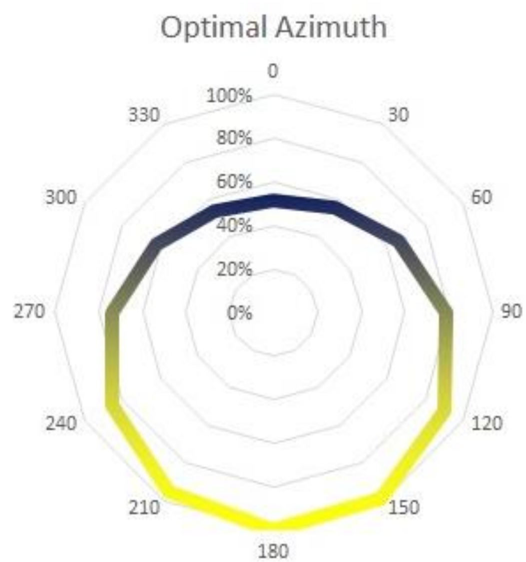


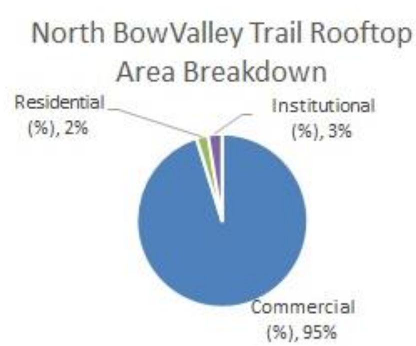


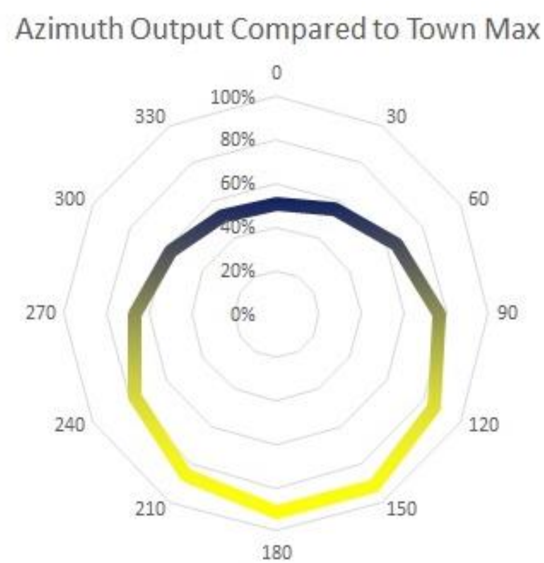


North Bow Valley Trail

Value/Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**13.14%**	**12.81%**	**9.72%**	**22317.27**	**25047.26**	**551.83**	**470.08**	**21.06**	**2.04**	**37.63%**
Rank	**33**	**11**	**14**				**32**	**33**	**33**	**31**

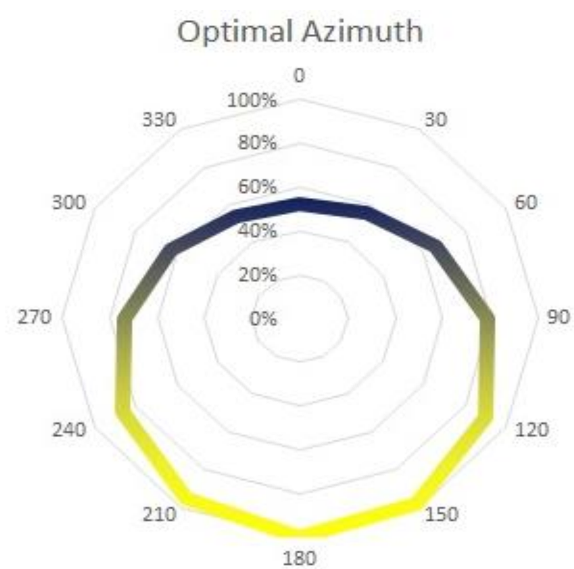


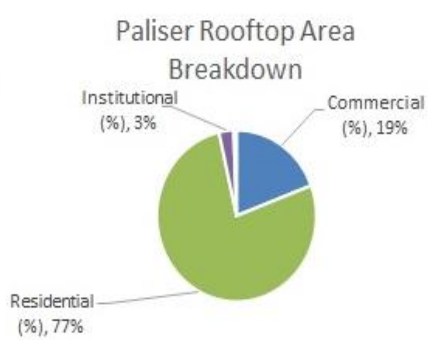


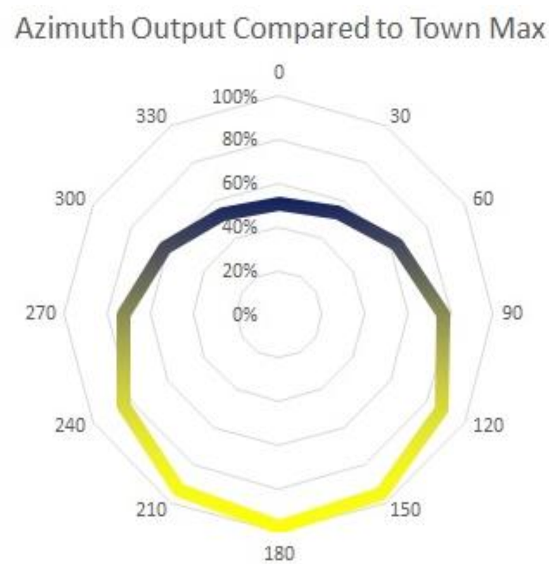


Palliser

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**14.44%**	**12.82%**	**9.75%**	**10474.05**	**11755.30**	**284.61**	**242.96**	**23.20**	**31.39**	**41.44%**
Rank	**31**	**10**	**9**				**35**	**31**	**2**	**29**

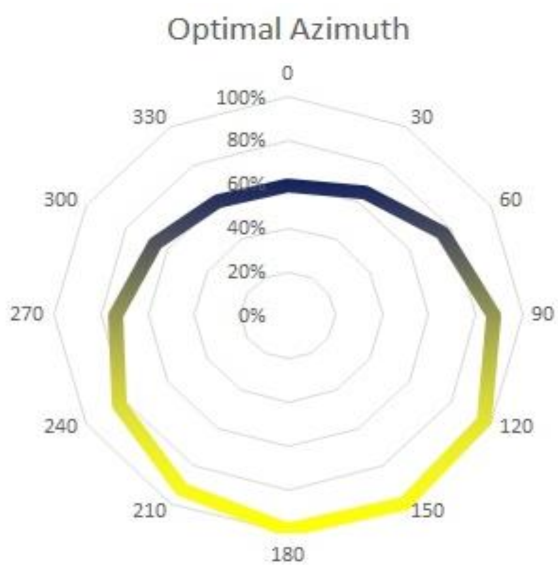


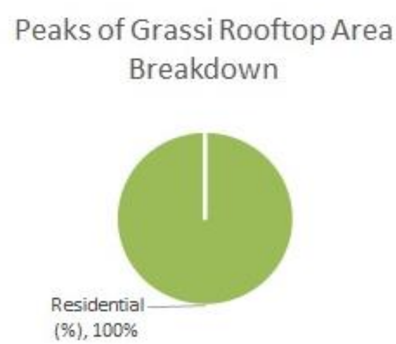


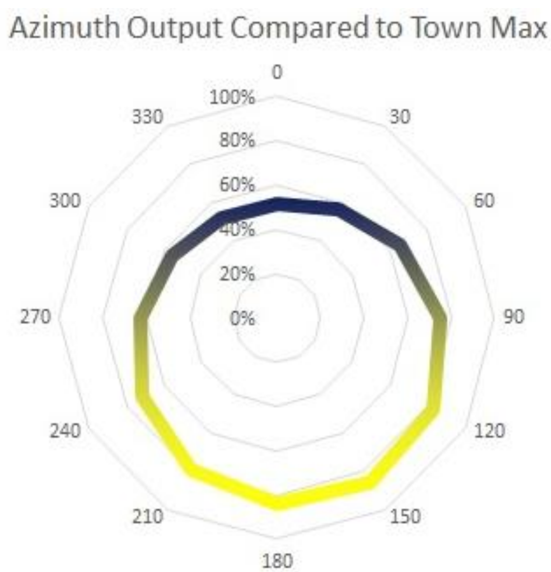


Peaks of Grassi

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**27.79%**	**11.08%**	**8.85%**	**40633.47**	**45604.01**	**2124.91**	**1646.52**	**40.52**	**6.92**	**72.40%**
Rank	**11**	**36**	**36**				**8**	**13**	**16**	**11**

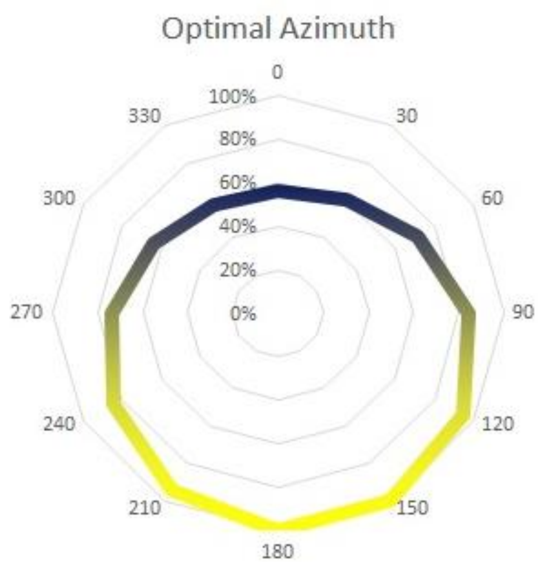


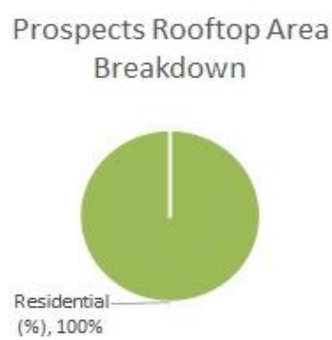


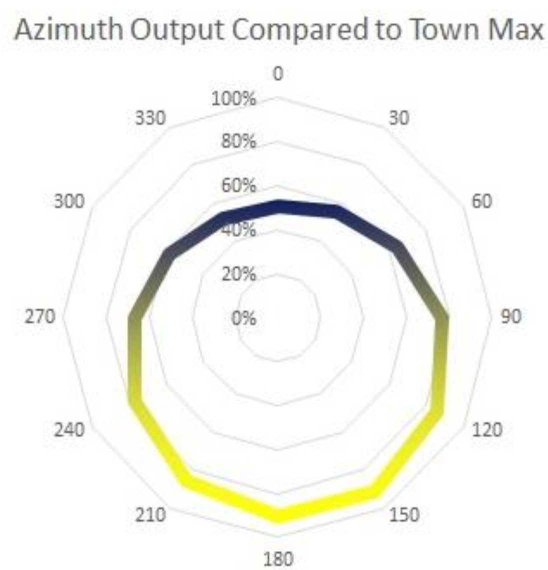


Prospects

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**19.72%**	**11.93%**	**9.34%**	**14784.50**	**16593.04**	**548.63**	**449.09**	**30.38**	**10.97**	**54.27%**
Rank	**22**	**32**	**32**				**33**	**24**	**8**	**22**

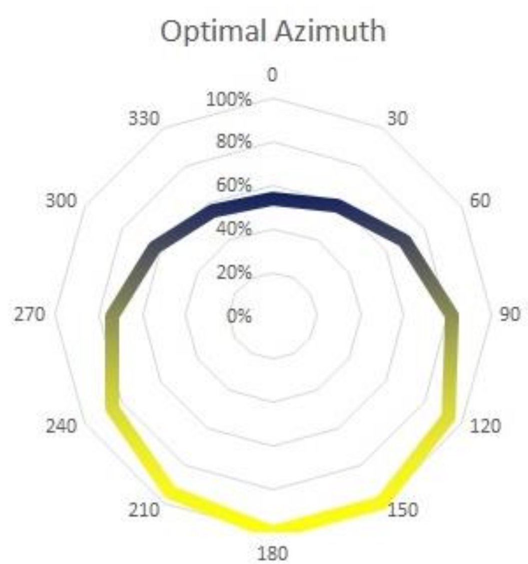


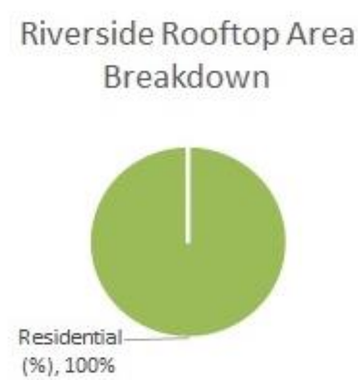


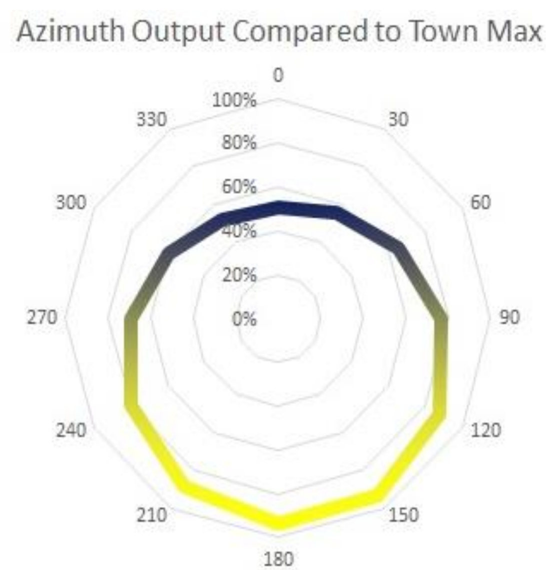


Riverside

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**33.43%**	**12.36%**	**9.56%**	**10638.45**	**11939.82**	**669.24**	**560.40**	**52.68**	**8.57**	**94.12%**
Rank	**5**	**27**	**26**				**29**	**5**	**10**	**4**

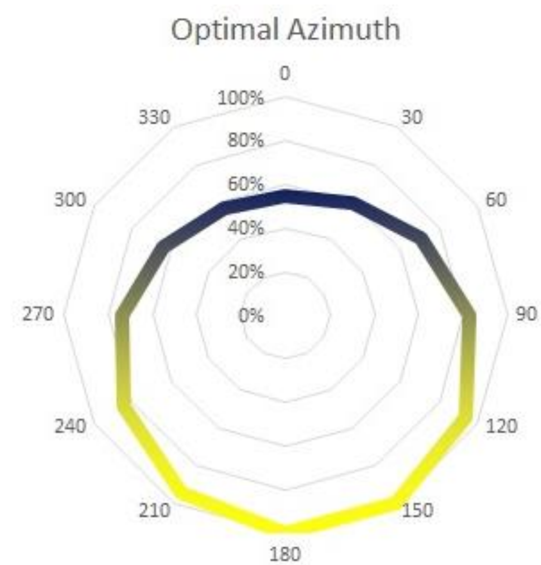


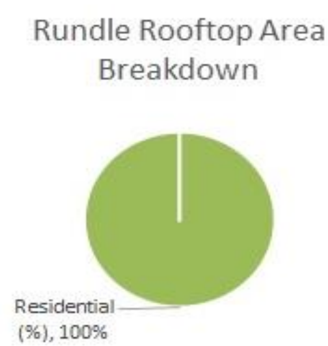


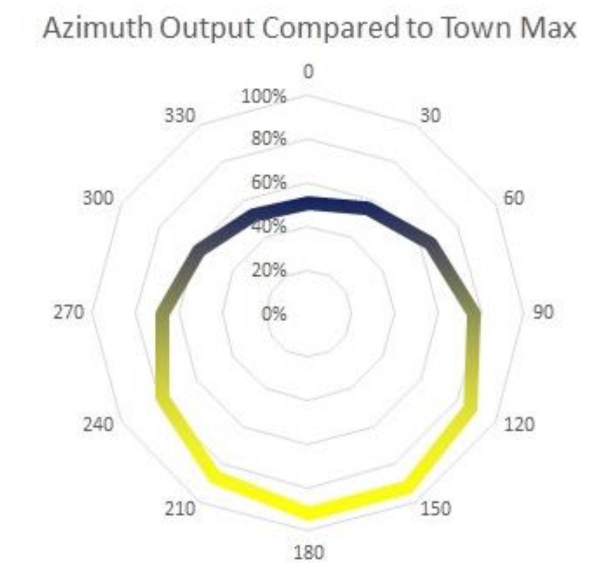


Rundle

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**13.84%**	**12.13%**	**9.44%**	**22506.23**	**25259.33**	**586.15**	**484.47**	**21.53**	**5.98**	**38.46%**
Rank	**32**	**29**	**29**				**30**	**32**	**23**	**30**

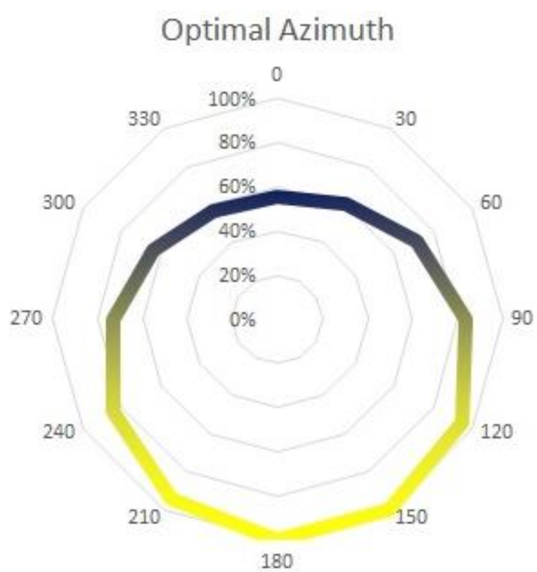


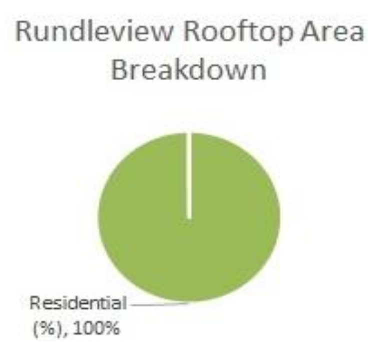


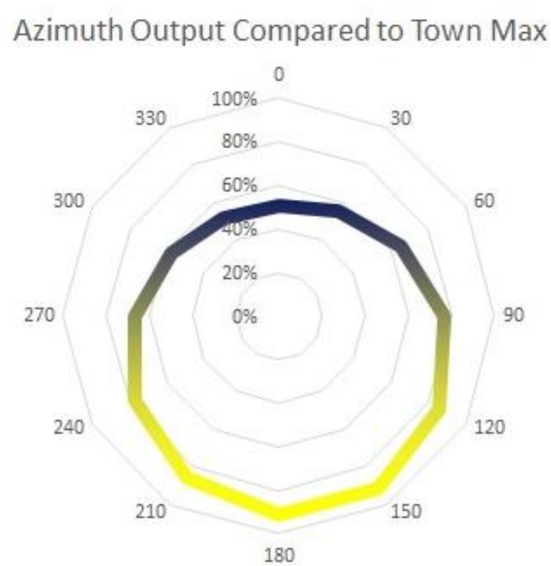


Rundleview

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**25.01%**	**11.96%**	**9.34%**	**26984.66**	**30285.59**	**1269.98**	**1038.77**	**38.49**	**7.93**	**68.78%**
Rank	**14**	**31**	**33**				**17**	**16**	**13**	**14**

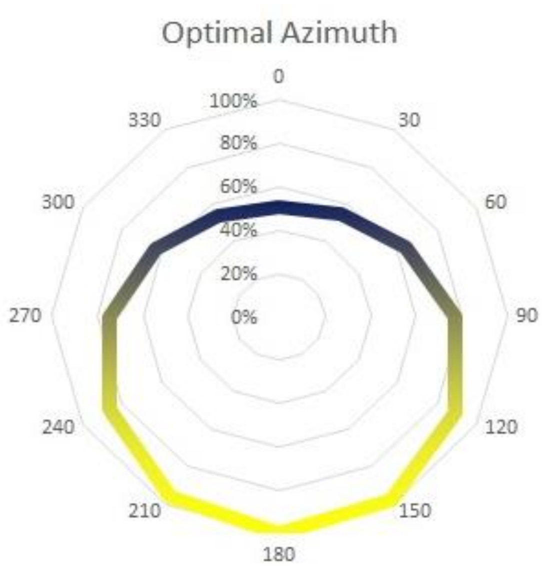


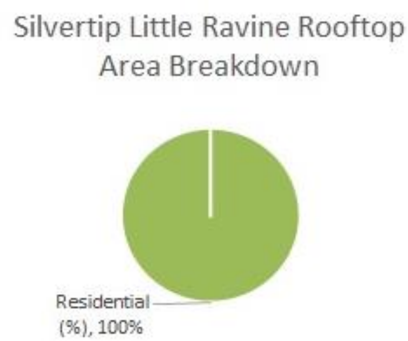


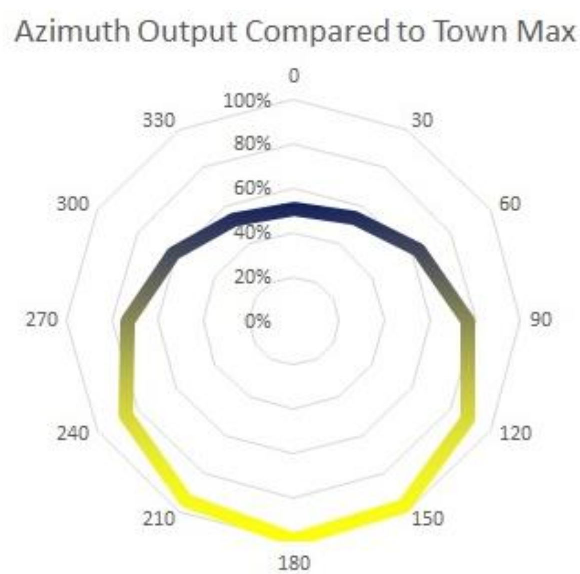


Silvertip Little Ravine

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**12.96%**	**13.02%**	**9.84%**	**22765.87**	**25550.74**	**555.21**	**478.63**	**21.02**	**6.53**	**37.56%**
Rank	**34**	**2**	**2**				**31**	**34**	**20**	**32**

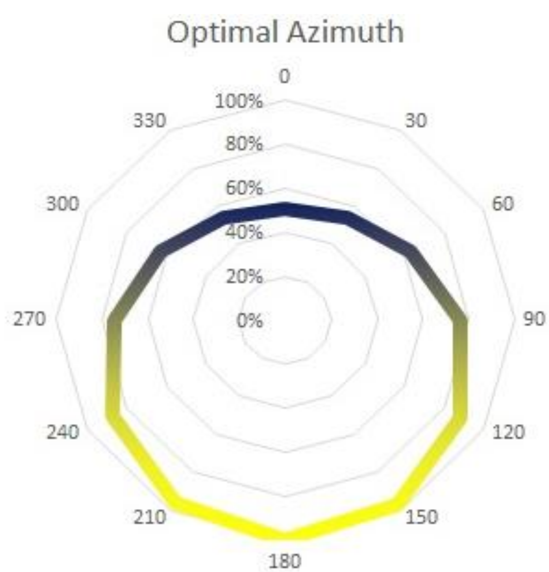


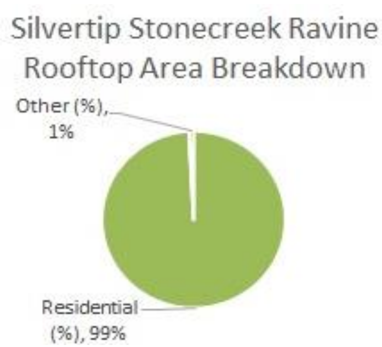


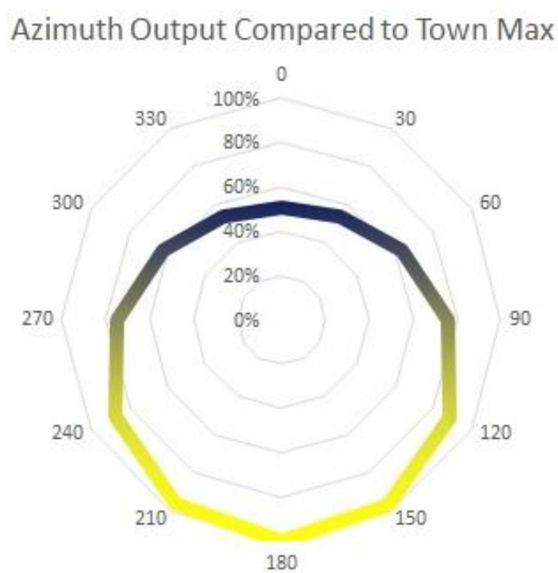


Silvertip Stonecreek

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**15.88%**	**13.18%**	**9.91%**	**36115.14**	**40532.97**	**1079.21**	**937.31**	**25.95**	**9.23**	**46.37%**
Rank	**30**	**1**	**1**				**20**	**29**	**9**	**27**

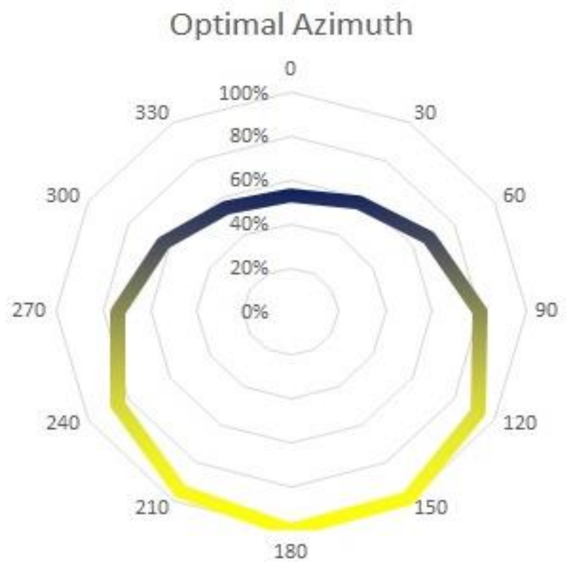


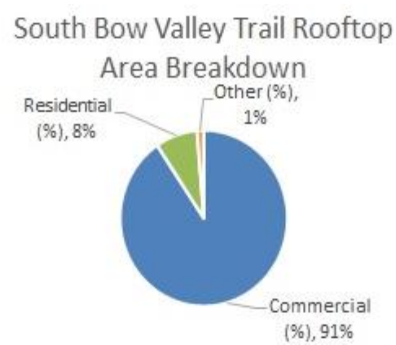


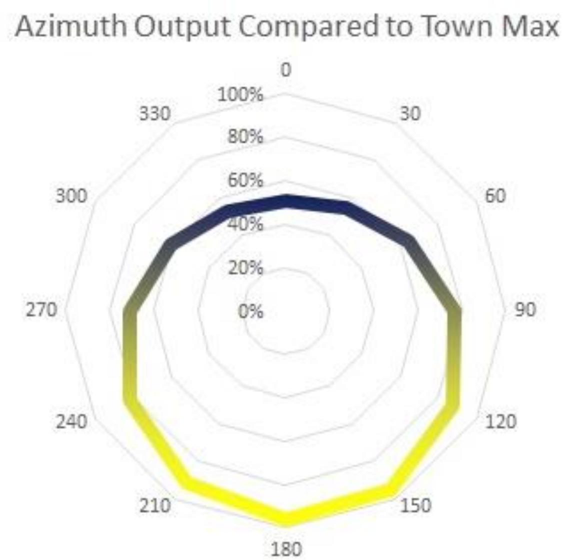


South Bow Valley Trail

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**15.94%**	**12.63%**	**9.69%**	**61548.01**	**69076.95**	**1846.16**	**1567.27**	**25.46**	**30.01**	**45.49%**
Rank	**29**	**18**	**16**				**9**	**30**	**3**	**28**

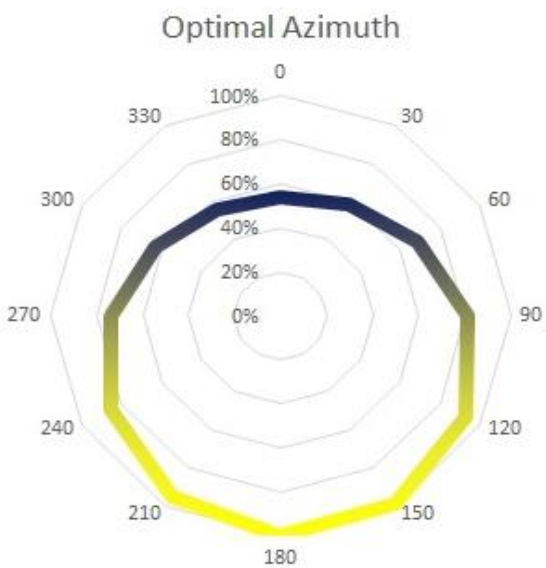


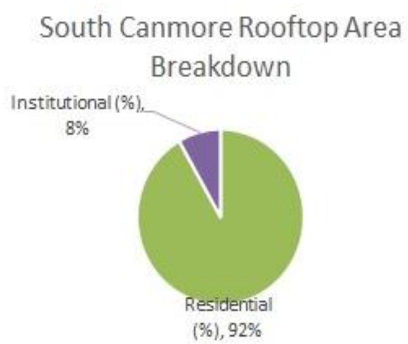


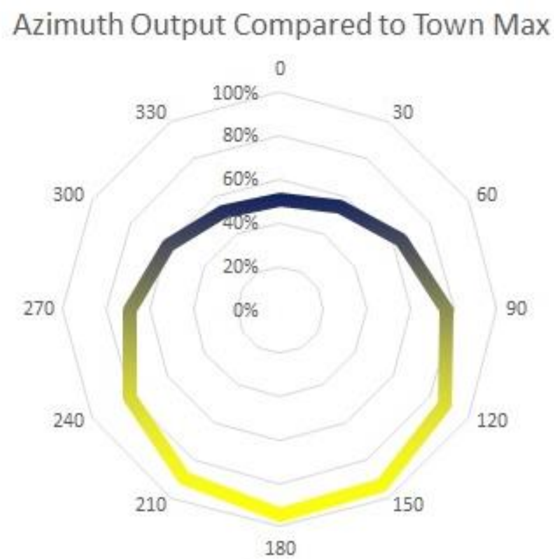


South Canmore

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**19.90%**	**12.38%**	**9.55%**	**103315.40**	**115953.59**	**3868.88**	**3235.02**	**31.31**	**5.77**	**55.94%**
Rank	**21**	**26**	**27**				**2**	**20**	**26**	**18**

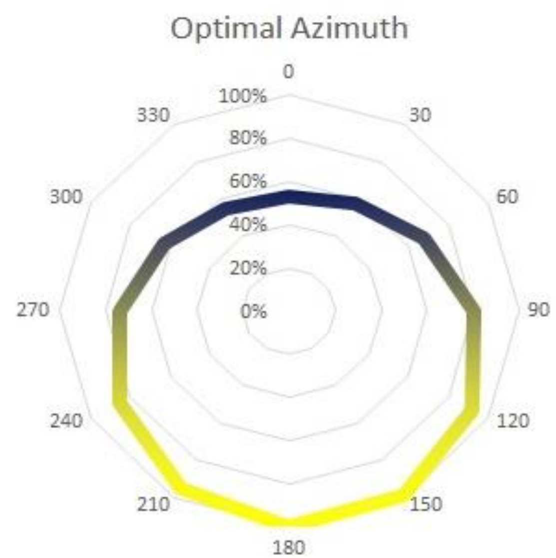


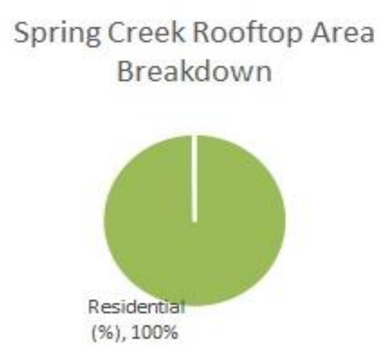


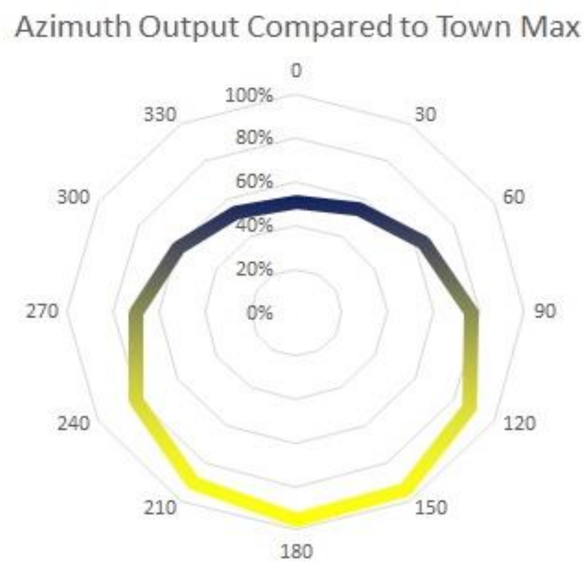


Spring Creek

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**34.51%**	**12.59%**	**9.67%**	**22171.50**	**24883.65**	**1439.82**	**1219.75**	**55.01**	**8.07**	**98.29%**
Rank	**3**	**21**	**19**				**14**	**3**	**12**	**2**

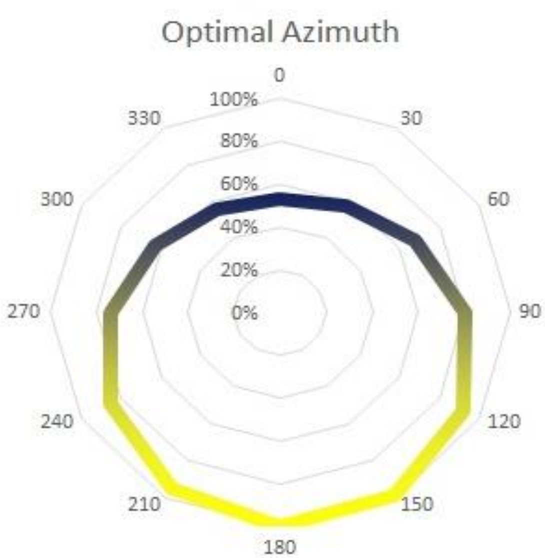


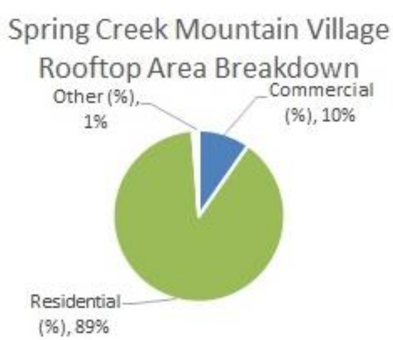


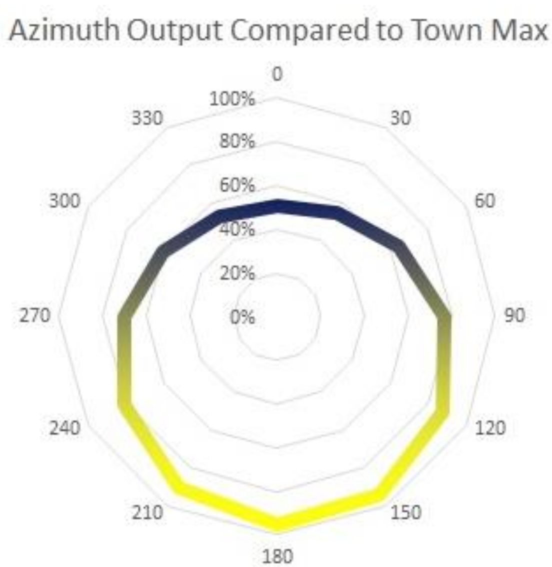


Spring Creek Mountain Village

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**26.36%**	**12.49%**	**9.60%**	**41607.15**	**46696.79**	**2063.86**	**1735.46**	**41.71**	**6.76**	**74.52%**
Rank	**12**	**24**	**25**				**6**	**12**	**18**	**10**

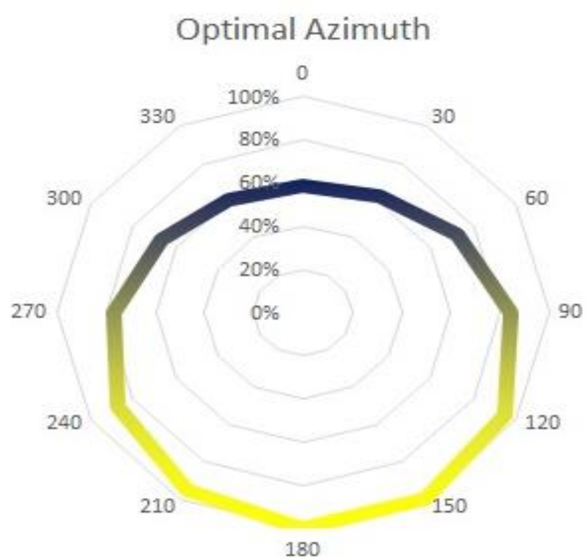


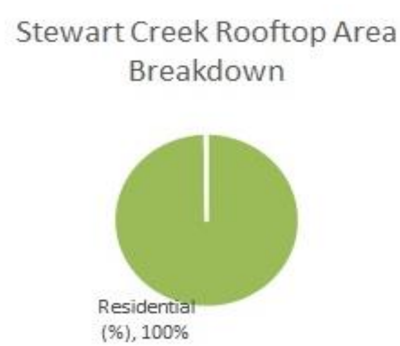


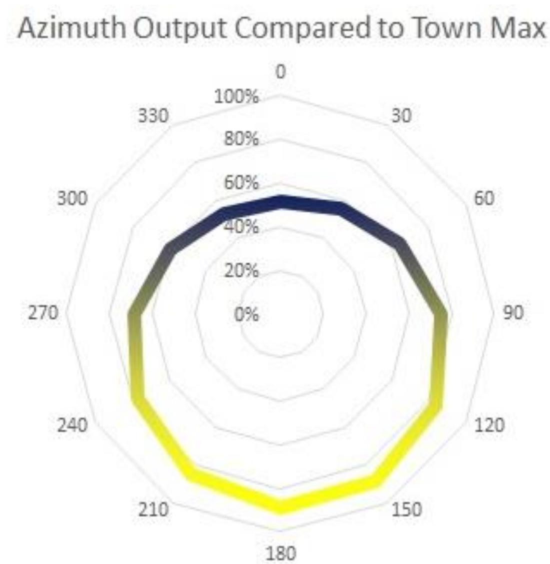


Stewart Creek

Value/Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**20.01%**	**11.69%**	**9.34%**	**29967.16**	**33632.93**	**1128.39**	**922.81**	**30.79**	**16.56**	**55.02%**
Rank	**20**	**35**	**34**				**21**	**22**	**5**	**20**

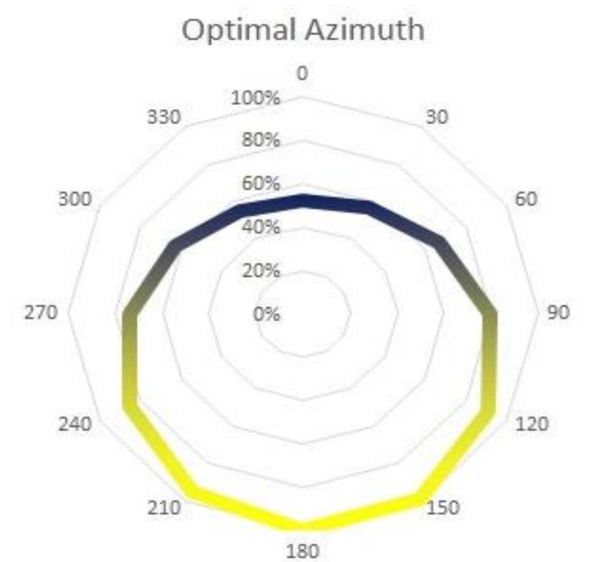


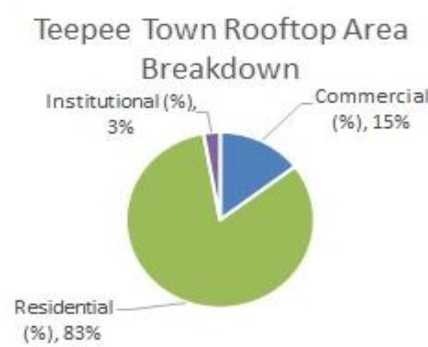


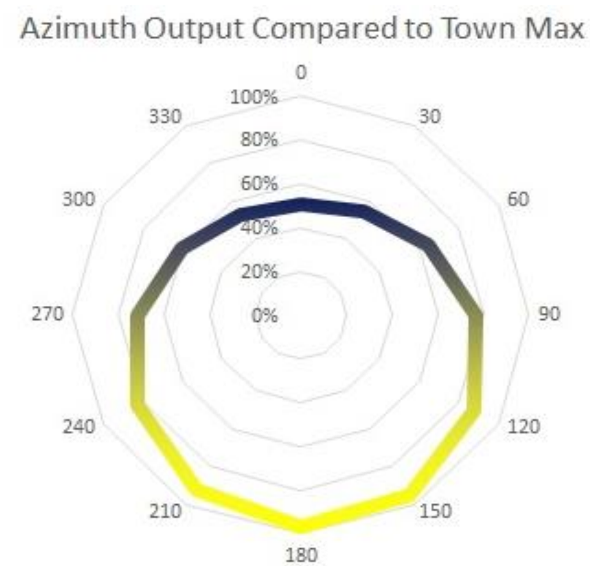


Teepee Town

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**32.03%**	**12.75%**	**9.73%**	**19347.11**	**21713.77**	**1166.11**	**993.94**	**51.37**	**5.35**	**91.79%**
Rank	**6**	**14**	**11**				**19**	**6**	**27**	**5**

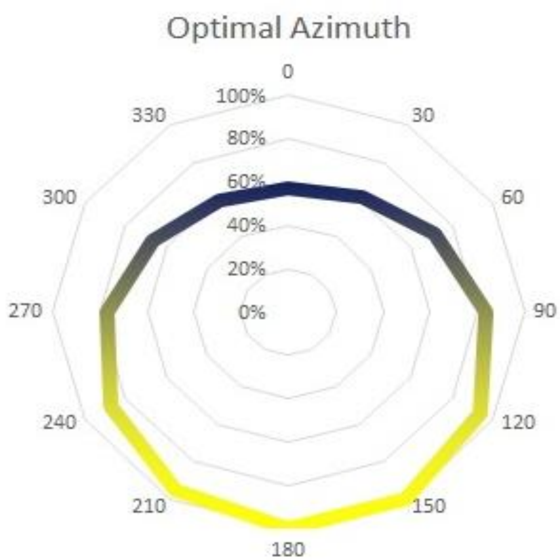


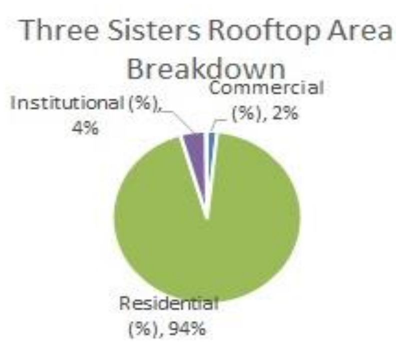


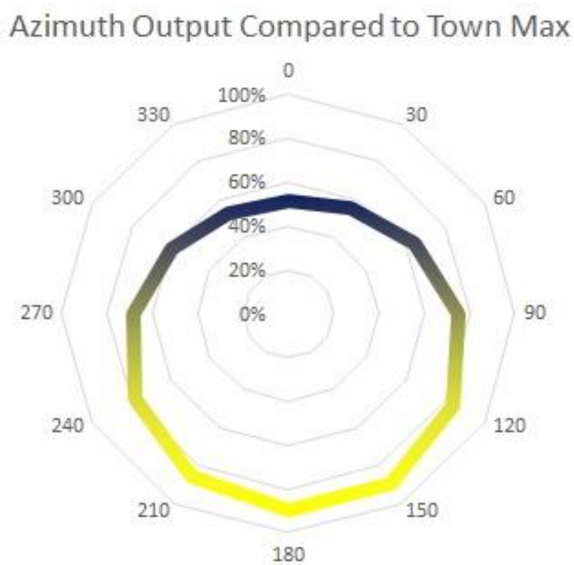


Three Sisters

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**20.94%**	**11.78%**	**9.36%**	**103379.81**	**116025.87**	**4073.61**	**3338.53**	**32.29**	**12.39**	**57.70%**
Rank	**18**	**33**	**31**				**1**	**19**	**7**	**17**

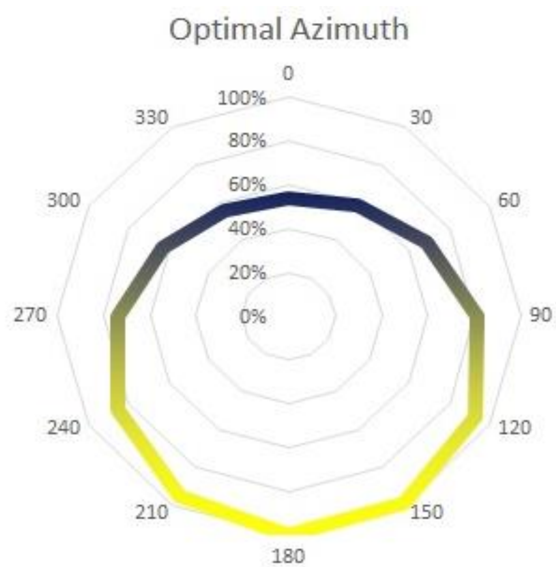


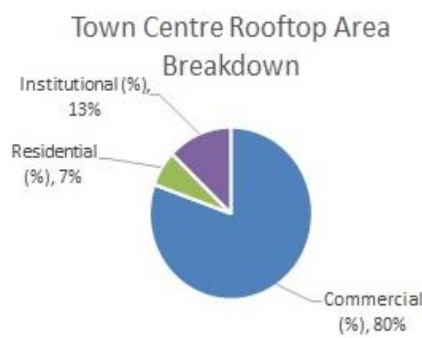


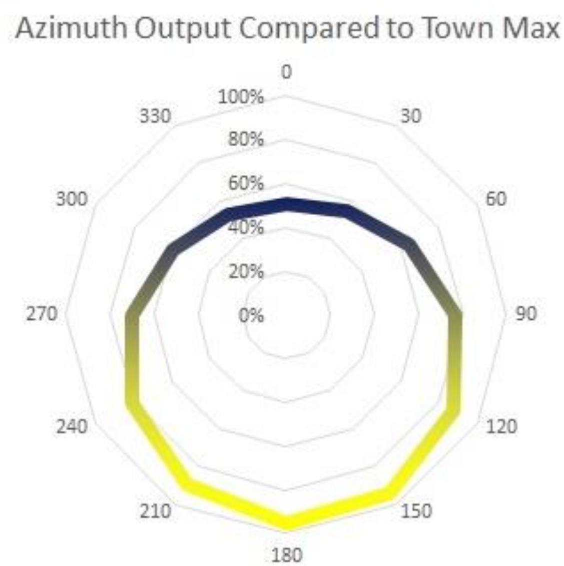


Town Centre

Value/ Rank	Application Factor	Maximum Neighbourhood Capacity Factor (180 Degrees)	Average Neighbourhood Capacity Factor (Cumulative)	Total Building Area (m2)	Total Roof Area (m2)	Total Array Size (kW)	Total Output (MWh/year)	Overall Suitability (kWh/m2/year)	Average Residential Array Size (kW)	Residential % Energy Offset
Value	**18.05%**	**12.49%**	**9.63%**	**37274.23**	**41833.85**	**1266.06**	**1067.93**	**28.65**	**3.84**	**51.19%**
Rank	**27**	**23**	**22**				**16**	**28**	**31**	**26**







Capacity Factor Values Per Neighbourhood:

Azimuth Breakdown Per Neighbourhood (% of Neighbourhood Maximum)

Community	330	300	270	240	210	180	150	120	90	60	30	0
Aspen	55%	63%	74%	85%	95%	100%	99%	91%	80%	67%	57%	53%
Avens	55%	63%	75%	86%	96%	100%	98%	89%	77%	64%	55%	52%
Benchlands Terrace	54%	63%	75%	86%	96%	100%	98%	90%	78%	65%	55%	51%
Bow Meadows	55%	63%	75%	87%	96%	100%	98%	89%	77%	64%	55%	51%
Bow Valley Trail Centre	55%	63%	74%	86%	95%	100%	99%	91%	80%	67%	57%	53%
Cairns	57%	64%	75%	86%	95%	100%	100%	93%	82%	70%	60%	55%
Canyon Ridge	54%	63%	75%	87%	96%	100%	97%	88%	76%	63%	54%	51%
Cougar Creek	55%	63%	75%	86%	96%	100%	98%	90%	77%	65%	55%	52%
Cougar Point	55%	63%	74%	86%	95%	100%	98%	90%	78%	65%	56%	52%
Eagle Terrace	54%	63%	75%	87%	96%	100%	97%	88%	76%	63%	54%	51%
Elk Run	55%	63%	75%	86%	95%	100%	98%	90%	78%	65%	56%	52%
Fairholm	55%	63%	74%	85%	94%	100%	99%	93%	81%	68%	58%	54%
Gateway	55%	63%	74%	85%	95%	100%	99%	92%	80%	67%	57%	53%
Grotto Mountain Village	55%	63%	75%	86%	95%	100%	98%	90%	78%	65%	56%	52%
Homesteads	58%	64%	74%	84%	93%	99%	100%	95%	84%	72%	61%	57%
Industrial Place	54%	62%	74%	85%	95%	100%	99%	91%	79%	66%	56%	52%
Larch	55%	62%	74%	85%	95%	100%	99%	92%	80%	67%	57%	53%
Lion's Park	55%	62%	73%	85%	95%	100%	99%	92%	80%	68%	58%	53%
Mineside	57%	63%	73%	84%	94%	100%	100%	94%	84%	71%	61%	56%
North Bow Valley Trail	54%	62%	74%	86%	95%	100%	98%	90%	78%	66%	56%	52%
Paliser	54%	63%	74%	86%	95%	100%	98%	90%	78%	65%	56%	52%
Peaks of Grassi	60%	65%	74%	83%	92%	98%	100%	96%	88%	76%	65%	60%
Prospects	57%	64%	74%	84%	94%	100%	100%	94%	84%	71%	61%	56%
Riverside	56%	63%	74%	85%	95%	100%	99%	93%	82%	69%	59%	54%
Rundle	56%	63%	74%	85%	94%	100%	100%	94%	83%	70%	60%	55%
Rundleview	57%	63%	73%	84%	94%	100%	100%	94%	84%	71%	61%	56%
Silvertip Little Ravine	54%	63%	74%	86%	96%	100%	98%	89%	77%	64%	55%	51%
Silvertip Stonecreek	54%	63%	75%	87%	96%	100%	97%	88%	76%	63%	54%	50%
South Bow Valley Trail	55%	63%	74%	85%	95%	100%	99%	92%	80%	67%	57%	53%
South Canmore	56%	63%	74%	85%	95%	100%	99%	92%	81%	68%	58%	54%
Spring Creek	55%	63%	74%	85%	95%	100%	99%	92%	81%	68%	58%	53%
Spring Creek Mountain Village	56%	63%	74%	85%	95%	100%	99%	92%	80%	67%	57%	53%
Stewart Creek	60%	67%	77%	87%	95%	100%	100%	95%	85%	73%	63%	58%
Teepee Town	55%	63%	74%	86%	95%	100%	99%	91%	79%	66%	56%	52%
Three Sisters	59%	67%	77%	87%	95%	100%	100%	94%	84%	72%	62%	58%
Town Centre	55%	63%	74%	85%	95%	100%	99%	92%	81%	68%	58%	54%

180 degrees = South ; 0 Degrees = North

Azimuth Breakdown Per Neighbourhood (% of Town Maximum)

Community	330	300	270	240	210	180	150	120	90	60	30	0
Aspen	53%	60%	71%	82%	91%	96%	95%	88%	77%	64%	55%	51%
Avens	54%	62%	73%	85%	94%	98%	96%	87%	76%	63%	54%	50%
Benchlands Terrace	53%	62%	73%	85%	94%	98%	96%	88%	76%	64%	54%	51%
Bow Meadows	53%	62%	73%	85%	94%	98%	95%	87%	75%	63%	53%	50%
Bow Valley Trail Centre	53%	61%	72%	83%	92%	96%	95%	88%	77%	64%	55%	51%
Cairns	53%	59%	69%	79%	88%	93%	92%	86%	76%	64%	55%	51%
Canyon Ridge	53%	62%	74%	85%	95%	99%	96%	87%	75%	62%	53%	50%
Cougar Creek	53%	62%	73%	84%	94%	98%	96%	88%	76%	63%	54%	51%
Cougar Point	53%	61%	72%	84%	93%	97%	95%	88%	76%	64%	54%	51%
Eagle Terrace	53%	62%	74%	85%	95%	99%	96%	87%	75%	62%	53%	50%
Elk Run	53%	61%	72%	83%	92%	97%	95%	87%	76%	63%	54%	51%
Fairholm	52%	59%	69%	80%	89%	94%	94%	87%	77%	65%	55%	51%
Gateway	53%	60%	71%	82%	91%	96%	95%	88%	77%	64%	55%	51%
Grotto Mountain Village	53%	61%	72%	83%	92%	97%	95%	87%	76%	63%	54%	51%
Homesteads	52%	58%	67%	76%	84%	90%	90%	86%	76%	65%	55%	51%
Industrial Place	52%	60%	71%	83%	92%	97%	95%	88%	77%	64%	55%	51%
Larch	52%	60%	70%	82%	91%	96%	95%	88%	77%	64%	55%	51%
Lion's Park	52%	59%	70%	81%	90%	95%	94%	88%	77%	64%	55%	51%
Mineside	52%	58%	67%	77%	86%	91%	91%	86%	77%	65%	55%	51%
North Bow Valley Trail	53%	61%	72%	83%	93%	97%	96%	88%	76%	64%	54%	50%
Paliser	53%	61%	72%	84%	93%	97%	96%	88%	76%	64%	54%	51%
Peaks of Grassi	52%	56%	63%	71%	79%	84%	86%	83%	75%	65%	56%	51%
Prospects	52%	58%	67%	77%	85%	91%	91%	86%	76%	65%	55%	51%
Riverside	52%	59%	69%	80%	89%	94%	94%	87%	77%	65%	55%	51%
Rundle	52%	59%	68%	78%	87%	92%	92%	87%	77%	65%	55%	51%
Rundleview	52%	58%	67%	77%	86%	91%	91%	86%	77%	65%	56%	51%
Silvertip Little Ravine	53%	62%	74%	85%	95%	99%	97%	88%	76%	64%	54%	51%
Silvertip Stonecreek	54%	63%	75%	87%	96%	100%	97%	88%	76%	63%	54%	50%
South Bow Valley Trail	53%	60%	71%	82%	91%	96%	95%	88%	77%	64%	55%	51%
South Canmore	52%	59%	70%	80%	89%	94%	94%	87%	77%	64%	55%	51%
Spring Creek	53%	60%	70%	81%	90%	95%	95%	88%	77%	65%	55%	51%
Spring Creek Mountain Village	53%	60%	70%	81%	90%	95%	94%	87%	76%	64%	55%	51%
Stewart Creek	53%	59%	68%	77%	84%	89%	89%	84%	75%	64%	56%	52%
Teepee Town	53%	60%	72%	83%	92%	97%	95%	88%	77%	64%	55%	51%
Three Sisters	53%	60%	69%	78%	86%	90%	90%	84%	75%	64%	56%	52%
Town Centre	53%	60%	70%	81%	90%	95%	94%	88%	77%	65%	55%	51%

180 degrees = South ; 0 Degrees = North

Appendix B: Solar Survey Results

The survey conducted had 3 main goals:

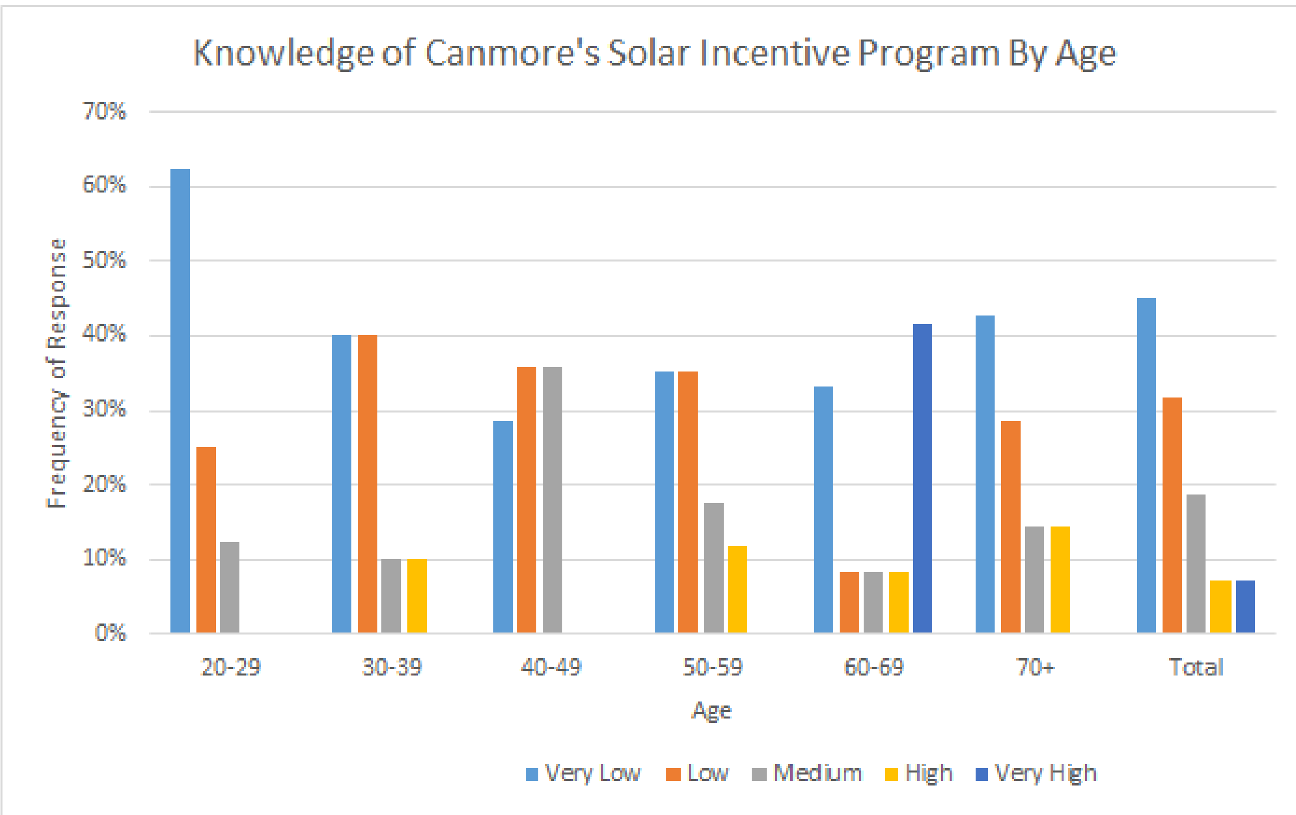
1) To gauge the neighbourhood understanding of solar, and of existing incentive programs.

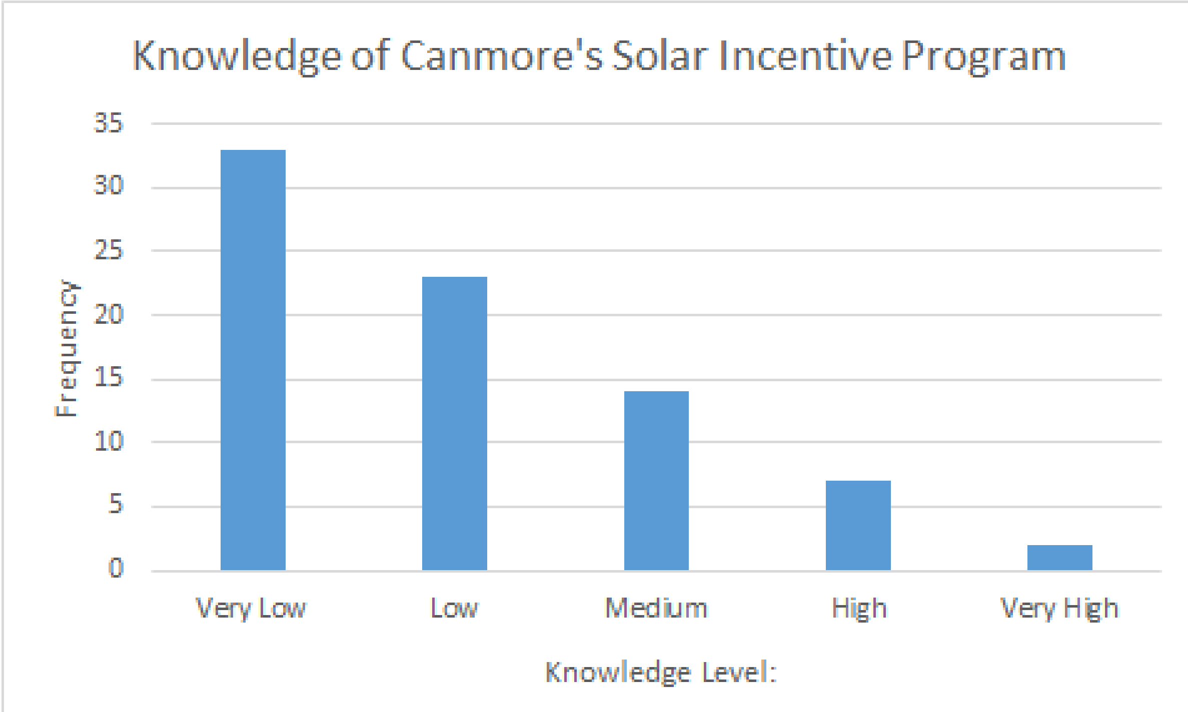
2) To understand how much the neighbourhood cares about GHG emissions reductions.

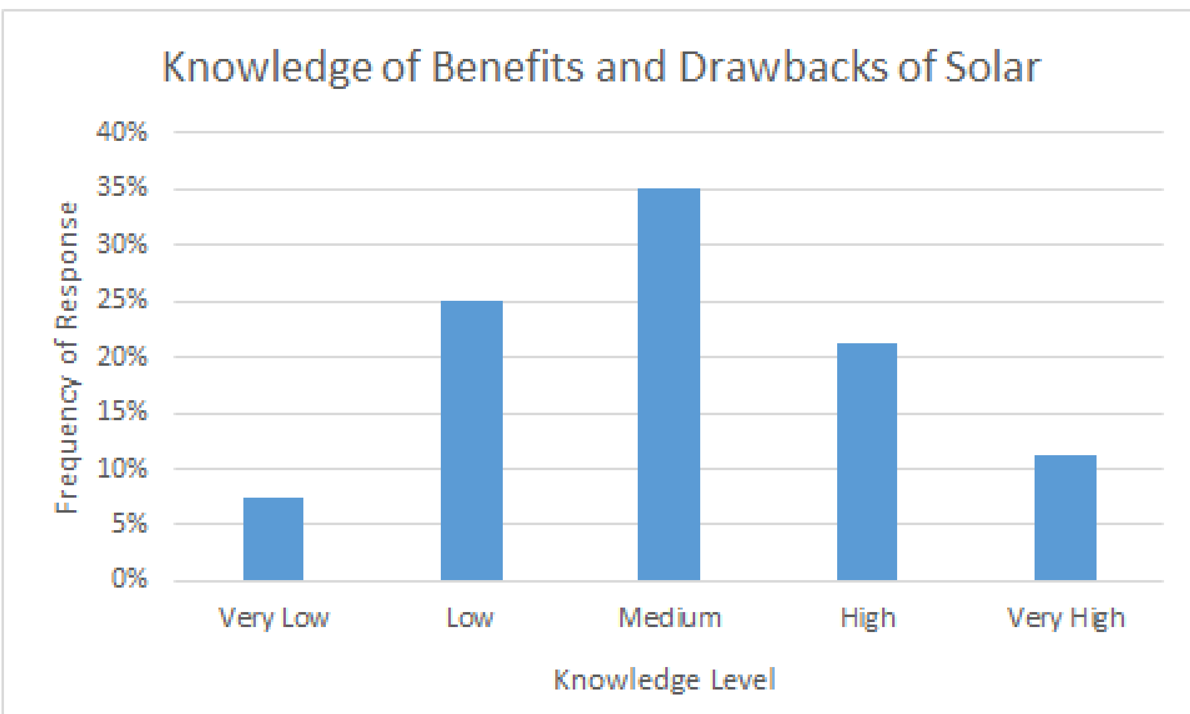
3) To find the payback period at which residents will invest in rooftop solar.

Complete data set can be provided upon request. The survey 80 residents of Canmore with an 11% margin of error, at a 95% confidence.

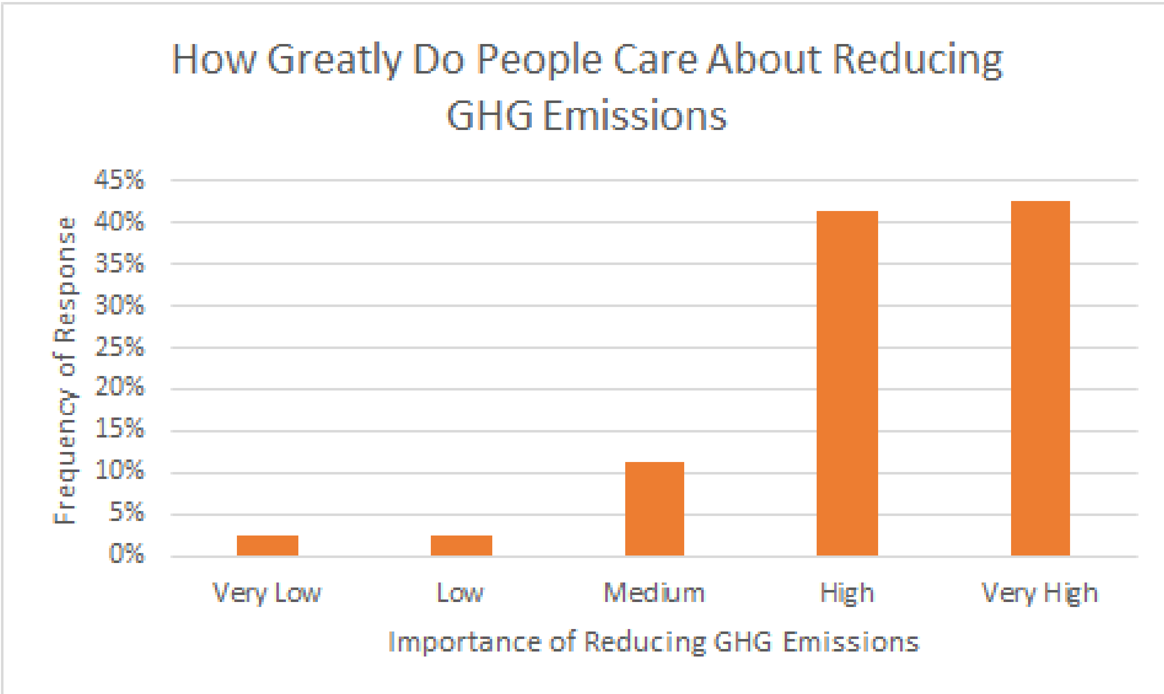
Goal 1: Neighbourhood Understanding

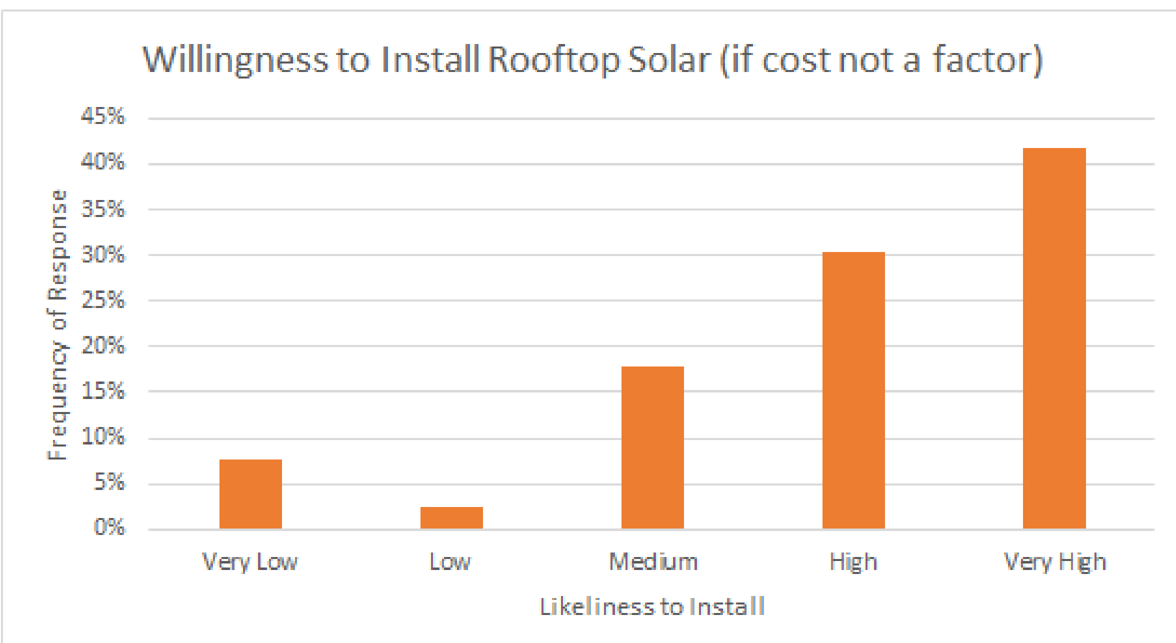



Knowledge of Canmore's Solar Incentive Program
Frequency
35
30
25
20
15
10
5
0
Very Low
Low
Medium
High
Very High
Knowledge Level:


Knowledge of Benefits and Drawbacks of Solar
Frequency of Response
40%
35%
30%
25%
20%
15%
10%
5%
0%
Very Low
Low
Medium
High
Very High
Knowledge Level

Goal 2: Neighbourhood concern about GHG Emissions





Goal 3: Acceptable neighbourhood payback periods