SOLAR PHOTOVOLTAICS VIABILITY ASSESSMENT

for the

City of Medicine Hat
Land and Properties Division
Southlands 6C

Prepared by

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TABLE OF CONTENTS

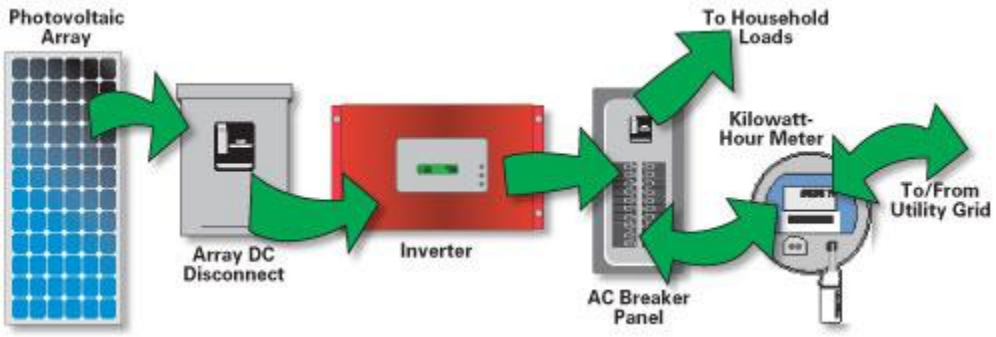
1.0 Executive Summary

The City of Medicine Hat, Land and Properties Division has selected Southlands 6C for a solar viability assessment. Southlands 6C consists of approximately 85 lots, separated into five blocks. The purpose of this report is to assess the sites designated by the City of Medicine Hat for possible rooftop solar installations. The following report will offer unbiased suggestions and make recommendations for these 85 lots, outlining advantages and disadvantages with respect to solar photovoltaic installations. Potential system equipment, budgetary cost estimations, system foot print and structural load data will be provided, as well as suggestions regarding building orientation, roofing materials, slope and pitch.

Terralta Inc. located in the City of Medicine Hat has been part of the solar industry since 2008 and to date has installed numerous residential and commercial systems. Since 2008, these systems have created close to 300 mega watt hours of free energy. Terralta is also involved in other renewable technologies, such as geothermal and solar thermal. We are members of CanSIA (Canadian Solar Industries Association) and certified solar thermal installers. We have also been recognized by the CGC (Canadian Geoexchange Coalition) as certified installers, and designers. Terralta takes great pride in the products we carry and services we provide to our customers. Solar PV training with Conergy and SAIST have given us the expertise and knowledge that our industry demands. We install all of our systems in accordance with the standards put forth in CSA *SPE-900-13* Solar photovoltaic rooftop-installation best practices.

2.0 Solar Introduction

Solar photovoltaics (PV) are semiconductor devices that convert sunlight directly into electricity. This is achieved without any moving parts and without generating any noise or pollution. Ideally, a solar array should be mounted in an unshaded area. Typical locations or mounting types include rooftop, ground mount or pole mount. Solar PV systems work very well in Medicine Hat, Alberta where the average annual solar resource is 3.5-4.5 kWh/m2/day. This number, however, is not the amount of energy that can be produced by a solar PV panel. The amount of energy produced by a panel depends on several factors. These factors include the type of collector, the tilt and azimuth of the collector, the temperature, the level of sunlight and weather conditions. An inverter is required to convert the direct current (DC) to alternating current (AC) of the desired voltage compatible with building and utility power systems. The balance of the system consists of conductors/conduit, switches, disconnects and fuses. Solar systems have been separated into 3 different categories, the most common and cost effective being grid tied, pictured below.



3.0 Solar Equipment and Components

In today's competitive solar markets there are many different types of technologies available. Modules vary in wattage size and make up. The two most common modules are made of polycrystalline or monocrystalline silicone cells.

- Monocrystalline: a silicon wafer made from a single silicone crystal grown in the form of a cylindrical ingot. Chunks of highly pure polysilicon are melted in a crucible, along with boron.
- Polycrystalline: a silicon wafer made from a cast silicon ingot that is composed of many silicone crystals. Often distinguished by their square corners. Slightly lower efficiencies than Monocrystalline modules.

In the past few years the introduction of the micro-inverter has significantly changed the solar industry. Prior to the 2005, most residential and commercial solar systems consisted of string inverters that combined the power of all the solar modules in a specified array into one source. Typically, string inverters are mounted in the mechanical room and a DC wire is brought into the unit. This is where the unit converts the DC power created by the modules to usable AC for the home or building. The disadvantage associated with string inverters is if one panel in the array experiences shading, the total power output of the array decreased not just that panel's power capabilities.

Micro inverters have made the solar industry safer and more cost effective, especially from a residential perspective. Micro inverters are mounted right behind the modules on the roof. They convert the DC current to usable AC power right at the module. If one module is affected by shading it only decreases that module's capacity versus a string inverter that decreases the whole array's production. A key advantage associated with the micro inverters is they allow for future expansion. This allows the customer to purchase an introductory solar system with the possibilities of expanding in the future.

A typical solar installation should include the following equipment:

- CSA approved modules
- CSA approved micro-inverters, complete with inter-connection cables or wiring
- Racking and CSA approved mounting hardware. (Note: racking should be connected to the structures integral truss system with approved hardware)
- Grounding equipment (web clips, grounding lugs)
- A weather proof AC disconnect switch
- Wire run from the roof to the electrical panel complete with a continuous bare #6 copper grounding wire. (**Note:** wire gauge should be sized according to the loads applicable to the array)

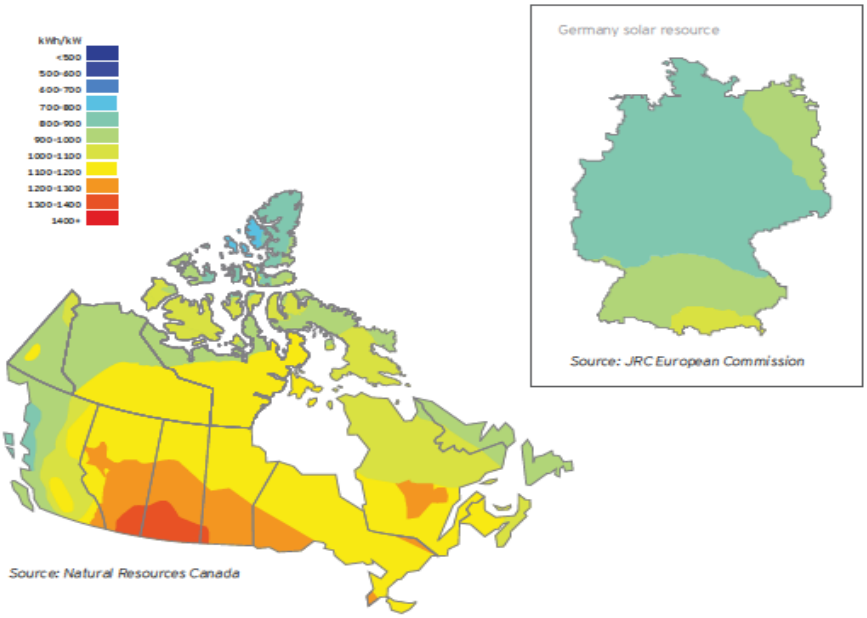
Racking systems vary depending on the installation. Residential home installations are typically flush mounted taking advantage of the homes already accessible tilt/slope. The roofing material will dictate the attachment method. Asphalt shingles and metal roofs are the simplest to deal with whereas clay tiled roofs can be challenging. Specific racking products are available to overcome the hurdles associated with tiled roofs, however, they are more costly and labour intensive. Consulting with a roofing contractor for clay tile application is always suggested.

Flat roof structures for example require a system that is either ballasted or attached to the building's structural trusses. When dealing with a flat roof installation it is extremely important to ensure that we are not overloading the roofs weight limits and that we incorporate snow and wind loading data. Acquiring the services of an engineer is suggested.

4.0 Solar Exposure and Potential

Prior to 2010, the orientation and placement of a solar system required the proper tilt or sloped roof and great southern exposure with no shading issues. Maximizing the system's potential was crucial given the initial upfront costs and extracting every ounce of solar energy from the array was imperative.

With the drastic reduction in solar costs and advances in technology we can now harvest more energy from the sun and concerns of shading, tilt and direct Southern exposure have somewhat become less important. Installing a system on a North facing roof is not suggested. Installations that face South East, South West and South still produce great power, especially in Southern Alberta. Below is a map that depicts the solar resources available in Canada. Medicine Hat, located in the southeast corner of Alberta is highlighted in dark orange proving that our location is amongst the best in Canada and the world. Germany has far less solar potential as depicted in the upper right photo yet they are a global leader in the solar community.



Data provided by the CMHC (Canadian Mortgage and Housing Corporation) show Medicine Hat as the best location for solar energy with its potential listed as 1367kw/year, however other sources such as Retscreen state that with an optimal tilt of 46 degrees, the solar potential in Medicine Hat is listed at 1732kw/year. These values are based on the installation of a 1kw solar system.

Comparison of Solar PV Potential (Data source: CMHC)

City	Solar PV potential
Medicine Hat , Alberta	1,367 kW/year
Calgary, Alberta	1,292
Edmonton, Alberta	1,245
Toronto, Ontario	1,161
Berlin, Germany	848
Los Angeles, USA	1,485
Cairo, Egypt	1,635

There are numerous solar reports which provide varying data regarding solar production all of which should be considered useful. Given Terralta's experiences and the data we have access to from the Enphase Monitoring System, Terralta believes that 1500kw hours/year is a reasonable expectation of a 1kw system. Alberta Energy states that an average household in Alberta consumes approxiamtely 7200kw hours of electricity per year. Based on Alberta Energies statistics the installation of a 1kw system in Medicine Hat, AB would offset 21% of an average households overall electrical consumption.

5.0 System Size, Footprint and Budgetary Cost

As advised by Jane Zwicker, the proposal for this subdivision is to include 1kw (1000watts) of solar electricity on every home. Below is a budgetary cost and system footprint for a number of different options including the industry's most current products.

NOTE: these costs are strictly budgetary and do not include the interior electrical work required. When a new home is constructed, electrical work is required. This additional portion can be included into the homes overall scope of work.

1kw Solar Array (1040watts)

- 260watt solar modules (x4), M250 Enphase micro inverters (x4), Conergy Alpha aluminum racking system, monitoring system, AC disconnect, grounding wire, mounting hardware and installation labour.

COST: $4,445.33 + GST

Physical foot print: 14' x 6' or 84 sq ft.

Approx weight: 3lbs per sq ft.

2kw Solar Array (2080watts)

- 260watt solar modules (x8), M250 Enphase micro inverters (x8), Conergy Alpha aluminum racking system, monitoring system, AC disconnect, grounding wire, mounting hardware and installation labour.

COST: $7,544.00 + GST

Physical foot print: 2 rows of 4: 14' x 12' or 168 sq ft. **Approx weight:** 3lbs per sq ft.
1 row of 8: 28' x 6' or 168 sq ft. **Approx weight:** 3lbs per sq ft.

3kw solar array (3120watts)

- 260watt solar modules (x12), M250 Enphase micro inverters (x12), Conergy Alpha aluminum racking system, monitoring system, AC disconnect, grounding wire, mounting hardware and installation labour.

COST: $10,568.00 + GST

Physical foot print: 2 rows of 6: 21' x 12' or 252 sq ft. **Approx weight:** 3lbs per sq ft.
3 rows of 4: 14' x 18' or 252 sq ft. **Approx weight:** 3lbs per sq ft.

6.0 Southlands 6C Report

6.1 Block 4: Lots 67 – 114

- **Lots 67 - 72** Will have great South West exposure. This is great for afternoon production when the sun is at its most powerful. Ideal lots for solar production.
- **Lots 73 - 80** Will have Southern exposure. Great for all day production. Ideal lots for solar production.
- **Lots 81 - 85** Will have South Eastern exposure. Good morning production. Good lots for solar production during most of the year. Very small decrease in yearly production versus a South or South West lot. Still very good lots.

These lots are ideal for solar production. Solar systems would be mounted on the back side of the homes. A hip, cross-hipped, gable or cross gable roof design would be acceptable for all of these lots. Design of the roof lines may vary from these suggestions, as long as we have workable roof space to mount to and South East, South or South West exposure.

- **Lots 86 – 100** Will have great all day exposure. Systems will be mounted on the back side of the homes. This is dependent on the design of the homes roof line. Really good lots. Hip, cross hipped, gable or cross gabled roof design is suggested. Design of the roof lines may vary from these suggestions, as long as we have workable roof space to mount to and Southern exposure.
- **Lots 101 – 108** Great Southern exposure as long as the home is built with a workable roof line that is positioned properly. These homes should all be of the same elevation. The potential issue may be having a three story home next to a single story home, creating possible shading issues. If positioned properly, these systems will be mounted on the right hand side (view from the street facing east) of the home. Systems may be visible from the street. Hip, cross hipped, gable or cross gabled roof design is suggested. Design of the roof lines may vary from these suggestions, as long as we have workable roof space to mount to and Southern exposure.

NOTE: Lot 101 will have South West exposure and Lot 108 South East exposure.

- **Lots 109 – 114** Great lots. System will be mounted on the front of the homes with straight Southern exposure (Lot 109 will face south West). Roof design for these lots will be very important, given that it is the front of the home. Please refer to the foot print information mentioned earlier in this document.

6.2 Block 13: Lots 1 – 27

- **Lots 1 - 7** Will have either South East or South West exposure depending on home design. These homes should all be of the same elevation to avoid one structure shading the other. Solar systems will be mounted on the back side (South East exposure) of the home or on the side of the home (South West exposure). Roof design will be important with this block. A hip, cross-hipped, gable or cross gable roof design would be acceptable.
- **Lots 8 – 15** Great lots for solar production. Lots 8 and 9 will have South West exposure and Lots 10 -15 will have straight Southern exposure. Systems will be mounted on the back side of the homes. Roof design may include but is not limited to a hip, cross-hipped, gable or cross gable. Please refer to the foot print information mentioned earlier in this document.
- **Lots 16 - 27** Great lots for solar production. System should be mounted on the front of the homes facing the street. Lots 26 and 27 will have more of a South West exposure, which is great for afternoon production when the sun is the most powerful. Roof design will be very important with these lots given they will be mounted on the front. Please refer to the foot print information mentioned earlier to ensure enough workable roof space is made available.

6.3 Block 3: Lots 21 – 30

- **Lots 25 - 30** Will have either South East or South West exposure. South East exposure if the systems are mounted on the front of the home facing the street or South West if mounted on side. A South West mounting location will demand that all of the homes are symmetrical in elevation. Roof design will be very important for these lots. Please refer to the system footprint information mentioned earlier. **Most challenging of all the proposed blocks.**
- **Lots 21 - 24** Have great Southern exposure. Systems will be mounted on the back side of the home. These homes will have to be of the same elevation as Lots 25 - 30 to eliminate possible shading issues. Ideally, the homes on Lots 21 - 24 should be slightly taller to overcome this issue.

NOTE: Lot 30. As long as a high rise apartment isn't proposed for this location it should not impact Lots 25 - 29.

6.4 Block 10: Lots 39 - 48

- Possibly the best lots of them all. Great Southern exposure. Systems will be mounted on the front on the homes facing Somerside Road SE. Roof design is extremely crucial with these lots. Ideally, the homes should all be of the same elevation to allow maximum production.

NOTE: All proposed roof lines outlined in the above sections should try to minimize the amount of plumbing stacks/vents, attic vents and chimneys on the solar side of the home. This suggestion will allow for a cleaner more symmetrical solar installation.

7.0 Conclusion

Out of the 95 proposed lots for solar PV, there are some definite winners, but all of the lots can be manipulated to make them feasable solar lots.

A number of lots standout as the best and brightest. These lots require no manipulation or directional change. A solar system mounted on these lots, properly placed with South facing exposure will produce very well. These lots include:

- Block 4: Lots 67 - 100 and Lots 109 - 114
- Block 13: Lots 10 - 27
- Block 3: Lots 21 - 24
- Block 10: Lots 39 - 48

The remaining lots will require the builder to take roof line and orientation into account. A hip, cross hipped, gable or cross gabled roof design is suggested for all of the lots in Southlands 6C; however we are also aware that styles and architectural design has changed drastically over the past decade. We also acknowledge that we are not architects or home designers. The builder must take into consideration the footprints mentioned in Section 5.0 when designing the home.

Southlands 6C has the potential to be a viable solar location. Of the proposed 95 lots, 76 lots or 80% of them are ideal locations. If the City of Medicine Hat wishes to move forward with a solar community, restrictions and limitations should be placed on the builder. Details involving elevation, roof design, orientation and material need to be clearly communicated to ensure the home owners have the best solar potential at the most economical rate.

A flush mounted and primarily South facing solar installation for Southlands 6C is feasbile. An East/West facing install in Southlands 6C would still out produce a perfect installation in Vancouver or most of Europe. Most residents of a fanatical solar community, like Germany would be envious of our options.

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