Solar Glare Hazard Analysis Report – Stirling Solar Project

Solar Krafte Utilities Inc., Stirling, Alberta

Version 3.0 – Issued for Use

Confidential

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Document Purpose

This report provides an assessment of glare hazard from the proposed Stirling Solar Project, Stirling, Alberta, Canada.

Document History

Stirling Solar Project Solar PV Glare Analysis

Version	Date	Comments
1.0 – Issued for Review	20 June 2017	Initial Version for Client Review
2.0 – Issued for Review	22 November 2017	Updated Project details and name change from SK Stirling 2 to Stirling Solar Project, Issued for review.
3.0 – Issued for Review	24 November 2017	Issued for Use

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Glossary

Abbreviation or term	Definition
After-image	Visual image that persists after the stimulus that caused it has stopped.
AUC	Alberta Utilities Commission
Azimuth	Horizontal angle of the Sun around an object – north is 0°, east is 90°, south is 180°, and west is 270°.
FP	Flight path
kW_{DC}	Kilowatts Direct Current
mrad	Measure of angle, 1/1000th of a radian
MW_{DC}	Megawatts Direct Current
OP	Observation point
Subtended Angle	Size of an object divided by the distance from the observer.
W_{DC}	Watts Direct Current

1 INTRODUCTION

Solar Krafte Utilities Inc. (Solar Krafte) is developing a utility-scale solar photovoltaic system in southern Alberta. The 21 MW_{DC} solar photovoltaic plant called the Stirling Solar Project (Project) is located along Highway 4, approximately 1.5 kilometres east of the village of Stirling in the County of Warner, Alberta.

Photovoltaic (PV) solar panels convert sunlight into electricity; however, up to 10 percent of the sunlight may be reflected into the surrounding areas[1]. In certain situations, the reflected sunlight can produce a glint (a momentary flash of bright light) and glare (a continuous source of bright light) that may have a visual impact on individuals.

Solar Krafte retained Solas Energy Consulting Inc. (Solas) to conduct a glare analysis for observation points at nearby residences and from major roadways near the Project. Solas performed an analysis from residential locations, at intersections, and points along roads adjacent to the Project.

This report documents the potential for solar glare from the Project on individuals at the observation points.

[1] Solar Glare Hazard Analysis Tool (SGHAT) User's Manual v 1.0, Ho and Sims, Sandia National Laboratories, 2013.

2 PROJECT DESCRIPTION AND ASSUMPTIONS

The 21 MW_{DC} Project is ground-mounted, single-axis tracking solar PV array located on agricultural land. Figure 1 shows the Project's approximate location. The Project will connect to the distribution system, and is expected to be built in 2018-2019.

The Project is split into two arrays by an irrigation canal. Highway 4 is located along the southwest boundary of the project area, while Township Road 64 is located along the southern edge of the Project. The Stirling Substation is located adjacent to the northwest corner of the Project. The Project is also located 1.5 kilometres (km) east of the village of Stirling, which has a population of 1,215[2]. The terrain is relatively flat and the surrounding land has few trees or waterbodies.

The Lethbridge (Mercer Field) Aerodrome is located 8.5 kilometres northwest of the Project, which is considered too far from the Project to require specific analysis.

The Project will use approximately 174,180 solar PV panels of 120 W_{DC} each. These panels will use a single-axis tracking system with tracking axes oriented one degree west of south (181 degrees azimuth). The tracking axis will be horizontal (parallel to the ground), and the panel will not have a vertical offset angle. The panel tracking angle will be limited to 60 degrees from horizontal in either direction. The tracking axis will be 2.00 metres above ground level. At full rotation, the edges of the panels will extend from 0.91 metres to 3.09 metres (3.0 feet to 10.0 feet) above ground level[3].

The Project integrates setbacks from property lines, irrigation canals, roads, and highways.

[2] 2016 Municipal Affairs Population List - http://www.municipalaffairs.alberta.ca/documents/2016_Municipal_Affairs_Population_List.pdf

[3] Data provided by Solar Krafte

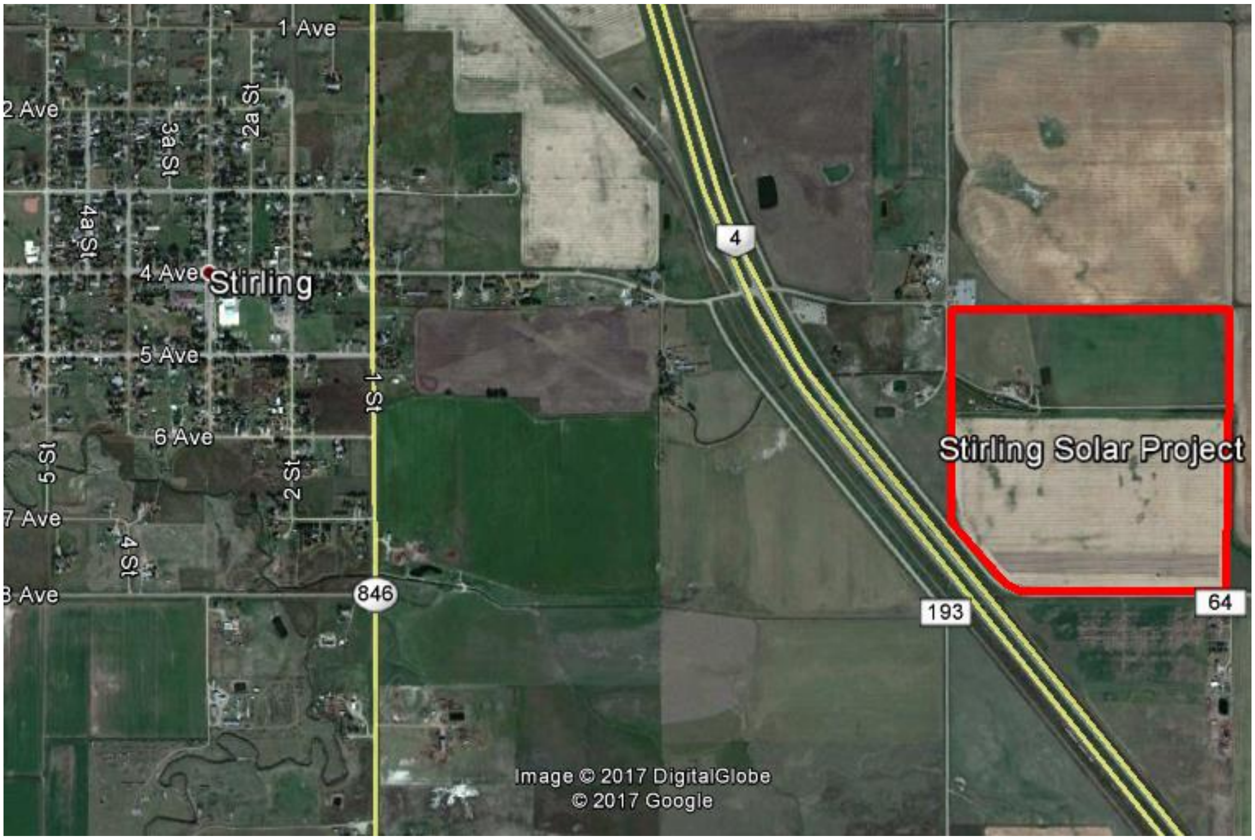

Figure 1: Project Location – Stirling Solar Project and Proximity to the Town of Stirling and Highway 4

The Project is on approximately 150 acres of land. Figure 2 outlines the Project area in red shows the solar arrays as the dark interior area.

Figure 2: Project Boundary and Proposed Stirling Solar Panel Arrays

2.1 Project Assumptions

Solas assumed a constant elevation for the entire site to emulate the approximate grading that will occur during construction. A change of grade will modify the results from the glare analysis.

Solas used approximate locations for the vertices of the solar arrays in the analysis, as exact coordinates were not available. Solas assumed the bottom of the panels is 3.0 feet (0.91 metres) from the ground while the top of the panels is 10.0 feet (3.09 metres) from the ground, when the panels are fully rotated (60 degrees from horizontal).

The model assumes the reflective surface lies in a plane defined by the array vertices, so the analysis was run at the top and bottom elevations to determine glare due to different parts of the panels. The analysis was also run at an elevation of 6.5 feet (2.00 metres) to help identify trends in the frequency and size of glare. Detailed input parameters and assumptions can be found in Appendix A.

3 GLARE REGULATIONS AND RECEPTORS

At the time of writing, there are no Canadian federal, provincial or municipal regulations or requirements regarding glare from solar projects. In the United States, the Federal Aviation Administration stipulates that any glare along an aircraft's flight landing path must have a low potential of producing after-image[4]. Glare outside of 50 degrees of the pilot's line of sight is not considered a risk.

Solas selected multiple observation points to assess the potential glare on nearby residents and vehicle routes. Roadway intersections were also identified as locations that could be subject to risk due to glare. Solas evaluated observation points for residences at an elevation of six feet above ground level to mimic a person standing at a window. Solas evaluated observation points on roads at an elevation of four feet to mimic a driver sitting in a small truck or passenger vehicle.

Solas completed a review of registered airstrips and helipads within three kilometres of the Project, and did not find any. Therefore, Solas did not take flight paths into consideration.

Solas analyzed the potential for glare at the observation points shown in Figure 3.

[4] https://www.federalregister.gov/documents/2013/10/23/2013-24729/interim-policy-faa-review-of-solar-energy-system-projects-on-federally-obligated-airports

Figure 3: Stirling Solar Array with Observation Points 1 to 8

Table 1 lists the observation points used in the analysis and describes the number of vehicles travelling along Highway 4, as identified by Alberta Transportation.[5,6]

Table 1: Description of Observation Points

Observation Point	Location	Notes
1	Residence	
2	Residence	
3	Residence	
4	Twp Rd 64 & private driveway	
5	Southbound Hwy 4	Expected average 1,290 vehicles per day
6	Northbound Hwy 4	Expected average 1,260 vehicles per day
7	Hwy 4	Expected average 1,290 vehicles per day
8	Residence	

[5] http://www.transportation.alberta.ca/mapping/2016/TM/70000058.pdf
[6] http://www.transportation.alberta.ca/mapping/2016/TM/00110040.pdf

4 GLARE PREDICTION METHOD

The impact of glare depends on the interaction between the position of the sun, the tilt of the solar panels, the reflectivity of the panels' surface, the size of the project, and the relative location of the driving path or the observer. Solas did not consider the screening effect from existing or proposed hedgerows or other objects in this evaluation.

The sun's position is described using the angle of elevation and solar azimuth. The angle of elevation is described as the angle between the horizon and the centre of the sun. The azimuth is measured as the angle from true north in a clockwise direction.

Solas performed the glare analysis using the Forge Solar Glare Gauge[7] software tool. This tool uses project inputs and solar positioning calculations to determine if glare will occur at identified observation points. If glare is found, the tool calculates the retinal irradiance (brightness) and subtended angle (size divided by distance) of the glare source. These two factors predict ocular hazards ranging from temporary after-image to retinal burn. Minor topographic features are not always identified in Glare Gauge, as the topographic contours are based on information from Google Earth.

"Green" rated glare indicates a low potential for after-image, while "yellow" rated glare indicates the potential for after-image exists, and "red" rated glare indicates the potential for retinal damage. Glare that is beyond 50 degrees from a driver's line-of-sight does not constitute a safety hazard.[8]

The amount of light reflected by a solar panel depends on the angle of incidence of the sunlight on the panel, as illustrated in Figure 4.

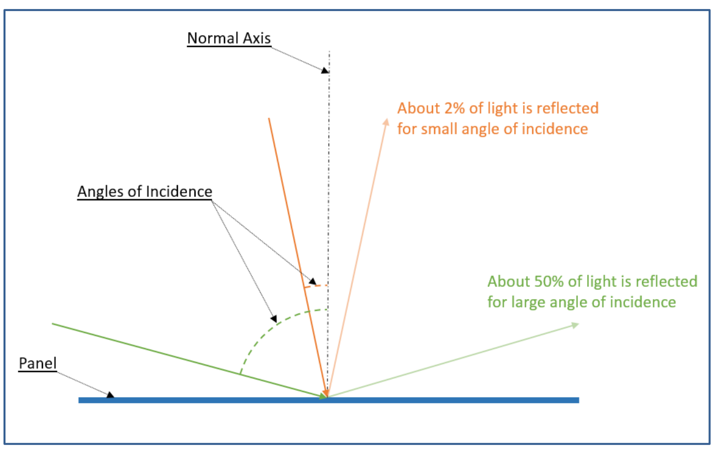

Figure 4: Reflected Light and Angle of Incidence

[7] Copyright, Sims Industries, 2015
[8] SGHAT_Users_Manual_v2-F.pdf

On average, a solar panel reflects approximately 10 percent of sunlight [9], which is about the same as open water[10]. Anti-reflection coating on the solar panel can reduce the reflection to one to two percent on average. The software models the reflectivity for each angle of incidence based on experiments Sandia National Laboratories performed for a variety of different panel constructions[11]. Very little light is reflected when the sun is nearly perpendicular to the panel, but much more light is reflected when the sun is at a shallow angle to the panel.

The software uses an interactive Google map. Solas uses Google maps to define the location and size of the PV arrays, characteristics of the PV array, and the observers' position.

[9] Lasnier and Ang, 1990, Photovoltaic Engineering Handbook. Taylor & Francis, New York.
[10] US EPA, 2013, AERSURFACE User's guide, EPA-454/B-08-001.
[11] Sandia National Laboratories, 2014, Solar Glare Hazard Analysis Tool (SGHAT) User's Manual v. 2F, Appendix E

5 RESULTS OF THE ANALYSIS

Given the parameters and assumptions listed in Appendix A, it is predicted that the Stirling Solar Project arrays will not produce glare at any hazard level, from either array, at any height for the observation points evaluated.

6 CONCLUSIONS AND DISCUSSION

The results of the analysis of the Project indicate that, based on the assumptions used, there will not be any hazard due to glare at any of the observation points evaluated. Drivers on Highway 4 travelling in either direction will not be adversely affected by the installation of the Project.

This analysis is limited in that cloud cover and other obstructions have not been modelled. In addition, any change in grade from that specified will change the results of the analysis.

Appendix A Forge Solar Modelling Assumptions

Axis tracking: Single

Tilt of tracking axis: 0 degrees (parallel to ground)

Orientation of tracking axis (Array Azimuth): 181 degrees (1 degree west of due south)

Offset angle of module (Panel tilt from tracking axis): 0 degrees

Maximum tracking angle: 60 degrees

Panel material: Smooth glass without anti-reflective coating

Vary reflectivity with sun position? Yes

Ground elevation: North array – 3084 feet (940 m), South array – 3072 feet (936 m)

Height above ground: 3.0 feet to 10.0 feet (0.91 m – 3.09 m)