

Technical Memorandum

To: Jonathan Roberts, Soltage, LLC
From: Stephen Barrett
Date: December 26, 2018
RE: Glare Study, Diamond Solar PV Project at Lorang and Seavey Roads, Elburn, Illinois

Executive Summary

Soltage LLC is developing a nominal 2 MWac solar photovoltaic (PV) project referred to as the Diamond Project at Lorang and Seavey Roads in Elburn, Illinois. It has engaged Barrett Energy Resources Group (BERG) to analyze potential impacts of glare from the project on residential receptors.

BERG has utilized the Solar Glare Hazard Analysis Tool (SGHAT) which was developed by the US Department of Energy for the Federal Aviation Administration (FAA) to protect aviation sensitive receptors. For this project, BERG has used SGHAT to assess glare on the three closest residences.

The modeling results recorded no glare on the three residential receptors. This Technical Memorandum describes the project, methodology, and results.

Project Description

The Diamond Solar Photovoltaic (PV) Project is proposed on 10 acres of undeveloped land southeast of the intersection of Lorang and Seavey Roads in Elburn, IL as shown on **Figure 1**. The project will use a fixed tilt design and has a nameplate capacity of 2 MWac.



Figure 1. Diamond Solar Project Locus

FAA Solar Policy

On October 23, 2013, the Federal Aviation Administration (FAA) published "Interim Policy, FAA Review of Solar Energy System Projects on Federally-Obligated Airport" in the *Federal Register*. The Policy sets forth methods for assessing glare and the standards for determining impact for projects proposed on airport property. It also requires the use of modeling to assess glare and directs project proposers to the Solar Glare Hazard Analysis Tool (SGHAT) which was developed by the US Department of Energy at the request of the FAA. The US Department of Defense (DOD) has also adopted SGHAT and the associated requirements to analyze glare under Instruction (DODI) 4165.57. Given the critical safety issues associated with aviation, the model produces a credible result that is being used to evaluate other glare sensitive receptors such as motor vehicles and residences.

Glare Methodology and Standard of Impact

Determination of glare occurrence from a solar PV project requires knowledge of the sun position, observer location, and the characteristics of the solar panels (e.g. tilt, orientation, location, extent, etc.). Vector algebra is then used to determine if glare is visible from the prescribed observation points. **Figure 2** provides a simple representation of how the sun can produce glare on an automobile for a specific time and location. The angle of the light source from the sun must be equal to the angle of the reflection on a receptor. Therefore, when receptors are close to the ground (like house or cars), the reflection is only possible when the sun is also close to the ground (i.e., near sunrise or sunset). As the sun moves, the incidence of glare ends.

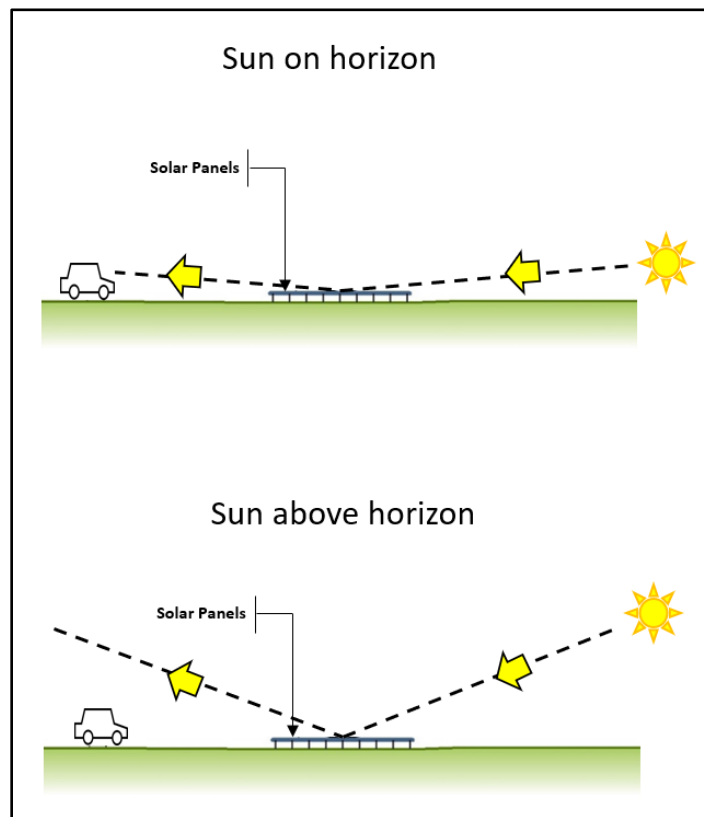


Figure 2. Geometric Representation of Potential Glare Impacts from the Sun

The SGHAT model is a credible tool for predicting glare based on the characteristics of the project and the identified receptor. It produces results that identify three categories of glare: green (low potential for an after-image), yellow (potential for an after-image), and red (retinal burn). These categories apply to the FAA Policy and are not specifically relevant for glare assessment of other receptors. For non-aviation receptors, like the Diamond Project, the results are simply used to determine if glare is predicted or not.

SGHAT Model Setup for Proposed Project

Regardless of the receptor to be analyzed, the model set-up entails locating the solar project, inputting its design characteristics, and identifying sensitive receptors for analysis. The position and movement of the sun throughout the year is built into the modeling program.

For the Diamond Project, the PV project polygon tool was used to draw the footprint of the solar array on SGHAT's interactive Google map. The specific attributes of the solar array were then input into the model. For this fixed tilt system, the design characteristics were loaded including a tilt angle of 25°, azimuth of 180°, average panel height of 6 feet above ground level (agl), and panel surface with smooth glass and no anti-reflective coating to allow for maximum flexibility in selecting a module for deployment.

The sensitive receptors for analysis in this case are residences located just south of the project. The model's observation point tool was used to select individual points located on the Google Map for glare assessment. The observer location was set at 15 feet agl for the two-story dwelling to assess a second-floor view. **Figure 3** shows the location of the three receptors.



Figure 3. Residence Near the Diamond Project Analyzed for Glare

The glare analysis button was activated and the model evaluated glare from various sun angles at 1-minute intervals throughout the year to predict if glare could be observed by the sensitive receptors.

Glare Model Results

The SGHAT Report with model results is provided for the three residential receptors in Attachment A. The results show no glare on the residential receptors. These results are consistent with past experience whereby the potential for glare is greatest when the sun is low on the horizon shortly after sunrise or shortly before sunset. Given the sun's position at those times, receptors to the east or west of the solar array are the locations where glare is possible.

Conclusions

Barrett Energy Resources Group (BERG) has utilized the SGHAT modeling tool developed by the US Department of Energy to assess the potential effects of glare from a solar photovoltaic (PV) project on residential receptors near Soltage's proposed solar project in Elburn, IL. The SGHAT model recorded no glare on the residential receptors analyzed. Based on these results, it is found that the proposed Diamond Solar Project will produce no glare impacts on those receptors.

Attachment A
Glare Modeling Results
Residential Receptors



GlareGauge Glare Analysis Results

Site Configuration: Kane

Project site configuration details and results.



Created Dec. 20, 2018 8:50 a.m.
 Updated Dec. 20, 2018 8:57 a.m.
 DNI varies and peaks at 1,000.0 W/m²
 Analyze every 1 minute(s)
 0.5 ocular transmission coefficient
 0.002 m pupil diameter
 0.017 m eye focal length
 9.3 mrad sun subtended angle
 Timezone UTC-6
 Site Configuration ID: 23715.4171

Summary of Results No glare predicted!

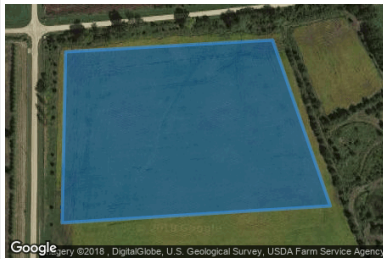
PV name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh
PV array 1	25.0	180.0	0	0	-

Component Data

PV Array(s)

Name: PV array 1
 Axis tracking: Fixed (no rotation)
 Tilt: 25.0 deg
 Orientation: 180.0 deg
 Rated power: -
 Panel material: Smooth glass without AR coating
 Vary reflectivity with sun position? Yes
 Correlate slope error with surface type? Yes
 Slope error: 6.55 mrad

Vertex	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total elevation ft
1	41.821814	-88.488899	767.97	6.00	773.97
2	41.820199	-88.488942	767.14	6.00	773.14
3	41.820359	-88.485552	773.93	6.00	779.93
4	41.821926	-88.486282	759.62	6.00	765.62



Discrete Observation Receptors

Number	Latitude deg	Longitude deg	Ground elevation ft	Height above ground ft	Total Elevation ft
OP 1	41.817826	-88.488503	775.12	15.00	790.12
OP 2	41.817006	-88.488562	767.32	5.00	772.32
OP 3	41.817382	-88.487192	768.15	5.00	773.16

PV Array Results

PV array 1

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0

Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Refer to the **User's Manual** for assumptions and limitations not listed here.