Appendix E: Solar Glare Hazard Analysis Report

8/12/2017

Solar Glare Hazard Analysis

Camas, Fumaria, Penstemon, Typha, and Urtica Solar Projects

Kittitas County, WA

CLIENT
Tuusso Energy
Jason Evans

CONSULTANT
MaxPV Engineering
Larry Booth, PE
Principal Engineer

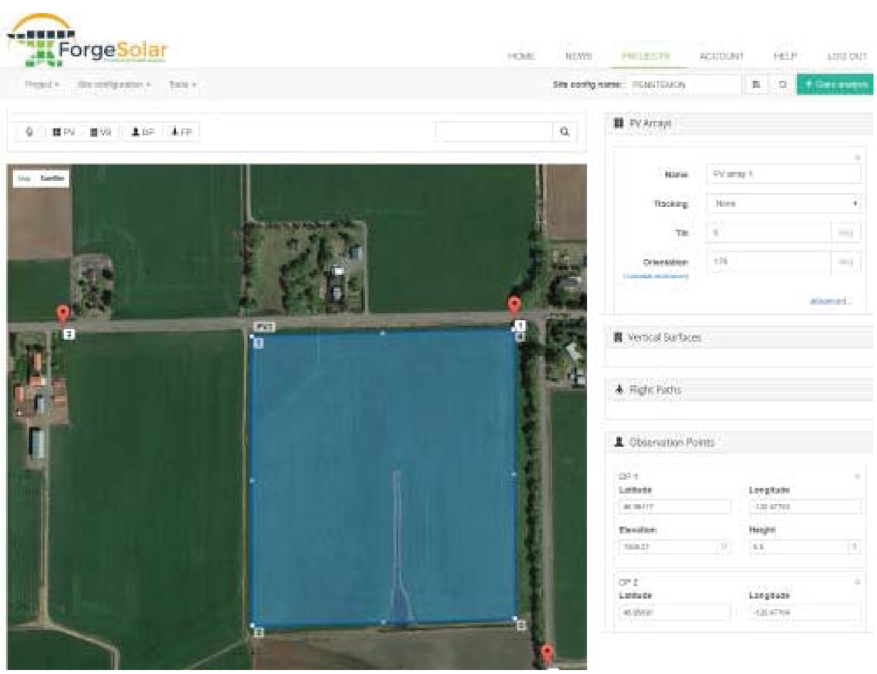
Executive Summary

This Solar Glare Hazard Analysis has been prepared to evaluate the potential for glare at each photovoltaic (PV) system from Key Observation Points (KOPs). The analysis takes into consideration the location, orientation, and reflective characteristics of the PV system relative the KOPs.

The results of this analysis show that the predicted glare hazards for the proposed PV system are within acceptable levels for potential glare contribution. The general standard for acceptable glare is met by maintaining that no stationary observers have potential for ocular after-image that could impair vision for safety reasons (such as air traffic control towers). For moving observers, low (green) and potential (yellow) after image are considered acceptable given the observer is moving, glare is momentary, and within normal driving conditions.

The KOPs in this study were all considered roadway-based and thus moving observers, none of which experienced glare events outside of those expected in normal driving conditions.

The time of day when glare potential exists at an intensity that can cause a temporary after image are sunrise and sunset periods, when the glare potential from the solar modules is insignificant to the greater danger of viewing the unfiltered Sun, and therefore the solar reflection intensities at these times are not considered significant at less than .01x of other present sources.



Modeling in the SGHAT/ForgeSolar Glare Analysis tool

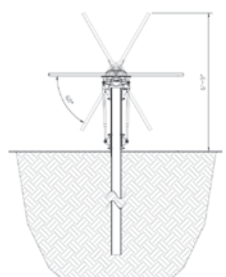
Purpose

The purpose of this analysis is to determine possible glare hazards and their severity due to the PV system being proposed for various project locations in Kittitas County. Any possible glare hazards will be evaluated against the current FAA guidelines and industry standards for acceptable glare.

Technology and Inputs

Modules
The solar photovoltaic (PV) modules are standard flat-face (non-concentrating) solar modules, which have the industry standard anti-reflective glass face. The modules are approximately 3.5’ by 6.5’ in size.

Solar Tracking
The solar modules will be supported by horizontal axis trackers, to track the Sun’s hourly progress across the sky for a better energy yield. The movement of the modules is considered in the SolarForge GlareGauge (formerly SGHAT) tool and calculates the resulting glare for each time of year. The module racking height of elevation 5’-0” was chosen.



Tracker Profile

Tracker Spacing
The solar array energy yield is very intolerant of small amounts of direct shading, and as such rows of modules are spaced for clear sky access. This results in roughly 13’-0” empty ground spacing for a 6’-6” length module-width between each module tracker assembly in the east-west directions. This translates to roughly a 33% module ground coverage ratio when in the horizontal or stow position. The remaining ground will be native vegetation or access paths.

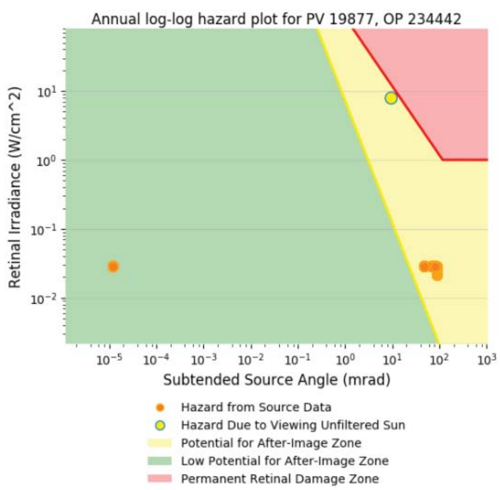
However, for this analysis, all areas within the project site are analyzed for glare in order to determine the worst case conditions. We view this as a conservative input.

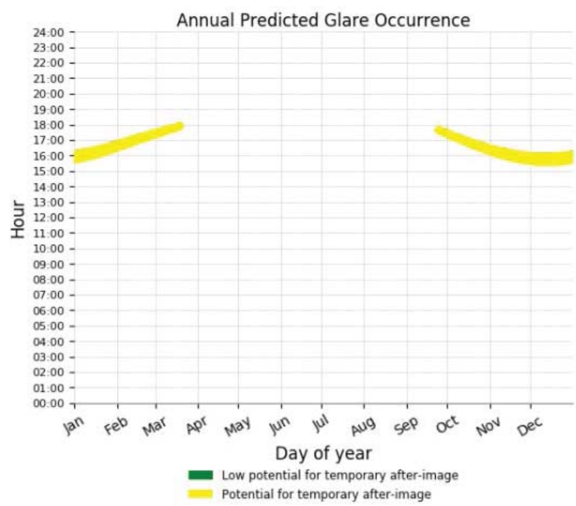
Tool & Approach

The tool used for this analysis is based on the Solar Glare Hazard Analysis Tool (SGHAT) created by Sandia National Laboratories. In 2017, the Solar Glare Hazard Analysis Tool was licensed to the private company Forge Solar run by one of the original engineers behind the popular glare modeling tool, which now appears on the reports and have a new, simpler format for presenting ocular impacts.

Representative models of the five proposed PV system were constructed in the SGHAT application for each of the project's 3 KOPs relative to the solar module arrays.

The below example shows how the SGHAT tool results are displayed.





In the above case, yellow glare potential is indicated for temporary after image during sunset hours in winter months. However, the source data intensity is 2 orders of magnitude below the direct sun intensity and within normal driving conditions during sunset hours as indicated in the plot to the top left.

It is generally accepted that flat plate solar PV modules are designed to be non-reflective, given than maximum power harvest correlates with light capture, the opposite of reflectance. In practice from satellite view and airplanes, large arrays of solar modules resemble a dark blue body of water and are not a significant contributor of glare in most conditions due to the flat plate and anti-reflective module design.

Project Specific Results

For all projects, the ocular impact, or glare intensity is below $2x10^{-2}$ W/cm^2 in the 'Hazard plot for PV' and therefore the projects have no dangerous or detrimental visual impact to the KOPs.

Camas Solar Project
Camas KOPs 2 and 3 indicate as expected that the elevated approach above the lower lying solar project would result in some longer periods of green and yellow potential indicators during morning hours.

Fumaria Solar Project
All KOPs are a significant distance and at similar elevation to the solar project. As such there is practically no glare component contributing to the KOPs.

Penstemon Solar Project
KOPs #1 and #2 indicate a reasonable amount of yellow potential glare indications. However, all are low intensity and acceptable. It is also noted that between both observations showing more potential glare minutes per month, both will have visual obstructions between them not reflected in this model. KOP #1 will have a future fence and #2 an existing vegetative screen. Both are within acceptable glare intensity levels for observers in motion as shown.

Typha Solar Project
Similar to Fumaria, all KOPs for Typha are a significant distance to the solar project. As such there is practically no glare component from the solar project contributing to the KOPs.

Urtica Solar Project
All KOPs for Urtica are green and yellow indicators and within acceptable intensities for KOPs in motion.

End Report

Attachments Follow