Wautoma Solar Energy Project
Solar Glare Analysis

Prepared for:

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April 2022

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Acronyms and Abbreviations

Applicant	Innergex Renewable Development USA, LLC
ATC	air traffic control
ATCT	Air Traffic Control Tower
BESS	battery energy storage system
CFR	Code of Federal Regulations
DNI	direct normal irradiance
FAA	Federal Aviation Administration
MWac	megawatt of alternating current
NCT	Notice Criteria Tool
O&M	operations and maintenance
OEG	Obstruction Evaluation Group
Project	Wautoma Solar Energy Project
PV	photovoltaic
SAT	Single-axis trackers
SGHAT	Solar Glare Hazard Analysis Tool
SR	State Route

1.0 Overview

Innergex Renewable Development USA, LLC (the Applicant) proposes to construct and operate the Wautoma Solar Energy Project (Project). The Project is a 470-megawatt[1] solar photovoltaic (PV) generation facility coupled with a 4-hour battery energy storage system (BESS) sized to the maximum capacity of the Project, as well as related interconnection and ancillary support infrastructure, located in unincorporated Benton County, Washington (Figure 1).

2.0 Project Location and Site Setting

2.1 Location

The Project is generally located 12.5 miles northeast of the city of Sunnyside and 1 mile south of the State Route (SR) 241 and SR 24 interchange in Benton County, Washington.

This following terms are used to describe areas associated with Project development:

- **Project Lease Boundary**: The approximately 5,852-acre area that encompasses 35 privately owned assessor parcels that the Applicant has executed or is pursuing a Lease Agreement with the underlying property owner (Figure 2). Construction and operation of the Project are limited to the Project Area described below.

- **Project Area:** The approximately 4,573-acre area that includes all of the Project facilities, including solar PV system and BESS, Project substation, transmission line, operations and maintenance (O&M) building, and associated access roads.

2.2 Existing Setting

Current land uses in the Project Area include irrigated agriculture, rangeland, undeveloped land, local roads, and existing electrical utility infrastructure. Lands to the north, west, and south are zoned for agricultural purposes in Benton and Yakima counties with similar land uses as the Project Lease Boundary, as well as several rural residences. The Hanford Reach National Monument Rattlesnake Unit is located to the east.

The Project is located entirely on parcels in unincorporated Benton County within the Growth Management Act Agricultural District zone, defined by Benton County Code.

[1] Megawatt rating provided in alternating current (MWac)

3.0 Glare Analysis

3.1 Background

Tetra Tech conducted a glare analysis of the proposed Project (Appendix A). The Federal Aviation Administration (FAA) developed a Technical Guidance for Evaluating Selected Solar Technologies on Airports in 2018 and a final policy in 2021.

As an industry standard, the term "glint and glare analysis" is typically used to describe an analysis of potential ocular impacts to defined receptors. ForgeSolar defines glint and glare in the following statement:

> *Glint is typically defined as a momentary flash of bright light, often caused by a reflection off a moving source. A typical example of glint is a momentary solar reflection from a moving car. Glare is defined as a continuous source of bright light. Glare is generally associated with stationary objects, which, due to the slow relative movement of the sun, reflect sunlight for a longer duration* (Sandia Laboratories 2016).

Based on the ForgeSolar definitions of glint and glare and the unlikelihood that the Project's solar modules would rotate faster than the relative daily motion of the sun, the potential reflectance from the Project modeled throughout this report will be referred to as glare.

3.2 Regulatory

The FAA developed Technical Guidance for Evaluating Selected Solar Technologies on Airports in 2018 and finalized it in 2021 with 14 Code of Federal Regulations (CFR) Part 77 (86 FR 25801) (FAA 2021). The FAA's technical guidance is in addition to FAA regulatory guidance under 78 FR 63276 Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports (collectively referred to as FAA Guidance). The FAA Guidance recommends that glare analyses should be performed on a site-specific basis using the Sandia Laboratories Solar Glare Hazard Analysis Tool (SGHAT). This guidance applies to solar facilities located on federally obligated airport property; it is not mandatory for a proposed solar installation that is not on an airport (and for which a Form 7460-1 is filed with FAA pursuant to CFR Title 14 Part 77.9, as discussed below), but is considered to be an industry best practice for solar facilities in general. The SGHAT is the standard for measuring potential ocular impact as a result of solar facilities (78 FR 63276).

According to 78 FR 63276, the FAA has determined that "glint and glare from solar energy systems could result in an ocular impact to pilots and/or air traffic control (ATC) facilities and compromise the safety of the air transportation system" (FAA 2013). With the updated final FAA policy with 86 FR 25801, the narrative states that:

> *FAA has subsequently concluded that in most cases, the glint and glare from solar energy systems to pilots on final approach is similar to glint and glare pilots routinely experience from water bodies, glass facade buildings, parking lots, and similar features. However, FAA has continued to receive reports of potential glint and glare from on-airport solar energy systems on personnel working in Air Traffic Control Tower (ATCT) cabs. Therefore, FAA has determined the scope of agency policy should be focused on the impact of on-airport solar*

> *energy systems to federally-obligated towered airports, specifically the airport's ATCT cab* (FAA 2021).

The FAA has developed the following criteria for analysis of solar energy projects located on jurisdictional airports:

- No potential for glint or glare in the existing or planned ATC tower cab.
- Glint or glare along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds) as shown on the current FAA-approved Airport Layout Plan is allowed. The final approach path is defined as 2 miles from 50 feet above the landing threshold using a standard three-degree glidepath.

3.3 Methodology

3.3.1 FAA Notice Criteria Tool

The online FAA Notice Criteria Tool (NCT) reports whether a proposed structure is in proximity to a jurisdictional air navigation facility and if formal submission to the FAA Obstruction Evaluation Group (OEG) under CFR Title 14 Part 77.9 (Safe, Efficient Use, and Preservation of the Navigable Airspace) is recommended (FAA 2010). The NCT also identifies final approach flight paths that may be considered vulnerable to a proposed structure's impact on navigation signal reception. The NCT was used to determine if the proposed Project is located within an FAA-identified impact area based on the Project area boundaries and height above ground surface (FAA 2022). The FAA NCT report stated that the Project Area does not exceed notice criteria (see Appendix B). Based on this information, there is no need to submit to FAA OEG.

3.3.2 Sandia Laboratories Solar Glare Hazard Analysis Tool

Tetra Tech used the SGHAT technology as part of an online tool (GlareGauge) developed by Sandia National Laboratories and hosted by ForgeSolar (Sandia Laboratories 2016). GlareGauge provides a quantitative assessment of the following:

- When and where glare has the potential to occur throughout the year for a defined solar array polygon; and
- Potential effects on the human eye at locations where glare is predicted.

The following statement was issued by Sandia Laboratories regarding the SGHAT technology:

> *Sandia developed SGHAT v. 3.0, a web-based tool and methodology to evaluate potential glint/glare associated with solar energy installations. The validated tool provides a quantified assessment of when and where glare will occur, as well as information about potential ocular impacts. The calculations and methods are based on analyses, test data, a database of different photovoltaic module surfaces (e.g. anti-reflective coating, texturing), and models developed over several years at Sandia. The results are presented in a simple easy-to-interpret plot that*

specifies when glare will occur throughout the year, with color indicating the potential ocular hazard (Sandia Laboratories 2016).

Note that technology changes continue to occur to address issues such as reflectivity. The model, therefore, presents a conservative assessment based on simplifying assumptions inherent in the model as well as industry improvements since the most recent update of such assumptions.

Based on the predicted retinal irradiance (intensity) and subtended angle (size/distance) of the glare source to receptor, the GlareGauge categorizes potential glare where it is predicted by the model to occur in accordance with three tiers of severity (ocular hazards) that are shown by different colors in the model output:

- Red glare: glare predicted with a potential for permanent eye damage (retinal burn)
- Yellow glare: glare predicted with a potential for temporary after-image
- Green glare: glare predicted with a low potential for temporary after-image

These categories of glare are calculated using a typical observer's blink response time, ocular transmission coefficient (the amount of radiation absorbed in the eye prior to reaching the retina), pupil diameter, and eye focal length (the distance between where rays intersect in the eye and the retina). As a point of comparison, direct viewing of the sun without a filter is considered to be on the border between yellow glare and red glare, while typical camera flashes are considered to be lower tier yellow glare (approximately 3 orders of magnitude less than direct viewing of the sun). Upon exposure to yellow glare, the observer may experience a temporary spot in their vision temporarily lasting after the exposure. Upon exposure to green glare, the observer may experience a bright reflection but typically no spot lasting after exposure.

3.3.3 Glare Analysis Assumptions

The GlareGauge model is bound by conservative limitations. The following assumptions provide a level of conservatism to the GlareGauge model:

- The GlareGauge model simulates solar arrays as infinitesimally small modules within planar convex polygons exemplifying the tilt and orientation characteristics defined by the user. Gaps between modules, variable heights of the solar array within the polygons, and supporting structures are not considered in the analysis. Since the actual module rows will be separated by open space, this model assumption could result in indication of glare in locations where solar modules will not be located. In addition, the supporting structures are considered to have reflectivity values that are negligible relative to the module surfaces included in the model.
- The GlareGauge model assumes that the observation point receptor can view the entire solar array segment when predicting glare minutes. However, it may be that the receptor at the observation point may only be able to view a small portion (typically the most proximal edge) of the solar array segment. Therefore, the predicted glare minutes and intensity from a specific solar array to a specific observation point are conservative because the observer will likely not experience glare from the entire solar array segment at once.

- The GlareGauge model does not consider obstacles (either man-made or natural) between the defined solar arrays and the receptors such as vegetative screening (existing or planted), buildings, topography, etc. Where such features exist, they would screen views of the Project, thus minimizing or eliminating glare from those locations.
- The GlareGauge model does not consider the potential effect of shading from existing topography between the sun and the Project outside of the defined areas.
- The direct normal irradiance (DNI) is defined as variable using a typical clear day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum of 1,000 watts per square meter at solar noon. The irradiance profile uses the coordinates from Google Maps and a sun position algorithm to scale the DNI throughout the year. The actual daily DNI would be affected by precipitation, cloud cover, atmospheric attenuation (radiation intensity affected by gaseous constituents), and other environmental factors not considered in the GlareGauge model. This may result in modeled predicted glare occurrences when in fact the glare is not actually occurring due to cloud cover, rain, or other atmospheric conditions.

Hazard zone boundaries shown in the Glare Hazard plots are an approximation; actual ocular impacts encompass a continuous, not discrete, spectrum.

3.3.4 Glare Analysis Methodology

The SGHAT (GlareGauge) was used to evaluate the potential for glare in areas surrounding the Project (Appendix A). The Project layout inputted into the GlareGauge model consists of 18 separate “PV Array Areas,” which are segmented polygons generally representative of the proposed Project layout (Figure 1).

Two separate glare analyses were conducted that included three proximal segmented vehicular traffic routes and four observation points (Figure 2). The observation points correspond with four non-participating receptor residence locations as shown on Figure 2. The two analyses differ in the height assumed for these points with Analysis Scenario 1 representing the point of view from an average first floor residential/commercial structure and typical commuter car, while Analysis Scenario 2 represents the point of view from an average second floor residential/commercial structure and typical semi-tractor-trailer truck.

The glare analysis represents single-axis trackers, or SAT systems, which follow the rotation of the sun along the east-west axis throughout the day. SAT arrays are typically oriented with their axis of rotation aligned north to south. The rotation angles over which the modules track the sun was set to +/- 60° east to west.

3.4 Glare Impacts

Glare impact analysis was conducted for the two analysis scenarios (see Appendix A). There was no glare predicted for Analysis Scenario 1 (average first floor residential/commercial structure and typical commuter car) or Analysis Scenario 2 (average second floor residential/commercial structure and typical semi-tractor-trailer truck). SAT systems may reduce glare for nearby receptors because they typically reduce the incidence angle between the modules and the sun, yielding smaller glancing angles and a higher vertical trajectory for glare reflections.

As previously noted, the GlareGauge model does not account for varying ambient conditions (i.e., cloudy days, precipitation); atmospheric attenuation; screening due to existing topography not located within the defined array layouts; or existing vegetation or structures (including fences or walls); therefore, the predicted results are considered to be conservative.

Based on the results of the FAA NCT, the Project does not need to formally file with the FAA OEG because it did not exceed notice criteria.

4.0 References

FAA (Federal Aviation Administration) 2010. CFR Title 14 Part 77.9 Notice of Proposed Construction or Alteration Requiring Notice.

FAA. 2013. Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports. 78 FR 63276. October 23, 2013.

FAA. 2021. FAA Policy: Review of Solar Energy System Projects on Federally-Obligated Airports. 86 FR 25801. May 11, 2021.

FAA. 2022. Federal Aviation Administration Notice Criteria Tool. Obstruction Evaluation Version 2018.1.4. Accessed online at: https://oeaaa.faa.gov/oeaaa/external/gisTools/gisAction.jsp?action=showNoNoticeRequiredToolForm.

Sandia Laboratories. 2016. Sandia Solar Glare Hazard Analysis Tool, GlareGauge hosted by ForgeSolar. Accessed online at: https://www.forgesolar.com/.

Figures

Appendix A: Sandia Glare Analysis Reports

Appendix B: FAA Notice Criteria Tool