TETRA TECH

MEMO

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From:	Drew Timmis, Tetra Tech, Inc.
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Date:	January 20, 2023
Subject:	Glint and Glare Analysis of the Proposed Carriger Solar Project in Klickitat County, Washington

At the request of Cypress Creek Renewables, LLC (Cypress Creek), Tetra Tech, Inc. (Tetra Tech) conducted a glint and glare analysis of the proposed Carriger Solar Project (Project) located in Klickitat County, Washington. The Project area covers approximately 2,011 acres of private lands and includes a generation interconnection with the Bonneville Power Administration's 500-kilovolt (kV) Knight substation, located adjacent to the northern portion of the Project area. The Project is divided into two geographic areas separated by approximately 1 mile, with the Project area mainly composed of agricultural and fallow fields.

This memorandum provides a description of the glint and glare anticipated from use of the Project as a solar energy generating facility. Included are a Project photovoltaic (PV) array area figure including identified observation points and roads subject to the analysis (Appendix A), the Sandia glare analysis reports (Appendix B), and the Federal Aviation Administration (FAA) Notice Criteria Tool Output (Appendix C).

GLARE ANALYSIS METHOD

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 ForgeSolar's definitions of glint and glare, and considering that the Project's solar modules are not likely to 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.

The FAA issued an Interim Policy (78 FR 63276) on October 23, 2013, describing methods for obtaining FAA review and approval of proposed solar arrays on airport property (FAA 2013). These methods involved the use of the Sandia Laboratories Solar Glare Hazard Analysis Tool (SGHAT), a modeling/compliance analysis tool now licensed for public use within the ForgeSolar GlareGauge cloud software application. The SGHAT complies with FAA 78 FR 63276.

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). There are three ocular hazards categories/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 three 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 after the exposure. Upon exposure to green glare, the observer may experience a bright reflection but typically no spot lasting after exposure.

On May 11, 2021, 14 CFR Part 77 was updated with final FAA policy (86 FR 25801), designed to ensure that solar projects on airport property do not produce hazardous glare. The updated policy includes narrative stating:

> *Initially, FAA believed that solar energy systems could introduce a novel glint and glare effect to pilots on final approach. 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).

Additionally, the updated policy results in solar project sponsors on airport property attesting to the FAA that sponsors conducted an ocular analysis of potential impacts to ATCT cabs, instead of submitting analysis to FAA for review and approval. This change results in the FAA withdrawing the mandate that the SGHAT tool be used for analyzing ocular impact of solar projects on airport property.

Therefore, the FAA has developed the following criteria for analysis of solar energy projects located near jurisdictional airports:

- No potential for glint or glare in the existing or planned ATCT cab for federally obligated airports.

- Glare with a "low potential for after-image" 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 3-degree glidepath.

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 under CFR Title 14 Part 77.9 is recommended (FAA 2010a). The NCT was used to determine if the proposed Project is located within an FAA-identified impact area based on the Project boundaries and height above ground surface. The Project is located approximately 1 mile west of the Goldendale Municipal Airport (FAA 2022). The airport does not have an ATCT cab.

The SGHAT (GlareGauge, hosted by ForgeSolar) was used to evaluate the potential for glint and glare 1) when driving along segments of Butts Road, Mesecher Road, Knights Road, Pine Forest Road, and Route 142; 2) from eleven nearby locations selected to represent observer views at neighboring residential and commercial properties within the surrounding area; and 3) and from the 2-mile final approach paths for the nearby Goldendale Municipal Airport.

The panels to be used on the proposed Project are smooth glass surface material with an anti-reflection coating, which is noted in the glare analysis. The analysis was performed to simulate panels with single-axis tracking with a 60-degree maximum tracking range and backtracking with a resting angle of 5 degrees. Backtracking is the movement of the panels when the sun is outside the range of rotation, with the resting angle being the angle that the panels are set to when backtracking. The analysis was conducted for a panel height of 5 feet above ground surface (centroid height) with applicable panel specifications. The panel orientation, location, and specifications used in the analysis were provided by Cypress Creek in January 2023. The analysis includes calculations to predict potential glare minutes at the following specified receptors (see location of receptors/observation points in Appendix A, Figure 2):

- Viewing height of observer in standard first floor building at 6 feet above ground surface (Appendix B Analysis 1);
- Viewing height of observer in standard vehicle at 5 feet above ground surface (Appendix B Analysis 1);
- Viewing height of observer in standard second floor building at 16 feet above ground surface (Appendix B Analysis 2);
- Viewing height of observer in standard commercial truck at 9 feet above ground surface (Appendix B Analysis 2);
- Goldendale Municipal Airport 2-mile final approach path for Runway 07 (Appendix B Analysis 3)
- Goldendale Municipal Airport 2-mile final approach path for Runway 25 (Appendix B Analysis 3)

GLARE ANALYSIS RESULTS

FAA Notice Criteria Tool

The NCT output (Appendix C) noted that the Project does exceed notice criteria with the nearest airport being the Goldendale Municipal Airport and its two runways. Based on this information, formal filing with the FAA Obstruction Evaluation Group is necessary, and an analysis of the airport's 2-mile final approach paths was conducted.

Sandia Laboratories Solar Glare Hazard Analysis Tool

The SGHAT GlareGauge modeled the results for the Project. Analysis 1 and 2 predicted similar results with yellow glare predicted along a section of Route 142, with minimum yellow glare predicted at observation point (OP) 2 and along sections of Knights Road in Analysis 2. Glare is generally predicted between April through August from 4:00 to 5:30 a.m. and 7:00 to 8:00 p.m. for Route 142, with glare predicted between May through July for OP 2 and Knights Road. For Analysis 3, there is significant levels of green and yellow glare predicted for runway 07. For Runway 07 has green glare predicted between February through May and August through November from 2:00 to 5:00 p.m., and yellow glare predicted between September through March from 6:00 to 9:00 a.m. The glare summaries are outlined in the tables below.

Table 1. Analysis 1 Annual Minutes of Glare Summary

Receptor	Green Glare	Yellow Glare	Red Glare
OP 1	0	0	0
OP 2	0	0	0
OP 3	0	0	0
OP 4	0	0	0
OP 5	0	0	0
OP 6	0	0	0
OP 7	0	0	0
OP 8	0	0	0
OP 9	0	0	0
OP 10	0	0	0
OP 11	0	0	0
Butts/Mesecher Road	0	0	0
Knights Road	0	0	0
Pine Forest Road	0	0	0
Route 142	0	2,520	0

OP = Observation Point

Table 2. Analysis 2 Annual Minutes of Glare Summary

Receptor	Green Glare	Yellow Glare	Red Glare
OP 1	0	0	0
OP 2	0	203	0
OP 3	0	0	0
OP 4	0	0	0
OP 5	0	0	0
OP 6	0	0	0
OP 7	0	0	0
OP 8	0	0	0
OP 9	0	0	0
OP 10	0	0	0
OP 11	0	0	0
Butts/Mesecher Road	0	3,024	0
Knights Road	0	7	0
Pine Forest Road	0	0	0
Route 142	0	3,556	0

OP = Observation Point

Table 3. Analysis 3 Annual Minutes of Glare Summary

Receptor	Green Glare	Yellow Glare	Red Glare
S20 RWY 07	8,650	40,161	0
S20 RWY 25	0	0	0

S20 = FAA identifier for Goldendale Municipal Airport; RWY = Runway

Table 4. Analyses Detailed Glare Summary

Receptor	Type of Glare	Minutes per Day	Time of Day	Time of Year
OP 2	Green	Less than 5	4:00 – 5:00 a.m.	May through July
Knight Road	Yellow	Less than 2	4:00 – 5:00 a.m.	June
Route 142	Yellow	Less than 50	4:00 – 5:30 a.m 7:00 – 8:00 p.m.	May through August
S20 RWY 07	Green	Less than 100	2:00 – 5:00 p.m.	February through May; August through November
	Yellow	Less than 100	5:00 – 9:00 a.m	September through March

OP = Observation Point

S20 = FAA identifier for Goldendale Municipal Airport; RWY = Runway

SUMMARY

The Project layout was modeled on SGHAT GlareGauge in order to evaluate the potential extent of any glint and glare the proposed Project may have upon nearby points of observation and vehicle routes within the surrounding area of the Project, and the airport and associated flight paths referenced within the NCT report. Three analyses were performed:

- Analysis 1 represented the point of view from an average first floor residential/commercial structure and typical commuter car (6 feet and 5 feet, respectively);
- Analysis 2 represented the point of view from an average second-floor residential/commercial structure and typical semi-tractor-trailer truck (16 feet and 9 feet, respectively); and
- Analysis 3 represented the two 2-mile final approach flight paths for Goldendale Municipal Airport.

Analysis 1 and 2 predicted yellow glare at sections of Route 142, and additionally Analysis 2 predicted yellow glare at OP 2 and sections of Knight Road. Analysis 3 predicted green glare and yellow glare for runway 07. The predicted amounts of glare are considered conservative because 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), nor does the tool allow proposed landscaping to be included. In the case of this Project, existing topography and intervening structures and vegetation are expected to reduce the potential for glare at the OPs and roadway segments.

The times for predicted glare were generally around times of dawn (4:00 – 5:00 a.m.) and dusk (7:00 – 8:00 p.m.) during periods when the panels would be at resting angles. The module backtracking program that will be implemented on the Project detects the rising sun light and begins to tilt the modules out of the resting position

until they reach the maximum tracking angle (60 degrees). Five degrees was used for the resting angle, it is common for panels to have a slight tilt to prevent buildup of moisture and precipitation on the panels overnight. It is predicted that if there was an increase in the resting angle, or if the module backtracking program was removed, that there will be significant reductions in predicted glare.

Yellow glare was predicted for the 2-mile final approach path for runway 07. Based on the flight approach paths as described in the original 2013 FAA interim policy that the SGHAT tool is based on, the analysis would fail because there is yellow glare predicted (glare with a potential for temporary after-image). The 2-mile final approach path for runway 07 comes in close proximity and above four panel array areas, with predicted yellow glare only at those locations. The predicted duration of yellow glare is less than 100 minutes, but the actual duration of exposure of glare to a pilot is predicted to be much less during landing and takeoff. However, based on the final May 11, 2021 14 CFR Part 77 policy, this policy does not apply to proponents of solar energy systems located off airport property, and the FAA 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-façade buildings, parking lots, and similar features. The FAA has determined that the scope of agency policy should be focused on the impact of solar energy systems on airport property to federally obligated towered airports, specifically the airport's ATCT cab. Based on the FAA website on airport data, there is no ATCT located at the Goldendale Municipal Airport. Therefore, under the final policy, there would be no detrimental effects to the airport based on predicted glare.

The results of the FAA NCT showed that the Project does exceed Notice Criteria and would require filing with the FAA Obstruction Evaluation/Airport Airspace Analysis.

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/.

Appendix A: Figures

Appendix B: Sandia Glare Analysis Reports

Appendix B, Analysis 1

Appendix B, Analysis 2

Appendix B, Analysis 3

Appendix C: FAA Notice Criteria Tool Output