MASER CONSULTING

Engineers
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MEMORANDUM

To: **P. Shorr, Hecate Energy**

From: **E. Myers, Maser Consulting**

Date: **August 10, 2020**

Re: **Hecate Energy Highland 2, LLC - 35MW Landscaping Review**
MC Project No. 20000800A

In the results of a comprehensive glare study provided to Hecate Energy by Maser Consulting, it was recommended that the owner/developer look into additional screening along Stringtown Road (Route 60) to the west and Edwards Road (Route 56) to the north of the PV project in order to provide suitable concealment of the project site and mitigate any predicted glare on any observations points and/or routes in those areas highlighted with a yellow line below.

A comparison of the results of the aforementioned glare study and the latest proposed landscaping plan provided to Maser Consulting by Hecate Energy for review (below) shows that the areas of predicted glare will likely be completely mitigated by the proposed addition of the lines of screening indicated by areas marked with WHITE in between the PV array itself and the limits of the project area.

cc: E. Kosmalski, Terracon – Email
J. Dering, Maser Consulting – Email

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August 10, 2020

VIA E-MAIL

Ms. Patti Shorr
Hecate Energy Highland 2, LLC
621 West Randolph Street
Chicago, IL 60661

RESULTS OF PROFESSIONAL GLARE STUDY

35MW Photovoltaic (Solar) Project in Highland County, OH

MC Proposal No. 20000800A

Dear Ms. Shorr,

Maser Consulting P.A. (Maser) is pleased to submit this letter to summarize our findings in regard to the glint/glare potential of the 35MW New Market Solar II project in Highland County, OH.

EXECUTIVE SUMMARY

The purpose of the requested glare study was to closely examine the 35MW of area to provide detailed feedback regarding areas that warrant closer boots-on-the-ground examination in order to mitigate any possible problematic glare to the businesses, residences, and roads surrounding the project area.

PV modules do not focus reflected sunlight and therefore retinal burn is typically not possible. Rather, the glare we look to identify is much like sunrise and sunset glare for drivers who struggle to find the perfect angle for their visors so they can continue to operate their vehicle safely while traveling through areas of such glare.

In general, photovoltaic panel systems of any size produce some glare predominately during early sunrise and sunset throughout the Spring through Fall months. While it is impossible to study every possible point and/or angle surrounding a photovoltaic (solar) project, Maser has modeled the project and surrounding areas as best as possible with the most likely points of concern.

Per information sent to Maser by Hecate Energy, the project's single-axis tracker panels are programmed to a 15-degree tracking tilt axis facing south at 180° with a maximum tracking angle of 60-degrees, a resting angle of 0-degrees, and an assumed midpoint height of 6 feet from the ground. It is further assumed that these panels are constructed of Smooth Glass with an Anti-Reflective coating.
Observation Points (OPs) 1 through 40 were placed at different points around the site and were programmed to an average height of five and a half (5.5) feet to model someone standing in these

spots and to a height of 15 feet to model a person five and a half (5.5) feet tall standing on the second floor of a home with eight (8) foot ceilings and a one and a half (1.5) foot plenum space.

Route Receptors (labeled Routes 1 through 19) were programmed for two-way traffic to heights of 4.25 feet and 13 feet, effectively representing the eyeline of an average person sitting on/in any vechicle from a bike to a motorcyle, a standard car or SUV, through to the approximated height of the cab of an 18-wheel truck.

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.
- 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.

RESULTS AND RECOMMENDATIONS

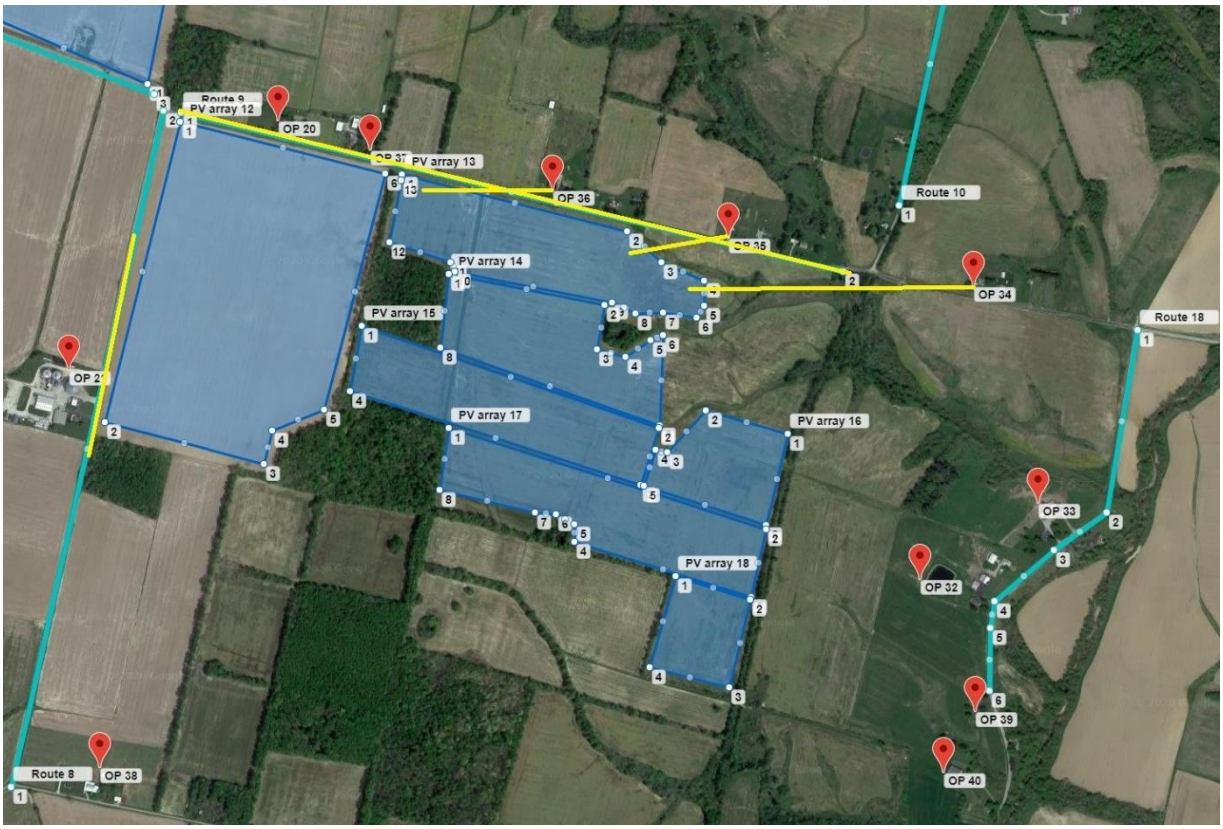
In the analysis that Maser Consulting performed for the the 35MW New Market Solar II project in Highland County, OH, findings show that the placement of the project, for the most part, will not present issue. Natural obstructions such as large areas of pre-existing foliage and/or enough distance with some elevation changes will likely screen many of the array areas effectively.

That said, as shown in the graphic on the next page, there is one route programmed to the north of the new array areas where there looks to be sparse to no existing natural foliage between the project array and the route—as well as the residences directly north this array area. There is also a route to the west of the new array area where one business/residence is not screened by existing natural foliage or marked elevation changes.

It is recommended that the owner/developer pay particular attention to the businesses and residences located in yellow highlighted areas, as well as to consider drivers moving through these areas in all types of vehicles, as they will most likely to be affected by possible sunrise and sunset glare from this project.

If found necessary, mitigation can be reached with the installation of landscaping/foliage measures appropriate for this area of the United States.

* Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.



METHODOLOGY

(Source Information: https://forgesolar.com/help/#intro)

Maser employs staff specifically trained on glare analyses utilizing *ForgeSolar*, a web-based interactive software that provides a quantified assessment of (1) when and where glare is predicted to occur throughout the year for a prescribed solar installation, and (2) potential effects on the human eye at locations where glare is predicted to occur. *ForgeSolar* includes *GlareGauge*, a standard solar glare hazard analysis software used in the industry. *ForgeSolar* is based on the Solar Glare Hazard Analysis Tool ("SGHAT") licensed from Sandia National Laboratories. These tools meet the FAA standards for glare analysis.

Determination of glare occurrence requires knowledge of the following: sun position, observer location, and the tilt, orientation, location, extent, and optical properties of the modules in the solar array. Vector algebra is then used to determine if glare is likely to be visible from the prescribed observation points.

If glare is predicted, the software calculates the retinal irradiance and subtended angle (size/distance) of the glare source to predict potential ocular hazards ranging from temporary after-image to more severe possible retinal damage. These results are presented in a simple, easy-to-interpret plot that

* Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.

specifies when glare is predicted to occur throughout the year, with color codes indicating the potential ocular hazard.

It is important to note that within this analysis, the PV array panels are approximated with simplified geometry and that blocking and shading (via buildings, elevation changes, and foliage, etc.) **are not** considered.

BACKGROUND INFORMATION

(Source Information: https://forgesolar.com/help/#glare)

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.

The difference between glint and glare is duration. Industry-standard glare analysis tools evaluate the occurrence of glare on a minute-by-minute basis; accordingly, they generally refer to solar hazards as 'glare.'

The ocular impact of solar glare is quantified into three categories (*Ho, 2011*[1]):

- **Green** - Low potential to cause after-image (*flash blindness*).
- **Yellow** - Potential to cause temporary after-image.
- **Red** - Potential to cause retinal burn (*permanent eye damage*).

These categories assume a typical blink response in the observer.

Note that retinal burn is typically not possible for PV glare since PV modules do not focus reflected sunlight.

The ocular impact of glare is visualized with the Glare Hazard Plot.

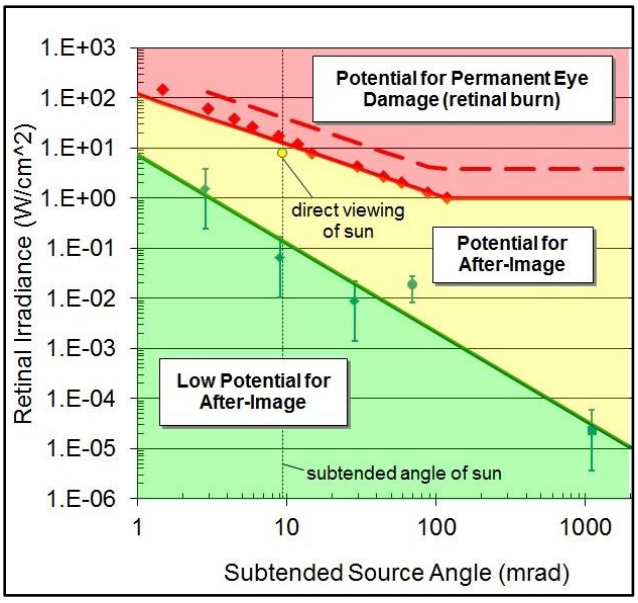


Figure 1 – From ForgeSolar website (Sample glare hazard plot defining ocular impact as function of retinal irradiance and subtended source angle (Ho, 2011)

This chart displays the ocular impact as a function of glare subtended source angle and retinal irradiance. Each minute of glare is displayed on the chart as a small circle in its respective hazard zone.

* Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.

FULL PARAMETERS AND DETAILED RESULTS OF THIS STUDY

As requested by the client, Maser analyzed the planned installation of solar panels at the 35MW New Market Solar II project location in Highland County, OH to examine what glare might exist in the surrounding areas.

GENERAL GLARE STUDY

Per plans sent to Maser by Hecate Energy, the project's ground-mount fixed panels were programmed to a 25-degree tilt facing south at 180° with an assumed midpoint height of 6 feet from the ground. It was further assumed that these panels are constructed of Smooth Glass with an Anti-Reflective coating.

Observation Points (OPs) were placed at different points around the site and were programmed to an average height of five and a half (5.5) feet to model someone standing in these spots and to a height of 15 feet to model a person five and a half (5.5) feet tall standing on the second floor of a home with eight (8) foot ceilings and a one and a half (1.5) foot plenum space.

Route Receptors programmed for two-way traffic to heights of 4.25 feet and 13 feet, effectively representing the eyeline of an average person sitting on/in any vechicle from a bike to a motorcyle, a standard car or SUV, through to the approximated height of the cab of an 18-wheel truck.

It is noted again here that the ForgeSolar program does not factor any obstructions into the results; thus providing a worst-case scenario. **After examining each point and then factoring in buildings, naturally occuring lines of foliage and elevation changes, points where predicted glare is blocked by these natural obstructions were removed from the listing of points to be examined more closely.**

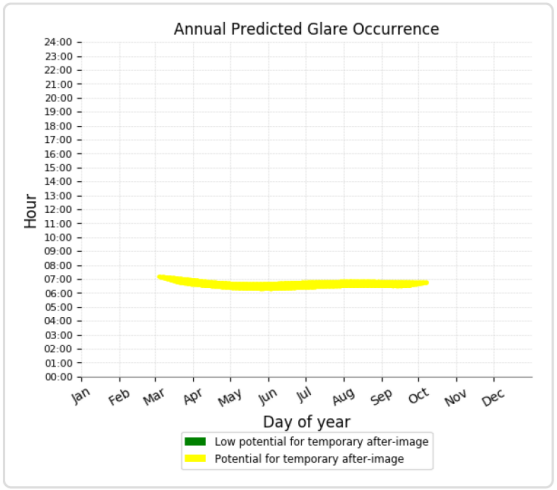
Finally, where glare was predicted and not naturally mitigated, this analyst will address the areas that present the most possibility for glare.

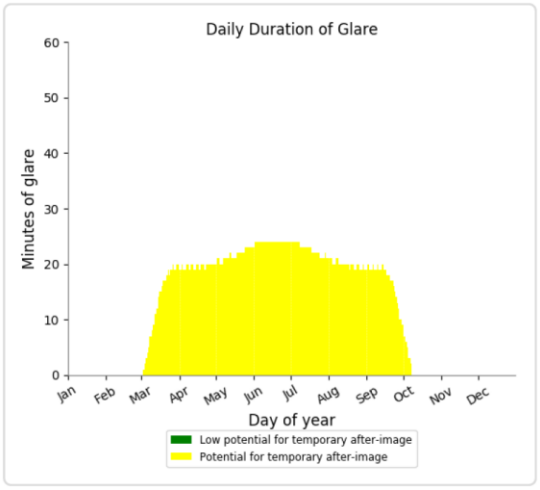
* Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.

PV ARRAY 12

OP21 / Route 8 / Route 9
Low-grade YELLOW glare is noted from PV Array 12 at Observation Point 21 at both the 5.5 and 15 foot height. Additionally, low-grade YELLOW glare from PV Array 12 is noted on both Route 8 and Route 9 at both the 4.25 (Car)and 13 foot (18-Wheel Truck) height.

OP21
Predicted lower-grade YELLOW glare at OP21 occurs in the morning between 6 AM and 7 AM* starting at approximately 5 minutes per day in early-March, peaking at just about 19 minutes per day from May through August, and then descending back down through to 0 minutes per day in very-early-October. No marked glare is predicted from through the Fall and Winter months.

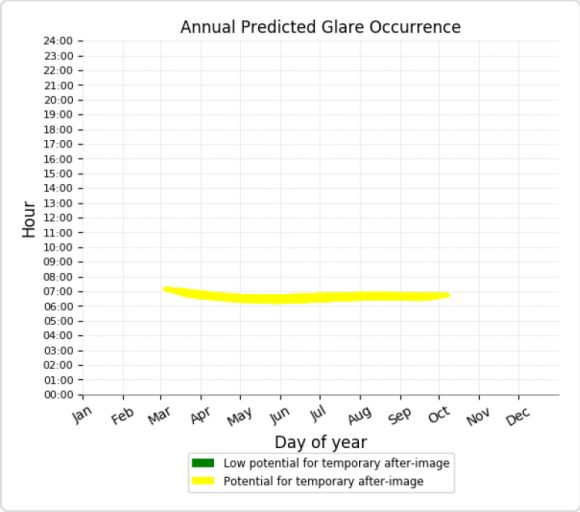


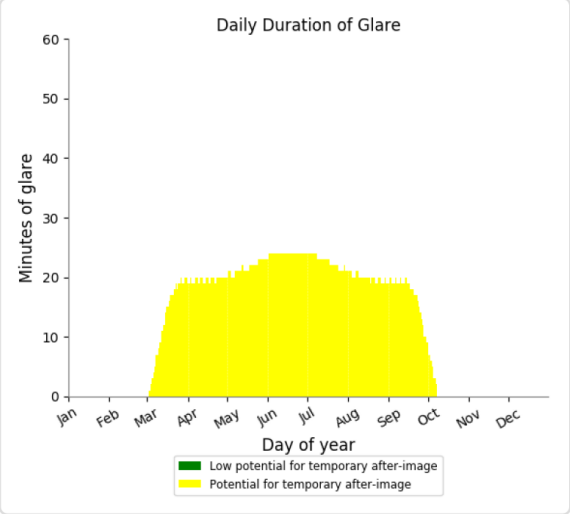


* Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.

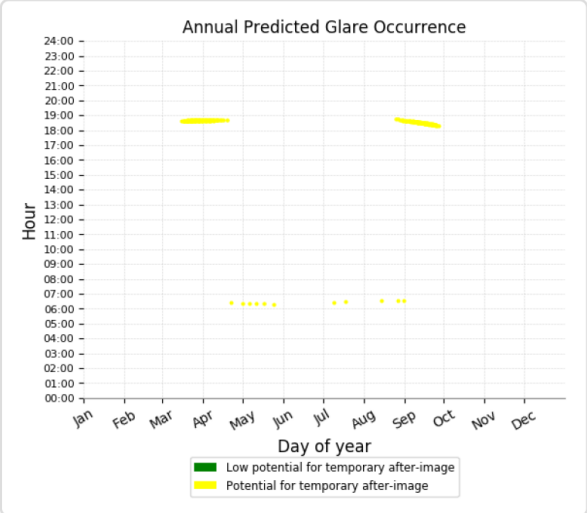
ROUTE 8 / ROUTE 9

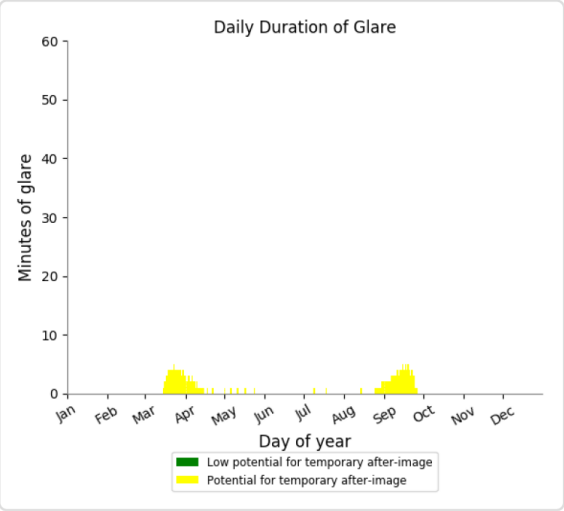
YELLOW glare is predicted on Route 8 between approximately 6 AM and 7:15 AM* at the 13-foot 18-Wheel truck height for over 20 minutes per day from March through early-to-mid-October.





YELLOW glare is predicted very lightly on Route 9 only between 6 PM and 7 PM* predominantly in mid-March to mid-April and then again from August-end to September-end.



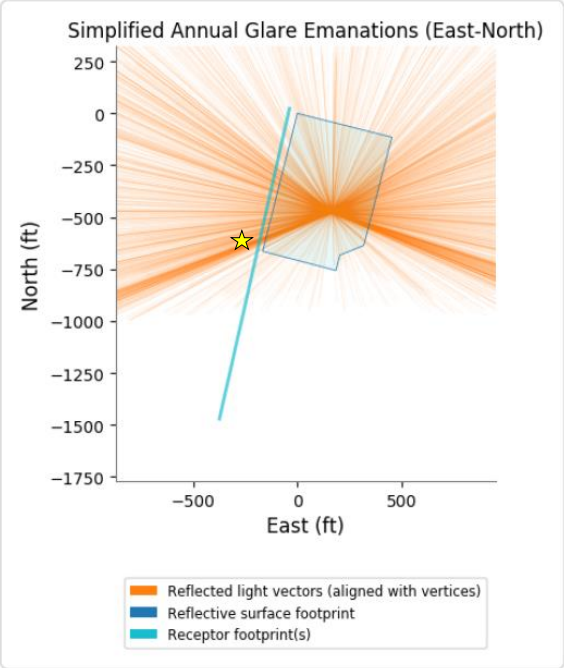


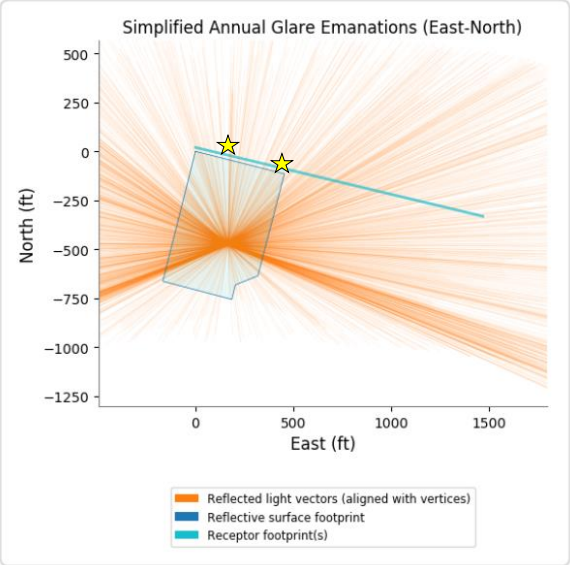
* Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.

PV ARRAY 12 RECOMMENDATION

Study points and routes are very close to the array so distance will not help to mitigate the predicted glare. No marked visible natural obstructions shown on available Google earth images of this study area, and an examination of elevations shows that the area is relatively flat.

PV Array 12 likely does not presently have adequate natural mitigation for predicted glare.





The yellow stars represent the approximate locations of the residences closest to the Route and Array.

Residents in the homes, pedestrians and drivers traveling through this predicted area of glare would likely be impacted.

It is suggested that the owner/developer look into additional screening along Stringtown Road (Route 60) to the west and Edwards Road (Route 56) to the north of PV Array 12 in order to provide suitable concealment of the project site and mitigate predicted glare at Observation Point 21 and along the Routes 8 and 9.

* Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.

PV ARRAY 13
OP34 / OP35 / OP36

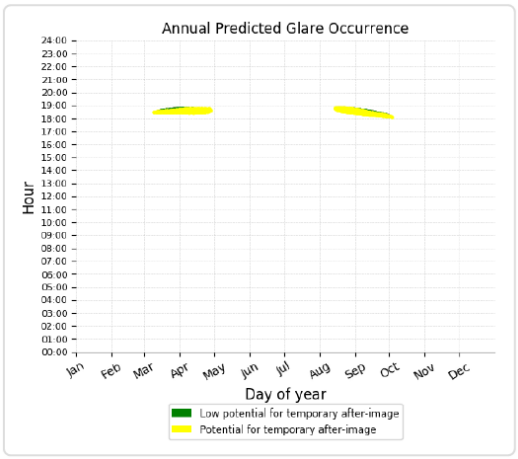
GREEN and low-grade YELLOW glare is predicted in the evening between the hours of 6 PM and 7 PM* at Observation Points 34, 35, and 36 both from the 5.5 and 15 foot heights for a few minutes up to approximately 20 minutes per day from early-March through late-April and then again from mid-August until early-October.

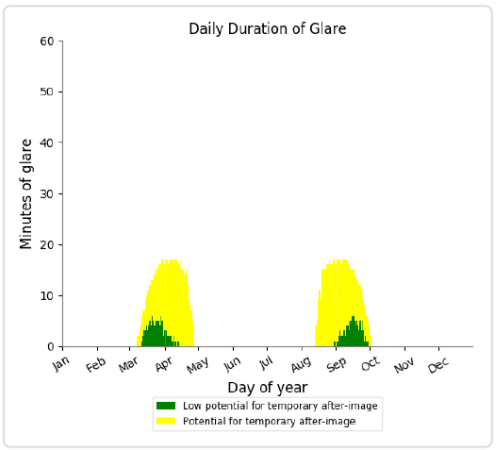
While high levels and/or long periods of glare are not predicted, these points do represent what look to be private residences directly across the road from the project site. The distance from the arrays and residences and negligible elevation changes are likely not enough to screen the project site from view as there is little naturally occurring foliage at most of the observation points studied.

It is suggested that the owner/developer look into additional screening along Edwards Road (Route 56) to the north of PV Array 13 in order to provide suitable concealment of the project site and mitigate predicted glare at Observation Points 34, 35, and 36. Although no model scenario predicted glare along the Route in question, any landscaping for these residence would also work to effectively screen the route for drivers.

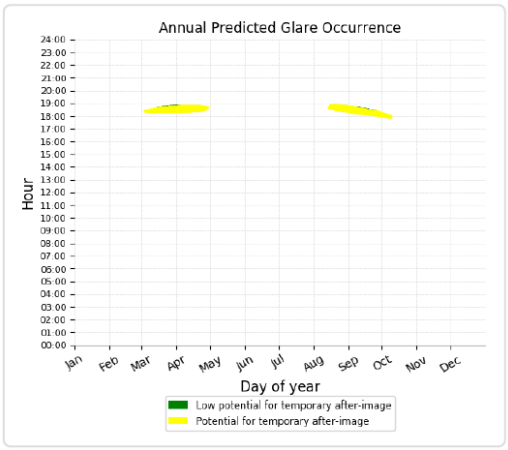
* Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.

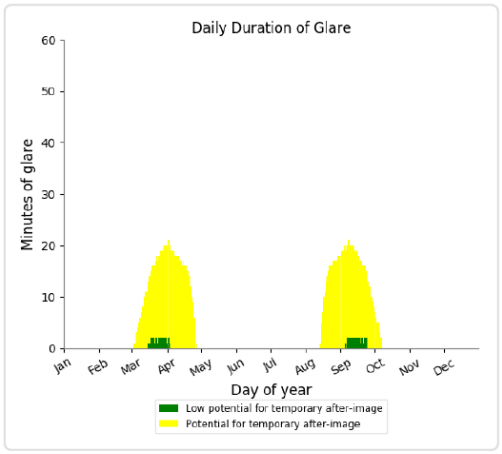
OP34



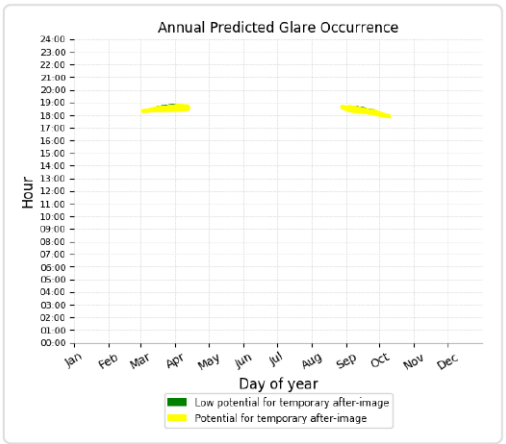


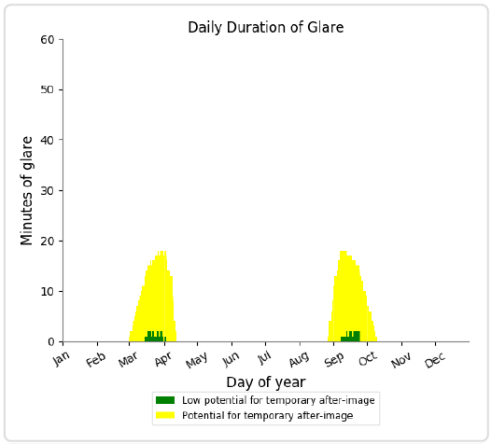
OP35





OP36





* Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.

CONCLUSIONS

In general, photovoltaic panel systems produce some glare predominately during early sunrise and sunset during the spring through fall months.

In the analysis that Maser Consulting performed for the 35MW New Market Solar II W at the project location in Highland County, OH, it was found that while glare will not present a large additional issue to the project, it is suggested that owner/developer look into additional landscaping to the north and west side of the new 35MW area to ensure suitable concealment of this portion of the project site.

Please feel free to contact me if you would like to go over these results or if you have any additional questions.

Very truly yours,

MASER CONSULTING P.A.

Elizabeth Claire Myers, PMP
Project Manager, Energy/Solar
Certified Glare Analyst through Sims Industries

ECM/jmd

Additional Resources and Information

[1] Ho, C. K., Ghanbari, C. M., and Diver, R. B., 2011, Methodology to Assess Potential Glint and Glare Hazards From Concentrating Solar Power Plants: Analytical Models and Experimental Validation, *ASME J. Sol. Energy Eng., 133*.

Solar Glare Hazard Analysis Tool (SGHAT) Technical Reference Manual
https://forgesolar.com/static/docs/SGHAT_Technical_Reference-v6.pdf

* Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.

APPENDIX A

GLARE STUDY RESULT REPORTING

Summary: Exhibit Application Exhibit J (Part 2) electronically filed by Ms. Karen A. Winters on behalf of Hecate Energy Highland 4 LLC