

FORGESOLAR GLARE ANALYSIS

Project: **Green Bay-Oak Lane - PE Co VA**

Site configuration: **Oak Lane - final**

Client: CEP Solar

Created 31 Aug, 2024

Updated 17 Feb, 2025

Time-step 1 minute

Timezone offset UTC-5

Minimum sun altitude 0.0 deg

DNI peaks at 1,000.0 W/m²

Category 500 kW to 1 MW

Site ID 128118.21892

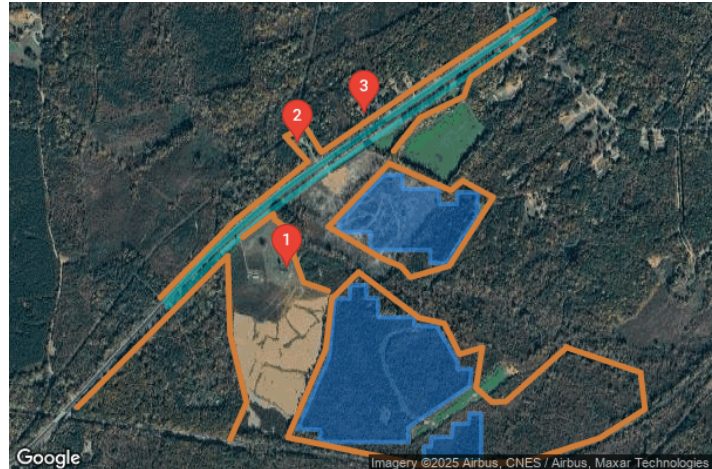
Ocular transmission coefficient 0.5

Pupil diameter 0.002 m

Eye focal length 0.017 m

Sun subtended angle 9.3 mrad

PV analysis methodology V2



Summary of Results

Glare with low potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy kWh
	°	°	min	hr	min	hr	
PV array 1	SA tracking	SA tracking	0	0.0	0	0.0	4,050,000.0
PV array 2	SA tracking	SA tracking	119	2.0	0	0.0	7,135,000.0
PV array 3	SA tracking	SA tracking	0	0.0	0	0.0	1,336,000.0

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
US-360 East	0	0.0	0	0.0
US-360 West	0	0.0	0	0.0
OP 1	119	2.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0

CEP Solar, LLC, is proposing a 5 MW solar project in Prince Edward County, VA, and commissioned a glint/glare analysis using ForgeSolar software to determine ocular impact on adjacent properties and roads. The analysis includes a 6' security fence to be erected by the developer, and predicts minimal diffuse glare -- 119 minutes annually, or 0.02% of the calendar year -- for neighbors and zero glare for motorists on US-360.

Component Data

PV Arrays

Name: PV array 1

Axis tracking: Single-axis rotation

Backtracking: Shade

Tracking axis orientation: 180.0°

Max tracking angle: 60.0°

Resting angle: 0.0°

Ground Coverage Ratio: 0.5

Rated power: 1500.0 kW

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	37.112911	-78.345692	566.95	3.00	569.95
2	37.114306	-78.344007	577.10	3.00	580.10
3	37.114310	-78.343320	569.72	3.00	572.72
4	37.113904	-78.343310	582.42	3.00	585.42
5	37.113904	-78.342001	557.10	3.00	560.10
6	37.113468	-78.341969	550.27	3.00	553.27
7	37.113470	-78.341336	556.29	3.00	559.29
8	37.113810	-78.341303	548.94	3.00	551.94
9	37.113810	-78.340542	565.84	3.00	568.84
10	37.113100	-78.340595	567.92	3.00	570.92
11	37.111731	-78.341722	528.66	3.00	531.66
12	37.111756	-78.342301	554.79	3.00	557.79
13	37.112120	-78.342301	560.19	3.00	563.19
14	37.112124	-78.344500	562.21	3.00	565.21
15	37.112650	-78.344500	575.68	3.00	578.68
16	37.112646	-78.345627	589.17	3.00	592.17
17	37.112971	-78.345606	563.86	3.00	566.86

Name: PV array 2

Axis tracking: Single-axis rotation

Backtracking: Shade

Tracking axis orientation: 180.0°

Max tracking angle: 60.0°

Resting angle: 0.0°

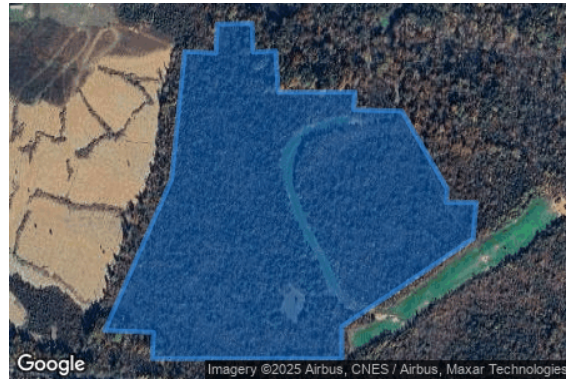
Ground Coverage Ratio: 0.5

Rated power: 3000.0 kW

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	37.110713	-78.345563	572.17	3.00	575.17
2	37.110704	-78.345262	567.03	3.00	570.03
3	37.111098	-78.345241	543.11	3.00	546.11
4	37.111106	-78.344640	553.87	3.00	556.87
5	37.110713	-78.344619	564.44	3.00	567.44
6	37.110730	-78.344232	561.90	3.00	564.90
7	37.110165	-78.344189	573.67	3.00	576.67
8	37.110165	-78.342870	556.15	3.00	559.15
9	37.109925	-78.342891	574.13	3.00	577.13
10	37.109908	-78.342065	543.50	3.00	546.50
11	37.108856	-78.341293	569.24	3.00	572.24
12	37.108659	-78.341303	577.66	3.00	580.66
13	37.108659	-78.340788	562.91	3.00	565.91
14	37.108163	-78.340842	592.65	3.00	595.65
15	37.106965	-78.343100	608.42	3.00	611.42
16	37.106530	-78.343095	620.48	3.00	623.48
17	37.106529	-78.346357	575.64	3.00	578.64
18	37.106888	-78.346335	566.86	3.00	569.86
19	37.106914	-78.347172	568.42	3.00	571.42
20	37.108976	-78.346024	596.28	3.00	599.28
21	37.110721	-78.345799	570.36	3.00	573.36

Name: PV array 3

Axis tracking: Single-axis rotation

Backtracking: Shade

Tracking axis orientation: 180.0°

Max tracking angle: 60.0°

Resting angle: 0.0°

Ground Coverage Ratio: 0.5

Rated power: 500.0 kW

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	37.106674	-78.342280	616.54	3.00	619.54
2	37.106683	-78.341529	594.93	3.00	597.93
3	37.107068	-78.341464	598.08	3.00	601.08
4	37.107068	-78.340896	572.08	3.00	575.08
5	37.107367	-78.340864	581.70	3.00	584.70
6	37.107359	-78.340430	577.57	3.00	580.57
7	37.105998	-78.340434	597.36	3.00	600.36
8	37.105998	-78.342540	622.70	3.00	625.70
9	37.106409	-78.342537	622.08	3.00	625.08
10	37.106400	-78.342280	619.28	3.00	622.28

Route Receptors

Name: US-360 East

Path type: One-way (toward increasing index)

Observer view angle: 50.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	37.110467	-78.351901	541.57	6.00	547.57
2	37.112050	-78.349916	516.13	6.00	522.13
3	37.113231	-78.348194	512.15	6.00	518.15
4	37.114471	-78.346011	528.66	6.00	534.66
5	37.117226	-78.340893	568.34	6.00	574.34
6	37.118862	-78.337876	577.99	6.00	583.99

Name: US-360 West

Path type: One-way (toward increasing index)

Observer view angle: 50.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	37.119091	-78.338061	573.83	6.00	579.83
2	37.116813	-78.342283	557.62	6.00	563.62
3	37.113964	-78.347530	514.83	6.00	520.83
4	37.112719	-78.349405	511.50	6.00	517.50
5	37.111871	-78.350537	519.96	6.00	525.96
6	37.110615	-78.351999	539.72	6.00	545.72

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (ft)	Height (ft)
OP 1	1	37.111604	-78.347560	569.94	6.00
OP 2	2	37.115242	-78.347154	524.00	6.00
OP 3	3	37.116093	-78.344721	557.37	6.00

Obstruction Components

Name: Fence 1
Top height: 6.0 ft



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	37.112800	-78.346035	568.54
2	37.114648	-78.343814	556.77
3	37.113861	-78.341550	554.00
4	37.114144	-78.341110	551.08
5	37.113656	-78.339995	576.29
6	37.111660	-78.341610	508.10
7	37.111330	-78.343030	529.42
8	37.111650	-78.343374	546.93
9	37.111893	-78.344114	569.30
10	37.112800	-78.346035	568.54

Name: Fence 2
Top height: 6.0 ft



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	37.110738	-78.345863	570.18
2	37.111483	-78.344930	552.70
3	37.110148	-78.342709	546.18
4	37.109985	-78.341786	525.07
5	37.109087	-78.341228	554.53
6	37.109292	-78.340391	576.42
7	37.108112	-78.340628	594.37
8	37.107701	-78.340048	591.60
9	37.107709	-78.339533	575.25
10	37.109290	-78.337310	544.79

Name: Fence 3
Top height: 6.0 ft



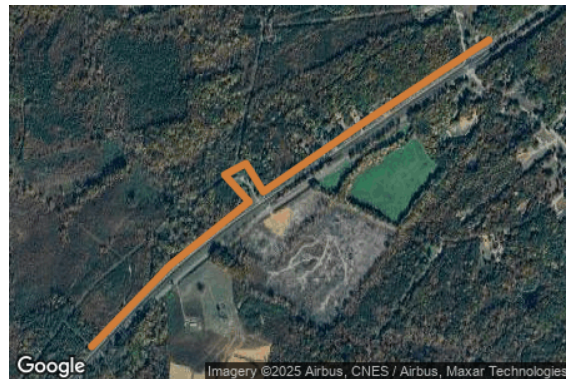
Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	37.109292	-78.337334	533.69
2	37.108557	-78.334598	547.06
3	37.107487	-78.334437	566.80
4	37.106648	-78.336100	593.94
5	37.105955	-78.338814	579.49
6	37.105861	-78.342612	607.01
7	37.106666	-78.347526	585.24
8	37.109232	-78.346131	591.26
9	37.110755	-78.345895	570.85

Name: Treeline 1
Top height: 32.8 ft



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	37.107544	-78.355235	599.65
2	37.111959	-78.349720	518.87
3	37.109666	-78.349634	564.99
4	37.107681	-78.349033	570.57
5	37.106603	-78.349634	582.19

Name: Treeline 2
Top height: 32.8 ft



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	37.110744	-78.352188	555.12
2	37.112969	-78.349484	515.23
3	37.114697	-78.346780	524.23
4	37.115433	-78.347617	521.73
5	37.115741	-78.346888	541.85
6	37.114971	-78.346287	538.01
7	37.116990	-78.342596	565.36
8	37.119111	-78.338540	589.01

Name: Treeline 3
Top height: 32.8 ft



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	37.115005	-78.343647	541.17
2	37.115980	-78.342682	540.39
3	37.116596	-78.341072	560.61
4	37.117161	-78.340815	569.37
5	37.118820	-78.337768	581.86

Name: Treeline 4
Top height: 32.8 ft



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	37.112498	-78.349173	517.78
2	37.113182	-78.348046	518.68
3	37.113003	-78.347993	524.99
4	37.112635	-78.347360	547.10
5	37.111968	-78.347301	571.39
6	37.111185	-78.346947	623.90
7	37.110937	-78.346045	588.69

Glare Analysis Results

Summary of Results Glare with low potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy kWh
	°	°	min	hr	min	hr	
PV array 1	SA tracking	SA tracking	0	0.0	0	0.0	4,050,000.0
PV array 2	SA tracking	SA tracking	119	2.0	0	0.0	7,135,000.0
PV array 3	SA tracking	SA tracking	0	0.0	0	0.0	1,336,000.0

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
US-360 East	0	0.0	0	0.0
US-360 West	0	0.0	0	0.0
OP 1	119	2.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0

PV: PV array 1 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
US-360 East	0	0.0	0	0.0
US-360 West	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0

PV array 1 and Route: US-360 East

No glare found

PV array 1 and Route: US-360 West

No glare found

PV array 1 and OP 1

No glare found

PV array 1 and OP 2

No glare found

PV array 1 and OP 3

No glare found

PV: PV array 2 low potential for temporary after-image

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
US-360 East	0	0.0	0	0.0
US-360 West	0	0.0	0	0.0
OP 1	119	2.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0

PV array 2 and Route: US-360 East

No glare found

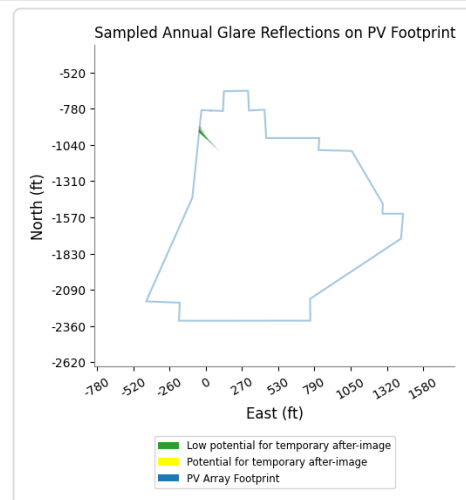
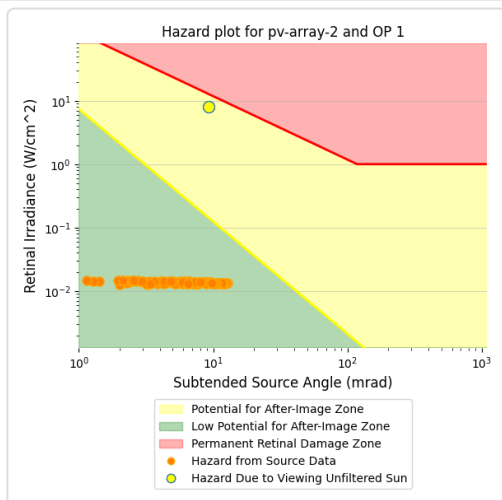
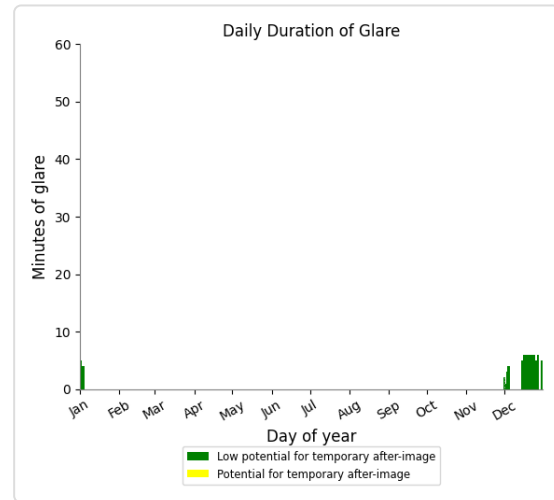
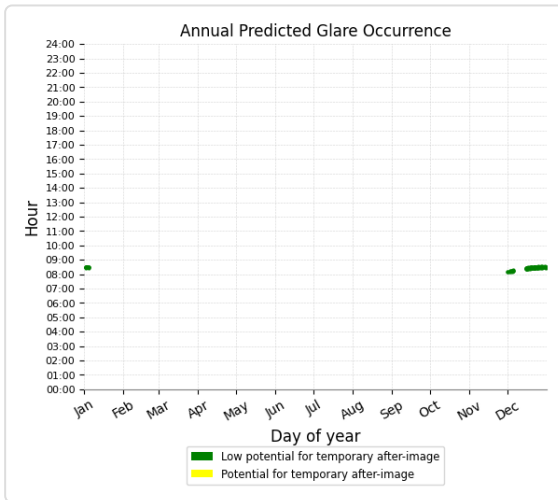
PV array 2 and Route: US-360 West

No glare found

PV array 2 and OP 1

Yellow glare: none

Green glare: 119 min.



PV array 2 and OP 2

No glare found

PV array 2 and OP 3

No glare found

PV: PV array 3 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
US-360 East	0	0.0	0	0.0
US-360 West	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0

PV array 3 and Route: US-360 East

No glare found

PV array 3 and Route: US-360 West

No glare found

PV array 3 and OP 1

No glare found

PV array 3 and OP 2

No glare found

PV array 3 and OP 3

No glare found

Assumptions

"Green" glare is glare with low potential to cause an after-image when observed prior to a typical blink response time.

"Yellow" glare is glare with potential to cause an after-image when observed prior to a typical blink response time.

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

The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.

Several V1 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. This primarily affects V1 analyses of path receptors.

Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.

The analysis does not automatically consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.

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.)

The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.

The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.

The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.

Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.

Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.

Refer to the Help page at www.forgesolar.com/help/ for assumptions and limitations not listed here.

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

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