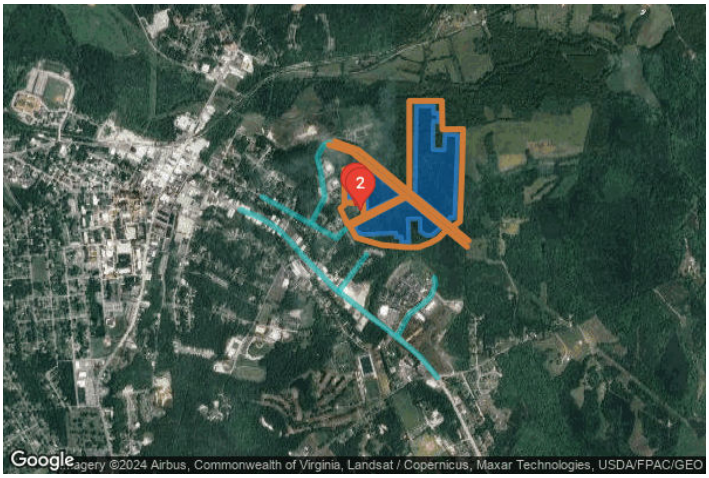
FORGESOLAR GLARE ANALYSIS

Project: **High Bridge Solar**
proposed 16.148MW DC and 12MW AC Fixed Tilt installation in Farmville, VA

Site configuration: **Ground Mount**

Created 26 Feb, 2024
Updated 28 Feb, 2024
Time-step 1 minute
Timezone offset UTC-5
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 10 MW to 100 MW
Site ID 113005.19489

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 No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy	Peak Luminance
	°	°	min	hr	min	hr	kWh	cd/m^2
PV Ground - Array 1	25.0	180.0	0	0.0	0	0.0	9,468,000.0	0
PV Ground - Array 2	25.0	180.0	0	0.0	0	0.0	9,467,000.0	0
PV Ground - Array 3	25.0	180.0	0	0.0	0	0.0	9,467,000.0	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
Dosewell Street	0	0.0	0	0.0
E 2nd Street	0	0.0	0	0.0
E 3rd Street	0	0.0	0	0.0
Hylawn Ave	0	0.0	0	0.0
Sunchase Blvd	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV Ground - Array 1
Axis tracking: Fixed (no rotation)
Tilt: 25.0°
Orientation: 180.0°
Rated power: 4000.0 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	37.304922	-78.371248	387.53	10.00	397.53
2	37.300092	-78.371484	380.70	10.00	390.70
3	37.300126	-78.371827	381.81	10.00	391.81
4	37.299802	-78.371870	358.04	10.00	368.04
5	37.301440	-78.374402	416.36	10.00	426.36
6	37.306629	-78.374295	386.87	10.00	396.87
7	37.306612	-78.373029	378.79	10.00	388.79
8	37.306185	-78.373029	396.49	10.00	406.49
9	37.306185	-78.372664	385.40	10.00	395.40
10	37.305673	-78.372664	397.89	10.00	407.89
11	37.305707	-78.373050	403.17	10.00	413.17
12	37.304069	-78.373072	407.56	10.00	417.56
13	37.304054	-78.372261	388.99	10.00	398.99
14	37.304967	-78.372202	393.31	10.00	403.31

Name: PV Ground - Array 2
Axis tracking: Fixed (no rotation)
Tilt: 25.0°
Orientation: 180.0°
Rated power: 4000.0 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	37.301405	-78.375269	403.68	10.00	413.68
2	37.302847	-78.377511	404.51	10.00	414.51
3	37.302783	-78.379362	392.98	10.00	402.98
4	37.301230	-78.379335	408.67	10.00	418.67
5	37.301238	-78.378729	414.18	10.00	424.18
6	37.301102	-78.378729	413.86	10.00	423.86
7	37.301098	-78.378241	416.80	10.00	426.80
8	37.301102	-78.378058	417.81	10.00	427.81
9	37.301098	-78.377940	418.39	10.00	428.39
10	37.300556	-78.377946	421.44	10.00	431.44
11	37.300556	-78.378107	420.47	10.00	430.47
12	37.300359	-78.378090	424.67	10.00	434.67

Name: PV Ground - Array 3
Axis tracking: Fixed (no rotation)
Tilt: 25.0°
Orientation: 180.0°
Rated power: 4000.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

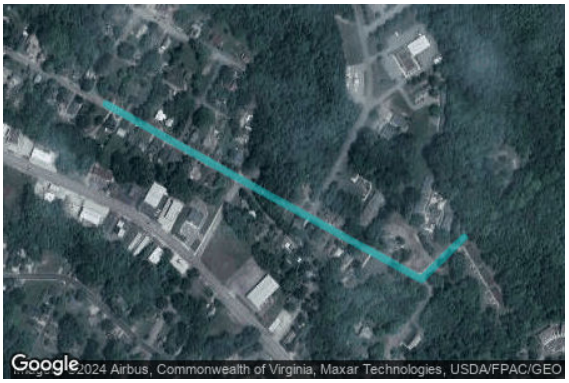
Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	37.301251	-78.375054	410.65	10.00	420.65
2	37.299741	-78.378761	425.33	10.00	435.33
3	37.299250	-78.378718	418.75	10.00	428.75
4	37.299250	-78.378466	422.92	10.00	432.92
5	37.299130	-78.378471	418.60	10.00	428.60
6	37.299220	-78.375778	420.41	10.00	430.41
7	37.298981	-78.375789	409.25	10.00	419.25
8	37.298990	-78.375403	411.87	10.00	421.87
9	37.298674	-78.375403	403.33	10.00	413.33
10	37.298682	-78.374824	392.86	10.00	402.86
11	37.300039	-78.374899	420.27	10.00	430.27
12	37.300056	-78.374030	412.52	10.00	422.52
13	37.299297	-78.374008	406.64	10.00	416.64
14	37.299083	-78.373568	390.10	10.00	400.10
15	37.299109	-78.373085	380.38	10.00	390.38
16	37.299596	-78.372463	356.94	10.00	366.94

Route Receptors

Name: Dosewell Street
Path type: Two-way
Observer view angle: 50.0°

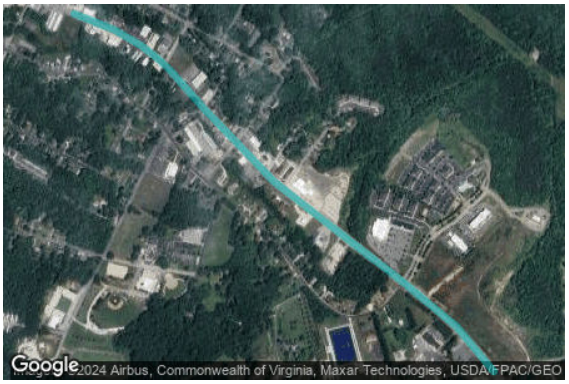
Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	37.299890	-78.381925	395.86	5.00	400.86
2	37.301306	-78.381002	368.66	5.00	373.66
3	37.302928	-78.381346	366.80	5.00	371.80
4	37.303636	-78.381549	354.52	5.00	359.52
5	37.304319	-78.381110	321.55	5.00	326.55
6	37.304464	-78.380702	312.60	5.00	317.60

Name: E 2nd Street
Path type: Two-way
Observer view angle: 50.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	37.299505	-78.379409	420.40	5.00	425.40
2	37.298929	-78.380144	415.71	5.00	420.71
3	37.300141	-78.382907	400.67	5.00	405.67
4	37.301323	-78.385562	360.01	5.00	365.01

Name: E 3rd Street
Path type: Two-way
Observer view angle: 50.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	37.290825	-78.372750	423.81	5.00	428.81
2	37.292054	-78.374038	428.89	5.00	433.89
3	37.293283	-78.375904	429.55	5.00	434.55
4	37.294786	-78.378351	421.35	5.00	426.35
5	37.296015	-78.380325	420.80	5.00	425.80
6	37.296766	-78.381226	418.12	5.00	423.12
7	37.297927	-78.382642	415.13	5.00	420.13
8	37.298951	-78.383779	383.96	5.00	388.96
9	37.299309	-78.384230	371.07	5.00	376.07
10	37.299685	-78.384831	357.61	5.00	362.61
11	37.300128	-78.385775	342.34	5.00	347.34
12	37.300572	-78.387170	326.89	5.00	331.89

Name: Hylawn Ave
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	37.295878	-78.379940	423.48	5.00	428.48
2	37.297952	-78.377955	391.93	5.00	396.93

Name: Sunchase Blvd
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	37.293309	-78.375616	428.74	5.00	433.74
2	37.294487	-78.374822	427.60	5.00	432.60
3	37.295110	-78.373803	416.99	5.00	421.99
4	37.295494	-78.373277	411.59	5.00	416.59
5	37.296203	-78.372880	407.29	5.00	412.29
6	37.296621	-78.372966	401.14	5.00	406.14

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (ft)	Height (ft)
OP 1	1	37.300735	-78.378692	414.07	20.00
OP 2	2	37.300474	-78.378370	421.62	20.00

Obstruction Components

Name: Obstruction 1
Top height: 35.0 ft

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	37.298428	-78.370579	368.69
2	37.303917	-78.379016	368.37
3	37.304352	-78.380695	324.08

Name: Obstruction 2
Top height: 35.0 ft

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	37.298781	-78.370471	377.68
2	37.304034	-78.378502	369.05
3	37.304546	-78.380240	315.26

Name: Obstruction 3
Top height: 35.0 ft

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	37.301383	-78.375159	404.25
2	37.299742	-78.379323	420.34

Name: Obstruction 4
Top height: 35.0 ft

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	37.301305	-78.375037	407.89
2	37.299610	-78.379143	422.52

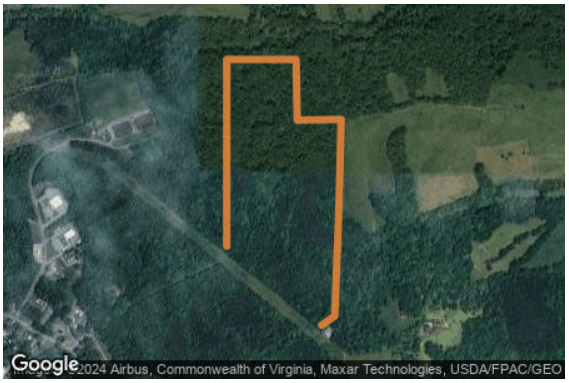
Name: Obstruction 5
Top height: 35.0 ft

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	37.299607	-78.379147	422.45
2	37.298957	-78.378702	409.57
3	37.298530	-78.376867	407.14
4	37.298393	-78.374968	388.33
5	37.298402	-78.374126	385.82
6	37.298649	-78.373284	388.58
7	37.298923	-78.372656	394.73
8	37.299324	-78.372168	353.49

Name: Obstruction 6
Top height: 35.0 ft

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	37.300372	-78.378163	424.10
2	37.300929	-78.378192	416.55
3	37.301005	-78.379571	405.92
4	37.302917	-78.379571	387.94
5	37.302959	-78.377768	404.67
6	37.302942	-78.377940	410.70

Name: Obstruction 7
Top height: 35.0 ft



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	37.299639	-78.371546	351.67
2	37.299895	-78.371095	367.06
3	37.302584	-78.370961	377.70
4	37.305264	-78.370870	384.18
5	37.305246	-78.372382	393.05
6	37.306900	-78.372423	368.21
7	37.306900	-78.374805	372.54
8	37.301805	-78.374805	415.47

Name: Obstruction 8
Top height: 35.0 ft

Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	37.299743	-78.379329	420.28
2	37.300652	-78.379874	401.41
3	37.300844	-78.379576	405.82
4	37.300995	-78.379573	405.92

Glare Analysis Results

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy	Peak Luminance
	°	°	min	hr	min	hr	kWh	cd/m^2
PV Ground - Array 1	25.0	180.0	0	0.0	0	0.0	9,468,000.0	0
PV Ground - Array 2	25.0	180.0	0	0.0	0	0.0	9,467,000.0	0
PV Ground - Array 3	25.0	180.0	0	0.0	0	0.0	9,467,000.0	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
Dosewell Street	0	0.0	0	0.0
E 2nd Street	0	0.0	0	0.0
E 3rd Street	0	0.0	0	0.0
Hylawn Ave	0	0.0	0	0.0
Sunchase Blvd	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0

PV: PV Ground - Array 1 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare		Peak Luminance
	min	hr	min	hr	cd/m^2
Dosewell Street	0	0.0	0	0.0	0
E 2nd Street	0	0.0	0	0.0	0
E 3rd Street	0	0.0	0	0.0	0
Hylawn Ave	0	0.0	0	0.0	0
Sunchase Blvd	0	0.0	0	0.0	0
OP 1	0	0.0	0	0.0	0
OP 2	0	0.0	0	0.0	0

PV Ground - Array 1 and Route: Dosewell Street

No glare found

PV Ground - Array 1 and Route: E 2nd Street

No glare found

PV Ground - Array 1 and Route: E 3rd Street

No glare found

PV Ground - Array 1 and Route: Hylawn Ave

No glare found

PV Ground - Array 1 and Route: Sunchase Blvd

No glare found

PV Ground - Array 1 and OP 1

No glare found

PV Ground - Array 1 and OP 2

No glare found

PV: PV Ground - Array 2 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare		Peak Luminance
	min	hr	min	hr	cd/m^2
Dosewell Street	0	0.0	0	0.0	0
E 2nd Street	0	0.0	0	0.0	0
E 3rd Street	0	0.0	0	0.0	0
Hylawn Ave	0	0.0	0	0.0	0
Sunchase Blvd	0	0.0	0	0.0	0
OP 1	0	0.0	0	0.0	0
OP 2	0	0.0	0	0.0	0

PV Ground - Array 2 and Route: Dosewell Street

No glare found

PV Ground - Array 2 and Route: E 2nd Street

No glare found

PV Ground - Array 2 and Route: E 3rd Street

No glare found

PV Ground - Array 2 and Route: Hylawn Ave

No glare found

PV Ground - Array 2 and Route: Sunchase Blvd

No glare found

PV Ground - Array 2 and OP 1

No glare found

PV Ground - Array 2 and OP 2

No glare found

PV: PV Ground - Array 3 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare		Peak Luminance
	min	hr	min	hr	cd/m^2
Dosewell Street	0	0.0	0	0.0	0
E 2nd Street	0	0.0	0	0.0	0
E 3rd Street	0	0.0	0	0.0	0
Hylawn Ave	0	0.0	0	0.0	0
Sunchase Blvd	0	0.0	0	0.0	0
OP 1	0	0.0	0	0.0	0
OP 2	0	0.0	0	0.0	0

PV Ground - Array 3 and Route: Dosewell Street

No glare found

PV Ground - Array 3 and Route: E 2nd Street

No glare found

PV Ground - Array 3 and Route: E 3rd Street

No glare found

PV Ground - Array 3 and Route: Hylawn Ave

No glare found

PV Ground - Array 3 and Route: Sunchase Blvd

No glare found

PV Ground - Array 3 and OP 1

No glare found

PV Ground - Array 3 and OP 2

No glare found

Assumptions

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