

FORGESOLAR GLARE ANALYSIS

Project: **Big Timber Solar Farm LLC**

Big Timber Solar Farm is a proposed solar facility located SE of the intersection of Big Timber Rd. & Rt.72 Gilberts, IL. The Approx. +/- 46 acre parcel is located in unincorporated Kane County, IL and is subject to County ordinance development standards for solar use. The project will be using single axis tracking systems that follow the positioning of the sun's location. The facility is to be connected to Commonwealth Edison Utility grid with the intention on supplying energy as a community solar project.

Site configuration: **Big Timber Solar Farm LLC**

Created 26 Aug, 2024
 Updated 26 Aug, 2024
 Time-step 1 minute
 Timezone offset UTC-8
 Minimum sun altitude 0.0 deg
 DNI peaks at 1,000.0 W/m²
 Category 1 MW to 5 MW
 Site ID 127701.21826

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 kWh
			min	hr	min	hr	
PV array 1	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 2	SA tracking	SA tracking	0	0.0	0	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
Big Timber Road	0	0.0	0	0.0
Illinois Route 72	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
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 9	0	0.0	0	0.0
OP 10	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array 1
Description: West of Badger Pipeline
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.3
Rated power: -
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	42.096070	-88.400901	904.85	10.00	914.85
2	42.096086	-88.395107	892.16	10.00	902.16
3	42.097809	-88.395145	890.89	10.00	900.89
4	42.098848	-88.396856	894.94	10.00	904.94
5	42.097383	-88.400134	903.53	10.00	913.53
6	42.097164	-88.401523	907.17	10.00	917.17

Name: PV array 2
Description: East of Badger Pipeline
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 60.0°
Resting angle: 0.0°
Ground Coverage Ratio: 0.3
Rated power: -
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	42.098967	-88.396496	894.19	10.00	904.19
2	42.099720	-88.394952	891.75	10.00	901.75
3	42.098908	-88.394120	889.80	10.00	899.80
4	42.098370	-88.394120	889.21	10.00	899.21
5	42.098358	-88.394715	890.31	10.00	900.31
6	42.098155	-88.394705	889.82	10.00	899.82
7	42.098064	-88.395000	890.39	10.00	900.39

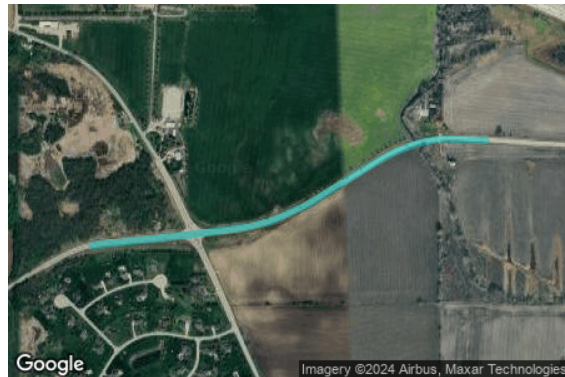
Route Receptors

Name: Big Timber Road
Path type: Two-way
Observer view angle: 50.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	42.101544	-88.405193	914.63	5.00	919.63
2	42.099140	-88.403101	916.13	5.00	921.13
3	42.096903	-88.401781	910.52	5.00	915.52
4	42.092795	-88.399400	900.20	5.00	905.20

Name: Illinois Route 72
Path type: Two-way
Observer view angle: 50.0°



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	42.097531	-88.405852	932.45	5.00	937.45
2	42.097809	-88.402430	911.22	5.00	916.22
3	42.098008	-88.400445	902.36	5.00	907.36
4	42.098151	-88.399705	894.95	5.00	899.95
5	42.098557	-88.398492	898.02	5.00	903.02
6	42.099616	-88.396196	895.68	5.00	900.68
7	42.099903	-88.395488	895.40	5.00	900.40
8	42.100150	-88.394619	895.13	5.00	900.13
9	42.100245	-88.393868	895.00	5.00	900.00
10	42.100205	-88.392345	894.17	5.00	899.17

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (ft)	Height (ft)
OP 1	1	42.096438	-88.402193	918.91	15.00
OP 2	2	42.095484	-88.401584	911.63	15.00
OP 3	3	42.095482	-88.402195	916.29	15.00
OP 4	4	42.095508	-88.402756	917.19	15.00
OP 5	5	42.096264	-88.403158	918.73	15.00
OP 6	6	42.097019	-88.403786	917.03	15.00
OP 7	7	42.095554	-88.403319	911.36	15.00
OP 8	8	42.096276	-88.404145	919.04	15.00
OP 9	9	42.096840	-88.404247	920.04	15.00
OP 10	10	42.095606	-88.404269	912.94	15.00
OP 11	11	42.094900	-88.401219	909.37	15.00
OP 12	12	42.093797	-88.400634	908.91	15.00
OP 13	13	42.094822	-88.401761	911.78	15.00
OP 14	14	42.094269	-88.401973	913.27	14.00
OP 15	15	42.093746	-88.401197	908.58	15.00
OP 16	16	42.092765	-88.400147	909.34	15.00
OP 17	17	42.092267	-88.399667	902.62	15.00
OP 18	18	42.093332	-88.401784	912.75	15.00
OP 19	19	42.092739	-88.401403	913.29	15.00
OP 20	20	42.093675	-88.402213	917.02	15.00
OP 21	21	42.094845	-88.402690	912.76	15.00
OP 22	22	42.094327	-88.402830	912.44	15.00
OP 23	23	42.099787	-88.402900	916.85	15.00
OP 24	24	42.089853	-88.395863	892.70	15.00
OP 25	25	42.096783	-88.404848	920.98	15.00
OP 26	26	42.092946	-88.400760	909.45	15.00
OP 27	27	42.092764	-88.402006	916.48	15.00

Obstruction Components

Name: Existing Vegetation East of Property Boundary
Top height: 15.0 ft



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	42.097847	-88.393876	887.78
2	42.096012	-88.393881	889.80

Name: Existing Vegetation NE
Top height: 15.0 ft



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	42.099951	-88.394552	885.92
2	42.099079	-88.393828	888.05

Name: Existing Vegetation South of Property Boundary
Top height: 15.0 ft



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	42.096013	-88.398878	898.67
2	42.096031	-88.397212	894.99

Name: Neighborhood Vegetation

Top height: 10.0 ft



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	42.095731	-88.401334	910.46
2	42.095497	-88.401176	908.97
3	42.095413	-88.401206	906.83

Name: Neighborhood Vegetation

Top height: 20.0 ft



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	42.096956	-88.402067	912.25
2	42.097213	-88.402222	911.15
3	42.097321	-88.402440	911.03
4	42.097350	-88.402955	912.01
5	42.097352	-88.404054	923.24

Name: Neighborhood Vegetation

Top height: 30.0 ft



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	42.095282	-88.401103	907.22
2	42.094478	-88.400596	907.92

Name: Proposed Vegetation Screening

Top height: 30.0 ft



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	42.095985	-88.401060	907.33
2	42.095991	-88.399732	901.72

Name: Proposed Vegetation Screening

Top height: 30.0 ft



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	42.097443	-88.401922	910.70
2	42.095986	-88.401063	906.80

Name: Proposed Vegetation Screening
Top height: 30.0 ft



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	42.097349	-88.401835	909.73
2	42.097559	-88.400440	905.15
3	42.098411	-88.398525	897.27

Name: Proposed Vegetation Screening
Top height: 30.0 ft



Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)
1	42.099102	-88.396645	894.38
2	42.099874	-88.394980	892.16
3	42.099948	-88.394572	887.17

Glare Analysis Results

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	SA tracking	SA tracking	0	0.0	0	0.0	-
PV array 2	SA tracking	SA tracking	0	0.0	0	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
Big Timber Road	0	0.0	0	0.0
Illinois Route 72	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
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0
OP 9	0	0.0	0	0.0
OP 10	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	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
Big Timber Road	0	0.0	0	0.0
Illinois Route 72	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
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0
OP 9	0	0.0	0	0.0
OP 10	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0

PV array 1 and Route: Big Timber Road

No glare found

PV array 1 and Route: Illinois Route 72

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 array 1 and OP 4

No glare found

PV array 1 and OP 5

No glare found

PV array 1 and OP 6

No glare found

PV array 1 and OP 7

No glare found

PV array 1 and OP 8

No glare found

PV array 1 and OP 9

No glare found

PV array 1 and OP 10

No glare found

PV array 1 and OP 11

No glare found

PV array 1 and OP 12

No glare found

PV array 1 and OP 13

No glare found

PV array 1 and OP 14

No glare found

PV array 1 and OP 15

No glare found

PV array 1 and OP 16

No glare found

PV array 1 and OP 17

No glare found

PV array 1 and OP 18

No glare found

PV array 1 and OP 19

No glare found

PV array 1 and OP 20

No glare found

PV array 1 and OP 21

No glare found

PV array 1 and OP 22

No glare found

PV array 1 and OP 23

No glare found

PV array 1 and OP 24

No glare found

PV array 1 and OP 25

No glare found

PV array 1 and OP 26

No glare found

PV array 1 and OP 27

No glare found

PV: PV array 2 no glare found

Receptor results ordered by category of glare

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Big Timber Road	0	0.0	0	0.0
Illinois Route 72	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
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
OP 7	0	0.0	0	0.0
OP 8	0	0.0	0	0.0
OP 9	0	0.0	0	0.0
OP 10	0	0.0	0	0.0
OP 11	0	0.0	0	0.0
OP 12	0	0.0	0	0.0
OP 13	0	0.0	0	0.0
OP 14	0	0.0	0	0.0
OP 15	0	0.0	0	0.0
OP 16	0	0.0	0	0.0
OP 17	0	0.0	0	0.0
OP 18	0	0.0	0	0.0
OP 19	0	0.0	0	0.0
OP 20	0	0.0	0	0.0
OP 21	0	0.0	0	0.0
OP 22	0	0.0	0	0.0
OP 23	0	0.0	0	0.0
OP 24	0	0.0	0	0.0
OP 25	0	0.0	0	0.0
OP 26	0	0.0	0	0.0
OP 27	0	0.0	0	0.0

PV array 2 and Route: Big Timber Road

No glare found

PV array 2 and Route: Illinois Route 72

No glare found

PV array 2 and OP 1

No glare found

PV array 2 and OP 2

No glare found

PV array 2 and OP 3

No glare found

PV array 2 and OP 4

No glare found

PV array 2 and OP 5

No glare found

PV array 2 and OP 6

No glare found

PV array 2 and OP 7

No glare found

PV array 2 and OP 8

No glare found

PV array 2 and OP 9

No glare found

PV array 2 and OP 10

No glare found

PV array 2 and OP 11

No glare found

PV array 2 and OP 12

No glare found

PV array 2 and OP 13

No glare found

PV array 2 and OP 14

No glare found

PV array 2 and OP 15

No glare found

PV array 2 and OP 16

No glare found

PV array 2 and OP 17

No glare found

PV array 2 and OP 18

No glare found

PV array 2 and OP 19

No glare found

PV array 2 and OP 20

No glare found

PV array 2 and OP 21

No glare found

PV array 2 and OP 22

No glare found

PV array 2 and OP 23

No glare found

PV array 2 and OP 24

No glare found

PV array 2 and OP 25

No glare found

PV array 2 and OP 26

No glare found

PV array 2 and OP 27

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

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