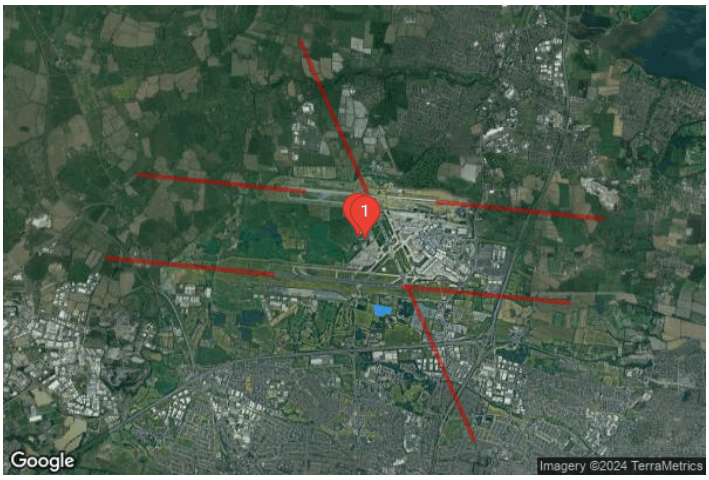
FORGESOLAR GLARE ANALYSIS

Project: **SGHAT**
Site configuration: **Site**

Created 26 Feb, 2024
Updated 27 Feb, 2024
Time-step 1 minute
Timezone offset UTC0
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Site ID 113038.9717

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



Glare Policy Adherence

The following table estimates the policy adherence of this glare analysis according to the **2021** U.S. Federal Aviation Administration Policy:

Review of Solar Energy System Projects on Federally-Obligated Airports

This policy may require the following criteria be met for solar energy systems on airport property:

- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics, including 1-minute time step.

ForgeSolar is not affiliated with the U.S. FAA and does not represent or speak officially for the U.S. FAA. ForgeSolar cannot approve or deny projects - results are informational only. Contact the relevant airport and FAA district office for information on policy and requirements.

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
ATCT(s)	PASS	Receptor(s) marked as ATCT do not receive glare

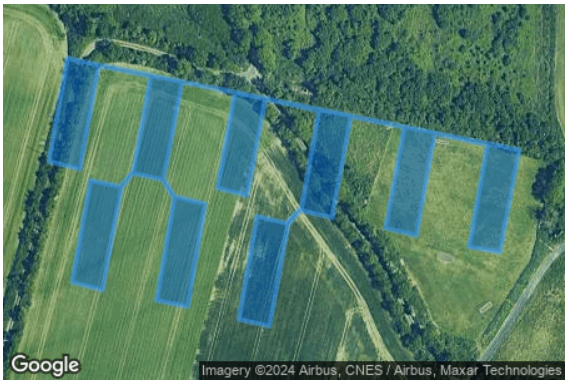
The referenced policy can be read at https://www.federalregister.gov/d/2021-09862

Component Data

This report includes results for PV arrays and Observation Point ("OP") receptors marked as ATCTs. Components that are not pertinent to the policy, such as routes, flight paths, and vertical surfaces, are excluded.

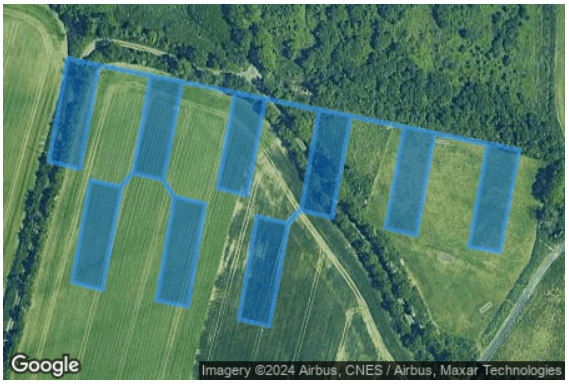
PV Arrays

Name: SE Facing
Axis tracking: Fixed (no rotation)
Tilt: 6.0°
Orientation: 100.0°
Rated power: -
Panel material: Light textured glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	53.416855	-6.259084	62.17	12.83	75.00
2	53.416388	-6.255200	61.84	13.16	75.00
3	53.415865	-6.255367	59.94	15.06	75.00
4	53.415893	-6.255633	59.86	15.14	75.00
5	53.416414	-6.255477	61.08	13.92	75.00
6	53.416469	-6.255928	61.19	13.81	75.00
7	53.415951	-6.256086	59.90	15.10	75.00
8	53.415989	-6.256352	60.44	14.56	75.00
9	53.416502	-6.256191	61.30	13.70	75.00
10	53.416558	-6.256648	61.33	13.67	75.00
11	53.416041	-6.256809	61.60	13.40	75.00
12	53.416079	-6.257080	60.67	14.33	75.00
13	53.416008	-6.257185	60.53	14.47	75.00
14	53.415489	-6.257347	60.73	14.27	75.00
15	53.415522	-6.257613	60.63	14.37	75.00
16	53.416050	-6.257456	60.75	14.25	75.00
17	53.416015	-6.257208	60.53	14.47	75.00
18	53.416092	-6.257074	60.71	14.29	75.00
19	53.416587	-6.256924	61.67	13.33	75.00
20	53.416646	-6.257382	62.70	12.30	75.00
21	53.416155	-6.257539	60.30	14.70	75.00
22	53.416193	-6.257796	60.50	14.50	75.00
23	53.416680	-6.257648	61.65	13.35	75.00
24	53.416733	-6.258096	61.20	13.80	75.00
25	53.416240	-6.258256	60.64	14.36	75.00
26	53.416151	-6.258165	60.82	14.18	75.00
27	53.416113	-6.257898	60.49	14.51	75.00
28	53.415588	-6.258049	60.65	14.35	75.00
29	53.415620	-6.258319	61.03	13.97	75.00
30	53.416138	-6.258169	60.84	14.16	75.00
31	53.416235	-6.258266	60.65	14.35	75.00
32	53.416268	-6.258521	61.35	13.65	75.00
33	53.416193	-6.258620	61.39	13.61	75.00
34	53.415672	-6.258782	61.51	13.49	75.00
35	53.415714	-6.259045	61.88	13.12	75.00
36	53.416233	-6.258887	61.72	13.28	75.00
37	53.416201	-6.258630	61.40	13.60	75.00
38	53.416282	-6.258517	61.37	13.63	75.00
39	53.416764	-6.258370	60.82	14.18	75.00
40	53.416816	-6.258813	61.94	13.06	75.00
41	53.416289	-6.258975	62.13	12.87	75.00
42	53.416329	-6.259244	63.81	11.19	75.00
43	53.416855	-6.259084	62.17	12.83	75.00

Name: SW Facing
Axis tracking: Fixed (no rotation)
Tilt: 6.0°
Orientation: 190.0°
Rated power: -
Panel material: Light textured glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



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6	53.416468	-6.255929	61.19	13.81	75.00
7	53.415951	-6.256086	59.90	15.10	75.00
8	53.415989	-6.256352	60.44	14.56	75.00
9	53.416502	-6.256190	61.30	13.70	75.00
10	53.416557	-6.256649	61.33	13.67	75.00
11	53.416041	-6.256809	61.60	13.40	75.00
12	53.416079	-6.257080	60.67	14.33	75.00
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33	53.416193	-6.258620	61.39	13.61	75.00
34	53.415672	-6.258782	61.51	13.49	75.00
35	53.415714	-6.259045	61.88	13.12	75.00
36	53.416233	-6.258887	61.72	13.28	75.00
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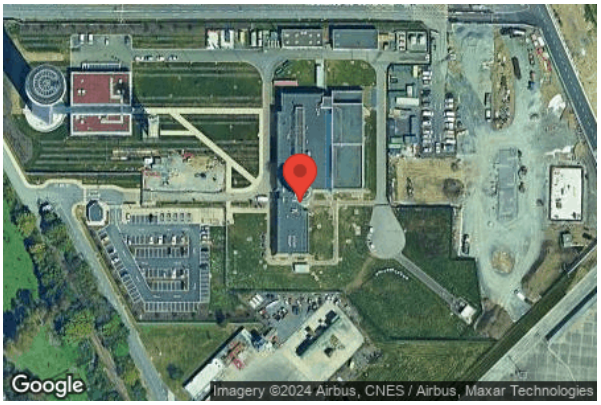
38	53.416282	-6.258517	61.37	13.63	75.00
39	53.416763	-6.258370	60.82	14.18	75.00
40	53.416816	-6.258812	61.94	13.06	75.00
41	53.416289	-6.258975	62.13	12.87	75.00
42	53.416329	-6.259244	63.81	11.19	75.00
43	53.416855	-6.259084	62.17	12.83	75.00

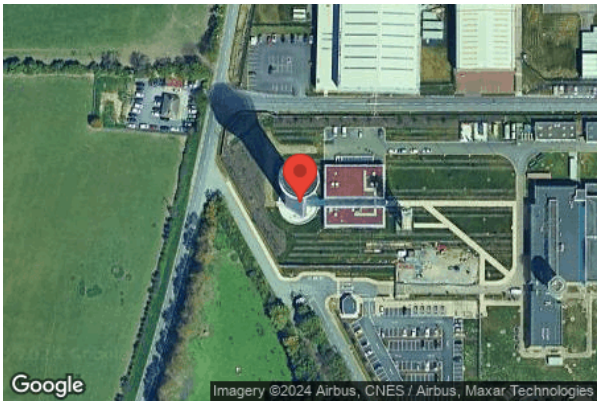
Observation Point ATCT Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	53.428489	-6.262201	65.90	21.90
2-ATCT	2	53.428937	-6.264259	65.60	75.60

Map image of 1-ATCT



Map image of 2-ATCT



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
SE Facing	6.0	100.0	0	0.0	0	0.0	-
SW Facing	6.0	190.0	0	0.0	0	0.0	-

Total annual 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
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0

PV: SE Facing

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0

SE Facing and 1-ATCT

Receptor type: ATCT Observation Point
No glare found

SE Facing and 2-ATCT

Receptor type: ATCT Observation Point
No glare found

PV: SW Facing

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
1-ATCT	0	0.0	0	0.0
2-ATCT	0	0.0	0	0.0

SW Facing and 1-ATCT

Receptor type: ATCT Observation Point
No glare found

SW Facing and 2-ATCT

Receptor type: ATCT Observation Point
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