FORGESOLAR GLARE ANALYSIS

Project: **BRINDISI_valutazione ENAC**

impianto agrivoltaico da 45,7 MWp superficie occupata 44 ha distanza minima da aeroporto 2 km distanza massima da aeroporto 3 km

Site configuration: **BRINDISI_rev0**

Client: SUN LEGACY 4 SRL

Created 18 Apr, 2024
Updated 18 Apr, 2024
Time-step 1 minute
Timezone offset UTC1
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
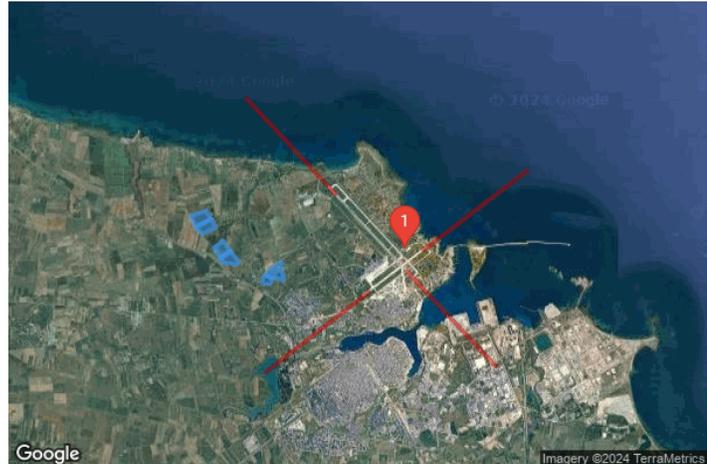**Site ID** 117130.20143

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: PV array 1
Description: lotto 1 del layout
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 55.0°
Resting angle: 10.0°
Ground Coverage Ratio: 0.4
Rated power: 710.0 kW
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	40.667142	17.886211	13.92	0.00	13.92
2	40.668916	17.890588	12.01	0.00	12.01
3	40.670714	17.889290	11.60	0.00	11.60
4	40.669567	17.884601	12.20	0.00	12.20

Name: PV array 2
Description: lotto 2 del layout
Axis tracking: Single-axis rotation
Backtracking: Shade-slope
Tracking axis orientation: 180.0°
Max tracking angle: 55.0°
Resting angle: 10.0°
Ground Coverage Ratio: 0.4
Rated power: 710.0 kW
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	40.667036	17.886329	13.80	0.00	13.80
2	40.666531	17.886801	13.58	0.00	13.58
3	40.665465	17.888131	13.72	0.00	13.72
4	40.666955	17.892090	12.13	0.00	12.13
5	40.668802	17.890792	12.25	0.00	12.25

Name: PV array 3

Description: lotto 3 del layout

Axis tracking: Single-axis rotation

Backtracking: Shade-slope

Tracking axis orientation: 180.0°

Max tracking angle: 55.0°

Resting angle: 10.0°

Ground Coverage Ratio: 0.4

Rated power: 710.0 kW

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	40.662479	17.891532	13.77	0.00	13.77
2	40.661233	17.892648	14.25	0.00	14.25
3	40.660086	17.893388	14.26	0.00	14.26
4	40.661697	17.896349	12.68	0.00	12.68
5	40.664049	17.894289	13.48	0.00	13.48

Name: PV array 4

Description: lotto 4 del layout

Axis tracking: Single-axis rotation

Backtracking: Shade-slope

Tracking axis orientation: 180.0°

Max tracking angle: 55.0°

Resting angle: 10.0°

Ground Coverage Ratio: 0.4

Rated power: 710.0 kW

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	40.661608	17.896414	13.00	0.00	13.00
2	40.659345	17.898924	14.54	0.00	14.54
3	40.658596	17.897658	14.61	0.00	14.61
4	40.658930	17.896585	14.41	0.00	14.41
5	40.658946	17.895051	13.97	0.00	13.97
6	40.659036	17.894343	14.11	0.00	14.11
7	40.659109	17.894107	14.25	0.00	14.25
8	40.660005	17.893463	14.13	0.00	14.13

Name: PV array 5

Description: lotto 5 del layout

Axis tracking: Single-axis rotation

Backtracking: Shade-slope

Tracking axis orientation: 180.0°

Max tracking angle: 55.0°

Resting angle: 10.0°

Ground Coverage Ratio: 0.4

Rated power: 710.0 kW

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	40.656318	17.906767	22.88	0.00	22.88
2	40.655723	17.905877	23.44	0.00	23.44
3	40.654698	17.905877	23.18	0.00	23.18
4	40.654527	17.905587	23.21	0.00	23.21
5	40.654389	17.907625	23.15	0.00	23.15
6	40.654429	17.908087	23.57	0.00	23.57
7	40.655618	17.908709	22.87	0.00	22.87
8	40.655756	17.908280	22.49	0.00	22.49

Name: PV array 6

Description: lotto 6 del layout

Axis tracking: Single-axis rotation

Backtracking: Shade-slope

Tracking axis orientation: 180.0°

Max tracking angle: 55.0°

Resting angle: 10.0°

Ground Coverage Ratio: 0.4

Rated power: 710.0 kW

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	40.656407	17.906917	23.33	0.00	23.33
2	40.658190	17.909170	19.49	0.00	19.49
3	40.659182	17.911445	16.90	0.00	16.90
4	40.658515	17.911584	17.32	0.00	17.32
5	40.658222	17.909707	18.53	0.00	18.53
6	40.657197	17.909900	19.85	0.00	19.85
7	40.657490	17.911595	18.81	0.00	18.81
8	40.655170	17.912121	22.78	0.00	22.78
9	40.655609	17.909599	23.06	0.00	23.06
10	40.656895	17.909278	19.97	0.00	19.97
11	40.656668	17.908730	21.08	0.00	21.08
12	40.655772	17.908430	22.60	0.00	22.60

Observation Point ATCT Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	40.662269	17.947830	5.90	15.00

Map image of 1-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
PV array 1	SA tracking	SA tracking	0	0.0	0	0.0	1,926,000.0
PV array 2	SA tracking	SA tracking	0	0.0	0	0.0	1,937,000.0
PV array 3	SA tracking	SA tracking	0	0.0	0	0.0	1,926,000.0
PV array 4	SA tracking	SA tracking	0	0.0	0	0.0	1,862,000.0
PV array 5	SA tracking	SA tracking	0	0.0	0	0.0	1,958,000.0
PV array 6	SA tracking	SA tracking	0	0.0	0	0.0	1,899,000.0

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

PV: PV array 1

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

PV array 1 and 1-ATCT

Receptor type: ATCT Observation Point
No glare found

PV: PV array 2

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

PV array 2 and 1-ATCT

Receptor type: ATCT Observation Point
No glare found

PV: PV array 3

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

PV array 3 and 1-ATCT

Receptor type: ATCT Observation Point
No glare found

PV: PV array 4

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

PV array 4 and 1-ATCT

Receptor type: ATCT Observation Point
No glare found

PV: PV array 5

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

PV array 5 and 1-ATCT

Receptor type: ATCT Observation Point
No glare found

PV: PV array 6

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

PV array 6 and 1-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