E | P | D SOLUTIONS, INC

WHERE EXPERIENCE AND PASSION MEET

Date:	February 23, 2024
Prepared by:	Abby Pal, Mark Polunin
To:	Norah Jaffan
Site:	North Coast Highway Solar Project
Subject:	PV Array Installation Glare Analysis

This technical memorandum evaluates the potential solar glare resulting from the installation of 2.8 megawatt-alternation current (MWac) photovoltaic power generating facility in Humboldt County. The Assessor's Parcel Numbers for the site are 204-081-002, 204-081-004, 204-081-007, and 204-171-047. Access to the site is provided by County Route 36. The solar glare analysis assesses the compatibility of the proposed solar panels as per the requirements of Rohnerville Airport. The analysis and findings of this memo are intended for review and acceptance by Humboldt County, Humboldt County Airport Land Use Commission (ALUC) and Rohnerville Airport.

Project Description

As mentioned above, the proposed solar power generating facility would be located along County Route 36 in Humboldt County. The location of the project with respect to Rohnerville Airport and County Route 36 are shown in *Attachment A*. The site plan of the proposed solar generating facility is shown in *Attachment B*. The solar power generating facility that encompasses the solar panel area assumes approximately 11.24 acres in area. The solar panel installation was assumed to be smooth glass with anti-reflective coating, fixed mounted at 5 feet above the ground with a resting angle of 75° and a maximum tracking angle of 65° with the panel array orientated at 180.0°. These configurations were noted to result in maximum power.

Solar Glare Analysis Tools and Methodology

The potential impact of glint and glare from photovoltaic modules, concentrating solar collectors, receivers, and other components has received increased attention as a potential hazard or distraction for pilots, air-traffic control, and other airport personnel. Hazards from reflected solar radiation include the potential for permanent eye injury (e.g., retinal burn from concentrated sunlight) and temporary disability or distractions (e.g., glint, glare, after-images). The Federal Aviation Administration (FAA) requires the sponsor of proposed construction or alteration to confirm that the potential for glint and glare has been analyzed and determined to have no potential for ocular impacts to the airport's Air Traffic Control Tower (ATCT) cab[1].

Sandia National Laboratories (National Technology and Engineering Solutions of Sandia, LLC.) developed early Solar Glare Hazard Analysis Tools (SGHAT) which included programs for modeling and analyzing potential hazards from solar glare. These tools and programs had been adopted as a standard for FAA and other airport/user reviews. Due to new cybersecurity restrictions at Sandia, SGHAT is now available for internal Sandia use only. All external use of SGHAT is restricted, however the glare tool source code and algorithms were made available for licensing. The FAA policy to demonstrate compliance with *14 CFR 77.5 (c)*[2] updated on May 11, 2021 withdrew their recommendation of the Solar Glare Hazard Analysis Tool (SGHAT) to analyze ocular impact as the tool is no longer available to all users at no cost. However, EPD Solutions obtained the use of the ForgeSolar Glare Analysis tool which utilizes the SGHAT glare tool source

[1] Federal Register. Referenced at https://www.federalregister.gov/documents/2021/05/11/2021-09862/federal-aviation-administration-policy-review-of-solar-energy-system-projects-on-federally-obligated

[2] Code of Federal Regulations. Referenced at https://www.ecfr.gov/current/title-14/chapter-I/subchapter-E/part-77/subpart-B/section-77.5#p-77.5(c)

code and algorithms under subscription made available by Sims Industries (d/b/a ForgeSolar) which offers comparable tools for FAA-certifiable glare analysis.

This solar glare analysis memo incorporates the following:

1) Potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATCT) cab. It is to be noted that there is no ATCT at Rohnerville Airport.

2) Potential for glare or "low potential for after-image" along the final approach path for any existing landing threshold or future landing thresholds. The final approach path is defined as 2 miles from 50 feet above the landing threshold using a standard 3˚ glidepath.

3) Ocular impact analyzed over the entire calendar year in one-minute intervals from when the sun rises above the horizon until the sun sets below the horizon.

Findings

The light reflected from the surface of solar panels can result in glint (a momentary flash of bright light) and glare (a continuous source of bright light). These two effects can cause a brief loss of vision which can hamper the safe maneuvering of the aircraft while in flight. Ocular impacts from solar glare can result in green glare or yellow glare. Green glare can be defined as glare with low potential to cause after image or flash blindness for a few seconds which would not hamper safe aircraft maneuvering. Yellow glare can be defined as glare with potential to cause temporary after-image lasting more than a few seconds that might hamper safe aircraft maneuvering. Yellow glare is not acceptable as per glare hazard model criteria and would require mitigation to reduce ocular impact to green glare or better.

As per the solar glare analysis conducted, the proposed solar power generating faciality would result in green glare as shown in Table 1 below. No yellow glare is predicted. Therefore, the proposed solar power facility would pass the glare hazard model criteria, with zero minutes per year outside the 'green zone' of acceptable reflected solar energy. The glare analysis results for all flight paths are presented in *Attachment* C.

The maximum amount of resting angle before yellow glare is produced was tested in ForgeSolar. Do not set panels under 17˚ resting angle. Resting angles below 17˚ were noted to produce yellow glare. Configuration resulting in yellow glare is also presented in Attachment C for reference.

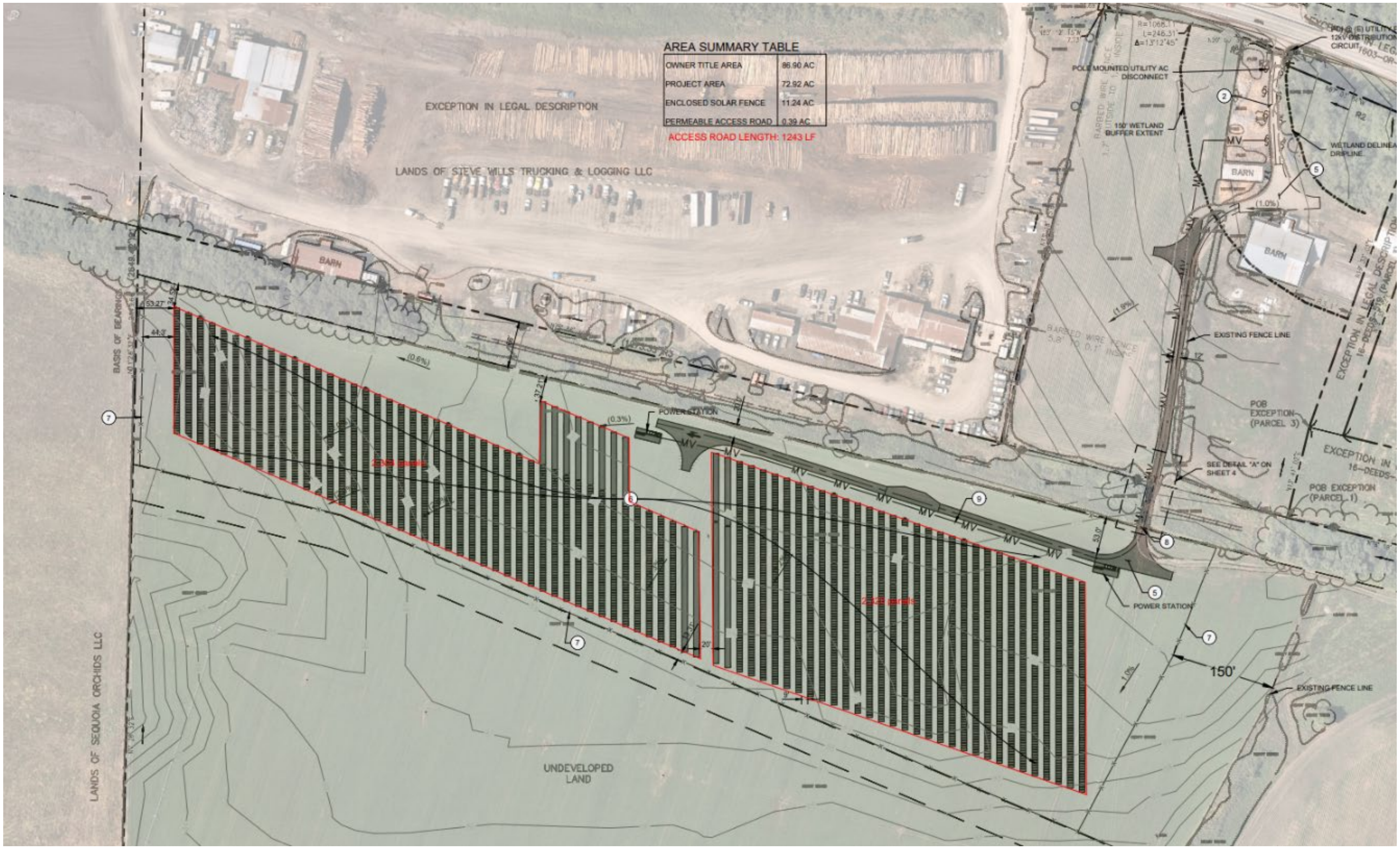
Table 1: Glare Minutes per Year

Analysis Component	Green Glare (min)	Yellow Glare (min)	Pass?
1. Runway 11 Final	0	0	**Yes**
2. Runway 29 Final	25,955	0	**Yes**

If you have any questions about this information, please contact me at (412) 636-2713 or abby@epdsolutions.com.

Attachment A: Solar Power Facility Location

Attachment B: Project Site Plan



Attachment C: North Coast PV Facility Solar Glare Analysis Results

FORGESOLAR GLARE ANALYSIS

Project: **Rohnerville Airport**

Solar array near Rohnerville Airport, Humboldt County

Site configuration: **North Coast Solar PV_75_65**

Created 04 Apr, 2023
Updated 22 Feb, 2024
Time-step 1 minute
Timezone offset UTC-7
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 1 MW to 5 MW
Site ID 99113.15476

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
	°	°	min	hr	min	hr	kWh
North Coast Hwy PV	SA tracking	SA tracking	25,955	432.6	0	0.0	1,986.0

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
Rwy 11 - Final	0	0.0	0	0.0
Rwy 29 - Final	25,955	432.6	0	0.0

Component Data

PV Arrays

Name: North Coast Hwy PV
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 180.0°
Max tracking angle: 65.0°
Resting angle: 75.0°
Ground Coverage Ratio: 0.468
Rated power: 0.585 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	40.543920	-124.116250	90.90	5.00	95.90
2	40.543110	-124.116220	88.30	5.00	93.30
3	40.544420	-124.120970	84.90	5.00	89.90
4	40.544920	-124.121000	86.80	5.00	91.80
5	40.544360	-124.119110	90.30	5.00	95.30
6	40.544583	-124.119080	107.68	5.00	112.68
7	40.544440	-124.118640	106.00	5.00	111.00
8	40.544390	-124.118190	91.80	5.00	96.80

Flight Path Receptors

Name: Rwy 11 - Final
Description:
Threshold height: 50 ft
Direction: 127.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	40.557143	-124.138160	340.50	50.00	390.50
Two-mile	40.574543	-124.168588	340.50	603.43	943.93

Name: Rwy 29 - Final
Description:
Threshold height: 50 ft
Direction: 307.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	40.550769	-124.127265	392.70	50.00	442.70
Two-mile	40.533368	-124.096841	392.70	603.43	996.13

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
	°	°	min	hr	min	hr	kWh
North Coast Hwy PV	SA tracking	SA tracking	25,955	432.6	0	0.0	1,986.0

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
Rwy 11 - Final	0	0.0	0	0.0
Rwy 29 - Final	25,955	432.6	0	0.0

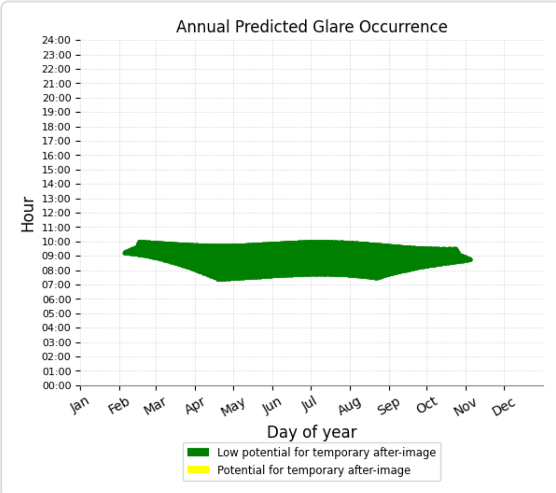
PV: North Coast Hwy PV low potential for temporary after-image

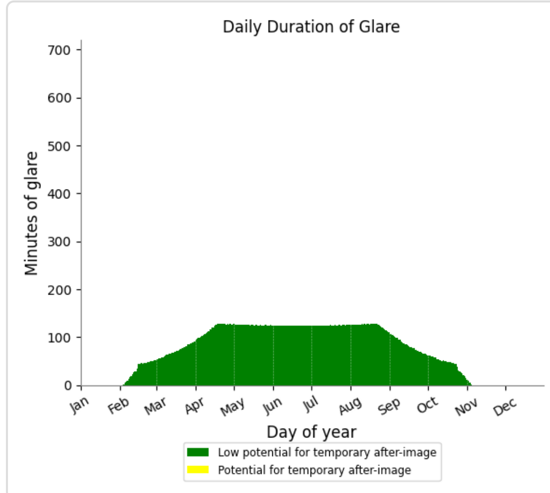
Receptor results ordered by category of glare

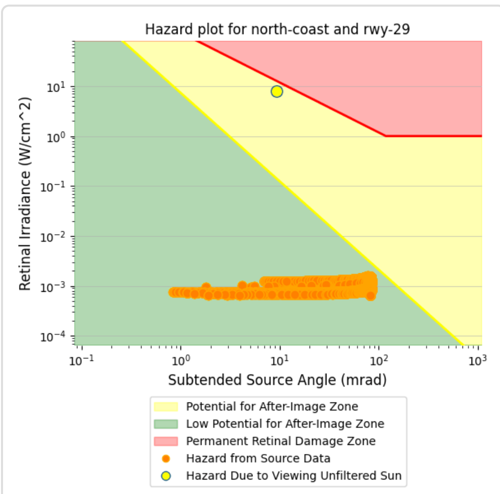
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Rwy 29 - Final	25,955	432.6	0	0.0
Rwy 11 - Final	0	0.0	0	0.0

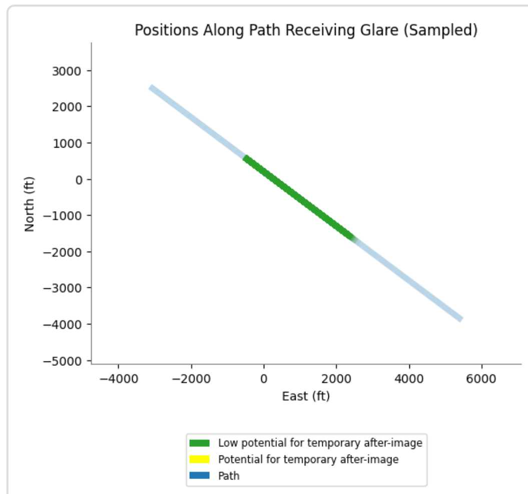
North Coast Hwy PV and FP: Rwy 29 - Final

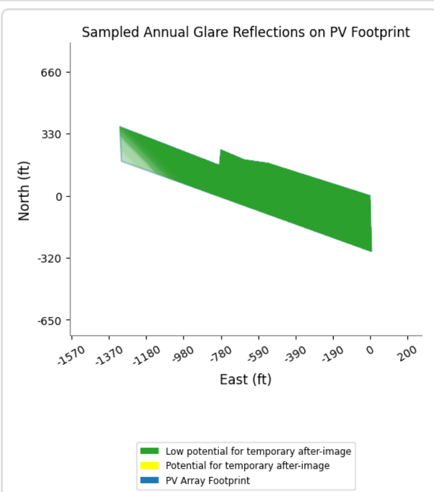
Yellow glare: none
Green glare: 25,955 min.

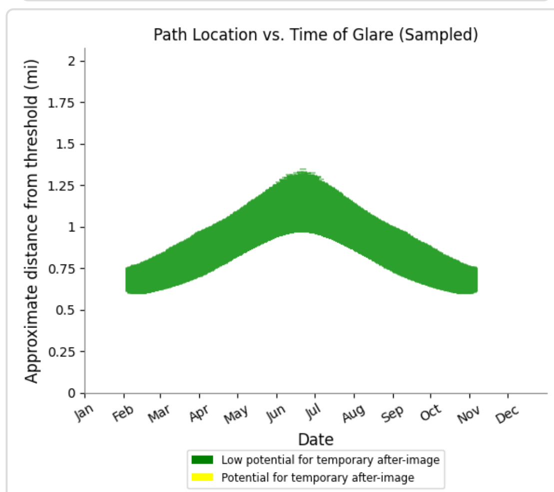












North Coast Hwy PV and FP: Rwy 11 - Final

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

FORGESOLAR GLARE ANALYSIS

Project: **Rohnerville Airport**

Solar array near Rohnerville Airport, Humboldt County

Site configuration: **North Coast Solar PV_75_65**

Created 04 Apr, 2023
Updated 22 Feb, 2024
Time-step 1 minute
Timezone offset UTC-7
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Site ID 99113.15476

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)	N/A	No ATCT receptors assessed

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: North Coast Hwy PV
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 180.0°
Max tracking angle: 65.0°
Resting angle: 75.0°
Ground Coverage Ratio: 0.468
Rated power: 0.585 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	40.543920	-124.116250	90.90	5.00	95.90
2	40.543110	-124.116220	88.30	5.00	93.30
3	40.544420	-124.120970	84.90	5.00	89.90
4	40.544920	-124.121000	86.80	5.00	91.80
5	40.544360	-124.119110	90.30	5.00	95.30
6	40.544583	-124.119080	107.68	5.00	112.68
7	40.544440	-124.118640	106.00	5.00	111.00
8	40.544390	-124.118190	91.80	5.00	96.80

Observation Point ATCT Receptors

No ATCT receptors were included in the analysis.

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
North Coast Hwy PV	SA tracking	SA tracking	0	0.0	0	0.0	1,986.0

No ATCT receptors were included in the analysis.

PV: North Coast Hwy PV

No ATCT receptors assessed.

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

FORGESOLAR GLARE ANALYSIS

Project: **Rohnerville Airport**

Solar array near Rohnerville Airport, Humboldt County

Site configuration: **North Coast Solar PV_75_65**

Analysis conducted by Abby Pal (abby@epdsolutions.com) at 23:34 on 22 Feb, 2024.

U.S. FAA 2013 Policy Adherence

The following table summarizes the policy adherence of the glare analysis based on the 2013 U.S. Federal Aviation Administration Interim Policy 78 FR 63276. This policy requires the following criteria be met for solar energy systems on airport property:

- No "yellow" glare (potential for after-image) for any flight path from threshold to 2 miles
- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics (see list below)

ForgeSolar does not represent or speak officially for the FAA and cannot approve or deny projects. Results are informational only.

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
2-mile flight path(s)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	N/A	No ATCT receptors designated

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

FAA Policy 78 FR 63276 can be read at https://www.federalregister.gov/d/2013-24729

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 99113.15476
Methodology: V2

PV Array(s)

Name: North Coast Hwy PV
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 180.0°
Max tracking angle: 65.0°
Resting angle: 75.0°
Ground Coverage Ratio: 0.468
Rated power: 0.585 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	40.543920	-124.116250	90.90	5.00	95.90
2	40.543110	-124.116220	88.30	5.00	93.30
3	40.544420	-124.120970	84.90	5.00	89.90
4	40.544920	-124.121000	86.80	5.00	91.80
5	40.544360	-124.119110	90.30	5.00	95.30
6	40.544583	-124.119080	107.68	5.00	112.68
7	40.544440	-124.118640	106.00	5.00	111.00
8	40.544390	-124.118190	91.80	5.00	96.80

Flight Path Receptor(s)

Name: Rwy 11 - Final
Description:
Threshold height: 50 ft
Direction: 127.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	40.557143	-124.138160	340.50	50.00	390.50
Two-mile	40.574543	-124.168588	340.50	603.43	943.93

Name: Rwy 29 - Final
Description:
Threshold height: 50 ft
Direction: 307.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	40.550769	-124.127265	392.70	50.00	442.70
Two-mile	40.533368	-124.096841	392.70	603.43	996.13

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
North Coast Hwy PV	SA tracking	SA tracking	25,955	0	1,986.0

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
Rwy 11 - Final	0	0
Rwy 29 - Final	25955	0

Results for: North Coast Hwy PV

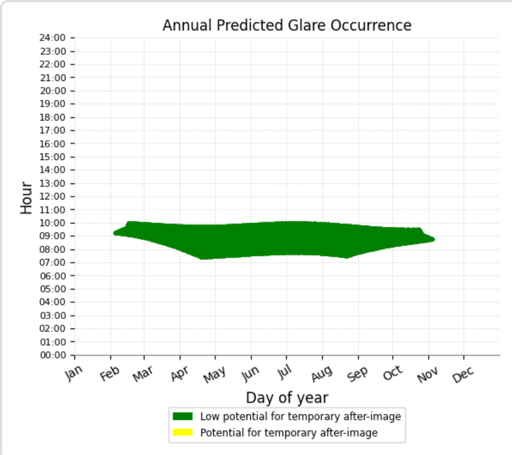
Receptor	Green Glare (min)	Yellow Glare (min)
Rwy 11 - Final	0	0
Rwy 29 - Final	25955	0

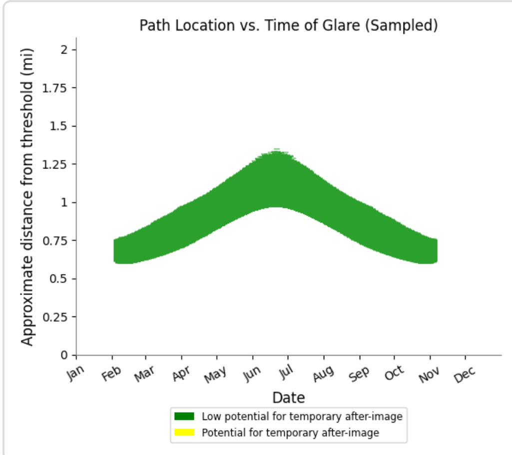
Flight Path: Rwy 11 - Final

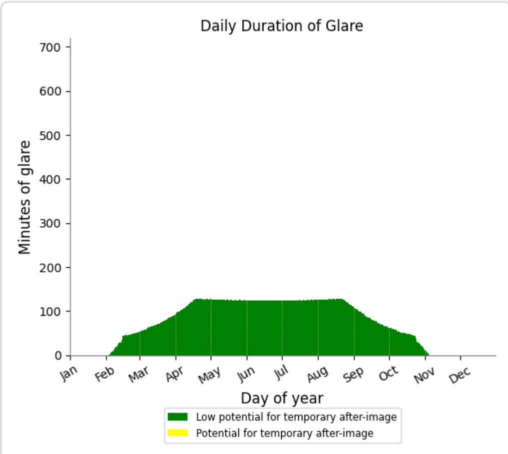
0 minutes of yellow glare
0 minutes of green glare

Flight Path: Rwy 29 - Final

0 minutes of yellow glare
25955 minutes of green glare







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.
Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to V1 algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
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.)
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual results and glare occurrence may differ.
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.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

17 degrees resting angle resulting in green glare. Resting angles below 17 degrees will cause yellow glare.

FORGESOLAR GLARE ANALYSIS

Project: **Rohnerville Airport**

Solar array near Rohnerville Airport, Humboldt County

Site configuration: **North Coast Solar PV_17_65**

Created 04 Apr, 2023
Updated 23 Feb, 2024
Time-step 1 minute
Timezone offset UTC-7
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 1 MW to 5 MW
Site ID 99113.15476

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
	°	°	min	hr	min	hr	kWh
North Coast Hwy PV	SA tracking	SA tracking	18,257	304.3	0	0.0	1,787.0

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
Rwy 11 - Final	0	0.0	0	0.0
Rwy 29 - Final	18,257	304.3	0	0.0

Component Data

PV Arrays

Name: North Coast Hwy PV
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 180.0°
Max tracking angle: 65.0°
Resting angle: 17.0°
Ground Coverage Ratio: 0.468
Rated power: 0.585 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	40.543920	-124.116250	90.90	5.00	95.90
2	40.543110	-124.116220	88.30	5.00	93.30
3	40.544420	-124.120970	84.90	5.00	89.90
4	40.544920	-124.121000	86.80	5.00	91.80
5	40.544360	-124.119110	90.30	5.00	95.30
6	40.544583	-124.119080	107.68	5.00	112.68
7	40.544440	-124.118640	106.00	5.00	111.00
8	40.544390	-124.118190	91.80	5.00	96.80

Flight Path Receptors

Name: Rwy 11 - Final
Description:
Threshold height: 50 ft
Direction: 127.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	40.557143	-124.138160	340.50	50.00	390.50
Two-mile	40.574543	-124.168588	340.50	603.43	943.93

Name: Rwy 29 - Final
Description:
Threshold height: 50 ft
Direction: 307.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	40.550769	-124.127265	392.70	50.00	442.70
Two-mile	40.533368	-124.096841	392.70	603.43	996.13

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
	°	°	min	hr	min	hr	kWh
North Coast Hwy PV	SA tracking	SA tracking	18,257	304.3	0	0.0	1,787.0

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
Rwy 11 - Final	0	0.0	0	0.0
Rwy 29 - Final	18,257	304.3	0	0.0

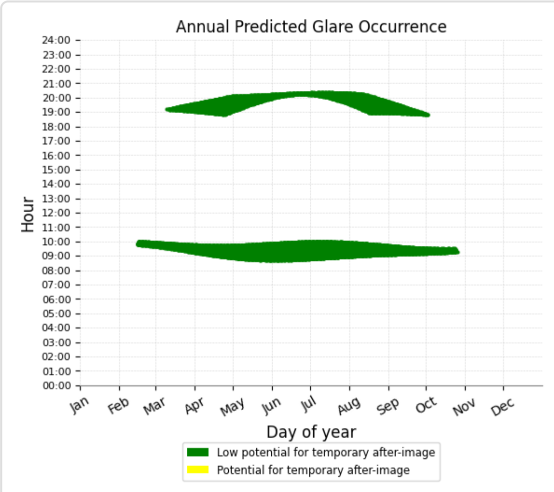
PV: North Coast Hwy PV low potential for temporary after-image

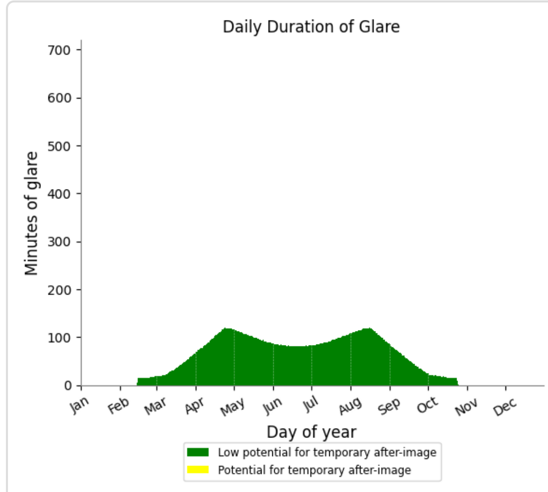
Receptor results ordered by category of glare

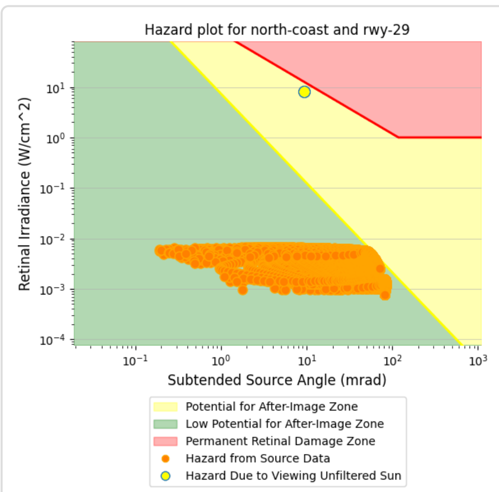
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Rwy 29 - Final	18,257	304.3	0	0.0
Rwy 11 - Final	0	0.0	0	0.0

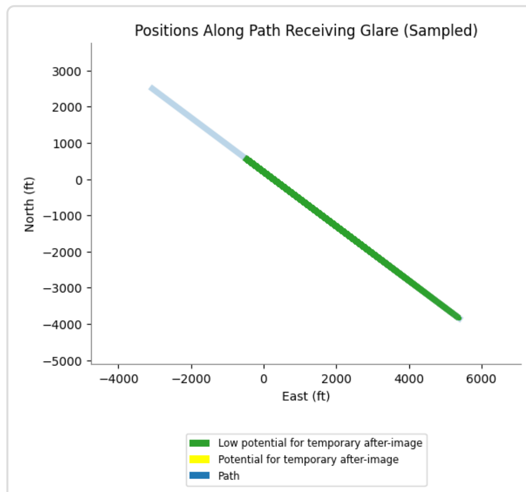
North Coast Hwy PV and FP: Rwy 29 - Final

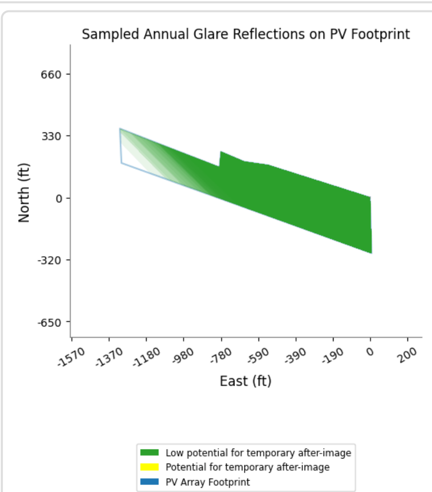
Yellow glare: none
Green glare: 18,257 min.

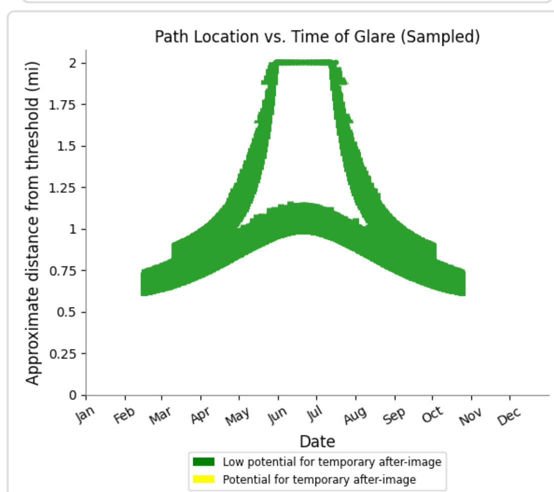












North Coast Hwy PV and FP: Rwy 11 - Final

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

FORGESOLAR GLARE ANALYSIS

Project: **Rohnerville Airport**

Solar array near Rohnerville Airport, Humboldt County

Site configuration: **North Coast Solar PV_17_65**

Created 04 Apr, 2023
Updated 23 Feb, 2024
Time-step 1 minute
Timezone offset UTC-7
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Site ID 99113.15476

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)	N/A	No ATCT receptors assessed

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: North Coast Hwy PV
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 180.0°
Max tracking angle: 65.0°
Resting angle: 17.0°
Ground Coverage Ratio: 0.468
Rated power: 0.585 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	40.543920	-124.116250	90.90	5.00	95.90
2	40.543110	-124.116220	88.30	5.00	93.30
3	40.544420	-124.120970	84.90	5.00	89.90
4	40.544920	-124.121000	86.80	5.00	91.80
5	40.544360	-124.119110	90.30	5.00	95.30
6	40.544583	-124.119080	107.68	5.00	112.68
7	40.544440	-124.118640	106.00	5.00	111.00
8	40.544390	-124.118190	91.80	5.00	96.80

Observation Point ATCT Receptors

No ATCT receptors were included in the analysis.

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
North Coast Hwy PV	SA tracking	SA tracking	0	0.0	0	0.0	1,787.0

No ATCT receptors were included in the analysis.

PV: North Coast Hwy PV

No ATCT receptors assessed.

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

FORGESOLAR GLARE ANALYSIS

Project: **Rohnerville Airport**

Solar array near Rohnerville Airport, Humboldt County

Site configuration: **North Coast Solar PV_17_65**

Analysis conducted by Abby Pal (abby@epdsolutions.com) at 00:06 on 23 Feb, 2024.

U.S. FAA 2013 Policy Adherence

The following table summarizes the policy adherence of the glare analysis based on the 2013 U.S. Federal Aviation Administration Interim Policy 78 FR 63276. This policy requires the following criteria be met for solar energy systems on airport property:

- No "yellow" glare (potential for after-image) for any flight path from threshold to 2 miles
- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics (see list below)

ForgeSolar does not represent or speak officially for the FAA and cannot approve or deny projects. Results are informational only.

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
2-mile flight path(s)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	N/A	No ATCT receptors designated

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

FAA Policy 78 FR 63276 can be read at https://www.federalregister.gov/d/2013-24729

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 99113.15476
Methodology: V2

PV Array(s)

Name: North Coast Hwy PV
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 180.0°
Max tracking angle: 65.0°
Resting angle: 17.0°
Ground Coverage Ratio: 0.468
Rated power: 0.585 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	40.543920	-124.116250	90.90	5.00	95.90
2	40.543110	-124.116220	88.30	5.00	93.30
3	40.544420	-124.120970	84.90	5.00	89.90
4	40.544920	-124.121000	86.80	5.00	91.80
5	40.544360	-124.119110	90.30	5.00	95.30
6	40.544583	-124.119080	107.68	5.00	112.68
7	40.544440	-124.118640	106.00	5.00	111.00
8	40.544390	-124.118190	91.80	5.00	96.80

Flight Path Receptor(s)

Name: Rwy 11 - Final
Description:
Threshold height: 50 ft
Direction: 127.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	40.557143	-124.138160	340.50	50.00	390.50
Two-mile	40.574543	-124.168588	340.50	603.43	943.93

Name: Rwy 29 - Final
Description:
Threshold height: 50 ft
Direction: 307.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	40.550769	-124.127265	392.70	50.00	442.70
Two-mile	40.533368	-124.096841	392.70	603.43	996.13

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
North Coast Hwy PV	SA tracking	SA tracking	18,257	0	1,787.0

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
Rwy 11 - Final	0	0
Rwy 29 - Final	18257	0

Results for: North Coast Hwy PV

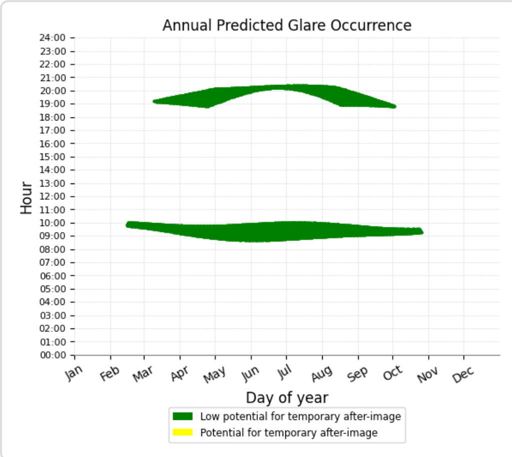
Receptor	Green Glare (min)	Yellow Glare (min)
Rwy 11 - Final	0	0
Rwy 29 - Final	18257	0

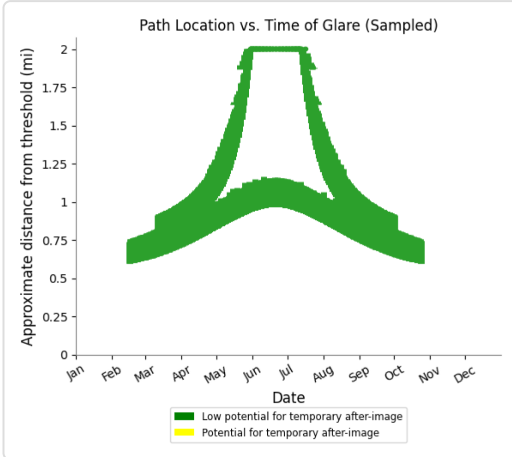
Flight Path: Rwy 11 - Final

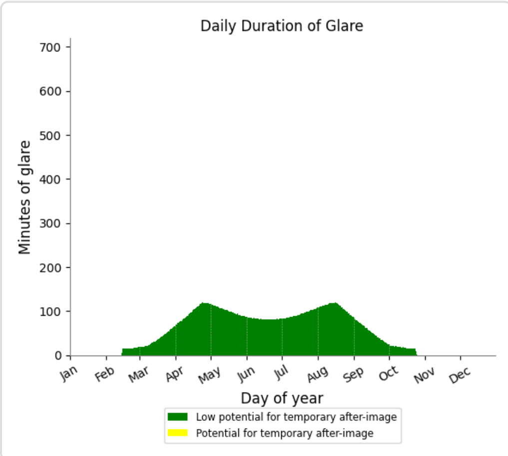
0 minutes of yellow glare
0 minutes of green glare

Flight Path: Rwy 29 - Final

0 minutes of yellow glare
18257 minutes of green glare







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.
Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to V1 algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
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.)
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual results and glare occurrence may differ.
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.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

15 degrees resting angle resulting in yellow glare

FORGESOLAR GLARE ANALYSIS

Project: **Rohnerville Airport**
Solar array near Rohnerville Airport, Humboldt County

Site configuration: **North Coast Solar PV_15_65**

Created 04 Apr, 2023
Updated 23 Feb, 2024
Time-step 1 minute
Timezone offset UTC-7
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 1 MW to 5 MW
Site ID 99113.15476

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 potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
North Coast Hwy PV	SA tracking	SA tracking	22,286	371.4	288	4.8	1,780.0

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
Rwy 11 - Final	0	0.0	0	0.0
Rwy 29 - Final	22,286	371.4	288	4.8

Component Data

PV Arrays

Name: North Coast Hwy PV
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 180.0°
Max tracking angle: 65.0°
Resting angle: 15.0°
Ground Coverage Ratio: 0.468
Rated power: 0.585 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	40.543920	-124.116250	90.90	5.00	95.90
2	40.543110	-124.116220	88.30	5.00	93.30
3	40.544420	-124.120970	84.90	5.00	89.90
4	40.544920	-124.121000	86.80	5.00	91.80
5	40.544360	-124.119110	90.30	5.00	95.30
6	40.544583	-124.119080	107.68	5.00	112.68
7	40.544440	-124.118640	106.00	5.00	111.00
8	40.544390	-124.118190	91.80	5.00	96.80

Flight Path Receptors

Name: Rwy 11 - Final
Description:
Threshold height: 50 ft
Direction: 127.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	40.557143	-124.138160	340.50	50.00	390.50
Two-mile	40.574543	-124.168588	340.50	603.43	943.93

Name: Rwy 29 - Final
Description:
Threshold height: 50 ft
Direction: 307.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	40.550769	-124.127265	392.70	50.00	442.70
Two-mile	40.533368	-124.096841	392.70	603.43	996.13

Glare Analysis Results

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

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
North Coast Hwy PV	SA tracking	SA tracking	22,286	371.4	288	4.8	1,780.0

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
Rwy 11 - Final	0	0.0	0	0.0
Rwy 29 - Final	22,286	371.4	288	4.8

PV: North Coast Hwy PV potential temporary after-image

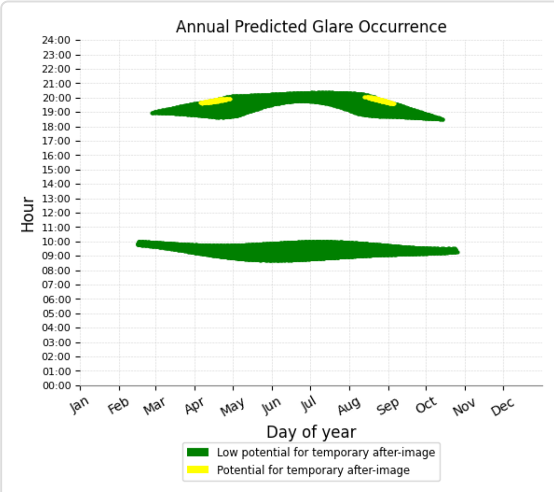
Receptor results ordered by category of glare

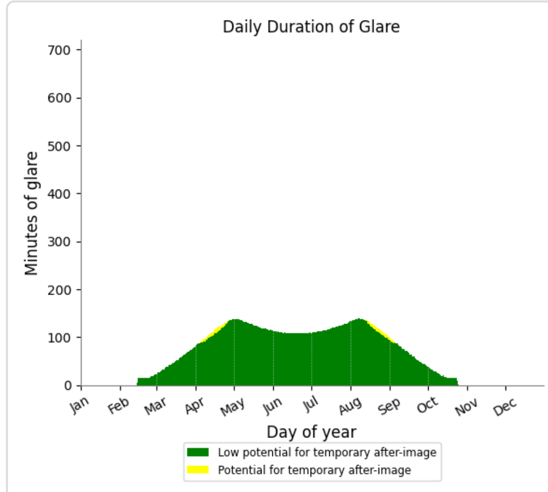
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Rwy 29 - Final	22,286	371.4	288	4.8
Rwy 11 - Final	0	0.0	0	0.0

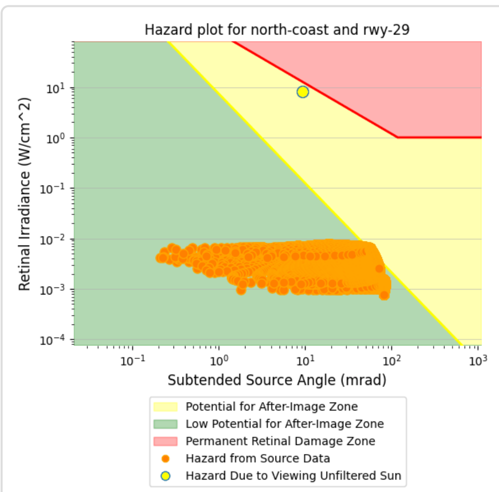
North Coast Hwy PV and FP: Rwy 29 - Final

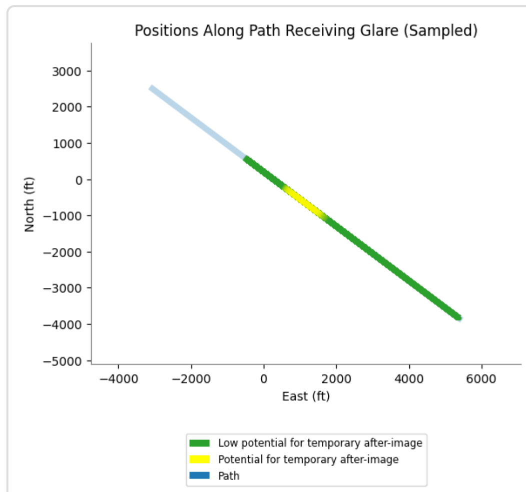
Yellow glare: 288 min.

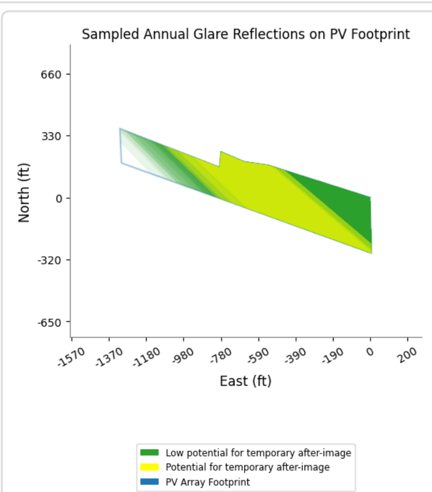
Green glare: 22,286 min.

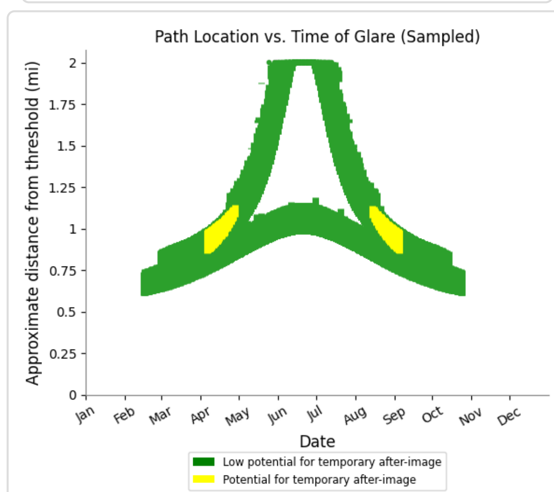












North Coast Hwy PV and FP: Rwy 11 - Final

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

FORGESOLAR GLARE ANALYSIS

Project: **Rohnerville Airport**
Solar array near Rohnerville Airport, Humboldt County

Site configuration: **North Coast Solar PV_15_65**
Analysis conducted by Abby Pal (abby@epdsolutions.com) at 00:00 on 23 Feb, 2024.

U.S. FAA 2013 Policy Adherence

The following table summarizes the policy adherence of the glare analysis based on the 2013 U.S. Federal Aviation Administration Interim Policy 78 FR 63276. This policy requires the following criteria be met for solar energy systems on airport property:

- No "yellow" glare (potential for after-image) for any flight path from threshold to 2 miles
- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics (see list below)

ForgeSolar does not represent or speak officially for the FAA and cannot approve or deny projects. Results are informational only.

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
2-mile flight path(s)	FAIL	Flight path receptor(s) receive yellow glare
ATCT(s)	N/A	No ATCT receptors designated

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

FAA Policy 78 FR 63276 can be read at https://www.federalregister.gov/d/2013-24729

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 99113.15476
Methodology: V2

PV Array(s)

Name: North Coast Hwy PV
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 180.0°
Max tracking angle: 65.0°
Resting angle: 15.0°
Ground Coverage Ratio: 0.468
Rated power: 0.585 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	40.543920	-124.116250	90.90	5.00	95.90
2	40.543110	-124.116220	88.30	5.00	93.30
3	40.544420	-124.120970	84.90	5.00	89.90
4	40.544920	-124.121000	86.80	5.00	91.80
5	40.544360	-124.119110	90.30	5.00	95.30
6	40.544583	-124.119080	107.68	5.00	112.68
7	40.544440	-124.118640	106.00	5.00	111.00
8	40.544390	-124.118190	91.80	5.00	96.80

Flight Path Receptor(s)

Name: Rwy 11 - Final
Description:
Threshold height: 50 ft
Direction: 127.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	40.557143	-124.138160	340.50	50.00	390.50
Two-mile	40.574543	-124.168588	340.50	603.43	943.93

Name: Rwy 29 - Final
Description:
Threshold height: 50 ft
Direction: 307.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	40.550769	-124.127265	392.70	50.00	442.70
Two-mile	40.533368	-124.096841	392.70	603.43	996.13

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
North Coast Hwy PV	SA tracking	SA tracking	22,286	288	1,780.0

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
Rwy 11 - Final	0	0
Rwy 29 - Final	22286	288

Results for: North Coast Hwy PV

Receptor	Green Glare (min)	Yellow Glare (min)
Rwy 11 - Final	0	0
Rwy 29 - Final	22286	288

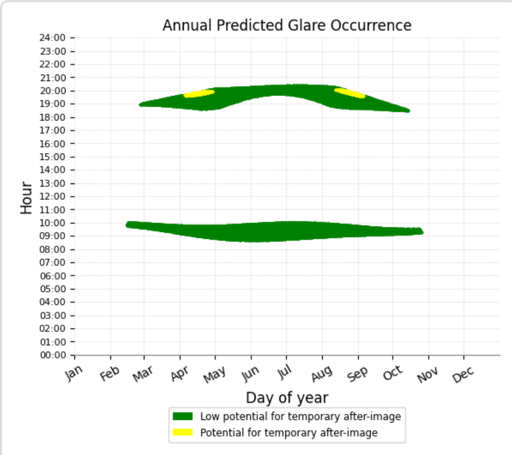
Flight Path: Rwy 11 - Final

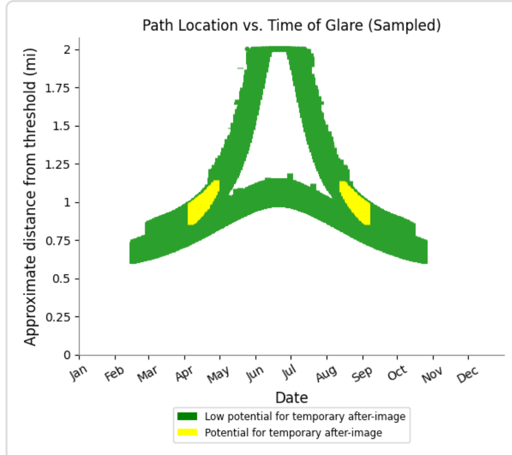
0 minutes of yellow glare
0 minutes of green glare

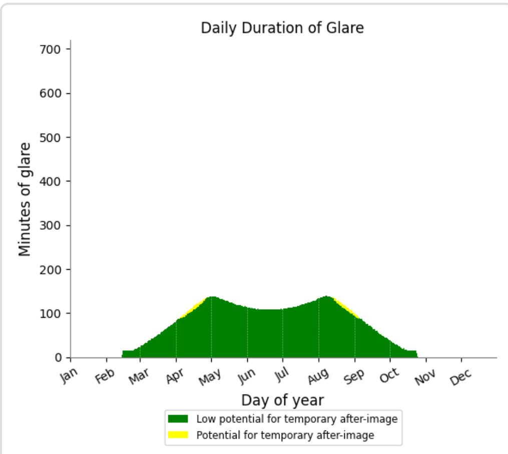
Flight Path: Rwy 29 - Final

288 minutes of yellow glare

22286 minutes of green glare







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.
Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to V1 algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
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.)
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual results and glare occurrence may differ.
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.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

FORGESOLAR GLARE ANALYSIS

Project: **Rohnerville Airport**
Solar array near Rohnerville Airport, Humboldt County

Site configuration: **North Coast Solar PV_15_65**

Created 04 Apr, 2023
Updated 23 Feb, 2024
Time-step 1 minute
Timezone offset UTC-7
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Site ID 99113.15476

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)	N/A	No ATCT receptors assessed

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: North Coast Hwy PV
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 180.0°
Max tracking angle: 65.0°
Resting angle: 15.0°
Ground Coverage Ratio: 0.468
Rated power: 0.585 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	40.543920	-124.116250	90.90	5.00	95.90
2	40.543110	-124.116220	88.30	5.00	93.30
3	40.544420	-124.120970	84.90	5.00	89.90
4	40.544920	-124.121000	86.80	5.00	91.80
5	40.544360	-124.119110	90.30	5.00	95.30
6	40.544583	-124.119080	107.68	5.00	112.68
7	40.544440	-124.118640	106.00	5.00	111.00
8	40.544390	-124.118190	91.80	5.00	96.80

Observation Point ATCT Receptors

No ATCT receptors were included in the analysis.

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
North Coast Hwy PV	SA tracking	SA tracking	0	0.0	0	0.0	1,780.0

No ATCT receptors were included in the analysis.

PV: North Coast Hwy PV

No ATCT receptors assessed.

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