LA CROSSE REGIONAL AIRPORT,

LA CROSSE, WISCONSIN

SOLAR FEASABILITY STUDY

MARCH 20TH, 2018

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SOLAR FEASABILITY STUDY SUMMARY

Mead & Hunt Architects and Engineers in partnership with Sustainable Engineering Group (SEG) have prepared the following Solar Photovoltaic (PV) Feasibility Study for the La Crosse Regional Airport Terminal Building. This feasibility study involved reviewing the building's energy usage and space availability to provide recommended options for installing solar electric generation. As part of this effort an on-site assessment was performed on Tuesday February 6th 2018 to review the incoming electrical service configuration and rooftop/parking lot areas for the suitability of a solar electric system.

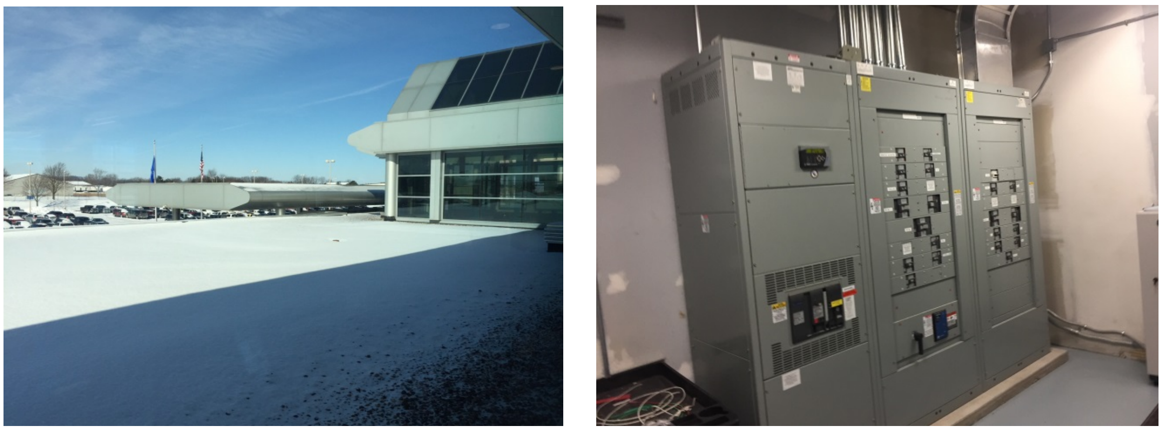

Figure 1- Terminal rooftop view (typical) and incoming electrical service panel

As part of this study we also reviewed the most recent 12 month utility data for the terminal building.

Based on our analysis we are proposing three options for solar electric systems. These are summarized in the table below:

Table 1- Summary of Solar Electric System Options

Solar PV System Option	Size [kW]	Annual Electric Energy [kWh]	Annual Utility Value [$]	Opinion of First Cost [$]	Life Cycle Payback [years]
A - Terminal Roof Mounted	100 kW	101,784 kWh/yr	$7,635/yr	$235,000	23 years
B - Short Term Parking Solar Canopy	100 kW	111,891 kWh/yr	$8,392/yr	$404,000	36 years
C - Long Term Parking Solar Canopy	100 kW	111,891 kWh/yr	$8,392/yr	$379,000	34 years

Based on current Federal Aviation Administration (FAA) funding opportunities through the Airport Improvement Program (AIP) these solar electric systems would qualify for grant-in-aids. This involves a two-step process:

Step 1 – Perform a Comprehensive Airport-Wide Energy Planning and Assessment Study

Step 2 – Install Energy Efficient Power Sources and Implement Energy Efficiency Improvements

AIP grant-in-aid funds are available for both steps in this process. Funding levels from the FAA through this program are based on the AIP eligibility factor, typically between 50% and 90%. It is recommended that the airport apply for funding from the FAA for Step 1, a Comprehensive Airport-Wide Energy Planning and Assessment Study, as a path to achieving AIP funding for the solar energy project(s).

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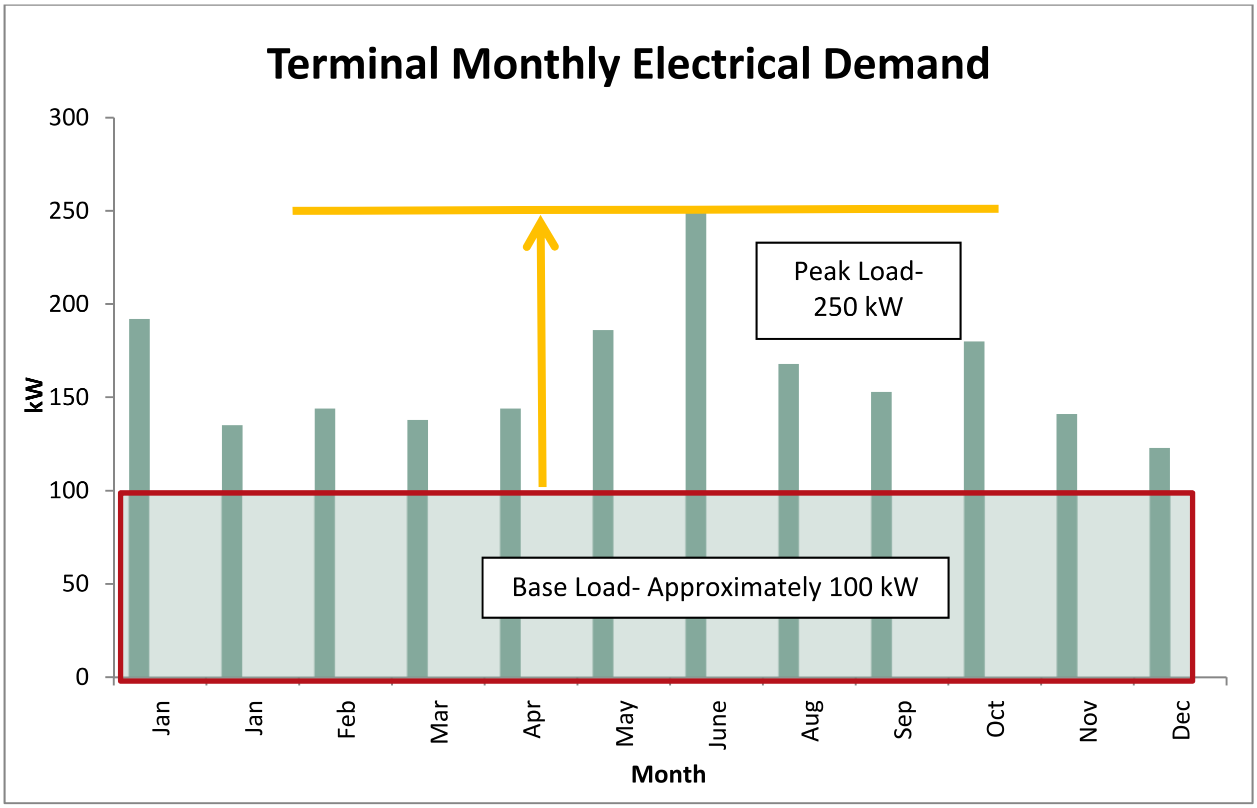
La Crosse Airport Annual Energy Summary, 2017 Utility Data							
Facility	Area [ft^2]	Gas usage [therms]	Gas Cost [$]	Electric Usage [kWh]	Electric Cost [$]	Total Cost [$]	Building EUI [$kBTU/ft^2$]
Terminal Building	73,000	25,859	$17,281	858,300	$74,371	$91,652	75.1

Based on the annual utility data for 2017, 81% of the utility cost of the building is electric energy. Because of the high cost per energy of electric as a fuel source, solar PV electric generation would be an ideal renewable option for La Crosse Airport Terminal.

To size the solar PV system so that all of the electric generation would be used onsite, we estimated the electric baseload of the building based on the billed monthly electric demand.



Based on the monthly demand data for the terminal building, the electric demand baseload is estimated at 100 kW. The solar PV system options shown in this report are sized to keep the maximum generation under this estimated baseload.

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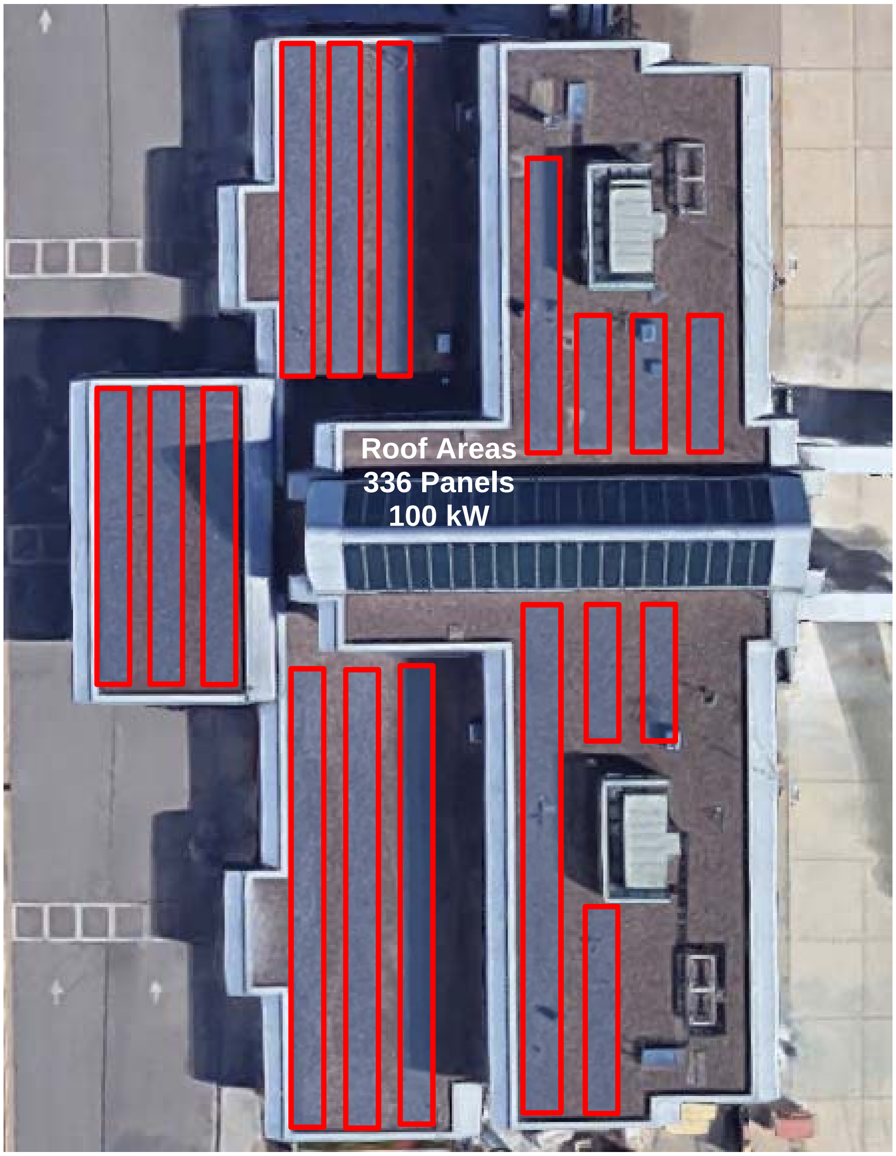
ROOF MOUNTED SOLAR PV SYSTEM- OPTION A

Based on our preliminary glare analysis we found that the ideal solar PV panel orientation for a roof-mounted system is due West (270°). This orientation will comply with the FAA glare requirements.



Total Possible Array: 336 Panels Total, 100 kW Peak Capacity
Panel Basis of Design: Sunmodule Plus SW 300 http://www.solarworld-usa.com/technical-downloads/datasheets
Assumptions: Ground coverage ratio of 0.65, 20° tilt angle, facing 200° South-West

To accommodate 100KW of solar panels on the roof it is likely that a large portion of the available rooftop area would need to be utilized.

Solar sizing calculations and glare analysis are included in the appendices.

SHORT TERM PARKING SOLAR CANOPY LAYOUT- OPTION B

The short term parking areas are often more desirable to have a covered parking option because of the higher rate of use and, potentially, higher parking revenue. The parking lot orientation of N-S along its long axis makes it challenging to orient the solar PV panels in an ideal south-facing (180°) orientation (our preliminary glare analysis indicates that panels facing 180° would cause potential for glare at the air traffic control tower (ATCT)). However, by orientating the panels towards the west (270°) we are able to meet the FAA glare requirements with only a small 6% loss in panel output compared to an array facing due south (180°).

The single stall configuration of the short term parking lot will allow for a solar canopy that would cover one row of cars (as shown).

Total Possible Array: 336 Panels Total, 100 kW Peak Capacity, Single Solar Canopy Structure
Panel Basis of Design: Sunmodule Plus SW 300 http://www.solarworld-usa.com/technical-downloads/datasheets
Assumptions: Solar Canopy has room for 112x3 panel array, 7° tilt angle, facing West (270°)

LONG TERM PARKING SOLAR CANOPY LAYOUT- OPTION C

As the long term parking lot has areas with double stalls, we are presenting this as another option that will be at a lower cost that Option B.

Since the parking lot orientation and glare considerations are the same in Option C as in Option B we have orientated the arrays towards the west (270°). Our preliminary glare analysis shows that this conforms with the FAA glare requirements with only a small 6% loss in panel output compared to an array facing due south (180°).

Total Possible Array: 336 Panels Total, 100 kW Peak Capacity, Single Solar Canopy Structure
Panel Basis of Design: Sunmodule Plus SW 300 http://www.solarworld-usa.com/technical-downloads/datasheets
Assumptions: Solar Canopy has room for 48x7 panel array, 7° tilt angle, facing West (270°)

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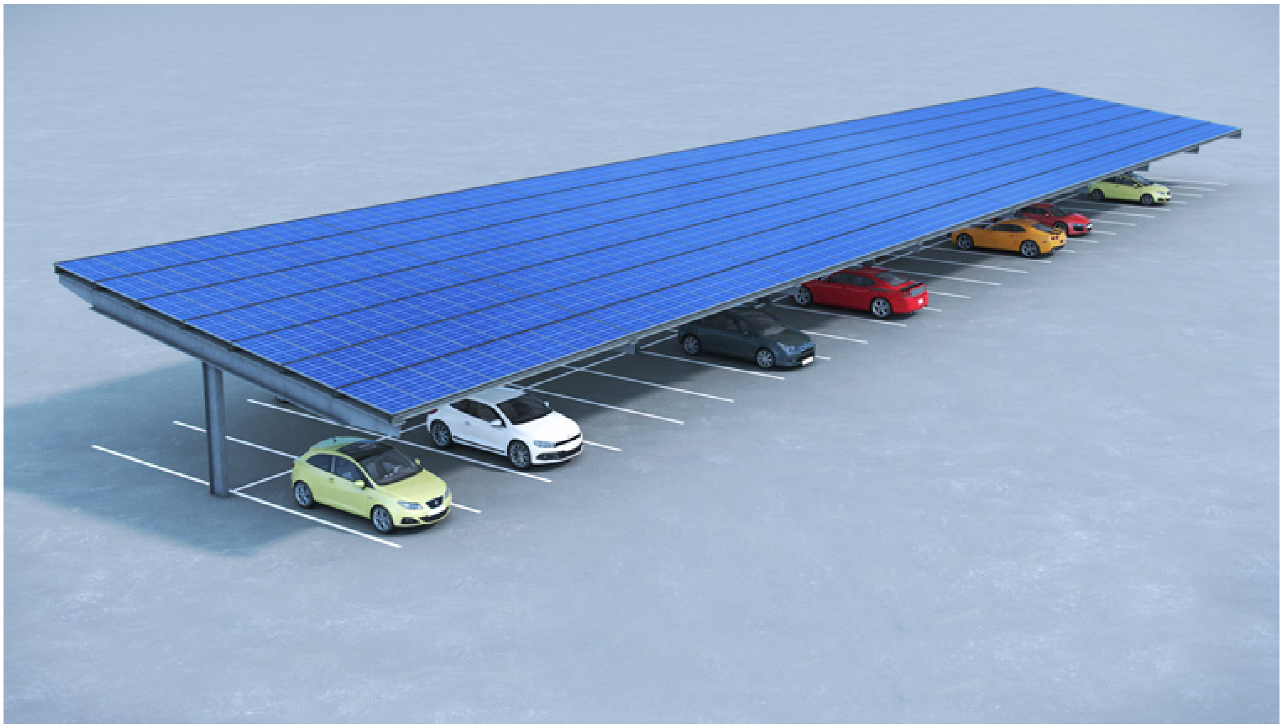

Figure 2- Example solar canopy, similar to Option C layout

Figure 3- Example structure detail and lighting concept, similar to Option C layout

BUDGET COMPARISON

Opinion of Line Item Cost	A: Rooftop Mounted Solar	B: Short Term Parking – Solar Canopy	C: Long Term Parking – Solar Canopy
Solar Panels and Install	$1.11/W	$1.11/W	$1.11/W
Racking System and Install	$0.37/W	$0.37/W	$0.37/W
Canopy Structure	-	$1.32/W	$1.07/W
Inverter, BOS, Design, Misc	$0.87/W	$1.24/W	$1.24/W
Total	**$2.35/W**	**$4.04/W**	**$3.79/W**
Budget	$235,000	$404,000	$379,000
Solar System Size	100 kW	100 kW	100 kW
Solar PV/Total Cost %	100%	67%	72%

PRODUCTION AND ECONOMIC COMPARISON

	A: Rooftop Mounted Solar	B: Short Term Parking – Solar Canopy	C: Long Term Parking – Solar Canopy
Annual Electric Production	101,784 kWh/yr	111,891 kWh/yr	111,891 kWh/yr
Annual Utility Value	$7,635/yr	$8,392/yr	$8,392/yr
Simple Payback (ROI)	31 years	48 years	45 years
20 Year Production Value	$205,123/ 20 years	$225,491/ 20 years	$225,491/ 20 years
20 Year Life Cycle Payback	23 years	36 years	34 years

ROOFTOP MOUNTED SOLAR DESIGN CONSIDERATIONS

- Ballasted roof mounted system would require fewer roof penetrations
- When roof replacement is necessary, solar system will need to be dismounted and re-mounted
- Some movement of existing rooftop equipment may be necessary to accommodate a 100 kW solar system

SOLAR CANOPY DESIGN CONSIDERATIONS

- Ice and snow protection system will be required at bottom edge of panels
- Geotechnical tests of soil conditions are needed to determine extent of required foundation
- Need to coordinate any underground utilities in parking lot area
- Height of panels will need to accommodate highest expected vehicle to be parked under canopy

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FEASIBILITY OF AREA P8 FOR USE AS A SOLAR FARM

The area marked in the figure below as 'P8' was noted as a location for a potential solar farm. For this location we analyzed the glare impact on the runways and control tower for a variety of orientations and angles.

Figure 4- Map of airport with area P8 marked

In all the locations modeled we found that this location produced excessive amounts of glare and would not be able to meet the FAA regulations. The table below summarizes our findings:

PV Array Configuration	Glare Analysis Results	Electric Production Performance Penalty
South facing, 30 degrees tilt	FAIL	0%
South facing, 20 degrees tilt	FAIL	5% less
South facing, 10 degrees tilt	FAIL	10% less
East facing, 30 degrees tilt	FAIL	21% less
West facing, 20 degrees tilt	FAIL	18% less
West facing, 40 degrees tilt	PASS*	23% less

* Marginal pass – also has a large energy penalty (23% less than at an optimum configuration)

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FAA AIRPORT IMPROVEMENT PROGRAM (AIP) - ENERGY ASSESSMENT GRANTS-IN-AID

The Airport Improvement Program (AIP) provides grants for the planning and development of infrastructure improvements made at public-use airports that are in the National Plan of Integrated Airport Systems. These grants are funded through the Airport and Airway Trust Fund, which is supported by revenues collected from the sale of domestic passenger tickets, domestic flight segments, international arrivals and departures, domestic waybill freight and mail, and aviation fuel. Airport projects that are eligible for funding through revenue collected by the AIP program are those related to the enhancement of airport safety, capacity, security and environmental issues. Areas in a passenger terminal that are eligible for the program are public spaces that are directly related to the movement of passengers and baggage. It is expected that a large proportion of the space in the La Crosse terminal building is eligible for this type of FAA funding.

The following two step process is used by the FAA for AIP funding of energy efficiency projects at airports:

- **Step 1 – Planning and Assessment:** Comprehensive Airport-Wide Energy Planning and Assessment
- **Step 2 – Implementation:** Installation of energy efficiency systems and optimization of on-site power usage and generation

Airport Improvement Program (AIP) grants-in-aid are available for both steps of the process. The amount of the grant is determined by the cost of the work and the AIP eligibility factor.

Step 1: Comprehensive Airport-Wide Energy Planning and Assessment

An energy assessment is an evaluation of how and where energy is used at an airport. This includes evaluating current energy sources and demand, performance and efficiency of facilities, systems, devices, or vehicles that consume energy, and future energy needs – see Table 2 below. An energy assessment/review is a prerequisite for Step 2 - Implementation.

Table 2- Sample Breakdown of Energy Assessment Systems/Areas

Landside	Terminal	Airside
• Roadways • Rental Car Facilities • Landside Commercial Facility • Landside Noncommercial Facility • Parking lots • Parking Garage • Airport Vehicle Fleet (separated by security/police, ARFF, maintenance, administration, passenger shuttle) • Any other space/use not listed	• Gates and Loading Bridges • Tenant or Airport Space (separated by entity occupying space, i.e. airport administration, TSA screening and office space, bookstore) • Public Space • Airline Space • Ground Support Equipment • Any other space/use not listed	• Runway and Taxiway lighting and sign systems (separated by airfield lighting vault, indicating if the system is supported by back-up power) • Airport Support Space (i.e. ARFF building, SRE building) • FAA space (i.e. Air Traffic Control Tower, FSDO, AVS) • Any other space/use not listed

An assessment funded through AIP must result in the following information; heating and cooling requirements, base load, back-up power requirements, and power for on-road airport vehicles and ground support equipment.

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The key output of an assessment is a list of strategies, actions, improvements, or practices that will increase energy efficiency. It may be a project (e.g., solar photovoltaic, geothermal, energy efficient lighting, daylighting controls, etc.) or practice (e.g., turning off lights and equipment at night, turning off certain systems overnight, etc.).

Step 2: Implement Energy Efficiency and On-Site Power Improvements

The next step is implementing the energy improvements found in the energy assessment (Step 1). Grant-in-aids are available to help cover the first cost of implementing these projects. The amount of grant is determined by the AIP eligibility factor. AIP eligibility factor would need to be determined, but past experience has shown that this falls into the range of 50% to 80% for similar types of airports. Additional information for the AIP program is found here: https://www.faa.gov/airports/aip/

For the solar PV options laid out in this report, it is our opinion that the 100 kW system sizing would result in a 100% eligibility factor – based on the following analysis:

Annual Electric Use in Terminal	858,300 KWh
Annual Electric Use in AIP Eligible Spaces (based on 80% eligibility)	686,640 KWh
Annual Electric Produced by Solar PV System (Canopy Options)	111,891 KWh
% of Solar PV Production Used in AIP Eligible Spaces	100%
AIP Eligibility Factor	100%

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ANNUAL PRODUCTION ESTIMATED USING PV WATTS

The following pages show the estimated annual energy production for a typical solar canopy system.

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Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at http://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

111,891 kWh/Year*

System output may range from 106,599 to 116,087kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	1.86	4,973	449
February	2.63	6,270	566
March	3.59	9,288	839
April	4.90	11,930	1,077
May	5.83	14,266	1,288
June	6.17	14,297	1,291
July	6.00	14,017	1,266
August	5.25	12,400	1,120
September	4.05	9,402	849
October	2.85	7,078	639
November	1.64	4,023	363
December	1.51	3,946	356
Annual	**3.86**	**111,890**	**$ 10,103**

Location and Station Identification

Requested Location	la cross, WI
Weather Data Source	(TMY3) LA CROSSE MUNICIPAL ARPT, WI 4.0 mi
Latitude	43.87° N
Longitude	91.25° W

PV System Specifications *(Commercial)*

DC System Size	100 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	7°
Array Azimuth	270°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Economics

Average Cost of Electricity Purchased from Utility	0.09 $/kWh

Performance Metrics

Capacity Factor	12.8%

OCULAR (GLARE ANALYSIS)

Glare analysis was performed using the ForgeSolar GlareGauge software based on the Scandia National Laboratories SGHAT tool found at www.sandia.gov/glare.

There was no significant glare found in either of the two runs performance (6 total flight paths, 2 flight paths each analysis).

Option A- Rooftop Location:

Observation Point	Glare Analysis Results	Reference Sheet
Air Traffic Control Tower	No glare found - pass	
North East Flight Path	No glare found - pass	
North Flight Path	No glare found - pass	
North West Flight Path	Low Potential glare found, winter months - pass	
South East Flight Path	No glare found - pass	
South Flight Path	No glare found - pass	
South West Flight Path	No glare found - pass	

Option B- Short Term Parking Lot Location:

Observation Point	Glare Analysis Results	Reference Sheet
Air Traffic Control Tower	No glare found - pass	
North East Flight Path	No glare found - pass	
North Flight Path	No glare found - pass	
North West Flight Path	No glare found - pass	
South East Flight Path	No glare found - pass	
South Flight Path	No glare found - pass	
South West Flight Path	No glare found - pass	

Option C- Long Term Parking Lot Location:

Observation Point	Glare Analysis Results	Reference Sheet
Air Traffic Control Tower	No glare found - pass	
North East Flight Path	No glare found - pass	
North Flight Path	No glare found - pass	
North West Flight Path	No glare found - pass	
South East Flight Path	No glare found - pass	
South Flight Path	No glare found - pass	
South West Flight Path	No glare found - pass	

The following pages have the glare analysis software output of both the rooftop and solar canopy options.

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FORGESOLAR GLARE ANALYSIS

Project: **La Crosse Airport PV Feasability Study**
Study of rooftop and car port mounted solar systems.

Site configuration: **Parking Lot Ideas**
Analysis conducted by Alexander Harris (aharris@sustaineng.com) at 22:00 on 24 Feb, 2018.

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
Flight path(s)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	PASS	Receptor(s) marked as ATCT do not receive glare

Default glare analysis and observer eye characteristics are as follows:

- 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: 15712.2440

PV Array(s)

Name: Parking Structure West
Axis tracking: Fixed (no rotation)
Tilt: 7.0°
Orientation: 270.0°
Rated power: -
Panel material: Smooth glass without AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

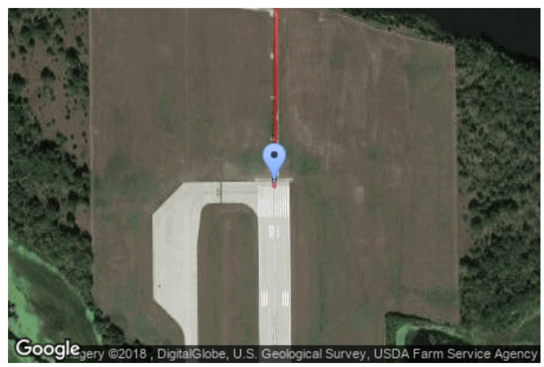
Vertex	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
1	43.875577	-91.264485	650.12	12.50	662.62
2	43.875579	-91.264330	649.20	17.00	666.20
3	43.876055	-91.264335	649.25	17.00	666.25
4	43.876055	-91.264480	649.72	12.50	662.22

Flight Path Receptor(s)

Name: North East Flight Path
Description:
Threshold height: 50 ft
Direction: °
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 120.0°

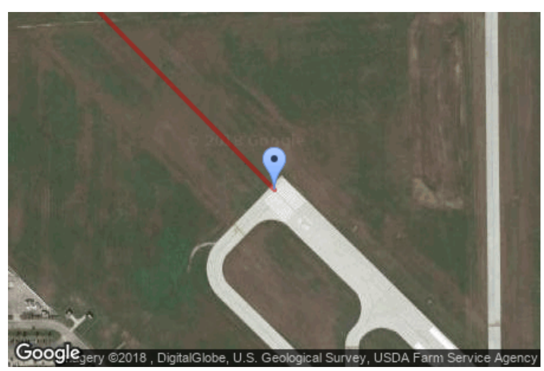
Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	43.881629	-91.247949	652.75	50.00	702.75
Two-mile	43.904567	-91.223501	719.21	536.99	1256.21

Name: North Flight Path
Description:
Threshold height: 50 ft
Direction: °
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 120.0°



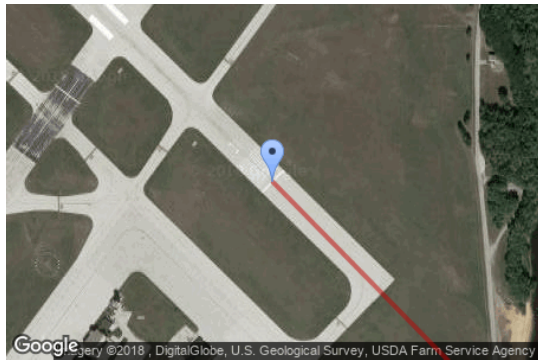
Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	43.893205	-91.258889	651.91	50.00	701.91
Two-mile	43.922116	-91.258469	640.46	614.91	1255.37

Name: NW Flight Path
Description:
Threshold height: 50 ft
Direction: °
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 120.0°



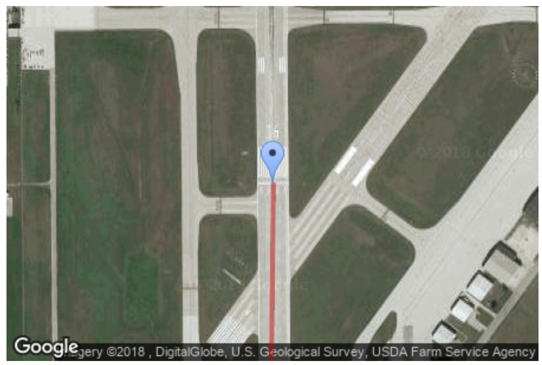
Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	43.885028	-91.264270	654.79	50.00	704.79
Two-mile	43.905650	-91.292421	636.96	621.28	1258.24

Name: South East Flight Path
Description:
Threshold height: 50 ft
Direction: °
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 120.0°



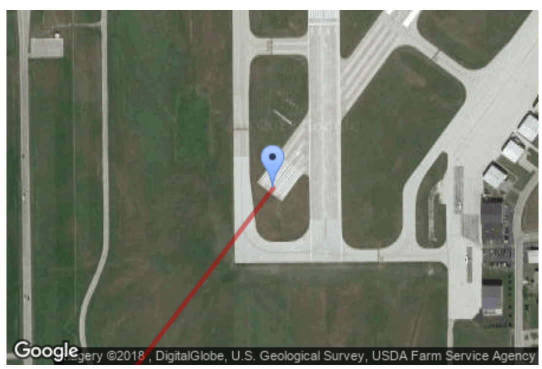
Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	43.874883	-91.249947	652.87	50.00	702.88
Two-mile	43.854262	-91.221801	650.81	605.52	1256.33

Name: South Flight Path
Description:
Threshold height: 50 ft
Direction: °
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 120.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	43.872389	-91.258615	647.49	50.00	697.49
Two-mile	43.843478	-91.259036	632.02	618.92	1250.94

Name: South West Flight Path
Description:
Threshold height: 50 ft
Direction: °
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 120.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	43.870257	-91.259541	645.89	50.00	695.89
Two-mile	43.847319	-91.283985	631.17	618.18	1249.35

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (ft)	Height (ft)
ATCT 1	1	43.873301	-91.252804	652.13	75.00

Map image of ATCT 1

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
Parking Structure West	7.0	270.0	0	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
North East Flight Path	0	0
North Flight Path	0	0
NW Flight Path	0	0
South East Flight Path	0	0
South Flight Path	0	0
South West Flight Path	0	0
1	0	0

Results for: Parking Structure West

North East Flight Path	0	0

Receptor	Green Glare (min)	Yellow Glare (min)
North Flight Path	0	0
NW Flight Path	0	0
South East Flight Path	0	0
South Flight Path	0	0
South West Flight Path	0	0
ATCT 1	0	0

Flight Path: North East Flight Path

0 minutes of yellow glare
0 minutes of green glare

Flight Path: North Flight Path

0 minutes of yellow glare
0 minutes of green glare

Flight Path: NW Flight Path

0 minutes of yellow glare
0 minutes of green glare

Flight Path: South East Flight Path

0 minutes of yellow glare
0 minutes of green glare

Flight Path: South Flight Path

0 minutes of yellow glare
0 minutes of green glare

Flight Path: South West Flight Path

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: ATCT 1

0 minutes of yellow glare
0 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.
The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values 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.

FORGESOLAR GLARE ANALYSIS

Project: **La Crosse Airport PV Feasability Study**
Study of rooftop and car port mounted solar systems.

Site configuration: **Feasability Study**
Analysis conducted by Alexander Harris (aharris@sustaineng.com) at 21:30 on 24 Feb, 2018.

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
Flight path(s)	PASS	Flight path receptor(s) do not receive yellow glare
ATCT(s)	FAIL	Receptor(s) marked as ATCT receive green and/or yellow glare

Default glare analysis and observer eye characteristics are as follows:

- 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: 15708.2440

PV Array(s)

Name: Rooftop Array A SW
Axis tracking: Fixed (no rotation)
Tilt: 20.0°
Orientation: 200.0°
Rated power: -
Panel material: Smooth glass without 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	43.875677	-91.263699	650.41	22.00	672.41
2	43.875468	-91.263694	650.58	20.00	670.58
3	43.875472	-91.263581	651.22	20.00	671.22
4	43.875678	-91.263581	650.33	22.00	672.33

Name: Rooftop Array B SW
Axis tracking: Fixed (no rotation)
Tilt: 20.0°
Orientation: 200.0°
Rated power: -
Panel material: Smooth glass without 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	43.875445	-91.263878	649.69	22.00	671.69
2	43.875447	-91.263748	650.21	22.00	672.21
3	43.875247	-91.263745	650.04	20.00	670.04
4	43.875247	-91.263876	650.07	20.00	670.08

Name: Rooftop Array C SW
Axis tracking: Fixed (no rotation)
Tilt: 20.0°
Orientation: 200.0°
Rated power: -
Panel material: Smooth glass without 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	43.874957	-91.263683	650.57	20.00	670.57
2	43.875265	-91.263689	650.05	22.00	672.05
3	43.875265	-91.263563	650.26	22.00	672.27
4	43.874955	-91.263563	651.14	20.00	671.14

Flight Path Receptor(s)

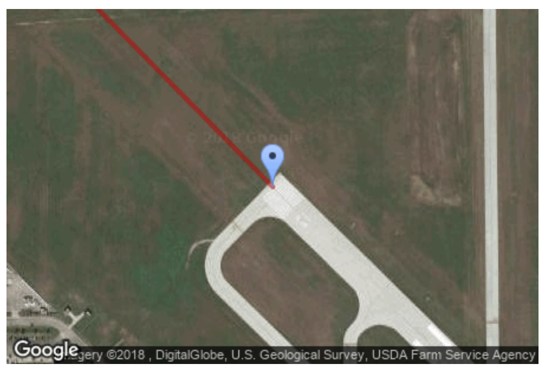
Name: North East Flight Path
Description:
Threshold height: 50 ft
Direction: °
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 120.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	43.881629	-91.247949	652.75	50.00	702.75
Two-mile	43.904567	-91.223501	719.21	536.99	1256.21

Name: North Flight Path
Description:
Threshold height: 50 ft
Direction: °
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 120.0°

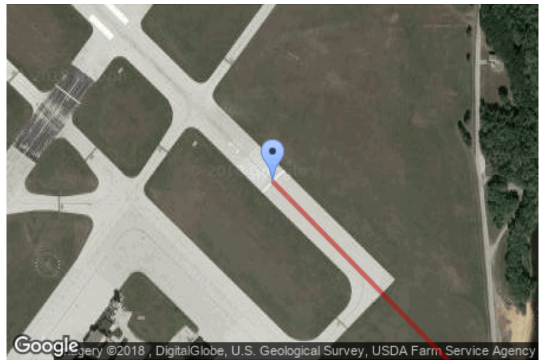
Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	43.893205	-91.258889	651.91	50.00	701.91
Two-mile	43.922116	-91.258469	640.46	614.91	1255.37

Name: NW Flight Path
Description:
Threshold height: 50 ft
Direction: °
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 120.0°



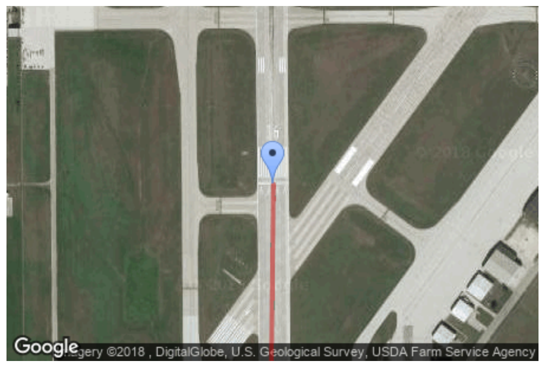
Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	43.885028	-91.264270	654.79	50.00	704.79
Two-mile	43.905650	-91.292421	636.96	621.28	1258.24

Name: South East Flight Path
Description:
Threshold height: 50 ft
Direction: °
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 120.0°



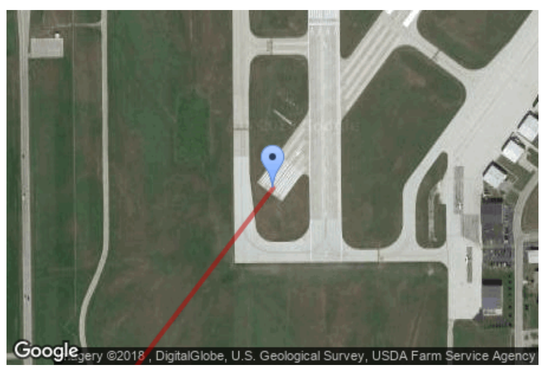
Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	43.874883	-91.249947	652.87	50.00	702.88
Two-mile	43.854262	-91.221801	650.81	605.52	1256.33

Name: South Flight Path
Description:
Threshold height: 50 ft
Direction: °
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 120.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	43.872389	-91.258615	647.49	50.00	697.49
Two-mile	43.843478	-91.259036	632.02	618.92	1250.94

Name: South West Flight Path
Description:
Threshold height: 50 ft
Direction: °
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 120.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (ft)	Height above ground (ft)	Total elevation (ft)
Threshold	43.870257	-91.259541	645.89	50.00	695.89
Two-mile	43.847319	-91.283985	631.17	618.18	1249.35

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (ft)	Height (ft)
ATCT 1	1	43.873301	-91.252804	652.13	75.00

Map image of ATCT 1

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
Rooftop Array A SW	20.0	200.0	339	0	-
Rooftop Array B SW	20.0	200.0	368	0	-
Rooftop Array C SW	20.0	200.0	296	0	-

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
North East Flight Path	0	0
North Flight Path	0	0
NW Flight Path	0	0
South East Flight Path	1001	0
South Flight Path	0	0
South West Flight Path	0	0
1	2	0

Results for: Rooftop Array A SW

Receptor	Green Glare (min)	Yellow Glare (min)
North East Flight Path	0	0
North Flight Path	0	0
NW Flight Path	0	0
South East Flight Path	337	0
South Flight Path	0	0
South West Flight Path	0	0
ATCT 1	2	0

Flight Path: North East Flight Path

0 minutes of yellow glare
0 minutes of green glare

Flight Path: North Flight Path

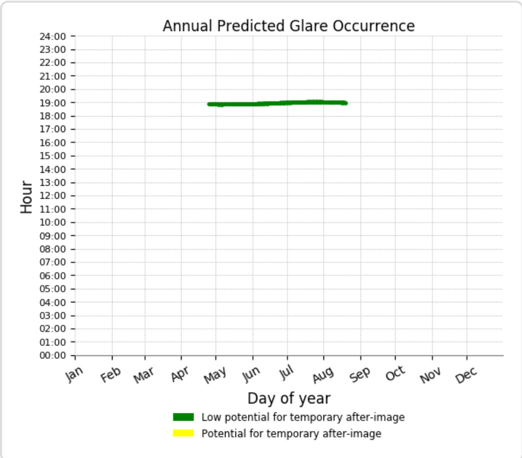
0 minutes of yellow glare
0 minutes of green glare

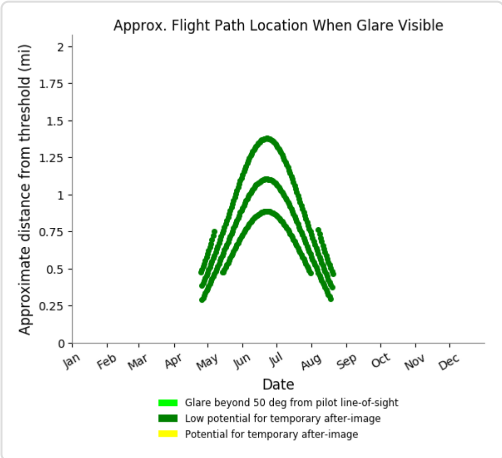
Flight Path: NW Flight Path

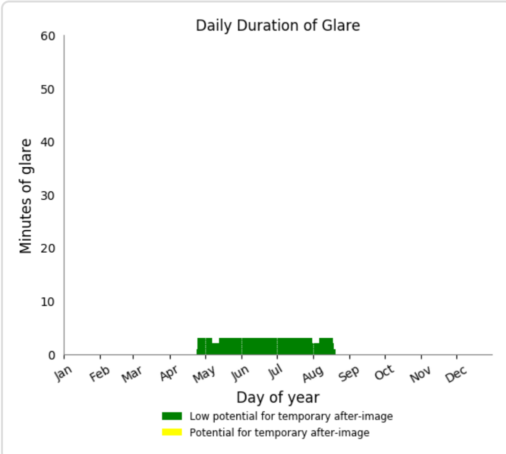
0 minutes of yellow glare
0 minutes of green glare

Flight Path: South East Flight Path

0 minutes of yellow glare
337 minutes of green glare







Flight Path: South Flight Path

0 minutes of yellow glare

0 minutes of green glare

Flight Path: South West Flight Path

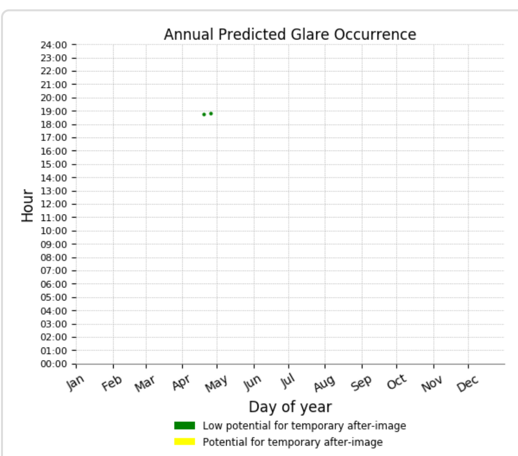
0 minutes of yellow glare

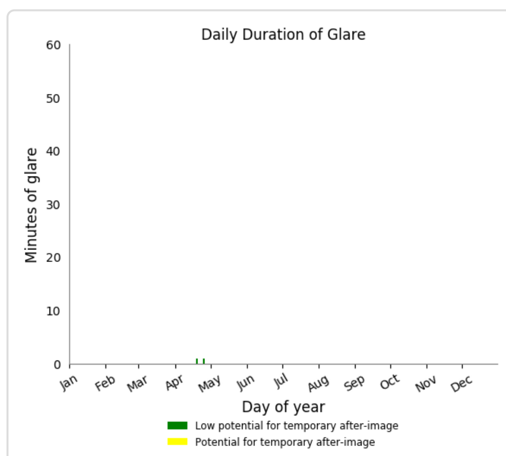
0 minutes of green glare

Point Receptor: ATCT 1

0 minutes of yellow glare

2 minutes of green glare





Results for: Rooftop Array B SW

Receptor	Green Glare (min)	Yellow Glare (min)
North East Flight Path	0	0
North Flight Path	0	0
NW Flight Path	0	0
South East Flight Path	368	0
South Flight Path	0	0
South West Flight Path	0	0
ATCT 1	0	0

Flight Path: North East Flight Path

0 minutes of yellow glare
0 minutes of green glare

Flight Path: North Flight Path

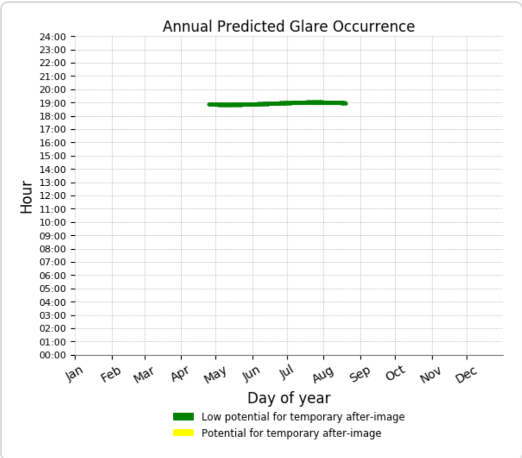
0 minutes of yellow glare
0 minutes of green glare

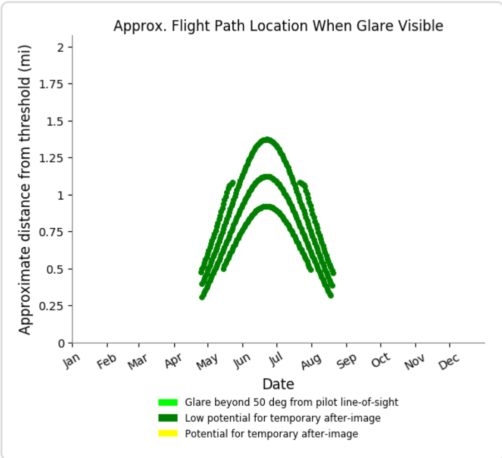
Flight Path: NW Flight Path

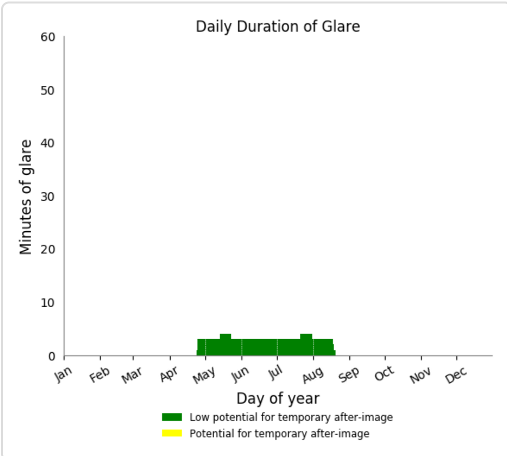
0 minutes of yellow glare
0 minutes of green glare

Flight Path: South East Flight Path

0 minutes of yellow glare
368 minutes of green glare







Flight Path: South Flight Path

0 minutes of yellow glare
0 minutes of green glare

Flight Path: South West Flight Path

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: ATCT 1

0 minutes of yellow glare
0 minutes of green glare

Results for: Rooftop Array C SW

Receptor	Green Glare (min)	Yellow Glare (min)
North East Flight Path	0	0
North Flight Path	0	0
NW Flight Path	0	0
South East Flight Path	296	0
South Flight Path	0	0
South West Flight Path	0	0
ATCT 1	0	0

Flight Path: North East Flight Path

0 minutes of yellow glare
0 minutes of green glare

Flight Path: North Flight Path

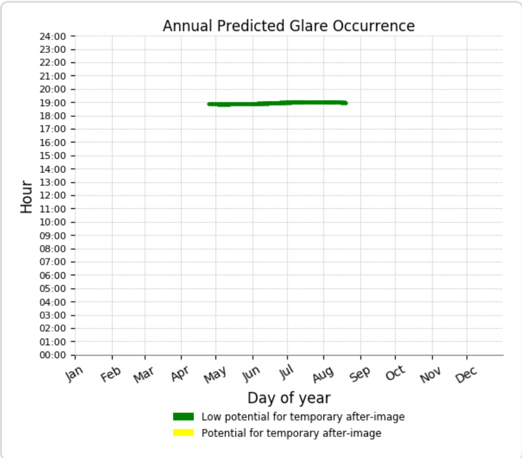
0 minutes of yellow glare
0 minutes of green glare

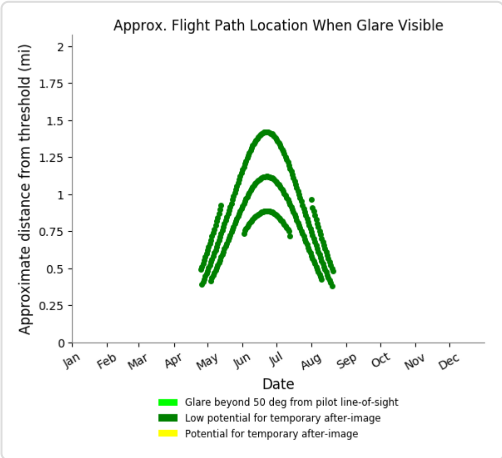
Flight Path: NW Flight Path

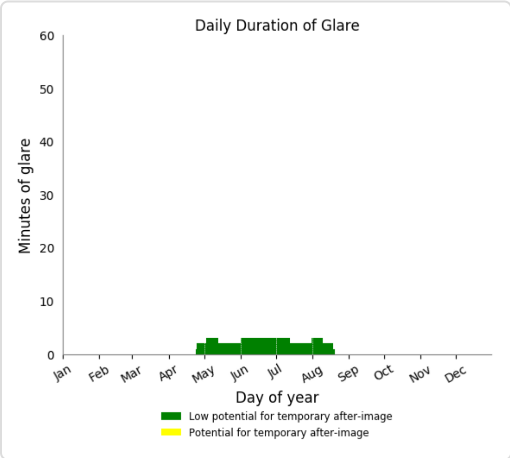
0 minutes of yellow glare
0 minutes of green glare

Flight Path: South East Flight Path

0 minutes of yellow glare
296 minutes of green glare







Flight Path: South Flight Path

0 minutes of yellow glare
0 minutes of green glare

Flight Path: South West Flight Path

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: ATCT 1

0 minutes of yellow glare
0 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.
The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values 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.