Sunrun Installation Services Inc.
2309 South Mount Prospect Rd
Des Plaines, IL 60018

To Orland Park Development Services Department,

For Property: 7420 W 157th St, Orland Park, IL 60462

This letter certifies that Sunrun Installation Services Inc, has taken reasonable effort to comply with section 6-314.E.5.g of the Environmental Technology Standards: SES collector panels shall be placed such that concentrated solar radiation or glare shall not be directed onto nearby properties, roadways or public right-of-ways.

Sunrun Installation Services use LG and REC panels. LG is using anti-reflective technology on the glass and on the cells of the panels to ensure light is absorbed in the panel and not reflected. The study undertaken at SERIS demonstrates the advantage of AR-treated glass as used by REC. Please see the attached studies.

Thank you,

Sunrun Installation Services

ASSESSING REFLECTION FROM REC PEAK ENERGY SERIES PANELS

When light hits a surface, a certain percentage is returned without being absorbed; this is reflection. In general, transmittance and absorption of light vary according to the angle of incidence of the incoming radiation, i.e., the more angled the incidence, the higher the reflectance. Solar panels are designed to capture as much light as possible in order to produce electricity, so the more angled an installation is in relation to the sun, the more light is lost due to reflection off the surface, which could otherwise have contributed to energy output. To measure reflection rates and their impact on energy production, REC Peak Energy Series panels were submitted to an assessment by a third party testing center.

Accounting for reflection in system calculations

Photovoltaic simulation software tools are frequently used for the design of solar installations and to provide predictions of performance over time. In order to achieve reliable results, the data used in the calculations must be accurate. One aspect of the required data is the amount of reflectance from the panel; getting this wrong can have a significant impact on system expectations.

The efficiency and reflectance of solar panels at a given level of radiation is a function of the sun's position relative to the panel. A value known as the Incidence Angle Modifier (IAM) accounts for expected rates of reflection when compared to incidence at the normal plane (i.e., 90°) and identifies expected impact on performance as the angle of the sun changes position in relation to the panel surface throughout the day and the year.

The IAM is defined as efficiency at the given angle of incidence divided by the efficiency at normal incidence and is therefore equal to 1 for normal incidence of direct radiation. It is generally accepted that the IAM decreases with greater angles, i.e., the higher the angle of incidence, the lower the (relative) efficiency.

Assessing the reflectance of REC panels

In order to quantify the effect reflection has on the yield of an REC panel, production panels were submitted to a study into reflection at different angles by the independent laboratory, Solar Energy Research Institute of Singapore (SERIS). In its solar panels, REC uses an anti-reflective glass treatment (AR), which reduces the amount of reflection from the panel surface, therefore a panel without AR glass was also submitted for comparison. The detailed findings are discussed below[1].

SERIS measured the reflectivity of the panel using a goniophotometer, a device for the measurement of the bidirectional reflectance and transmittance distribution (BRTD). The measurement is angular resolved. The device consists of three main components:

- A converging beam light source (xenon lamp); the spectral range of the emitted light can be restricted using filters
- The sample holder, rotated to vary the incident angle
- A rotating detector, which is mounted on an arm a constant distance around the center of the sampled area.

As energy production is one of the most important factors in monitoring panel performance, this paper considers only the results on reflectance from the cell surface which is the area relevant to yield, i.e., energy generation.[2]

One change compared to previous test methods is the increase in spectrum of light to 350 – 1100nm (from 350 – 750nm in earlier studies). This is the range of energy generating visible light and therefore is more appropriate for the purpose of the study.

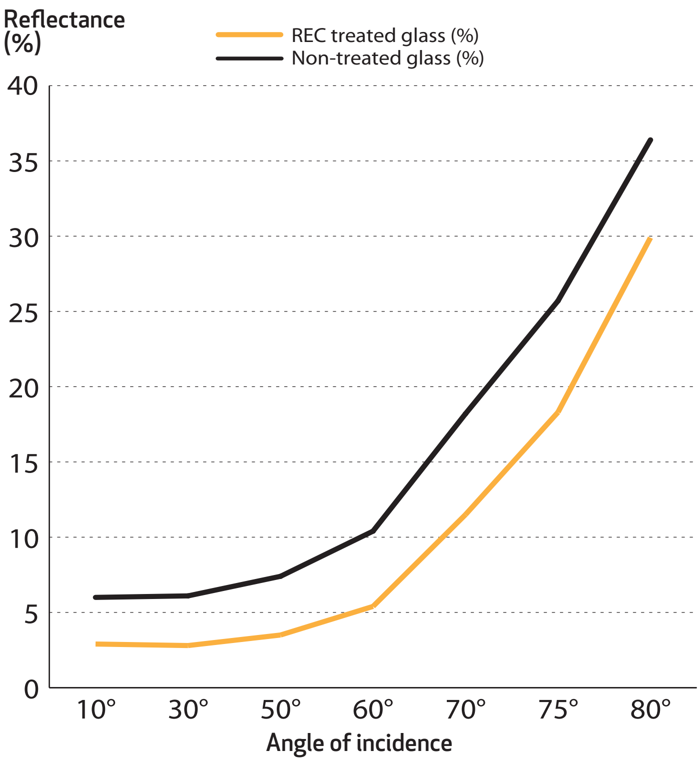
The study

An incident light beam with a diameter of approximately 20 mm was focused on the cell surface as the predominant area of the panel and the area relative to energy yield. The amount of reflection is then captured by the goniophotometer as the percentage of light reflected from the surface (assuming that the value at 10° is nearly the same as the value for normal incident):

Table 1: Measurements of cell loss due to reflectance

Angle	Non-treated glass (%)	AR-treated glass (%)	Difference (%)
10°	6.0	2.9	-3.1
30°	6.1	2.8	-3.3
50°	7.4	3.5	-3.9
60°	10.4	5.4	-5.0
70°	18.2	11.5	-6.7
75°	25.7	18.3	-7.4
80°	36.4	29.9	-6.5

Graph 1: Reflectance levels of glass types at different angles of incidence



The BRTD report results (as given in Table 1) have a relative expanded uncertainty of 5.6% with a 95% confidence level and a coverage factor of k = 2.

1 *The full report from SERIS is available from REC upon request.*
2 *Further study was carried out into glare from the complete panel surface. This is available in a separate paper.*

The results

The study undertaken at SERIS clearly demonstrates the advantage of AR-treated glass as used by REC over standard glass types. The results confirm that with higher angles of incidence, higher rates of reflection from the cell surface can be expected. With sensible system design however, the higher angles of reflectivity will only be seen when the sun is low in the sky e.g., in the winter months and at dusk and dawn, and therefore the strength of the sunlight will be at its weakest.

Applying IAM values in simulation software

When using simulation tools, there is often the option to modify the IAM values of the selected panel. As default settings in many simulation softwares are based on non-treated glass, the use of specific IAM values for REC Peak Energy Series panels is supported by the results of the SERIS study and the difference in reflection performance between the AR-treated glass used by REC and non-treated glass types. Translating the reflectance values into an IAM is done by comparing the reflectance against the 10° level, e.g.,:

$$\text{IAM @ } 50^\circ = \frac{(100 - 3.5)}{(100 - 2.9)} \cdot 100 = 99.4\%$$

Dependent on the software (and version) used, the IAM values for REC in Table 2 (opposite) should be entered into simulation programs instead of the default values to achieve more realistic system and yield predictions.

Table 2: Conversion of reflectance rates to IAM values

Angle	Non-treated glass (%)	IAM non-treated glass (%)	AR-treated glass (%)	IAM REC panels (%)
10°	6.0	100.0	2.9	100.0
30°	6.1	99.9	2.8	100.1
50°	7.4	98.5	3.5	99.4
60°	10.4	95.3	5.4	97.4
70°	18.2	87.0	11.5	91.1
75°	25.7	79.0	18.3	84.1
80°	36.4	67.7	29.9	72.2

Conclusion

As a panel manufacturer, REC works hard to ensure any reflectance is kept as low as possible and does not lead to lost energy. The SERIS study shows the advantages of the AR glass treatment as used by REC and that the level of reflection from REC panels is only significantly affected after an angle of around 60°. The benefits of these low reflectivity values, supported by independent testing, can be seen in performance simulation software by using the above IAM values for REC panels, enabling accurate predictions of system performance.

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The Canberra Times

NATIONAL ACT

Solar glare safe: CASA

By John Thistleton
13 November 2013 — 3:00am

Reflected light from a proposed new solar farm near Canberra Airport would not blind pilots of approaching or departing aircraft, and would reflect less than glass and similarly to a forest or a crop, the Civil Aviation Safety Authority says.

Opponents of the development, Canberra Airport and Qantas, said glare was a potential safety hazard and the solar farm should not be approved on land below the approach to runway 17 at the airport.

Airport managing director Stephen Byron previously quoted a US Air Force study that showed people exposed to bright light flashes took four to 12 seconds to recover vision to read instruments.

''On what planet do we have to be to work out that this is probably not a smart idea to allow the construction of this aviation safety hazard,'' Mr Byron said.

A consultation report from Commonwealth planning agency, the National Capital Authority, shows CASA had by this stage advised the authority the solar farm, on land near Mount Majura Winery, did not appear to be an aviation hazard. Undeterred, the airport requested the advice to be reviewed.

MYSTIFIED: Canberra Airport managing director Stephen Byron believes the solar farm a hazard.

Photo: Andrew Taylor

Proponent Solar Choice commissioned glare analysis reports from CBRE and Canadian Solar, which used a range of variables, such as height and angle of the sun in the sky, vantage points and heights of the viewer.

Both reports concluded some level of glare was to be expected from the solar arrays, but the impact to vehicles or aircraft was low and unlikely to be hazardous. ''The modelling used tends to overstate the likelihood of reflective glare because it does not take into consideration the prospect that the view of the panels from many locations will be obstructed by landscape features or other panels within the array,'' the CBRE report said.

The NCA's consultation report says aircraft issues had been resolved. The authority is now waiting for information on environmental matters before making a decision on works approval. Air Services Australia said the 4MW farm, which will take three months to build on 13.8 hectares, would not affect aircraft, nor the radar installation at Majura.

Initially concerned about safety of military aircraft, the Department of Defence was later satisfied with CASA's assessment.

Canberra Airport also criticised the proposed Mount Majura Solar Farm because it was on a major transport corridor, including for a possible high-speed train.

But the NCA said a second study on a high-speed train included a refined alignment south of the farm site.

John Thistleton

John Thistleton is a reporter for The Canberra Times.

Solar farm projects near airports: Is glare an issue?

by Solar Choice Staff on 19 September, 2013

in Commercial solar power,Positioning solar PV panels,ACT,Solar Farms

The Canberra Times recently published a piece about the concerns about potential glare from the solar panels of the proposed 4 megawatt (MW) Mount Majura Solar Farm, given its proximity to Canberra Airport. This article addresses concerns about glare from solar panels in aviation and examines a number of similar case studies both internationally and elsewhere in Australia.

1. Solar panels are designed to absorb light, and accordingly reflect only reflect a small amount of the sunlight that falls on them compared to most other everyday objects. Most notably, solar panels reflect significantly less light than flat water.

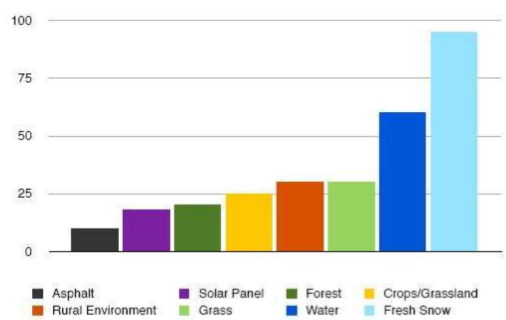
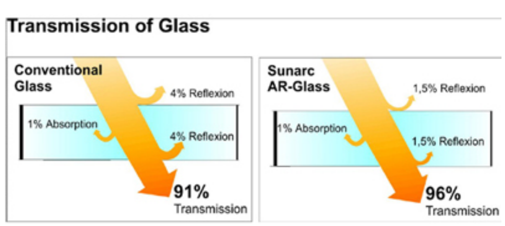


Figure 3: Comparative reflection analysis

In fact, glass, one of the uppermost and important components of a solar panel, reflects only a small portion of the light that falls on it– about 2-4%, depending on whether it has undergone an anti-reflective treatment. These days, to increase solar panel efficiency and power output, most panels are treated with some kind of anti-reflective coating. Below is an example of how Sunarc's antireflective technology– just one available on the market–can increase light transmission in glass and reduce reflection.



(Image via Sunarc.)

The chart below compares the reflectivity of smooth surfaces at different angles of sunlight. Solar panels treated with antireflective coating reflect a lower percentage of light than smooth water. Steel, a common building material, reflects far more incident sunlight than either.

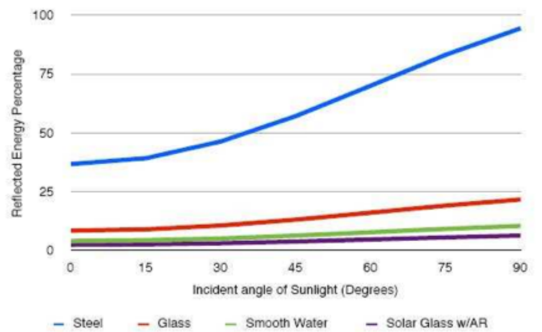


Figure 4: Analysis of typical material reflectivity with sunlight angle[3]

2. Of course, it may not seem fair to compare the quality of light reflected from grass to that reflected off of water or glass. Smooth surfaces such as glass and still water exhibit 'specular reflection'. This is when light hits the surface at one angle and 'bounces off' in another direction, much like a mirror. Specular reflection can be contrasted with 'diffuse reflection', which occurs when light reflects off of microscopically rough surfaces and scatters. Diffuse reflection is what happens when light hits virtually everything in our field of vision.

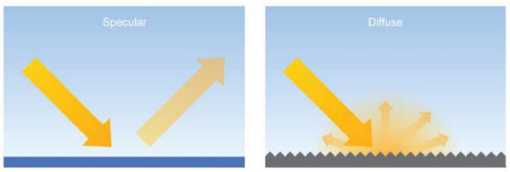


Figure 1: Specular vs diffuse reflections [Source: FAA]

When the sun is reflected on a smooth surface, it can result in glint (a quick reflection) or glare (a longer reflection) for those who are on the 'receiving' angle. In both cases the light reflected is diminished by having first hit the substrate that reflected it–unless that surface is a perfect mirror. When the sun is the original source of the light reflected off a reflective surface, the time and position at which glare or glint might occur depends on the original position of the sun in the sky in relation to the location of the viewer.

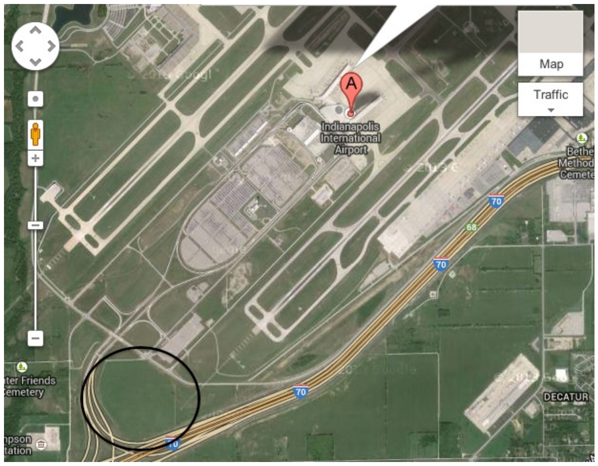
Pilots are familiar with this sort of reflection, usually from bodies of water (which, as noted above, has a higher level of reflectivity than glass or solar panels). Airports are commonly found in close proximity to lakes and the ocean (Sydney's Kingsford Smith being one such case).

3. The biggest glare hazard in aviation is the sun itself–particularly when it is low on the horizon. In an international, comprehensive analysis of potential glare hazards (pdf – see section 7) in aviation from solar panels, the UK's Spaven Consulting points out that a trawl of UK and US aviation incident databases between the years 2000 and 2010 for accidents in which glare was cited as a factor reveals that in the overwhelming majority of these cases, the source of the glare was the sun itself. The handful of other cases were mainly related to glare from water on the tarmac or from a nearby body of water. In no case was glare from solar panels or 'similar facilities' cited as a contributing factor to an accident.

4. Numerous airports around the world have solar installations *located on their premises.* Among those in Australia that have installed large arrays are Adelaide Airport, Alice Springs Airport, Newman Airport (WA), and Ballarat Airport. Internationally, solar arrays have been installed at or near airports in Singapore's Changi Airport, London's Gatwick Airport, California's San Jose Airport, Germany's Dusseldorf Airport, the US's Denver International Airport, Nellis Air Force Base in Nevada, and Ontario's Thunder Bay Airport, to name a few. The preponderance of examples in which solar panels have been installed at, on or near airports is testament to fact that they are not automatically a hazard to pilots.

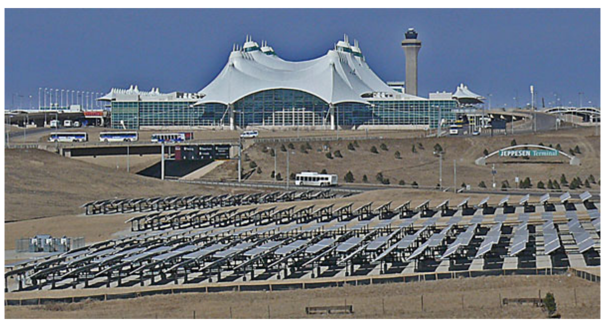
Particularly noteworthy and a close analogue to the Majura Solar Farm with regard to its position in relation to an airport is the Indiana Solar Farm. 2MW of solar panels facing due south are located under 1km south-west of runways. Stephen Barrett of US consultancy HMMH, which has undertaken glare assessments of numerous solar installations at or near airports across the US–including Indianapolis Airport–said that the majority of projects that HMMH had been involved in were developed by the airports themselves and were therefore careful to adhere to FAA guidance. He also noted that the FAA only requires glare assessments for developments that occur within 2 miles (about 3.22km) of touch-down.

The Indiana Solar Farm, less than 1km southwest of the landing strip at Indianapolis International Airport. (Photo by Alex Dierkman.)



The location (circled) of the Indiana Solar Farm in relation to Indianapolis Airport runways. Panels are not visible because the map is out of date. (Image via Google Maps.)

Dusseldorf International Airport, Germany (Image via AvaiationPros.)



Denver International Airport , Colorado, USA (Image via Worldwater & Solar.)

Nellis Air Force Base in Nevada, USA (Image via Nellis Air Force Base.)

The 8.5MW Thunder Bay Airport Solar Park (Image via [Recharge News](#).)

Two Californian airports specifically noted in Spaven Consulting's report–Bakersfield and Oakland–have solar arrays directly adjacent to the tarmac or even between runways (images below). Both of these arrays underwent analysis during the planning process to ensure that glare was not an issue, and neither has reported complaints about glare from pilots since the arrays were installed.

Figure 5: Location of solar PV array at Oakland Airport

Figure 7: Bakersfield Airport showing location of solar array

5. The Spaven Consulting report notes that because of their low reflectivity solar developments 'en route' to an airport (but not actually located on the premises of an airport) are unlikely to warrant a glare analysis. In the event that such an analysis is deemed necessary, the above points (about the low reflectivity of panels) are should be taken into account. The Mount Majura Solar Farm will be located 7km north of the airport, making it unlikely that pilots flying in and out will experience any interference due to reflection of light from the panels. Furthermore, because the nose of a commercial aircraft is tilted slightly upwards prior to landing, should any light be reflected off the panels during a landing, it is more likely to fall on the underside of the plane than shine into its cockpit.

Further reading: Spaven Consulting's report on reflectivity & glare with solar panels (pdf)

Images via Spaven Consulting

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Tagged as: adelaide, alice springs, ballarat, glare, majura, solar farms

{ 5 comments }

Ella 16 June, 2016 at 7:05 am

Can I ask about Figure 4? It looks wrong; as the angle of incidence approaches 90 degrees, for example, the percent of light reflected from glass gets very near 100%, not 25%. This is well known. Look:
http://research.vuse.vanderbilt.edu/bmeoptics/bme285/mainframes/module3/module3pics/m3pic26.jpg
I realize this article was posted years ago…

Chew c k 9 December, 2014 at 2:30 am

Any law suit about solar PV reflection?