Impact of solar PV on aviation and airports

Summary of evidence compiled by the Solar Trade Association to help inform the debate around permitted development for non-domestic solar PV in Scotland.

Background on situation in Scotland

A Scottish Government consultation in June 2015 on extending Permitted Development Rights for **non-domestic roof-mounted solar** (with no upper limit on array size) has seen the re-emergence of the issue of glint and glare after concerns expressed by airports, notably in responses from Glasgow Airport and Glasgow Prestwick Airport. The consultation seeks to remove the clause in the Town and Country Planning (General Permitted Development) (Non-Domestic Microgeneration) (Scotland) Amendment Order (SSI 2011/136) that "permitted development rights do not apply… within 3km of the perimeter of an aerodrome or technical site." This would level with domestic rooftop solar, for which permitted development rights exist with no requirement for prior approval next to airports and no reports of issues in Scotland or England. The airport responses note concerns over safeguarding against glint and glare, interference with Communications Navigational and Surveillance equipment, and infringement of obstacle limitation surfaces in aircraft flightpaths. However, while they cite aerodrome safeguarding legislation and Civil Aviation Publications (CAPs) they do not provide any factual or anecdotal evidence of solar causing problems. The Scottish Government has yet to issue a response to the consultation.

Civil Aviation Authority (CAA) guidance issued in 2010 states that a developer should "provide safety assurance documentation regarding the full potential impact of the installation on aviation interests". This is something that at the moment can be requested by airports through the planning system, normally in the form of a risk assessment or glare assessment. We understand that the Civil Aviation Authority have argued that if this is removed then there will be no mechanism for airports to request developers fulfil safety requirements regarding glare, which could result in an accumulation of solar developments around an airport with a potential to cause glare.

Permitted development rights in England were extended to 1MW for solar PV in April 2015. The Statutory Instrument states that "development is permitted subject to the condition that before beginning the development the developer must apply to the local planning authority for a determination as to whether the prior approval of the authority will be required as to the design or external appearance of the development, in particular the impact of glare on occupiers of neighbouring land." Therefore there is a pre-notification/prior-approval period – a form of 'planning-lite'. However developers and planning authorities have raised concerns that developers still have to submit broadly the same information, which often costs the same amount in terms of fees and planning authority resources and takes the same amount of time (6-7 weeks).

Legislation and guidance

Ultimately it is up to each planning and local authority to determine what is required in terms of an impact assessment and each authority has different requirements. There can be no requirement at all, a 'tick-box' exercise, or a more thorough assessment, for example: Infrastructure Planning SI (SI

2016/17) (The East Midlands Gateway Rail Freight Interchange and Highway Order 2016): "The prior approval of the airport operator (acting as the statutory aerodrome safeguarding authority) must be obtained by the undertaker for the installation of any solar photovoltaic panels or apparatus within the authorised development, such approval not to be unreasonably withheld or delayed. Any request for such approval must be accompanied by a full solar glare assessment and detailed risk assessment."

There are no EU provisions or requirements from the European Aviation Safety Agency (and none planned) concerning solar PV developments on or near aerodromes – therefore the expectation from CAA is that solar PV developments are managed by aerodromes in accordance with the well-established statutory safeguarding arrangements (together with local planning authorities, as required) in accordance with the DfT/ODPM Circular 1/2003.

There is various guidance available on the topic. The US Federal Aviation Authority (FAA) had technical guidance, which has directly informed the CAA's stance on solar PV around airports. However, this is due to be updated, with the following disclaimer on the cover: "the FAA is reviewing multiple sections… based on new information and field experience, particularly with respect to compatibility and glare… the FAA cautions users against relying solely on this document at this time. Users should refer instead to the Interim Policy." In sum, the FAA interim policy asserts that proposed solar developments on a federally-obligated aerodrome must undergo ocular impact assessments as outlined in the document and submit these to the FAA for approval. This is a precautionary measure based on the FAA's authority over airspace and construction on an aerodrome. Any solar developments next to or outside the aerodrome are not obligated to undergo assessments. The policy is due to be updated pending new evidence, overdue since 2013.

The CAA interim guidance follows suit: if the proposed solar development is 'on-aerodrome' then the process outlined in CAP 791 must be followed. All of those that have made such an application to the CAA to date have been approved. If any aerodrome operator wishes to install solar PV outside of the licensed boundary (i.e. on the roofs of terminals or other buildings or adjacent land) then there is ***no requirement*** for the aerodrome operator or developer to consult ***or*** notify CAA, nor seek CAA approval. However, engagement with the aerodrome/developer is advised so as to ensure the relevant safety issues have been fully considered. The CAA guidance is due to be updated after the FAA update theirs.

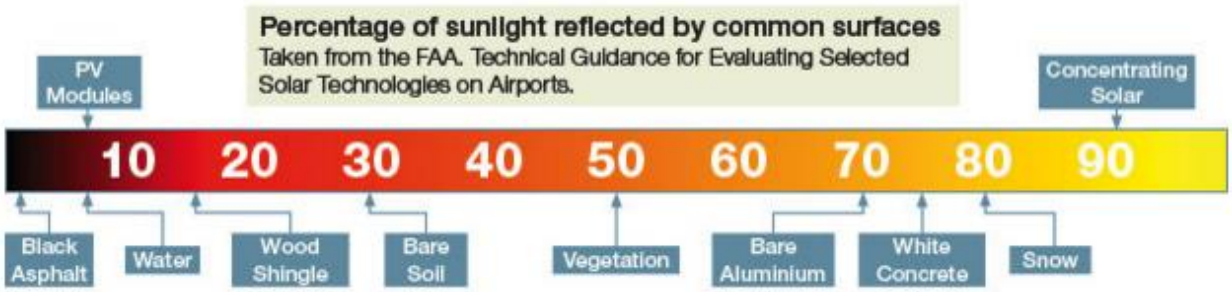
Glint and glare

Glint and glare refers to light reflected off smooth surfaces, either momentarily and intense (glint) or less intense for a more sustained period (glare). This could potentially have an impact in two areas:

1. Pilot distraction on take-off, landing or flight circuit
2. Air traffic controller distraction

The FAA guidance on this topic states: "solar PV employs glass panels that are designed to maximize absorption and minimize reflection to increase electricity production efficiency. To limit reflection, solar PV panels are constructed of dark, light-absorbing materials and covered with an anti-reflective coating. Today's panels reflect as little as 2% of the incoming sunlight." Evidence produced in the guidance shows that this is slightly more than black asphalt, about level with bodies of water, and much below bare soil, vegetation, rooftops, glass, snow or metal. However, the guidance finds that

"because the panels are a flat, polished surface, it is a reasonable assumption that most of the light is reflected in a specular way" different to a rough surface, potentially having an ocular impact.



(Diagram source)

Crucially, the FAA guidance finds that "solar installations are presently operating at a number of airports including megawatt-sized solar facilities covering multiple acres…. To date, there have been no serious complaints from pilots or air traffic control due to glare impacts from existing airport solar PV installations. Any potential problems in this area have apparently been resolved prior to construction through one or a combination of the strategies described above. The anecdotal evidence suggests that either significant glare is not occurring during times of operation or if glare is occurring, it is not a negative effect and is a minor part of the landscape to which pilots and tower personnel are exposed."

Pre-emptive and remedial strategies suggested by the FAA include:

- assessing baseline reflectivity conditions ("At airports, existing reflecting surfaces may include hangar roofs, surface parking, and glassy office buildings. To minimize unexpected glare, windows of air traffic control towers and airplane cockpits are coated with anti-reflective glazing and operators will wear polarized eye wear. Potential glare from solar panels should be viewed in this context.");
- tests in the field, i.e. moving , testing and altering the tilt of the panels ("For the two known cases where such a field test was conducted, the tower personnel determined that the effect of the glare produced by the solar panels was not significant");
- geometric analysis (similar to the glint and glare assessments widely used today).

Evidence gathered by the STA on glint and glare

As a starting point the STA contacted several experts in glint and glare analysis for solar around airports. This was then followed by a call for evidence (case studies) and further research specifically to find examples where glint and glare *has* caused a problem. There are hundreds, perhaps thousands of examples worldwide of solar PV installations operational on or around aerodromes. To demonstrate this a short list of examples of airports with large installations on aerodrome, next to runway or under flightpath is included below, which we believe to be only a small fraction of the total. However, while listing PV installations safely sited on or next to aerodromes adds to a growing list of anecdotal evidence to suggest glare is not a cause for concern, it is not a falsifiable test. This was the reason for searching for examples where glare from solar PV has caused a sustained issue.

Following our research we have found no examples of issues or sustained complaints arising on grounds of pilot distraction. This is demonstrable in the expert opinions and case studies below. We have found some evidence of complaints from air traffic controllers, one of these from an installation at Manchester-Boston regional airport, New Hampshire, USA. Air traffic controllers reported a patch of glare from panels for 45 minutes each morning, which was then resolved. No pilots or aircraft reported any issues with glare (link). Malcolm Spaven of Aviatica Ltd also suggested glare for air traffic controllers could potentially be a problem in some instances, but that this is easily remediable. See below for further information.

The other example we found was a solar array near Doncaster Sheffield Robin Hood Airport, which the airport opposed on several grounds including glare, specifically that PV would have an adverse impact on safety "through critical stage flight distraction or eye-damaging glare to air crews within aircraft operating in the vicinity." The array did not go ahead, though the local council's decision was based on concerns about potential impact on public rights of way close to the site: "The proposal fails to protect and enhance public rights of way or add additional links between Low Closes Turbary and the existing recreation network in Belton" (link). Another proposed installation near the flightpath of the Doncaster Sheffield Robin Hood Airport has been approved. The solar farm is now consented and operational (link).

Expert opinions

Below is a summary of conversations the Solar Trade Association has had with experts in this field.

Danny Scrivener, Technical Analyst, Pager Power Ltd - +44 (0)1787 319001

- Over 200 glint and glare assessments conducted for airports and developers – c.20 of these have been commercial rooftop, the rest ground mount
- None have led to the solar development being refused.
- Circa 80% have been passed without any need to revisit proposals – i.e. no risk of glare
- Circa 20% have needed revisiting, asking developer to consult airport on plans
- Maximum five projects have involved the airport asking the solar developer to revisit the scheme and work on the design. These projects have subsequently gone ahead, e.g. Hayle Farm and Woodtown Farm, a joint installation at the end of the runway of Bournemouth airport. Both installations completed in early 2016. The Sandia model for aviation glint and glare assessment was used. They altered the elevation angles to reduce impact.

Michael McGhee, Director, Neo Environmental - +44 (0)0141 773 6262

- Glint and glare assessments are currently required by the Planning Authority if the solar PV station is anywhere in the airfield/airport's safeguarded zone or within 30km of an airport.
- All Neo Environmental's glint and glare assessments have showed no problems so far. He also assesses impact on air traffic control and hasn't had any problems there so far.
- Within the safeguarded zone it is correct that buildings have to be within a certain height, so in theory CAA could have a concern with height but the reality is that the additional height from a solar PV station is so small it will never be a problem (more of a precautionary measure about an airport's authority on building in an airport's safeguarded zone).

Malcolm Spaven, Director, Aviatica Ltd - +44 (0)1875 830750

- There is no evidence that glint and glare is a significant issue for pilots and planes.
- Air traffic control towers with a solar PV installation to the North can reflect light towards controllers.
- A 3km exclusion zone is likely too excessive as it would exclude a lot of areas that would not pose any risk to the aerodrome.
- Glare can be mitigated by vegetation or slightly less reflective panels.
- Solar PV emits less glare than bodies of water, car windscreens and greenhouses.
- Spaven Consulting report: "No evidence could be found from existing solar energy projects around the world of any reported problems of glare affecting pilots. This includes many projects in the USA where the Federal Aviation Administration routinely assess such projects for potential glare impacts." (link)

Charles Morelli, Managing Director, AARDVaRC Ltd - +44 (0)1787 468539

- AARDVaRC has conducted 20 airport assessments and 50 non-airport assessments, solar PV has never been an issue and none of his findings have ever been challenged.
- Never seen a site refused planning permission due to glint and glare
- Never seen a sustained objection once the topic has been understood.
- He has seen instances of airports scaring off developers on grounds of glint and glare before assessments have been carried out. He feels this is a spillover of airports having had disputes with the wind industry.
- FAA guidance is originally based on evidence from studies conducted by the US Airforce on the effect of flash blindness on their pilots from nuclear flash. The guidance states that flash blindness can be caused at levels of 650-1,100 lumens/m^2, which on a quick internet search shows up as levels equivalent to "an overcast day; typical TV studio lighting" (link). According to AARDVaRC, the real problem with flash blindness is not the level of light itself, but on stepping quickly from areas of low light to high light without time for your eyes to tune (e.g. stepping from shadow directly into a bright light). From the perspective of a pilot, being in the open sky, unless an overcast day with shadow from cloud cover (and no sun), aircraft do not fly in shadow. If facing the sun, the lux from the direct sunlight will far outshine the lux from glare from PV panels (solar panels reflect 2% of light).

Case studies

Examples of airports with large installations on aerodrome, next to runway or under flightpath (this is based on a brief scoping exercise, and we believe the list to be a small fraction of the total):

- Gatwick (50kW 150m from runway)
- Heathrow – floating array on Thames QEII reservoir (6.3MW under flightpath)
- Belfast International (4.8MW adjacent to airport)
- Stanstead airport (2.5MW)
- Photon - Birmingham Airport (50kW on terminal)
- Southend Airport – (120kW on terminal and 5MW under landing flightpath)
- Birmingham Airport (50kW terminal roof)

- East Lanford, Cornwall (5MW)
- Dunsfold Aerodrome, Surrey (2MW)
- Cornwall Newquay airport (5MW)
- Prestwick airport (50kW)
- Manston Airport (large solar farm 1.2km from runway 28 threshold)

- San Francisco (0.5MW on terminal)
- Oakland (6000 panels on terminal)
- Denver (11MW)
- Boston
- Indianapolis (12.5MW)
- Fresno Yosemite Airport (2MW on site)
- Las Vegas
- Los Angeles
- Chattanooga Airport USA (5 acre array on aerodrome)
- Nellis Air Base Nevada (15MW)
- Kramer Junction, Victorville, CA, USA
- Blythe, CA, USA
- Pena Boulevard, Colorado, USA
- Bakersfield, CA, USA
- Oakland Airport, CA, USA
- Albuquerque Airport, NM, USA
- Boston Logan Airport, MA, USA
- San Jose Airport, CA, USA
- Houston Airport, TX, USA
- Prescott Airport, AZ, USA
- Yuma Airport, AZ, USA
- Ben Gurion Airport, Israel
- Adelaide Airport, Australia
- Ancona Falconara Airport, Italy (45kW on roof surrounding control tower)
- Athens International in Athens, Greece (8MW on aerodrome)
- Cochin International Airport, India (12MW)
- Munich
- Saarbrucken, Germany (1.4MW)
- Zurich
- Changi
- Stuttgart

Non-glare issues arising from solar PV on and around airports

Blocking of flightpaths

The FAA technical guidance note says “due to its broad authority to protect airspace, the FAA must be given data to review any construction or alteration on a public use airport regardless of height or location”. It then states “solar panels, when tilted properly to the south-facing sun, extend to a height

of as little as three feet above the ground making it possible for siting close to runways without penetrating an imaginary surface. The low profile of solar panels allows for greater flexibility in finding the most appropriate location on the airport for electricity generation." We understand this to mean authorisation is to be given as a precautionary measure, but solar generally does not interfere with airspace. Note also that the proposal from the Scottish Government is for roof-mounted solar, which on a pitched roof will add only a few inches to the roof height, and on a flat roof will add less than one metre without accounting for other objects on the roof. After our own research and asking experts in the industry we have found no examples of issues or complaints arising on these grounds. It is thought that complaints in this area are a consequence of disputes over wind energy.

Interference with communications equipment

The FAA technical guidance states that "studies conducted during project siting should identify the location of radar transmission and receiving facilities and other NAVAIDS, and determine locations that would not be suitable for structures based on their potential to either block, reflect, or disrupt radar signals. Due to their low profiles, however, solar PV systems typically represent little risk of interfering with radar transmissions. In addition, solar panels do not emit electromagnetic waves over distances that could interfere with radar signal transmissions, and any electrical facilities that do carry concentrated current are buried beneath the ground and away from any signal transmission." After our own research and asking experts in the industry we have found no examples of issues or complaints arising on these grounds. It is thought that complaints in this area are a consequence of disputes over wind energy.

Conclusions

The STA is not an expert in either aviation or glint and glare. This paper is only intended as a basic summary of the evidence available, and further work could be done to investigate the issue. However, from the evidence we have seen so far the STA does not believe that there is cause for concern in relation to the impact of glint and glare from solar PV on aviation and airports, nor relating to infringement on airspace or interference with communications equipment. Solar PV panels are designed to absorb not reflect light, and their level of reflectivity is lower than that of other objects commonly visible on and around aerodromes, e.g. metal roofs, glass windows, cars, and bodies of water. Permitted development rights already exist for domestic roof-mounted PV adjacent to airports, with no reported issues, although these are much smaller sized systems. Under Article 221 of the Air Navigation Order a mechanism exists to address glare post hoc if it emerges as a problem.

Further Resources

BRE National Solar Centre 'Planning guidance for the development of large scale ground mounted solar PV systems' (link)

South Somerset Council Planning: "As stated previously, photovoltaic panels are designed to absorb light and not to reflect it. They have a smooth surface, however, which means that incident light from a specific direction is reradiated in a specific direction. This means that photovoltaic panels can cause reflections which are considerably less intense than direct sunlight. Photovoltaic panels typically reflect 2% of incident light." (link) I.e. generally, it is rare for aircraft to fly through areas of glint, due to

the specific angles needed from the sunlight. Where it does occur it is much less intense than direct sunlight.

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