AERODROME SAFEGUARDING ADVICE NOTICE

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Subject:	Renewable Energy Developments
Action required:	For Information

1. Introduction

Aerodrome safeguarding ensures the safety of aircraft and their occupants when in the vicinity of an aerodrome by controlling potentially hazardous development and activity around it. For an overview of the safeguarding process see Advice Note 1 ‘Aerodrome Safeguarding – An Overview’, available at [CAST publications | Civil Aviation Authority (caa.co.uk).](https://www.caa.co.uk)

The types of renewable energy that are known to have an impact on aviation are: solar energy, wind and renewable energy plants. Developers of renewable energy projects should consult early with the respective authorities and any affected aerodromes. This advice notice highlights the potential issues that should be considered.

2. Impact of Solar energy on Aviation

Large-scale solar energy developments on, or off-aerodromes are increasing. In certain situations, the surfaces of the solar energy systems can reflect sunlight and produce glint and glare.

In addition to glint and glare, there are other considerations such as engine failure after take-off (EFATO), physical safeguarding, effects to rescue and firefighting services and wildlife. The potential Electromagnetic Interference (EMI) effects upon CNS (Communication, Navigation & Surveillance) may also be a consideration.

In all instances, where a developer is proposing an on or off-aerodrome solar energy development, early consultation with the aerodrome authority is recommended.

2.1 Safety Considerations

Safety considerations should be assessed in relation to Air Traffic Services (ATS) personnel, pilots and CNS equipment:

- **ATS personnel** – The control tower (if applicable) is the most important location for visual surveillance across an aerodrome for monitoring operations on the ground as well as in the air. It is therefore of critical importance that the development of solar energy does not significantly hinder the view from a control tower's visual control room (VCR).

- **Pilots** – A pilot's ability to safely navigate the airspace around an aerodrome is paramount. A pilot is required to look for other aircraft and obstructions on the ground, as well as navigate towards a runway or reference points. This applies to both pilots of fixed wing aircraft and helicopters in the air, and sometimes on the ground. The standard operations that should be considered are:

    - Pilots on approach
    - Pilots in a visual circuit
    - Pilots on the ground (departing and taxiing aircraft)

- **CNS equipment** – Where CNS infrastructure is present, consideration of specific safeguarding criteria may be required to safely develop solar energy. There may be a requirement to apply a setback distance to nearby solar panels, or other mitigation measures.

2.2 Safety Impacts

2.2.1 Glint & Glare

A key safety concern when considering a solar energy development on- or off-aerodrome is commonly referred to as 'glint and glare' caused by reflections of sunlight from the array. 'Glint and Glare' is the general term used to describe the reflection of sunlight from a reflective surface, typically one that can produce specular solar reflections.

The definition of glint and glare is as follows:

- **Glint** – A momentary flash of bright light typically received by moving receptors or from moving reflectors.
- **Glare** – A continuous source of bright light typically received by static receptor or from large reflective surfaces.

Typical surfaces that are considered with respect to glint and glare are glass, metallic structures e.g. roofs and solar panels. The orientation of a solar panel (azimuth and elevation angle) as well as its height will determine whether glint and glare effects are possible towards the assessed receptors.

It is essential to conduct an aviation perspective glint and glare assessment when a reflective surface is to be located on or immediately adjacent to an aerodrome. In most cases, an assessment should be undertaken for a solar energy development which is being proposed within a specific distance from an aerodrome as determined by the aerodrome authority. For many aerodromes, 5km is the distance of choice but it could be considered out to 10km. In exceptional circumstances assessments may be required beyond 10km.

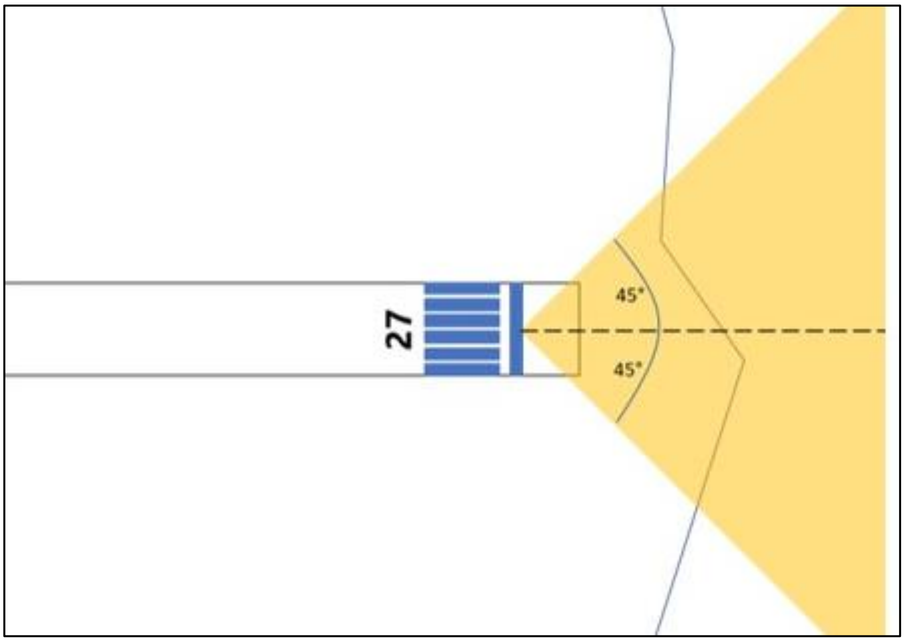
The UK CAA and US FAA have produced guidance with respect to glint and glare, however, neither of them mandates a specific methodology for assessing the effect of glint and glare.

The effects of glint and glare may mean that some solar energy developments are unacceptable, however layout modifications such as changes to panel tilt, panel type, and elevation angle can often alleviate these concerns and overcome objections. The benefit of early consultation with the aerodrome authority cannot be understated.

2.2.2 Engine Failure after Take-Off (EFATO)

An engine failure after take-off (EFATO) may result in an aircraft having to conduct a forced landing in an area around the aerodrome, often off the end of a runway and often not within the aerodrome's land ownership. Following an EFATO, it is recommended that a pilot does not conduct a turn greater than 45 degrees straight ahead to ensure airspeed and height are maintained as much as possible to facilitate a safe forced landing.

There is no defined safeguarding area for an EFATO, however, considering the above, an area extending 45 degrees either side of the extended runway centreline can be established, and this is shown below. There is no given distance for this area and the image is not to scale.



EFATO zone based on recommended aircraft manoeuvres

Given there is no official safeguarding criteria for safeguarding against an EFATO even for licensed or certificated aerodromes, the safeguarding of this area must be considered reasonably and pragmatically by both an aerodrome operator and a solar developer. Both parties are likely to benefit from the implementation of a cooperative solution that can accommodate an EFATO area. The benefits being:

- The aerodrome will benefit because it will reduce the risk of collision in the unlikely event that an EFATO occurs;
- The developer will benefit as there is a lesser risk of damage to a solar PV development if an EFATO (or other aviation accident) occurs.

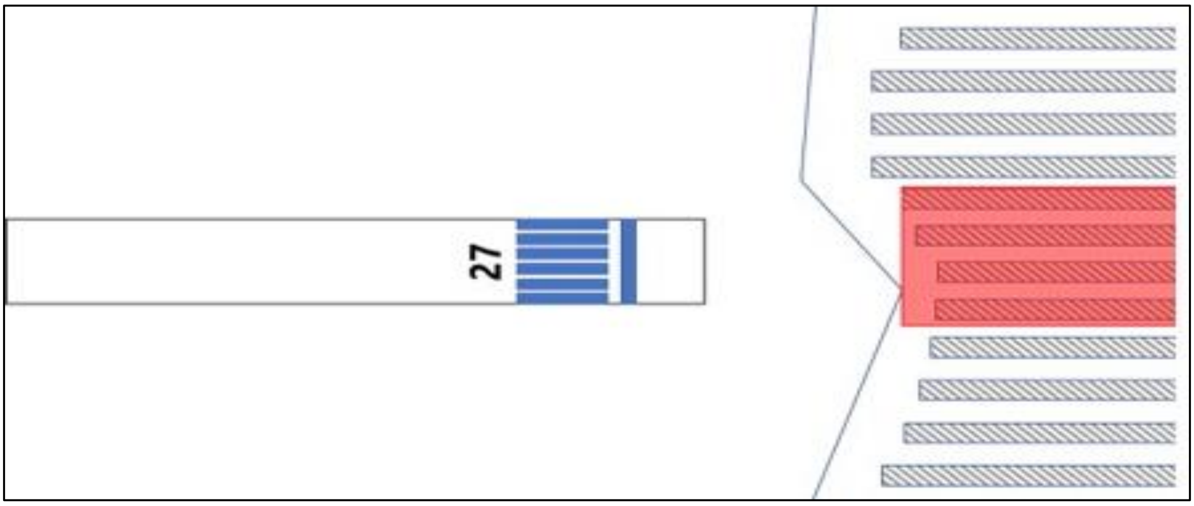
On this basis, a designated EFATO safeguarded area could be considered for any proposed solar energy development that is to be located along the extended runway centre line (dashed line as per the image above).

Considerations of the size and scale of this zone should include:

- Specific aerodrome operations
- Availability of additional land for use in an EFATO should the solar energy development be built
- Size and scale of the solar energy development

- Distance of the solar energy development from the runway threshold
- Frequency of air traffic movements
- History of air traffic incidents
- Availability of other runways

The image below shows an example of where solar panels are proposed along the extended runway centreline (rows of blue/grey diagonally filled zones). The panels with the red area may be omitted for the benefit of aviation safety in the event an EFATO occurs. It is also potentially limiting risk to the solar PV developer.



Potential exclusion zone for solar development (image not to scale)

2.2.3 Physical Safeguarding

For the most part, it is unlikely that a solar PV development will infringe an Obstacle Limitation Surface[1] (OLS) due to their typically low mounting height when located on the ground (typically up to 3m for static panels, 1-2m more if tracking). However, when locating solar panels on a roof or near a runway, infringements are possible. Infringements of the 'Approach', 'Take-Off Climb' and 'Transitional' surfaces are most likely for ground mounted PV. The possible surface affected by roof mounted panels would depend on the size and location of the building. There will almost certainly be the presence of an Obstacle-Free Zone (OFZ) near the runway whereby all objects should be mounted to a frangible structure, with any such objects being essential to aviation operations, for example runway lights.

[1] The OLS completely surround the airport and generally extend out to 15km, however this can vary. They are designed to protect aircraft from obstacles when manoeuvring on the ground, taking off, landing or flying in the vicinity of the airport. It is important that these surfaces are not infringed by development. https://www.caa.co.uk/combined-aerodrome-safeguarding-team-cast/frequently-asked-questions/

Careful consideration should be made when mounting panels near to a runway or on buildings that are already close to the limit of the OLS.

An OLS assessment can be undertaken for unlicensed and licensed / certificated aerodromes, with these surfaces being strictly applicable to licensed / certificated aerodromes. Ensuring there is no breach of any applied surface can bring benefits to both the operations at an unlicensed aerodrome and reduce risks for a solar energy developer. For licensed and certificated aerodromes, any infringement would likely be unacceptable unless a suitable safety case is made, or the principle of shielding has been applied through review of other obstructions such that no significant operational impact is expected.

There will be enhanced safety implications where ATS personnel have comprehensive views over an aerodrome. Therefore, if a proposed solar energy development is predicted to affect visibility from a visual control room, there will likely be concerns from an aerodrome operator.

Impacts to Instrument Flight Procedures (IFPs) could also be possible if the solar energy development is located in an operationally sensitive location. Early liaison with the aerodrome authority will likely reveal any issues with installations of height impacting IFPs. See Advice Note 1 ‘Aerodrome Safeguarding an Overview’ for further details available at CAST publications | Civil Aviation Authority (caa.co.uk).

2.2.4 Birds and Wildlife

The potential for solar panels to attract nesting birds or other wildlife should be a consideration when developing a solar array. For birds, the risk is mostly associated with bird strike, whereby a bird collides with an aircraft. Of greatest concern is large bird species, however, large numbers of small birds can also cause a problem. For other land-based fauna, the concerns are typically the intrusion to operational areas e.g. entering the runway or taxiways and collision with aircraft.

The typical concerns include birds using the solar array as a potential nesting site. For both birds and land-based fauna, they may also use the array for shelter. Separately, both may be attracted to the planting associated with the biodiversity improvements across a site as part of the solar development. The requirement to enhance biodiversity could lead to an increased number of fauna if the location and type of flora to be planted is not considered carefully.

A developer should therefore consider:

- The type/species of planting
- The location of planting
- Having a wildlife hazard management plan in place

The aim of a developer should be to not encourage any birds or wildlife that may affect aviation safety and therefore certain steps may need to be taken to avoid encouraging certain species onto the site of a solar development. See Advice Note 3 'Wildlife Hazards Around Aerodromes' for further details available at [CAST publications | Civil Aviation Authority (caa.co.uk)](https://www.caa.co.uk).

2.2.5 Rescue and Firefighting Services (RFFS)

Developers / aerodrome operators should be aware of the potential hazards to RFFS from a solar panel/ Battery Energy Storage Systems (BESS) installation which can be categorised as:

- Fire and explosion
- Electrical
- Stored energy (BESS)
- Physical
- Chemical

These hazards should be considered for RFFS because they impact RFFS's ability to protect the environment when firefighting and should be identified as part of the planning process. Furthermore, the aerodrome operator should be familiar with the water runoff/containment and site access arrangements as part of the installation.

Developers in conjunction with the aerodrome operator should ensure adequate and suitable surfaces and routes are provided for emergency vehicles as part of the site access arrangements especially if off-aerodrome.

RFFS personnel should have an understanding of the "safe design" concept regarding such installations and the guards and protective devices that have been installed. It's essential that RFFS have access to information about how the facility operates.

2.2.6 Communication, Navigation & Surveillance

Solar panels are relatively passive pieces of equipment. The DC-power that they create is converted to AC-power. The DC-power cabling and the inverters used can create electromagnetic interference (EMI).

Poorly wired cable looms are a prime source of interference. Certified inverters can, despite their certification, still generate interference at various frequencies. The frequency range that is most susceptible to interference is 100 to 200 MHz which may affect aeronautical radio frequencies dependent on the location of the development. Aerodrome operators should assure themselves that there is no risk of electromagnetic interference affecting any part of their ATS infrastructure (if applicable).

Simplistically, electromagnetic interference is produced by varying voltage and/or current through an electrical system which in turn produces an electromagnetic field around its location of origin. This field can impact upon other electronic infrastructure however most commercial electronic equipment is built to national and European standards whereby EMI would not be expected. It may however be a consideration where equipment that operates with high voltage or current is proposed next to CNS equipment.

As an initial assessment, it is worth considering the safeguarding surfaces defined within the relevant Civil Aviation Publication (‘CAP 168: Licensing of Aerodromes’ available at www.caa.co.uk) or ICAO DOC 015. ICAO guidance dictates Building Restricted Areas (BRAs) around CNS equipment. Similar guidance is also presented within ‘CAP 670: Air Traffic Services Safety Requirements’ available at www.caa.co.uk. The results of this type of assessment may have implications upon the panel layout and height, however it is anticipated that the requirement for this type of assessment is limited mostly to on-aerodrome developments or those located close to a navigation aid.

Early contact and liaison with the aerodrome authority will allow for the identification of potential issues and thus the need or otherwise of assessment.

2.2.7 Aerodrome Operator Safety Assurance

The aerodrome operator in conjunction with any ATS personnel should, as part of the change management process in their safety management system, consider all the potential hazards posed by solar energy developments / BESS on or in the vicinity to their aerodrome and within the aerodrome’s physical and technical safeguarded areas, in order to ensure the safety of the overall operation. The developer should provide the aerodrome with a safety survey which should include:

- a glint and glare survey when a development is within a distance specified by the aerodrome from an Aerodrome Reference Point (ARP) (5km in most cases)
- impacts to CNS facilities (if applicable) up to a distance specified by the aerodrome (typically 6km) from the ARP
- A wildlife hazard safety assessment

In addition to the safety survey, developers should provide the aerodrome operator and / or ATS provider with adequate technical and safety assurance documentation which addresses the safety impacts provided in sections 2.2.1 to 2.2.6. Further consideration may be given to the following:

- turbulence
- thermal plume
- 1000m off aerodrome RFFS response areas
- access routes for fire and rescue vehicles
- passenger evacuation
- damage to aircraft slides impeding passenger self-evacuation
- electrical hazards
- interference with CNS equipment and meteorological equipment
- HV cable routes which may interfere with compass swing bases or other
- sensitive items
- any lighting employed on the development
- frangibility of structures (where required)
- site fire risk and prevention measures

The aerodrome operator should also ensure both impact and safety assessments are undertaken to provide assurance that any on- or off-aerodrome planned development does not introduce unacceptable hazards to aircrew, ATS personnel, RFFS and aerodrome vehicle operators undertaking their tasks. As part of the aerodrome and or ATS change management process, safety assurances should take into account any potential adverse effect to critical ATS infrastructure and equipment. The assessment should also consider any impacts to aircraft utilising instrument flight procedures and aircraft in the visual circuit.

The developer in conjunction with the aerodrome operator, ATS personnel, RFFS and aerodrome operations should seek to develop adequate mitigation to mitigate any risks identified.

Developers should apply the same principles for safety assurance for unlicensed aerodromes and airfields as they would for licenced or certificated aerodromes.

3. Impact of Wind Turbines on Aviation

Wind Turbine developments have the potential to impact on aviation interests in a number of ways. Further guidance for aviation stakeholders, wind energy developers and Local Planning Authorities (LPAs) when assessing the viability of wind turbine developments is available within 'CAP 764: Policy and Guidelines on Wind Turbines' available at www.caa.co.uk. Useful information can also be found in 'EUROCONTROL Guidelines for Assessing the Potential Impact of Wind Turbines on Surveillance Sensors' available at www.eurocontrol.int.

Aviation stakeholders should review wind turbine development proposals within a minimum of a 30km radius or in the vicinity of a civil aerodrome. The individual aerodrome operator and air navigation service provider should be consulted by the Local Planning Authority.

3.1 Physical Impact

The height of wind turbines can potentially infringe aerodrome safeguarding surfaces. Further information is given in Advice Note 1 'Aerodrome Safeguarding – An Overview', available at CAST publications | Civil Aviation Authority (caa.co.uk).

Similarly, cranes and other tall equipment might require permission when used in the construction of wind turbines. Further information with regards to the construction process is available in Advice Note 4 'Cranes and Other Construction Issues' available at CAST publications | Civil Aviation Authority (caa.co.uk).

The addition of aviation warning lights or marking of obstacles and tall structures is intended to reduce the hazards to aircraft. The aerodrome safeguarding process will determine whether a wind turbine(s) will need to be fitted with one or more obstacle lights. This is applicable to temporary obstacles such as cranes or anemometer masts in addition to permanent structures. For further information please refer to Advice Note 2 'Lighting Near Aerodromes' available at CAST publications | Civil Aviation Authority (caa.co.uk).

Guidance with regard to obstacle lighting requirements can be found in CAA Publication 'CAP 764: CAA Policy and Guidelines on Wind Turbines' available at www.caa.co.uk.

Anemometer masts installed to test wind conditions prior to the installation of a wind turbine(s), should be assessed individually by the aerodrome operator in relation to aerodrome safeguarded protected surface infringements and obstacle lighting. Permission for anemometer masts does not preclude the requirement for wind turbine development proposal assessments.

Any tall and narrow profile structures located in areas used for military low flying are assessed and managed separately by the Ministry of Defence.

3.2 Technical Impact

3.2.1 Radar and Electronic Aids to Air Navigation

There are two principal types of radar system in use at aerodromes - Primary Surveillance Radar (PSR) and Secondary Surveillance Radar (SSR) and both systems can be impacted by wind turbines.

In order to determine whether the wind turbine development will have an impact on radar performance, a line of sight (LOS) assessment is a useful basic indication. However, to ascertain whether a turbine is likely to be detected by a radar, a propagation assessment will be required. This study can be carried out by NATS En Route for the radars they operate or by other specialist organisations. Such an assessment will consider a number of factors such as: terrain profile, maximum height of the wind turbines, signal levels and operational range of the radar.

In low visibility conditions pilots are entirely dependent on the accuracy of the information displayed on the instruments in the cockpit to navigate and land aircraft. Similarly, air traffic controllers rely on the accuracy of the information displayed on radar screens to maintain safe separation between aircraft. It is essential, therefore, that this information has not been distorted by interference to the radio signals involved in the operation of the navigation aids.

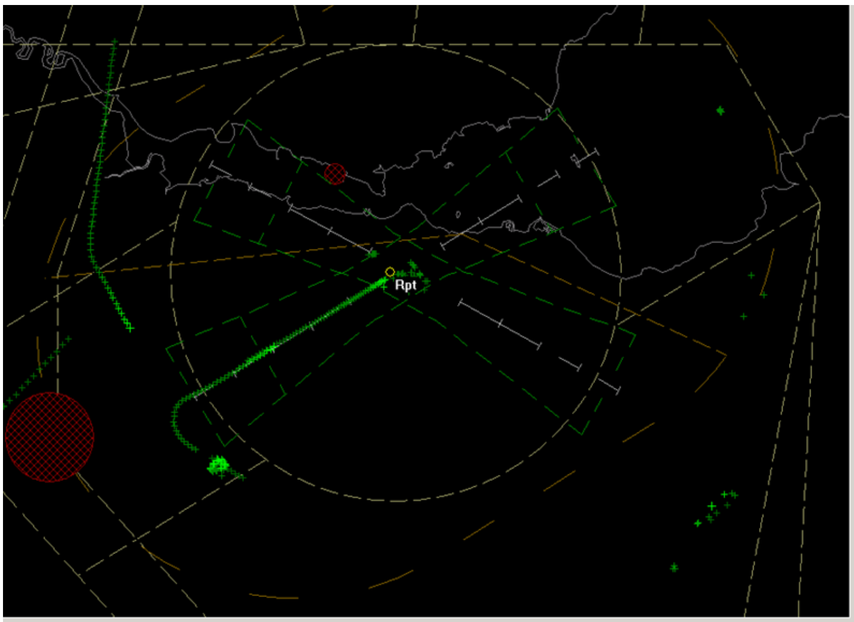
Signal processing can be used to filter buildings, birds, weather, and other objects and prevent them from producing radar returns on the screen – so-called radar ‘clutter’ but, this is not effective in reducing returns from wind turbine blades. Experience of wind turbine developments that have been constructed show that the turbine blades will regularly produce radar returns that are identical to and easily confused with, those produced by small or slow-moving aircraft. In addition, radar clutter produced by the turbines can mask any aircraft within the airspace above the wind turbine development that is not using SSR.

3.2.2 Primary Surveillance Radar (PSR)

PSR systems send out pulses of energy which are reflected back to the radar head and the position of objects detected is plotted on the radar screen. These primary 'returns' show only the position of an aircraft or any other object that is detected by the radar system and not the height.

PSR can be affected by wind turbines and may produce moving radar returns on the radar screen when the turbine blades are 'visible' to the radar head. The apparent movement of the turbines is caused by the rotation of the turbine blades 'confusing' the PSR circuitry and bypassing the radar filtering, just as real moving targets (i.e aircraft) do.

Aerodromes will often raise concerns to any wind turbine proposal within (radar) line of sight of its PSR equipment. Whether an objection will follow will depend on several site specific factors including (but not limited to): the location and size of the development, the amount of 'clutter' it is likely to generate, the rules relating to the operation of the airspace, how heavily the area is trafficked, the proximity to potential areas of conflict such as glider or GA facilities or other wind turbines and, ultimately the controllers perception on whether they consider safety would be compromised. Each wind turbine proposal must therefore be assessed on its own merits.



Example of Clutter on a Radar Screen

3.2.3 Secondary Surveillance Radar (SSR)

SSR systems send out an interrogation signal to a transponder, a piece of equipment located on board the aircraft. The on-board equipment responds with a signal that produces both the position of the aircraft and other data such as height and identification data.

The propagation of the SSR radar signal in space can be affected by wind turbines where the wind turbine structures are sufficiently close. Civil aerodromes may raise concerns to wind turbine developments inside this distance if the turbines are also within (radar) line of sight of its SSR equipment.

3.2.4 Wind Turbine Wake turbulence

Depending on the size of the wind turbine rotors a wind turbine can generate wake vortices that might potentially generate risks to nearby flying aircraft.

Wind turbine wake turbulence guidance is provided in ‘CAP 764: Policy and Guidelines on Wind Turbines’ available at www.caa.co.uk.

3.3 Mitigation Solutions

A number of mitigation solutions have been developed to mitigate the effect of wind turbines on radar performance. Each proposal needs to be assessed individually to determine the best solution that can be implemented depending on the location and type of degradation. Several mitigation solutions are available and can be categorised in several key types: workarounds, in-fill radar, 3-dimensional radars, high PRF radars, use of spectrum filters, predictive and multi-sensor trackers or use alternative technologies, less susceptible to wind turbine interference, and stealth technology.

The analysis and acceptance of the mitigation solution rest with the airport licence/certificate holder (or aerodrome operator at military aerodromes) and it needs to consider present and future implications on their operations. Guidance for the ANSPs is detailed in Civil Aviation Authority (CAA) Publication ‘CAP 764: Policy Guidance on Wind Turbines’ and ‘CAP 670: Air Traffic Services Safety Requirements’ available at www.caa.co.uk.

4. Impact of Renewable Energy Plants

Biomass and biogas plants have the potential to pose a risk to the safety of flight by their physical height, bird attraction, visual impacts of vapour and, by the production of gasses which create thermal plumes.

4.1 Physical Impact (Aerodrome Safeguarded Surfaces)

Depending on the location of the Biomass / Biogas energy development, infringements of the safety clearances against aerodrome safeguarded surfaces should be assessed by the aerodrome operator, especially as proposals can use high stacks for the plant. Power plants can also present a physical obstruction to radar and other communication signals.

4.1.1 Thermal Plume Turbulence

Thermal plume turbulence is caused by the release of hot air from a power plant. The thermal plume rises causing upward moving air turbulence. As aircraft pass within the vicinity of the structure they could become subject to the turbulence without warning. Modelling tools are available to assess and model any potential impact on air safety, it is recommended that such tools are utilised when doing safety assurance assessments.

4.1.2 Visual Impacts of a Vapour Plume

Vapour plumes produce a vapour cloud that can result in localised visual impairment to pilots who rely on the ability to see clearly during visual conditions.

4.1.3 Radar Clutter

Thermal plumes can cause clutter on the radar screen which may affect the accuracy of detection for aircraft. A radar clutter impact assessment should be taken if the location is close to the approach areas for the aerodrome.

4.1.4 Birdstrike Avoidance

Due to the materials used at Biomass and biogas plants they may attract species of birds that are hazardous to aircraft; therefore, operators of the plants may be required by a nearby aerodrome to employ effective bird hazard management practices.

This advice note has been revised and updated by the Combined Aerodrome Safeguarding Team (CAST) from that produced by the Airport Operators Association (Safeguarding Working Group) with the support of the CAA. Its contents may be reproduced as long as the source is acknowledged.

Further CAST Safeguarding Information is available at https://www.caa.co.uk/combined-aerodrome-safeguarding-team-cast/.