

13 Aviation, Radar and Other Issues

13.1 Introduction

- 13.1.1 This chapter assesses the potential effects of the proposed development in relation to:
- Aviation, Radar & Defence;
 - Television and Telecommunications; and
 - Shadow Flicker.
- 13.1.2 Elements relating to Major Accidents and Disasters have been addressed in the individual technical discipline chapters where relevant.
- 13.1.3 Impacts on Population and Human Health have been addressed in the individual EIA topic chapters where relevant.
- 13.1.4 This assessment has been undertaken by the applicant.

13.2 Aviation, Radar & Defence

Introduction

- 13.2.1 This section of the chapter considers the likely significant effects on aviation and radar associated with the construction, operation and decommissioning of the proposed development. It also considers the likely effects on the Eskdalemuir Seismic Array (EKA) associated with the construction, operation and decommissioning of the proposed development.
- 13.2.2 The assessment of potential effects on aviation and defence considers technical acceptability, based on air navigation safety, rather than following a strict EIA process of assessing the significance of effects. Such effects often require the implementation of technical mitigation solutions to ensure continued safe operation in the presence of a wind farm. The assessment of effects on these receptors is therefore one of technical analysis and consultation and seeks to identify whether the effect is likely to be 'acceptable' or 'not acceptable' to air navigation services provision.

Statement of Competence

- 13.2.3 The aviation, radar and defence assessment was conducted by Sam Johnson of RES. Sam is the Senior Aviation Manager at RES, with an MMath in Mathematics. Sam has over 20 years' experience in the radar industry with over 15 years specifically in the

area of wind farms. Sam is a member of the Renewable UK Aviation Working Group and is Chair of Aviation Investment Fund Company Limited (AIFCL).

Guidance

- 13.2.4 This assessment has been prepared with reference to Civil Aviation Authority (CAA) Publication (CAP) 764, Policy and Guidelines on Wind turbines (CAA, 2016). This is the primary guidance in relation to the assessment of wind turbines on aviation in the UK.

Scope of Assessment

Effects Scoped Out

- 13.2.5 Interference with surveillance systems and radar can occur when wind turbine blades are moving, therefore potential effects during construction are not assessed.
- 13.2.6 Upon decommissioning, the Ministry of Defence Geographic Centre (AIS Information Centre) will be informed of the removal of wind turbines. Following this, no decommissioning effects are expected and are not considered further.

Effects Assessed in Full

- 13.2.7 The assessment identifies and considers the potential effects that the proposed development may have on civilian and military aviation, air safeguarding and EKA and, if required, the mitigation measures proposed to prevent, reduce or offset any potential adverse effects where possible.
- 13.2.8 In relation to military and civil aviation assets it considers potential impacts on the military Air Traffic Control (ATC) Radars at RAF Spadeadam; Deadwater Fell and Berry Hill, the NATS En Route Ltd (NERL) radar at Lowther Hill and nearby airports, and the potential mitigation measures identified to address these.
- 13.2.9 Impacts on the EKA are also considered.
- 13.2.10 The assessment is based on an evaluation of existing data sources and desk studies, and consultation with key stakeholders.
- 13.2.11 The effects of wind turbines on aviation interests are well known but the primary concern is one of safety. The two principal scenarios that can lead to effects on the operations of aviation stakeholders are:
- physical obstruction: wind turbines can present a physical obstruction at or close to an aerodrome or in the military low flying environment, which itself presents a health and safety risk or otherwise requires changes to flight routes in the area which brings about other operational effects; and

- radar/air traffic services (ATS): wind turbine clutter appearing on a radar display can affect the safe provision of ATS as it can mask unidentified aircraft from the air traffic controller and/or prevent them from accurately identifying aircraft under control. In some cases, radar reflections from wind turbines can affect the performance of the radar system itself.

13.2.12 In this context the scope of the assessment is to consider the impact of the proposed development on aviation stakeholders, including military, en route, airports and other airfields, radar systems and air space users. This assessment also considers civil and military stakeholder aviation obstruction lighting requirements.

13.2.13 As standard, the Ministry of Defence (MOD) and the Defence Geographic Centre (AIS Information Centre) will be provided with the following information for incorporation on to aeronautical charts and documentation:

- the date of commencement of the proposed development.
- the exact position of the wind turbine towers in latitude and longitude;
- a description of all structures over 300 feet high;
- the maximum extension height of all construction equipment;
- the height above ground level of the tallest structure; and
- details of a visible and/or infrared aviation lighting scheme.

Baseline Characterisation

Study Area

13.2.14 Consideration is given to aviation infrastructure that is within operational range of the proposed development. Operational range varies with the type of infrastructure but broadly includes regional and military airports operating radar within 30 - 40km of the proposed development, non-radar aerodromes within 17km, parachute drops zones within 3km, and military radar and en route radar systems up to 100km from the proposed development (dependent on operational range).

Desk Study

13.2.15 The applicant has a dedicated aviation manager who has provided input to the proposed development since its inception. This has included:

- civil and military radar line of sight (LoS) analysis;
- review of relevant aviation charts;
- review of military low flying charts; and
- general aviation advice based on prevailing civil and aviation issues
- proximity to EKA.

Significance Criteria

13.2.16 Significance criteria for aviation impacts are typically difficult to establish; they are not strictly based on the sensitivity of the receptor or magnitude of change but on whether the industry regulations for safe obstacle avoidance or radar separation (from radar clutter) can be maintained in the presence of the wind turbines.

13.2.17 Any anticipated impact upon aviation stakeholders which results in restricted operations is therefore considered to be of significance.

Assessment Limitations

13.2.18 No limitations have been identified that would affect the findings of the assessment, based on the information available at the time of writing.

Consultation

Table 13.1: Consultation Responses relating to Aviation, Radar & Defence

Consultee and Date	Scoping / Other Consultation	Issue Raised	Response / Action
Defence Infrastructure Organisation (16.05.22)	Scoping	<p>The proposed development is in the vicinity of sites used by the RAF Spadeadam electronic warfare tactical training facility and may cause unacceptable interference to the operation of threat radars that can be deployed at these sites.</p> <p>The turbines will be approximately 34.7km from, detectable by, and will cause unacceptable interference to the ATC radar at RAF Spadeadam Berry Hill.</p> <p>The turbines will be approximately 36.4km from, detectable by, and will cause unacceptable interference to the ATC radar at RAF Spadeadam Deadwater Fell.</p> <p>The airspace over the UK land mass is used to provide the UK Military Low Flying System to deliver essential military low flying training. The development site occupies Tactical Training Area 20T (TTA 20T). The proposed turbines will impact upon military low flying training activities conducted in this area.</p> <p>This site is within the statutory consultation zone of the seismological recording station at Eskdalemuir (the array), a UK asset that contributes to the</p>	<p>The Defence Infrastructure Organisation (DIO) indicated a potential impact on threat radars and two ATC radars at RAF Spadeadam; Deadwater Fell and Berry Hill. The MOD will be consulted to ascertain the extent of the impact on the radars and agree a suitable scheme of mitigation.</p> <p>The DIO indicated that the proposed site lies within a low flying tactical training area. The MOD Low Flying team will be consulted to agree a suitable aviation lighting scheme if deemed necessary.</p> <p>While not specifically an aviation issue, the DIO also safeguards the EKA. There is no available noise budget for new wind farm developments, but RES is a</p>

Consultee and Date	Scoping / Other Consultation	Issue Raised	Response / Action
		<p>Comprehensive Nuclear Test Ban Treaty. Research has confirmed that wind turbines of current design generate seismic noise which can interfere with the operational functionality of the array. In order to ensure the United Kingdom can continue to implement its obligations in maintaining the Comprehensive Nuclear Test Ban Treaty a noise budget, based on the findings of research for the 50km radius surrounding the array, is managed by the MOD.</p> <p>At this time, there is no noise budget available. Therefore, this proposed wind energy development will be of concern due to the impact upon the array.</p>	<p>member of the Scottish Government Chaired Eskdalemuir Working Group that is working towards a solution.</p>
Carlisle Lake District Airport Limited (10.05.22)	Scoping	Carlisle Airport confirmed they have no objection to the proposed development.	No further action required.
Newcastle International Airport (14.09.22)	Scoping	The eastern edge of the proposed development is approximately 45 nautical miles west of the Airport and sits outside of the Declared Operational Coverage (DOC) and therefore has no impact on the Air Traffic Services of Newcastle Airport.	No further action required.
Glasgow Prestwick Airport Ltd (09.05.22)	Scoping	The proposed development is outwith the safeguarding zone for Glasgow Prestwick Airport (GPA) and GPA has no aviation objection to this scoping consultation for this proposed development.	No further action required.
NATS (21.04.22)	Scoping	NATS has indicated an impact from the proposed development on the Lowther Hill NATS (En Route) plc (NERL) radar.	Dialogue is ongoing with NATS to identify the most appropriate mitigation scheme.

Baseline

CAA

13.2.19 Of the three civil airports that responded to Scoping; Carlisle, Newcastle and Glasgow Prestwick Airport, none of them has any concerns related to the proposed development.

13.2.20 The Civil Aviation Authority will require the proposed development to have visible lighting to assist with air safety.

NERL

13.2.21 The proposed development is approximately 52km south-east of the NERL Lowther Hill radar.

13.2.22 NERL has indicated that the proposed development will have an unacceptable impact upon the Lowther Hill en route radar as it has LoS to all wind turbines at the proposed development.

Military Aviation

13.2.23 The proposed development is approximately 32km south-west of the Deadwater Fell Radar and approximately 32km east of the Berry Hill Radar. The DIO has also indicated the proposed development is in close proximity to the mobile Threat Radars located within the RAF Spadeadam electronic warfare tactical training area. The DIO has indicated that the proposed development will have an unacceptable impact upon the Deadwater Fell and Berry Hill Radars as they have LoS to all wind turbines at the proposed development.

13.2.24 While not expressed specifically in scoping opinion, the DIO is likely to have a requirement for the proposed development to agree a suitable scheme of visible and/or infrared lighting to assist military aircraft in avoiding the proposed development.

EKA

13.2.25 The proposed development is approximately 25km south of the EKA and within the 50km safeguarded zone around the array.

13.2.26 The DIO has indicated that the proposed development will have an unacceptable impact upon the EKA as it lies within the 50km protection range.

Mitigation and Residual Effects

Predicted Operational Effects

13.2.27 Wind turbines have the potential to impact the performance of air traffic control radars. These impacts include:

- The creation of "false" targets, whereby the wind turbines present on the radar display. Multiple false targets can lead to the radar initiating false aircraft tracks.

- False returns can also cause track seduction, i.e. real aircraft tracks are ‘seduced’ away from the true position as the radar updates the aircraft track with the false return. This can lead to actual aircraft not being detected.
- Shadowing whereby the aircraft is not detected by the radar as it is flying within the physical ‘shadow’ of the wind turbine.

Aviation & Radar

13.2.28 Prior to mitigation, it is considered that the proposed development would affect the operation of the military ATC radars at Deadwater Fell and Berry Hill and also and the NERL Lowther Hill radar.

EKA

13.2.29 The MOD maintains that the Eskdalemuir ‘noise budget’ within the 50km zone has been fully allocated to other wind farm sites and there are numerous other sites in the queue. This restriction will therefore apply to the proposed development.

Proposed Mitigation

Aviation & Radar

13.2.30 There are a number of mitigation options available to alleviate problems caused by wind turbines to aviation and radar. Mitigation solutions are highly specific to the effect in questions. Consultation with relevant consultees is key to establishing the appropriate method of mitigation. A Radar Mitigation Scheme (RMS) will be agreed with MOD that will remove or reduce to an acceptable level, the impact of the proposed development on the military radars at RAF Spadeadam. The RMS will be agreed prior to the proposed development becoming fully operational.

13.2.31 An RMS will be agreed with NATS that will remove or reduce to an acceptable level, the impact of the proposed development on the NERL Lowther Hill Radar. The RMS will be agreed prior to the proposed development becoming fully operational.

13.2.32 A reduced visible aviation lighting scheme has been agreed with the CAA. The reduced scheme means that not every perimeter wind turbine needs to be lit and no tower lights are required provided an infrared scheme is agreed with the DIO. A copy of the correspondence between the applicant and CAA can be seen in Technical Appendix 13.1 and the results of the assessment for night-time lighting are contained in Chapter 5: Landscape & Visual Impact Assessment. An infrared lighting scheme will be agreed with the DIO prior to the proposed development becoming fully operational.

EKA

13.2.33 The Eskdalemuir Working Group (EWG), Chaired by Scottish Government, and whose membership comprises a number of Developers, including the applicant, has commissioned studies to more accurately model the effect of wind turbines on the EKA and also to re-evaluate the current noise limitations.

13.2.34 Once Scottish Government and MOD have considered both the technical and allocation policy aspects, it is anticipated that additional ‘noise budget’ will be released, enabling the MOD to withdraw their objection.

Summary

13.2.35 The proposed development will potentially impact MOD radars at RAF Spadeadam (Deadwater Fell and Berry Hill) and the NERL radar at Lowther Hill. In both cases it is expected that the impact can be mitigated with a suitable mitigation scheme that could be secured through an appropriately worded suspensive planning condition. Infrared lighting will be agreed with the DIO for the MOD low flying requirements and a visible lighting scheme has been agreed with the CAA.

13.2.36 The proposed development will impact the EKA. It is expected that the impact can be mitigated once the MOD and Scottish Government has agreed on the updated technical ‘noise budget’ and allocation policy. Again, this mitigation could be secured through an appropriately worded suspensive planning condition.

13.3 Television and Telecommunications

Introduction

13.3.1 This section of the chapter summarises the potential television and telecommunications effects associated with the proposed development.

Guidance

13.3.2 Tall structures such as wind turbines may cause interference of nearby television and telecommunications links. As such, any links in the vicinity of the proposed development must be identified and operators must be consulted.

13.3.3 The Ofcom Spectrum Information Portal¹ was used in the first instance to identify fixed microwave links crossing or adjacent to the site.

13.3.4 A number of other telecommunications services in addition to fixed microwave links may be present, however most of these services are generally only affected if wind turbines are located in immediate vicinity. Furthermore, where other services are

¹ <https://www.ofcom.org.uk/spectrum/information/spectrum-information-system-sis/spectrum-information-portal> (last accessed 03/10/2022)

present, there is usually a supporting fixed microwave link to allow onward signal transmission, which would be identified in this assessment. It is therefore considered that the search for fixed microwave links, and discussion with identified operators, also covers all other services.

Scope of Assessment

Effects Scoped Out

- 13.3.5 Effects on television and telecommunications have been scoped out of detailed assessment for the following reasons:
- Operational effects on television / radio broadcasting: digital television is less likely to be affected by the atmospheric conditions that rendered analogue television unwatchable and does not suffer from reflection effects or ghosted image generation.
 - It is not considered likely that radio broadcasting signals will be affected by the proposed development once operational. This is because:
 - the length of radio broadcast signal wavelengths are such that interference from wind turbines is unlikely; and
 - any interference to the radio signal is unlikely to noticeably affect the audio signal.

Microwave Fixed Links and Scanning Telemetry

- 13.3.6 Fixed microwave links are direct line-of-sight communication links between transmitting and receiving dishes placed on masts generally located on hilltops that vary in length from a few kilometres to over 70km. They are used for the transmission of information to broadcasting masts for television and radio and for the mobile telephone networks.
- 13.3.7 Telecommunications and broadcasting network operators were consulted during the scoping exercise.
- 13.3.8 BT responded the 3rd of May 2022, to confirm that the proposed development should not cause interference to BT's current and presently planned radio network.
- 13.3.9 The Joint Radio Company (JRC) Limited, which provides Scanning Telemetry Services, responded on the 20th of April 2022, to confirm that the proposed development should not cause interference to JRC's current and presently planned radio network.

- 13.3.10 Arqiva responded the 3rd of May 2022, to confirm that the proposed development should not cause interference to Arqiva's current and presently planned radio network.
- 13.3.11 It is acknowledged that the layout of the proposed development has changed since scoping however from information gained these particular assets do not feature within the site and therefore it is expected that these stakeholders will remain unaffected.
- 13.3.12 With the information available to the applicant, the proposed development does not directly affect microwave fixed links and the potential effect on microwave fixed links is not significant. Pre-construction checks would be undertaken to ensure this remains the case nearer the time of construction.

Summary

- 13.3.13 The proposed development does not directly affect microwave fixed links and the potential effect on microwave fixed links is not significant
- 13.3.14 The potential effect of the proposed development is considered to be not significant with respect to other television or radio communication networks.

13.4 Shadow Flicker

Introduction

- 13.4.1 This section of the chapter summarises the potential effect of shadow flicker associated with the proposed development.
- 13.4.2 Wind turbines are tall structures which can cast long shadows when the sun is low in the sky. Given a conjunction of certain meteorological conditions (clear skies, enough wind for the wind turbines to be rotating and a low angle of the sun in the sky), observers close to a wind farm could experience a phenomenon commonly known as 'shadow flicker', where the rotating wind turbine blades pass between the sun and the observer, usually through narrow openings such as doors/windows, creating an intermittent shadow. It is, however, part of the nature of long shadows that they pass any particular point relatively quickly and the effect, if present, lasts a short period of time, due to the movement of the sun across the sky. They are generally only observed in the period after dawn and before sunset as the sun is rising and setting.

Planning Policy

13.4.3 The following policy documents have been referred to in undertaking the assessments:

- Scottish Planning Policy²
- Dumfries and Galloway Council's Local Development Plan 2 in its Supplementary Guidance: Wind Energy³

Guidance

13.4.4 The following guidance documents have been referred to in undertaking the assessments:

- Scottish Government - Onshore wind turbines: planning advice⁴
- Department of Energy & Climate Change (DECC) guidelines⁵

13.4.5 A report on shadow flicker from the Department of Energy & Climate Change (DECC) indicates a general rule of ten rotor diameters should be used for separation distance from a wind turbine position to a dwelling. Scottish Government guidance advocates that beyond this distance, shadow flicker should not be a problem

Scope of Assessment

13.4.6 Dumfries and Galloway Council's Local Development Plan 2 Supplementary Guidance: Wind Energy Development states that *"Maintaining a separation distance of at least 10 times the turbine rotor blade diameter from sensitive uses/receptors can help reduce the effects but this may need to be extended depending on specific locational circumstances."*

13.4.7 Dumfries and Galloway Council's Local Development Plan Supplementary Guidance: Planning for Wind Energy similarly mentions that *"Careful siting of turbines can reduce or eliminate most instances of shadow flicker and of instances where sunlight reflects of the blades (usually only seen when the blades are wet and the sun is at a particular angle in relation to the viewer). Developers should*

demonstrate that these aspects have been properly considered and addressed as far as is practicable (this could include proposals to limit turbine use at identified particularly sensitive times of the day/year)."

13.4.8 Wind turbines are to be located a minimum distance of 10 times the rotor diameter of the proposed wind turbines from any regularly occupied buildings not associated with the proposed development. Within a distance less than 10 rotor diameters, a shadow flicker assessment will be required.

13.4.9 The assessment was therefore carried out based on the 10-rotor diameter distance following the DECC guidelines, however in the event of shadow flicker being reported beyond this radius, reports will be investigated and mitigatory measures will be put in place.

Baseline Characterisation

Study Area

13.4.10 Properties have been assessed within a radius of 10 rotor diameters distance as per DECC guidelines. A total of 12 properties were identified within this radius, all of which are currently listed as occupied in the UK address database. Two of the 12 properties are financial beneficiaries of the proposed development.

Desk Study

13.4.11 Impacts due to shadow flicker were assessed based on a 150m rotor diameter with a mix of tip heights of 180m, 200m and 230m for the operational year 2027, resulting to a study area of 1,500m around the wind turbine locations.

13.4.12 The locations of the nearest neighbours to the proposed wind turbines that lie within, or close to, the distance considered appropriate for assessment according to relevant policy are shown in Figure 13.1. H22 and H23 are financial beneficiaries of the proposed development. The minimum non-financial beneficiary occupied property-to-wind turbine separation is approximately 1,050m away.

13.4.13 A shadow flicker analysis has been implemented using the Shadow Flicker module of the WindPRO software package. This model accounts for latitude and longitude of the proposed development and uses a model of the sun's position in the sky throughout the year to calculate shadow lengths, positions and times. A digital terrain model was used in the assessment to take account of the topography between receptors and wind turbines.

² Available online: <https://www.gov.scot/publications/scottish-planning-policy/pages/6/>, (last accessed 18/10/2022)

³ Available online: https://www.dumgal.gov.uk/media/22639/Wind-Energy-Development-Development-Management-Considerations/pdf/Wind_Energy_SG_Final_PDF_February_2020_Version.pdf?m=637184984806630000,p18, (last accessed 18/10/2022)

⁴ Available online: <https://www.gov.scot/publications/onshore-wind-turbines-planning-advice/>, (last accessed 18/10/2022)

⁵ Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/48052/1416-update-uk-shadow-flicker-evidence-base.pdf_p12, (last accessed 18/10/2022)

Assessment Limitations

13.4.14 The actual instances of shadow flicker experienced at the distances considered will always be less than those predicted in the model as the following assumptions have been made in those calculations:

- the wind turbines rotors are always turning (in reality this only occurs when there is sufficient wind to turn the rotor blades and the wind turbines are not undergoing maintenance);
- the orientation of the wind turbines is always aligned so as to cast a sufficient shadow towards the property (in reality the wind turbines automatically turn to face the prevailing wind which may, or may not, create this condition)
- the sunshine is always of sufficient intensity to cause shadow flicker (in cloudy skies it is unlikely to do so - Met Office⁶ estimates that the proposed development experiences an approximate value of sunshine hours of 20%);
- all receptors have relevantly orientated windows (in reality this may not be true); and
- no trees or walls obscure the view of the wind turbines and hence block any potential shadow flicker (in reality many properties have trees or bushes near to the property that may obscure the view to the proposed development).

Assessment Results

13.4.15 There are 12 properties within 10 rotor diameters (1,500m) of the wind turbines. Of these, two are occupied by financial beneficiaries to the proposed development. The significance of the shadow flicker effect to the surrounding properties has been assessed according to the Department of Energy & Climate Change (DECC) guidelines.

13.4.16 Table 13.2 provides a summary of the results. Property H23, Bloch Farm, located 836m north-west of the nearest wind turbine, T16, could experience the most significant impact of shadow flicker on 351 days of the year with maximum duration of up to 83 minutes per day. Figure 13.1 details the locations of affected properties relative to the proposed development.

13.4.17 It should be emphasised that this analysis provides an extremely conservative estimate of the extent that the properties could be affected by shadow flicker. Due to frequent cloud cover, low irradiance intensity, wind turbines not turning at all

⁶ https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/regional-climates/western-scotland_-_climate---met-office.pdf, p5, (last accessed 18/10/2022)

times and wind turbine rotors not being aligned with the sun in a way to cast maximum shadow onto the property, the actual amount of shadow flicker affecting the aforementioned properties is likely to be much less.

Table 13.2: Shadow Flicker Assessment Summary of Results

Property	Description	Easting	Northing	Days per year	Max hours per day	Total hours per year
H13	MARCH COTTAGE	333887	578115	0	0.0	0.0
H14	PINGLE BRIDGE COTTAGE	332204	578349	0	0.0	0.0
H15	PINGLE FARM	332018	578373	11	0.1	1.1
H18	BARNGLIESHEAD	332392	578594	58	0.4	21.0
H19	KERR	334390	579396	88	0.8	35.7
H24	COLLIN	330429	581507	120	0.9	54.9
H25	HOLMFOOT COTTAGE	330609	581523	116	1.0	70.0
H27	HOUSE, FALCON FARM	330754	581685	89	0.9	47.7
H28	THE FLAT, FALCON FARM	330762	581685	89	0.9	48.0
H29	WAUCHOPE SCHOOL HOUSE	332510	581700	220	1.5	153.2
H22	1 BIGHOLMS COTTAGE	331145	581155	193	1.7	202.8
H23	BLOCH FARM	332823	581273	351	1.4	276.7

Mitigation and Residual Effects

13.4.18 All reports of shadow flicker events will be investigated, regardless of the distance of the property to the proposed development.

13.4.19 In the event of shadow flicker causing a nuisance, a range of mitigation measures could be incorporated at the operational phase of the proposed development to reduce the instance of shadow flicker. Mitigation measures include:

- Installing shut down modules and shutting down individual wind turbines when during times when wind and climactic conditions are such that shadow flicker could occur.

Summary

13.4.20 Ten out of the twelve occupied properties within 10 rotor diameters may potentially experience shadow flicker from the proposed development, two of which are financial beneficiaries to the proposed development. The applicant is committed to shut down the operation of individual wind turbines when shadow flicker could impact nearby properties, via the use of a shadow flicker shut down module in the turbines.