17 Other Issues - Health and Safety, Air and Climate and Shadow Flicker

Health and Safety

Introduction

17.1 This section describes the potential health and safety issues relating to the construction and operation of the proposed wind farm. The paragraphs below outline the procedures that will be put in place and followed to ensure the health and safety of the workforce and the public, specifically in relation to the following:

- Safe construction;
- Turbine safety and safe operation;
- Safety during adverse weather conditions;
- Public safety during operation;
- Services.

General Approach to Safe Construction, Operation and Maintenance

17.2 Since its first schemes were constructed in 1992, RES has had a long track record of safe operation and maintenance of wind farms across the UK and elsewhere, and ensures safe, prudent and cost effective long-term operation of its plant. RES manages and operates a range of wind farms that it has developed and constructed itself, and also manages wind farms for other owners, to the highest international safety and environmental standards.

17.3 As for any mechanical or electrical installation, wind farms could pose a safety risk if not managed and maintained correctly. Under the Construction (Design and Management) Regulations 2007, detailed risk analysis and avoidance limitation measures are required for every facet of the development and operation of a wind farm. These measures would be contained in the Health and Safety file for the proposed wind farm site, which would be open to inspection by the Health and Safety Executive. All site personnel will have full safety training, to ensure an absolute minimal risk of accidents occurring.

17.4 Safety of the public and its staff are of paramount importance to RES. During construction and subsequent operation of the proposed wind farm, site safety procedures will be strictly enforced and followed. All work on site will comply with:

- the Construction (Design and Management) Regulations 2007 (HSE, 2007);
- the Health and Safety at Work Act 1974 (HMSO, 1974); and
- the Construction (Health, Safety and Welfare) Regulations 1996 (HMSO, 1996).

17.5 This would be done in conjunction with:

- the revised edition of the Renewable UK Health and Safety in the Wind Energy Industry Guidelines; and
- the Management of Health and Safety at Work Regulations 1999 (HMSO, 1999).

Safe Construction

17.6 Due to the inherently hazardous nature of construction sites, there will be some risks to public safety. However, these will be minimised by the implementation of well-established health and safety measures which are closely regulated.

17.7 The construction of the proposed wind farm must comply with the requirements of the Construction (Design and Management) Regulations 2007. These regulations oblige the developer to notify the Health and Safety Executive (HSE) of the project, and to establish a safety management system encompassing risk assessment, design measures and management instructions to ensure the safety of construction (and operational) staff and the public. Best practice health and safety guidelines published by Renewable UK (2010), will be adhered to and speed limits will be put in place to regulate traffic flows. (See SNH Good Practice Guide, 2010 for more information: http://www.snh.org.uk/pdfs/strategy/renewables/Good%20practice%20during%20windfarm%20construction.pdf).

Turbine Safety and Safe Operation

17.8 RES will require the selected wind turbine model to have full certification from a recognised authority against internationally recognised standards, and to have a proven track record of safe operation. The main certification agencies, such as Germanischer Lloyd, have well developed and proven certification procedures whilst a mature suite of safety and testing standards developed over many years by the International Electrotechnical Commission are now in place and are widely accepted. Working in parallel, these standards and certification procedures have ensured that wind turbines adhering to them enjoy high levels of intrinsic safety.

17.9 Modern wind turbines incorporate sophisticated supervisory control systems that continually interrogate the operational status and safe working of key components of each turbine and allow an operator to remotely monitor the turbines via modem. Under fault conditions, affected turbines automatically shut down and send an alarm to the maintenance engineer. For safety-critical faults, turbines do not re-start until the maintenance engineer has diagnosed and rectified the problem.

17.10 In terms of general safety during operation, the Solwaybank turbines would be supported by the manufacturer's operational and maintenance safety manuals, which would be available on site supplementing RES safety manuals and procedures. These manuals would form the basis of the regular safety checks that would be undertaken throughout the life of the development.

17.11 RES has developed its own wind farm safety manual, which would be adhered to throughout the lifetime of the project. The Solwaybank Wind Farm, in compliance with relevant safety regulations, would display appropriate warning signs concerning restricted areas on the turbines, substation enclosure and control building. Authorised personnel and persons under their supervision who visit the restricted areas of the site during its operation would operate under site-specific safety rules established by the owner and operator. Electrical installation will be to standards and recognised codes of practice with adequate signage and protection.

Safety During Adverse Weather Conditions

17.12 Although the possibility of attracting lightning strikes applies to all tall structures, wind turbines have specific protection requirements due to their size and nature. Specific design features are required to ensure safety and to ensure that the turbines can ride through lightning storms without damage and without impact on reliability. Specific features are incorporated into the blades to ensure strikes are conducted harmlessly past the sensitive parts of the nacelle and down the tower into the earth. Protection also includes a buried earthing mat round each turbine foundation and/or a deeply sunk lightning conduction cable which is sunk to a substantial depth into the earth, sufficient to ensure appropriate conduction to ground.

17.13 As for any structure, storm damage to turbines can be sustained during severe events. As stated in the Scottish Government's web based renewable advice on onshore wind turbines[1] *"Danger to human or animal life from falling parts or ice is rare"*. The highest risk of damage is in extreme wind speed conditions (>100 mph) when the likelihood of anyone being on site is remote. A few isolated cases of turbine blade damage have occurred in exceptionally high wind conditions. However, Renewable UK maintains that there is no record of any member of the public having been injured as a result of their operation (Gipe, 1995).

17.14 Even under extreme wind speed conditions, the risk of damage is small (for example, the Wigton wind farm in Jamaica which RES constructed and commissioned in 2004 was left undamaged by Hurricane Ivan which caused devastation throughout the island on 10 September later that year). The turbines proposed for the proposed wind farm site would be certified to withstand appropriately extreme conditions. In very high winds, brakes on the wind turbines rotor are engaged, locking the rotor in a safe position.

17.15 In some countries, icing of wind turbine blades presents a potential risk that must be managed. In the warmer climates of the UK, icing has not been a problem to date, but at higher elevations and at locations further north, the risk will be greater and needs to be suitably assessed.

17.16 Generally, there is no inherent danger in operating a wind turbine at low temperatures, and there is no particular risk simply because it is frosty or snowing. However under certain atmospheric conditions, such as freezing-fog, which specifically involve low temperature and high humidity, hard ice can form on the blades (this can also happen either when rain freezes on contact with a blade or should the turbine be operating in low cloud). If action is not taken to shut the turbine down, then a build-up of ice ultimately resulting in ice-throw might happen.

17.17 Given the proposed wind farm's location, elevation and remoteness it is not considered that icing represents a significant risk.

17.18 At locations where icing risk is higher, automatic shut-down systems and operational re-start protocols can be put in place to ensure that icing events do not turn into hazards. RES has developed and implemented such measures at other wind farms. These are not considered necessary at Solwaybank.

[1] http://www.scotland.gov.uk/resource/doc/212607/0120077.pdf

Public Safety During Operation

17.19 After construction is completed, there would be no reason under normal circumstances to restrict access to the operating wind farm for public safety reasons. Current access arrangements to the proposed wind farm site would therefore not change substantially, albeit that improved access has the likelihood of generating additional visitor numbers than the current land-use.

17.20 The plant, equipment and their enclosures are designed to incorporate the best available technology and access to the proposed wind farm site should pose no danger to the public. During routine maintenance operations, 'warning men at work' signs would be erected.

17.21 At the main entrance to the site, signs would be deployed giving basic safety information including speed limits, appropriate personal protective equipment and also giving details of whom to contact in an emergency. Emergency contact information would also be posted at the local police station and with the local power distribution company, ScottishPower Energy Networks.

Services

Consultation

17.22 Scottish Water, Transco (now National Grid) and British Telecom were all consulted prior to the previous planning application and their responses can be found in Table 7.1. A 'utility search' was carried out in March 2011 to identify any utilities/services such as gas pipelines, electricity transmission cables or overhead lines, water mains, telecom land lines etc, which may cross or be in close proximity to the main site or along the abnormal load delivery route.

Baseline

17.23 The following utilities were recorded:

<u>Main Site</u>

- High pressure gas pipeline crossing the main site from south-east to north-west;
- 33 kV overhead line crossing the site from south-west to north-east.

<u>Northern site entrance</u>

- Intermediate pressure gas pipeline running along the B7068 (other side of road from the northern site entrance;
- Water main pipeline running along the B7068;
- 11 kV overhead line running along the B7068 and crossing the north site entrance;
- BT cable running along the B7068
- Fibre optic cable link running parallel with site before crossing into the northern most corner of the site and traversing a short section of the Solwaybank Wind Farm access route before joining the B7068 and crossing our northern entrance.

<u>Southern site entrance</u>

- Two water mains cross the site entrance, one running along the road from Solwaybank to Pingle and the other running parallel.
- An 11 kV overhead lines crosses the site entrance and another low voltage line supplying Pingle Farm crosses the access track just after the entrance.

<u>Access Route</u>

- Road crosses the high pressure gas pipeline just before reaching Pingle Farm.
- A water main runs almost the full length of the Tympanheck to Solwaybank road
- A BT line runs almost the full length of the Tympanheck to Solwaybank road.

- Low voltage overhead line at widening works at Cadghillhead Farm.
- 33kV and 11kV overhead lines crossing road at Tympanheck

Layout Considerations

17.24 The location of the high pressure pipeline was recorded on the constraints map and a minimum separation distance of 120 m (1.5 x hub height as per National Grid guidelines) was included when designing the turbine layout.

Mitigation

Relocation of existing services

17.25 Where existing services are found to obstruct or interfere with the proposed wind farm infrastructure, these may be relocated to a position mutually agreed between RES and the utility provider in question. Full consultation will take place with the utility provider to ensure that any relocation works are programmed and carried out in such a manner as to minimise disruption or down time to the utility customers. All services shall be constructed as per methods of work agreed with the utility provider in advance of any works taking place.

Marking out on site

17.26 Prior to any work commencing on site, all utility providers will be re-consulted to establish the most up to date service locations for the development site and surrounding area. Using these service plans and, where possible, under supervision from the utility provider themselves, the services shall be 'pegged out' on site using cable locators or other specialist equipment designed to detect the location of buried services.

Protective slabs

17.27 Where proposed on site access tracks cross the existing high pressure gas pipeline, a full ground investigation will be undertaken to ascertain the exact location and depth to the pipe in addition to the bearing capacity of the existing rock or soils. Using this information, a reinforced concrete cover slab will be designed to protect the pipeline across the full width of the crossing point from loadings imposed by construction plant and delivery vehicles. This design and a detailed method of work will be submitted to National Grid for their approval prior to any works commencing on site.

Air and Climate

Introduction

17.28 This section deals with the potential effects on air quality associated with the wind farm and also with matters relating to the overall carbon balance associated with the wind farm development over the course of its life.

Emissions to Air

Construction and Decommissioning Phase

17.29 Emissions to air associated with a wind farm are predominantly associated with the construction period. Dust created during dry spells and exhaust emissions from construction vehicles are the main aspects to consider. Given the short term nature of the construction period, lack of local residences and limited nature of emissions, it has not been considered necessary to carry out a full impact assessment on air quality.

17.30 Mitigation measures designed to minimise air quality impacts will be incorporated into the Construction and Decommissioning Method Statement (CMS). These will include the following measures:

- All vehicles will be well maintained.
- Vehicle engines will not be left running while not in use.
- When required, dust suppression techniques will be employed such as the spraying of tracks with water.
- All vehicles leaving the site will pass through a dry wheel wash to prevent mud being tracked onto the public highway.
- Vehicle loads of loose material (soils, wastes etc) will be covered.

17.31 Potential for air quality effects are similar during decommissioning and, as such, the same mitigation measures will be implemented where required.

Operational Phase

17.32 Wind farms do not emit any pollutants to air during their operational life. Vehicle exhaust emissions associated with traffic during the operational phase are not considered to be significant as vehicle trips are likely to be very low.

17.33 Should any significant maintenance be required during the wind farm lifetime the measures outline in paragraph 17.30 would also be applicable.

Carbon Balance

Carbon Savings

17.34 With a minimum installed capacity of around 30 MW Solwaybank Wind Farm is conservatively estimated to generate 78.84 GWh, electricity equivalent to the average annual demand of more than 17,000[2] households. That equates to approximately 25% of the households in Dumfries and Galloway.

17.35 Electricity generation from the wind farm can offset the equivalent amount of electricity generated by fossil fuels thus reducing the amount of CO_2 being emitted into the atmosphere. Table 17.1 gives a variety of carbon dioxide offset figures ranging from equivalent emissions given off by generating electricity by burning only coal in the worst instance to that emitted by burning gas. In reality, electricity comes from a variety of sources (nuclear, gas, coal, renewable, oil) and, as such, the overall 'grid' mix emission figures are used as the most likely savings.

Table 17.1: Carbon Dioxide Offset Savings by Fuel Type

Fuel Type	CO_2 emissions[3] (tonnes CO_2 / GWh)	Annual CO_2 Saving (tonnes CO_2)	Lifetime CO_2 Saving[4] (tonnes CO_2)

[2] Based on RES studies and annual average homes consumption figures from DECC statistics on household consumption from 2009

[3] Based on DECC provisional 2010 statistics.

[4] Assumes a 25 year operational life.

Coal Fired	872	68,748	1,718,700
Gas Mix	364	28,698	717,450
Fossil Fuel Mix	555	43,756	1,093,900
Grid Mix	434	34,217	855,425

Payback Period

17.36 The Scottish Government has provided a tool for calculating carbon emission savings associated with wind farm developments on Scottish peatlands (Nayak et al, 2011)[5].

17.37 This tool looks at the full life cycle of the wind farm including manufacturing, construction, forestry and peat.

17.38 The carbon payback period is a measurement/indicator to help assess a wind farm proposal. The shorter the payback, the greater benefit the wind farm will have in displacing emissions associated with electricity generated by burning fossil fuels. The payback period is calculated taking the total carbon cost (carbon loses) associated with the wind farm and dividing by the annual carbon savings. Carbon losses associated with the wind farm development. A printout of the tool inputs and results can be found in **Appendix 17.1**. Assuming a 'grid mix' scenario, the carbon payback for Solwaybank Wind Farm will be 1.7 years (just over 20 months).

17.39 As well as contributing towards meeting Scotland's ambitious renewable energy generation targets, Solwaybank Wind Farm will also, for the great majority of its operational life, positively contribute to Scotland's drive to reduce its CO_2 emissions.

Shadow Flicker

Introduction

17.40 In sunny conditions, any shadow cast by a wind turbine will mirror the movement of the rotor. When the sun is high, any shadows will be confined to the wind farm area, but when the sun sinks to a lower azimuth, then moving shadows can be cast further afield and potentially over adjacent properties. Shadow flicker is generally not a disturbance in the open as light outdoors is reflected from all directions. The possibility of disturbance is greater for occupants of buildings when the moving shadow is cast over an open door or window, since the light source is more directional.

17.41 Whether shadow flicker is a disturbance depends upon the observer's distance from the turbine, the direction of the dwelling and the orientation of its windows and doors from the wind farm, the frequency of the flicker and the duration of the effect, either on any one occasion or averaged over a year.

17.42 In any event, and irrespective of distance from the turbines, the flickering frequency will depend upon the rate of rotation and the number of blades. It has been recommended (Clarke, 1991) that the critical frequency should not be above 2.5 Hz, which, for a three bladed turbine, is equivalent to a rotational speed of 50 rpm. The proposed turbines at Solwaybank Wind Farm would rotate at approximately 20 rpm, well below this threshold.

[5] http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Energy-sources/19185/17852-1/CSavings

Methodology

17.43 The Scottish Government's web based renewable advice on onshore wind turbines[6], Planning Policy Statement PPS22[7] and Clarke (1991)[8] & (1995)[9] have predicted that houses located further than ten rotor diameters away from a wind turbine are unlikely to experience a disturbance from shadow flicker.

17.44 The closest properties are listed in Table 17.2. There are no properties within 10 rotor diameter (10D) (maximum 930 m) of these turbines, therefore shadow flicker is not expected to be an issue at Solwaybank Wind Farm.

17.45 Despite there being no properties within 10D at Solwaybank and therefore no issue expected, an analysis of shadow flicker throughout the year from Solwaybank Wind Farm was carried out for diligence on the closest properties, as a precautionary measure, taking into account the behaviour of the sun, the local topography and the turbine layout and dimensions[10]. The analysis was performed using a turbine layout consisting of 15 turbines, each with maximum tip heights of 126.5 m and maximum rotor diameters of maximum 93 m.

Table 17.2: Location of the Closest Properties

House Name	Easting (m)	Northing (m)	Nearest Turbine ID	Distance (m)
ALLFORNOUGHT	329294	577858	T14	938
STABLE COTTAGE, EAST LINBRIDGEFORD	326974	579529	T15	1382
EAST LINNBRIDGEFORD	326949	579514	T15	1409
BARN COTTAGE, EAST LINBRIDGEFORD	326949	579514	T15	1409
MEGSFIELD	327603	580990	T15	1424
CALLISTERHALL	328925	581617	T1	1433
CHAPELHILL	327933	578102	T12	1446
CONHESS FARM	327649	578387	T11	1453
KIRTLETON HOUSE	326899	580144	T15	1484
HALSYKE	327087	578946	T15	1495
HALSYKE COTTAGE	327087	578946	T15	1495

Assumptions

17.46 It should be noted that the analysis was performed using the following assumptions:

[6] http://www.scotland.gov.uk/resource/doc/212607/0120077.pdf

[7] Planning Policy Statement PPS22 (2004), Office of the Deputy Prime Minister.
http://www.communities.gov.uk/documents/planningandbuilding/pdf/147444.pdf

[8] Clarke A.D (1991), A case of shadow flicker/flashing: assessment and solution, Open University, Milton Keynes

[9] Clarke, A.D (1995), Assessment of Proposed Wind energy Project at Meenacahan, Donegal, Ireland, for Shadow Flicker, Report for B9 Energy Services Ltd

[10] 01307R000012, turbine ref 01307D0007-09, house ref 01307D0201-02

- The sun will always be visible during daylight hours (conservative ('worst-case') assumption as the location is known to encounter cloud cover approximately 80% of the year, (IPCC, 2005)[11]).
- The wind will always be sufficient to turn turbine blades at these times (conservative assumption).
- The alignment of the turbine rotor blades with respect to the sun's position will always produce maximum shadow casting (conservative assumption; it is unlikely that the wind, and therefore the rotor blades will track the sun in practice).
- The analysis looks at shadow casting over the building from all directions rather than over vertical orientated windows only (conservative assumption).
- The intensity of the sun will be insufficient to cast strong shadows at elevations less than 5°.
- Shielding due to features such as trees or other obstacles has not been taken into account. Terrain shielding, however, is modelled.

Results

17.47 Results from the modelling show that seven of the houses considered in the analysis could be theoretically subject to shadow flicker from Solwaybank Wind Farm although given the distances involved this is not likely to cause disturbance. These are detailed in Table 17-3. The times when shadow could occur at each house have been rounded up to the nearest quarter of an hour.

Table 17-3: Predicted Times of Potential Shadow Flicker

House Name	Days with flicker	Max Time [h]	Annual Total [h]	Month and Time of potential flicker (GMT)
CONHESS FARM	83	0.39	20.9	May-Aug; 0400-0530
HALSYKE (2 Properties)	76	0.30	18.5	Apr-Aug; 0415-0530
EAST LINNBRIDGEFORD (2 Properties)	25	0.30	5.8	Apr; 0530-0600 Aug; 0530-0600
STABLE COTTAGE, EAST LINBRIDGEFORD	26	0.30	6.0	Apr; 0530-0600 Aug; 0530-0615
KIRTLETON HOUSE	37	0.28	7.8	Mar; 0630-0730 Sep-Oct; 0615-0715

N.b. Please note that where 2 properties share the same coordinates they have been reduced to one row.

17.48 Conhess Farm will experience the longest duration of shadow flicker at 19.8 hours per year, but as previously mentioned, due to this property being located further than 10D from the wind farm the intensity of the effect at that distance is not expected to disturb the inhabitants.

17.49 It should also be emphasised that this analysis provides an extremely conservative 'worst-case' estimate of the extent that houses will be affected by shadow flicker. Due to frequent cloud cover, turbines not turning at all times and turbine rotors not being aligned with the sun in a way to cast maximum shadow onto habitations, the actual amount of shadow flicker seen in these areas is likely to be considerably less.

17.50 It is therefore concluded that Solwaybank Wind Farm will not cause a significant reduction to residential amenity owing to shadow flicker.

Reflected Light

17.51 A related visual effect to shadow flicker is that of reflected light. Theoretically, should light be reflected off a rotating turbine blade onto an observer, then a stroboscopic effect would be experienced. In practice, a number of factors limit the severity of the phenomenon and there are no known reports of reflected light being a significant problem at other wind farms.

17.52 Firstly, wind turbines have a semi-matt surface finish which means that they do not reflect light as strongly as materials such as glass or polished vehicle bodies.

17.53 Secondly, due to the convex surfaces found on a turbine, light will generally be reflected in a divergent manner.

17.54 Thirdly, the variability in flow within a wind farm results in slightly differing orientation of rotor directions, therefore it is unlikely that an observer will experience simultaneous reflections from a number of turbines.

17.55 Fourthly, as with shadow flicker, certain weather conditions and solar positions are required before an observer would experience the phenomenon.

17.56 It is therefore concluded that Solwaybank Wind Farm will not cause a material reduction to amenity owing to reflected light.

[11] Cloud Cover Statistics from the IPCC Data Distribution Centre: Visualisation Pages (2005), http://www.ipcc-data.org/java/visualisation.html