12 Material Assets & Other Issues

12.1 Introduction

This chapter of the EIAR assesses the impacts of the Development on the material assets of the area surrounding the Site. Following preliminary consultations with key consultees during the scoping process, desk-based assessments, Site visits and field surveys were undertaken. In line with the EIA Directive 2011/92/EU as amended by EIA Directive 2014/52/EU and current (draft) EPA Guidelines, this EIAR aims to focus the assessment solely on those elements likely to have a significant effect on the environment. Where a topic / factor identified has been addressed over more than one chapter, findings are briefly summarized e.g. Section 12.2. fisheries. Other topics deemed unlikely to have a significant effect are outlined very briefly and 'closed out' with a summary of reasoning, e.g. Section 12.3 agriculture.

Where negative effects on other topics/factors are predicted, the chapter identifies appropriate mitigation strategies therein. The material assets considered include:

- Telecommunications and Electromagnetic Interference
- ESB Networks
- Air Navigation
- Air and Climate
- Shadow flicker

The assessments will consider the potential effects during the following phases of the Development:

- Decommissioning of the Operational Barnesmore Windfarm (initial phase of the Development)
- Construction of the Development (likely to occur in tandem with the above phase)
- Operation of the Development
- Decommissioning of the Development (final phase)

The decommissioning of the Operational Barnesmore Windfarm and the construction of the Development are likely to occur partly in tandem and would have a greater effect than if the two processes were to arise at different times. This represents a worst-case scenario for assessment purposes. Any effects arising as a result of the future decommissioning of the Development, are considered to be no greater than the effects arising when these two phases are combined. As a result, the final decommissioning phase has not been considered further in this assessment.

For each material asset, a description of the baseline environment is provided along with an analysis of what, if any, effects are predicted. Mitigation measures that will be implemented to reduce or remove the effects are subsequently outlined.

This chapter is supported by Figures outlined in Volume III and the following Technical Appendices provided in Volume IV of this EIAR.

- **Technical Appendix 12.1:** Irish Aviation Authority (IAA) ASSET Assessment
- **Technical Appendix 12.2:** Shadow Flicker Assessment Output

A glossary of common acronyms can be found in **Technical Appendix 1.4** and full responses from consultees are provided in **Technical Appendix 1.3** of this EIAR.

This chapter includes the following elements:

- Introduction
- Individual Assessment of Topic/Factor
- Statement of Significance

12.2 Assessment Methodology and Significance Criteria

Chapter 1: Introduction, Section 1.8.1 outlines in detail, the assessment methodology and significance criteria undertaken during assessments for the EIAR. Section 1.5.1 outlines the national legislation and requirements and approach of an EIA, while **Chapter 4: Planning Policy** outlines the planning and legislative context to the Application.

Under the specification and guidance of these outlining chapters, assessments have been undertaken on material assets.

12.3 Fisheries

Chapter 6: Biodiversity noted that **'***the watercourses on and within the immediate environs of the Site offer low potential for most fish, except for resident brown trout (these also occur within local lake waterbodies and are regularly caught by local fishermen)'.* **Section 6.6.3.2.1** outlines mitigation measures for the protection of watercourses. In addition to these measures, **Chapter 9: Hydrology and Hydrogeology** also outlines details of design requirements to protect watercourses.

Potential impacts on *Salmo salar* (Atlantic salmon) are covered in the accompanying Natura Impact Statement (NIS). Mitigation measures include measures required during both the initial decommissioning and construction phase and operational phase of the Development. During construction, these include buffer zones (for works and storage of potential pollutants), temporary cut-off drains, minimisation of ground disturbance, avoidance of working in high rainfall conditions, appropriate specification of sediment ponds, protocols for refuelling, working with pollutants and spill response, and active re-vegetation. During operation, mitigation measures include blocking of temporary construction-phase drains, active revegetation and embedded drainage design to avoid potential erosion. Where appropriate, these have been incorporated into an outline Construction Environmental Management Plan (CEMP).

Fisheries has been assessed in the earlier chapters of this EIAR and also in the accompanying NIS and therefore does not require further consideration.

12.4 Agriculture

The Site currently functions as an operational windfarm and is not used for agricultural purposes. The Natural Heritage Area (NHA) designation (covering 21.93 km²) surrounding the windfarm precludes the Site from being exploited for commercial agricultural purposes. The Development given its nature, is unlikely to result in indirect effects within its immediate footprint, and therefore effects on agriculture are considered **imperceptible** and not considered any further.

12.5 Telecommunications and Electromagnetic Interference

12.5.1 Introduction

It should be noted at the outset that the Development will involve the replacement of the 25 turbines that form the Operational Barnesmore Windfarm which have been operating successfully for the last 22 years, with 13 turbines.

During operation, wind turbines have the potential to interfere with electromagnetic signals passing above the ground due to the nature and size of the windfarm. During the initial decommissioning and construction phase, signals may be passed below ground via existing infrastructure. Impacts may include overground or underground communication cables, microwave links, telecommunication links, business radio and television reception.

The Republic of Ireland saw the roll out of Digital Terrestrial Television (DTT), locally known as Saorview TV, in October 2010, incorporating the switchover from analogue to digital television. According to Ofcom (a regulatory UK body) (2009), *digital television signals are much better at coping with signal reflections, and digital television pictures do not suffer from ghosting*[1]. Since digital switchover, there have been very few known cases of wind turbine interference with domestic analogue reception. Modern turbine blades are also typically made of synthetic materials which have a minimal impact on the transmission of electromagnetic radiation. Therefore, given the advancements in technology and the extended distance of 2 km to the nearest dwelling, as well as the consultee RTÉ (Ireland's national television and radio broadcaster) response, the potential effects on television and radio signals from the Development will be negligible and are not considered further.

Microwave links need an unobstructed line of sight from end to end because blocked links will perform inadequately. It is therefore necessary to ensure tall wind turbines will not interrupt links. Impacts can include reflection, diffraction, blocking and radio frequency interference.

[1] Ofcom (2009) *Tall Structures and Their Impact on Broadcast and Other Wireless Services*, OFCOM, United Kingdom. Available online at: https://www.ofcom.org.uk/__data/assets/pdf_file/0026/63494/tall_structures.pdf [Accessed 14 November 2019]

12.5.2 Guidance

Potential effects generated by the Development have been assessed with reference to the following document and comment:

- Department of the Environment (2009), Planning Policy Statement 18 (PPS18): Renewable Energy[2]
- Ofcom (2009) Tall Structures and Their Impact on Broadcast and Other Wireless Services Information about Electric & Magnetic Fields and the Electricity Transmission System in Ireland, Eirgrid[3]
- Irish Wind Energy Association (2012) Best Practice Guidelines for the Irish Wind Energy Industry[4]
- Wind Energy Development Guidelines: Planning Guidelines, Department of Housing, Planning, Community and Local Government (DHPCLG) 2006[5]
- Department of Housing, Planning and Local Government (2017) Department Circular PL5/2017. Interim Guidelines for Planning Authorities on Statutory Plans, Renewable Energy and Climate[6]
- Wind Energy Development Guidelines: revised Draft (2019), Department of Housing, Planning and Local Government[7]

12.5.3 Scoping and Consultation

Telecommunications providers were consulted on the Development. A summary of responses is outlined in **Table 12.1** and **Technical Appendix 1.3** outlines full consultation responses.

Table 12.1: Summary of Consultations

Consultee	Response	Further Information
EIR	Response 15 April 2019 confirmed they don't anticipate any interference to the *Eir* microwave radio network.	
Three/Meteor:	Response 12 April 2019: "*Most of the turbines won't pose any issue for our transmission network. T05 (123 m away) and T07 (175 m away) are close to links. The greatest concern would be T06, which is located between a number of our links…..if T06 can be relocated further south-west that will increase the distance to our closest links which would help greatly. Apart from this one turbine, the rest of the development should have no impact on our transmission network".* *"the first 15GHz link is Drumbar to Barnesmore, a path length of 11.113 km. At approx. 396 m from the Barnesmore site (mast location) is the point where the link comes closest to T06. …for that particular link, 30m clearance would probably work."* There are an additional two links which use the mast onsite and are close to the proposed T5. However, *Three* confirmed that these are to be decommissioned in the medium term and will not	Embedded measures moved the location of T6 to provide a 30 m clearance to the link and reduce the likelihood of any significant effects. **Chapter 3: Alternatives Considered, Section 3.4.6.1** T5 was moved further to the north-east during the design process to avoid potential conflict in any case.

[2] Department of the Environment. Planning Policy Statement 18 'Renewable Energy'. Available online at: https://www.planningni.gov.uk/index/policy/planning_statements_and_supplementary_planning_guidance/planning_policy_statement_18__renewable_energy.pdf [Accessed on 15 November 2019]
[3] Eirgrid (2014) *Information on Electric and Magnetic Fields*. Available online at : http://www.eirgridgroup.com/site-files/library/EirGrid/Information%20on%20Electric%20and%20Magnetic%20Fields.pdf [Accessed on 18 November 2019]
[4] Irish Wind Energy Association (2012) Best Practice Guidelines for the Irish Wind Energy Industry, Available online at https://www.iwea.com/images/files/9660bdfb5a4f1d276f41ae9ab54e991bb600b7.pdf [Accessed on 17 December 2019]
[5] Department of Housing, Planning, Community and Local Government (2006) *Planning Guidelines*. Available online at: https://www.housing.gov.ie/sites/default/files/migrated-files/en/Publications/DevelopmentandHousing/Planning/FileDownLoad%2C1633%2Cen.pdf [Accessed on 18 November 2019]
[6] Department of Housing, Planning, Community and Local Government (2017) Department Circular PL5/2017. Interim Guidelines for Planning Authorities on Statutory Plans, Renewable Energy and Climate https://www.housing.gov.ie/sites/default/files/publications/files/interim_guidelines-statutory_plans_renewable_energy_climate_change.pdf [Accessed on 16 December 2019]
[7] Department of Housing, Planning and Local Government (2019) Wind Energy Development Guidelines: revised Draft. Available online at: https://www.housing.gov.ie/sites/default/files/public-consultation/files/draft_revised_wind_energy_development_guidelines_december_2019.pdf [Accessed on 16 December 2019]

Consultee	Response	Further Information
	be an issue for the Development.	
Vodafone/Netshare	Response 01 April 2019: "*Turbine 6 is closest to our links but is still approximately 970m away from it. There are no other links in close proximity.*"	
Virgin Media	Response: 26 July /2019: No record of underground services in this location.	
RTÉ	Response 04 September 2019: There is a low risk of interference to television viewers from the Development.	
Broadcasting Authority of Ireland (BAI)	Response 14 June 2019: They are not aware of issues from existing windfarms in the area. The Development is not located to any existing or proposed FM transmission sites.	

12.5.4 Assessment Methodology

Site investigations noted no overhead or underground communication cables onsite. There is however, an existing telecommunications mast present on the Site. A number of links (eight) were also identified during desktop studies in the vicinity of the Development that use the existing mast onsite; these have been outlined in **Figure 12.1**. The mast on the Site is operated by '*Three*' Ireland, which is also used by Meteor.

Consultation with telecommunications operators was initiated during the scoping phase of this EIA to identify any potential microwave or telecommunication links that could be affected by the Development. Details of the Development were shared with link operators. Responses included '*no implications from the EIA design*' and '*the windfarm is not located close to any existing or planned FM transmission sites*'. Telecommunications operator '*Three*' responded with concerns over distances from their mast.

Any potential effects, which are associated with the operational phase of the Development, are classified as long-term effects. In the event that significant effects do occur, appropriate mitigation measures can be implemented such that there will either be a negligible effect, or no effect, on infrastructure as a result of the Development.

12.5.5 Assessment of Potential Effects

12.5.5.1 Initial Decommissioning and Construction Phase

During the initial decommissioning and construction phase, there are likely to be several sources of temporary electromagnetic emissions. Chief among these will be the brief use of electrical power tools and the use of electrical generators which may be brought onsite before mains electricity is provided. These devices are required by Irish and European law to comply with the EMC Directive 2014/30/EU. Compliance with this Directive will mean that the electromagnetic emissions from these devices will not likely cause interference to other equipment.

The only other potential effects during initial decommissioning and construction phase are likely to be as a result of tall cranes used for constructing the turbines. These cranes are likely to be in the vicinity of the proposed turbines, and as such any effects are likely to be similar to those identified during the operational phase of the Development.

12.5.5.2 Operational Phase

The turbine and substation control electronics will be typical of any circuits used by industry or a conventional generating station. In the operational phase, all electrical components, equipment, apparatus and systems will be required by Irish and European law to comply with the EMC Directive 2014/30/EU. Compliance with this Directive will mean that the electromagnetic emissions from these devices will not cause interference to other equipment and electromagnetic emissions from these devices will be well below those specified in the ICNIRP 1998 Guidelines and in the EU Council Recommendation 1999/519/EC.

The likely sources of electromagnetic emissions from the Development will have low strength and will be located at such a distance from potential receptors (2 km from nearest dwelling) that any likely effect will be imperceptible.

The levels likely to be generated during the initial decommissioning and construction phase are well below those specified in the International Commission on Non-Ionising Radiation Protection (ICNIRP) 1998 Guidelines[8] on the limit of exposure to radio frequency electromagnetic fields and electronic and magnetic fields at 50/60Hz and in the EU Council Recommendation 1999/519/EC

Consultation was carried out with mobile phone operators Meteor / Three and Vodafone. Vodafone indicated that there was no risk of interference with their transmission links as the closest turbine (T6) is over 970 m from their link. Consultation with Meteor / *Three* indicated that the proposed location of T6 was in close proximity to their transmission links to the mast currently located on the Site. All comments were considered, and mitigation measures incorporated into the design phase.

12.5.5.3 Final Decommissioning Phase

The application for the Development is for an 'in perpetuity' permission. However, if decommissioning of the Development should take place, effects associated with this phase will be broadly similar, but less than, those at the initial decommissioning and construction phase.

12.5.6 Mitigation Measures

Embedded measures were undertaken in the design phase and T6 was relocated to a distance accepted by telecommunications operator '*Three*'. Link buffers have been maintained (as per the Operational Barnesmore Windfarm). As a precautionary measure, T5 was moved further north-east during the design process to avoid potential conflict in any case.

Compliance with the EMC Directive 2014/30/EU will mean that the electromagnetic emissions from devices uses is unlikely to cause interference to other equipment.

Mitigation options, such as technical solutions including re-alignment or replacement of TV antenna, re-tuning to alternative TV transmitters or provision of subscription free satellite television services can be implemented.

12.5.7 Cumulative Effects

Cumulative impacts could arise if dwellings are at risk from potential electromagnetic impacts from more than one windfarm. In this instance, effects could arise from the operational Meenadreen Windfarm and / or the consented Meenbog Windfarm. Given the distance of the Development from receptors, it is unlikely that any significant cumulative effects will be experienced. However, if interference on television or telecommunications reception is experienced, then it will need to be ascertained which windfarm / turbine is responsible and implement the mitigation measures outlined above.

12.5.8 Statement of Significance

The potential effect to telecommunication links passing through the Site has been mitigated with the relocation of Turbines. There is no potential for interference with the links from other windfarms in combination with the Development. Based on the remote location of the Development and a distance of 2 km to the nearest residential dwelling, no effects are predicted on telecommunications or radio reception as a result of the Development. The potential effects of the Development are therefore considered **not significant**.

12.6 Grid Connection and Grid Network

12.6.1 Introduction

The Operational Barnesmore Windfarm is currently connected to the Cathaleen's Fall-Golagh Tee 110 kV Overhead Line (OHL) (**Technical Appendix 2.1**). It is proposed to reconfigure this OHL to connect directly to the 110 kV Clogher Substation, removing the tee-connection with the Cathaleen's Fall – Letterkenny line as the current arrangement does not have the capacity for the increased Maximum Export Capacity (MEC) of the repowered windfarm. This will involve the construction of a new cable interface tower between Structure 130T and structure 310. The location of these structures is outlined in Drawing No. PE687-D318-005-004-000 in **Technical Appendix 2.1 and Planning Drawing No.**

[8] International Commission on Non-Ionising Radiation Protection (1998) ICNIRP *Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)* Available online at: https://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf [Accessed on 18 November 2019]

5952-100-108. A full description of the associated works is outlined in **Chapter 2: Development Description, Section 2.5.8**. These works lie outside of the Site.

Further works within the Site include the retirement of a 1.15 km section of OHL within the Operational Barnesmore Windfarm. This line will be relocated underground along a 1.20 km stretch of existing Site access track. The associated existing steel 'end mast' will also be retired and a new end mast erected at the western end of the undergrounded section of the OHL.

12.6.2 Methodology

EirGrid was consulted on the Development and confirmed that the proposed modifications to the existing connection to the national grid is a viable option. The onsite 110 kV Substation will need to be upgraded to allow for the additional capacity and to meet the specification requirements of EirGrid.

There will be a temporary outage while the OHL is being redirected underground. There will be a reduced visual impact with the removal of a stretch of OHL and associated poles (poles will be cut at the base).

There is potential short-term inconvenience during the works associated with the severance from the Cathaleen's Fall – Letterkenny line and the development of the new infrastructure. Delivery of components and building materials along the Haul Route could potentially impact local residents.

12.6.3 Mitigation Measures

There is no anticipated effect upon the grid network outside of the infrastructure for Barnesmore windfarm itself. Predicted traffic volumes associated with the works are outlined in **Chapter 14: Traffic and Transport, Section 14.3.7** with mitigation measures including a traffic management plan outlined in **Section 14.6.**

12.6.4 Statement of Significance

The proposed 110 kV grid connection reconfiguration works are subject to detailed design and will be agreed with EirGrid during the pre-construction phase. No significant impacts on the grid connection or grid network are anticipated.

12.7 Air Navigation

12.7.1 Introduction

Operating windfarms have the potential to cause a variety of adverse effects on aviation. Rotating wind turbine blades may have an impact on certain aviation operations, particularly those involving radar. The physical height of turbines can cause obstruction to aviation and the overall performance of communications, navigation and surveillance equipment. According to the IAA Guidance Material Annex 14, *Structures that extend to a height of 150m or more above ground elevation should be regarded as an obstacle*[9]. The Authority may require the marking and lighting of an obstacle[10].

Enniskillen/St. Angelo Airport (Co. Fermanagh) is located 43.7 km south-east of the Site. It has a Civil Aviation Authority (CAA) ordinary licence that allows flights for the public transport of passengers for flying instruction as authorised by the licensee. There are also four private air strips located north-east of the Site, namely, Carnowen at 23.5 km, Roskey at 23.0 km, Finn Valley at 23.1 km and Letterkenny at 31 km. Donegal airport, located 48 km north-west of the Site, is the largest airport in the county and offers commuter-type air service. Sligo airport is located approximately 60 km south-west of the Development.

European Commission Regulation (EC) No 2150/2005 of 23 December 2005 laid down a set of common rules for the flexible use of airspace and reinforces and harmonises the application, within the Single European Sky (SES), of the concept of the flexible use of airspace. In order to facilitate this flexible airspace management within the limits of Ireland and with the goal of being a best practice in the European Union for aeronautical harmonisation, the Irish Aviation Authority (IAA) has developed and currently implements an SES common transport policy through its Aeronautical

[9] Irish Aviation Authority (2015) *Guidance Material on Aerodrome Annex 14 Surfaces*. Available online at: https://www.iaa.ie/docs/default-source/publications/advisory-memoranda/aeronautical-services-advisory-memoranda-(asam)/guidance-material-on-aerodrome-icao-annex-14-surfaces.pdf?sfvrsn=e2ae0df3_6 [Accessed on 02 December 2019]
[10] Irish Aviation Authority (2005) Statutory Instrument No. 215 of 2005, Obstacles to Aircraft in Flight Order, 2005. Available online at: https://www.iaa.ie/docs/default-source/publications/legislation/statutory-instruments-(orders)/irish-aviation-authority-(obstacles-to-aircraft-in-flight)-order.pdf?sfvrsn=fcb70df3_4 [Accessed on 02 December 2019]

Surface Evaluation Tool (ASSET) web service. Through ASSET, all entities responsible for managing and protecting airspace (including navigation warning areas, significant points) can collaborate on obstacle determinations that may impact existing procedures. The ASSET display of map location of proposed and existing obstacles provides the State with a mechanism for compliance with International Civil Aviation Organisation (ICAO) publication standards[11].

Other air-related operations/activities in Donegal include parachuting. While there is no specific Donegal parachute club, sky jumps often take place from Donegal airport. Paragliding is also a sport that is undertaken in the county but tends to largely focus on the south-west of the county featuring Malin More and Sliabh League. Banagher Hill however, has a peak height of 378m and is a location utilised for take-off, for gliders. It is located within the Bluestack mountains Grid ref G94900 85800 and 9.1 km west of the Site Boundary. There are no records of any accidents with any gliders or sky jumpers and the Operational Barnesmore Windfarm.

The Helicopter Search and Rescue Base has moved from Donegal Airport to Sligo Airport. Finner Camp is a military base located over 28 km south-west of the Site Boundary. All fixed wing flying has ceased at the Camp.

The wind turbine heights at the Development will stand up to 180 m above ground level during operation.

12.7.2 Consultation

Consultation with the relevant aviation organisations was initiated during the scoping process, to identify any potential aviation issues that could be affected by the Development. The findings are summarised in **Table 12.2**.

Table 12.2: Summary of Consultation Response

Consultee	Type and Date	Summary of Consultee Response
Irish Aviation Authority (IAA)	Letter in Response to Scoping Report issued 16.07.19	In relation to Donegal Airport*, the Authority has no specific observations or requests for inclusion within the EIS at this time.* *In the event of planning consent being granted, the applicant should be conditioned to contact the Irish Aviation Authority to:* *(1) Agree an aeronautical obstacle warning light scheme for the wind farm development,* *(2) Provide as-constructed coordinates in WGS84 format together with ground and tip height elevations at each wind turbine location* (3*) Notify the Authority of intention to commence crane operations with a minimum of 30 days prior notification of their erection."*

12.7.3 Assessment of Potential Effects

An ASSET assessment was undertaken on 26 August 2019 of the peripheral turbines closest to both Donegal Airport and Sligo Airport (**Technical Appendix 12.1**). T13 lies 47 km from Donegal Airport and T5, 45.7 km. Sligo airport is at a greater distance; T13 is 61.3 km from the Development and T5, 63.7 km.

The output of the ASSET evaluation noted that both T5 and T13 breached Area 1, which is defined as the entire territory of the State. They also noted that Section 5.4.4.2.3 of the ICAO Annex 15 states that '*the obstacle data shall be provided for obstacles in Area 1 higher than 100 m above the surface*' and also Section 8 of Annex 15 states that '*data on every obstacle within Area 1 whose height above the ground is 100 m or higher shall be collected and recorded in the database in accordance with the Area 1 numerical requirements specified in PANS-AIM, Table A1-8*'.

[11] Aeronautical Information Service (2015) Aeronautical Information Management AIMSG/12-SN-3- Appendix A. New Annex 15 (Consolidated draft, 14 October 2015). Available online at: https://www.icao.int/safety/ais-aimsg/AISAIM%20Meeting%20MetaData/AIS-AIMSG%2012/Study%20Notes/SN%203%20Appendix%20A%20-%20New%20Annex%2015%20(consolidated%20draft).pdf [Accessed on 19 November 2019]

12.7.4 Mitigation Measures

The IAA will be consulted and upon request, any specified turbine or obstacle 100 m or greater will be installed with a warning light system under direct specification and in accordance with Annex 15. It should be noted that infra-red lights are not visible to the naked eye. The IAA and the Local Authority will be informed of the coordinates of the constructed positions of the turbines and the highest point of turbines or any infrastructure greater than 100 m.

12.7.5 Statement of Significance

In adherence with IAA Safety Regulations and ICAO Annex 15, aeronautical obstacle warning light schemes will be installed as requested by IAA, co-ordinates of ground and tip height elevations at each wind turbine location as constructed delivered and the identification of the provision of the intention to commence crane operations provided within a minimum of 30 days prior to erection. The potential effects of the Development on air navigation are considered **not significant**.

No significant impacts are predicted in terms of air navigation.

12.8 Air and Climate

12.8.1 Introduction

This section assesses how the Development is likely to interact with a changing climate and air quality. Climate change has begun to manifest itself in Ireland with increased air temperatures and changes in precipitation patterns[12]. The most recent climate projection iteration Regional Climate Model Predictions for Ireland (2021-2060) has identified the following climatic trends as a result of climate change:

- Temperature: Mean monthly increase in temperatures typically between 1.25 and 1.5°C.
- Precipitation: Change in the frequency and distribution (June shows a decrease of c. 10%; December shows an increase between 10 and 25%) and intensity (increase in the frequency of extreme precipitation - events may exceed 20 mm per day) of rainfall events and cyclones (increase by 15%) compared with the climate of 2005.
- River Flooding: Significant increase in more intense discharge episodes and an increase in the frequency of extreme discharges.

Preliminary calculations regarding net surface water runoff increases are driven by worst case 30-year max data (c. 415 mm/month, or c. 14 mm/day). The resulting net increase in surface water runoff as a product of the site is approximately 0.05% relative to the scale of the Site i.e. Imperceptible. Accounting for 100-year return values, the net increase could potentially be an order of magnitude greater i.e. approximately 0.5% relative to the scale of the Site, also considered Imperceptible. Therefore, it is unlikely that the combination of increased rainfall and increased surface water runoff as a product of the Development will impact significantly on flooding risk within or directly downstream of the site (**Chapter 9: Hydrology and Hydrogeology**).

The peat stability risk assessment factors in 1 m peat fill on top of current peat depths (a fabricated worst-case scenario); this can be viewed to account for increased weight loading of peat i.e. holding increased water quantities and associated increase in pore water pressure. Landslide risk ranges from negligible to low according to the assessment. Increased water loading in peat is unlikely to lead to significant stability issues e.g. landslides. However, it will likely lead to increasing the risk of localised stability issues in terms of the construction phase of the Development (**Chapter 8: Soils and Geology**).

The main concern in relation to increased rates of rainfall and surface water runoff is the associated increase of erosion in already formed or newly formed natural surface water drainage features. Enhanced erosion has the potential to lead to peat degradation and localised stability issues, however this phenomenon conforms to baseline conditions (**Chapter 8: Soils and Geology and Chapter 9: Hydrology and Hydrogeology**).

The climate change trends listed above are considered unlikely to affect the Development; the Development's vulnerabilities and resilience to climate change is not considered further in the EIA.

[12] Environmental Protection Agency (2005) Climate Change: Regional Climate Model Predictions for Ireland (2001-CD-C4-M2), Environmental RTDI Programme 2000-2006. Available online at https://www.epa.ie/pubs/reports/research/climate/EPA_climate_change_regional_models_ERTDI36.pdf [Accessed 13 November 2019]

However, this section will assess the effect of the Development on air quality, given the potential for peat disturbance and dust emissions, and the likely CO_2 reduction effects of the Development in operation.

12.8.2 Relevant Legislation

The Clean Air for Europe (CAFE) Directive (Directive 2008/50/EC on ambient air quality) (as amended by Directive EU 2015/1480) covers in particular, nitrogen dioxide (NO_2) and particulate matter or fine dust (PM_{10}) which is emitted by traffic and combustion engines. It sets down limit values to be respected by Member States in their zones (the Site is designated as 'Zone D': rural Ireland). The CAFE Directive has been transposed into Irish legislation by the Air Quality Standards Regulations 2011 (S.I. No. 180 of 2011) as amended by the Air Quality Standards (Amendments) and Arsenic, Cadmium, Mercury, Nickel and Polycyclic Aromatic Hydrocarbons in Ambient Air Regulations, 2016 (S.I. 659 2016).

12.8.3 Consultation

Consultation with the relevant organisations was undertaken during the scoping stage of the EIA to identify any potential effects that could be attributable to the Development. A summary of the responses is detailed in **Table 12.3**.

Table 12.3: Summary of Consultation Response on Air Quality and Human Health

Consultee	Type and Date	Summary of Consultee Response
Environmental Health Service	Letter in Response to Scoping Report issued 21.06.19	***Air Quality*** *Due to the nature of the proposed construction works, generation of airborne particulate matter has the potential to cause problems and may cause nuisance and also be injurious to the health of employees and the local community. The impact of dust generation from construction activity must be assessed and a dust minimisation plan/mitigation measures that satisfies the current national standards for construction activity must be incorporated into the EIA.*

12.8.4 Assessment Methodology

- A desk study of the air quality / climate baseline of the Site (where data available) and nationally
- Evaluation of the potential and significance of effects
- Evaluation of the reduction in climate change emissions
- Identification of measures to avoid and mitigate potential effects identified

12.8.5 Baseline Climate

The Irish climate is defined as a temperate oceanic climate on the Köppen climate classification system. Ireland's climate is mild, moist and changeable with abundant rainfall and a lack of temperature extremes. The country generally receives cool summers and mild winters and is considerably warmer than other areas on the same latitude. Ireland's land mass is warmed by the North Atlantic current all year and as a result does not experience a great annual range of air temperatures.

'Ardnawark Barnesmore' (Station 2440) is a Met Éireann rainfall station located approximately 670 m West of the Site Boundary. 'Finner Camp', located between Ballyshannon and Bundoran, Co. Donegal is the closest Met Éireann climate station (measuring a range of parameters) to the Development and is situated approximately 30 km due south-west. The mean annual air temperature at 'Finner Camp' between 2016 and 2019 (up to and including 16 Sept 2019) is 9.7 °C. Mean monthly temperatures over the same period ranged from 5.1 °C in January to 15.1 °C in July. Mean annual rainfall over the same period was 1249.1 mm, with a maximum monthly mean rainfall of 136.8 mm in October and a minimum monthly mean rainfall of 72.3 mm in June[13]. Maximum effective rainfall data from Ardnawark Barnesmore station indicates that the Site could potentially receive approximately 206 mm/month of effective rainfall during the wettest months, or approximately an average of 13 mm of effective rainfall per day during the wettest months. However, Minerex Environmental Limited calculated (**Chapter 8: Soils and Geology**) that 100 year return periods, or a 1 in a 100 year storm event data at the Site, could potentially receive up to or more than 150 mm of rainfall in a day, and potentially 40 mm of rainfall in an hour during extreme weather events.

[13] Met Eireann. Monthly Data – Finner camp. Available online at: https://www.met.ie/climate/available-data/monthly-data [Accessed on 11 September 2019]

12.8.6 Baseline Air Quality

World Health Organisation (WHO) air quality guideline values for 2018, were exceeded at several monitoring sites in Ireland for fine Particulate Matter (PM_{10} and $PM_{2.5}$), nitrogen oxides (NO_X) and ozone. According to the EPA (2019) [14] PM from solid fuel burning remains the greatest threat to good quality air in Ireland. This is closely followed by nitrogen dioxide (NO_2) from transport emissions in urban areas. The European Environment Agency reference level for atmospheric Polycyclic Aromatic Hydrocarbon (PAH – chemicals formed mainly by anthropogenic processes, especially the combustion of organic fuels) has also been exceeded. The EU Commission has imposed targets on Ireland's emissions. Ireland's long-term energy policy framework is set out in the Climate Action Plan 2019 (**Chapter 4: Planning Policy, Section 4.5.2**).

The latest figures from the Central Statistics Office (CSO) outlined Ireland as the third highest producer of greenhouse gases (GHG) per capita in Europe as of 2017, behind Estonia and Luxembourg. The Environmental Indicators Ireland 2019 report[15] examined a number of factors relating to the environment and the country; key findings relating to GHG showed that Ireland produced 60.7 m tonnes of CO_2 equivalent for 2017, which marked an increase of 9.6 percent compared with the 1990 figure of 55.4 m tonnes. The most recent published report on air quality in Ireland is the 'Air Quality in Ireland 2017' report published by the EPA in 2017. There are three monitoring stations in Donegal; the closest station to the Development is Letterkenny (this is classed however as Zone C, an urban area, located 41 km due north). Results from the monitoring campaign during 2017, show no levels above EU limit values were recorded from the ambient air quality monitoring site in Letterkenny. Due to the non-industrial nature of the Development and the general character of the surrounding environment, it is expected that air quality is 'good', since there are no major sources of air-polluting industries in the immediate vicinity of the Site.

12.8.7 Assessment of Potential Effects

The main potential source of impacts on air quality during the initial decommissioning and construction phase is dust. Mitigation measures are outlined in **Chapter 14: Traffic and Transport**, **Section 14.6**. These measures are in alignment with Guidelines for the Treatment of Air Quality during the Planning and Construction of National Road Schemes (NRA, 2011)[16]. The nearest inhabited residential dwellings are located over 2 km from the Site Boundary (north of the Site). After (standard practice) mitigation, the residual effects have been assessed as ***imperceptible/ slight, negative and short-term*** in nature. During the initial decommissioning phase, the potential impact from dust becoming friable and being a nuisance to workers, residents and local road users is considered***, a slight, negative, short-term, direct*** impact.

Emissions from plant and machinery, including trucks, during the initial decommissioning and construction phase of the Development are a potential impact. The engines of these machines produce emissions such as carbon dioxide (CO_2), carbon monoxide (CO), NO_x, and PM (PM_{10} and $PM_{2.5}$). This phase is likely to lead to small localised increases in these emission levels, which is likely to lead to a **temporary imperceptible** effect. There are no such emissions associated with the operational phase of wind turbines. The decommissioning/removal phase is assessed as smaller in scale than the initial decommissioning and construction phase and therefore impacts are assessed as less significant.

The construction of turbines, such as the Development will result in lower environmental levels of harmful emissions and consequential benefits on human health, where they are offsetting electricity generation that would otherwise come from fossil fuel sources.

The CO_2 'payback time', which is the period of windfarm operation required until there is a net saving of CO_2 (until achieved savings equal whole-lifetime emissions) can be calculated as the total CO_2 offset associated with the Development divided by its carbon footprint. Candidate turbines being considered could result in a total installed capacity ranging from 53.3 Megawatts (MW) to 75.4 MW. Based on an estimated generation capacity of 149,411,000 kWh / year

[14] Environmental Protection Agency (2019). *Air Quality in Ireland 2018*. Available online at http://www.epa.ie/pubs/reports/air/quality/ [Accessed on 12 September 2019]

[15] Central Statistics Office. Environmental Indicators Ireland 2019. Available online at: https://cso.ie/en/releasesandpublications/ep/p-eii/eii19/ [Accessed on 12 September 2019]

[16] National Roads Authority (2011) Guidelines-for-the-Treatment-of-Air-Quality-during-the-Planning-and-Construction-of-National-Road-Schemes. Available online at: https://www.tii.ie/technical-services/environment/planning/Guidelines-for-the-Treatment-of-Air-Quality-during-the-Planning-and-Construction-of-National-Road-Schemes.pdf [Accessed on 12 November 2019]

(53.3 MW), the Development will have a carbon footprint of approximately 2,241-3,170 tCO_2eq/year or 89,640 over a 40-year period (40 years taken as an example time period; 75.4 MW = 126,180 tCO_2eq/ 40 years)[17].

The Development design layout has considered the reuse of the existing infrastructure as much as possible to minimise disturbance of active blanket bog. From an ecological point of view, foremost in Site selection has been the avoidance of Barnesmore Natural Heritage Area (NHA Site Code 002375), designated for its complex mosaic of upland blanket bog, wet heath and flushes, in as far as possible. The selection of breaking new ground at chosen sites, impacting on natural habitat has been kept to a minimum; thus greatly influencing the overall volume of peat loss. The Development involves the removal of 15 MW of power and the installation of up to 75.4 MW, therefore the impact of the Development is never more than 60 MW.

Minerex, carried out extensive peat probe exercises throughout the Site in locations where excavations may be undertaken. Cumulative peat depths were calculated, and it has been estimated that approximately 23,093 m^3 of peat soil is required to be excavated for the Development. This volume of peat excavation can be characterised as low for the size of this Development; it has been greatly reduced due to embedded design measures and prudent reuse of existing hardstands, Site Access Tracks etc. This volume equates to approximately 46 t of dry peat fuel.[18] If this amount of peat were to be combusted, at worst-case scenario (considering not all carbon may be released where peat is reinstated), this equates to 62 tCO_2eq.[19]

Indicative figures have been applied to the Development to estimate the annual CO_2 offset of the Development. It is estimated to be 72,165 tCO_2/yr or 2,886,600 tCO_2 over 40 years (102,087 tCO_2/yr or 4,083,480 tCO_2/yr over 40 years). The estimated carbon footprint of the Development for worst and best -case scenarios ranges from approximately 3.09% -3.10% of this volume[20], meaning that the time it would take to displace emissions equivalent to those used in the manufacture and construction of the Development (dependent on candidate turbine) is between approximately 14.8-14.9 months.

Taking into consideration however, the reduced offset (15 MW) due to the existing turbines, the estimated net time it would take to offset the emissions for the Development is therefore between 17.9 months to 19.2 months.

CO_2 emission savings for the operational lifetime beyond this ‘payback time’ would see a net positive benefit of the Development in reducing climate change. The Development will have a beneficial effect on carbon emission savings which increases proportionally with the duration of the operational phase in perpetuity.

12.8.8 Evaluation of the Reduction in Climate Change Emissions

The Development does not contain any element, which will produce GHG emissions or odorous emissions. Indeed, the Development will contribute to a net national reduction in the emissions of greenhouse and other gases resulting from the combustion of fossil fuels. The gases of main concern are those that contribute to an increase of the Greenhouse Effect (carbon dioxide, methane, nitrous oxide and other nitrogen oxides) and those that contribute to Acid Rain (principally sulphur dioxide). The degree to which wind energy reduces levels of emissions depends on the method of electricity generation which it is replacing. This assessment assumes two scenarios; the lowest potential output of 53.3 MW from a 4.1MW turbine and the optimum output from a 5.8 MW model. Even taking into account the peat soils displaced by the turbine foundations and hardstands, the calculated carbon footprint of the Development represents a relatively small percentage of the predicted overall CO_2 offset. **Table 12.4** shows the approximate emission savings that can be achieved each year through running at assumed 32% capacity for each turbine model.

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[17] Thomson, R.C. and Harrison, G. P. (2015) *Life Cycle Costs and Carbon Emissions of Onshore Wind Power.* A ClimateXChange Report. Available online at: https://www.climatexchange.org.uk/media/1463/main_report_-_life_cycle_costs_and_carbon_emissions_of_onshore_wind_power.pdf [Accessed on 18 November 2019] (0.015kg CO_2eq/kWh x 149,411,000 kWh/year = 2,241 tCO2eq/year for a 53.3 MW installation; 3,170 tCO2eq/year for 75.4 MW)

[18] Environmental Protection Agency (2007) *Measurements of soil bulk density across differing soil types and land uses in Ireland*. A soil bulk density of 0.2g /cm^3 derived from this study was used (i.e. 0.2 g/cm^3 = 2 kg/m^3 x 23,093m^3 = 46 t of dry peat fuel).

[19] *Bigeosciences* (2015) *Derivation of greenhouse gas emission factors for peatlands managed for extraction in the Republic of Ireland and the United Kingdom*, Eds. D. Wilson, S. D. Dixon, R. R. E. Artz, T. E. L. Smith, C. D. Evans, H. J. F. Owen, E. Archer, and F. Renou-Wilson Volume 12, 5291-5308. (1.346 CO^2 x 46 = 62 tCO_2eq).

[20] For a turbine with a 53.3MW output: 89,640 tCO_2eq over a 40-year lifetime + 62 tCO_2eq combusted peat = 89,702 tCO_2eq / CO_2 offset of 2,886,600 tCO_2 = 3.10% or 14.9 months.

Table 12.4: Statistics relating to Emissions Avoidance of the Development (per annum)

Factor	Contribution based on 53.3 MW Capacity	Contribution based on 75.4 MW Capacity
Energy Produced (MWh per annum)	149,411[21]	211,361
Number of Homes Powered (per annum)	32,284[22]	45,670
CO_2 offset (tonnes per annum)	72,165[23]	102,087
Nitrous oxides offset (tonnes per annum)	448[24]	634
Sulphur dioxide offset (tonnes per annum)	1,494[25]	2,114

The relative reductions in GHG emissions in the energy sector will serve to reduce the effects of climate change on a national and global level, albeit at a small scale. This will be a **small positive impact** in the medium term in helping Ireland reduce its GHG emissions and meet its international obligations.

12.8.9 Mitigation Measures
Mitigation measures in relation to dust during all phases of the Development are outlined in **Chapter 14: Traffic and Transport, Section 14.5**.

12.8.10 Residual Impacts of the Development
The production of energy from the Development will have no direct emissions at the point of generation, unlike typical fossil fuel-based power stations. Harnessing energy by means of repowering the Operational Barnesmore Windfarm will result in a reduction in harmful emissions that can be damaging to human health and the environment.

12.8.11 Cumulative Effects
In Ireland, a record high of 532 MW of wind-generation capacity was installed in 2017. Renewable energy displaced 1.8 Mtoe of fossil fuel consumption and avoided 4.2 $MtCO_2$ of GHG emissions in 2017[26]. This was equivalent to 11% of total energy-related CO_2 emissions. Renewable electricity accounted for over 60% of renewable energy. There is no binding EU target for renewable electricity. However, Ireland has set a target of 40% of electricity to come from renewable sources by 2020. The target for 2030 is to generate 70% of the country's electricity from renewable sources. The Development will contribute up to 75.4 MW of new installed capacity. The cumulative effect with other Irish renewable generation is considered to be a fundamental change in the climate effects of Ireland's energy supply, which is a **major, positive effect,** that is significant under the EIA Regulations and will contribute to Ireland's binding emission reduction targets.

The initial decommissioning and construction phase is a short-term activity, so the potential cumulative impact could be predicted to be **slight, negative, temporary/short-term, direct** given the extended distance of over two km of the Development to sensitive receptors.

12.8.12 Summary of Significant Effects
This assessment has identified no potentially significant effects, given the mitigation measures embedded in the design and recommended for the implementation of the Development. In isolation, the Development will have a significant

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[21] 53.3 MW x 0.32 x 365 x 24 (53.5 MW turbines x 0.32 (32% capacity factor average) x no. of days x no. of hours) = 149,411 MWh per annum and 60.0 MW x 0.32 x 365 x 24 = 168,192 MWh per annum.

[22] Sustainable Energy Authority of Ireland (2018) *Energy in the Residential Sector 2018 Report*. Page 45, Table 19 shows "In *2016, the average dwelling consumed 18,325 kWh of energy, based on climate corrected data, indicating 4.2% annual growth. This comprised 13,697 kWh (74.7 %) of non-electric and 4628 kWh (25.2%) of electricity*." Therefore, the Development can be expected to meet the average electricity consumption of (149,411 MWh x 1000 = 149,411,000 kWh / 4628 kWh) = 32,284 homes.

[23] Sustainable Energy Authority of Ireland (2018) '*Energy in the Residential Sector 2018 Report*'. Page 49 highlights *"between 2000 and 2016 the CO_2 emissions per unit of electricity decreased by 37 %".* In 2016 the carbon intensity of grid electricity was calculated as *483g CO_2/kWh* (Table 21, Pg. 50) The expected generation (149,411,000 kWh) is multiplied by 0.483 to calculate the kg of CO_2 equivalent saved per year. (149,411,000 kWh x 0.483)/1000 = 72,165 tonnes/annum CO_2 equivalent.

[24] 149,411000kWh x 0.003kg / 1000 = 448 t (based on British Wind Energy Association figure of 3g NO_x/kW/h http://www.bwea.org/edu/calcs.html).

[25] 149,411,000MWh x 0.010kg / 1000 = 1,494 t (based on British Wind Energy Association figure of 10g SO_2/kW/h (http://www.bwea.org/edu/calcs.html)

[26] Sustainable Energy Authority of Ireland (2019). *Renewable Energy in Ireland.* Available online at: https://www.seai.ie/publications/Renewable-Energy-in-Ireland-2019.pdf [Accessed on 14 November 2019]

positive effect on carbon savings and cumulatively, a significant positive effect when considered with Ireland's renewable energy deployment.

12.8.13 Statement of Significance

This Section has assessed the significance of potential effects of the Development on climate change and air quality. The Development has been assessed as having the potential to result in slight, negative, temporary/short-term effects during decommissioning/construction phase and a **slight, positive, long-term effect** in terms of helping Ireland meet its international obligations to reduce GHG emissions.

Given that only effects of significant impact or greater are considered "significant" in terms of the EIA Regulations, the potential effects of the Development on air quality and climate are considered **not significant**.

12.9 Shadow Flicker

12.9.1 Introduction

This section assesses the potential shadow flicker effects of the Development. Where negative effects are predicted, this section identifies appropriate mitigation strategies therein. The assessment will consider the potential effects during the operational phase of the Development:

Shadow flicker computer models were used to calculate the occurrence of shadow flicker at relevant receptors of the Development. The outputs from the calculations are analysed to identify and assess potential shadow flicker impacts.

Wind turbines, like other tall structures, can cast long shadows when the sun is low in the sky. The 2018 Review of the 2006 Guidelines confirms that:

"Shadow Flicker occurs when the sun is low in the sky and the rotating blades of a wind turbine casts a moving shadow which, if it passes over a window in a nearby house or other property results in a rapid change or flicker in the incoming sunlight. The time period in which a neighbouring property may be affected by shadow flicker is completely predictable."
The 2006 Guidelines state that:

> *This effect lasts only for a short period and happens only in certain specific combined circumstances, such as when:*
>
> - *the sun is shining and is at a low angle (after dawn and before sunset), and*
> - *the turbine is directly between the sun and the affected property, and*
> - *there is enough wind energy to ensure that the turbine blades are moving".*

The recently published 2019 Draft Revision of the Wind Energy Development Guidelines (WEDG) also added the circumstance where:

- *"there is sufficient direct sunlight to cause shadows (cloud, mist, fog or air pollution could limit solar energy levels)*" and note that
- "*Generally only properties within 130 degrees either side of north, relative to the turbines, can be affected at these latitudes in the UK and Ireland – turbines do not cast long shadows on their southern side"*.

Careful Site selection, design and planning, and good use of relevant software to control the turbine operation can help avoid the possibility of shadow flicker in the first instance. Modern wind turbines have the facility to measure sunlight levels and to reduce or stop turbine rotation if the conditions that would lead to shadow flicker at any neighbouring property occur.

The distance and direction between the turbine and property is of significance because:

- The duration of the shadow will be shorter the greater the distance (i.e. it will pass by quicker)
- The shadow flicker cast will be reduced, the further a dwelling is from an operating turbine

Shadow flicker is more likely to occur on sunny winter days, when the sun is lower in the sky and shadows are cast a greater distance from the turbine. Shadow flicker is more likely to take place where turbines are sited to the east, south-east, west or south-west of properties.

No shadow flicker is experienced at some dwellings due to the orientation of these dwellings with respect to the proposed turbines.

Shadow flicker may have the potential to cause disturbance and annoyance to residents if it affects occupied rooms of a house.

Persons with photosensitive epilepsy can be sensitive to flickering light between 3 and 60 Hertz (Hz)[27]. This is supported by research in recent years asserting that flicker from turbines must interrupt or reflect sunlight at frequencies greater than 3 Hz to pose a potential risk of inducing photosensitive seizures. The frequencies of flicker caused by modern wind turbines are less than 1 Hz[28], and are well below the frequencies known to trigger effects in these individuals. Therefore, any potential shadow flicker effect from the Development is considered an effect on residential amenity, rather than having the potential to affect the health or well-being of residents.

12.9.2 Relevant Legislation

Although there is no agreed standard for shadow flicker impact in Ireland, the Department of Environment, Community and Local Government in its Wind Energy Development Guidelines (2006) (the 2006 Guidelines) considers that:

> "*At distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low. Where shadow flicker could be a problem, developers should provide calculations to quantify the effect and where appropriate take measures to prevent or ameliorate the potential effect, such as by turning off a particular turbine at certain times*".

The 2006 Guidelines also state that:

> "*It is recommended that shadow flicker at neighbouring offices and dwellings within 500m should not exceed 30 hours per year or 30 minutes per day*".

The preferred approach in the review of the 2006 Guidelines (Review of the Wind Energy Development Guidelines 2006 Preferred Draft Approach) is to eradicate shadow flicker altogether. This is indicative of likely emerging guidance, the documents states:

> *"The 'preferred draft approach' proposes that technology and appropriate modelling at design stage to eradicate the occurrence of shadow flicker must be confirmed in all planning applications for wind energy development.*
>
> *Moreover, there will be clearly specified measures for automatic wind turbine shut down, where the issue arises as a condition planning permission. In effect, no neighbouring property will experience the occurrence of shadow flicker."*

The revised draft of Wind Energy Development Guidelines 2019 outlines that

> *"A condition should be attached to all planning permissions for wind energy development to ensure that there will be no shadow flicker at any existing nearby dwelling or other relevant existing affected sensitive property and that the necessary measures outlined in the shadow flicker assessment submitted with the application, such as turbine shut down during the associated time periods, should be taken by the wind energy developer or operator to eliminate the shadow flicker".*

Therefore, the approach taken in this assessment is for the eradication of shadow flicker effects on sensitive receptors.

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[27] Epilepsy Action (2012) *Other Possible Triggers of Photosensitive Epilepsy*. Available online at: http://www.epilepsy.org.uk/info/photosensitive-epilepsy [Accessed on 27 November 2019]
[28] Harding, G., Harding, P., & Wilkins, A. (2008). *Wind turbines, flicker, and photosensitive epilepsy*. *Epilepsia* (49) 6, pp. 1095-1098.

Taking the above into consideration, JOD examined maps to identify receptors (dwellings) in the local area within ten rotor diameters (1,580 m) of the worst-case turbines under consideration with a rotor diameter of 158 m of the Development. There is only one potential dwelling (H19) within this radius of the turbines. This is an uninhabited structure used as a shed for livestock. However, this building has been assessed as it has a roof and could therefore theoretically be restored and used as a dwelling house in the future. However, it is not currently considered a sensitive receptor. It is also worth noting that the front of the house faces in a southerly direction and the back faces north with only the eastern gable of the house facing the windfarm turbines. The house is also screened by a row of trees between the house and the Development.

It should be noted that there are no occupied houses within ten rotor diameters of a proposed turbine and therefore, the potential for shadow flicker is very low, even before modelling has been undertaken.

12.9.3 Scoping Responses and Consultation

Consultation responses are outlined in **Table 12.5.**

Table 12.5: Summary of Consultation Responses on Shadow Flicker

Consultee	Type & Date	Summary of Response	Response to Consultee
Environmental Health Service	Letter in Response to Scoping Report received on 24 June 2019	Shadow flicker assessment should be carried out identifying all impacted dwellings and sensitive receptors together with appropriate mitigation measures required. The assessment should include identification of the room use in properties potentially impacted by shadow flicker. If the turbine height or position has not been finalised at the EIS stage, then potential differences in shadow flicker for different height options should be considered.	Addressed within this EIAR / Chapter.

12.9.4 Shadow Flicker Modelling

An industry standard windfarm assessment software package, WindFarm from ReSoft Limited computer software Version 4.2.1.7 was used to prepare a model of the Development. The programme facilitates the analysis of a windfarm for possible shadow flicker occurrence at nearby houses and allows for the production of maps, merged shadow flicker occurrence listings and a shutdown list if required. The data output from the programme can be analysed and any receptors identified as potentially vulnerable to shadow flicker can be identified and the significance of the effect calculated.

Generic windows of 1 m squared, of which the centre is 2 m above ground are applied to each side of the house. These windows represent an approximation of the existing windows on the house facing north, south, east and west and provide an estimate of potential shadow flicker to a window on each side of the house. The software determines the times of day/year when the sun will be in line with the rotational components of the turbine and the house/receptor, thereby having the potential to cause shadow flicker. The software outputs details of potential shadow flicker, in this case by mean and maximum duration of the shadow flicker events, days per year and times of occurrence and maximum hours per year and maximum minutes per day of shadow flicker.

The following data inputs were required and used to produce an estimate of the effect of shadow flicker at the windfarms:

- Ordnance Survey Ireland Raster base map
- Digital elevation model of the Development and areas around all properties within the model (10 m resolution – OS X, Y, and Z data points)
- Turbine locations
- Turbine dimensions (rotor diameter and hub height)
- Receptor locations (i.e. property locations)
- Height above ground level of the ‘window’ (1 m above ground level)

The software creates a mathematical model of the Development and its surroundings and uses this information to calculate specific theoretical times and durations of flicker effects for the identified properties. The following 'worst-case' assumptions were incorporated into the shadow flicker modelling:

- there are no clouds and sunlight is always bright and direct
- the turbines are always rotating
- the turbine rotor will always be facing directly towards a given property and the property window will also always face each turbine, thus maximising the size of the shadow and duration of the effect
- there is no intervening structures or vegetation (other than topography) that may restrict the visibility of a turbine, preventing or reducing the effect
- a limit to human perception of shadow flicker is not considered by the model

The model operates by simulating the path of the sun during the year and assessing at each time interval the possible shadow flicker at one or multiple receptor positions. The results of the model provide a calculation of theoretical specific times and durations of flicker effects for the identified properties. As previously stated, given the assumptions incorporated into the model, the calculations overestimate the duration of effects. This worse-case scenario is considered to be sufficient for the purposes of this assessment.

The model also outputs a more realistic scenario, or the "expected values". In this scenario, the only change in assumptions is that the statistically likely monthly sunshine frequency and wind direction frequency data is assessed. This assessment only changes the annual hours per year metric and is not applied to the daily data. The data used in the model was the:

- Long-term sunshine probability data from the Met Éireann synoptic station in Malin Head
- Long-term wind frequency data for the Site downloaded from the Sustainable Energy Authority of Ireland (SEAI) Wind Atlas[29]

12.9.5 Baseline Description

A preliminary assessment was carried out to record property locations identified as potentially affected by shadow flicker. The location of the property and distance from the closest turbine (T13) are listed in **Table 12.6** and shown on **Figure 1.3**.

The defined study area was based on the 2006 Guidelines which is for properties within 10 Rotor Diameters (1,580 m) which resulted in one property being assessed.

It should be noted that H19 is an abandoned dwelling house which is currently used for livestock, the front and back of the house do not face the turbines and there is a row of trees/vegetation on the eastern side of the house. The property was identified using a combination of Ordnance Survey of Ireland (OSI) Maps, AutoCAD drawings, Google Street View, Google Earth and Bing Maps and from a visit to the Site. This information was then used in the Shadow Flicker model to assess the theoretical worst-case scenario of potential shadow flicker events.

Table 12.6: Properties within 10 Rotor Diameters of Proposed Turbines

Property No.	Easting (ING)	Northing (ING)	Easting (ITM)	Northing (ITM)	Closest Turbine	Distance to Turbine (m)
H19	201753.72	381258.26	601705.09	881253.62	T13	1,300

12.9.6 Assessment of Potential Effects

This assessment considers the potential shadow flicker impact of the Development on the sole property located within 10 rotor diameters of T13 in terms of:

- Predicting and assessing the extent of shadow flicker experienced of the proposed turbine locations

[29] Sustainable Energy Authority of Ireland. Wind Mapping System. Wind Data extract. Available online at http://maps.seai.ie/wind/

- Specifying mitigation measures, where deemed necessary

The calculation of the days of shadow flicker per year and the maximum hours per year of shadow flicker experience are as calculated by the computer software.

Details of the annual and daily shadow flicker estimates for the single house location can be found in **Table 12.7**. Full assessment outputs are outlined in **Technical Appendix 12.2**. A predicted shadow flicker occurrences contour map is outlined in **Figure 12.2**.

Table 12.7: Summary of Annual and Daily Potential Shadow Flicker Listing for All Properties (worst -case scenario)

Property No.	Easting (ING)	Northing (ING)	Potential Total hours of Shadow Flicker per year (worst-case) (h:min)	Potential Shadow Days per year (worst -case) (d/y)	Potential maximum hours of Shadow Flicker per day (worst-case) (h:min)	Predominant Contributing Turbine
H19	201753.72	381258.26	14:00	48	0:48	T12 & T13

One property is within 10 Rotor Diameters of a turbine at the Development with T13 being the closest turbine (**Table 12.7**). The predicted shadow flicker occurrences figure above is based on a “worst case” scenario and assumes the sun is always shining, that there is no cloud cover and the dwelling is always occupied. As previously stated, this calculation is based on topography alone and excludes vegetation, buildings and other man-made structures.

It has been determined through the calculation completed that the property will potentially experience less than 30 hours of shadow flicker per year but greater than 30 minutes per day in a worst-case scenario. The contributing turbines are indicated in **Table 12.7** and are T12 and T13.

12.9.7 Assessment of Actual Shadow Flicker Impact

12.9.7.1 Reduction of Shadow Flicker due to absence of Sunlight

In order to assess ‘projected’ occurrences for the property that was identified as potentially vulnerable to shadow flicker, it was necessary to identify the likely meteorological conditions which are expected to be experienced at the Site. To estimate the impact of sunshine occurrence on the potential shadow flicker effects, historical meteorological data from Met Éireann was obtained. This data was utilised to consider the probability of sunshine occurrence, and thus allow the determination of ‘projected’ values for shadow flicker occurrence.

The World Meteorological Organization (WMO) recommends that climate averages are computed over a 30-year period of consecutive records[30]. The period of 30 years is considered long enough to smooth out year to year variations. Henceforth Met Éireann reference 1981 to 2010 as the baseline period for day-to-day weather and climate comparisons. The closest climatic station to the Development is located in Malin Head, County Donegal. The 30-year average report (1981-2010) was obtained for Malin Head weather station[31], this provided the mean daily duration sunshine hours. The shadow flicker experienced can be greatly affected by sunshine occurrence. Ireland normally gets between 1100 and 1600 hours of sunshine each year. The sunniest months are May and June. During these months, sunshine duration averages between 5 and 6.5 hours per day over most of the country. The extreme southeast gets most sunshine, averaging over 7 hours a day in early summer. December is the dullest month, with an average daily sunshine ranging from about 1 hour in the north to almost 2 hours in the extreme southeast. Over the year as a whole, most areas get an average of between 3.25 and 3.75 hours of sunshine each day.[32] The area of the Site receives 1,050 to 1,100 hours per year.

As discussed earlier, to estimate the impact of sunshine occurrence, historical meteorological data is utilised to consider the likelihood of sunshine (the sunshine probability) at different times of the year, and thus allow the determination of

[30] World Meteorological Organization Available online at: https://www.met.ie/climate/30-year-averages [Accessed on 22 August 2019]
[31] Met Eireann. https://www.met.ie/climate-ireland/1981-2010/malin.html [Accessed on 22 August 2019]
[32] Met Eireann. Insert actual document name. https://www.met.ie/climate/what-we-measure/sunshine [Accessed on 22 August 2019]

'expected' values for shadow flicker occurrence. This is achieved by applying a reductive factor to the worst case total hours per year of shadow flicker occurrence in which 'long term average sunshine hours' refers to data collected by Met Éireann, and 'potential sunshine hours' refers to the intervening time period between modelled sunrise and sunset.

Data for the period 1980-2010 was obtained for Malin Head weather station. The historical meteorological data collected and analysed from Malin Head station revealed that the area received only 3.5 hours of average sunshine per day between 1981 and 2010[33]. To determine the probability of sunshine occurrence a shadow flicker reduction factor was calculated based on the following information:

- 4,397 hours of daylight per year at Sligo[34]
- 1207.5 hours of actual sunshine per year (based on 3.5 hours of average sunshine per day as recorded by Met Éireann at Malin Head between 1981 and 2010)

The long-term annual average hours of sunlight at the Site is approximately 28% of the total hours of daylight, therefore, the total annual average shadow flicker will be approximately 28% of the predicted worst case for the total annual hours per year scenario.

By applying this reduction factor to the shadow flicker hours experienced at the property, the house will experience 4 projected hours of shadow flicker per year.

Table 12.8 below shows a list of the expected shadow flicker values per year which is likely to be experienced by the property.

Table 12.8: Summary of Potential Annual Shadow Flicker Listing for All Properties (worst -case scenario)

Property No.	Easting (ING)	Northing (ING)	Potential Total hours of Shadow Flicker per year (worst case) (h:min)	Expected Shadow Values per year (h/y)
H19	201753.72	381258.26	14:00	3.92

The projected total hours per year occurrences of shadow flicker in the absence of sunlight satisfy the recommended 30-hours/year and 30-minutes/day guidance limit for the assessed property (which is currently derelict, does not face the turbines and has vegetative screening).

12.9.8 Mitigation Measures & Residual Effects

Where significant shadow flicker effects are predicted to affect a sensitive receptor, these can be mitigated by either introducing additional screening or adapting turbine control systems to stop the offending turbine when shadow flicker conditions are present. Both methods can be used to completely eliminate the effect in line with the draft Guidelines.

In this instance, no mitigation is proposed as the single affected receptor is not considered sensitive, due to the property being derelict, not facing the turbines and has existing vegetative screening, and the predicted effects are below the current guidance levels. However, it should be noted that the function to stop the turbine if required to do so, is available.

12.9.9 Cumulative Effects

Cumulative shadow flicker impacts could arise if dwellings are at risk from potential shadow flicker impacts as a result of more than one windfarm. While separate windfarms are not likely to cause effects simultaneously, they could increase the cumulative total hours where a receptor is impacted. In this instance, there are no operational or consented windfarm developments in the vicinity of the Development with the potential to cause significant shadow flicker effects at property H19. Therefore, no cumulative shadow flicker impacts are possible.

12.9.10 Summary of Significant Effects

This assessment has identified no significant effects, given the projected total hours per year occurrences of shadow flicker in the absence of sunlight satisfy the recommended 30-hour guidance limit and the house is derelict.

[33] https://www.met.ie/climate-ireland/1981-2010/malin.html [Accessed on 22 August 2019]
[34] https://www.timeanddate.com/sun/ireland/sligo?month=12&year=2017 [Accessed on 22 August 2019]

12.9.11 Statement of Significance

This assessment has identified no significant effects, given that shadow flicker is unlikely to cause a nuisance to nearby inhabited dwellings which are greater than ten rotor diameters from the turbines.

Given that only effects of significant impact or greater are considered “significant” in terms of the EIA Regulations, the potential effects of the Development from shadow flicker are considered to be **not significant**.