5. POPULATION AND HUMAN HEALTH

5.1 Introduction

This section of the Environmental Impact Assessment Report (EIAR) identifies, describes and assesses the potential impacts and effects of the Proposed Development on human beings, population and human health and has been completed in accordance with the EIA guidance and legislation set out in Chapter 1: Introduction, Section 1.3.3. The full description of the Proposed Development is provided in Chapter 4 of this EIAR.

One of the principal concerns in the development process is that individuals or communities, should experience no significant diminution in their quality of life from the direct or indirect effects arising from the construction, operation and decommissioning of a development. Ultimately, all the impacts of a development impinge on human health, directly and indirectly, neutral, positively and negatively. The key issues examined in this chapter of the EIAR include population, human health, employment and economic activity, land-use, residential amenity, community facilities and services, tourism, property values, shadow flicker, noise and health and safety.

There are 109 No. properties located within one kilometre of the proposed turbine locations, of which six are derelict, while the remaining 103 No. properties are habitable dwellings. A minimum separation distance of 724m from the wind turbine (T8) to the nearest point of any occupied, non-participating, residential dwelling (H62) has been achieved with the project design.

5.1.1 Statement of Authority

This section of the EIAR has been prepared by David Naughton and Órla Murphy and reviewed by Michael Watson, of MKO. David is an Environmental Scientist with over four years of consultancy experience with MKO and has been involved in a number of wind energy EIAR applications. David holds a BSc (Hons) in Environmental Science. Órla is a Project Environmental Scientist with over 6 years' experience in the environmental sector where she has acted as Project Manager for a number of EIAR applications for wind energy developments, compiling numerous chapters including chapters on Population and Human Health. Órla holds a BSc. in Geography and MSc. in Environmental Protection and Management. Michael Watson is a Project Director with MKO; with over 18 years' experience in the environmental sector. His project experience includes the management and productions of Environmental Impact Statements (EISs)/EIARs, particularly within the wind energy sector.

5.2 Population

5.2.1 Receiving Environment

This socio-economic study of the receiving environment included an examination of the population and employment characteristics of the area. Information regarding population and general socio-economic data were sourced from the Central Statistics Office (CSO), the County Roscommon Development Plan 2022-2028 and Fáilte Ireland. Where there is any relevant literature pertinent to the area, this will be referenced below. The study included an examination of the population and employment characteristics of the area. This information was sourced from the Census of Ireland 2016, which is the most recent census for which a complete dataset is available, also the Census of Ireland 2011, the Census of Agriculture 2010 and from the CSO website (www.cso.ie). Census information is divided into State, Provincial, County, Major Town and District Electoral Division (DED) level.

The Proposed Development is located within several townlands as listed in Section 1.1, Table 1-1 of this EIAR. The Proposed Development site is located northeast and southeast of the village of Dysart, approximately 1.5 kilometres away at its closest point and approximately 11 kilometres northwest/west of the town of Athlone, Co. Roscommon. Please refer to Figure 1-1 of Chapter 1: Introduction, for the site location.

For the purposes of this EIAR, where the 'Proposed Development' is referred to, this relates to all the project components of the proposed Seven Hills Wind Farm, described in detail in Chapter 4 of this EIAR. Where the 'the site' is referred to, this relates to the primary study area for the development, as delineated by the EIAR Site Boundary in green as shown on the EIAR figures. The actual site boundary for the purposes of the planning permission application occupies a smaller area within this primary area.

In order to assess the population in the vicinity of the Proposed Development, the Study Area for the Population section of this EIAR was defined in terms of the District Electoral Divisions (DEDs) where the proposed Wind Farm site is located, and where relevant, nearby DEDs which may be affected by the Proposed Development. The site of the Proposed Development lies within Turrock, Dysart, Taghmaconnell, Castlesampson, Kilcar and Ballinamona DEDs as shown in Figure 5-1. All of these DEDs will collectively be referred to hereafter as the Study Area for this chapter.

The Population Study Area has a population of 2,642 persons, as of 2016 and comprises a total land area of 2,639km^2 (Source: CSO Census of the Population 2016).

In order to assess potential impacts on population and human health along the Grid Connection route, a review of properties and planning applications in the vicinity of the proposed works was carried out, with the majority of developments along the route comprising single houses. The land-use along the Grid Connection route is comprised of public roads and some agriculture. The active construction area for the Grid Connection will be small, ranging from 150 to 300 metres in length at any one time, and it will be transient in nature as it moves along the route.

The closest third-party dwelling to the Proposed Development is located approximately 724m from the nearest proposed turbine (T8), i.e. greater than the recommended setback distance (i.e. 4 times the tip height, 720m), as per the *Draft Revised Wind Energy Development Guidelines* (Department of Housing, Planning and Local Government, December 2019 (currently out for public consultation)).

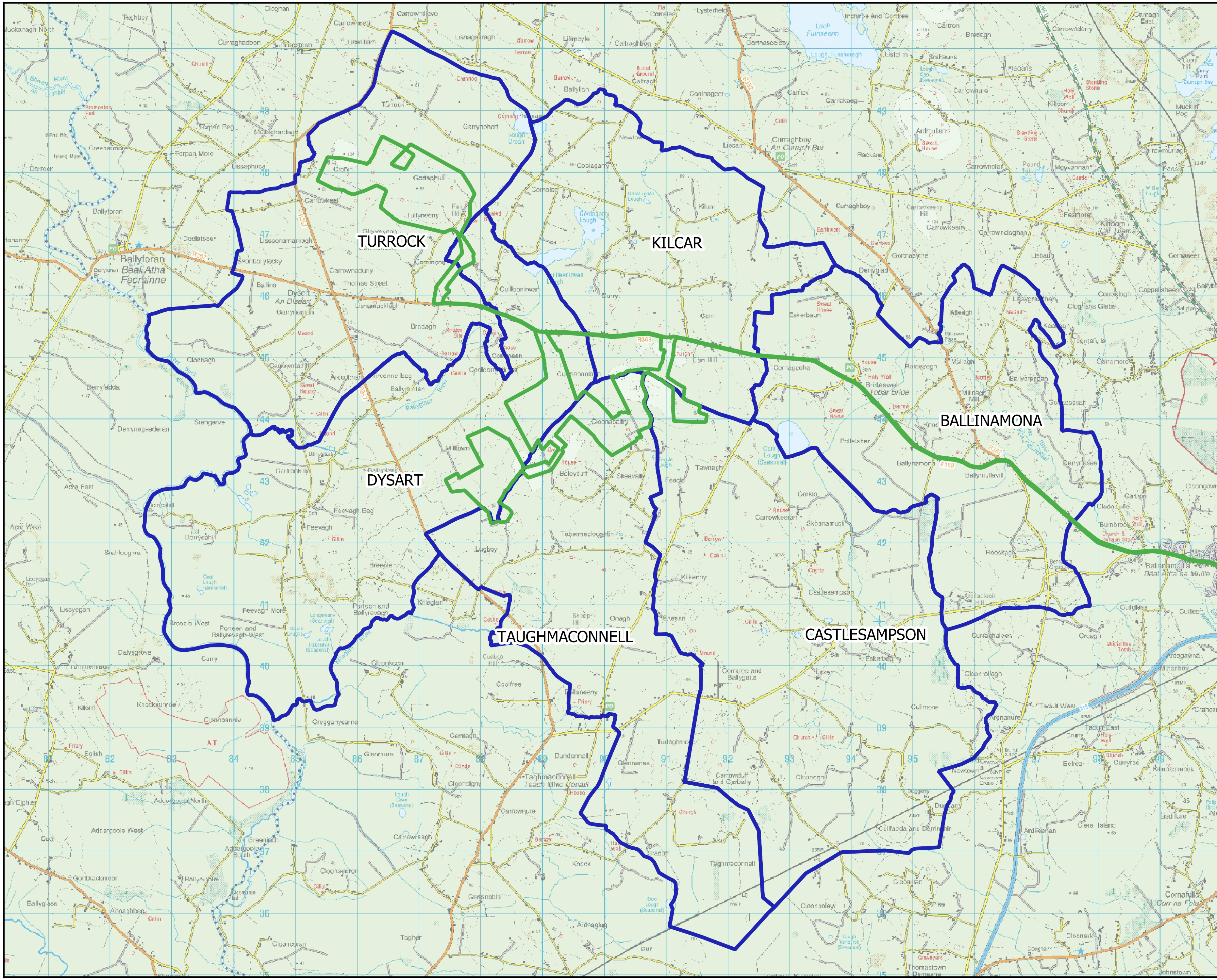
5.2.2 Population Trends

In the period between the 2011 and the 2016 Census, the population of Ireland increased by 3.8%. During this time, the population of County Roscommon grew by 0.7% to 64,544 persons. Other population statistics for the State, County Roscommon and the Study Area have been obtained from the Central Statistics Office (CSO) and are presented in Table 5-1.

Table 5-1 Population 2011 – 2016 (Source: CSO)

Area	Population Change		% Population Change
	2011	2016	2011 - 2016
State	4,588,252	4,761,865	3.8%
County Roscommon	64,065	64,544	0.7%
Study Area	2,166	2,129	-1.7%

The data presented in Table 5-1 shows that the population of the Study Area fell by 1.7% (37 persons) between 2011 and 2016. This trend of population decline is in contrast to the slight population growth observed at both County and State level during the same period. When the population data is examined in closer detail, it shows that the rate of population change within the Study Area is very uneven across each of the District Electoral Divisions (DEDs). Dysart DED experienced a slight growth of 0.4% in population while Castlesampson (DED) experienced much a larger population growth rate of 4.8%. The remaining DEDs (i.e., Turrock, Taghmaconnell, Kilcar and Ballinamona) all experienced a decrease in population ranging from -1.8% to -5.9%. Of the DEDs that make up the Study Area for this assessment, the highest population was recorded in Ballinamona DED, with 506 persons recorded during the 2016 Census, while Dysart DED had the lowest recorded population with 243 persons recorded during the 2016 Census.



Map Legend

- EIAR Site Boundary
- Study Area (DEDs)

Drawing Title	Population Study Area
Project Title	Seven Hills Wind Farm, Co. Roscommon
Drawn By: DN	Checked By: ÓM
Project No.: 190907	Drawing No.: Figure 5-1
Scale: 1:80000	Date: 31.05.2022

MKO
Planning and Environmental Consultants
Tuam Road, Galway
Ireland, H91 VW84
+353 (0) 91 735611
email:info@mkoireland.ie
Website: www.mkoireland.ie

5.2.3 Population Density

The population densities recorded within the State, County Roscommon and the Study Area during the 2011 and 2016 Census are shown in Table 5-2.

Table 5-2 Population Density in 2011 and 2016 (Source: CSO)

Area	Population Density (Persons per square kilometre)	
	2011	2016
State	65.6	68.1
County Roscommon	25.1	25.3
Study Area	6.0	5.9

The population density of the Study Area recorded during the 2016 Census was 5.9 persons per km^2. This figure is significantly lower than both the national population density of 68.1 persons per km^2 and the county population density of 25.3 persons per km^2. These findings confirm that the site of the Proposed Development is located within a sparsely populated area in comparison to the average population density of both the County and State.

Similar to the trends observed in population, the population density recorded during 2016 around the Proposed Development site varies between DEDs. Dysart DEDs had the lowest population density, at 3.6 persons per km^2, while Ballinamona DED had the highest population density, at 9.0 persons per square kilometre.

5.2.4 Household Statistics

The number of households and average household size recorded within the State, County Roscommon and the Study Area during the 2011 and 2016 Censuses are shown in Table 5-3.

Table 5-3 Number of Household and Average Household Size 2011 – 2016 (Source: CSO)

Area	2011		2016	
	No. of Households	Avg. Size (persons)	No. of Households	Avg. Size (persons)
State	1,654,208	2.8	1,702,289	2.8
County Roscommon	23,672	2.7	31,285	2.1
Study Area	726	3.0	862	2.5

In general, the figures in Table 5-3 show that while the number of households within the State, County and Study Area all experienced slight increases from 2011 to 2016, the average number of people per household has stayed the same at State level but decreased for both the County and Study Area. In 2011 average household size recorded was largely similar for State, County and Study Area, before significant decreases in housing densities were observed for County and Study Area in 2016. Similar to the trends observed above, the average household size recorded across the Study Area varies between DEDs. Castlesampson DED had the highest, with 2.7 persons per household recorded in 2016, while Dysart DED was lower with an average of 2.1 persons per housed in 2016.

5.2.5 Age Structure

Table 5-4 presents the population percentages of the State, County Roscommon and Study Area within different age groups as defined by the Central Statistics Office during the 2016 Census. This data is also displayed in Plate 5-1.

Table 5-4 Population per Age Category in 2016 (Source: CSO)

Area	Age Category				
	0 - 14	15 – 24	25 - 44	45 - 64	65 +
State	1,006,552	576,452	1,406,291	1,135,003	637,567
County Roscommon	13,662	6,757	16,325	17,057	10,743
Study Area	441	222	505	609	352

The proportion of the DED Study Area population highlights an older population than those recorded at national level, but similar to the County level. For the Study Area, the highest population percentage occurs within the 45-64 age category followed by the 25-44 age category, while the two least represented age categories are 15-24 and 65+.

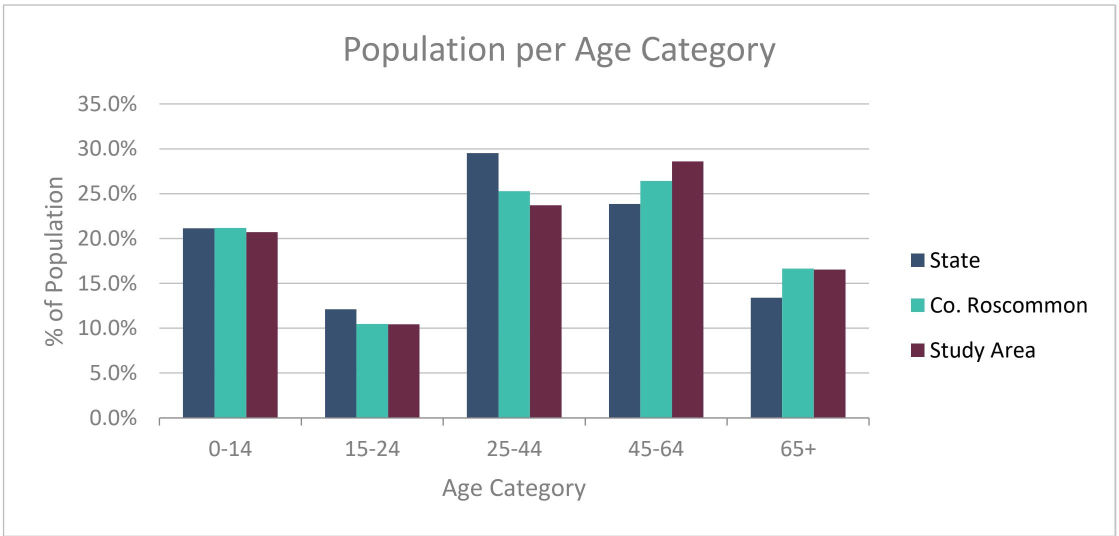


Plate 5-1 Population per Age Category in 2016 (Source: CSO)

5.2.6 Employment and Economic Activity

5.2.6.1 Economic Status of the Study Area

The labour force consists of those who are able to work, i.e., those who are aged 15+, out of full-time education and not performing duties that prevent them from working. In 2016, there were 2,304,037 persons in the labour force in the State. Table 5-5 shows the percentage of the total population aged 15+ who were in the labour force during the 2016 Census. This figure is further broken down into the percentages that were at work or unemployed. It also shows the percentage of the total population aged 15+ who were not in the labour force, i.e., those who were students, retired, unable to work or performing home duties.

Table5-5 Economic Status of the Total Population Aged 15+ in 2016 (Source: CSO)

Status		State	County Roscommon	Study Area
% of population aged 15+ who are in the labour force		**61.4%**	**58.3%**	**60.2%**
% of which are:	At work	87.1%	87.0%	91.8%
	First time job seeker	1.4%	1.4%	0.9%
	Unemployed	11.5%	11.6%	7.3%
% of population aged 15+ who are not in the labour force		**38.6%**	**41.7%**	**39.8%**
% of which are:	Student	29.4%	23.7%	25.5%
	Home duties	21.1%	21.2%	24.3%
	Retired	37.6%	41.2%	38.5%
	Unable to work	10.9%	11.9%	11.3%
	Other	1.0%	2.0%	0.4%

Overall, the principal economic status of those living in the Study Area is broadly similar to that recorded at State and County level. During the 2016 Census, the percentage of people over the age of 15 who were in the labour force for the Study Area was similar to state and county levels. Of those who were not in the labour force during the 2016 Census, the highest percentage of the Study Area population were 'Retired' individuals, similar to state and county populations.

5.2.6.2 Employment by Socio-Economic Group

Socio-economic grouping divides the population into categories depending on the level of skill or educational attainment required. The 'Higher Professional' category includes scientists, engineers, solicitors, town planners and psychologists. The 'Lower Professional' category includes teachers, lab technicians, nurses, journalists, actors and driving instructors. Skilled occupations are divided into manual skilled such as bricklayers and building contractors; semi-skilled such as roofers and gardeners; and unskilled, which includes construction labourers, refuse collectors and window cleaners. Plate 5-2 shows the percentages of those employed in each socio-economic group in the State, County Roscommon and the Study Area during 2016.

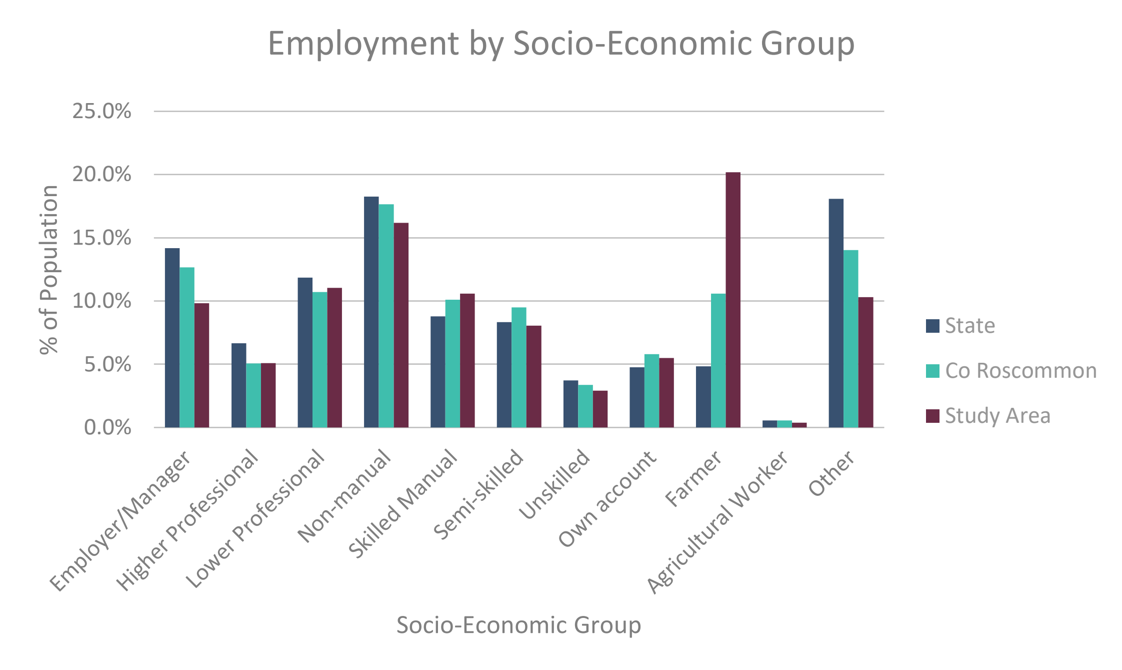


Plate 5-2 Employment by Socio-Economic Group in 2016 (Source: CSO)

The highest level of employment within the Study Area was recorded in the Farmer category. The levels of employment within the Employer/Manager, Higher Professional, Non-Manual, Semi-skilled, Unskilled and Other categories in the Study Area were lower than those recorded for the State and County Roscommon, while those recorded within the Skilled Manual and Farmer categories were higher.

The CSO employment figures grouped by socio-economic status includes the entire population for the Study Area, County and State in their respective categories. As such, the socio-economic category of 'Other' is skewed to include those who are not in the labour force.

5.2.6.3 Employment and Investment Potential in the Irish Wind Energy Industry

5.2.6.3.1 *Background*

A report entitled '*Jobs and Investment in Irish Wind Energy – Powering Ireland's Economy*' was published in 2009 by Deloitte, in conjunction with the Irish Wind Energy Association (IWEA). This report focused on the ability of the Irish wind energy industry to create investment and jobs. In terms of the overall economic benefit to be obtained from wind energy, the report states in its introduction:

> *"Ireland is fortunate to enjoy one of the best wind resources in the world. Developing this resource will reduce and stabilise energy prices in Ireland and boost our long-term competitiveness as an economy. It will also significantly reduce our dependence on imported fossil fuels."*

More recently, a report published in 2014 by Siemens entitled '*An Enterprising Wind - An economic analysis of the job creation potential of the wind sector in Ireland*', also in conjunction with the Irish Wind Energy Association (IWEA), concluded that, *'a major programme of investment in wind could have a sizeable positive effect on the labour market, resulting in substantial growth in employment.'* The report considers the three potential types of direct employment created, as a result of increased investment in wind energy, to be:

- Wind Energy Industry Employment:

- Installation
- Development
- Planning
- Operation and Maintenance
- Investor activity
- Electricity Grid Network Employment
- Potential Wind Turbine Manufacturing Employment

The Sustainable Energy Authority of Ireland[1] demonstrates in their '*Wind Energy Roadmap 2011-2050*', that '*the wind energy resource represents a significant value to Ireland by 2050. This value is presented in terms of its ability to contribute to our indigenous energy needs, the benefits of enhanced employment creation and investment potential, and the ability to significantly abate carbon emissions to 2050.'*

5.2.6.3.2 *Energy Targets*

The Climate Action Plan 2021 (CAP), recently published in November 2021 by the Department of the Environment, Climate and Communications, aims to increase the proportion of renewable electricity to up to 80% by 2030. It provides a detailed plan for taking decisive action to achieve a 51% reduction in overall greenhouse gas emissions by 2030 and setting us on a path to reach net-zero emissions by no later than 2050, as committed to in the Programme for Government and set out in the Climate Act 2021. Further information on energy and climate change targets is detailed in Chapter 10, Section 10.2.1.

5.2.6.3.3 *Employment Potential*

The 2014 report *"An Enterprising Wind: An economic analysis of the job creation potential of the wind sector in Ireland"* published by the Irish Wind Energy Association (IWEA) predicted that the wind energy sector in Ireland would result in 6,659 direct jobs in a scenario where 4GW capacity is achieved by 2020. This figure of 6,659 is broken down further; 5,596 of these jobs are associated directly with the construction and installation of windfarms, while the remaining 1,063 jobs are associated with the national grid. Under this scenario this contributes 1.66 direct jobs per Megawatt (MW) of wind capacity throughout the various stages of installation. According to Wind Energy Ireland, the installed wind capacity in Ireland is over 4.2GW as of February 2021, which would support employment during the last decade. Ireland needs to achieve a total of 8.2GW of onshore wind by 2030 which will further support further employment.

The Sustainable Energy Authority of Ireland[2] estimates, in their '*Wind Energy Roadmap 2011-2050*', note that '*Onshore and offshore wind could create 20,000 direct installation and O&M jobs by 2040*'. Furthermore, '*wind energy resource represents a significant value to Ireland by 2050. This value is presented in terms of its ability to contribute to our indigenous energy needs, the benefits of enhanced employment creation and investment potential, and the ability to significantly abate carbon emissions to 2050*'

The 2014 report '*The Value of Wind Energy to Ireland*', published by Pőyry, stated that growth of the wind sector in Ireland could support 23,850 jobs (construction and operational phases) by 2030. If Ireland instead chooses to not develop any more wind, then by 2030 the country will be reliant on natural gas for most of our electricity generation, at a cost of €671 million per annum in fuel import costs.

[1] *SEAI (2019), https://www.seai.ie/publications/Wind_Energy_Roadmap_2011-2050.pdf*
[2] *SEAI (2019), https://www.seai.ie/publications/Wind_Energy_Roadmap_2011-2050.pdf*

A new report published by MaREI, the SFI Research Centre for Energy, Climate and Marine, hosted by University College Cork[3] (March 2021) details that in order to meet the government target of net-zero carbon emissions by 2050, at least 25,000 jobs will be created in the development of onshore and offshore wind to meet our zero carbon targets.

Internationally, a report issued by WindEurope in September 2017, entitled '*Wind energy in Europe: Scenarios for 2030'* details various scenarios in Europe in respect to the EU target for renewable energy. According to WindEurope's High Scenario, which assumes favourable market and policy conditions including the achievement of a 35% EU renewable energy target (slightly higher than the 32% EU target for renewables), '*397 GW of wind energy capacity would be installed in the EU by 2030, 298.5 GW onshore and 99 GW offshore. In this scenario, the wind energy industry would invest €351bn by 2030, and it would create 716,000 jobs'.*

As of February 2022, there were 5,585 Megawatts (MW) of wind energy capacity installed on the island of Ireland[4]. Of this, 4,309 MW was installed in the Republic of Ireland, with 1,276MW installed in Northern Ireland. The majority of the Republic of Ireland's installed wind energy capacity is located in Counties Donegal, Galway, Cork, Clare and Kerry, contributing to employment potential on the Island of Ireland.

5.2.6.3.4 Economic Value

A 2019 report by Baringa, '*Wind for a Euro: Cost-benefit analysis of wind energy in Ireland 2000-2020'*, has analysed the financial impact for end consumers of the deployment of wind generation in Ireland over the period 2000-2020. The report calculates how the costs and benefits for consumers would have differed if no wind farms had been built. The analysis indicated that the deployment of 4.1 GW of wind generation capacity in Ireland between 2000 and 2020 (2018-2020 results being projective) will result in a total net cost to consumers, over 20 years, of €0.1bn (€63 million to be exact), which equates to a cost of less than €1 per person per year since 2000. Further cost benefit analysis noted that wind energy has delivered €2.3 billion in savings in the wholesale electricity market. As such, the economic benefit of renewable energy to consumers is greater than what would have been if Ireland did not invest in wind power. This corresponds with the Deloitte report which indicates that more wind energy feeding into the national grid will result in lower and more stable energy costs for consumers.

Furthermore, in May 2020, IWEA released its 70by30 Implementation Plan Reports which further details the savings that can be made from the continuation of onshore wind. The report, entitled '*Saving Money - 70 by 30 Implementation Plan'*, notes that '*Baringa calculated previously that if onshore wind in Ireland can be delivered at €60/MWh, on average, between 2020 and 2030, then the 70 per cent renewable electricity target set out in the Climate Action Plan will actually be cost neutral for the consumer. If we can achieve prices under €60/MWh then Ireland's electricity consumers will be saving money'.*

The Proposed Development will, if consent is granted, contribute to the economic value that renewable energy brings to the country.

5.2.7 Land-Use

The Proposed Development site is currently used for small-scale agricultural practices, predominantly livestock grazing, pasture and sileage. The predominant surrounding land use within the Population study area is also farmland. The total area of farmland within the DEDs around the Proposed Development site measures approximately 9,319 hectares, comprising approximately 3.5% of the Study Area land mass, according to the CSO Census of Agriculture 2020. There are 300 farms located within

[3] *https://www.marei.ie/our-climate-neutral-future-zeroby50/*
[4] *Wind Energy Ireland – Facts and Stats, https://windenergyireland.com/about-wind/facts-stats*

the Study Area, with an average farm size of 30.8 hectares. This is slightly larger than the 27.1 hectare average farm size for Co. Roscommon.

5.2.8 Services

The Proposed Development is located northeast and southeast of the village of Dysart, approximately 1.5 kilometres away at its closest point and approximately 11 kilometres northwest/west of the town of Athlone, Co. Roscommon. There is a small retail store, community centre and electrical store within the village of Dysart. The main services for the study area are located within the town of Athlone which offers large scale retail and services.

5.2.8.1 Education

The nearest school to the Proposed Development is Ballintleva National School, located approximately 500m east from the EIAR Site Boundary at its closest point. Scoil Mhuire Gan Smal, a gaelscoil, is located approximately 2km to the west of the EIAR Site Boundary at its closest point. Brideswell National School is located approximately 2.5 km to the east of the EIAR Site Boundary in the village of Brideswell.

The closest secondary school is Colaiste Mhuire in Ballygar County Galway, located approximately 8km northwest of the Proposed Development site. Colaiste Chiarain secondary school is located approximately 9.5 km southeast of the Proposed Development site in Monksland, Athlone, Co. Roscommon.

The closest third-level institutes to the site are Athlone Institute of Technology, approximately 15km southeast of the development site and National University of Ireland Galway (NUIG), which is located in excess of 50km west of the Proposed Development.

5.2.8.2 Access and Public Transport

The site of the Proposed Development is accessed via the R363 Regional Road which runs in an east west direction, connecting the two villages of Dysart and Brideswell. There is a weekly local bus route (RR29) which runs every Friday from Knockcroghery to Roscommon town via Dysart village. There is also a weekly bus route (WR22) which runs every Friday between Curraghboy and Athlone town making stops in the village of Brideswell. There is also a daily bus route (Bus Éireann Route 440) which runs between Athlone and Westport, making several connections along the way, including a stop at the nearby parish of Kitoom, approximately 7.5km east of the Proposed Development site.

5.2.8.3 Amenities and Community Facilities

Most of the amenities and community facilities, including GAA, soccer, other sports clubs, and recreational areas are available in the nearby settlements of Dysart, Brideswell, Skyvalley and Ballyforan. The nearby areas of Kiltoom and Hodson Bay, located between 7.5km and 10km east-northeast of the Proposed Development offer a range of amenities including a golf course, driving range, GAA club, hotel, Bay Water Sports and more. Larger scale retail and personal services are available in the larger surrounding settlements of Athlone and Roscommon towns.

A number of options for walking and cycling are available within the study area and surrounding lands. The green heartlands cycling route passes has stages which pass through both Dysart and Brideswell village. As previously mentioned above, the nearby Hodson Bay Hotel on the shores of Lough Ree, approximately 10km east of the Proposed Development, offers a number of activities and attractions including golfing, fishing, watersports and more. There are a number of walking routes and trails around Lecarrow village and the medieval site of Rindoon approximately 14km northeast of the Proposed Development. Directly adjacent to the medieval village of Rindoon is St. John's Wood, an ancient woodland on the shores of Lough Ree believed to be approximately 7,000 years old making it one of the oldest native broadleaf woodlands in the country.

Community Benefit proposals, which would enhance local amenities and community facilities are described in Chapter 4: Description of the Proposed Development.

5.3 Tourism

5.3.1 Tourism Numbers and Revenue

Tourism is one of the major contributors to the national economy and is a significant source of full time and seasonal employment. During 2019, total tourism revenue generated in Ireland was approximately €9.5 billion, an increase on the €9.1 billion revenue recorded in 2018. Overseas tourist visits to Ireland in 2018 grew by 6.5% to 9.6 million ('*Tourism Facts 2019*, Fáilte Ireland, March 2021).

Ireland is divided into seven tourism regions. Table 5-7 shows the total revenue and breakdown of overseas tourist numbers to each region in Ireland during 2018 ('*Tourism Facts 2019*, Fáilte Ireland, March 2021).

Table 5-6 Overseas Tourists Revenue and Numbers 2019 (Source: Fáilte Ireland)

Region	Total Revenue (€m)	Total Number of Overseas Tourists (000s)
Dublin	€2,210m	6,644
Mid-East/Midlands	€348m	954
South-East	€261m	945
South-West	€970m	2,335
Mid-West	€472m	1,432
West	**€653m**	**1,943**
Border	€259m	768
Total	€5,173 m	15,021

The Proposed Development site is located within the West Region. According to '*Regional tourism performance in 2018'* (Fáilte Ireland, September 2019) the West Region which comprises County Galway, County Mayo and County Roscommon, benefited from approximately 13.0% of the total number of overseas tourists to the country and approximately 13.9% of the associated tourism income generated in Ireland in 2018.

Although data for 2018 is not available, Table 5-8 presents the breakdown of overseas tourist numbers and revenue to the West region during 2017 ('*2017 Topline Tourism Performance by Region,* Fáilte Ireland, August 2018). As observed in Table 5-8, County Roscommon has the lowest tourism revenue within the Region during 2017 at €18 million, which is considerably less than both Co. Mayo and Co. Galway.

Table 5-7 Overseas Tourism to the West Region during 2017 (Source: Fáilte Ireland)

Region	Total Revenue (€m)	Total Number of Overseas and Domestic Tourists (000s)
Galway	€836m	2,697
Mayo	€186m	827
Roscommon	€45m	184

5.3.2 Tourist Attractions

There are no key identified tourist attractions pertaining specifically to the site of the Proposed Development itself.

A number of options for walking and cycling are available within the study area and surrounding lands. The green heartlands cycling route passes has stages which pass through both Dysart and Brideswell village.

As previously mentioned above, the nearby Hodson Bay Hotel on the shores of Lough Ree, approximately 10km east of the Proposed Development, offers a number of activities and attractions including golfing, fishing, water-sports and more. There are a number of walking routes and trails around Lecarrow village and the medieval site of Rindoon is approximately 14km northeast of the Proposed Development. Directly adjacent to the medieval village of Rindoon is St. John's Wood, an ancient woodland on the shores of Lough Ree believed to be approximately 7,000 years old making it one of the oldest native broadleaf woodlands in the country. Mote Park, located approximately 13km north of the Proposed Development just outside Roscommon town, is a recreational woodland which offers a number of walking trails.

The nearby towns of Athlone and Roscommon offer a number of tourism attractions. Roscommon Castle, built in 1269, acted as seat to the O'Connor family who were High Kings of Connacht, and is located within the grounds of Loughnaneane Park, a 14-acre recreational area which includes a children's playground and crannog. Roscommon town has a number of other tourist attractions including Roscommon Arts Centre, hotels and restaurants.

Athlone town, located approximately 11 kilometres from the Proposed Development, also offers a number of tourism attractions including Athlone Castle, built in the 13th Century, which offers an interactive historic tour of the castle. A number of other attractions are also located within Athlone, including The Church of Saints Peter and Paul, Luan Art Gallery, Sean's Bar (believed to be the oldest existing pub in Europe and possibly the world), as well as a number of hotels, restaurants and amenity areas.

5.3.3 Tourist Attitudes to Wind Farms

5.3.3.1 Scottish Tourism Survey 2016

BiGGAR Economics undertook an independent study in 2016, entitled '*Wind Farms and Tourism Trends in Scotland*', to understand the relationship, if any, that exists between the development of onshore wind energy and the sustainable tourism sector in Scotland. In recent years, the onshore wind sector and sustainable tourism sector have grown significantly in Scotland. However, it could be argued that if there was any relationship between the growth of onshore wind energy and tourism, it would be at a more local level. This study therefore considered the evidence at a local authority level and in the immediate vicinity of constructed wind farms.

Eight local authorities had seen a faster increase in wind energy deployment than the Scottish average. Of these, five also saw a larger increase in sustainable tourism employment than the Scottish average, while only three saw less growth than the Scottish average. The analysis presented in this report shows that, at the Local Authority level, the development of onshore wind energy does not have a detrimental impact on the tourism sector. It was found that in the majority of cases (66%) sustainable tourism employment performed better in areas surrounding wind farms than in the wider local authority area. There was no pattern emerging that would suggest that onshore wind farm development has had a detrimental impact on the tourism sector, even at the very local level.

Overall, the conclusion of this study is that published national statistics on employment in sustainable tourism demonstrate that there is no relationship between the development of onshore wind farms and tourism employment at the level of the Scottish economy, at local authority level, nor in the areas immediately surrounding wind farm development. However, the report also concluded that '*Although this study does not suggest that there is any direct relationship between tourism sector growth and wind farm development, it does show that wind farms do not cause a decrease in tourism employment either at a local or a national level.*'

5.3.3.2 Fáilte Ireland Surveys 2007 and 2012

In 2007, Fáilte Ireland in association with the Northern Ireland Tourist Board carried out a survey of domestic and overseas holidaymakers to Ireland in order to determine their attitudes to wind farms. The purpose of the survey was to assess whether the development of wind farms impacts on the enjoyment of the Irish scenery by holidaymakers. The survey involved face-to-face interviews with 1,300 tourists (25% domestic and 75% overseas). The results of the survey are presented in the Fáilte Ireland Newsletter 2008/No.3 entitled 'Visitor Attitudes on the Environment: Wind Farms'.

The Fáilte Ireland survey results indicate that most visitors are broadly positive towards the idea of building wind farms in Ireland. There exists a sizeable minority (one in seven) however who are negative towards wind farms in any context. In terms of awareness of wind farms, the findings of the survey include the following:

- Almost half of those surveyed had seen at least one wind farm on their holiday to Ireland. Of these, two thirds had seen up to two wind farms during their holiday.
- Typically, wind farms are encountered in the landscape while driving or being driven (74%), while few have experienced a wind farm up close.
- Of the wind farms viewed, most contained less than ten turbines and 15% had less than five turbines.

Regarding the perceived impact of wind farms on sightseeing, the Fáilte Ireland report states:

> *"Despite the fact that almost half of the tourists interviewed had seen at least one wind farm on their holiday, most felt that their presence did not detract from the quality of their sightseeing, with the largest proportion (45%) saying that the presence of the wind farm had a positive impact on their enjoyment of sightseeing, with 15% claiming that they had a negative impact."*

In assessing the perceived impact of wind farms on beauty, visitors were asked to rate the beauty of five different landscapes types: Coastal, Mountain, Farmland, Bogland and Urban Industrial, and then rate on a scale of 1-5 the potential impact of a wind farm being sited in each landscape. The survey found that each potential wind farm must be assessed on its own merits. Overall, however, in looking at wind farm developments in different landscape types, the numbers claiming a positive impact on the landscape due to wind farms were greater than those claiming a negative impact, in all cases.

Regarding the perceived impact of wind farms on future visits to the area, the Fáilte Ireland survey states:

> *"Almost three quarters of respondents claim that potentially greater numbers of wind farms would either have no impact on their likelihood to visit or have a strong or fairly strong positive impact on future visits to the island of Ireland. Of those who feel that a potentially greater number of wind farms would positively impact on their likelihood to visit, the key driver is their support for renewable energy and potential decreased carbon emissions."*

The report goes on to state that while there is a generally positive disposition among tourists towards wind development in Ireland, it is important also to take account of the views of the one in seven tourists who are negatively disposed towards wind farms. This requires good planning on the part of the wind farm developer as well as the Local Authority. Good planning has been an integral component of the Proposed Development throughout the site design and assessment processes. Reference has been made to the '*Planning Guidelines on Wind Energy Development 2006*' and the '*Draft Revised Wind*

Energy Development Guidelines December 2019' in addition to IWEA best practice guidance, throughout all stages, including pre-planning consultation and scoping.

The 2007 survey findings are further upheld by a more recent report carried out by Fáilte Ireland on tourism attitudes to wind farms in 2012. The results of the updated study were published in the 'Fáilte Ireland Newsletter 2012/No.1 entitled 'Visitor Attitudes on the Environment: Wind Farms – Update on 2007 Research'. The updated survey found that of 1,000 domestic and foreign tourists who holidayed in Ireland during 2012, over half of tourists said that they had seen a wind turbine while travelling around the country. Of this number of tourists, 21% claimed wind turbines had a negative impact on the landscape. However, 32% said that it enhanced the surrounding landscape, while 47% said that it made no difference to the landscape. Almost three quarters of respondents claim that potentially greater numbers of wind farms would either have no impact on their likelihood to visit or have a strong or fairly strong positive impact on future visits to the island of Ireland.

Further details regarding the general public perception of wind energy, including those living in the vicinity of a wind farm, are presented in Section 5.4 below.

5.4 Public Perception of Wind Energy

5.4.1 Sustainable Energy Ireland Survey 2003

5.4.1.1 Background

The results of a national survey entitled '*Attitudes Towards the Development of Wind Farms in Ireland'* were published by the Sustainable Energy Authority of Ireland (SEAI) in 2003 and updated in 2017 – see Section 5.4.1.3 below. A catchment area survey was also carried out by SEAI (formerly SEI) in order to focus specifically on people living with a wind farm in their locality or in areas where wind farms are planned.

5.4.1.2 2003 Findings

The SEAI survey published in 2003, found that the overall attitude to wind farms is very positive, with 84% of respondents rating it positively or very positively. One percent rates it negatively and 14% had no opinion either way. Approximately two thirds of respondents (67%) were found to be positively disposed to having a wind farm in their locality. Where negative attitudes were voiced towards wind farms, the visual impact of the turbines on the landscape was the strongest influence. The report also notes however that the findings obtained within wind farm catchment areas showed that impact on the landscape is not a major concern for those living near an existing wind farm.

With regards to the economic and environmental impacts of wind farm development, the national survey reveals that attitudes towards wind energy are influenced by a perception that wind is an attractive source of energy:

> *"Over 8 in 10 recognise wind as a non-polluting source of energy, while a similar number believe it can make a significant contribution to Ireland's energy requirements."*

The study reveals uncertainty among respondents with regards to the issues of noise levels, local benefits and the reliability or otherwise of wind power as an energy source. It goes on to state however that the finding that people who have seen wind farms rate these economic and environmental factors more favourably is a further indication that some experience of the structures tends to translate into positive attitudes towards wind energy.

Similar to the national survey, the surveys of those living within the vicinity of a wind farm also found that the findings are generally positive towards wind farms. Perceptions of the impact of the development on the locality were generally positive, with some three-quarters of interviewees believing it had impacted positively.

In areas where a wind farm development had been granted planning permission but was not yet under construction, three quarters of the interviewees expressed themselves in favour of the wind farm being built in their area. Four per cent were against the development. The reasons cited by those who expressed themselves in favour of the wind farm included the fact that wind energy is clean (78%), it would provide local jobs (44%), it would help develop the area (32%) and that it would add to the landscape (13%). Those with direct experience of a wind farm in the locality are generally impressed with it as an additional feature in the landscape. The report states:

> *"It is particularly encouraging that those with experience of wind turbines are most favourable to their development and that wind farms are not solely seen as good in theory, but are also seen as beneficial when they are actually built."*

Few of those living in proximity either to an existing wind farm or one for which permission has been granted believe that the development damages the locality, either in terms of damage to tourism potential or to wildlife. The survey found that there is a clear preference for larger turbines in smaller numbers over smaller turbines in larger numbers.

5.4.1.3 Survey Update 2017

Additionally, a survey carried out by Interactions in October 2017, published by the SEAI, show 47% of Irish adults polled said they were are strongly in favour of wind power in Ireland while a further 38% favour it. Overall, this is a 4% increase in favourable attitudes towards wind power compared with similar research in 2013.

The SEAI survey found that the overall attitude to wind farms is very positive, with 84% of respondents in favour of the use of wind energy in Ireland. Approximately two thirds of respondents (70%) would prefer to power their home with renewable energy over fossil fuels, and 45% would be in favour of a wind farm development in their area.

The survey also captured the perceived benefits of wind power among the public. Of those surveyed three quarters selected good for the environment and reduced Carbon Dioxide emissions while fewer people, just over two in three, cited cheaper electricity.

5.4.1.4 Conclusions

The main findings of the SEAI survey in 2017 indicate that the overall attitude to wind farms is "almost entirely positive". The study highlights that two-thirds of Irish adults are either very favourable or fairly favourable to having a wind farm built in their locality, with little evidence of a "Not In My Back Yard" (NIMBY) effect. The final section of the 2017 report states:

> *"The overwhelming indication from this study is that wind energy enjoys great support and, more specifically, that the development of wind farms is supported and welcomed. The single most powerful indicator of this is to be found among those living in proximity to an existing wind farm: over 60% would be in favour of a second wind farm or an extension of the existing one. This represents a strong vote in favour of wind farm developments – especially important since it is voiced by those who know from direct experience about the impact of such developments on their communities."*

5.4.2 Public Perceptions of Wind Power in Scotland and Ireland Survey 2005

5.4.2.1 Background

A survey of the public perception of wind power in Scotland and Ireland was carried out in 2003/2004 by researchers at the School of Geography & Geosciences, University of St. Andrews, Fife and The Macaulay Institute, Aberdeen ('*Green on Green: Public Perceptions of Wind Power in Scotland and Ireland*', Journal of Environmental Planning and Management, November 2005). The aims of the study were to ascertain the extent to which people support or oppose wind power, to investigate the reasons for these attitudes and to establish how public attitudes relate to factors such as personal experience of operational wind farms and their proximity to them.

5.4.2.2 Study Area

Surveys were carried out at two localities in the Scottish Borders region, one surrounding an existing wind farm and one around a site at which a wind farm had received planning permission but had not yet been built. Surveys were also carried out in Ireland, at two sites in Counties Cork and Kerry, each of which had two wind farms in proximity to each other.

5.4.2.3 Findings

The survey of public attitudes at both the Scottish and Irish study sites concluded that large majorities of people are strongly in favour of their local wind farm, their personal experience having engendered positive attitudes. Attitudes towards the concept of wind energy were described as "overwhelmingly positive" at both study sites in Scotland, while the Irish survey results showed almost full support for renewable energy and 92% support for the development of wind energy in Ireland.

The results of the survey were found to agree with the findings of previous research, which show that positive attitudes to wind power increase through time and with proximity to wind farms. With regards to the NIMBY effect, the report states that where NIMBY-ism does occur, it is much more pronounced in relation to proposed wind farms than actual wind farms. The Scottish survey found that while positive attitudes towards wind power were observed among those living in proximity to both the proposed and existing wind farm sites, people around the proposed site were less convinced than those living in proximity to the existing site. Retrospective questioning regarding pre- and post-construction attitudes at the existing site found that attitudes remained unchanged for 65% of respondents. Of the 24% of people who altered their attitudes following experience of the wind farm, all but one became more positive. The report states:

> *"These results support earlier work which has found that opposition to wind farms arises in part from exaggerated perceptions of likely impact, and that the experience of living near a wind farm frequently dispels these fears. Prior to construction, locals typically expect the landscape impacts to be negative, whereas, once in operation, may people regard them as an attractive addition."*

The reasons that people gave for their positive attitude to the local wind farm were predominantly of a global kind, i.e. environmental protection and the promotion of renewable energy, together with opposition to a reliance on fossil fuels and nuclear power. Problems that are often cited as negative impacts of wind farms, such as interference with telecommunications and shadow flicker were not mentioned at either site. With regards to those who changed to a more positive attitude following construction of the wind farm, the reasons given were that the wind farm is *"not unattractive (62%), that there was no noise (15%), that community funding had been forthcoming (15%) and that it could be a tourist attraction (8%)".*

The findings of the Irish survey reinforce those obtained at the Scottish sites with regards to the increase in positive attitudes to wind power through time and proximity to wind farms. The survey of public attitudes at the sites in Cork and Kerry found that the highest levels of support for wind power were recorded in the innermost study zone (0 – 5 kilometres from a point in between the pair of wind farms). The data also suggests that *"those who see the wind farms most often are most accepting of the visual impact".* The report also states that a previous Irish survey found that most of those with direct experience of wind farms do not consider that they have had any adverse impact on the scenic beauty of the area, or on wildlife, tourism or property values. Overall, the study data reveals *"a clear pattern of public attitudes becoming significantly more positive following personal experience of operational wind farms".*

With regards to wind farm size, the report notes that it is evident from this and previous research that wind farms with small numbers of large turbines are generally preferred to those with large numbers of smaller turbines.

5.4.2.4 Conclusions

The overall conclusions drawn from the survey findings and from the authors' review of previous studies show that local people become more favourable towards wind farms after construction, that the degree of acceptance increases with proximity to them, and that the NIMBY effect does not adequately explain variations in public attitudes due to the degree of subjectivity involved.

5.4.3 IWEA Interactions Opinion Poll on Wind Energy

Published in January 2020, IWEA undertook a national opinion poll on Wind Energy November 2019 with the objective to "*measure and track public perceptions and attitudes around wind energy amongst Irish adults.*" Between November 20th – 30th 2019, a nationally represented sample of 1,019 adults and a booster sample of 200 rural residents participated in an online survey. The 2019 results indicate that 79% of both the nationally represented sample and rural sample strongly favour or favour wind power while 16% of both samples neither favour or oppose it. Amongst those in favour of wind power, the majority cited environmental and climate concerns as their main reasons for supporting such developments. Other reasons cited for supporting wind energy developments include: "economic benefits," "reliable/efficient," "positive experience with wind energy" and recognise it as a "safe resource." When questioned about wind developments in their local area, 55% of nationally represented sample favour or tend to favour such proposals and 51% of the rural population reported the same. Reasons cited for supporting wind developments in their local area include: "good for the environment," "social responsibility," "create jobs," "good for the community."

The IWEA November 2019 survey follows previous national opinion polls on wind energy undertaken in October 2017 and November 2018. The 2019 survey results are consistent with the 2017 and 2018 figures and thus indicate that approximately 4 out of 5 Irish adults have continued to support for wind energy in recent years.

5.5 Health Impacts of Wind Farms

5.5.1 Health Impact Studies

While there are anecdotal reports of negative health effects on people who live very close to wind turbines, peer-reviewed research largely does not support these statements. There is currently no published credible scientific evidence to positively link wind turbines with adverse health effects. The main publications supporting the view that there is no evidence of any direct link between wind turbines and health are summarised below.

1. ***'Wind Turbine Sound and Health Effects – An Expert Panel Review',*** *American Wind Energy Association and Canadian Wind Energy Association, December 2009*

This expert panel undertook extensive review, analysis and discussion of the large body of peer-reviewed literature on sound and health effects in general, and on sound produced by wind turbines in particular. The panel assessed the plausible biological effects of exposure to wind turbine sound. Following review, analysis, and discussion of current knowledge, the panel reached consensus on the following conclusions:

- "There is no evidence that the audible or sub-audible sounds emitted by wind turbines have any direct adverse physiological effects.
- The ground-borne vibrations from wind turbines are too weak to be detected by, or to affect, humans.
- The sounds emitted by wind turbines are not unique. There is no reason to believe, based on the levels and frequencies of the sounds and the panel's experience with sound exposures in occupational settings, that the sounds from wind turbines could plausibly have direct adverse health consequences."

The report found, amongst other things, that:

- "Wind Turbine Syndrome" symptoms are the same as those seen in the general population due to stresses of daily life. They include headaches, insomnia, anxiety, dizziness, etc.

- Low frequency and very low-frequency 'infrasound' produced by wind turbines are the same as those produced by vehicular traffic and home appliances, even by the beating of people's hearts. Such 'infrasounds' are not special and convey no risk factors;
- The power of suggestion, as conveyed by news media coverage of perceived 'wind-turbine sickness', might have triggered 'anticipatory fear' in those close to turbine installations."

2. ***'Wind Turbine Syndrome – An independent review of the state of knowledge about the alleged health condition',*** *Expert Panel on behalf of Renewable UK, July 2010*

This report consists of three reviews carried out by independent experts to update and understand the available knowledge of the science relating to infrasound generated by wind turbines. This report was prepared following the publication of a book entitled '*Wind Turbine Syndrome*', in 2009 by Dr. Pierpont, which received significant media attention at the time. The report discusses the methodology and assessment carried out in the 2009 publication and assessed the impact of low-frequency noise from wind turbines on humans. The independent review found that:

- "The scientific and epidemiological methodology and conclusions drawn (in the 2009 book) are fundamentally flawed;
- The scientific and audiological assumptions presented by Dr Pierpont relating infrasound to WTD are wrong; and
- Noise from Wind Turbines cannot contribute to the symptoms reported by Dr. Pierpont's respondents by the mechanisms proposed."

Accordingly, the consistent and scientifically robust conclusion remains that there is no evidence to demonstrate any significant health effects in humans arising from noise at the levels of that generated by wind turbines.

3. ***'A Rapid Review of the Evidence',*** *Australian Government National Health and Medical Research Council (NHMRC) Wind Turbines & Health, July 2010*

The purpose of this paper was to review evidence from current literature on the issue of wind turbines and potential impacts on human health and to validate the finding of the 'Wind Turbine Sound and Health Effects - An Expert Panel Review' (see Item 2 above) that:

- "There are no direct pathological effects from wind farms and that any potential impact on humans can be minimised by following existing planning guidelines."
- There is currently no published scientific evidence to positively link wind turbines with adverse health effects.
- 'This review of the available evidence, including journal articles, surveys, literature reviews and government reports, supports the statement that: There are no direct pathological effects from wind farms and that any potential impact on humans can be minimised by following existing planning guidelines."

4. ***'Position Statement on Health and Wind Turbines',*** *Climate and Health Alliance, February 2012*

The Climate and Health Alliance (CAHA) was established in August 2010 and is a coalition of health care stakeholders who wish to see the threat to human health from climate change and ecological degradation addressed through prompt policy action. In its Position Statement in February 2012, CAHA states that:

> *"To date, there is no credible peer reviewed scientific evidence that demonstrates a direct causal link between wind turbines and adverse health impacts in people living in proximity to them. There is no evidence for any adverse health effects from wind turbine shadow flicker or electromagnetic frequency. There is no evidence in the peer reviewed published scientific*

literature that suggests that there are any adverse health effects from infrasound (a component of low frequency sound) at the low levels that may be emitted by wind turbines."

The Position Statement explores human perceptions of wind energy and notes that some people may be predisposed to some form of negative perception that itself may cause annoyance. It states that:

> *"Fear and anxious anticipation of potential negative impacts of wind farms can also contribute to stress responses, and result in physical and psychological stress symptoms... Local concerns about wind farms can be related to perceived threats from changes to their place and can be considered a form of "place-protection action", recognised in psychological research about the importance of place and people's sense of identity."*

CAHA notes the existence of *"misinformation about wind power"* and, in particular, states that:

> *"Some of the anxiety and concern in the community stems originally from a self-published book by an anti-wind farm activist in the United States which invented a syndrome, the so-called "wind turbine syndrome". This is not a recognised medical syndrome in any international index of disease, nor has this publication been subjected to peer review."*

CAHA notes that:

> *"Large scale commercial wind farms however have been in operation internationally for many decades, often in close proximity to thousands of people, and there has been no evidence of any significant rise in disease rates."*

This, it states, contrasts with the health impacts of fossil fuel energy generation.

5. ***'Wind Turbine Health Impact Study -Report of Independent Expert Panel'*** – *Massachusetts Departments of Environmental Protection and Public Health (2012)*

An expert panel was established with the objective to, inter alia, evaluate information from peer-reviewed scientific studies, other reports, popular media and public comments and to assess the magnitude and frequency of any potential impacts and risks to human health associated with the design and operation of wind energy turbines. In its final report, the expert panel set out its conclusions under several headings, including noise and shadow flicker.

In relation to noise, the panel concluded that there was limited or no evidence to indicate any causal link between noise from wind turbines and health effects, including the following conclusions:

> *"There is no evidence for a set of health effects, from exposure to wind turbines that could be characterized as a "Wind Turbine Syndrome."*
>
> *The strongest epidemiological study suggests that there is not an association between noise from wind turbines and measures of psychological distress or mental health problems. There were two smaller, weaker, studies: one did note an association, one did not. Therefore, we conclude the weight of the evidence suggests no association between noise from wind turbines and measures of psychological distress or mental health problems.*
>
> *None of the limited epidemiological evidence reviewed suggests an association between noise from wind turbines and pain and stiffness, diabetes, high blood pressure, tinnitus, hearing impairment, cardiovascular disease, and headache/migraine."*

In relation to shadow flicker, the expert panel found the following:

> *"Scientific evidence suggests that shadow flicker does not pose a risk for eliciting seizures as a result of photic stimulation.*

There is limited scientific evidence of an association between annoyance from prolonged shadow flicker (exceeding 30 minutes per day) and potential transitory cognitive and physical health effects."

6. ***Wind Turbines and Health, A Critical Review of the Scientific Literature,*** *Massachusetts Institute of Technology (Journal of Occupational and Environmental Medicine Vol. 56, Number 11, November 2014)*

This review assessed the peer-reviewed literature regarding evaluations of potential health effects among people living in the vicinity of wind turbines. The review posed a number of questions around the effect of turbines on human health, with the aim of determining if stress, annoyance or sleep disturbance occur as a result of living in proximity to wind turbines, and whether specific aspects of wind turbine noise have unique potential health effects. The review concluded the following with regard to the above questions:

- Measurements of low-frequency sound, infrasound, tonal sound emission, and amplitude-modulated sound show that infrasound is emitted by wind turbines. The levels of infrasound at customary distances to homes are typically well below audibility thresholds.
- No cohort or case–control studies were located in this updated review of the peer-reviewed literature. Nevertheless, among the cross-sectional studies of better quality, no clear or consistent association is seen between wind turbine noise and any reported disease or other indicator of harm to human health.
- Components of wind turbine sound, including infrasound and low frequency sound, have not been shown to present unique health risks to people living near wind turbines.
- Annoyance associated with living near wind turbines is a complex phenomenon related to personal factors. Noise from turbines plays a minor role in comparison with other factors in leading people to report annoyance in the context of wind turbines.

A further 25 reviews of the scientific evidence that universally conclude that exposure to wind farms and the sound emanating from wind farms does not trigger adverse health effects, were compiled in September 2015 by Professor Simon Chapman, of the School of Public Health and Sydney University Medical School, Australia, and is included as Appendix 5-1 of this EIAR. Another recent publication by Chapman and Crichton (2017) entitled '*Wind turbine syndrome; A communicated disease'* critically discusses why certain health impacts might often be incorrectly attributed to wind turbines.

7. ***Position Paper on Wind Turbines and Public Health:*** *HSE Public Health Medicine Environment and Health Group, February 2017*

The Health Service Executive (HSE) position paper on wind turbines and public health was published in February 2017 to address the rise in wind farm development and concerns regarding potential impacts on public health. The paper discusses previous observations and case studies which describe a broad range of health effects that are associated with wind turbine noise, shadow flicker and electromagnetic radiation.

A number of comprehensive reviews conducted in recent years to examine whether these health effects are proven has highlighted the lack of published and high-quality scientific evidence to support adverse effects of wind turbines on health.

The HSE position paper determines that current scientific evidence on adverse impacts of wind farms on health is weak or absent. Further research and investigative processes are required at a larger scale in order to be more informative for identifying potential health effects of exposure to wind turbine effects. They advise developers on making use of the Draft Wind Energy Development Guidelines (2006), as a means of setting noise limits and set back distances from the nearest dwellings.

8. ***Environmental Noise Guidelines for the European Region:*** *World Health Organisation Regional Office for Europe, 2018.*

The WHO Environmental Noise Guidelines provide recommendations for protecting human health from exposure to environmental noise originating from various sources such as transportation noise, wind turbine noise and leisure noise. The Guideline Development Group (GDG) defined priority health outcomes and from this were able to produce guideline exposure levels for noise exposure.

For average noise exposure, the GDG conditionally recommends reducing noise levels produced by wind turbines below 45 dB Lden. The GDG recognise the potential for increased risk of annoyance at levels below this value but cannot determine whether this increase risk can impact health. Wind turbine noise above this level is associated with adverse health effects.

The GDG points out that evidence on health effects from wind turbine noise (apart from annoyance) is either absent or rated low/very low quality. Furthermore, public perception towards wind turbines are hard to differentiate from reported effects related to noise and the two may be inextricably linked. The GDG also recognises that the percentage of people exposed to noise from wind turbines is far lower than other sources such as road traffic and state that any benefit from specifically reducing population exposure to wind turbine noise in all situations remains unclear.

That being said, the GDG recommends renewable energy policies include provisions to ensure noise levels from wind farm developments do not rise above the guideline values for average noise exposure. The GDG also provides a conditional recommendation for the implementation of suitable measures to reduce noise exposure, however, it states that no evidence is available to facilitate the recommendation of one type of intervention over another.

9. ***Infrasound Does Not Explain Symptoms Related to Wind Turbines:*** *Finnish Government's Analysis, Assessment and Research Activities (VN TEAS), 2020*

The study targeted to adverse health effects of wind turbine infrasound and was funded by the Finnish Government's Analysis, Assessment and Research Activities (VN TEAS).

It was found that the low-frequency, inaudible sounds made by wind turbines are not damaging to human health despite fears that they cause unpleasant symptoms. The project, which was carried out over two years, examined the impact of low-frequency—or infrasound—emissions which cannot be picked up by the human ear.

People in many countries have blamed the infrasound waves for symptoms ranging from headaches and nausea to tinnitus and cardiovascular problems, researchers said.

Interviews, sound recordings and laboratory tests were used to explore possible health effects on people living within 20 kilometres (12 miles) of the generators.

The report notes:

> *'...the behavioral findings of the current study suggest that wind turbine infrasound cannot be reliably perceived and it does not result in increased annoyance. Participants that showed health effects did not show signs of increased infrasound sensitivity and did not rate wind turbine sounds more annoying.*

As a result:

> *'These findings do not support the hypothesis that infrasound is the element in turbine sound that causes annoyance. Instead, they suggest that people who have health symptoms which they associate with wind turbine sound are not likely to have these symptoms because they perceive turbine sound more annoying than controls, at least in laboratory settings. It is more likely that these symptoms are triggered by other factors such as symptom expectancy'.*

5.5.2 Turbine Safety

Turbines pose no threat to the health and safety of the general public. The Department of the Environment, Heritage and Local Government (DoEHLG)'s '*Wind Energy Development Guidelines for Planning Authorities 2006*' and the '*Draft Revised Wind Energy Development Guidelines'* (Department of Housing, Planning and Local Government (DoHPLG), December 2019) (currently out for public consultation), iterate that there are no specific safety considerations in relation to the operation of wind turbines. Fencing or other restrictions are not necessary for safety considerations and should be kept to a minimum. People or animals can safely walk up to the base of the turbines.

The adopted 2006 Guidelines and the Draft 2019 Guidelines state that there is a very remote possibility of injury to people from flying fragments of ice or from a damaged blade. However, most blades are composite structures with no bolts or separate components and the danger is therefore minimised. The build-up of ice on turbines is unlikely to present problems. The wind turbines will be fitted with anti-vibration sensors, which will detect any imbalance caused by icing of the blades. The sensors will cause the turbine to wait until the blades have been de-iced prior to resuming operation.

Turbine blades are manufactured of glass reinforced plastic which will prevent any likelihood of an increase in lightning strikes within the site of the Proposed Development or the local area. Lightning protection conduits will be integral to the construction of the turbines. Lightning conduction cables, encased in protection conduits, will follow the electrical cable run, from the nacelle to the base of the turbine. The conduction cables will be earthed adjacent to the turbine base. The earthing system will be installed during the construction of the turbine foundations.

5.5.3 Electromagnetic Interference

The provision of underground electric cables of the capacity proposed is common practice throughout the country and installation to the required specification does not give rise to any specific health concerns.

The extremely low frequency (ELF) electric and magnetic fields (EMF) associated with the operation of the proposed cables fully comply with the international guidelines for ELF-EMF set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), a formal advisory agency to the World Health Organisation, as well as the EU guidelines for human exposure to EMF. Accordingly, there will be no operational impact on properties (residential or other uses) as the ICNIRP guidelines will not be exceeded at any distances even directly above the cables.

The ESB document 'EMF & You' (ESB, 2017)[5] provides further practical information on EMF.

Further details on the potential impacts of electromagnetic interference to telecommunications and aviation are presented in Chapter 14: Material Assets.

5.5.4 Assessment of Effects on Human Health

As set out in the Department of Housing, Planning, Community and Local Government '*Key Issues Consultation Paper on the Transposition of the EIA Directive 2017*' and the guidance listed in Section 1.3.3 of Chapter 1: Introduction, the consideration of the effects on populations and on human health should focus on health issues and environmental hazards arising from the other environmental factors, for example water contamination, air pollution, noise, accidents, disasters.

[5] *EMF & You: Information about Electric & Magnetic Fields and the electricity network in Ireland Available at: https://esb.ie/docs/default-source/default-document-library/emf-public-information_booklet_v9.pdf?sfvrsn=0.*

Chapter 8: Land, Soils and Geology, Chapter 9: Water, Chapter 10: Air and Climate, Chapter 11: Noise and Vibration and Chapter 14: Material Assets (Traffic and Transport) provide an assessment of the effects of the Proposed Development on these areas of consideration. There is the potential for negative effects on human health during the Wind Farm construction phase related to potential emissions to air of dust, potential emissions to land and water of hydrocarbons, release of potentially silt-laden runoff into watercourses and noise emissions.

The proposed site design and mitigation measures outlined in Chapter 8 and Chapter 9 ensures that the potential for impacts on the water environment are not significant. No impacts on local water supplies are anticipated.

As set out in Chapter 9, potential health effects are associated with negative impacts on public and private water supplies and potential flooding. There are no mapped public or group groundwater scheme within the Proposed Development site. There are 2 no. mapped Public Water Schemes (PWS) within 6km of the Wind Farm site (Mount Talbot PWS and Killeglan PWS (Tobermore Spring source). The Zone of Contribution to the Killeglan Spring PWS has been mapped by the GSI which encompasses a small area of the Proposed Development site. Based on the separation distance, the relative area of the Proposed Development site within the Killeglan Spring ZoC and the mitigation measures outlined in Chapter 9, no significant effects on the Killeglan PWS will occur.

The detailed Flood Risk Assessment in Appendix 9-1 has also shown that the risk of the Proposed Development contributing to flooding is low.

A wind farm is not a recognised source of pollution. It is not an activity which requires Environmental Protection Agency licensing under the Environmental Protection Agency Act 1992, as amended. As such, a wind farm is not considered to have ongoing significant emissions to environmental media and the subsequent potential for human health effects.

The proposed project is for the development of a renewable energy project, a wind farm, capable of offsetting carbon emissions associated with the burning of fossil fuels. During the operational stage the Wind Farm will have a long term, significant, positive effect on air quality as set out in Chapter 10 which will contribute to positive effects on human health.

The provision of aviation lighting on permitted turbines is a standard and accepted part of any wind farm development. This is a safety requirement of the Irish Aviation Authority (IAA). The standard lighting required by the IAA are medium intensity lights. Such lighting is designed specifically for aviation safety and is not intended to be overbearing or dominant when viewed from the ground thus striking a reasonable balance between aviation safety and visual impact. The IAA generally only confirm lighting arrangements required for wind farm developments once a consent is in place.

It is considered that aviation lighting on the proposed turbines will have no significant effect on human health, beyond increasing aircraft safety in the context of the Proposed Development. The applicant will continue its engagement with IAA as required in relation to aviation lighting.

The assessments show that the residual impacts are not significant and do not have the potential to cause negative health effects for human beings. On this basis, the potential for negative health effects associated with the Proposed Development is imperceptible.

5.5.5 Vulnerability of the Project to Natural Disasters and Major Accidents

As outlined in Section 5.5.4 above, a wind farm is not a recognised source of pollution. Should a major accident or natural disaster occur, the potential sources of pollution onsite during the construction, operational and decommissioning phases, are limited. Sources of pollution with the potential to cause significant environmental pollution and associated negative effects on health, such as bulk storage of hydrocarbons or chemicals, storage of wastes etc., are limited. A Major Accidents and Natural Disasters assessment is included as Chapter 16.

In the context of the Proposed Development site, there is limited potential for significant natural disasters to occur. Ireland is a geologically stable country with a mild temperate climate. The potential natural disasters that may occur are therefore limited to peat instability, flooding and fire. The risk of flooding and potential for contamination of groundwater and drinking water due to the construction of the Proposed Development is addressed in Chapter 9: Hydrology and Hydrogeology, with the risk being limited due to the proposed mitigation measures and site drainage plan, meaning there is limited risk to human health. It is considered that the risk of significant fire occurring, affecting the Wind Farm and causing the Wind Farm to have significant environmental effects is limited and therefore a significant effect on human health is similarly limited. As described earlier, there are no significant sources of pollution in the Wind Farm with the potential to cause environmental or health effects. Also, the spacing of the turbines and distance of turbines from any properties limits the potential for impacts on human health. The issue of turbine safety is addressed in Section 5.5.2.

Major industrial accidents involving dangerous substances pose a significant threat to humans and the environment; such accidents can give rise to serious injury to people or serious damage to the environment, both on and off the site of the accident. The Wind Farm site is not regulated under the Control of Major Accident Hazards Involving Dangerous Substances Regulations i.e. SEVESO sites and so there are no potential effects from this source. A Major Accidents and Natural Disasters assessment is included as Chapter 16.

5.6 Property Values

In the absence of any Irish studies on the effect of wind farms on property values, this section provides a summary of the largest and most recent studies from the United States and Scotland.

The largest study of the impact of wind farms on property values has been carried out in the United States. '*The Impact of Wind Power Projects on Residential Property Values in the United States: A multi-Site Hedonic Analysis*', December 2009, was carried out by the Lawrence Berkley National Laboratory (LBNL) for the U.S Department of Energy. This study collected data on almost 7,500 sales of single-family homes situated within ten miles of 24 existing wind farms in nine different American states over a period of approximately ten years. The conclusions of the study are drawn from eight different pricing models including repeat sales and volume sales models. Each of the homes included in the study was visited to demonstrate the degree to which the wind facility was visible at the time of the sale, and the conclusions of the report state that "*The result is the most comprehensive and data rich analysis to date on the potential impacts of wind energy projects on nearby property values.*"

The main conclusion of this study (as detailed on Page XVII) is as follows:

> *"Based on the data and analysis presented in this report, no evidence is found that home prices surrounding wind facilities are consistently, measurably, and significantly affected by either the view of wind facilities or the distance of the home to those facilities. Although the analysis cannot dismiss the possibility that individual or small numbers of homes have been or could be negatively impacted, if these impacts do exist, they are either too small and/or too infrequent to result in any widespread and consistent statistically observable impact.*"

This study has been recently updated by LBNL who published a further paper entitled '*A Spatial Hedonic Analysis of the Effects of Wind Energy Facilities on Surrounding Property Values in the United States*', in August 2013. This study analysed more than 50,000 home sales near 67 wind farms in 27 counties across nine U.S. states, yet was unable to uncover any impacts to nearby home property values. The homes were all within 10 miles of the wind energy facilities - about 1,100 homes were within 1 mile, with 331 within half a mile. The report is therefore based on a very large sample and represents an extremely robust assessment of the impacts of wind farm development on property prices. It concludes that:

> *"Across all model Specifications, we find no statistical evidence that home prices near wind turbines were affected in either the post-construction or post announcement/pre-construction periods."*

Both LBNL studies note that their results do not mean that there will never be a case of an individual home whose value goes down due to its proximity to a wind farm – however if these situations do exist, they are considered to be statistically insignificant. Therefore, although there have been claims of significant property value impacts near operating wind turbines that regularly surface in the press or in local communities, strong evidence to support those claims has failed to materialise in all the major U.S. studies conducted thus far.

A further study was commissioned by RenewableUK and carried out by the Centre for Economics and Business Research (Cebr) in March 2014. Its main conclusions are:

- Overall, the analysis found that the county-wide property market drives local house prices, not the presence or absence of wind farms.
- The econometric analysis established that construction of wind farms at the five sites examined across England and Wales has not had a detectable negative impact on house price growth within a five-kilometre radius of the sites.

A relatively new study issued in October 2016 '*Impact of wind Turbines on House Prices in Scotland*' (2016) was published by Climate Exchange. Climate Exchange is Scotland's independent centre of expertise on climate change which exists to support the Scottish Governments policy development on climate and the transition to a low carbon economy. A copy of the report is included as Appendix 5-2 of this EIAR.

The report presents the main findings of a research project estimating the impact on house prices from wind farm developments. It is based on analysis of over 500,000 property sales in Scotland between 1990 and 2014. The key findings from the study are:

- No evidence of a consistent negative effect on house prices: Across a very wide range of analyses, including results that replicate and improve on the approach used by Gibbons (2014[6]), we do not find a consistent negative effect of wind turbines or wind farms when averaging across the entire sample of Scottish wind turbines and their surrounding houses. Most results either show no significant effect on the change in price of properties within 2km or 3km or find the effect to be positive.
- Results vary across areas: The results vary across different regions of Scotland. Our data does not provide sufficient information to enable us to rigorously measure and test the underlying causes of these differences, which may be interconnected and complex.

Although there have been no empirical studies carried out in Ireland on the impacts of wind farms on property prices, the literature described above demonstrates that at an international level, wind farms have not impacted property values in the local areas. It is a reasonable assumption based on the available international literature, that the provision of a wind farm at the proposed location would not impact on the property values in the area.

---

[6] *Stephen Gibbons, 2014. "Gone with the Wind: Valuing the Visual Impacts of Wind Turbines through House Prices," SERC Discussion Papers 0159, Spatial Economics Research Centre, LSE.*

5.7 Shadow Flicker

5.7.1 Background

Shadow flicker is an effect that occurs when rotating wind turbine blades cast shadows over a window in a nearby property. Shadow flicker is an indoor phenomenon, which may be experienced by an occupant sitting in an enclosed room when sunlight reaching the window is momentarily interrupted by a shadow of a wind turbine's blade. Outside in the open, light reaches a viewer (person) from a much less focused source than it would through a window of an enclosed room, and therefore shadow flicker assessments are typically undertaken for the nearby adjacent properties around a proposed Wind Farm site.

The frequency of occurrence and the strength of any potential shadow flicker impact depends on several factors, each of which is outlined below.

1. ***Whether the sunlight is direct and unobstructed or diffused by clouds:***

If the sun is not shining, shadow flicker cannot occur. Reduced visibility conditions such as clouds, haze, and fog greatly reduce the chance of shadow flicker occurring.

Cloud amounts are reported as the number of eights (okta) of the sky covered. Irish skies are completely covered by cloud (8 oktas) for over 50% of the time. The mean cloud amount for each hour is between five and six okta. This is due to Ireland's geographical position off the northwest of Europe, close to the path of Atlantic low-pressure systems which tend to keep the country in humid, cloudy airflows for much of the time. A study at 12 stations over a 25-year period showed that the mean cloud amount was at a minimum in April and maximum in July. Cloud amounts were less at night than during the day, with the mean minimum occurring roughly between 2100 and 0100 GMT and the mean maximum occurring between 1000 and 1500 GMT at most stations. (*Source: Met Éireann, www.met.ie*)

2. ***The presence of intervening obstructions between the turbine and the observer:***

For shadow flicker to occur, the windows of a potentially affected property must have direct visibility of a wind turbine, with no physical obstructions such as buildings, trees and hedgerows, hills or other structures located on the intervening land between the window and the turbine.

Any obstacles such as trees or buildings located between a property and the wind turbine will reduce or eliminate the occurrence and/or intensity of the shadow flicker.

3. ***How high the sun is in the sky at a given time:***

At distances of greater than approximately 500m between a turbine and a receptor, shadow flicker generally occurs only at sunrise or sunset when the shadow cast by the turbine is longer. The current adopted '*Wind Energy Development Guidelines for Planning Authorities'* published by the Department of Environment, Heritage and Local Government (DoEHLG, 2006), iterates that at distances greater than ten rotor diameters from a turbine, the potential for shadow flicker is very low (*'Wind Energy Development Guidelines for Planning Authorities'*, DoEHLG, 2006).

Figure 5-2 illustrates the shadow cast by a turbine at various times during the day; the red shading represents the area where shadow flicker may occur. When the sun is high in the sky, the length of the shadow cast by the turbine is significantly shorter.

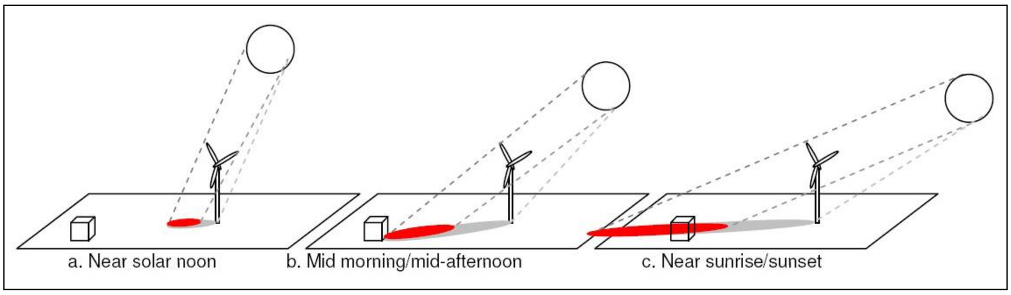


Figure 5-2 Shadow-Prone Area as Function of Time of Day (Source: Shadow Flicker Report, Helimax Energy, Dec 2008)

4. ***Distance and bearing, i.e. where the property is located relative to a turbine and the sun:***

The further a property is from the turbine the less pronounced the impact will be. There are several reasons for this: there are fewer times when the sun is low enough to cast a long shadow; when the sun is low it is more likely to be obscured by either cloud on the horizon or intervening buildings and vegetation; and, the centre of the rotor's shadow passes more quickly over the land reducing the duration of the impact.

At a distance, the turbine blades do not cover the sun but only partly mask it, substantially weakening the shadow. This impact occurs first with the shadow from the blade tip, the tips being thinner in section than the rest of the blade. The shadows from the tips extend the furthest and so only a very weak impact is observed at distance from the turbines. (Source: Update of Shadow Flicker Evidence Base, UK Department of Energy and Climate Change, 2010).

5. ***Property usage and occupancy:***

Where shadow flicker is predicted to occur at a specific location, this does not imply that it will be witnessed. Potential occupants of a property may be sleeping or occupying a room on another side of the property that is not subject to shadow flicker, or completely absent from the location during the time of shadow flicker events. As shadow flicker usually occurs only when the sun is at a low angle in the sky, i.e. very early in the morning after sunrise or late in the evening before sunset, even if there is a bedroom on the side of the property affected, the shadow flicker may not be witnessed if curtains or blinds in the bedroom are closed. It should be noted, that the below assessment considers a worst-case assessment as detailed in Section 5.7.4.3 below.

6. ***Wind direction, i.e. position of the turbine blades:***

The direction of wind turbine blades changes according to wind direction, as the turbine rotor turns to face the wind. In order to cast a shadow, the turbine blades must be facing directly toward or away from the sun, so they are moving across the source of the light relative to the observer. This is demonstrated in Figure 5-3 below.

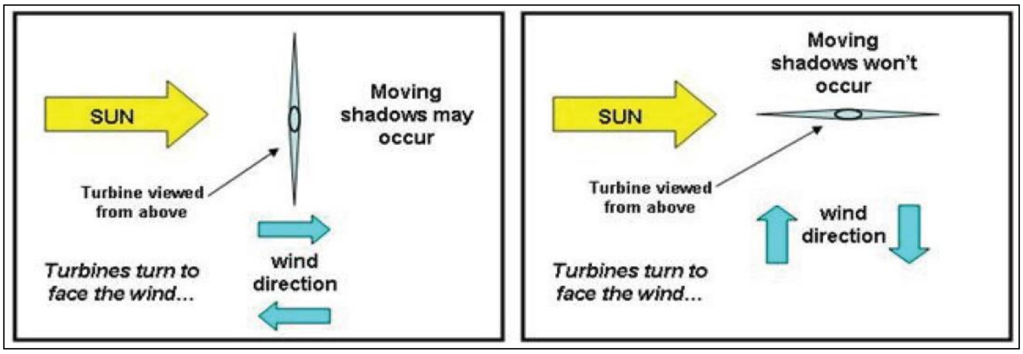


Figure 5-3 Turbine Blade Position and Shadow Flicker Impact (Source: Wind Fact Sheet: Shadow Flicker, Noise Environment Power LLC)

7. ***Rotation of turbine blades:***

Shadow flicker occurs only if there is sufficient wind for the turbine blades to be continually rotating. Wind turbines begin operating at a specific wind speed referred to as the 'cut-in speed', i.e. the speed at which the turbine produces a net power output, and they cease operating at a specific 'cut-out speed'. Therefore, even during the sunlight hours when shadow flicker has been predicted to occur, if the turbine blades are not turning due to insufficient wind speed, then no shadow flicker will occur.

5.7.2 Guidance

The current guidance for shadow flicker in Ireland is derived from the '*Draft Revised Wind Energy Development Guidelines for Planning Authorities 2019'* (DoEHLG), and the '*Best Practice Guidelines for the Irish Wind Energy Industry'* (Irish Wind Energy Association, 2012).

The 2019 draft wind energy guidelines have been revised from the 2006 version (DoEHLG), recommending that there should be no shadow flicker at any properties from a wind farm proposal. Which is lower threshold than the 2006 guidelines of less than 30 hours per year or 30 minutes per day of shadow flicker at dwellings within 500 metres of a proposed turbine location. A significant minimum separation distance of 724m from third party dwellings has been achieved with the project design. There are 296 No. properties located within 1.62 kilometres (i.e., the shadow flicker study area of ten times the rotor diameter; 10x162 = 1,620m as per the 2006 DoEHLG guidelines) of the proposed turbines, of which 278 are dwellings, 15 are in a derelict condition and the remaining 3 No. properties are planning permissions.

The 2006 DoEHLG guidelines state that shadow flicker lasts only for a short period of time and occurs only during certain specific combined circumstances, as follows:

- the sun is shining and is at a low angle in the sky, i.e. just after dawn and before sunset, **and**
- the turbine is located directly between the sun and the affected property, **and**
- there is enough wind energy to ensure that the turbine blades are moving, **and**
- the turbine blades are positioned so as to cast a shadow on the receptor.

The current 2006 DoEHLG guidelines are currently under review. The DoHPLG released the '*Draft Revised Wind Energy Development Guidelines'* in December 2019 which was released for public consultation. The Draft 2019 guidelines recommend local planning authorities and/or An Bord Pleanála impose conditions to ensure that:

> *"no existing dwelling or other affected property will experience shadow flicker as a result of the wind energy development subject of the planning application and the wind energy development shall be installed and operated in accordance with the shadow flicker study submitted to accompany the planning application, including any mitigation measures required."*

The Draft 2019 Guidelines are based on the recommendations set out in the '*Proposed Revisions to Wind Energy Development Guidelines 2006 – Targeted Review'* (December 2013) and the '*Review of the Wind Energy Development Guidelines 2006 – Preferred Draft Approach'* (June 2017). The assessment herein is based on compliance with the 2019 draft guidelines to ensure that no existing dwelling or other affected property will experience shadow flicker as a result of the wind energy development.

5.7.3 Shadow Flicker Prediction Methodology

Shadow flicker occurs only under certain, combined circumstances, as detailed above. Where shadow flicker does occur, it is generally short-lived. The 2006 DoHPLG guidelines state that careful site selection, design and planning, and good use of relevant software can help avoid the possibility of shadow flicker, all of which have been employed at the site of the Proposed Development. Proper siting of wind turbines is key in eliminating shadow flicker.

The occurrence of shadow flicker can be precisely predicted using specialist computer software programmes specifically developed for the wind energy industry, such as WindFarm (ReSoft) or WindFarmer (DNV.GL) or AWS OpenWind. The computer modelling of the occurrence and magnitude of shadow flicker is made possible by the fact that the sun rises and sets in the same position in the sky on every day each year.

Any potential impact can be precisely modelled to give the start and end time (accurate to the second) of any incidence of shadow flicker, at any location, on any day or all days of the year when it might occur. Where a shadow flicker impact is predicted to occur, the total maximum daily and annual durations can be predicted, along with the total number of days. Any incidence of predicted shadow flicker can be attributed to a particular turbine or group of turbines to allow effective mitigation strategies to be planned and proposed as detailed further below.

For the purposes of this shadow flicker assessment, the software package WindFarm Version 5.0.1.2 has been used to predict the level of shadow flicker associated with the Proposed Development. WindFarm is a commercially available software tool that enables developers to analyse, design and optimise proposed wind farms. It allows proposed turbine layouts to be optimised for maximum energy yield whilst taking account of environmental, planning and engineering constraints.

5.7.4 Shadow Flicker Assessment Criteria

5.7.4.1 Turbine Dimensions

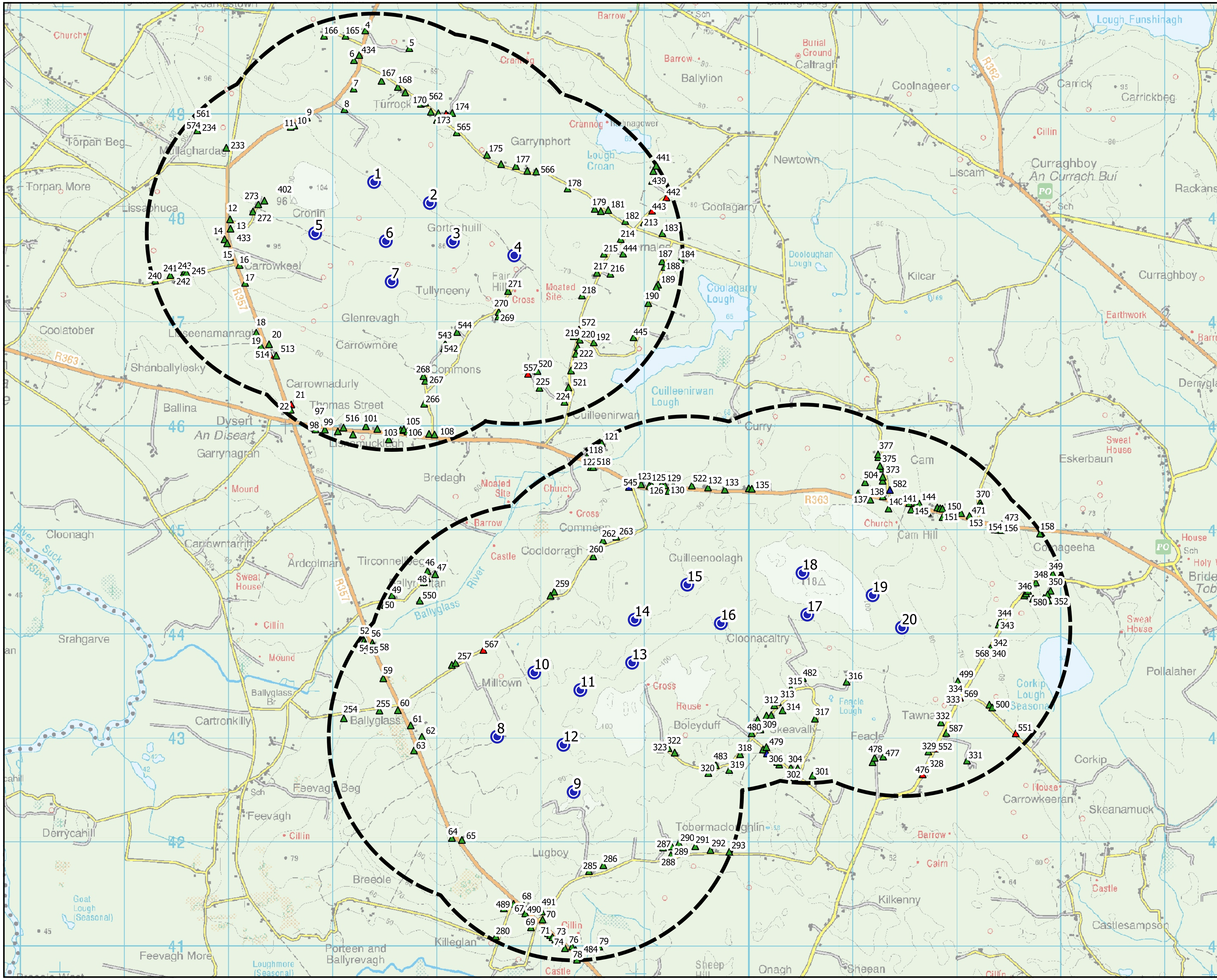
Planning permission is being sought for a turbine size envelope with a tip height of 180 metres, a rotor diameter of 162m and a hub height of 99m. For the purposes of this assessment, a turbine with a rotor diameter of 162m and a hub height of 99m was modelled.

Regardless of the make or model of the turbine eventually selected for installation on site, it will have a tip height of 180 metres and the potential shadow flicker impact it will give rise to will be no more than that predicted in this assessment. With the benefit of the mitigation measures outlined in Section 5.9.3.4, all turbines installed onsite will comply with the 2019 Draft DoEHLG guidelines, to ensure there is no shadow flicker occurrences at any property within the 1.62km study area as a result of the Proposed Development. This will be achieved through the use of turbine control software throughout the entire operational period of the Proposed Development. Any references to the turbine dimensions in this shadow flicker assessment should be considered in the context of the above.

5.7.4.2 Study Area

At the outset of the project, during the constraints mapping process detailed in Chapter 3 of this EIAR, all sensitive receptors within 2km of the EIAR Site Boundary were identified and mapped. This included all occupied and unoccupied dwellings. In addition, a planning history search to identify properties that may have been granted planning permission, but not yet been constructed, was carried out. Any property with a valid planning permission for a dwelling house was also added to the sensitive receptors' dataset.

The study area for the shadow flicker assessment is ten times rotor diameter from each turbine as set out in the 'Wind Energy Development Guidelines for Planning Authorities', DoEHLG, 2006. All residential properties located within ten rotor diameters which is assumed to be 1.62 kilometres have been included in the assessment. A significant minimum separation distance of 724m from third party dwellings has been achieved with the project design. There are 296 No. properties located within 1.62 kilometres of the proposed turbines as detailed above, of which 278 are dwellings, 15 are in a derelict condition and the remaining 3 No. properties are planning permissions. The shadow flicker study area and sensitive receptor locations are shown in Figure 5-4.



Map Legend

Proposed Turbine Layout

Shadow Flicker Study Area (10 X Rotor Diameter (162m) = 1.62km)

Properties within Shadow Flicker Study Area

- Dwelling
- Derelict
- Planning Permission

Drawing Title	
Shadow Flicker Study Area	
Project Title	
Seven Hills Wind Farm, Co. Roscommon	
Drawn By: DN	Checked By: ÓM
Project No.: 190907	Drawing No.: Figure 5-4
Scale: 1:47500	Date: 31.05.2022

MKO
Planning and Environmental Consultants
Tuam Road, Galway Ireland, H91 VW84
+353 (0) 91 735611
email:info@mkoireland.ie
Website: www.mkoireland.ie

5.7.4.3 Assumptions and Limitations

Due to the latitude of Ireland and the UK, shadow flicker impacts are only possible at properties 130 degrees either side to the north as turbines do not cast shadows on their southern side (ODPM Annual Report and Accounts 2004: Housing, Planning, Local Government and the Regions Committee; Planning Policy Statement 22; Draft Revised Wind Energy Development Guidelines 2019). As such properties located outside of this potential shadow flicker zone will not be impacted. However, in this assessment, all 296 no. properties within 360 degrees of the Proposed Development within the study area were assessed for shadow flicker impact.

At each property, shadow flicker calculations were carried out based on 4 no. notional windows facing north, east, south and west, labelled Windows 1, 2, 3 and 4 respectively. The degrees from north value for each window is:

- Window 1: 0 degrees from North
- Window 2: 90 degrees from North
- Window 3: 180 degrees from North
- Window 4: 270 degrees from North

Each window measures one-metre-high by one-metre-wide, and tilt angle is assumed to be zero. The centre height of each window is assumed to be two metres above ground level and no screening due to trees or other buildings or vegetation is assumed. It was not considered necessary or practical to measure the dimensions of every window on every property in the study area. While the actual size of a window will marginally influence the incidence and duration of any potential shadow flicker impact, with larger windows resulting in slightly longer shadow flicker durations, any incidences or durations or shadow flicker can be countered by the measures outlined in Section 5.9.3.4 below.

The use of computer models to predict the amount of shadow flicker that will occur is known to produce an over-estimate of possible impact, referred to as the *'worst-case impact'*, due to the following limitations:

- The sun is assumed to be shining during all daylight hours such that a noticeable shadow is cast. This will not occur in reality.
- The wind is always assumed to be within the operating range of the turbines such that the turbine rotor is turning at all times, thus enabling a periodic shadow flicker. Wind turbines only begin operating at a specific 'cut-in speed', and cease operating at a specific 'cut-out speed'. In periods where the wind is blowing at medium to high speeds, the probability of there being clear or partially clear skies where the sun is shining and could cast a shadow, is low.
- The wind turbines are assumed to be available to operate, i.e. turned on at all times. In reality, turbines may be switched off during maintenance or for other technical or environmental reasons.
- The turbine rotor is considered (as a sphere) to present its maximum aspect to observers in all directions. In reality, the wind direction and relative position of the turbine rotor would result in a changing aspect being presented by the turbine. The rotor will actually present as ellipses of varying sizes to observers from different directions. The time taken for the sun to pass across the sky behind a highly elliptical rotor aspect will be shorter than the modelled maximum aspect.

The total annual shadow flicker calculated for each property assumes 100% sunshine during daytime hours, as referred to above. However, weather data for this region shows that the sun shines on average for 30% of the daylight hours per year. This percentage is based on Met Eireann data recorded at Mullingar weather station over the 30-year period from 1979-2008 (www.met.ie). The actual sunshine hours at the Proposed Development site and therefore the percentage of time shadow flicker could actually occur is 30% of daylight hours. Table 5-9 therefore lists the annual shadow flicker calculated for each property when corrected for the regional average of 30% sunshine, to give a more accurate annual average shadow flicker prediction.

Table 5-9 below outlines whether a shadow flicker mitigation strategy is required for any property within the study area which may be impacted by shadow flicker.

5.7.5 Shadow Flicker Assessment Results

5.7.5.1 Daily and Annual Shadow Flicker

The WindFarm computer software was used to model the predicted daily and annual shadow flicker levels in significant detail, identifying the predicted daily start and end times, maximum daily duration and the individual turbines predicted to give rise to shadow flicker.

The model results assume worst-case conditions, including

- 100% sunshine during all daylight hours throughout the year,
- An absence of any screening (vegetation or other buildings),
- That the sun is behind the turbine blades,
- That the turbine blades are facing the property, and
- That the turbine blades are moving.

The maximum daily shadow flicker model assumes that daylight hours consist of 100% sunshine. This is a conservative assumption which represents a worst-case scenario. Following the detail provided above on sunshine hours, a sunshine factor of 30% has been applied to the annual shadow flicker results as detailed above. Taking this information into consideration, the predicted shadow flicker which is estimated to occur at nearby dwellings is presented in Table 5-9.

The predicted maximum daily and annual shadow flicker levels are then considered in the context of the DoEHLG's 2019 draft guidelines recommendation of committing to zero shadow flicker at all properties within the study. If there is any predicted occurrence of shadow flicker at any property, the turbines that contribute to the exceedance are also identified, with mitigation measures required for these contributing turbines.

There are 296 No. properties located within 1.62 kilometres (i.e., the shadow flicker study area of ten times the rotor diameter; 10x162 = 1,620m) of the proposed turbines, of which 278 are dwellings, 15 are in a derelict condition and the remaining 3 No. properties are planning permissions.

The 296 No. buildings have been modelled as part of the shadow flicker assessment, the results of which are presented in Table 5-9. Former residential dwellings termed as "derelict" within this assessment are defined as properties that are currently in an uninhabitable condition, but which may have the potential to be restored to their former use.

Table 5-8 Maximum Potential Daily & Annual Shadow Flicker – Proposed Seven Hills Wind Farm, Co. Roscommon

House ID	ITM (Easting)	ITM (Northing)	Description	Distance to Nearest Turbine (metres)	Nearest Proposed Turbine No.	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Proposed Turbine(s) Giving Rise to Daly Shadow Flicker Exceedance	Mitigation Strategy Required (Daily or Annual)?
271	587643	747316	Site Office/ Participating Property	347	4	00:35:24	23:06:00	14:07:48	T6, T7	No***
567	587405	743863	Derelict	536	10	01:28:12	16:24:00	00:07:12	T8, T10, T11, T12, T13, T14	No**
270	587553	747115	Dwelling/ Participating Property	564	4	00:37:48	18:18:00	19:53:24	T6, T7	No*
402	585299	748186	Dwelling/ Participating Property	581	5	01:34:12	13:00:00	15:54:00	T1, T2, T5, T6, T7	No*
269	587550	747072	Dwelling/ Participating Property	606	4	00:37:48	14:06:00	18:37:48	T6, T7	No*
482	590479	743592	Dwelling/ Participating Property	612	17	01:30:36	03:06:00	05:43:48	T15, T16, T20	No*
273	585240	748151	Dwelling/ Participating Property	614	5	01:32:24	13:54:00	08:58:12	T1, T5, T6, T7	No*
272	585188	748081	Dwelling/ Participating Property	634	5	01:18:00	02:12:00	05:27:36	T1, T5, T6, T7	No*
175	587440	748627	Dwelling/ Participating Property	695	2	00:56:24	00:30:00	12:09:00	T1, T2, T3, T6, T7	No*
565	587149	748843	Dwelling	727	2	01:16:12	01:36:00	05:16:48	T1, T2, T6	Yes
62	586814	743027	Dwelling	724	8	00:57:36	01:36:00	12:28:48	T8, T9, T10, T11, T12	Yes

House ID	ITM (Easting)	ITM (Northing)	Description	Distance to Nearest Turbine (metres)	Nearest Proposed Turbine No.	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Proposed Turbine(s) Giving Rise to Daly Shadow Flicker Exceedance	Mitigation Strategy Required (Daily or Annual)?
260	588463	744763	Dwelling	729	14	00:53:24	22:00:00	11:24:00	T14, T15, T16	Yes
315	590363	743490	Dwelling	729	17	00:34:48	08:48:00	17:02:24	T13, T20	Yes
316	590899	743557	Dwelling	744	20	00:31:48	04:00:00	08:24:00	T16	Yes
499	591970	743561	Dwelling	745	20	00:27:00	17:30:00	05:15:00	T17	Yes
218	588354	747274	Dwelling	757	4	00:55:12	16:06:00	02:25:48	T3, T4	Yes
8	586069	749066	Dwelling	757	1	01:18:00	09:24:00	00:25:12	T1, T2	Yes
258	588051	744385	Dwelling	758	10	01:07:48	07:18:00	14:11:24	T10, T11, T13, T14, T15	Yes
176	587576	748537	Dwelling	758	2	01:10:12	03:30:00	20:15:00	T1, T2, T3, T6, T7	Yes
261	588538	744840	Dwelling	759	14	00:52:12	04:00:00	06:00:00	T14, T15, T16	Yes
286	588559	741792	Dwelling	760	9	00:00:00	00:00:00	00:00:00	N/A	No
257	587139	743738	Dwelling	762	10	00:54:00	07:42:00	14:18:36	T8, T10, T11, T12	Yes
285	588421	741734	Dwelling	776	9	00:00:00	00:00:00	00:00:00	N/A	No
173	586959	748963	Dwelling	784	2	00:49:12	03:54:00	22:46:12	T1, T2, T5	Yes
16	585060	747567	Dwelling	789	5	01:18:36	20:24:00	18:07:12	T1, T5, T6, T7	Yes
543	587039	746807	Dwelling	791	7	00:00:00	00:00:00	00:00:00	N/A	No
544	587152	746922	Dwelling	794	7	00:39:36	01:18:00	07:35:24	T7	Yes
256	587102	743718	Dwelling	797	10	00:54:36	10:06:00	15:01:48	T8, T10, T11, T12	Yes
259	588087	744424	Dwelling	803	10	00:47:24	19:12:00	10:33:36	T10, T11, T13, T14, T15	Yes
341	592210	743854	Dwelling	809	20	01:17:24	10:48:00	08:02:24	T19, T20	Yes
63	586738	742895	Dwelling	811	8	00:48:36	04:48:00	06:14:24	T8, T9, T10, T12	Yes
217	588498	747492	Dwelling	813	4	00:48:36	22:30:00	13:57:00	T3, T4	Yes
542	587026	746766	Dwelling	814	7	00:00:00	00:00:00	00:00:00	N/A	No
13	584973	747916	Dwelling	816	5	00:47:24	06:42:00	16:24:36	T1, T5, T6	Yes

House ID	ITM (Easting)	ITM (Northing)	Description	Distance to Nearest Turbine (metres)	Nearest Proposed Turbine No.	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Proposed Turbine(s) Giving Rise to Daly Shadow Flicker Exceedance	Mitigation Strategy Required (Daily or Annual)?
568	592204	743813	Derelict	816	20	01:19:12	23:48:00	11:56:24	T19, T20	No**
263	588684	744952	Dwelling	819	14	00:51:00	23:54:00	21:34:12	T14, T15, T16	Yes
262	588557	744916	Dwelling	822	14	00:51:36	08:42:00	00:12:36	T14, T15, T16	Yes
178	588215	748303	Dwelling	825	4	00:46:48	02:54:00	05:40:12	T2, T3, T4	Yes
575	587828	748473	Dwelling	825	4	00:46:48	07:24:00	07:01:12	T1, T2, T3, T4, T6	Yes
17	585113	747395	Dwelling	825	5	00:54:36	20:36:00	20:34:48	T1, T5, T6, T7	Yes
12	584969	748006	Dwelling	830	5	00:48:00	04:36:00	15:46:48	T1, T5, T6	Yes
566	587914	748466	Dwelling	836	4	00:40:12	19:54:00	03:34:12	T1, T2, T3, T4, T6	Yes
334	591950	743420	Dwelling	836	20	00:00:00	00:00:00	00:00:00	N/A	No
563	587063	749003	Derelict	837	2	00:42:36	20:48:00	13:26:24	T1, T2	No**
61	586706	743137	Dwelling	839	8	00:46:12	13:24:00	18:25:12	T8, T10, T12	Yes
15	584969	747644	Dwelling	849	5	01:04:12	17:12:00	02:45:36	T1, T5, T6, T7	Yes
140	591303	745223	Dwelling	849	19	00:41:24	10:48:00	17:38:24	T17, T18, T19	Yes
172	586972	749027	Dwelling	849	2	00:43:12	11:06:00	17:43:48	T1	Yes
564	587046	749020	Derelict	850	2	00:42:36	23:36:00	14:16:48	T1	No**
433	584941	747775	Dwelling	852	5	00:46:12	14:06:00	18:37:48	T1, T5, T6	Yes
171	586900	749041	Dwelling	860	2	01:01:12	11:30:00	01:03:00	T1, T5	Yes
177	587718	748519	Dwelling	861	4	00:47:24	19:12:00	10:33:36	T1, T2, T3, T6	Yes
333	591920	743367	Dwelling	861	20	00:00:00	00:00:00	00:00:00	N/A	No
215	588564	747676	Dwelling	863	4	00:59:24	18:06:00	12:37:48	T3, T4	Yes
174	587105	749029	Dwelling	871	2	00:40:48	15:48:00	11:56:24	T1	Yes
14	584915	747814	Dwelling	874	5	00:45:00	07:30:00	16:39:00	T1, T5, T6	Yes
342	592283	743880	Dwelling	874	20	01:09:00	07:12:00	23:45:36	T19, T20	Yes
569	591990	743404	Derelict	874	20	00:00:00	00:00:00	00:00:00	N/A	No**

House ID	ITM (Easting)	ITM (Northing)	Description	Distance to Nearest Turbine (metres)	Nearest Proposed Turbine No.	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Proposed Turbine(s) Giving Rise to Daly Shadow Flicker Exceedance	Mitigation Strategy Required (Daily or Annual)?
323	589108	742907	Dwelling	875	13	00:46:12	10:36:00	07:58:48	T8, T9, T10, T11, T12	Yes
340	592269	743819	Dwelling	876	20	01:12:36	23:18:00	04:35:24	T19, T20	Yes
170	586804	749117	Dwelling	877	1	01:10:48	20:36:00	20:34:48	T1, T5	Yes
313	590238	743361	Dwelling	888	17	00:57:00	03:54:00	22:46:12	T13, T14, T20	Yes
137	591022	745306	Dwelling	891	18	00:43:12	10:06:00	17:25:48	T18	Yes
322	589186	742918	Dwelling	892	13	00:42:00	05:06:00	06:19:48	T9, T10, T11, T12	Yes
179	588477	748107	Dwelling	895	4	00:44:24	12:18:00	18:05:24	T2, T3, T4	Yes
9	585708	748985	Dwelling	896	1	01:13:48	09:36:00	00:28:48	T1, T2, T6	Yes
142	591520	745213	Dwelling	904	19	01:00:00	01:54:00	22:10:12	T17, T18, T19	Yes
562	586846	749128	Dwelling	908	1	00:42:36	00:42:00	14:36:36	T1	Yes
169	586654	749227	Dwelling	913	1	00:44:24	20:48:00	06:14:24	T1, T5	Yes
145	591587	745197	Dwelling	919	19	01:00:36	03:06:00	22:31:48	T17, T18, T19	Yes
138	591128	745308	Dwelling	920	19	00:40:48	07:30:00	16:39:00	T17, T18	Yes
130	589187	745393	Dwelling	920	15	00:27:36	14:48:00	04:26:24	T18	Yes
7	586157	749264	Dwelling	921	1	00:27:00	13:18:00	03:59:24	T1, T2	Yes
312	590205	743330	Dwelling	927	17	00:57:36	07:06:00	23:43:48	T13, T14, T20	Yes
136	591009	745366	Dwelling	931	18	00:41:24	00:54:00	14:40:12	T18	Yes
343	592363	744107	Dwelling	932	20	00:42:00	03:18:00	15:23:24	T19, T20	Yes
180	588536	748085	Dwelling	937	4	00:42:36	20:30:00	13:21:00	T3, T4	Yes
127	589102	745389	Dwelling	937	15	00:26:24	13:18:00	03:59:24	T18	Yes
146	591640	745188	Dwelling	938	19	00:59:24	04:24:00	22:55:12	T17, T18, T19	Yes
10	585587	748909	Dwelling	940	1	01:00:36	19:00:00	20:06:00	T1, T2, T6	Yes
216	588627	747482	Dwelling	942	4	00:42:00	08:24:00	09:43:12	T3, T4	Yes
168	586583	749280	Dwelling	943	1	00:14:24	03:18:00	00:59:24	T1	Yes

House ID	ITM (Easting)	ITM (Northing)	Description	Distance to Nearest Turbine (metres)	Nearest Proposed Turbine No.	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Proposed Turbine(s) Giving Rise to Daly Shadow Flicker Exceedance	Mitigation Strategy Required (Daily or Annual)?
126	589068	745385	Dwelling	943	15	00:25:48	15:12:00	04:33:36	T15, T18	Yes
135	589988	745413	Dwelling	946	18	01:21:36	15:42:00	02:18:36	T15, T18, T19	Yes
572	588325	746945	Derelict	947	4	00:30:00	03:00:00	08:06:00	T3	No**
344	592377	744146	Dwelling	948	20	00:41:24	00:48:00	14:38:24	T19, T20	Yes
314	590283	743281	Dwelling	951	17	00:31:12	18:30:00	12:45:00	T13, T20	Yes
558	588311	746927	Dwelling	952	4	00:29:24	00:18:00	07:17:24	T3	Yes
141	591501	745275	Dwelling	954	19	00:55:12	17:00:00	19:30:00	T17, T18, T19	Yes
522	589411	745444	Dwelling	955	15	00:30:36	20:48:00	06:14:24	T18	Yes
147	591682	745183	Dwelling	957	19	00:59:24	05:12:00	23:09:36	T17, T18, T19	Yes
321	589246	742875	Dwelling	957	13	00:39:36	21:00:00	03:54:00	T9, T10, T11, T12	Yes
132	589566	745426	Dwelling	957	15	00:34:12	23:00:00	14:06:00	T17, T18	Yes
139	591248	745341	Dwelling	957	19	00:39:00	23:00:00	14:06:00	T17, T18	Yes
268	586829	746498	Dwelling	959	7	00:00:00	00:00:00	00:00:00	N/A	No
11	585552	748896	Dwelling	962	1	00:57:00	16:42:00	19:24:36	T1, T2, T6	Yes
131	589232	745443	Dwelling	962	15	00:27:36	15:54:00	04:46:12	T18	Yes
134	589959	745417	Dwelling	964	18	01:13:48	12:18:00	01:17:24	T15, T18, T19	Yes
219	588275	746882	Dwelling	964	4	00:26:24	15:30:00	04:39:00	T3	Yes
167	586426	749339	Dwelling	976	1	00:00:00	00:00:00	00:00:00	N/A	No
129	589151	745447	Dwelling	981	15	00:26:24	14:12:00	04:15:36	T18	Yes
143	591571	745276	Dwelling	983	19	00:53:24	16:30:00	19:21:00	T17, T18, T19	Yes
133	589728	745405	Dwelling	984	15	01:03:00	11:06:00	17:43:48	T14, T17, T18	Yes
332	591807	743166	Dwelling	985	20	00:00:00	00:00:00	00:00:00	N/A	No
60	586583	743283	Dwelling	989	8	00:39:36	20:30:00	13:21:00	T8, T10	Yes
144	591600	745269	Dwelling	989	19	00:54:36	17:06:00	19:31:48	T17, T18, T19	Yes
310	590129	743232	Dwelling	991	16	00:55:48	21:54:00	20:58:12	T13, T14, T20	Yes

House ID	ITM (Easting)	ITM (Northing)	Description	Distance to Nearest Turbine (metres)	Nearest Proposed Turbine No.	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Proposed Turbine(s) Giving Rise to Daly Shadow Flicker Exceedance	Mitigation Strategy Required (Daily or Annual)?
128	589118	745452	Dwelling	993	15	00:26:24	13:36:00	04:04:48	T18	Yes
481	590043	743190	Dwelling	995	16	00:31:48	04:54:00	08:40:12	T13, T14	Yes
317	590595	743201	Dwelling	1004	17	00:00:00	00:00:00	00:00:00	N/A	No
181	588607	748096	Dwelling	1005	4	00:39:36	14:36:00	11:34:48	T3, T4	Yes
267	586846	746452	Dwelling	1008	7	00:00:00	00:00:00	00:00:00	N/A	No
311	590175	743235	Dwelling	1009	16	00:56:24	22:06:00	21:01:48	T13, T14, T20	Yes
151	591823	745141	Dwelling	1010	19	01:00:36	03:54:00	22:46:12	T17, T18, T19	Yes
287	589134	741962	Dwelling	1013	9	00:42:00	17:54:00	12:34:12	T9	Yes
125	589025	745448	Dwelling	1017	15	00:00:00	00:00:00	00:00:00	N/A	No
124	589001	745442	Dwelling	1020	15	00:09:00	01:12:00	00:21:36	T15	Yes
220	588333	746848	Dwelling	1027	4	00:26:24	16:30:00	04:57:00	T3	Yes
582	591316	745402	Planning Permission	1027	19	00:36:00	19:12:00	12:57:36	T17, T18	Yes
214	588726	747816	Dwelling	1037	4	00:55:12	09:24:00	10:01:12	T3, T4	Yes
444	588750	747676	Dwelling	1048	4	00:37:48	22:48:00	06:50:24	T4	Yes
148	591772	745234	Dwelling	1050	19	00:36:36	09:06:00	17:07:48	T18, T19	Yes
65	587199	742034	Dwelling	1050	8	00:36:00	10:06:00	10:13:48	T9	Yes
149	591799	745226	Dwelling	1060	19	00:36:36	10:06:00	17:25:48	T18, T19	Yes
504	591077	745477	Dwelling	1061	18	00:36:36	13:12:00	11:09:36	T18	Yes
123	588923	745457	Dwelling	1064	15	00:21:36	07:42:00	02:18:36	T15	Yes
64	587103	742054	Dwelling	1067	8	00:33:00	08:54:00	09:52:12	T9, T12	Yes
150	591822	745222	Dwelling	1071	19	00:36:36	10:12:00	17:27:36	T18, T19	Yes
221	588313	746777	Dwelling	1072	4	00:14:24	05:06:00	01:31:48	T3	Yes
523	589218	741972	Dwelling	1081	9	00:39:36	00:54:00	14:40:12	T9	Yes
309	590070	743098	Dwelling	1090	16	00:30:36	05:18:00	08:47:24	T13	Yes

House ID	ITM (Easting)	ITM (Northing)	Description	Distance to Nearest Turbine (metres)	Nearest Proposed Turbine No.	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Proposed Turbine(s) Giving Rise to Daly Shadow Flicker Exceedance	Mitigation Strategy Required (Daily or Annual)?
545	588805	745431	Planning Permission	1096	15	00:37:48	23:36:00	07:04:48	T15, T16	Yes
587	591858	743064	Dwelling	1098	20	00:00:00	00:00:00	00:00:00	N/A	No
480	589986	743061	Dwelling	1099	16	00:32:24	13:42:00	11:18:36	T13	Yes
372	591246	745490	Dwelling	1106	19	00:34:48	16:18:00	12:05:24	T18	Yes
18	585221	746915	Dwelling	1111	5	00:30:00	18:18:00	12:41:24	T6, T7	Yes
289	589209	741889	Dwelling	1115	9	00:37:48	09:48:00	10:08:24	T9	Yes
222	588295	746712	Dwelling	1117	4	00:00:00	00:00:00	00:00:00	N/A	No
182	588770	747990	Dwelling	1119	4	00:35:24	20:24:00	06:07:12	T4	Yes
335	592273	743336	Dwelling	1120	20	00:00:00	00:00:00	00:00:00	N/A	No
288	589170	741819	Dwelling	1124	9	00:26:24	13:12:00	03:57:36	T9	Yes
290	589286	742005	Dwelling	1126	9	00:39:00	05:36:00	16:04:48	T9, T12	Yes
192	588468	746822	Dwelling	1134	4	00:00:00	00:00:00	00:00:00	N/A	No
520	587926	746547	Dwelling	1134	4	00:00:00	00:00:00	00:00:00	N/A	No
373	591247	745529	Dwelling	1144	19	00:33:36	13:48:00	11:20:24	T18	Yes
557	587835	746520	Derelict	1146	4	00:27:36	03:42:00	08:18:36	T7	No**
20	585344	746804	Dwelling	1156	5	00:32:24	09:36:00	10:04:48	T7	Yes
330	591718	742955	Dwelling	1157	20	00:00:00	00:00:00	00:00:00	N/A	No
500	592300	743309	Dwelling	1159	20	00:00:00	00:00:00	00:00:00	N/A	No
255	586406	743279	Dwelling	1160	8	00:34:12	09:18:00	09:59:24	T8, T10	Yes
152	592001	745179	Dwelling	1162	19	00:36:00	17:36:00	12:28:48	T19, T20	Yes
233	584932	748695	Dwelling	1187	5	00:35:24	02:24:00	15:07:12	T1, T5	Yes
6	586160	749538	Dwelling	1189	1	00:00:00	00:00:00	00:00:00	N/A	No
491	587968	741346	Dwelling	1190	9	00:00:00	00:00:00	00:00:00	N/A	No
68	587796	741403	Dwelling	1193	9	00:00:00	00:00:00	00:00:00	N/A	No

House ID	ITM (Easting)	ITM (Northing)	Description	Distance to Nearest Turbine (metres)	Nearest Proposed Turbine No.	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Proposed Turbine(s) Giving Rise to Daly Shadow Flicker Exceedance	Mitigation Strategy Required (Daily or Annual)?
153	592130	745079	Dwelling	1199	19	00:34:12	03:36:00	15:28:48	T19, T20	Yes
19	585266	746786	Dwelling	1204	5	00:30:36	03:54:00	08:22:12	T6, T7	Yes
552	591752	742914	Derelict	1206	20	00:00:00	00:00:00	00:00:00	N/A	No**
471	592082	745154	Dwelling	1207	19	00:34:12	20:12:00	13:15:36	T19, T20	Yes
266	586836	746232	Dwelling	1216	7	00:00:00	00:00:00	00:00:00	N/A	No
329	591686	742886	Dwelling	1217	20	00:00:00	00:00:00	00:00:00	N/A	No
345	592609	744387	Dwelling	1218	20	00:32:24	07:06:00	09:19:48	T19, T20	Yes
374	591224	745607	Dwelling	1221	19	00:31:12	06:36:00	09:10:48	T18	Yes
66	587696	741420	Dwelling	1221	9	00:00:00	00:00:00	00:00:00	N/A	No
434	586212	749587	Dwelling	1231	1	00:00:00	00:00:00	00:00:00	N/A	No
59	586442	743589	Dwelling	1231	8	00:33:00	09:06:00	09:55:48	T8, T10	Yes
513	585413	746695	Dwelling	1235	5	00:33:00	11:48:00	10:44:24	T7	Yes
223	588249	746551	Dwelling	1235	4	00:00:00	00:00:00	00:00:00	N/A	No
472	592173	745081	Dwelling	1236	19	00:33:00	03:42:00	15:30:36	T19, T20	Yes
346	592626	744406	Dwelling	1239	20	00:32:24	06:18:00	09:05:24	T19, T20	Yes
67	587773	741357	Dwelling	1244	9	00:00:00	00:00:00	00:00:00	N/A	No
514	585354	746704	Derelict	1245	5	00:31:48	13:42:00	11:18:36	T7	No**
375	591221	745634	Dwelling	1247	19	00:30:36	04:06:00	08:25:48	T18	Yes
477	591251	742837	Dwelling	1253	20	00:00:00	00:00:00	00:00:00	N/A	No
490	587808	741328	Dwelling	1257	9	00:00:00	00:00:00	00:00:00	N/A	No
70	587975	741268	Dwelling	1264	9	00:00:00	00:00:00	00:00:00	N/A	No
347	592645	744432	Dwelling	1265	20	00:31:48	05:18:00	08:47:24	T19, T20	Yes
479	590127	742928	Dwelling	1270	16	00:28:48	06:42:00	09:12:36	T13	Yes
483	589642	742753	Dwelling	1273	13	00:28:48	10:00:00	17:24:00	T9, T11, T12	Yes
318	589875	742860	Dwelling	1274	16	00:06:36	01:18:00	00:23:24	T13	Yes

House ID	ITM (Easting)	ITM (Northing)	Description	Distance to Nearest Turbine (metres)	Nearest Proposed Turbine No.	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Proposed Turbine(s) Giving Rise to Daly Shadow Flicker Exceedance	Mitigation Strategy Required (Daily or Annual)?
478	591169	742825	Dwelling	1278	20	00:00:00	00:00:00	00:00:00	N/A	No
308	590096	742905	Dwelling	1281	16	00:28:48	04:00:00	08:24:00	T13	Yes
291	589444	741974	Dwelling	1282	9	00:33:00	21:48:00	13:44:24	T9, T12	Yes
213	588950	747976	Dwelling	1288	4	00:31:12	15:06:00	04:31:48	T4	Yes
320	589570	742679	Dwelling	1290	13	00:30:36	12:00:00	18:00:00	T9, T11, T12	Yes
580	592693	744356	Dwelling	1292	20	00:30:36	04:00:00	08:24:00	T19, T20	Yes
245	584549	747493	Dwelling	1295	5	00:31:48	20:36:00	06:10:48	T5	Yes
225	587945	746385	Dwelling	1297	4	00:00:00	00:00:00	00:00:00	N/A	No
154	592323	745023	Dwelling	1300	20	00:33:00	06:00:00	16:12:00	T19, T20	Yes
550	586794	744337	Dwelling	1301	10	00:31:48	19:48:00	05:56:24	T10	Yes
244	584534	747509	Dwelling	1305	5	00:31:48	19:54:00	05:58:12	T5	Yes
489	587602	741377	Dwelling	1305	9	00:00:00	00:00:00	00:00:00	N/A	No
155	592355	745019	Dwelling	1320	20	00:32:24	04:54:00	15:52:12	T19, T20	Yes
326	591149	742782	Dwelling	1324	20	00:00:00	00:00:00	00:00:00	N/A	No
243	584518	747482	Dwelling	1328	5	00:31:12	19:36:00	05:52:48	T5	Yes
579	590133	742867	Planning Permission	1329	16	00:28:12	02:12:00	07:51:36	T13	Yes
376	591205	745718	Dwelling	1331	19	00:28:48	19:30:00	05:51:00	T18	Yes
5	586693	749654	Dwelling	1333	1	00:00:00	00:00:00	00:00:00	N/A	No
156	592387	745016	Dwelling	1341	20	00:31:48	02:18:00	15:05:24	T19, T20	Yes
47	586941	744591	Dwelling	1344	10	00:31:48	11:36:00	10:40:48	T10	Yes
371	592188	745252	Dwelling	1350	19	00:31:12	14:06:00	11:25:48	T19, T20	Yes
377	591202	745745	Dwelling	1354	18	00:28:12	17:24:00	05:13:12	T18	Yes
348	592720	744512	Dwelling	1360	20	00:29:24	02:18:00	07:53:24	T19, T20	Yes
69	587863	741194	Dwelling	1365	9	00:00:00	00:00:00	00:00:00	N/A	No

House ID	ITM (Easting)	ITM (Northing)	Description	Distance to Nearest Turbine (metres)	Nearest Proposed Turbine No.	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Proposed Turbine(s) Giving Rise to Daly Shadow Flicker Exceedance	Mitigation Strategy Required (Daily or Annual)?
370	592184	745282	Dwelling	1367	19	00:30:36	11:30:00	10:39:00	T19, T20	Yes
190	588992	747200	Dwelling	1369	4	00:30:36	17:30:00	05:15:00	T4	Yes
521	588224	746389	Dwelling	1373	4	00:00:00	00:00:00	00:00:00	N/A	No
48	586832	744515	Dwelling	1374	10	00:30:36	22:54:00	06:52:12	T10	Yes
578	586864	744552	Dwelling	1374	10	00:30:36	01:42:00	07:42:36	T10	Yes
71	588027	741137	Dwelling	1381	9	00:00:00	00:00:00	00:00:00	N/A	No
473	592392	745071	Dwelling	1383	20	00:31:12	02:24:00	15:07:12	T19, T20	Yes
319	589770	742708	Dwelling	1392	13	00:27:00	23:00:00	06:54:00	T9, T12	Yes
445	588850	746871	Dwelling	1392	4	00:31:12	06:30:00	09:09:00	T4	Yes
443	589028	748090	Derelict	1395	4	00:28:48	13:06:00	03:55:48	T4	No**
72	588048	741119	Dwelling	1395	9	00:00:00	00:00:00	00:00:00	N/A	No
353	592798	744364	Dwelling	1396	20	00:28:48	13:54:00	04:10:12	T20	Yes
328	591664	742700	Dwelling	1396	20	00:00:00	00:00:00	00:00:00	N/A	No
307	590264	742827	Dwelling	1399	17	00:00:00	00:00:00	00:00:00	N/A	No
242	584462	747421	Dwelling	1399	5	00:30:00	18:30:00	05:33:00	T5	Yes
446	589068	747354	Dwelling	1400	4	00:29:24	14:42:00	04:24:36	T4	Yes
73	588070	741099	Dwelling	1412	9	00:00:00	00:00:00	00:00:00	N/A	No
189	589086	747377	Dwelling	1413	4	00:28:48	13:48:00	04:08:24	T4	Yes
101	586275	746015	Dwelling	1414	7	00:00:00	00:00:00	00:00:00	N/A	No
46	586868	744622	Dwelling	1419	10	00:30:00	07:54:00	09:34:12	T10	Yes
331	592058	742799	Dwelling	1423	20	00:00:00	00:00:00	00:00:00	N/A	No
187	589125	747602	Dwelling	1424	4	00:28:12	12:24:00	03:43:12	T4	Yes
102	586385	745989	Dwelling	1424	7	00:00:00	00:00:00	00:00:00	N/A	No
476	591632	742665	Derelict	1425	20	00:00:00	00:00:00	00:00:00	N/A	No**
105	586640	745986	Dwelling	1426	7	00:00:00	00:00:00	00:00:00	N/A	No

House ID	ITM (Easting)	ITM (Northing)	Description	Distance to Nearest Turbine (metres)	Nearest Proposed Turbine No.	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Proposed Turbine(s) Giving Rise to Daly Shadow Flicker Exceedance	Mitigation Strategy Required (Daily or Annual)?
292	589590	741937	Dwelling	1430	9	00:29:24	21:48:00	06:32:24	T9	Yes
74	588097	741076	Dwelling	1431	9	00:00:00	00:00:00	00:00:00	N/A	No
104	586610	745978	Dwelling	1431	7	00:00:00	00:00:00	00:00:00	N/A	No
352	592839	744339	Dwelling	1432	20	00:28:12	13:18:00	03:59:24	T20	Yes
165	586079	749772	Dwelling	1434	1	00:00:00	00:00:00	00:00:00	N/A	No
351	592833	744395	Dwelling	1437	20	00:28:12	13:06:00	03:55:48	T20	Yes
306	590232	742785	Dwelling	1440	16	00:00:00	00:00:00	00:00:00	N/A	No
183	589127	747873	Dwelling	1442	4	00:28:12	11:42:00	03:30:36	T4	Yes
241	584394	747470	Dwelling	1450	5	00:28:48	16:00:00	04:48:00	T5	Yes
518	588461	745623	Dwelling	1450	15	00:28:12	22:36:00	06:46:48	T15	Yes
106	586675	745964	Dwelling	1451	7	00:00:00	00:00:00	00:00:00	N/A	No
188	589149	747548	Dwelling	1452	4	00:28:12	12:12:00	03:39:36	T4	Yes
58	586361	743878	Dwelling	1452	8	00:28:48	05:36:00	08:52:48	T8, T10	Yes
4	586269	749824	Dwelling	1462	1	00:00:00	00:00:00	00:00:00	N/A	No
122	588439	745623	Dwelling	1465	15	00:28:12	23:30:00	07:03:00	T15	Yes
305	590251	742760	Dwelling	1467	17	00:00:00	00:00:00	00:00:00	N/A	No
350	592861	744432	Dwelling	1473	20	00:27:36	12:42:00	03:48:36	T20	Yes
57	586347	743903	Dwelling	1478	8	00:28:48	05:06:00	08:43:48	T8, T10	Yes
516	586060	746002	Dwelling	1479	7	00:00:00	00:00:00	00:00:00	N/A	No
304	590363	742730	Dwelling	1481	17	00:00:00	00:00:00	00:00:00	N/A	No
303	590429	742723	Dwelling	1482	17	00:00:00	00:00:00	00:00:00	N/A	No
254	586063	743205	Dwelling	1486	8	00:27:00	12:12:00	03:39:36	T8	Yes
76	588258	741009	Dwelling	1487	9	00:00:00	00:00:00	00:00:00	N/A	No
166	585873	749772	Dwelling	1488	1	00:00:00	00:00:00	00:00:00	N/A	No
224	588186	746250	Dwelling	1489	4	00:00:00	00:00:00	00:00:00	N/A	No

House ID	ITM (Easting)	ITM (Northing)	Description	Distance to Nearest Turbine (metres)	Nearest Proposed Turbine No.	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Proposed Turbine(s) Giving Rise to Daly Shadow Flicker Exceedance	Mitigation Strategy Required (Daily or Annual)?
551	592526	743060	Derelict	1493	20	00:00:00	00:00:00	00:00:00	N/A	No**
55	586292	743863	Dwelling	1500	8	00:28:12	02:48:00	08:02:24	T8, T10	Yes
56	586338	743930	Dwelling	1502	8	00:28:12	05:00:00	08:42:00	T8, T10	Yes
75	588190	740993	Dwelling	1506	9	00:00:00	00:00:00	00:00:00	N/A	No
234	584653	748863	Dwelling	1507	5	00:28:48	22:12:00	06:39:36	T5	Yes
79	588520	741009	Dwelling	1508	9	00:00:00	00:00:00	00:00:00	N/A	No
439	589028	748376	Dwelling	1509	4	00:27:36	13:12:00	03:57:36	T4	Yes
107	586882	745942	Dwelling	1509	7	00:00:00	00:00:00	00:00:00	N/A	No
100	586151	745935	Dwelling	1518	7	00:00:00	00:00:00	00:00:00	N/A	No
103	586495	745889	Dwelling	1518	7	00:00:00	00:00:00	00:00:00	N/A	No
77	588293	740975	Dwelling	1521	9	00:00:00	00:00:00	00:00:00	N/A	No
54	586282	743889	Dwelling	1523	8	00:27:36	16:00:00	04:48:00	T8	Yes
21	585557	746224	Derelict	1527	7	00:00:00	00:00:00	00:00:00	N/A	No**
108	586935	745935	Dwelling	1528	7	00:00:00	00:00:00	00:00:00	N/A	No
515	586006	745966	Dwelling	1531	7	00:00:00	00:00:00	00:00:00	N/A	No
349	592883	744595	Dwelling	1541	20	00:26:24	12:12:00	03:39:36	T20	Yes
574	584635	748901	Dwelling	1545	5	00:28:12	22:42:00	06:48:36	T5	Yes
97	585784	746044	Dwelling	1550	7	00:00:00	00:00:00	00:00:00	N/A	No
301	590572	742653	Dwelling	1550	17	00:00:00	00:00:00	00:00:00	N/A	No
53	586270	743921	Dwelling	1551	8	00:27:00	16:00:00	04:48:00	T8	Yes
484	588332	740945	Dwelling	1552	9	00:00:00	00:00:00	00:00:00	N/A	No
49	586526	744390	Dwelling	1560	10	00:26:24	13:24:00	04:01:12	T10	Yes
99	585881	745983	Dwelling	1562	7	00:00:00	00:00:00	00:00:00	N/A	No
118	588402	745721	Dwelling	1565	15	00:27:00	17:48:00	05:20:24	T15	Yes
440	589040	748471	Dwelling	1566	4	00:27:00	13:18:00	03:59:24	T4	Yes

House ID	ITM (Easting)	ITM (Northing)	Description	Distance to Nearest Turbine (metres)	Nearest Proposed Turbine No.	Max. Daily Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker: Pre-Mitigation (hrs:min:sec)	Max. Annual Shadow Flicker Adjusted for Average Regional Sunshine (hrs:min:sec)	Proposed Turbine(s) Giving Rise to Daly Shadow Flicker Exceedance	Mitigation Strategy Required (Daily or Annual)?
442	589166	748217	Derelict	1567	4	00:26:24	10:42:00	03:12:36	T4	No**
302	590397	742638	Dwelling	1569	17	00:00:00	00:00:00	00:00:00	N/A	No
22	585552	746174	Dwelling	1570	7	00:00:00	00:00:00	00:00:00	N/A	No
561	584625	748932	Dwelling	1574	5	00:27:36	00:06:00	07:13:48	T5	Yes
280	587525	741107	Dwelling	1578	9	00:00:00	00:00:00	00:00:00	N/A	No
50	586458	744295	Dwelling	1578	10	00:26:24	12:18:00	03:41:24	T10	Yes
52	586258	743953	Dwelling	1580	8	00:27:00	15:48:00	04:44:24	T8	Yes
120	588527	745832	Dwelling	1584	15	00:00:00	00:00:00	00:00:00	N/A	No
540	592947	744558	Derelict	1590	20	00:25:48	11:18:00	03:23:24	T20	No**
121	588545	745852	Dwelling	1591	15	00:00:00	00:00:00	00:00:00	N/A	No
98	585791	745985	Dwelling	1599	7	00:00:00	00:00:00	00:00:00	N/A	No
184	589303	747620	Dwelling	1602	4	00:25:12	09:18:00	02:47:24	T4	Yes
240	584248	747418	Dwelling	1604	5	00:25:48	13:06:00	03:55:48	T5	Yes
293	589771	741921	Dwelling	1605	9	00:26:24	15:36:00	04:40:48	T9	Yes
158	592760	744982	Dwelling	1608	20	00:26:24	14:36:00	04:22:48	T20	Yes
78	588306	740882	Dwelling	1614	9	00:00:00	00:00:00	00:00:00	N/A	No
441	589068	748521	Dwelling	1616	4	00:25:48	12:54:00	03:52:12	T4	Yes

* Participating Properties/Landowners will not require mitigation for shadow flicker events.
** Derelict properties will not require mitigation for shadow flicker events.
*** This dwelling is currently occupied and owned by a participating landowner. However, during the construction and operation of the Proposed Development this property will act as a site office and therefore will not require mitigation for shadow flicker events.

There are 296 No. properties located within 1.62 kilometres (i.e., the shadow flicker study area of ten times the rotor diameter; 10x162 = 1,620m) of the proposed turbines, of which 278 are dwellings, 15 are in a derelict condition and the remaining 3 No. properties are planning permissions.

The developer has adopted the current 2019 Draft Wind Energy Guidelines (DoEHLG) recommendation that no Shadow Flicker exceedance will occur at any property as a result of the Proposed Development.

Of the 296 No. properties modelled:

- 15 are in a derelict condition and;
- 8 are participating properties;

These properties will not require mitigation measures as a result.

Daily Shadow Flicker

From the remaining 273 No. properties, it is predicted that 194 of these may experience daily shadow flicker occurrences. This prediction is assuming worst-case conditions (i.e., 100% sunshine on all days where the shadow of the turbines passes over a house, wind blowing in the correct direction, no screening present, etc.) and in the absence of any turbine control measures.

Of these 194 No. properties:

- 191 No. properties are inhabitable dwellings; and
- 3 No. properties are planning permissions

Annual Shadow Flicker

Of the 273 no. properties modelled, when the regional sunshine average (i.e., the mean number of sunshine hours throughout the year) of 30% is taken into account, it is also anticipated that 194 of these may experience annual; shadow flicker occurrences. The 194 properties which are predicted to experience daily shadow flicker are the same properties which are anticipated to experience annual shadow flicker occurrences.

The predicted shadow flicker listed in Table 5-9 is considered conservative and the occurrence and/or duration of shadow flicker at these properties is likely to be eliminated or significantly reduced as the following items are not considered by the model:

- Receivers may be screened by topography, cloud cover and/or vegetation/built form i.e., adjacent buildings, farm buildings, garages or barns;
- Each receiver will not have windows facing in all directions onto the wind farm.
- At distances, greater than 500-1000m '*the rotor blade of a wind turbine will not appear to be chopping the light but the turbine will be regarded as an object with the sun behind it. Therefore, it is generally not necessary to consider shadow casting at such distances*' (Danish Wind Industry Association, accessed 2010).

Section 5.9.3.4 below outlines the mitigation strategies which may be employed at the potentially affected properties to ensure that the current Draft Revised Wind Energy Development Guidelines (2019) are complied with at any dwelling within the 1.62km study area. Therefore, the developer will commit to mitigation measures that will ensure that there are no occurrences of shadow flicker for any property within the 1.62km study area, as a result of the Proposed Development.

5.7.5.2 Cumulative Shadow Flicker

The cumulative assessment of shadow flicker arising from the Proposed Development and other wind farms was carried out based on the methodology, assumptions and criteria outlined in Section 5.7.3 and Section 5.7.4. For the assessment of cumulative shadow flicker, any other existing, permitted or proposed wind farms are considered where they are located within the shadow flicker study area of ten times the rotor diameter. In this case, the closest wind farm is the existing Skrine Wind Farm located 8.5km north of the Proposed Development at its closest point. At this distance, properties considered within the Skrine Wind Farm shadow flicker study area are excluded from the Proposed Developments study area and therefore are beyond the range for potential cumulative shadow flicker impacts. Therefore, there is no potential for shadow flicker in combination with the Proposed Development and therefore no cumulative shadow flicker assessment is required.

5.8 Residential Amenity

Residential amenity relates to the human experience of one's home, derived from the general environment and atmosphere associated with the residence. The quality of residential amenity is influenced by a combination of factors, including site setting and local character, land-use activities in the area and the relative degree of peace and tranquillity experienced in the residence.

As noted previously, the current land-use for Proposed Development site is small-scale agricultural practices, predominantly livestock grazing, pasture and sileage. The closest occupied dwelling to the Proposed Development is located approximately 347m from the closest turbine (Turbine No. 4). However, this property is owned by a participating landowner and an agreement has been reached that the dwelling will be leased by the developer throughout the duration of operation for the Proposed Development, to be used as a site office. The closest third-party property is located approximately 724m from the nearest proposed turbine location (T8). In addition, an assessment of roadside screening was also carried out for roads within 5km of the proposed turbine locations, with both the methodology and findings of this are described in Chapter 12.

When considering the amenity of residents in the context of a proposed wind farm, there are four main potential impacts of relevance: 1) Shadow Flicker, 2) Noise, 3) Visual Amenity and 4) Telecommunications. Shadow flicker and noise are quantifiable aspects of residential amenity while visual amenity is more subjective. Detailed shadow flicker and noise modelling have been completed as part of this EIAR (Section 5.7 above refers to shadow flicker modelling, Chapter 11 addresses noise). A comprehensive landscape and visual impact assessment have also been carried out, as presented in Chapter 12 of this EIAR. Impacts on human beings during the construction, operational and decommissioning phases of the Proposed Development is assessed in relation to each of these key issues and other environmental factors such as noise, traffic and dust; see Impacts in Section 5.9 below. The impact on residential amenity is then derived from an overall judgement of the combination of impacts due to shadow flicker, changes to land-use and visual amenity, noise, traffic, dust and general disturbance.

5.9 Likely Significant Impacts and Associated Mitigation Measures

5.9.1 'Do-Nothing' Scenario

If the Proposed Development were not to proceed, the existing uses for the site of small-scale agricultural farming practices, would continue.

If the Proposed Development were not to proceed, the opportunity to capture a significant part of County Roscommon's and Ireland's valuable renewable energy resource would be lost, as would the opportunity to contribute to meeting Government and EU targets for the production and consumption of electricity from renewable resources and the reduction of greenhouse gas emissions.

The opportunity to generate local employment and investment would also be lost, and the local economy would continue to rely primarily on small-scale agriculture as the main source of income. It is likely that the trends of population decline and rural deprivation that have been recorded within the Study Area would continue in the absence of investment.

5.9.2 Construction Phase

5.9.2.1 Health and Safety

Pre-Mitigation Impacts

Construction of the Proposed Development will necessitate the presence of a construction site. Construction sites and the machinery used on them pose a potential health and safety hazard to construction workers if site rules are not properly implemented. This will have a short-term potential significant negative impact.

Proposed Mitigation Measures

The Proposed Development will be constructed, operated and decommissioned in accordance with all relevant Health and Safety Legislation, including:

- Safety, Health and Welfare at Work Act 2005 (No. 10 of 2005);
- Safety, Health and Welfare at Work (General Application) Regulations 2007 (S.I. No. 299 of 2007), as amended;
- Safety, Health and Welfare at Work (Construction) Regulations 2013 (S.I. 291 of 2013), as amended; and
- Safety, Health and Welfare at Work (Work at Height) Regulations 2006 (S.I. No. 318 of 2006).

During construction of the Proposed Development, all staff will be made aware of and adhere to the Health & Safety Authority's '*Guidelines on the Procurement, Design and Management Requirements of the Safety, Health and Welfare at Work (Construction) Regulations 2006'.* This will encompass the use of all necessary Personal Protective Equipment, Risk Assessment and Method Statements and adherence to the site Health and Safety Plan.

Fencing will be erected in areas of the site where uncontrolled access is not permitted. Appropriate health and safety signage will also be erected on this fencing and at locations around the site.

The proposed on-site substation will be a live node on the national electricity grid, once constructed and connected to the existing110kV Monksland Substation approximately 11km to the east. It is intended that the Proposed Development will connect via an underground connection between the on-site substation and existing 110kV Monksland Substation. Health and safety guidelines for working within and around electrical substations and underground cables will be adhered to on site.

Residual Impact

With the implementation of the above, there will be a short-term potential slight negative residual impact on health and safety during the construction phase of the Proposed Development.

Significance of Effects

Based on the assessment above there will be no significant direct and indirect effects on health and safety during the construction phase of the Proposed Development.

5.9.2.2 Employment and Investment

The design, construction and operation of the Wind Farm will provide employment for technical consultants, contractors and maintenance staff. Up to approximately 100 jobs could be created during the construction, operation and maintenance phases of the Proposed Development. The construction phase of the wind farm will last between approximately between 18-24 months. Most construction workers and materials will be sourced locally, thereby helping to sustain employment in the construction trade. This will have a short-term significant positive impact.

The injection of money in the form of salaries and wages to those employed during the construction phase of the project has the potential to result in an increase in household spending and demand for goods and services in the local area. This would result in local retailers and businesses experiencing a short-term positive impact on their cash flow. This will have a short-term slight positive indirect impact.

The Proposed Development will result in an influx of skilled people into the area, bringing specialist skills for both the construction and operational phases that could result in the transfer of these skills into the local workforce, thereby having a long-term positive impact on the local skills base. Up-skilling and training of local staff in the particular requirements of the wind energy industry is likely to lead to additional opportunities for those staff as additional wind farms are constructed in Ireland. This will have a long-term moderate positive indirect impact. According to Wind Energy Ireland there are over 5,130 jobs related to onshore wind energy in Ireland in 2021, a figure which is projected to grow to 6,900 by 2030.

Rates payments for the Wind Farm will contribute significant funds to Roscommon County Council, which will be redirected to the provision of public services within Co. Roscommon. These services include provisions such as road upkeep, fire services, environmental protection, street lighting, footpath maintenance etc. along with other community and cultural support initiatives.

Proposed Community Benefit Scheme

The applicant company has given careful consideration to the issue of community gain arising from the Proposed Development, if permitted and constructed. Community gain from significant development proposals, including wind farms, whilst a relatively recent approach, is now a common consideration for developers and, indeed, planning authorities. This approach recognises that, with any significant wind farm proposal, the locality in which the site is situated is making a significant contribution towards helping achieve national renewable energy and climate change targets, and the local community should derive some benefit from accommodating such a development in their locality.

Community gain proposals can take a number of forms, generally depending on the nature and location of the Proposed Development and the nature and make-up of the local community. In some instances, funds are paid by the developer, either annually or as a one-off payment, to a community fund that is administered by a voluntary committee. These funds may then be used for a variety of projects, such as environmental improvements, local amenities and facilities, voluntary and sporting groups and clubs, educational projects and energy efficiency improvement works.

The community gain proposal for the Proposed Development is to contribute to community benefit scheme to support local environmental improvements and recreational, social or community amenities and initiatives in the locality of the Proposed Development.

The community benefit scheme proposes to provide a fund of €300,000 per annum over the 30 year lifespan of the Proposed Development based on the current estimated generating capacity. This will equate to potential funding of €9 million to the local community which is a substantial contribution.

The number and size of grant allocations will be decided by a Community Fund liaison committee with various groups and project benefiting to varying degrees depending on their funding requirement.

Overall, it is concluded that the socio-economic impacts of the Proposed Development will be beneficial on a local, regional and national level.

5.9.2.3 Population

Those working on the construction phase of the Proposed Development will travel daily to the site from the wider area. The construction phase will have no impact on the population of the area in terms of changes to population trends or density, household size or age structure.

5.9.2.4 Land-use

The existing land-use of small-scale agriculture and farming practices will continue on the site in conjunction with the Proposed Development. The Proposed Development will have no impact on existing land-uses as it has been designed to co-exist with these land-uses. Whilst there will be a small change of land use to facilitate the Proposed Development, the impact will be minimised due to the comparatively small development footprint associated with the Proposed Development.

5.9.2.5 Tourism and Amenity

Given that there are currently no tourism attractions specifically pertaining to the site there are no impacts associated with the construction phase of the development. With regard to tourist attractions and amenity use around the site, described in Section 5.3.2, traffic management safety measures will be in place. Please see Traffic impacts below for further details on proposed mitigation measures.

5.9.2.6 Noise

Pre-Mitigation Impacts

There will be an increase in noise levels in the vicinity of the Proposed Development site during the construction phase, as a result of heavy machinery and construction work which has the potential to cause a nuisance to sensitive receptors located closest the Proposed Development site. These impacts will be short-term in duration. The noisiest construction activities associated with wind farm development are excavation and pouring of the turbine bases. Excavation of a base can typically be completed in one to two days however, and the main concrete pours are usually conducted in one continuous pour, which is done within a matter of hours.

Construction noise at any given noise sensitive location will be variable throughout the construction project, depending on the activities underway and the distance from the main construction activities to the receiving properties. The potential noise impacts that will occur during the construction phase of the Proposed Development are further described in Chapter 11: Noise and Vibration.

Proposed Mitigation Measures

Best practice measures for noise control will be adhered to onsite during the construction phase of the Proposed Development in order to mitigate the slight short-term negative impact associated with this phase of the development. These measures will include:

- No plant used on site will be permitted to cause an on-going public nuisance due to noise.
- The best means practicable, including proper maintenance of plant, will be employed to minimise the noise produced by on site operations.
- All vehicles and mechanical plant will be fitted with effective exhaust silencers and maintained in good working order for the duration of the contract.
- Compressors will be attenuated models fitted with properly lined and sealed acoustic covers which will be kept closed whenever the machines are in use and all ancillary pneumatic tools shall be fitted with suitable silencers.

- Machinery that is used intermittently will be shut down or throttled back to a minimum during periods when not in use.
- Any plant, such as generators or pumps, which is required to operate outside of general construction hours will be surrounded by an acoustic enclosure or portable screen.
- During the course of the construction programme, supervision of the works will include ensuring compliance with the limits detailed in Chapter 11 using methods outlined in British Standard BS 5228-1:2014+A1:2019 Code of practice for noise and vibration control on construction and open sites – Noise.
- The hours of construction activity will be limited to avoid unsociable hours where possible. Construction operations shall generally be restricted to between 7:00hrs and 19:00hrs Monday to Saturday. However, to ensure that optimal use is made of good weather periods or at critical periods within the programme (i.e. concrete pours, large turbine component delivery, rotor/blade lifting) it could occasionally be necessary to work out of these hours

Where rock breaking is employed in relation to the Proposed Development, the following are examples of measures that will be employed, where necessary, to mitigate noise emissions from these activities:

- Fit suitably designed muffler or sound reduction equipment to the rock breaking tool to reduce noise without impairing machine efficiency.
- Ensure all leaks in air lines are sealed.
- Use a dampened bit to eliminate ringing.
- Erect acoustic screen between compressor or generator and noise sensitive area. When possible, line of sight between top of machine and reception point needs to be obscured.
- Enclose breaker or rock drill in portable or fixed acoustic enclosure with suitable ventilation.

Residual Impact

Following the implementation of the above mitigation measures, there will be a short-term imperceptible negative residual impact due to an increase in noise levels during the construction phase of the Proposed Development.

Significance of Effects

Based on the assessment above there will be no significant direct or indirect effects.

5.9.2.7 Dust

Pre-Mitigation Impacts

Potential dust emission sources during the construction phase of the Proposed Development include construction of new access roads and upgrading of existing access tracks, and excavation and construction of turbine foundations and substation. An increase in dust emissions has the potential to cause a nuisance to sensitive receptors in the immediate vicinity of the site. The entry and exit of construction vehicles from the site may result in the transfer of mud to the public road, particularly if the weather is wet. This may cause nuisance to residents and other road users. These impacts will not be significant and will be relatively short-term in duration. The potential dust impacts that may occur during the construction phase of the Proposed Development are further described in Chapter 10: Air and Climate.

Proposed Mitigation Measures

As discussed in Section 4.3.3 of Chapter 4, aggregate material for the construction of roads, substation and turbine hardstanding areas may need to be imported from nearby quarries, should sufficient material not be obtained during excavation works for the Proposed Development. The quarries that could potentially provide stone and concrete for the Proposed Development are listed in Section 4.3.3 of Chapter 4. Truck wheels will be washed to remove mud and dirt before leaving the site. All plant and materials vehicles shall be stored in the dedicated compound area. Areas of excavation will be kept to a minimum, and stockpiling will be minimised by coordinating excavation, spreading and compaction. Construction traffic will be restricted to defined routes and a speed limit will be implemented.

In periods of extended dry weather, dust suppression may be necessary along haul roads to ensure dust does not cause a nuisance. If necessary, water will be taken from the site's drainage system, and will be pumped into a bowser or water spreader to dampen down haul roads and the temporary site compound to prevent the generation of dust. Silty or oily water will not be used for dust suppression, because this would transfer the pollutants to the haul roads and generate polluted runoff or more dust. Water bowser movements will be carefully monitored, as the application of too much water may lead to increased runoff.

Residual Impact

Following the implementation of the above mitigation measures, there will be a short-term slight negative impact due to dust emissions from the construction of the Proposed Development.

Significance of Effects

Based on the assessment above there will be no significant direct or indirect effects.

5.9.2.8 Traffic

Pre-Mitigation Impacts

The construction phase of the Proposed Development will last for approximately 18-24 months. Turbines will be delivered to the site of the Proposed Development via, three newly proposed access roads along the R363 Regional Road in the townlands of Cam, Cuilleenoolagh and Bredah, in Co. Roscommon. Both turbine and non-turbine construction traffic will access the site via the above access roads. The proposed access junction locations and turbine delivery route is shown in Figures 4-19 and 4-23 in Chapter 4 respectively.

Non-turbine construction traffic will be comprised of Heavy Goods Vehicle (HGV) and Light Goods Vehicle (LGV) movements involved in the delivery of construction materials to the site and the export of excess construction materials and plant from the site. A complete Traffic and Transportation Assessment (TTA) of the Proposed Development has been carried out by Galetech Energy Services (GES). The full results of the TTA are presented in Section 14.1 of Chapter 14: Material Assets.

The types of vehicles that will be required to negotiate the local network represent abnormal size loads and a detailed assessment of the geometry of the proposed route was therefore undertaken. This will have a temporary slight to moderate negative impact on existing road users, which will be minimised with the implementation of the mitigation measures included in the proposed traffic management plan.

Proposed Mitigation Measures

A Traffic Management Plan will be developed and implemented to ensure any impact is short term in duration and slight in significance during the construction of the Proposed Development. Prior to commencement of any works, the occupants of dwellings in the vicinity of the proposed works will be contacted and the scheduling of works will be made clear. Although all works within the site will have little impact to locals, access to properties will be maintained throughout any construction works and local residents will also be supplied with the number of the works supervisor in order to ensure that disruption will be kept to a minimum. Deliveries of concrete and aggregate materials will occur early in the morning to reduce impact to road users. Furthermore, these deliveries will be sourced from local quarries which will reduce the distance of these deliveries, thereby reducing the impact to traffic and transport in the wider area.

Residual Impact

Once a traffic management plan is implemented for the construction phase of the Proposed Development, there will be a short-term imperceptible negative residual impact on local road users.

Significance of Effects

Based on the assessment above there will be no significant direct or indirect effects.

5.9.2.9 Shadow Flicker

Shadow flicker, which occurs during certain conditions due to the movement of wind turbine blades, as described in Section 5.7 of this chapter, occurs only during the operational phase of a wind energy development. There are therefore no shadow flicker impacts associated with the construction phase of the Proposed Development.

5.9.3 Operational Phase

The effects set out below relate to the operational phase of the Proposed Development including the period when turbines are being commissioned.

5.9.3.1 Health and Safety

Pre-Mitigation Impact

The operational phase of the Proposed Development poses little threat to the health and safety of the public. The Department of the Environment, Heritage and Local Government (DoEHLG)'s '*Wind Energy Development Guidelines for Planning Authorities 2006'* state that there are no specific safety considerations in relation to the operation of wind turbines. Fencing or other restrictions are not necessary for safety considerations. People or animals can safely walk up to the base of the turbines.

The DoEHLG Guidelines state that there is a very remote possibility of injury to people from flying fragments of ice or from a damaged blade. However, most blades are composite structures with no bolts or separate components and the danger is therefore minimised. The build-up of ice on turbines is unlikely to present problems. The wind turbines will be fitted with anti-vibration sensors, which will detect any imbalance caused by icing of the blades. The sensors will cause the turbine to wait until the blades have been de-iced prior to beginning operation.

The turbine blades are typically manufactured of wood and laminated layers of glass fibre which will prevent any likelihood of an increase in lightning strikes within the site of the Proposed Development or the local area. Lightning protection conduits will be integral to the construction of the turbines.

Lightning conduction cables, encased in protection conduits, will follow the electrical cable run, from the nacelle to the base of the turbine. The conduction cables will be earthed adjacent to the turbine base. The earthing system will be installed during the construction of the turbine foundations. There will be no impact on health and safety.

It is not anticipated that the operation of the Wind Farm will present a danger to the public and livestock. Rigorous safety checks are conducted on the turbines during design, construction, commissioning and operation to ensure the risks posed to staff, landowners and general public are negligible.

Proposed Mitigation Measures

Notwithstanding the above, the following mitigation measures will be implemented during the operation of the Proposed Development to ensure that ensure the risks posed to staff and landowners remain negligible throughout the operational life of the Wind Farm.

Access to the turbines is through a door at the base of the structure, which will be locked at all times outside maintenance visits.

Staff associated with the project will conduct frequent visits, which will include inspections to establish whether any signs have been defaced, removed or are becoming hidden by vegetation or foliage, with prompt action taken as necessary.

Signs will also be erected at suitable locations across the site as required for the ease and safety of operation of the Wind Farm. These signs include:

- Buried cable route markers at 50m (maximum) intervals and change of cable route direction;
- Directions to relevant turbines at junctions;
- “No access to Unauthorised Personnel” at appropriate locations;
- Speed limits signs at site entrance and junctions;
- “Warning these Premises are alarmed” at appropriate locations;
- “Danger HV” at appropriate locations;
- “Warning – Keep clear of structures during electrical storms, high winds or ice conditions” at site entrance;
- “No unauthorised vehicles beyond this point” at specific site entrances; and
- Other operational signage required as per site-specific hazards.

An operational phase Health and Safety Plan will be developed to fully address identified Health and Safety issues associated with the operation of the site, providing access for emergency services at all times.

The components of a wind turbine are designed to last up to 30 years and are equipped with a number of safety devices to ensure safe operation during their lifetime. During the operation of the Wind Farm regular maintenance of the turbines will be carried out by the turbine manufacturer or appointed service company. A project or task specific Health and Safety Plan will be developed for these works in accordance with the site’s health and safety requirements.

Residual Impact

With the implementation of the above mitigation measures, there will be a long-term, imperceptible residual impact on health and safety during the operational life of the Proposed Development.

Significance of Effects

Based on the assessment above there will be no significant direct or indirect effects.

5.9.3.2 Employment and Investment

The operational phase will present an opportunity for mechanical-electrical contractors and craftspeople to become involved with the maintenance and operation of the Wind Farm. On a long-term scale, the Proposed Development will create approximately 2 jobs during the operational phase relating to the maintenance and control of the Wind Farm, having a long-term slight positive effect.

5.9.3.3 Tourism

Pre-Mitigation Impacts

Given that there are currently no tourism attractions or amenity walkways located within the site there are no impacts associated with the operational phase of the development. The Department of the Environment, Heritage and Local Government's *Wind Energy Development Guidelines for Planning Authorities* 2006 state that "*the results of survey work indicate that tourism and wind energy can co-exist happily*". It is not considered that the Proposed Development would have an adverse impact on tourism infrastructure in the vicinity. Renewable energy developments are an existing feature in the surrounding landscape, which will assist in the assimilation of the Proposed Development into this environment.

5.9.3.4 Shadow Flicker

Pre-Mitigation Impacts

Assuming worst-case conditions, a total of 194 properties may experience daily and/or annual shadow flicker occurrences and would therefore require mitigation to reduce this to zero, as per the 2019 Draft Wind Energy Guidelines (DoEHLG). These mitigation measures are outlined below. There will be no perceived shadow flicker impacts on derelict properties and therefore, they are not subject to mitigation strategies.

Proposed Mitigation Measures

Where daily or annual shadow flicker exceedances are experienced at buildings, a site visit will be undertaken firstly to determine the existing screening and window orientation. This will determine if the receptor has an actual line of sight to any turbine. Once this is completed and all of the potential receptors identified, the following measures will be employed,

Screening Measures

In the event of an occurrence of shadow flicker at residential receptor locations, mitigation options will be discussed with the affected homeowner, including:

- Installation of appropriate window blinds in the affected rooms of the residence;
- Planting of screening vegetation;
- Other site-specific measures which might be agreeable to the affected party and may lead to the desired mitigation.

If agreement can be reached with the homeowner, then it would be arranged for the required mitigation to be implemented in cooperation with the affected party as soon as practically possible and for the full costs to be borne by the Wind Farm operator.

Wind Turbine Control Measures

If, due to unforeseen circumstances, it is not possible to mitigate any identified shadow flicker limit exceedance locally using the measures detailed above, wind turbine control measures will be implemented.

Wind turbines can be fitted with shadow flicker control units to allow the turbines to be controlled to prevent the occurrence of shadow flicker at properties surrounding the Wind Farm. The shadow flicker control units will be added to any required turbines.

A shadow flicker control unit allows a wind turbine to be programmed and controlled using the Wind Farm's Supervisory Control And Data Acquisition (SCADA) control system to change a particular turbine's operating mode during certain conditions or times, or even turn the turbine off if necessary.

All predicted incidents of shadow flicker can be pre-programmed into the Wind Farm's control software. The Wind Farm's SCADA control system can be programmed to shut down any particular turbine at any particular time on any given day to ensure that shadow flickers occurrences at properties which are not naturally screened or cannot be screened with measures outlined above. Where such wind turbine control measures are to be utilised, they need only be implemented when the specific combined circumstances occur that are necessary to give rise to the shadow flicker effect in the first instance. Therefore, if the sun is not shining on a particular day that shadow flicker was predicted to occur at a nearby property, there would be no need to shut down the relevant turbines that would have given rise to the shadow flicker at the property. Similarly, if the wind speed was below the cut-in speed that caused the turbine rotor to rotate and give rise to a shadow flicker effect at a nearby property, there would be no need to shut down the relevant turbines that otherwise would have caused shadow flicker.

The atmospheric variables that determine whether shadow flicker will occur or not, are continuously monitored at the Wind Farm site and the data fed into the Wind Farm's SCADA control system. The strength of direct sunlight is measured by way of photocells, and if the sunlight is of sufficient strength to cast a shadow, the shadow flicker control mechanisms come into effect. Wind speed and direction are measured by anemometers and wind vanes on each turbine and on the Wind Farm's met mast, and similarly, and if wind speed and direction is such that a shadow will be cast, the shadow flicker control mechanisms come into effect. The moving blades of the turbine will require a short period of time to cease rotating and as such there may be a very short period (less than 3 to 5 minutes) during which the blades are slowed to a complete halt. The turbines giving rise to shadow flicker may be turned off on different days to prevent excessive wear and tear on any single turbine.

In order to ensure that the model and SCADA system is accurate and working well a site visit will be carried out to verify the system. The shadow flicker prediction data will be used to select dates on which a shadow flicker event could be observed at one or multiple affected properties and the following process will be adhered to.

1. *Recording the weather conditions at the time of the site visit, including wind speeds and direction (i.e. blue sky, intermittent clouds, overcast, moderate breeze, light breeze, still etc.).*
2. *Recording the house number, time and duration of site visit and the observation point GPS coordinates.*
3. *Recording the nature of the sensitive receptor, its orientation, windows, landscaping in the vicinity, any elements of the built environment in the vicinity, vegetation.*
4. *In the event of shadow flicker being noted as occurring the details of the duration (times) of the occurrence will be recorded*
5. *The data will then be sent to the wind farm operational team to confirm that the model and SCADA system are working.*
6. *Following 12 months of full operation of the Proposed Development a report can be prepared for the Local Authority describing the shadow flicker mitigation measures*

used at the wind farm and confirming the implementation and successful operation of the system.

This method of shadow flicker mitigation has been technically well-proven at wind farms in Ireland and also in areas outside Ireland that experience significantly longer periods of direct sunlight. This measure can be utilised at the site of the Proposed Development to prevent incidences of shadow flicker values at any house in line with the Draft Revised Wind Energy Development Guidelines 2019.

Where a shadow flicker mitigation strategy is to be implemented, the control mechanisms would only have to be applied to the turbines which are causing the shadow flicker to occur.

Should a complaint be received within 12 months of commissioning of the Wind Farm, field investigation/monitoring will be carried out by the Wind Farm operator at the affected property. Notwithstanding the approach set out above should shadow flicker associated with the permitted development be perceived to cause a nuisance at any home, the affected homeowner is invited to engage with the Developer. The homeowner will be asked to log the date, time and duration of shadow flicker events occurring on at least five different days. The provided log will be compared with the predicted occurrence of shadow flicker at the residence, and if necessary, a field investigation will be carried out.

Residual Impact

Shadow flicker could potentially have a long-term slight negative impact. However, as the applicant has committed to a curtailment strategy for all turbines that cause any shadow flicker events at residential properties up to a distance of 10 rotor diameters from the Proposed Development, there will be no impact from shadow flicker on human beings.

Significance of Effects

Based on the assessment above and the mitigation measures proposed there will be no significant effects related to shadow flicker.

5.9.3.5 Interference with Communication Systems

Wind turbines, like all large structures, have the potential to interfere with broadcast signals, by acting as a physical barrier or causing a degree of scattering to microwave links. The alternating current, electrical generating and transformer equipment associated with wind turbines, like all electrical equipment, also generates its own electromagnetic fields, and this can interfere with broadcast communications. The most significant effect at a domestic level relates to a possible flicker effect caused by the moving rotor, affecting, for example, radio signals. The most significant potential effect occurs where the wind farm is directly in line with the transmitter radio path. This interference can be overcome by the installation of deflectors or repeaters.

As part of the scoping and consultation exercise undertaken by MKO, the national and regional broadcasters and fixed and mobile phone operators were contacted regarding potential interference from the Proposed Development. Full details are provided in of Chapter 2: Background to the Proposed Development and Section 14.2 and 14.3 (Telecommunications and Aviation) of Chapter 14: Material Assets. Copies of the scoping responses received are presented in Appendix 2-1 of the EIAR.

Responses were received from Airspeed Communications (Enet Ltd.), BT Communications Ireland, ESB Telecoms, Eir, Imagine Group, Ripplecom, RTE Transmission Network Ltd. (2rn), Tetra Ireland, Three Ireland, Towercom, Virgin Media, Vodafone Ireland Ltd., Commission for Communications Regulation, EMR Solutions, Ajisko Ltd. and Lighthouse Networks Ltd. Of the above list Eir, Imagine Group, Ripplecom, RTE Transmission Network Ltd. (2rn), Three Ireland, Vodafone Ireland Ltd. and Lighthouse Networks Ltd. had telecoms links within the area of the Proposed Development. Further detail on the actions taken to ameliorate any potential interference, can be found in Chapter 2 and Chapter 14. Following these measures, there will be no interference risk from any of the proposed turbines providing the design complies with recommended buffer zones and telecommunication solutions. Therefore, the Proposed Development will have no impact on telecommunications.

5.9.3.6 Residential Amenity

Pre-Mitigation Impacts

Potential impacts on residential amenity during the operational phase of the proposed Wind Farm could arise primarily due to noise, shadow flicker or changes to visual amenity. Detailed noise and shadow flicker modelling have been carried out as part of this EIAR, which shows that the Proposed Development will be capable of meeting all required guidelines in relation to noise thresholds and the shadow flicker thresholds set out in the current 2006 Wind Energy Guidelines and 2019 Draft Wind Energy Guidelines (DoEHLG), respectively.

The visual impact of the Proposed Development is addressed comprehensively in Chapter 12: Landscape and Visual. The Proposed Development has been designed to maximise turbine separation distances to dwellings in the area, with no turbines located within 724m from any occupied, non-participating, residential dwelling (H62). An assessment of roadside screening was carried out for roads within 5km of the proposed turbine locations, with both the methodology and findings of this are described in Chapter 12. Just over half of the total road length within 5km of turbines has no roadside screening. More than 40% of roads within 5km have some form or screening, and therefore intermittent views or no views of the turbines. Given the separation distance of the residential properties from the proposed turbines, and the level of existing screening in the area, the Proposed Development will have no significant impact on existing visual amenity at dwellings.

Proposed Mitigation Measures

The closest third-party dwelling to the Proposed Development is located approximately 724m from the nearest proposed turbine (T8), which is greater than 4 times the tip height (720m) from any occupied, non-participating, residential dwelling (H62), a recognised parameter in assisting in the protection of residential visual amenity. All mitigation as outlined under noise and vibration, dust, traffic, visual amenity and shadow flicker in this EIAR will be implemented in order to reduce insofar as possible impacts on residential amenity at properties located in the vicinity of the Proposed Development works, including along the proposed turbine and construction materials haul route.

Residual Impact

With the implementation of the mitigation measures outlined in relation to noise and vibration, dust, traffic, shadow flicker and visual amenity, the Proposed Development will have an imperceptible impact on residential amenity.

Significance of Effects

Based on the assessment above there will be no significant direct or indirect effects on residential amenity.

5.9.4 Decommissioning Phase

The wind turbines proposed as part of the Proposed Development are expected to have a lifespan of approximately 30 years. Following the end of their useful life, the wind turbines may be replaced with a new set of turbines, subject to planning permission being obtained, or the site may be decommissioned fully. The substation will remain in place as it will be under the ownership of ESB / EirGrid.

The works required during the decommissioning phase are described in Section 4.10 in Chapter 4: Description of the Proposed Development. Any impact and consequential effect that occurs during the decommissioning phase will be similar to that which occurs during the construction phase, however to a lesser extent, and the mitigation measures outlined above will be implemented during the decommissioning phase also. A decommissioning plan will be agreed with the local authorities three months prior to decommissioning the Proposed Development. The principles that will inform the final decommissioning plan are contained in the Construction and Environmental Management Plan (CEMP) in Appendix 4-9.

5.9.5 Cumulative and In Combination Effects

The potential cumulative impact of the Proposed Development (which includes the proposed means of Grid Connection) and other relevant developments has been carried out with the purpose of identifying what influence the Proposed Development will have on the surrounding environment when considered cumulatively and in combination with relevant approved, and existing projects in the vicinity of the Proposed Development.

For the assessment of cumulative impacts, any other existing, permitted or Proposed Developments (wind energy or otherwise) have been considered. The factors to be considered in relation to cumulative effects include population and human health, biodiversity, land, soil, water, air, climate, material assets, landscape, and cultural heritage as well as the interactions between these factors.

Further information on projects considered as part of the cumulative assessment are given in Chapter 2: Background to the Proposed Development. The impacts with the potential to have cumulative effects on human beings are discussed below and in more detail in the relevant chapters: Noise and Vibration (Chapter 11), Landscape and Visual (Chapter 12) and Traffic and Transportation (Chapter 14).

5.9.5.1 Health and Safety

The Proposed Development will have no impacts in terms of health and safety. There is no scientific evidence to link wind turbines with adverse health impacts.

5.9.5.2 Property Values

The Proposed Development will have no impact on property value. There is no statistical evidence that house prices near wind turbines are affected post or pre-construction periods after announcing development.

5.9.5.3 Services

Potential cumulative impact through investment into local services arising from the Proposed Development and other smaller scale developments in the area, through short and long-term employment and a community benefit fund (as detailed in Section 5.9.2.2), is expected to be a long-term positive cumulative impact.

5.9.5.4 Shadow Flicker

As outlined in Section 5.7.5.2, there are no wind farm developments within 10 rotors of the shadow flicker study area and therefore, there is no potential for shadow flicker from the Proposed Development in combination with other wind farm developments.

5.9.5.5 Residential Amenity

Pre-Mitigation Impacts

In the extremely unlikely event that all permitted and proposed projects as described in the cumulative assessment in Chapter 2 are constructed at the same time, there is the potential for a resulting short term, significant, cumulative, negative impact to occur on residential amenity, in relation to noise and vibration, dust, traffic, telecommunications and visual amenity.

Proposed Mitigation Measures

The closest third-party dwelling to the Proposed Development is located approximately 724m from the nearest proposed turbine (T8), i.e., greater than the recommended setback distance of 4 times the tip height (i.e., 720m), as per the *Draft Revised Wind Energy Development Guidelines* (Department of Housing, Planning and Local Government, December 2019 (currently out for public consultation)).

All mitigation measures as outlined under noise and vibration, dust, traffic, visual amenity and telecommunications in this EIAR will be implemented in order to reduce insofar as possible impacts on residential amenity at properties located in the vicinity of the Proposed Development works, including along the proposed turbine and construction materials haul route. It is assumed also that all mitigation measures in relation to the other cumulative projects will also be implemented.

Residual Impact

The Proposed Development will have a short-term, slight negative effect on residential amenity during construction works. During the operational phase, noise and shadow flicker from the proposed and permitted projects will be limited to below guideline levels or as committed to by the developer, resulting in a long-term, imperceptible residual impact from on residential amenity.

Significance of Effects

Based on the assessment above there will be no significant direct or indirect effects.

5.10 Summary

Following consideration of the residual impacts (post-mitigation) it is noted that the Proposed Development will not result in any significant effects on Human Beings in the area surrounding the Proposed Development. Following appropriate mitigation, as per the 2019 Draft Wind Energy Guidelines (DoEHLG), there will be no daily or annual shadow flicker at any dwelling within 1.62km of the Proposed Development.

Provided that the Proposed Development is constructed and operated in accordance with the design, best practice and mitigation that is described within this application, significant effects on population and human health, associated with health and safety, noise, dust, traffic and shadow flicker, are not anticipated.