Derrybrien Wind Farm Project

Gort Windfarms Ltd.

Remedial Environmental Impact Assessment Report
Chapter 12-Air & Climate

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12.1 Introduction

This chapter provides an assessment of the impact of the Derrybrien Wind Farm Project (the Project) from the baseline date prior to construction through construction, operation and ultimate decommissioning, with respect to air quality and climate. The Project comprises the wind farm, grid connection (overhead line and Agannygal Substation) and the works undertaken as a result of the peat slide.

The Derrybrien Wind Farm Project (the Project) was constructed during the period March 2003 to 2006 and became commercially operational in March 2006.

12.1.1 Chapter Scope

This chapter addresses the effects associated with the Derrybrien Wind Farm Project which have occurred, are occurring and are likely to occur with respect to air and climate.

The baseline year for the assessment is 1998.

As described in Chapter 2 Project Description, for the purposes of the Remedial Environmental Impact Assessment Report (rEIAR) the Project comprises:

- Derrybrien Wind Farm and associated ancillary works
- Grid connection comprising Derrybrien-Agannygal 110kV Overhead Line and Agannygal Substation connecting into the Shannonbridge -Ennis 110kV Overhead Line and associated ancillary works
- Works undertaken in response to peat slide which occurred during construction of the wind farm and associated ancillary works

The requirement to consider climate change was introduced in the “European Directive of the parliament and the Counsel of 2014” amending the Environmental Impact Assessment Directive and has been in force since May 2017.

Figures are contained in A4 format as they are referenced within the chapter. Where necessary for clarity these are reproduced at A3 in Appendix 12.3

12.1.2 Statement of Authority

The assessments with this chapter were undertaken by Dr. Paddy Kavanagh (BSc Hons Chemistry, PhD Chemistry), ESB Engineering and Major Projects. Dr. Kavanagh has over 39 years of experience in the field of chemistry, environment and environmental assessment both in Ireland and internationally. He has led and been involved in the preparation of environmental impact statements/environmental impact assessment reports and environmental management for power generation, transmission systems including the Donegal and Connemara 110 kV overhead lines and substations, the North South 400kV Interconnector and wind farm projects including Oweninny, Grousemount, Lissycasey wind farms for example.

The assessments undertaken with this chapter were carried out in association with Harry Griffin (BA BAI, MSc Hydrology and Climate Change), ESB Engineering and Major Projects (EMP). Mr. Griffin has 5 years of experience as an environmental engineer, working on a number of wind farm projects including Cappawhite, Grousemount and Castlepook.

12.2 Methodology

12.2.1 Assessment Significance

The effects associated with the development are described with respect to the EPA Draft Guidelines on the information to be contained in Environmental Impact Assessment Reports (EIAR), Draft, August 2017

(https://www.epa.ie/pubs/advice/ea/EPA%20EIAR%20Guidelines.pdf) .

12.2.2 Ambient Air Quality Standards and Guidelines

Air quality has been assessed based on the relevant standards prevailing to the baseline at the time of the project construction and during its operational life.

At the time of construction of the Project, protection of air quality in Ireland was afforded by the Air Quality Standards Regulations, 2002 (S.I. No. 271 of 2002) which transposed the requirements of the First, Second and Third Daughter EC adopted Air Quality Framework Directive (96/62/EC). Specific limits for: sulphur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter, ten microns in size or less, (PM_{10}) and lead (Pb) were set out in the First Daughter Directive, 99/30/EC (adopted April 1999), with the Second Daughter Directives (2000/69/EC adopted in 2001) establishing limits for benzene and carbon monoxide (CO) in ambient air and the Third Daughter Directive, 2002/3/EC, establishing target values and long term objectives for the concentration of ozone in air.

The Framework Directive and the three daughter directives were subsequently replaced in 2008 by the Ambient Air Quality and Clean Air for Europe (CAFÉ) Directive.

Currently, Ireland's air quality standards are derived from the CAFÉ Directive and the Fourth Daughter Directive (2004/107/EC). These Directives also include rules on how Member States should monitor, assess and manage ambient air quality. The CAFÉ Directive was transposed into Irish legislation by the Air Quality Standards Regulations 2011 (S.I. No. 180/2011). The fourth Daughter Directive was transposed into Irish legislation by the Arsenic, Cadmium, Mercury, Nickel and Polycyclic Aromatic Hydrocarbons in Ambient Air Regulations 2009 (S.I. No. 58 of 2009).

The Air Quality Standards Regulations 2011 replaced three earlier statutory instruments: the Air Quality Standards Regulations 2002, the Ozone in Ambient Air Regulations 2004 and S.I No.33 of 1999. These would have been in place at the time of construction of Derrybrien wind farm and their air quality requirements would have been applicable at that time as would those of the Fourth Daughter Directive.

However, the CAFÉ Directive did not change any existing air quality standards but introduced obligations relating to particulate matter of 2.5 microns or less in size

($PM_{2.5}$) which is considered to be particularly harmful to human health. The limits and targets to protect air quality set out in the Directives (and subsequently transposed into Irish Legislation) are therefore applicable to all stages of the Project, construction and operation including the period when the peat slide occurred. The relevant air quality standards are set out in Table 12-1 below.

Table 12-1 Air Quality Standards

Pollutant	Regulation Note 1	Limit Type	Basis of application of the Limit Value	Value
Sulphur dioxide	2008/50/EC	Hourly limit for protection of human health - not to be exceeded more than 24 times/year	Not to be exceeded more than 24 times in a calendar year	350 µg/m^3
		Daily limit for protection of human health - not to be exceeded more than 3 times/year	Not to be exceeded more than 3 times in a calendar year -	125 µg/m3
		Calendar Year Critical level for protection of vegetation	Annual Mean	20 µg/m^3
		1st October to 31st March Protection of Vegetation	Winter Mean	20 µg/m3
Oxides of Nitrogen	2008/50/EC	Hourly limit for protection of human health - not to be exceeded more than 18 times/year	Annual Mean	200 µg/m3 NO2
		Calendar Year limit for protection of human health	Annual Mean	40 µg/m3 NO2
		Critical level for protection of vegetation	None	30 µg/m^3 NO + NO2
Particulate Matter (as PM10)	2008/50/EC	24-hour limit for protection of human health - not to be exceeded more than 35 times/year	Not to be exceeded more than 35 times in a calendar year	50 µg/m^3 PM10

Pollutant	Regulation Note 1	Limit Type	Basis of application of the Limit Value	Value
		Calendar year limit for protection of human health	Annual Mean	40 µg/m^3 PM10
PM2.5 (Stage 1)	2008/50/EC	Calendar year limit for protection of human health	Annual Mean	25 µg/m^3 PM2.5
PM2.5 (Stage 2)	-	Calendar year limit for protection of human health	Annual Mean	20 µg/m^3 PM2.5
Lead	2008/50/EC	Calendar year limit for protection of human health	Annual Mean	0.5 µg/m^3
Benzene	2008/50/EC	Annual limit for protection of human health	Annual Mean	5 µg/m^3
Carbon Monoxide	2008/50/EC	8-hour limit (on a rolling basis) for protection of human health	Not to be exceeded	10,000 µg/m^3
Ozone (O_3)	2004/107/EC	Target value - Maximum Daily 8 hour mean for the protection of human health	Not to be exceeded more than 25 days per calendar year averaged over 3 years- -	120 µg/m^3
Ozone (O_3)	2004/107/EC	Target value – AOT40 calculated from 1 hour values from May to July	Averaged over 5 years	18,000 µg/m^3-h
Arsenic (As)	2004/107/EC	Target Value Concentration in the PM10 fraction for the protection of human health	averaged over a calendar year	6 ng/m^3**
Cadmium (Cd)	2004/107/EC	Target Value Concentration in the PM10 fraction	averaged over a calendar year	5 ng/m^3**
Nickel (N)	2004/107/EC	Target Value Concentration in the PM10 fraction for the protection of human health	averaged over a calendar year	20 ng/m^3**
Benzo (a) pyrene)	2004/107/EC	Target value Concentration in the PM10 fraction for the	averaged over a calendar year	1 ng/m^3

Pollutant	Regulation Note 1	Limit Type	Basis of application of the Limit Value	Value
		protection of human health		

** Target value effective from 31 December 2012

Under the CAFÉ Directive, EU member states must designate "Zones" for the purpose of managing air quality. For Ireland, four zones were defined in the Air Quality Standards Regulations (2011). The zones were amended on 1 January 2013 to take account of population counts from the 2011 CSO Census and to align with the coal restricted areas in 2012 Regulations (S.I. No. 326 of 2012).

Ireland is divided into four such zones as follows:

- Zone A is the Dublin conurbation,
- Zone B is the Cork conurbation,
- Zone C other cities and large towns comprising Limerick, Galway, Waterford, Drogheda, Dundalk, Bray, Navan, Ennis, Tralee, Kilkenny, Carlow, Naas, Sligo, Newbridge, Mullingar, Wexford, Letterkenny, Athlone, Celbridge, Clonmel, and Balbriggan, Greystones, Leixlip and Portlaoise.
- Zone D, principally rural, is the remaining area of Republic of Ireland/State.

  These zones are described in more detail on the EPA website http://www.epa.ie/pubs/reports/air/quality/airqualityzonesdefinition.html.

Derrybrien Wind Farm Project site is located in Zone D and would have been located in Zone D at the time of construction, see Figure 12-1 below.

Baseline air quality data has been obtained from the Environmental Protection Agency (EPA) network of air monitoring stations using historical publications and records where available and from current air quality monitoring data. The EPA is the designated competent authority for implementation of the EU Directives and the Irish Legislation. It monitors air pollutants levels and compares them to EU legal limit values and World Health Organisation (WHO) guideline values. The following pollutants are assessed by the EPA

• Particulate matter – $PM_{2.5}$ and PM_{10} • Nitrogen oxides (NO_2 & NO) • Sulphur dioxide (SO_2) • Ozone (O_3) • Carbon monoxide (CO) • Benzene and ozone precursors	• Benzo(a)Pyrene, a Polycyclic Aromatic Hydrocarbon (PAH) - both in PM_{10} and deposition • Heavy metals - both in PM_{10} and deposition • Chemical composition of $PM_{2.5}$ • Mercury

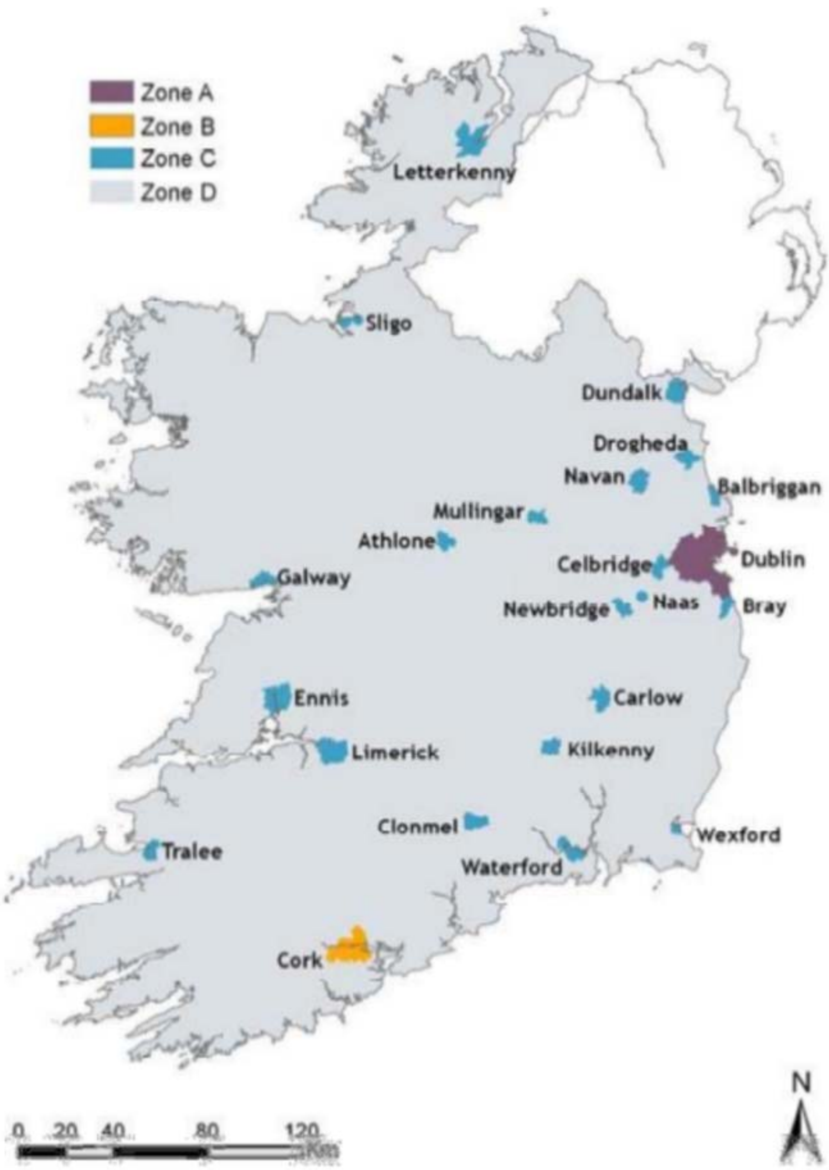


Figure 12-1: Air Quality Zones in Ireland

Source: https://gis.epa.ie/EPAMaps/

12.2.3 Air Quality

Baseline air quality monitoring data from monitoring stations which were in operation in 1998, during the construction period 2003 to 2006 and more recently is presented based on EPA published Annual Air Quality in Ireland Reports as follows:

- EPA Air Quality Monitoring Report 1998 (published in 1999)
- EPA Air Quality Monitoring Report 2003 (published in 2005)
- EPA Air Quality Monitoring Report 2004 (published in 2005)
- EPA Air Quality Monitoring Report 2005 (published in 2006)
- EPA Air Quality Monitoring Report 2006 (published in 2007)
- EPA Ireland's Environment an Assessment 2016
- EPA Air Quality in Ireland - Indicators of Air Quality 2017 (published in 2018)
- EPA Air Quality Monitoring Report 2018 (published in 2019)

The EPA compiles and collates the air quality monitoring data from the network of stations and historical and current air quality monitoring data from these stations has been obtained from the EPA SAFER online database as part of the baseline assessment.

EPA Air Quality Reports for the period 1998 to 2006 which encompasses the 1998 baseline year and the period of construction from 2003 to 2006 have been reviewed to provide a baseline of air quality in Ireland prior to and during construction. The EPA Air Quality in Ireland Report for 2018 published in 2019, the EPA data on the Air Quality Index for Health and SAFER data have been reviewed to assess the baseline quality for the current operational wind farm.

Potential impacts on air quality would have occurred principally during the construction phase of the project in the period 2003 to 2006 when significant excavation, earth moving and material transportation and the main felling took place. The potential for air quality impacts to occur during the operational phase are significantly less as levels of activity are significantly lower. The principal pollutants generated during the construction, operation and decommissioning of Derrybrien Wind Farm relate to air borne dust and equipment exhaust emissions. An assessment of the impacts of these pollutants against the baseline has been carried out based on the Institute of Air Quality Management Guidance document.

12.2.4 Climate Change - Calculating carbon losses and savings

The principal greenhouse gas associated with climate change is carbon dioxide. All organic material contains carbon which can be released when the material decays in a natural process or is released through fossil fuel combustion as part of a manufacturing or construction process. In the context of the Project, carbon can be lost through loss of sequestered carbon stored in peat, loss of sequestered carbon stored in forest plantations and loss of the future potential to store carbon in these carbon sinks. Combustion of fuels in construction and delivery equipment and to produce energy in the manufacturing of wind turbine and substation components as well as concrete and other materials will also give rise to carbon and other greenhouse gas emissions. Any such carbon losses need to be offset against carbon savings from production of renewable electricity to determine the effective displacement of fossil fuel generated electricity.

Derrybrien wind farm and grid connection (overhead line and Agannygal substation) were constructed on peat soil much of which was partially afforested with commercial coniferous species and partially under turbary for localised peat harvesting. The underlying soil type is peat.

Actively growing peat lands can be significant carbon sinks absorbing carbon dioxide from the atmosphere and converting it to organic carbon in the peat biomass. Decay of vegetation in these peatlands is also very slow due to the normally high water table and acidic conditions resulting in significant storage of carbon. Once peatland is drained or peat is excavated it no longer acts as a carbon sink and the stored carbon is released through the natural decay process as carbon dioxide. As indicated by COFORD," Black et al 2010, The greenhouse gas balance of peatland forests", Irish blanket bogs, whilst absorbing carbon, can also be an emitter of Methane, a powerful greenhouse gas and also lose carbon through streaming dissolved organic carbon. However, once drained with no vegetative regrowth the stored carbon will be lost.

Similarly, actively growing forest plantations also store carbon through absorption of carbon dioxide from the atmosphere and conversion into sugars and woody biomass with release of oxygen. COFORD (Black et al, 2010) indicates that typically after drained peat has been planted, carbon loss varying between 7 and 14 $tCO_2/ha/a$ occurs in the first 2 to 4 years and thereafter with tree growth and recolonised vegetation the planted area becomes a net absorber. Typically, 2-3 $tCO_2/ha/a$ absorption occurs between 4 and 8 years after planting, increasing up to $12tCO_2/ha/a$ by year 12 and 20 $tCO_2/ha/a$ by year 20. Thereafter the forest plantation, post thinning will typically absorb 10 $tCO_2/ha/a$. In commercial forest plantations, such as that at Derrybrien, carbon sequestration due to forestry would continue from shortly after the planting period up to the harvest time, typically a period of circa forty +years. After this, it would normally be clear-felled and the area replanted commencing the carbon sequestration cycle once again. Young forests in Ireland grow quickly, rapidly absorbing carbon dioxide from an early age. Carbon release from decaying brash from forest clear-felling would also occur but losses from wood products would occur over long periods. Carbon losses from drainage of the turbary areas would have been occurring prior to the Project.

The construction of the wind farm and associated ancillary works (including substation and grid connection) required forest plantation clear-felling, drainage and excavation of peat. Carbon stored in peat has therefore been lost during construction both from the excavated peat and from its drainage. The carbon sequestration potential which would have occurred from actively growing peat has also been lost. The peat slide event which occurred during construction also displaced a large quantity of peat resulting in additional carbon losses.

Carbon was also lost arising from the clear-felling of the commercial forest plantation, from forest plantation lost as a result of the peat slide and from potential loss of sequestration of carbon that would have occurred if the forest remained unfelled.

As part of the Project development and in accordance with the Felling Licence issued by the Forest Service afforestation of 119.3 ha of new land in areas in Counties Tipperary and Roscommon was undertaken, mainly on mineral type soils. This would partially offset the carbon loss from the forest felling on site.

During the operational period additional felling took place in 2016, 2017 and 2018 to ensure ongoing optimal wind farm operational efficiency

In addition, carbon losses to the atmosphere from anthropogenic sources such as energy and fuel used for wind turbine manufacture and delivery, construction material production (fill, steel and concrete) and from construction and transportation activities (fuel use) to build the wind farm and its ancillary developments will also have occurred.

Operation of the wind farm, generating renewable electricity, has and will continue to displace emissions from fossil fuel-based electricity production in Ireland. These emissions include carbon dioxide, oxides of nitrogen and sulphur dioxide, the principle atmospheric gases emitted by thermal combustion electricity generating stations operating on coal, gas, peat or oil, which contribute not only to climate change but also transboundary air pollution. Clean renewable energy also therefore displaces the release of thermal combustion by-products such as particulate matter and heavy metals released into the atmosphere in a controlled manner from thermal combustion plants.

It is important therefore that the balance of carbon costs from the construction of the wind farm and its ancillary infrastructure is assessed against the benefits of displacing fossil fuels arising from its operation to determine the significance of its contribution to greenhouse gases and climate change.

To assess the carbon losses the online carbon calculator tool developed by the Scottish Environmental Protection Agency (SEPA) specifically to assess, carbon losses and savings from the construction and operation of wind farm developments on peat lands has been used.

The carbon calculator tool is based on an approach developed by Nayak et al. (2008) and provides a transparent and user-friendly method for estimating the impacts of wind farms on the carbon dynamics of peat lands. The total carbon savings from a wind farm are estimated with respect to:

1. Emissions from different power generating sources;
2. Losses of carbon due to production, transportation, erection, operation and dismantling of the wind farm;
3. Loss of carbon from backup power generation;
4. Loss of carbon-fixing potential of peat land;
5. Loss of carbon stored in peat land (by peat removal and by drainage of the site);
6. Carbon saving due to restoration of habitat; and

7. Loss of carbon-fixing potential as a result of forest felling.

The carbon stored in the peat itself rather than in plants on peat land generally represents the largest potential source of carbon loss. During wind farm construction, carbon is lost from the excavated peat and from the area affected by drainage. The amount of carbon lost due to removal of drainage of the peat is estimated using default values from the Intergovernmental Panel on Climate Change (IPCC), as well as by more site-specific equations derived from the scientific literature and from site information (see Appendix 12.1 for data inputs and references).

The presence of extensive areas of forestry on and in the vicinity of the wind farm site could significantly reduce the yield of wind energy, so it was necessary to clear existing forestry prior to wind farm construction. If a forestry plantation was felled solely for the purposes of a development, changes in timber, residues and soil conditions are attributable to the wind farm. This would be partially offset by the afforestation of new lands.

The SEPA carbon calculator tool was intended primarily for applicants for consent to construct and operate an onshore wind farm in Scotland where peat is present. The results are used as a material consideration in determination of planning applications by the relevant Planning Authority.

The tool was adopted to analyse the carbon losses and savings associated with the Derrybrien Wind Farm Project. Results are presented in terms of carbon emissions, in CO_2 equivalents, and as the carbon payback time associated with emissions.

The SEPA guidance uses CO_2 emission factors for energy-related emissions from the guidelines for the measurement and reporting of emissions by direct participants in the UK Emissions Trading Scheme. Values for both coal-fired and fossil fuel-mix emission factors are updated from the Digest of UK Energy Statistics (DUKES) data for the UK. The source for the grid-mix emission factor is the list of emission factors used to report on greenhouse gas emissions by UK organisations published by the Department for Business, Energy and Industrial Strategy (formerly Department of Energy and Climate Change (DECC) and Department for Business, Innovation and Skills (BIS)).

In reality, renewable energy produced by Derrybrien will displace fossil fuel generation on the Island of Ireland and variable generators such as wind farms will likely displace natural gas fired plants. An assessment of the displacement of carbon emissions has therefore been carried out based on additional scenarios which include;

- FFC (The EU Fossil Fuel Comparator)
- iSEM (Single Electricity Market Mid merit generating plant) and
- CCGT (A demand load following CCGT (Combined Cycle Gas Turbine)

The projected energy output for Derrybrien wind farm was calculated based on the known capacity factor as a percentage of the theoretical output to date (23.5% between 2005 to 2020) and annual renewable energy output of the wind farm of circa 121,800 Megawatt hours of electricity (MWh). The annual wind energy generation was compared to the CO_2 emission intensity of the FFC, iSEM and a gas turbine following the electricity demand load to estimate the avoided emissions each year and also to estimate the carbon payback time for the project itself.

SEAI track and record Ireland's CO_2 emissions per kWh of electricity supplied on an annual basis in their Energy in Ireland Reports, the latest being the December 2019 Report.

12.2.5 Climate

12.2.5.1 Greenhouse Gas Emissions

Kyoto Agreement: Under the "Kyoto Protocol to the United Nations Framework Convention on Climate Change", which was adopted in Kyoto, Japan, on 11 December 1997 and entered into force on 16 February 2005, Ireland committed to limiting the increase of greenhouse gases to 13% above its 1990 levels during the period 2008-2012 and a 20% reduction in emissions of 1990 levels by 2020. The baseline emissions total for Ireland was calculated as the sum of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emissions in 1990 and the contribution from fluorinated gases in 1995.

The baseline value in CO_2 equivalent was established at 55.6 Mt and results in total allowable emissions of approximately 314.2 Mt over the commitment period, which equates to the average of 62.8 Mt per annum. Compliance with the Kyoto Protocol limit is achieved by ensuring that Ireland's total emissions in the period 2008-2012, adjusted for any offsets from activities under Article 3.3 (net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990) and the surrender of any purchased Kyoto Protocol credits, are below 314.2 Mt at the end of the five-year period.

EU Effort Sharing Directive and Regulation: The EU's Effort Sharing Decision (ESD)(Decision No 406/2009/EC) sets targets for the non-Emissions Trading Scheme sector for EU Members States including Ireland for 2020. Ireland was required to deliver a 20% reduction in non-ETS greenhouse gas emissions by 2020 (relative to 2005 levels). In addition, Ireland also has binding annual emission limits for the period 2013-2020 to ensure a gradual move towards the 2020 target. The non-ETS sectors cover those that are outside the EU Emissions Trading Scheme and includes the agriculture, transport, residential, commercial, waste and non-energy intensive industry.

The greenhouse gas emission inventory for 1990 – 2018 (EPA, 2020) [Error! Bookmark not defined.] is the sixth year that compliance under the European Union's Effort Sharing Decision (Decision 406/2009/EC) was assessed. This Decision sets 2020 targets for sectors outside of the Emissions Trading Scheme (known as ESD emissions) and annual binding limits for the period 2013-2020. Ireland's target is to reduce ESD emissions by 20% by 2020 compared with 2005 levels.

The EPA 2020 Report indicates that:

"The final inventory reviews for the years up to 2017 were completed in April 2019, following the submission of official data in March 2019 to the European Commission. Ireland has currently 7.13 Mt CO_2 eq additional annual emission allowances (AEAs) compared with greenhouse gas emissions for the period 2013 to 2017…"

"Ireland's annual limit for 2018 is 39.81 Mt CO_2 eq. Ireland's final 2018 greenhouse gas ESD emissions are 45.40 Mt CO2 eq, 5.59 Mt CO_2 eq more than the annual limit for 2018. This value is the national total emissions less emissions covered by the EU's emissions trading scheme for stationary and aviation operators. Agriculture and Transport accounted for 72.9% of total ESD emissions in 2018. This indicates that Ireland will not be in compliance with its 2018 Effort Sharing Decision annual limit, the third year in a row exceeding the assigned allowances."

12.2.5.2 Transboundary Gas Emissions

Displacement of thermal generation using fossil fuels by renewable electricity plant leads to a decrease in emissions of transboundary air pollutants. An assessment of the Project's effects on achieving the National targets under the National Emissions Ceilings Directive is provided. The original National Emissions Ceiling (NEC) Directive (2001/81/EC) required Member States to limit their annual national emissions of Sulphur dioxide (SO_2), Oxides of nitrogen (NOx), Volatile organic compounds (VOC) and Ammonia (NH_3) to amounts not greater than the emissions ceilings laid down in Annex 1 of the Directive by the year 2010 at the latest.

The Directive (EU) 2016/2284 (new National Emissions Ceilings Directive) on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC (old NEC Directive) entered into force on the 31st of December 2016.

Article 21(1) of Directive 2016/2284 provides that the commitments under Article 4 of the NEC Directive 2001/81/EC continued to apply until the 31st of December 2019.

Article 4(1) of Directive 2016/2284 and Annex II set out new national emission reduction commitments for SO_2, NOx, Non methane volatile organic compounds (NMVOC), NH_3 and Particulate matter of 2.5 microns in size ($PM_{2.5}$) applicable from 2020 to 2029 and 2030 onwards. These new reduction commitments are relative to the emissions of 2005 and are presented with the latest emission estimates in Table 12-2 below.

Table 12-2: National Emission Ceilings (2010-2030 onwards)

	SO_2 (kt)	NO_x (kt)	NMVOC (kt)	$PM_{2.5}$ (kt)
Annual Limit 2010	42	65	55	NA
Annual Limit 2010-2019	42	65	55	NA

	SO_2 (kt)	NO_x (kt)	NMVOC (kt)	$PM_{2.5}$ (kt)
Annual Limit 2020 to 2029	25.1	66.2	56.8	18.7
Annual Limit 2030 onwards	10.8	40.2	51.5	13.5

Based on the provisions of the original NEC Directive, Member States were obliged to annually report their national emission inventories and (in the period before 2010) their projections for 2010 to the European Commission and the European Environment Agency (EEA)

On 14th May 2018, the European Council adopted a regulation on greenhouse gas emission reductions. The regulation sets out binding emission reduction targets for Member States in sectors falling outside the scope of the EU emissions trading system for the period 2021-2030. The Regulation (Effort Sharing Regulation) maintains existing flexibilities under the current Effort Sharing Decision (e.g. banking, borrowing and buying and selling between Member States) and provides two new flexibilities (use of ETS allowances and credit from action undertaken in the Land Use, Land Use Change and Forestry (LULUCF) sector to allow for a fair and cost-efficient achievement of the targets.

An assessment of the impact of the Project on Transboundary Gas Emissions is provided below in Section 12.3.2.

12.2.6 Difficulties Encountered

Limited historical data on air quality was available for the applicable period from the historic records and database of the EPA. However, these were sufficient to provide an assessment of the air quality status that prevailed in 1998, the baseline year of the project and during the construction period 2003 to 2006 and subsequent operational years. As the EPA air quality monitoring network evolved more comprehensive data and reporting became available.

No significant difficulties were encountered in the preparation of this section of the remedial EIAR.

12.3 Receiving Environment

12.3.1 Baseline Air Quality

The EPA commenced reporting on Air Quality in Ireland in 1996. At that time the principle focus was on air quality in urban areas where air pollution by smoke and SO_2 from coal burning in the residential sector had been identified as a particular problem in the past. With the extension of smoke control legislation to several urban areas outside Dublin and Cork (Dundalk, Drogheda, Limerick, Arklow and Wexford) significant improvements in air quality in Ireland had occurred as evidenced by the monitoring data from urban air quality monitoring stations.

12.3.1.1 Air Quality in Ireland 1998

In 1999Error! Bookmark not defined., the third EPA air quality report (McGettigan M, 1999) covering the year 1998, the project baseline year, was published by the EPA. It reported on air quality data for a variety of air pollutants in Ireland assessing them against the air quality standards. Monitoring was undertaken at mainly Local Authority stations and some EPA sites. These monitoring locations were essentially all urban in nature (the major urban areas) with additional Ozone monitoring related rural air quality monitoring stations in operation.

At this time air quality monitoring remained concentrated mainly on smoke and sulphur dioxide (SO_2) with simultaneous measurement of daily values of the two pollutants at almost 60 monitoring sites throughout the country but mainly in urban areas. Measurement values indicated that the levels of both smoke and SO_2 in 1998/99 were very low and fully in compliance with the Irish air quality standards and the EU Directive on SO_2 and particulates.

The monitoring of particulate matter of ten microns in size or less (PM_{10}) was focused on four stations in Dublin and indicated a continuing trend in high concentrations which were closely associated with heavy traffic (the annual mean PM_{10} level in 1998 was 49 µg/m^3 and daily values exceeded 50 µg/m^3 on approximately 40 percent of days for which measurements were made.

Monitoring of Nitrogen oxides, a significant air pollutant, was also carried out in some urban area (Cork and Dublin) with monitoring indicating general compliance with air quality standards. However, in semi urban areas levels of Nitrogen Dioxide (NO_2) were identified as being related to traffic and approaching new target limits set by the EU.

Ozone levels recorded during 1998 were very low, which was regarded by the EPA as typical of the normal situation in Ireland. There were a few exceedances of the EU thresholds for the protection of human health (eight-hour health protection threshold of 110 µg/m^3 was exceeded for one or more periods on a total of only 10 days. There were no occasions when hourly mean ozone exceeded 180 µg/m^3 during 1998).

In relation to the thresholds for the protection of vegetation, the one-hour value of 200µg/m^3 was not reached but the 24-hour threshold of 65 µg/m^3 , which was close to the Northern European background level, was exceeded on as many as 294 days at the Mace Head station on the west coast of Ireland and also regularly at the other monitoring stations.

The1999 Report also identified ambient lead associated with traffic as being very low in line with the phasing out of leaded petrol in motor vehicles with annual mean concentrations recorded being five percent of the limit value of 2 µg/m^3.

Carbon monoxide data collected in Dublin City indicated that levels were well within the WHO guidelines for both one-hour and eight-hour averaging periods.

The 1999 Report also identified the clear need to expand the air quality monitoring network in Ireland to meet the requirements of EU and National legislation. This legislation also expanded the parameters to be monitored across the country. This was subsequently implemented through an expanded Network of monitoring stations.

Although no specific air quality monitoring focused on rural areas, given the fact that air quality in urban areas, where a significantly greater intensity of industrial, vehicular and domestic activities occur, was generally compliant with the air quality standards it can be assumed that the air quality in rural areas (Zone D) where Derrybrien is located would have generally been very good at that time.

12.3.1.2 Air Quality in Ireland 2003 - 2006

The EPA has operated and continue to operates a network of air monitoring stations including some in Zone D. Although there is no specific monitoring station at Derrybrien, it would be expected that air quality would be similar to that monitored at other Zone D monitoring stations. Typical Zone D monitoring stations that can be referenced for this purpose are Mountrath and Emo Court in County Laois, Ferbane in County Offaly and Kilkitt in County Monaghan. Both Mountrath and Ferbane monitoring stations operated for a period but are no longer in operation but still provide useful historic data.

These stations are described on the EPA air quality website (http://www.epa.ie/air/quality/data/) as follows:

*"Air monitoring was previously carried out **at Mountrath** in the yard of the old primary school on Patrick Street, approximately 10 metres from the N7. Monitoring began on 23rd September 2004 and finished on June 14th 2005. This work is part of a comprehensive assessment of air quality across Ireland. Mountrath was chosen as representative of a small town on a major road; the N7 between Dublin and Limerick passes through the town.*

Monitoring was done by a mobile unit containing continuous monitors for sulphur dioxide, nitrogen oxides, carbon monoxide, PM10 and benzene. Metals in air were measured by pumping air through filters which were changed at regular intervals"

*"The **Emo site** is located in the grounds of Emo Court, a stately home in County Laois. The site is heavily forested and was chosen to assess the levels of ozone in a forested area. Monitoring is done using a continuous monitor for ozone. Monitoring for oxides of nitrogen began in January 2013."*

*"Air monitoring was previously carried out **at Ferbane** between October 2006 and the March 2007. Monitoring was done by a mobile unit containing continuous monitors for sulphur dioxide, nitrogen oxides, carbon monoxide and particulate matter (PM_{10}). Metals in air were also measured"*

*"The **Kilkitt** site is located in the drinking water treatment works at Kilkitt in County Monaghan. This is a rural setting with little traffic or other influences on air quality. Monitoring is done using continuous monitors for nitrogen oxides, sulphur dioxide and ozone. PM_{10} heavy metals and Benzo (a) Pyrene are also measured at this site"*

The Kilkitt monitoring site continues to provide monitoring of nitrogen oxides, sulphur dioxide and ozone, PM_{10}, heavy metals and Benzo (a) Pyrene in County Monaghan. It is located in a setting similar in nature to the Derrybrien windfarm as it is situated in a rural forested area with limited traffic or other influences on air quality. Air quality at this station would be reflective of air quality likely to be found at Derrybrien.

Historical Air Quality

The air quality parameters were monitored at the stations listed in Table 12-3.

Table 12-3: Air Quality Parameters monitored at relevant Zone D stations

Monitoring Station	Proximity to Derrybrien Wind Farm (Centre)	Parameter Monitored	Monitoring period
Mountrath, County Laois	Circa 77km	PM_{10}, SO_2, NO_2, NOx, Ozone, Benzene	September 2004 to June 2005
Emo Court, County Laois	Circa 94km	Continuous NOx and Continuous Ozone	Continuous
Ferbane, County Offaly	Circa 56km	PM_{10}, SO_2, NO2, NOx, Ozone, Benzene	October 2006 to March 2007
Kilkitt, Water Treatment Plant, Co. Monaghan	Circa 157km	Continuous PM_{10}, SO_2, NO_2, NOx, Ozone, Benzene	Continuous

Historical and current air quality monitoring data has been obtained from the both the EPA Air Quality in Ireland publications for the period 2004 to 2006 and from the EPA SAFER online database . This is summarised in Table 12-4 and Table 12-5 below. The monitoring indicates general compliance (illustrated by green shading in the Tables below) with the National air quality standards. One non-compliance (shaded red) with the rolling 8 hour standard for Ozone occurred at Kilkitt monitoring station.

Table 12-4: Summary historical air quality monitoring data Mountrath and Kilkitt

	Monitoring Station	Mountrath			Kilkitt			Mountrath			Kilkitt			Kilkitt		
	Year	**2004**			**2004**			**2005**			**2005**			**2006**		
Parameter	**Parameter Limits**	**Mean**	**Max.**	**Med.**	**Mean**	**Max.**	**Med.**	**Mean**	**Max.**	**Med.**	**Mean**	**Max.**	**Med.**	**Mean**	**Max.**	**Med.**
PM_{10}	PM_{10} daily limit value: No more than 35 days >50 µg/m^3 PM_{10} annual mean Limit Value: 40 µg/m^3	26	25	44	no data	no data	no data	21	43	20	no data	no data	no data	10	47	8
SO_2	SO_2 annual mean limit value for the protection of ecosystems: 20 µg/m^3 applicable from 2001.SO_2 hourly limit value: No more than 24 hourly values > 350 µg/m^3 , SO_2 daily limit: No more than 3 daily values > 125 µg/m^3	4	28*	3	no data	no data	no data	4	22*	4	3	10*	3	2	13*	2
NO_2	NO_2 hourly limit value: No more than 18 hours >200 µg/m3 applicable from 2010 NO_2 annual mean limit value: 40 µg/m^3 applicable from 2010	13	57*	11	3	43	2	12	63*	10	2	33	1	3	58*	2
NOx	NOx annual mean limit value: 30 µg/m^3 applicable from 2010	20		13	4		2	9	67	7	4		2	4	81*	2
Lead (Pb)	Pb annual mean limit value for the protection of human health: 0.5 µg/m^3	no data	no data	no data	no data	no data	no data	0.03	0.04	0.03	no data	no data	no data	no data	no data	no data
Rolling 8-hr. Ozone at Emo Court	Max Ozone daily 8-hr mean limit: No more than 25 days >120 µg/m^3	42	123	42	57	108	57	48	105	49	56	121	57	62	194	61

	Monitoring Station	Mountrath			Kilkitt			Mountrath			Kilkitt			Kilkitt		
	Year	**2004**			**2004**			**2005**			**2005**			**2006**		
Parameter	**Parameter Limits**	**Mean**	**Max.**	**Med.**	**Mean**	**Max.**	**Med.**	**Mean**	**Max.**	**Med.**	**Mean**	**Max.**	**Med.**	**Mean**	**Max.**	**Med.**
Carbon Monoxide (CO)	CO Limit Value: Maximum daily 8-hr mean value of 10 mg/m^3	0.5	1.6	0.3	no data	no data	no data	0.3	0.8	0.3	no data	no data	no data	no data	no data	no data
Benzene	Benzene limit value: Annual mean limit value of 5 $\mu g/m^3$	no data	no data	no data	no data	no data	no data	0.3	17*		no data	no data	no data	no data	no data	no data

- Denotes hourly max values

Table 12-5: Summary historical air quality monitoring data Emo Court and Ferbane

	Monitoring Station	Emo			Emo			Ferbane			EMO		
	Year	**2004**			**2005**			**2006**			**2006**		
Parameter	**Parameter Limits**	**Mean**	**Max.**	**Med.**	**Mean**	**Max.**	**Med.**	**Mean**	**Max.**	**Med.**	**Mean**	**Max.**	**Med.**
PM_{10}	PM_{10} daily limit value: No more than 35 days >50 μg/m^3 PM_{10} annual mean Limit Value: 40 μg/m^3	no data	no data	no data	no data	no data	no data	17	45	15	no data	no data	no data
SO_2	SO_2 annual mean limit value for the protection of ecosystems: 20 μg/m^3 applicable from 2001.SO_2 hourly limit value: No more than 24 hourly values > 350 μg/m^3 , SO_2 daily limit: No more than 3 daily values > 125 μg/m^3	no data	no data	no data	no data	no data	no data	2	7	1	no data	no data	no data
NO_2	NO_2 hourly limit value: No more than 18 hours >200 μg/m^3 applicable from 2010 NO_2 annual mean limit value: 40 μg/m^3 applicable from 2010	no data	no data	no data	no data	no data	no data	4	40*	2	no data	no data	no data
NOx	NOx annual mean limit value: 30 μg/m^3 applicable from 2010	no data	no data	no data	no data	no data	no data	6	102	2	no data	no data	no data
Lead (Pb)	Pb annual mean limit value for the protection of human health: 0.5 μg/m^3	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data
Rolling 8-hr. Ozone at Emo Court	Max Ozone daily 8-hr mean limit: No more than 25 days >120 μg/m3	42	123*	42	48	105*	49	50	161	50	50	161	50

	Monitoring Station	**Emo**			**Emo**			**Ferbane**			**EMO**		
	Year	**2004**			**2005**			**2006**			**2006**		
Parameter	**Parameter Limits**	**Mean**	**Max.**	**Med.**	**Mean**	**Max.**	**Med.**	**Mean**	**Max.**	**Med.**	**Mean**	**Max.**	**Med.**
Carbon Monoxide (CO)	CO Limit Value: Maximum daily 8-hr mean value of 10 mg/m^3	no data	no data	no data	no data	no data	no data	0.2	1.5	0.1	no data	no data	no data
Benzene	Benzene limit value: Annual mean limit value of 5 $\mu g/m^3$	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data

- Denotes hourly max values

The EPA Assessment Report for Mountrath during the period 2004 to 2005 (http://www.epa.ie/pubs/reports/air/monitoring/EPA_air_assessment_Mountrath.pdf, indicated that Sulphur Dioxide, (SO_2), Nitrogen oxides (NO_2 and NOx,) Carbon Monoxide (CO), Benzene and Lead (Pb) were all below their respective Lower Assessment Thresholds. Particulate matter (of ten microns or less in size) (PM_{10},) was above the upper assessment threshold.

Historically at Emo Court: Nitrogen Oxides and Ozone have been monitored on a continuous basis. In 2006 Ozone (O_3) concentrations measured in Ireland in general were higher than previous years with a high concentration measured in July. The hourly information threshold of 180 µg/m^3 was exceeded at four stations: including Emo Court (Kilkitt, Valentia, Glashaboy and Emo Court). The 8-hour target value of 120 µg/m^3 was exceeded at almost every station. These exceedances were attributed to a combination of transboundary pollution and hot, sunny weather. Nitrogen oxide levels were below the Lower Assessment Threshold at Emo Court.

The EPA Assessment Report for Ferbane indicated that concentrations of carbon monoxide, sulphur dioxide, nitrogen dioxide and lead were below their respective lower assessment thresholds. Concentrations of PM_{10} exceeded the upper assessment threshold for this parameter.

http://www.epa.ie/pubs/reports/air/monitoring/Ferbane%20Report.pdf).

The EPA historic assessment reports for Kilkitt ("Air Quality Monitoring Annual Report 2002" and "Air Quality and Emissions to Air Report 2003") indicate that in 2002 and 2003 concentrations of carbon monoxide, nitrogen dioxide, sulphur dioxide, benzene and lead were below their respective Lower Assessment Thresholds. The EPA Air Quality Reports for 2004, 2005 and 2006 indicate that all parameters monitored were below the Lower Assessment Threshold with the exception of Ozone in 2006, the exceedance during this period was attributed to transboundary air pollution and climatic conditions.

The baseline data indicates that air quality in Zone D was generally very good at the time of construction of the Project.

12.3.1.3 Air Quality 2006 to 2020

In the EPA "Report Ireland's Environment an Assessment 2016" a summary of air quality between the period 2012 and 2015 is provided which is reflective of the operational period of Derrybrien Wind Farm. In general, the Report indicates that Ireland's air quality was good, relative to other EU Member States, with monitoring stations indicating that Ireland continued to meet all EU air quality standards but with some localised air quality issues.

The report also referenced the emerging challenges as the knowledge and understanding of the link between air quality and human health becomes better understood and indicated a growing realisation that compliance with EU air quality limit values is not enough to protect the health of people from the negative effects of poor air quality (WHO, 2016). When compared with the more stringent WHO guideline values and EEA reference level values, ozone, particulate matter and PAHs emerge as pollutants of concern in the short term, while NO_2 is expected to increase as road networks become more congested. The adoption of the stricter WHO air quality guidelines (Air Quality Guidelines, Global Update 2005) and their update relating to PM2.5 ((Krzyzanowski and Cohen, 2008) is identified as being required to protect human health. In 2018 the WHO bulletin of May 2nd indicated the following:

"Ambient (outdoor) air pollution in both cities and rural areas was estimated to cause 4.2 million premature deaths worldwide per year in 2016; this mortality is due to exposure to small particulate matter of 2.5 microns or less in diameter (PM2.5), which cause cardiovascular and respiratory disease, and cancers"

The WHO Air quality guidelines are currently under revision with an expected publication date in 2020.

The EPA Report attributed 1,200 premature deaths to poor air quality estimated at 1,200 people. The most common causes of premature death are attributable to strokes and heart disease.

The EPA Air Quality Reports for 2017 and 2018 provide a similar picture indicating that Ireland's air quality was compliant with the EU limits but was above the World Health Organization (WHO) air quality guideline value levels at a number of monitoring sites for fine particulate matter, ozone and nitrogen dioxide (NO2) and above the European Environment Agency reference level for PAH, a toxic chemical, at three monitoring sites. The EPA estimated the number of premature deaths from air quality at 1,180 people in 2018. For rural areas, particulate matter from the burning of fossil fuel is a key concern.

12.3.1.4 Current Air Quality Monitoring data

To provide up to date air quality information the EPA launched the 5-year National Ambient Air Monitoring Programme in November 2017. This has seen an expansion of the air monitoring network with upgrading of existing stations to provide real time for air borne particulate matter and other pollutants.

Based on this network the EPA publishes an Air Quality Index for Health (AQIH) map providing up to date information on air quality in any particular area. The AQIH is described by the EPA as

"*a number from one to 10 that tells you what the air quality currently is in the station nearest you and whether or not this might affect the health of you or your child. A reading of 10 means the air quality is very poor and a reading of one to three inclusive means that the air quality is good. The AQIH map updates every two to five minutes with the most up-to-date calculated Air Quality Index for Health (AQIH) for each station.*

The Derrybrien wind farm is located in the AQIH Region West, which area includes towns with population less than 5,000, villages and rural areas in Counties Clare, Cork, Donegal, Galway, Kerry, Leitrim, Limerick, Mayo, Roscommon and Sligo. It forms part of the air quality Zone D. The AQIH is based on measurements of five air pollutants all of which can harm health. The five pollutants are:

- Ozone gas
- Nitrogen dioxide gas

- Sulphur dioxide gas
- $PM_{2.5}$ particles and
- PM_{10} particles

The EPA data for assessment for these pollutants is derived from automatic air quality monitors. The AQIH for the Derrybrien Area (Region West) is generally Good. Continuous monitoring data from Emo Court shows that nitrogen dioxide concentration is consistently below the 200µg/m^3 limit value and Ozone concentration is consistently below the 180µg/m^3 limit (based on fourteen-day data available online), http://www.epa.ie/air/quality/data/emo/gas/.

Similarly, continuous monitoring data from the Kilkitt station shows that nitrogen dioxide concentration is consistently below the 200µg/m^{3}limit, sulphur dioxide concentrations are below the 350 ug m^3 limit and Ozone is below the information threshold of 180 ug m^3. PM_{10} levels are below the daily limit of 50 ug m^3 and heavy metals (Nickel, Arsenic, Cadmium and Lead) are all below the Lower Assessment Thresholds indicating good air quality in Zone D in the rural areas, http://www.epa.ie/air/quality/data/kt/.

The most recent 2018 summary data (EPA SAFER database) for the Kilkitt monitoring station is presented in Table 12-6 below. This indicates that all air quality parameters monitored in a rural zone of similar nature to Derrybrien are satisfactory and comply with the air quality limits. Similar air quality would be expected at Derrybrien wind farm and its surrounding areas.

Table 12-6: Kilkitt Air Quality Monitoring summary data

Parameter	Limit	Unit	Mean value
NO_X	NOx annual mean limit value: 30 µg/m^3 applicable from 2010	µg /m^3	3.5
NO		µg /m^3	0.5
NO_2	NO_2 hourly limit value: No more than 18 hours >200 µg/m^3 applicable from 2010 NO2 annual mean limit value: 40 µg/m^3 applicable from 2010	µg /m^3	2.8
SO_2	SO_2 annual mean limit value for the protection of ecosystems: 20 µg/m^3 applicable from 2001. SO_2 hourly limit value: No more than 24 hourly values > 350 µg/m^3 , SO_2 daily limit: No more than 3 daily values > 125 µg/m^3	µg /m^3	2.6
PM_{10}	PM10 daily limit value: No more than 35 days >50 µg/m^3 PM10 annual mean Limit Value: 40 µg/m^3	µg /m^3	9.4

Parameter	Limit	Unit	Mean value
Ozone	Max Ozone daily 8-hr mean limit: No more than 25 days >120 μg/m^3	μg /m^3	58.8
Arsenic	Lower assessment threshold of 2.4 ng m^3	ng/m^3	0.19
Cadmium	lower assessment threshold of 2.0 ng m^3	ng/m^3	0.08
Nickel	Lower assessment threshold of 10.0 ng m^3	ng/m^3	0.34
Lead	Lower assessment threshold of 0.25 ug m^3	ng/m^3	2.21
Benzo(a)pyrene	Limit value of 1 ng m^{-3}	ng/m^3	0.08

Overall it can be concluded that air quality at Derrybrien (within Zone D) has historically been good and continues to remain so.

12.3.2 Transboundary Gas Emissions

Air pollution is a local, regional and global problem that results from anthropogenic activity other than volcanic events. The impact of air pollutants is wide and varied, affecting both the environment and human health.

The pollutants sulphur dioxide (SO_2), nitrogen oxides (NOx), volatile organic compounds (VOC) and ammonia (NH_3) are responsible for long-range transboundary air pollution such as acidification, eutrophication and ground-level ozone pollution. Fossil fuel thermal electricity generation plants release significant quantities of these gases into the atmosphere as do other sectoral activities. The EPA compiles the inventory of on all emission and recently published "Ireland's Informative Inventory Report 2019" on the emissions during the period 1990 to 2017.

Inventory submissions for 1990-2017 data shows Ireland in compliance with the SO_2 emission ceilings for all years from 2010 to 2017. Ireland's position reported by the EPA, in relation to the above emission is provided in **Table 12-7**:

Table 12-7: National Air Emissions (1998-2017) and Limits (2010-2030 onwards)

	SO_2 (kt)	NO_x (kt)	NMVOC (kt)	NH_3 (kt)	$PM_{2.5}$ (kt)
Annual Limit 2010-2019	42	65	55	116	NA
Annual Limit 2020 to 2029	25.5	66.9	56.9	112..1	15.6
Annual Limit 2030 onwards	10.9	40.7	51.6	107.5	11.2
Annual Emissions					
Year	**SO_2 (kt)**	**NO_x (kt)**	**NMVOC (kt)**	**NH_3 (kt)**	**$PM_{2.5}$ (kt)**
1990	183.6	175.0	145.8	109.8	35.5
1991	181.7	175.4	146.1	111.4	35.1

	SO_2 (kt)	NO_x (kt)	NMVOC (kt)	NH_3 (kt)	$PM_{2.5}$ (kt)
1992	169.9	182.8	142.6	113.7	31.0
1993	160.9	174.5	140.5	112.6	30.6
1994	175.3	171.2	137.3	113.1	27.7
1995	161.1	169.3	136.3	113.6	25.8
1996	149.2	172.4	137.9	117.1	26.8
1997	165.9	162.9	134.6	119.6	24.8
1998	176.3	166.3	135.2	123.5	25.9
1999	158.4	164.0	125.5	120.8	22.6
2000	139.5	161.7	118.9	114.9	22.8
2001	134.1	162.1	119.8	114.6	22.8
2002	101.1	154.2	120.1	114.4	22.0
2003	79.1	156.1	119.5	114.2	21.9
2004	71.9	158.4	118.8	113.2	22.0
2005	71.8	161.7	119.2	113.3	22.8
2006	60.8	157.	119.1	111.9	22.3
2007	54.6	151.56	118.9	108.4	21.4
2008	45.2	142.4	114.9	109.7	21.1
2009	32.4	119.2	112.8	110.3	20.8
2010	26.3	113.3	109.2	108.2	18.9
2011	24.8	101.4	106.5	104.4	16.8
2012	23.4	104.7	107.9	106.3	16.5
2013	23.5	105.4	110.3	107.8	16.8
2014	16.9	104.1	106.1	108.3	15.6
2015	15.0	104.4	106.4	111.1	15.6
2016	13.8	107.3	108.3	116.7	14.9
2017	13.2	110.3	113.3	118.5	11.9

The EPA Informative Inventory Report 2019 provides detailed trend information in relation to the key transboundary air pollutants which have been summarised as follows:

- "Total sulphur dioxide emissions decreased by 92.8 per cent, from 183.62 kt in 1990 to 13.22 kt in 2017. Of this, the Public Electricity and Heat Production (1A1a) sector remains one of the main sources of SO_2 emissions, contributing 29.4% of the total in 2017, and decreased by 96.2% between 1990 (103.04 kt) and 2017 (3.89 kt).
- Total nitrogen oxides emissions have decreased by 37.0%, from 175 kt in 1990 to 110.3 kt in 2017. Road Transport is the principal source of NO_X emissions, contributing 34.5% (37.33 kt) of the total in 2017, with the transport sector as a whole accounting for 41.0 % (44.43 kt) of the national total. Agricultural sources of NOx, accounted for 30.9% of emissions in 2017 (33.46

kt), having reduced by 1.6% since 1990 (32.92 kt). The Public Electricity and Heat Production sector accounted for 7.5% of emissions in 2017. Emissions from this sector have decreased by 82.5% between 1990 (46.37 kt) and 2017 (8.11 kt).

- Total ammonia emissions have increased by 7.9%, from 109.8 kt in 1990 to 118.5 kt in 2017. Livestock production has historically accounted for the bulk of national total ammonia emissions in Ireland and, in 2017, manure management and animal manure applied to soil and nitrogen from urine and dung deposition by grazing animals combined accounted for 89.4% of the national total.
- Total non-methane volatile organic compound emissions have decreased by 22.4%, from 145.8 kt in 1990 to 113.32 kt in 2017. The NMVOC emissions are determined largely by the Agriculture sector accounting for 41.0% of the national total an increase of 16.6% between 1990 (39.85 kt) and 2017 (46.47 kt). The Food and Beverage Industry (2H2) contributed to 23.5 per cent of total emissions in 2017, having increased by 176.3 % from 9.62 kt in 1990 to 26.57 kt in 2017. The Public Electricity and heat sector contributed less than 0.5% in 2017.
- Carbon monoxide emissions continue to decline, driven by major reductions due to three way catalysts in gasoline vehicles in Road Transport (1A3b), which is the principal source of CO, and a large decrease in the use of solid fuels for space heating in the Residential sector (Figure 2.5). National total CO emissions have reduced from 352.17 kt in 1990 to 83.26 kt in 2017, a reduction of 76.4%.
- Emissions of particulate matter <10 μm diameter ($PM_{10)}$ amounted to 27.32 kt in 2017, a 41.8% reduction from 46.96 kt in 1990 (Figure 2.6). The main determinant of the trend in PM_{10} emissions is the Agriculture sector with 31.7 per cent share of the national total, and combustion in the Residential (1A4b) and Commercial/Institutional (1A4a) sectors combined with 23.8 per cent share of the total in 2017. Public Electricity and Heat Production sector emissions accounted for 2.0% of the national total in 2017 and at 0.56 kt reduced by 41.9% from 1990 levels (0.96 kt). The decrease was due to the increased use of natural gas and wind for electricity generation, in proportion to coal and peat which still accounted for a large share of the fuel mix used at the time.
- National total emissions of particulate matter <2.5 μm diameter ($PM_{2.5}$) amounted to 11.88 kt in 2017, a 66.5 reduction on 35.5 kt in 1990. Emissions from Residential and Commercial/Institutional sectors combined are the main determinant of the trend with their 53.4% share of the national total emissions in 2017. The Electricity and Heat Production sector accounted for 3.1% of the national total emissions in 2017, a reduction of 43.8% from 0.65 kt in 1990 and 0.36 kt in 2017".

In terms of meeting National emission ceiling targets, the data indicates that:

- "Emissions of sulphur dioxide (SO_2) continue to decrease and are well below the required EU emission limits, substantially due to the use of lower sulphur content fuels in electricity generation and transport.
- Two of the five main air pollutants increased – ammonia (ceilings exceeded in in 2016 and 2017 and non-methane volatile organic compounds.
- The emission ceiling for nitrogen oxides (NOx) and non-methane volatile organic compounds (NMVOCs) has been exceeded for all years since 2010
- Emissions of particulate matter ($PM_{2.5}$) continued to decline in 2017 with future emission trends dependent largely on the quantity and quality of solid fuel used in the residential and commercial sectors.
- Increased penetration of renewables for electricity generation has also seen reductions in transboundary air pollutants."

The latest projection estimates of the EPA, with respect to air pollutants that are subject to new 2020 and 2030 emission reduction targets, and drawn from the EPA 2019 Report indicates the following:

- "The emission projections predict compliance with the 2020 emission reduction target throughout the projected period. In 2030 total emissions are projected to be below the emission reduction target for that year under the With Additional Measures scenarios. Key sources of SO2 emissions include electricity generation and emissions from residential, commercial and industry
- Overall NOx emission projections predict compliance with the 2020 emission reduction target under the With Measures and With Additional measures scenarios. The projections predict non-compliance with the 2030 emission reduction target under both the With Measures and With Additional Measures scenarios. Emissions from transport is the largest contributor to NOx emissions.
- Overall the Ammonia emission projections predict compliance with the 2020 and 2030 emission reduction target under both the With Measures and With Additional Measures scenarios. The majority of projected emissions come from agriculture sources
- Overall NMVOCs emission projections predict compliance with the 2020 emission reduction target and non-compliance with the 2030 emission reduction target under both the With Measures and With Additional Measures scenarios. Large emission sources include solvents and other product use, and emissions from food and beverages industry.
- Overall the PM2.5 emission projections predict compliance with the 2020 and 2030 emission reduction target under both the With Measures and With Additional Measures scenarios. Emissions from Residential and Commercial combined are the largest contribution to the projected emissions."

12.3.3 Climate Change

Baseline climate and climate change information is presented based on published information. The sources of the information are as follows:

- EPA, Ireland's National Inventory Report 2020 Greenhouse Gas Emissions 1990 – 2018, Reported to the United Nations Framework Convention on Climate Change (EPA, Duffy et al 2020). http://www.epa.ie/pubs/reports/air/airemissions/ghg/nir2020/NIR%202020_Merge_finalv2.pdf
- EPA, Ireland's Informative Inventory Report 2019, Air Pollutant Emissions In Ireland 1990–2017 Reported to the Secretariat Of The UNECE Convention On Long-Range Transboundary Air Pollution and to the European Union (EPA, Duffey et al 2019)
- EPA, "Ireland's Transboundary Gas Emissions, 1990-2030", May 2019
- Department of Communications, Energy and Natural Resources, "Ireland's Transition to a Low Carbon Energy Future – 2015-2030", 2015
- Department of Communications Climate Action and Environment Climate Action Plan to Tackle Climate Change 2019, August 2019" https://www.dccae.gov.ie/en-ie/climate-action/publications/Documents/16/Climate_Action_Plan_2019.pdf
- IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf
- 2018 Department of Communications, Climate Action and Environment (DCCAE 2018), "National Adaptation Framework Planning for a Climate Resilient Ireland"
- EPA, Ireland's Final Greenhouse Gas Emissions, 1990-2019, October 2019

Climate change projections and climate change effects are identified in order to assess project vulnerabilities and resilience.

As stated in the SEAI Energy in Ireland Report 2019, there is a growing global momentum to reduce greenhouse gas emissions linked to climate change. This is also reflected by the European Commission's drive towards a low carbon economy underpinned by the Climate and Energy Framework 2030 which proposes to achieve a 40% reduction in greenhouse gas (GHG) by 2030 relative to 1990, and a binding EU-wide target for renewable energy of at least 32% by 2030.

The Irish Government's "Climate Action Plan - To Tackle Climate Breakdown 2019" sets an ambitious target to have 70% of electricity generated from renewable sources by 2030. To achieve this target onshore wind will need to grow from its current level (4 Gigawatts) to circa 8 Gigawatts of installed wind. It highlighted the fact that Ireland will miss the target set for the period 2013 to 2020 for renewables by about 12.5% with a possibility that further targets will be missed during the period 2021 to 2030.

In March 2020, ESB Networks announced that "A major milestone has been reached regarding renewable generation on Ireland's electricity network. ESB Networks has connected its 4,000th megawatt (MW) of wind capacity on to the electricity system,

12.3.3.1 Policy and agreements

In 1994 Ireland ratified the United Nations Framework Convention on Climate Change (UNFCCC) followed in 1997 by its ratification of the Kyoto Protocol (Framework Convention on Climate Change, 1999 and Framework Convention on Climate Change, 1997). Under the EU burden sharing agreement (Article 4 of the Kyoto Protocol), Ireland agreed to limit the net anthropogenic growth of the six Greenhouse Gases (GHGs) under the Kyoto Protocol to 13% above the 1990 level over the period 2008 to 2012 (ERM, 1998).

In 2015, an important milestone Conference of the Parties (COP21) was convened in Paris. The “Paris Agreement”, signed up to by over 200 nations, had a stated aim of limiting global temperature increases to no more than 2°C above pre-industrial levels with efforts to limit this rise to 1.5°C and limiting the global GHG emissions to 40 gigatons as soon as possible whilst acknowledging developing countries may not yet have reached their peak emissions. Arising from the agreement, contributions to greenhouse gas emissions will be based on Intended Nationally Determined Contributions (INDCs), underpinning climate actions post 2020. In parallel progress was also made on ensuring adaptation measures received the same focus as curbing emissions. Subsequent COP conferences have been held addressing climate change issues with the most recent in Madrid (COP25) in December 2019. However, COP 25 did not result in agreement on the guidelines for a carbon market seen as an essential part of the toolkit to harness the potential of the private sector and generate finance for adaptation. Support for developing countries to ensure their greening and resistance to climate change was also not fully addressed and it was felt that high-emitting countries did not send a clear enough signal in terms of improving climate strategies and in their level of ambition through the Nationally Determined Contributions to be submitted in 2020.

Despite this, international governments did express the need for more ambition and agreed to improve the ability of the most vulnerable to adapt to climate change. Many sectors of society overwhelmingly agreed on the need to follow the scientific evidence and to act urgently and appropriately to achieve the commitments of COP 21.

12.3.3.2 Greenhouse gases

Greenhouse gases in the earth’s atmosphere trap the earth’s outgoing infrared radiation and re-emit it in all directions, including back to the earth’s surface. The most important greenhouse gases are carbon dioxide (CO_2,), water vapour (H_2O), methane (CH_4), and ozone (O_3). As their concentrations rise, more outgoing radiation is absorbed resulting in an imbalance that warms the planet. Carbon Dioxide is seen as the most significant anthropogenic greenhouse gas.

The most up to date report on Global Warming has been released by the Intergovernmental Panel on Climate Change (IPCC). The Special Report on Global Warming of 1.5^{o}C. The “Special Report” demonstrates, with great scientific authority, the need for far-reaching and immediate reductions in greenhouse gas emissions. It states that the global average temperature is already more than 1°C higher than the pre-industrial era. The Report indicates the significant difference in the increase in impacts from global warming between a rise in temperature of 1.5^{0}C as opposed to

2^0C with increased impacts on ocean temperature and acidity, biodiversity, rainfall patterns (droughts and extreme weather events) and sea level rise. This highlights the need to curb carbon emissions to the atmosphere to limit global warming impacts.

12.3.3.3 Climate projections for Ireland

Ireland is vulnerable to climate change – including from sea level rise, increased storm frequency and changing precipitation patterns. Evidence of the impact of climate change in Ireland is emerging in the form of the increased frequency of extreme weather events.

Global modelling work has been carried out by Met Éireann and the Irish Centre for High-End Computing (ICHEC) as partners in the international EC-Earth consortium to develop the EC-Earth global climate model. The impacts of climate change for Ireland were assessed for the mid-century period 2041-2060 using an ensemble of down-scaled climate simulations. The modelling carried out by Met Eireann indicates the following likely impacts for Ireland, see https://www.met.ie/climate/climate-change:

- An increase of 1–1.6°C in mean annual temperatures, with the largest increases seen in the east of the country with highest daytime temperatures projected to rise by 0.7–2.6°C in summer and lowest night-time temperatures to rise by 1.1–3°C in winter.
- The number of frost days (days when the minimum temperature is less than 0°C) is projected to decrease by 50% for the medium-low emission scenario and 62% for the high-emission scenario.
- Milder winters will, on average, reduce the cold related mortality rates among the elderly and frail but this may be offset by increases due to heat stress in the warmer summers.
- Significant projected decreases in mean annual, spring and summer precipitation amounts by mid-century. The projected decreases are largest for summer, with reductions ranging from 0% to 13% and from 3% to 20% for the medium-to-low and high emission scenarios, respectively.
- The frequencies of heavy precipitation events show notable increases of approximately 20% during the winter and autumn months.
- The number of extended dry periods is projected to increase substantially by mid-century during autumn and summer. The projected increases in dry periods are largest for summer, with values ranging from 12% to 40% for both emission scenarios.
- Globally sea levels have been rising at an average rate of approximately 3 mm per year between 1980 and 2010. Rising sea levels around Ireland would result in increased coastal erosion, flooding and damage to property and infrastructure.
- Studies have shown significant projected decreases in the energy content of the wind for the spring, summer and autumn seasons, with the projected decreases largest for summer and no significant trend in winter. The overall

number of North Atlantic cyclones is projected to decrease by approximately 10 %.

- The paths of extreme storms will extend further south, bringing an increase in extreme storm activity over Ireland, although the number of individual storms is projected to be quite small.
- Changes in the climate will bring changes in the behaviour of species e.g. a spring warming in recent years has seen and advance in the timing of key phenological phases of a wide range of organisms, including trees, birds and insects. The pace of future change will cause stress to ecosystems which are unable to adapt quickly.

The need for Ireland to develop and implement policies to ensure that the country meets the challenges of expected changes in our climate and our international obligations was also highlighted by Met Eireann. The 2018 Department of Communications, Climate Action and Environment (DCCAE 2018), "National Adaptation Framework Planning for a Climate Resilient " noted that warming of the global climate system is unequivocal and it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century.

In summary the effects on climate comprise changes in the frequency, intensity and distribution of rainfall events, temperature increases, increased windstorms; and sea level rise with consequential impacts on Ireland' biodiversity and population health.

12.3.4 Irelands Greenhouse Gas Emissions

Increased atmospheric levels of greenhouse gases enhance the natural greenhouse effect and are widely recognised as the leading cause of climate change. The most important long-lived greenhouse gases are Carbon Dioxide (CO_2), Nitrous Oxide (N_2O), and Methane (CH_4). CO_2 arises both naturally and from a range of anthropogenic sources including the combustion of fossil fuels. The EPA compiles and publishes an annual report on Ireland's Greenhouse gas emissions which is reported to the UN . The latest EPA Report[Error! Bookmark not defined.] indicates the following:

Long Term 1990-2018: According to the EPA inventory of greenhouse gas emissions for 2018`, total greenhouse gas emissions were in 2018 were 9.9% higher than in 1990. The peak period for greenhouse gas emissions occurred in 2001 with the 2018 emission total some 13.2% lower.

The EPA Report 2020 indicates the trend in Irelands GHG emissions from 1990 to end 2018 as follows:

"Total emissions of the seven greenhouse gases in Ireland (including indirect CO_2 emissions without land use, land use change and forestry) increased steadily from 55,468.3 kt CO_{2eq} in 1990 to 70,221.2 kt CO_{2eq} in 2001, which is the highest level of GHG emissions ever reported in Ireland. Emissions then plateaued until 2008 with estimates ranging from 67,490.6 kt CO_{2eq} to 69,702.1 kt CO_{2eq}. There was then a sharp decrease from 67,490.6 kt CO_{2eq} in 2008 to 57,156.9 kt CO_{2eq} in 2011.

Emissions then plateaued again between 2011 and 2014. There was a rise in emissions between 2014 and 2015 of 3.6 per cent to 59,415.9 kt CO_{2eq}, and there was a further increase between 2015 and 2016 of 3.5 per cent to 61,491.4 kt CO_{2eq}. Emissions in 2018 at 60,934.5 kt CO_{2eq} are 0.1 per cent lower than 2017.

The largest annual change occurred from 2008 to 2009 when emissions decreased by 5,754.2 kt CO_{2eq} from 67,490.6 kt CO_{2e}q to 61,736.4 kt CO_{2eq} a reduction of 8.5 per cent. Total emissions in 2018 were 9.9 per cent higher than in 1990 and 13.2 per cent lower than the peak level in 2001 ."

This is portrayed graphically in **Error! Reference source not found.** below taken from the EPA 2020 Report.

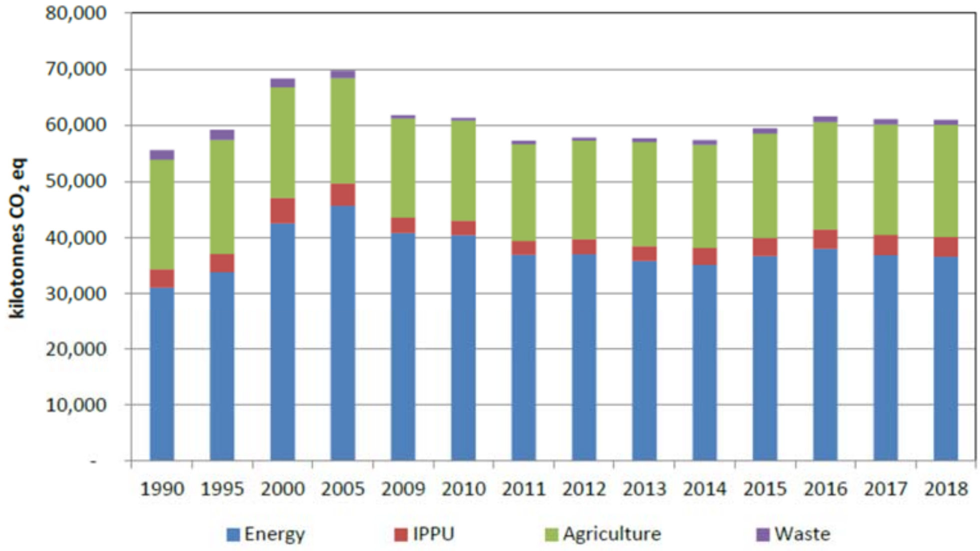


Figure 2.1 National total Greenhouse Gas emissions (excluding LULUCF) 1990-2018

Figure 12-2 National Total Greenhouse Gas emissions 1990 –2018

Reproduced from Ireland's National Inventory Report 2020

The report goes on to state that the total Energy Sector accounted for 60.0% of total emissions, Agriculture contributed 32.7% while a further 5.8% emanated from Industrial Processes and Product Use and 1.5% cent was due to Waste.

The energy sector itself covers a range of activities, see Table 12-8 below. Specifically, GHG emissions from public electricity and heat production comprised 35.3% in 1990 (10,953 kt of CO_2 equivalent) and 27.6% in 2018 (10,109 kt of CO_2 equivalent) of the total energy sector. This represents a decrease of 7.7% in GHG emissions associated with the electricity and heat production area over the 1990 - 2018 period compared to an overall increase in the energy sector of some 17.9%. It reflects the growing penetration of renewables into energy supply at time when demand is increasing.

Table 12-8 Energy Sector Activities and GHG emissions in kt CO_2eq

Activity	GHG	1990	2018
Public Electricity and Heat Production	CO_2, CH_4, N_2O	10,953.9	10,108.9
Petroleum Refining	CO_2, CH_4, N_2O	168.7	3222.2
Manufacture of Solid Fuels and Other Energy Industries	CO_2, CH_4, N_2O	100.5	119.3
Iron and Steel	CO_2, CH_4, N_2O	175.9	2.3
Non-Ferrous Metals	CO_2, CH_4, N_2O	811.5	1,407.0
Chemicals	CO_2, CH_4, N_2O	411.4	292.7
Pulp, Paper and Print	CO_2, CH_4, N_2O	28.5	17.2
Food Processing, Beverages and Tobacco	CO_2, CH_4, N_2O	1,021.4	899.8
Non-metallic minerals	CO_2, CH_4, N_2O	822.8	1304.3
Other	CO_2, CH_4, N_2O	690.4	818.1
Domestic Aviation	CO_2, CH_4, N_2O	48.4	16.8
Road Transportation	CO_2, CH_4, N_2O	4,789.4	11,677.5
Railways	CO_2, CH_4, N_2O	148.9	130.5
Domestic navigation	CO_2, CH_4, N_2O	85.8	260.2
Other transportation	CO_2, CH_4, N_2O	74.1	139.7
Commercial/Institutional	CO_2, CH_4, N_2O	2,244.1	2108.4
Residential	CO_2, CH_4, N_2O	7,523.7	6197.2
Agriculture/Fishing	CO_2, CH_4, N_2O	818.5	680.3
Coal mining and handling	CH_4	55.6	18.6
Oil	CO_2, CH_4	0.2	0.4
Natural gas	CO_2, CH_4	48.7	61.4
Total Energy		**31,022.1**	**36,582.9**

The change in GHG emissions between 1990 and 2018 for the public electricity and heat production sector is shown in Table 12-9 below.

Table 12-9: Public Electricity and Heat Production GHG emissions 1990 - 2018

Year	GHG (CO_2, CH_4, N_2O) kt CO_2eq
1990	10,953.9
1995	13,132.9
2000	15,754.4
2005	15,244.8

Year	GHG (CO_2, CH_4, N_2O) kt CO_2eq
2008	14,155.1
2009	12,610.6
2010	12,895.1
2011	11,557.1
2012	12,350.2
2013	10,977.5
2014	10,837.7
2015	11,401.0
2016	12,149.5
2017	11,379.2
2018	10,108.9

The trends in GHG emissions from the energy sector and particularly the electricity and heat production area reflect the mix of renewable generation or fossil fuel electricity generation (coal and natural gas) on the system.

This highlights the importance of maintaining and growing renewable energy generation and it is reflected in the Government's Climate Action Plan 2019 which sets an ambitious target of achieving 70% of electricity to be generated from renewable sources by 2030.

With respect to renewables, Section 7.2 of the Plan sets a target of increasing onshore wind renewable capacity by 8.2GW (it is currently 4GW) representing a doubling in onshore wind capacity.

Short term: In 2018 GHG emissions from the Public Electricity and Heat Production Sector were 10,108.9 kt CO_2 equivalent, a decrease of 11.2% on 2017 attributed mainly to a decrease in coal combustion and an increase in renewable electricity generation.

The SEAI 2019 Energy in Ireland Report indicated that electricity generated from renewable sources increased by 3.1% in 2018, to 33.2%, The carbon intensity of electricity fell from 437 gCO_2/kWh in 2017 to 375 gCO2/kWh, mainly due to the reduction in coal use and increased wind generation.

Renewable electricity generation in 2018 accounted for 33.2% (normalised) of gross electricity consumption. reducing CO_2 emissions by 4 Mt and avoiding €430 million in fossil fuel imports.

Wind generation accounted for 28.1% (normalised) of the electricity generated making it the second largest source of electricity generation after natural gas.

Table 12-10

Table 12-10: Irelands Greenhouse gas emissions for 2017 and 2018 for Ireland Mt CO2eq

shows the contributions from each of the sectors in 2017 and 2018.

Table 12-10: Irelands Greenhouse gas emissions for 2017 and 2018 for Ireland Mt CO2eq

	2017	2018	% Change
Energy Industries	11,819.8	10,550.4	-10.7
Manufacturing Industries and Construction	4,564.7	4,741.4	3.9
Transport	12,026.6	12,224.7	1,6
Other sectors	8,349.9	8,985.9	7.3
Solid Fuels	18.9	18.6	-1.6
Oil and Natural gas	60	61.8	3.0
Total	**36,839.9**	**36,582.8**	**0.7**

12.3.5 Ireland's Greenhouse Gas Emissions Projections 2018 – 2040

Ireland's Greenhouse gas emissions have been projected out to 2040 by the EPA and summarised in their EPA Greenhouse Gas Projections Report published in June 2019. The emission projections are based on inputs from and are a collaborative effort of key Government sources. The emissions are projected using two scenarios described as follows:

- With Existing Measures: these are based on existing policies and measures which were in place by the end of 2017 and assumes that these are implemented without additional policies or measures.
- With Additional Measures: this scenario assumes full implementation of the With Existing Measures scenario in addition to further implementation of Government renewable and energy efficiency policies and measures including those set out in the National Renewable Energy Action Plan (NREAP) and the National Energy Efficiency Action Plan (NEEAP) and more recently Ireland's National Development Plan 2018-2027.

The Report provides an assessment of progress towards achieving GHG emission reduction targets out to 2020 and 2030 set under the EU Effort Sharing Decision (Decision No 406/2009/EU) and Effort Sharing Regulation (Regulation (EU) 2018/842). The Regulation, in particular, sets binding annual greenhouse gas emission reduction targets on member states.

The Report quotes the Government's target of an 80% reduction in emissions by 2050 as follows:

"Over the longer-term Ireland's National Policy Position on Climate change has set a target of an aggregate reduction in carbon dioxide (CO_2) emissions of at least 80% (compared to 1990 levels) by 2050 across the electricity generation, built environment and transport sectors."

Emissions in the energy sector are attributed largely to the generation of electricity and continued use of fossil fuels with increasing renewable energy, mainly from wind, seen as a key downward driver in achieving GHG emission reduction targets from this sector. This is reflected in the projections for the Energy Industries (Under the With Existing Measures) which indicate an increase of 5% between 2018 and 2020 to 12.3 Mt CO_2eq and over the period 2018 to 2030 of 31% to 15.4 Mt CO_2eq attributed largely to increased demand and continued use of fossil fuels for electricity generation

In the With Existing Measures Scenario approximately 39% of electricity generation is projected to come from renewable energy sources by 2020. In 2030 it is estimated that renewable energy generation increases to approximately 41%. Renewable electricity generation capacity is dominated by wind.

The projected GHG emissions from both the energy industries and the public electricity sector out to 2040 are shown in Table 12-11. The effect of bringing in additional measures out to 2030 is shown in Figure 12-3.

Table 12-11: EPA 2018-2040 GHG Emissions Projections (kt CO_2eq)*

	With Existing Measures		With Additional Measures	
Year	Energy Industries	Public electricity and heat production	Energy Industries	Public electricity and heat production
2018	12764.35	12236.44	12481.21	11953.86
2019	12704.78	12215.00	12389.32	11900.62
2020	12319.04	11766.08	11954.31	11402.88
2021	12303.95	11750.46	11989.81	11437.99
2022	13151.08	12596.88	12786.99	12234.69
2023	13432.66	12878.49	13055.02	12503.12
2024	14363.31	13851.36	13091.46	12581.94
2025	14782.97	14228.16	13666.74	13115.26
2026	15087.48	14533.19	8532.10	7981.45
2027	15170.68	14616.78	8551.75	8002.61
2028	15522.40	14968.52	8968.60	8420.48
2029	15430.85	14920.29	8868.16	8364.25
2030	15409.35	14855.91	8626.60	8080.92
2031	11318.52	10763.19	8887.00	8340.68
2032	11985.33	11429.20	9686.33	9139.47
2033	12128.81	11572.42	9907.38	9360.43
2034	12294.54	11780.87	10154.79	9650.73
2035	12520.80	11963.79	10363.29	9816.12
2036	12676.92	12119.62	10732.95	10185.58
2037	12916.75	12359.09	11184.40	10636.76
2038	13081.18	12523.28	11387.82	10840.09
2039	13209.75	12694.59	11649.00	11144.17
2040	13383.01	12824.55	11789.94	11242.05

*Data derived from the EPA GHG Emission Projections Report**Error! Bookmark not defined.**

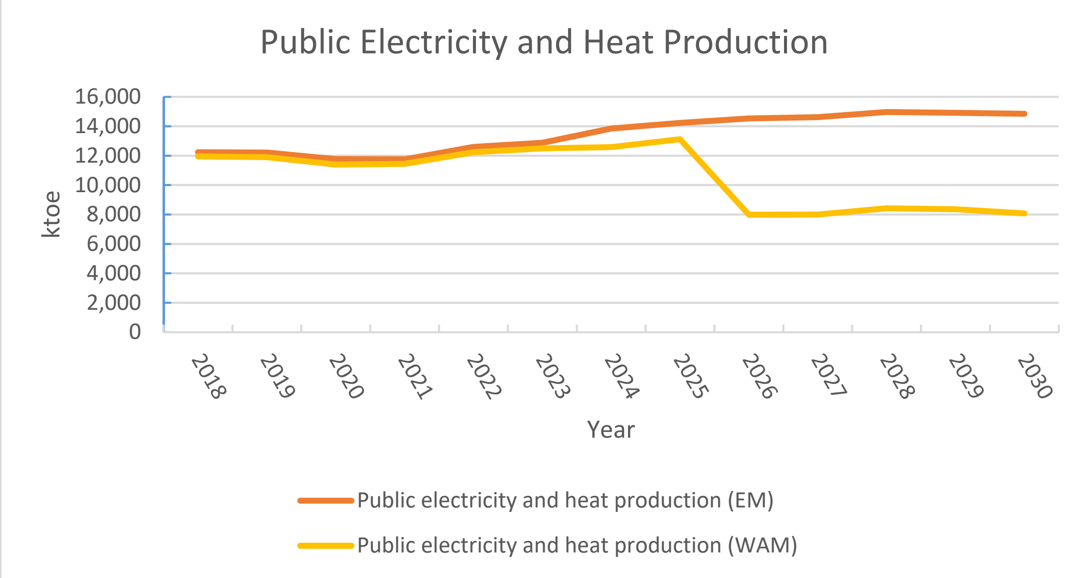


Figure 12-3: Projected emissions in Public Electricity and Heat Production.*

*Data derived from the EPA GHG Emissions Projections Report**Error! Bookmark not defined.**

It should be noted that at the time of the report preparation, the Government's Climate Action Plan had not yet been published and therefore any additional measures set out in the plan would not have been accounted for. In particular, the Annex of Actions to the Plan sets out targets to support increased penetration of renewable energy into the electricity market to meet the 70% RES-E target by 2030 and also key actions to ensure that grid development policies and infrastructure are there to support this target.

Derrybrien wind farm is already a grid connected renewable electricity generating facility contributing to the achievement of national targets for renewable generation.

12.4 Impact of the Development

12.4.1 Air Quality

This section describes the impacts which are likely to have occurred on air quality during the construction period, including the peat slide, those which have occurred during the operational phase to date and those that are likely to occur during the operational phase 2020 to circa 2040 and the subsequent decommissioning phase..

12.4.2 Air Quality Impacts which have occurred

12.4.2.1 Construction Phase 2003-2006

As indicated in Section 12.3.1 above the baseline air quality at the Project locations was of good quality at the time prior to construction. Air quality impacts during construction would have arisen primarily from dust emissions from dust generating activities on the site and from construction equipment and delivery vehicles exhaust gas emissions. Windblown dust emissions would potentially have occurred during the site construction from the following activities:

- Forest plantation clearance
- Site access track and hardstand construction
- Stockpiling of excavated material
- Extraction and crushing of material from borrow pits
- Blasting operations
- Excavation for wind turbine foundations, crane hardstanding, substation foundations, control building foundations and Overhead line tower foundations
- Transportation of materials within and to the site on unpaved roads

Emissions can vary substantially from day to day depending on the level of activity, the specific operations being undertaken, and the prevailing weather conditions.

Airborne dust from construction activities or land soiling, (that is where dust deposition has occurred which could be disturbed, particularly dust particles of ten microns in size or less (PM_{10}) and 2.5 microns in size or less ($PM_{2.5}$)), is the most important air pollutant that could impact on human beings. Dust of PM_{10} and $PM_{2.5}$ or less can enter the lungs and give rise to respiratory problems, illness and mortality. The potential for this type of air quality impact to occur is dependent on the proximity of the activity to the receptor, size and scale of the construction site and area of activities giving rise to dust, duration of activities and climatic factors.

Guidance on the assessment of the impact of dust has been published by the Institute of Air Quality Management. The Guidance states that an assessment will normally be required where there is a human receptor within:

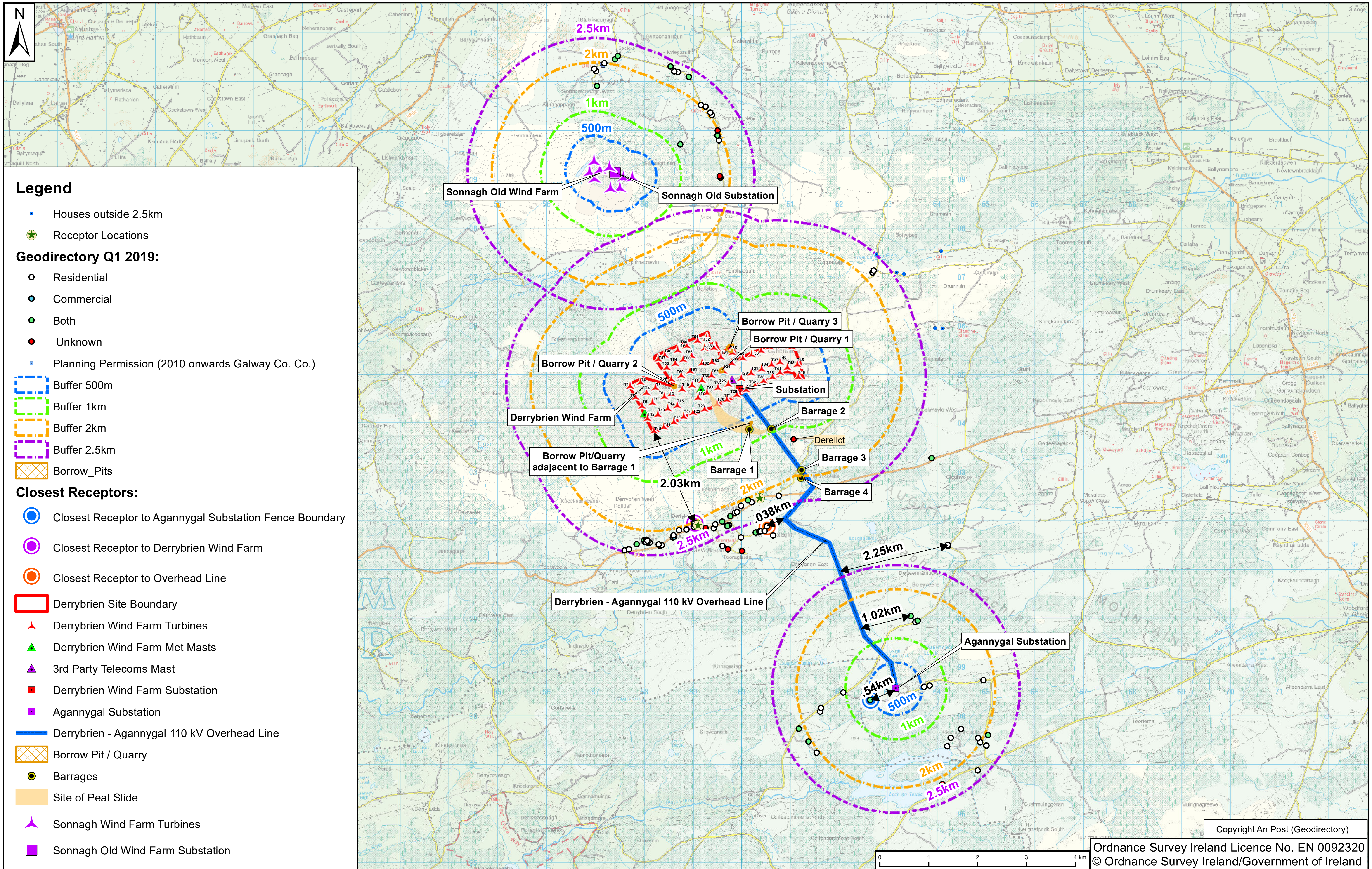
- 350m from the boundary of a site
- 50m of the route(s) used by construction vehicles on the public highway within 500m of the site entrance

Where no human receptors are located within the stated distances then the risk of an impact is negligible and no significant impact will occur.

The distances considered take account of the exponential decline in the concentration of airborne dust and the rate of deposition on lands with distance from the source. The distances from the project site boundaries to the nearest receptors is shown on Figure 12-4The construction on the Derrybrien wind farm site occurred at specific locations within the site and involved site preparation, access track and hardstand construction, foundation excavations for the wind turbine generators, substation and control building and materials and turbine deliveries. All of these activities could give rise to airborne dust. However, the nearest residential dwellings are located well in excess of 350m from the wind farm site construction areas with the nearest occupied dwellings to the wind farm site itself located over 2km distance from the nearest wind turbine and there are no human receptors within 500m of the site entrance hence the risk of air borne dust or dust deposition on human receptors is **negligible and no significant impact** would have occurred during the construction phase of the wind farm site.

The grid connection would have required angle mast construction and the erection of intermediary wooden pole sets along its route. Erection of wooden pole sets involves excavation and insertion of the wooden pole to a depth of circa 2.5 m. Typically a wooden pole set is erected in less than a day and would not give rise to significant dust as the footprint of the excavation is circa $3m^2$. Angle masts are erected along the line length where a change in direction occurs. Their construction requires excavation of foundations, typically a $2m^2$ excavation for each leg of the mast with temporary stockpiling of material for subsequent reinstatement. The closest proximity of a construction location (an angle mast) on the 110kV overhead line to an occupied dwelling is 380m. Construction would have been over a very short duration with limited excavation and earth moving at a small focused site. The location of construction along the overhead line would also have been variable occurring at different sites in a progressive manner. The impact from dust arising from construction of this line would therefore have been of **negligible risk and no significant impact** would have occurred.

The Agannygal substation would have required site preparation, excavation of the foundation, stockpiling of materials and substation construction. Construction would have lasted a period of circa six months but activities giving rise to dust would be intermittent. The nearest dwelling to the Agannygal site construction is located circa 540m from the site, with the site entrance also located more than 500m from any dwelling. The potential risk of dust impact on the nearest dwelling is therefore **negligible and no significant impact** would have occurred.



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PURPOSE OF ISSUE - PRELIMINARY UNLESS INDICATED

CLIENT APPROVAL ☐ PLANNING ☐ TENDER ☐ CONSTRUCTION ☐ AS-BUILT ☐

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CLIENT: Gort Windfarms Ltd

PROJECT: Derrybrien Wind Farm Co. Galway

CONTRACT

PRODUCTION UNIT: Civil & Environmental Engineering

DRAWING TITLE: Figure 12.4- Air and Climate distance from project site boundaries to receptors

DRAWN	PRODUCED	VERIFIED	APPROVED	APPROVAL DATE
E.O'Shea	E.O'Shea	P.Kavanagh	J.Fitzpatrick	06/08/2020

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The operation of construction equipment gives rise to combustion emissions such as carbon dioxide, nitrogen oxides and sulphur oxides from combustion of fossil fuels. In terms of air quality these could give rise to respiratory at high concentrations.

Exhaust emissions from construction and delivery vehicles would have been localised at the individual construction sites and would have quickly dispersed in the atmosphere. Given that the nearest occupied dwellings to the wind farm site itself are located over 2km distance **no significant impact** would have occurred during the construction phase of the wind farm site.

As noted above, the closest proximity of a construction location on the 110kV overhead line to an occupied dwelling is 380m and construction would have been for a very short duration with limited excavation and earth moving at a small focused site and **no significant impact** would have occurred.

The nearest dwelling to the Agannygal site construction is located circa 540m from the site, with the site entrance also located more than 500m from any dwelling and **no significant impact** would have occurred.

12.4.2.2 Peat Slide and remedial works October 2003 to end 2005

The peat slide incident impacted primarily on the aquatic environment and did not give rise to significant airborne dust particles as the slip material was mainly wet peat and forest materials. However, peat deposition on lands effected by the slide did occur and this peat could potentially dry out giving rise to localised airborne dust. Wet peat was also deposited in the peat repositories but did not give rise to airborne dust. Excavation of material for barrage construction and construction of the barrages themselves would have given rise to localised dust and exhaust emissions from the plant and equipment used at the time but this would have been confined to the period of construction of the remedial peat slide measures. The potential for impact from this source is again dependent on the distance to the receptor, size and scale of the construction site and area of activities giving rise to dust, weather conditions and dispersion through the air.

In the case of the peat slide the nearest occupied dwellings to the slide area, to areas where material to construct the barrages were excavated and to the areas where the barrages were constructed are located in excess of 350m distance. As stated in Chapter 2, Section 2.8.2.5 barrages 1 and 2 will be left in situ and barrages 3 and 4 will be removed at decommissioning stage. These barrages are constructed mainly of well-graded coarse rock pieces from about 300mm up to typically 1,200mm in size and should not give rise to significant dust generation.

In addition, construction works associated with these remedial works were of short duration and the risk of air borne dust or dust deposition on human receptors would have been **negligible and no significant** impact would have occurred.

Combustion emissions such as nitrogen oxides and sulphur oxides from equipment used to undertake the remedial works arising from the peat slide could also impact on air quality. The exhaust emissions from remedial construction and delivery vehicles would have been very localised at the peat deposition areas and at the barrage sites and would have quickly dispersed in the atmosphere. Given that the nearest occupied dwellings these locations are well in excess of 500m **no significant impact** on air quality would have occurred during the remedial works.

12.4.2.3 Operation Phase 2006-mid-2020

Air quality at the Project location was identified as being of good quality in Section 12.3.1 above. During the operational phase of the wind farm the project has not given rise to significant emissions to atmosphere and thus no adverse impact on general air quality has arisen. None of the air quality parameters for which limits values are set have been affected by the development. The effect of operation to date on air quality was **not significant.**

It has had a beneficial effect in providing energy without emissions of recognised environmental pollutants through displacement of fossil fuel energy production with clean renewable energy. Fossil fuel combustion emissions can give rise to pollutant oxides of nitrogen (NOx), sulphur oxides(SOx), non methane volatile organic carbons (NMVOC), carbon monoxide (CO) and particulate matter (dust PM_{10} and $PM_{2.5}$) being released into the atmosphere. The displacement of fossil fuel generation would therefore reduce such emissions. The project consistently generates some 121,800 Megawatt hours (MWh) of clean renewable electricity annually which has had a **medium term significant positive benefit** in reducing pollutant discharges to air.

12.4.2.4 Transboundary Gas Emissions

Electricity generation from renewable sources such as Derrybrien Wind Farm rather than fossil fuel sources has facilitated the reduction in atmospheric pollutants.

Derrybrien Wind Farm does not give rise to air emissions. Each new MW of electricity potentially displaces SO_2 and NOx emissions compared to equivalent thermal generation plant.

Utilising the European Environment Agency, EMEP/EEA air pollution emission inventory guidebook 2019, EEA Tier 1 default emission factors for electricity production using gaseous fuel and assuming an annual displacement of fossil fuel from gaseous generation of 121,500MWh equivalent to the annual renewable generation from Derrybrien, the range of annual reduction in equivalent direct air emissions is set out in **Table 12-12.**

The wind farm development has had **a minor positive effect in the medium term** on transboundary air quality.

Table 12-12: Approximate Annual Equivalent Air Emissions Displaced

Pollutant	Displacement (tonnes per annum)		
	Average	Lower	Upper
NOx	38.93	6.56	80.92
CO	17.06	8.75	26.24
NMVOC	1.14	0.28	4.55
SO_X	0.12	0.07	0.17
PM2.5	0.39	0.19	0.59

12.4.3 Air Quality Impacts which are occurring

12.4.3.1 Air Quality

During the current operational phase of the wind farm the project has not given rise to significant emissions to atmosphere and no adverse impact on general air quality has arisen. The effect of the current operation on air quality is **not significant.**

The operation of the wind farm continues to have a beneficial effect in providing for energy without emissions of recognised environmental pollutants through displacement of fossil fuel energy production with clean renewable energy as described in 12.4.2.3 above.

12.4.3.2 Transboundary Gas Emissions

Each MW of electricity generated by the Project potentially displaces SO_2 and NOx emissions compared to equivalent thermal generation plant as described in section 12.4.2.4 above and continues to have **a minor positive effect** on transboundary air quality.

12.4.4 Air Quality Impacts which are likely to occur

12.4.4.1 Operation Phase 2020-2040

Given the rural location of the Project baseline air quality during the operational period is likely to remain good. The impacts of continued operation will be similar to that which occurred during operation to date from 2006-2020. **No negative significant** effects in terms of air quality are likely to arise as there will no significant works undertaken on site that would give rise to air pollutants.

12.4.4.2 Transboundary Gas emissions

The positive significant benefit to air quality from a reduction in emissions of NOx, CO, NMVOC, SOx and $PM_{2.5}$ through displacement of fossil fuel combustion for electricity generation will continue to the end of the project operational period. The effect of this will continue to be moderately **positive in the medium term** on transboundary air quality.

12.4.4.3 Decommissioning Phase 2040- circa 2042

Decommissioning of the wind farm, overhead line grid connection and substation is described in detail in Chapter 2, Section 2.8. The proposed decommissioning strategy envisages minimal decommissioning works. This is considered to be the best approach from the environmental perspective. Decommissioning of the wind farm will involve the removal of the above ground elements, including dismantling of the wind turbines and meteorological mast and demolition of the substation structure above ground. The overhead line above ground structures (wooden pole sets and steel towers) between Derrybrien wind farm and the Agannygal substation will also be removed. The reinforced concrete turbine bases, site access tracks, crane, substation and control building hardstanding area, site drainage network will all be left in-situ. On-site peat repository/storage areas from the construction stage and borrow pits will also be left in-situ.

The decommissioning operations will give rise to airborne dust generation to a limited extent and for a short period of time, mainly from the demolition of the substation and control building with potential to impact on air quality and thus on human beings.

As it is not intended to remove structure foundations and to confine decommissioning to above ground structures the potential for generation of dust related emissions will be low and confined mainly to the demolition of the substation and control building at the wind farm site. Given the distances to the nearest occupied dwellings (over 2km) the risk of airborne dust or dust deposition on human receptors is **negligible and no significant impact will occur** during the decommissioning phase of the wind farm site.

Similarly, decommissioning of the OHL will be confined to removal of conductors, towers and intermediate pole sets. The nearest occupied dwelling to a decommissioning location is at a distance of 380m and works will be of very short duration at a small focused site. The impact from dust arising from decommissioning of this line will be **of negligible risk and no significant impact** will occur.

The nearest dwelling to the Agannygal site decommissioning is located circa 540m from the site. The potential risk of dust impact on the nearest dwelling is therefore **negligible and no significant impact** will occur.

Decommissioning mitigation measures to prevent airborne dust will be put in place such as road and stockpile dampening and minimising the area of exposed stockpiles of demolition materials. A dust management plan will also be developed and implemented. Decommissioning will also be undertaken under a Health & Safety Plan with all employees provided with the appropriate PPE.

Given the large distances to the nearest occupied dwellings and the mitigation measures which will be put in place, **no significant impact** on air quality will occur.

Exhaust emissions from decommissioning equipment will be localised and short term at any given location and will quickly disperse in the atmosphere. Given that the nearest occupied dwellings to the wind farm site (over 2km) **no significant impact** is predicted to occur.

With regard to the decommissioning of works undertaken as part of the peat slide these are described in Chapter 2, Section 2.8.2. It is envisaged that Barrages 3 and 4 will be removed and that the following will remain in place after decommissioning:

- Access track at T68 – within the wind farm site
- Access track between T23 and T70 – within the wind farm site
- Barrage 1
- Barrage 2, associated repository area & access track
- Repository area at Barrage 3
- Repository area at the Black Bridge

Barrages 3 and 4 are comprised mainly of well-graded coarse rock pieces from about 300mm up to typically 1,200mm and their decommissioning will not give rise to significant dust emissions. Transport of the decommissioned barrage material to final storage locations adjacent to the wind farm site entrance will have the potential to generate dust. However, Barrage 3 is located circa 692m and Barrage 4 is located circa 564m from the nearest occupied dwelling and following the Institute of Air Quality Guidance the risk of dust emissions impacting on these locations is **negligible and no significant impact** will occur.

Following the closure of the wind farm it will no longer generate renewable electricity and its potential impact on air quality and greenhouse gasses in terms of loss of displacement of fossil fuel generation plant will be dependent on the extent to which Ireland has achieved its Climate Action Plan targets and the level of activity of such plants at that time. Its closure can be considered to be **negative, minor and permanent.**

12.4.5 Climate Change and Greenhouse Gas Emissions

This section describes the impacts on climate change which are likely to have occurred in terms of changes in greenhouse gas emissions resulting from the construction process, including the peat slide, the operational phase to 2020 and those which are likely to occur up to circa 2040 when decommissioning will take place.

12.4.6 Climate change impacts which have occurred

12.4.6.1 Climate change impacts during construction 2003-2006

Greenhouse gas emissions from the construction of the Project arise from the losses due to wind turbine lifecycle (manufacture, construction. transport and decommissioning), changes in peat carbon and forest felling activities resulting in loss of stored carbon and sequestration. This includes the wind farm itself and grid connection (Overhead line and Agannygal substation).

The lifecycle of wind turbines, (manufacture, construction activities and decommissioning) requires energy and fuel use giving rise to greenhouse gas emissions.

Allowances are also made for what is termed backup power. Because wind generated electricity is inherently variable, accompanying backup power is required to stabilise the supply to the consumer. The extra capacity needed for backup power generation is currently estimated to be 5% of the rated capacity of the wind farm.

Organic material such as peat contains carbon which can be released as carbon dioxide when peat decomposition occurs. Actively growing peatland habitats absorb CO_2 from the atmosphere and store significant quantities of carbon due to the extremely slow decomposition rate of dead peat material in the acidic waters of the peat habitat. Peat lands accumulate carbon because mean annual primary production exceeds annual organic matter decomposition. Essentially the peat bog acts as a sink converting atmospheric CO_2 to peat biomass. Carbon accumulation is mainly due to the slow decomposition rate that is sustained by high water levels and anoxic conditions (Clymo, 1987). When soils are aerated through a fall in groundwater level, the rate of aerobic decomposition increases such that emissions usually exceed plant fixation.

The development of a wind farm on peatland will result in the loss of stored carbon back into the atmosphere within the footprint of the wind farm itself and indirectly from drainage associated with the wind farm construction. Works which lead to peat material drying out, directly through excavation or indirectly through drainage will result in full decay of the dried peat with release of the stored carbon as CO_2.

It should be noted that the site had been previously drained for both turbary and afforestation which would have led to carbon losses from bare peat areas.

Forests also capture and store carbon during their actively growing period prior to harvesting, with a typical commercial lifecycle for coniferous forest stands of between thirty five and forty years. When forests are felled as part of a wind farm development, as in the case of the Project, the carbon sequestration and carbon stored in the forest will also be lost.

The peat slide which occurred at Derrybrien resulted in large quantities of peat being displaced, estimated at 450,000 m^3 which it is assumed resulted in complete decay of this peat and release of the stored carbon back into the atmosphere. Additionally, the peat slide area was afforested (estimated at 25ha) and the carbon sequestration potential of the standing forest and its stored carbon would also have been lost.

The following carbon losses have been estimated using the Scottish carbon calculator. It should be noted that the carbon calculator looks at carbon losses across the entire lifecycle of the project including any that would occur during the operational phase and decommissioning as these are then used to derive the overall carbon benefit from operation of the wind farm and the estimated carbon payback period. Details are provided in Appendix 12.1:

Wind turbine lifecycle carbon costs:

The lifecycle carbon costs of the wind turbines (manufacture, construction and decommissioning) installed on site has been estimated to be **33,314 tCO_2eq**

Back-up Power carbon costs:

The back-up power carbon losses have been estimated at **20,523 tCO_2eq**.

Peat carbon losses:

During the construction phase carbon losses have occurred due to CO_2 losses from removed and drained peat during excavation and drainage to facilitate construction. CO_2 losses due to the loss of the carbon fixing potential of actively growing peat has also occurred as the surface vegetation lost from areas excavated as a result of the construction of the wind farm infrastructure, both vegetation and peat, can no longer photosynthesise. As such, its capacity to fix carbon is lost. Drainage of the wind farm peatland also has significant effects on vegetation and its ability to fix carbon. Although drainage would have been in place for both forestry and turbary additional drainage was put in place for turbine foundations, access tracks, hardstand areas and substation areas.

The loss of carbon fixing potential of peat land is calculated from the area affected by the development (both directly via the removal of peat and indirectly by drainage), the annual gains due to the carbon fixing potential of the peat land and the time required for habitat restoration.

Lowering the water table by drainage may also reduce the potential for dissolved organic carbon (DOC) and particulate organic carbon (POC) retention within the soil. Leached carbon is however generally regarded as a small component of the total losses from the system (Nayak et al., 2010).

The expected carbon losses have been calculated using the Scottish Carbon calculator and indicate the following quantities:

Table 12-13: Estimated carbon losses from peat drainage and excavation

Source	Tons of CO_2 equivalent (tCO_2eq)
Losses from soil organic matter:	97,502*
Losses due to reduced carbon fixing potential	3,078
Losses due to DOC and POC leaching	<1

Note* includes impact of the peat slide

CO_2 saving due to habitat improvement

Habitat improvement refers to the improvement of degraded habitat during the lifetime of the wind farm resulting from active management measures such as blocking drains, reintroducing species and sometimes resurfacing areas with peat. As active bog restoration measures are not included in the preferred decommissioning plan outlined in Chapter 2 – Project Description there will be no impact from this source.

When flooded soils are drained, loss of carbon will increase gradually until a stable state is reached. Chapter 11, Section 1.3.3.2 states that

"*Over time the drains will likely fill in and revegetate naturally and become less effective over time. The wind farm site will therefore revert over time to a more natural drainage regime similar to its pre-wind farm Project baseline environment. By the time of decommissioning the groundwater levels on the site will have stabilised at a new equilibrium steady state condition. As the efficiency of the drains reduces in the long term a gradual partial restoration of groundwater levels on the site will occur*".

No peatland restoration was undertaken and hence all the peat associated carbon would be lost to the atmosphere except where borrow pits were restored which resulted in active peat growing, Carbon captured by these small areas amounts to circa **122 tCO_2 eq**.

The construction of the Project therefore resulted in the permanent loss of circa 100,459 tCO_2eq from peat sources (including the peat slide).

Losses of carbon from forest felling.

The area of forest felled, which included the forest plantation loss associated with the Overhead line, Agannygal substation, peat slide and repositories was, with the exception of segments of the OHL route, in Coillte commercial ownership. It has been assumed that the loss of carbon sequestration will be permanent and no replanting will occur on the site following decommissioning of the wind farm .

A total of 334.4ha of forest plantation has been clearfelled as part of the Project lifecycle. This includes felling during the construction period (221.9ha for the wind farm area itself, 34.7ha for the grid connection, 25ha associated with the landslide and 5.9ha associated with emergency works) and operational period (46.9ha felled to ensure efficient operation of the wind farm).

In order to fell the required forest plantation areas a Felling Licence (Licence Reference Number FL3983) was required from and granted by the Forest Service (now part of the Department of Agriculture, Food and the Marine). This Licence required the replanting of a total of 119.3 hectares of forest plantation comprising Sitka Spruce (55%), diverse conifers (30%) and broadleaved species (15%) in Counties Tipperary and Roscommon. This replanting, which occurred mainly on mineral type soils would have led to an active cycle of carbon sequestration in the newly planted areas which would partially offset the carbon lost from forestry felling activities over a period of time as the forest grew.

Additionally, the 46.9ha planted external to the site to facilitate operation was also felled under a Felling Licence and was replanted.

The total nett loss of forest plantation was therefore the total area felled (334.4) less the areas planted in lieu of the wind farm construction (119.3 ha) and the operational felling area 46.9, that is 168.2 ha. This has been accounted for in the Scottish carbon calculator.

The clearfelling of forest plantation for the project development and subsequent operation resulted in an estimated loss of carbon of **73,392 tCO_2eq.**

A small area of improved habitat, estimated at 0.88ha occurred as a result of revegetation of the borrow pits. This is estimated to have reduced carbon losses by **122 tCO_2eq.**

Total estimated carbon losses

The total carbon cost of constructing the Derrybrien Project (wind turbine lifecycle, backup power, peat carbon including the peat slide and forest clearfelling)was therefore **227, 688 tCO_2eq**.

12.4.6.2 Peat slide and remedial works

Effect of peat slide on carbon losses

The carbon costs of construction of Derrybrien in the absence of the peat slide which occurred in 2003 has also been estimated using the Scottish carbon calculator and the results are provided in Appendix 12.2. In terms of carbon loss from the peat slide itself as a result of the displacement of 450,000 tonnes of peat and 25ha of forestry in the 2003 landslide this gave rise to an estimated CO_2 loss of **72,558 tCO2 eq. which has been included in the total carbon cost of the windfarm development**

The total carbon costs of the wind farm development from construction to decommissioning, in the absence of the peat slide is estimated at **155,130 tCO_2eq.**

12.4.6.3 Climate change impacts Operational Phase 2006-2020

Offsetting CO_2 from thermal power generation

The Scottish Natural Heritage carbon calculator has been used to estimate the carbon costs for the construction of the wind farm, grid connection and decommissioning including forest felling during the operational period. This must be offset against the carbon savings from operation of the wind farm and its displacement of fossil fuel electricity generation in Ireland.

The wind farm generates electricity by harnessing the wind and supplies the power generated to the national Electricity Network. The wind farm was commissioned in 2006 and has to date (mid 2020) generated circa 1,897,000 MWh of clean renewable electricity. Based on experience to date, it is anticipated that the wind farm will continue to generate approximately 121,500 MWh of electricity annually but this will be dependent on climatic factors. The pay back period of the wind farm carbon budget has been estimated using the Scottish Carbon Calculator Tool based on a grid mix of electricity generation and a fossil fuel mix of energy generation on the UK Grid which is the inherent data the calculator utilises.

It has also been estimated using the EU Fossil Fuel Comparator, the iSEM Mid merit plant value for Ireland and based on a demand following Combined Cycle Gas Turbine (CCGT) in Ireland. The estimated carbon payback period through renewable energy generation of the wind farm and displacement of fossil fuel based generation is provided in Table 12-14.

Table 12-14: Estimated Carbon Payback Period

	Emission Factor $kgCO_2eq/MWh$	Annual tCO_2eq avoided	Estimated carbon payback excluding peat slide Years	Estimated carbon payback including peat slide Years
SNH Calculator	UK Coal fired electricity generation		1.4	2.0
SNH Calculator	UK Grid mix of electricity generation		5.0	7.3
SNH Calculator	UK fossil fuel mix of electricity generation		2.8	4.1
EU Fossil Fuel Comparator	658	79,947	1.9	2.8
iSEM Mid Merit Plant	453	55,040	2.8	4.1
Demand following CCGT	400	48,600	3.2	4.7

In reality Derrybrien wind farm will displace a fossil fuel generator in Ireland. Variable renewable energy generators such as wind primarily displace electricity from the last fossil fuel plant dispatched to meet electricity demand, also known as the marginal generator. In Ireland these are mostly assumed to be gas generators (*Sustainable Energy Authority of Ireland, Renewable Energy Generation in Ireland 2019 Report*).

It would have been unlikely to have displaced coal electricity generation from Moneypoint , which was a baseload station and was operating consistently or to have displaced peat from the Midland peat stations as these were operating under a Public Service Obligation and would have been prioritised to generate electricity.

Based on the displacement of gas generated electricity the carbon pay back period for Derrybrien wind farm including the peat slide would be circa 4.7 years in a worst case scenario.

It should be noted that if the peat slide had not occurred the carbon payback period would have been shorter, circa 3.2 years.

The wind farm became fully operational (commissioned) in 2006 and since mid-2010, the approximate time when carbon payback for its construction would have occurred, has been displacing circa 48,600 tonnes of CO_2 equivalent annually from fossil fuel generation plant through the generation of circa 121,800 MWh annually of clean renewable electricity to the grid . The impact of this on reducing greenhouse gas emissions has been **positive and moderately significant in the medium term**.

The operational impact of the wind farm has therefore been positive overall, of moderate significance and medium term in nature.

Sulphur hexafluoride (SF_6) loss

As noted in Chapter 2 Project Description, SF_6 gas is used in circuit breaker and capacitor equipment within Derrybrien Substation within the wind farm site. Sulphur hexafluoride is the most potent greenhouse gas known with a greenhouse gas warming potential of 23,800 and when released into the atmosphere will only be removed exceedingly slowly due to its atmospheric lifetime in excess of circa 800 years. There was an accidental release of SF_6 from the outdoor switchgear at Derrybrien Substation in 2015. This comprised the initial loss of 8.1kg SF6 from the switchgear pipework. Repair of the switchgear was undertaken and the switchgear was refilled with SF_6. The initial repair to the switchgear failed and there was a further 8.1kg of SF_6 lost. The total SF_6 lost was therefore 16.2 kg. Thereafter the switchgear was replaced. There has been no further loss of SF_6.

The SF_6 loss represented a CO_2 equivalent loss of circa 370 tCO_2eq. This represents less than 1% of the CO_2 displacement by the wind farm for a single year of operation.

The impact of the loss of SF_6 on the carbon displacement potential of the wind farm was negative, imperceptible and long term in nature.

12.4.6.4 Estimated carbon pay back period using Irish derived CO_2 soil losses

An additional assessment of carbon loss and carbon pay back period has been carried out using typical peat carbon storage from Irish peat bogs. Holden & Connoly (2011) & Milne & Brown (1997) estimated that the mass of carbon stored in blanket peat is of the order of 0.055 tonnes/m3 This is equivalent to 0.2 tonnes CO_2 /m^3 if fully oxidised by decomposition.

The total volume of peat excavated for the turbines, crane hardstandings, substation and borrow pits was approximately 185,000m^3 with circa 450,000m^3 of peat displaced in the peat slide at the site in October 2003. Where all of this peat is assumed lost due to decomposition on exposure, which is very conservative (there is still approximately 200,000m3 of disturbed peat within the slide area, See Chapter 10), then this would be equivalent to releasing 127,000 tonnes of CO_2 into the atmosphere from peat soil loss.

Using this estimated loss of peat CO_2 and combining with the CO_2 equivalent losses from forest clearfelling and drainage as derived from the Scottish Calculator the carbon payback period of the wind farm increases slightly as indicated in

Table 12-15: Estimated Carbon Payback Period using estimated Irish peat carbon content.

	Emission Factor kgCO_2eq/MWh	Annual tCO_2eq avoided	Estimated carbon payback wind farm only Years	Estimated carbon payback including peat slide Years
EU Fossil Fuel Comparator	658	79,947	2.0	3.2
iSEM Mid Merit Plant	453	55,040	3.0	4.7
Demand following CCGT	400	48,600	3.4	5.3

Based on the displacement of gas generated electricity the carbon pay back period for Derrybrien wind farm including the peat slide would be circa 5.3 years in a worst case scenario.

It should be noted that if the peat slide had not occurred the carbon payback period would have been shorter, circa 3.4 years.

The wind farm became fully operational (commissioned) in 2006 and under this scenario would have been displacing circa 48,600 tonnes of CO2 equivalent annually from fossil fuel generation plant through the generation of circa 121,800 MWh annually of clean renewable electricity to the grid since mid 2011 . The impact of this on reducing greenhouse gas emissions would also have been **positive and moderately significant in the medium term**.

The operational impact of the wind farm has therefore been **positive overall, of moderate significance and medium term in nature.**

12.4.7 Climate impacts that are occurring

12.4.7.1 Climate change

The Project will continue to displace CO_2 from thermal power generation at a rate of circa 0.4 tCO_2eq for every MW of clean renewable electricity produced to the grid continuing to make a positive contribution to the reduction of greenhouse gases and contributing towards Ireland Climate Action Plan targets.

12.4.8 Climate Impacts which are likely to occur

12.4.8.1 Operation 2020- circa 2040

In the period 2020 to 2040 only very minor greenhouse gas emissions will arise from operational maintenance of the wind farm from a very small number of vehicle emissions associated with such activities. The Project will continue to generate circa

121,500 MWh of renewable electricity displacing circa 48,600 tCO_2eq annually from thermal electricity generation, likely to be gas generation. The continued production of renewable electricity will contribute to meeting Ireland's obligations under the Renewable Energy Directive, to decarbonising the Energy Sector and to achievement of the Government's ambitious targets set in the Government's Climate Action Plan.

The effect of the wind farm on climate change through reduction of greenhouse gases during this phase of operation will continue to be positive in terms of effect on climate change, of moderate significance and medium in term

12.4.8.2 Decommissioning

It is envisaged that only above ground infrastructure will be removed including turbine decommissioning. The CO_2 cost of decommissioning of the wind turbines, substation and grid connection has been taken account of in Scottish CO_2 calculator and has been accounted for in the carbon pay back period for the wind farm.

When the wind farm finally ceases operation and is decommissioned it will no longer generate renewable electricity and its carbon displacement potential will be lost. **The effect on reducing greenhouse gases linked to climate change from electricity generation will be negative, immediate and of medium term** as it would be expected that alternative renewable generation would be developed to ensure the national greenhouse gas reduction targets are adhered to.

12.4.9 Resilience to Climate Change

As described in 12.3.5 above, the main climate changes envisaged in Ireland relate to changes in rainfall patterns, changes in temperature, changes in sea rise and changes in the frequency of extreme storm events. None of the identified climate change trends listed is likely to affect the Wind Farm with the exception of increased windstorms. Breaking mechanisms installed on turbines allow them to be operated only under specific wind speeds and should severe windstorms be experienced then the turbines would be shut down. Therefore, it is concluded that the project is not vulnerable to climate change effects.

12.5 Cumulative Impacts

Cumulative impacts on the environment can occur from the Project Activities coinciding with other activities in the areas giving rise to a cumulative effect This section provides an assessment of the cumulative impacts which have occurred, which are occurring during the current operational phase and which are likely to occur in the future.

12.5.1 Cumulative impacts which have occurred

12.5.1.1 Turbary within and immediately adjacent to the wind farm

Domestic turf cutting (peat extraction) under turbary rights has historically been and continues to be carried out on drained turbary lands within the eastern part of the site, occupying approximately 67ha. Turbary lands also extend immediately beyond the site to the east covering an area of approximately 16ha. In general, turbary requires drainage of bog lands and harvesting of sod turf and domestic turf cutting is regarded as having a very high impact on the carbon store and carbon sink properties of peat lands (*Renou-Wilson F, et al., EPA Strive Report No 75. BOGLAND: Sustainable Management of Peatlands in Ireland*”). As stated in Chapter 2, Section 2.5. “In recent years a contractor has been retained by some plot owners to mechanically cut turf and there has been an increase in the number of plots where turf cutting has been carried out”. There would therefore have been a cumulative **negative, minor impact in the medium term** on carbon storage and loss from turbary operations during the construction phase of Derrybrien. Once the carbon cost payback period of the wind farm had been achieved in circa 2009 there would be **no further cumulative** impact.

12.5.1.2 Peat extraction outside Project site

Peat extraction outside the Project site also occurs but appears to be confined to turbary turf cutting and not to any licensable activity. It is therefore localised and small in scale and a **minor cumulative negative, impact** on carbon storage and loss **would have occurred in the medium term**. Again, once the carbon cost payback period of the wind farm had been achieved in circa 2013 there would be no further cumulative impact.

12.5.1.3 Wind farms in the Slieve Aughty Mountains

Sonnagh Old Wind Farm:

Sonnagh Old Wind Farm is located 3.4 km north west of Derrybrien wind farm within the Slieve Aughty Mountains and was commissioned circa one year before Derrybrien Wind Farm (2004). This wind farm comprises 9 no. Vestas V52-850KW turbines (same turbine model as at Derrybrien Wind Farm).

The construction of Sonnagh Old Wind Farm coincided with construction activity for Derrybrien Wind Farm in 2003-2005. There would therefore be some potential for cumulative air quality impacts during the construction phase but given the separation distances of the two wind farms this would be very **unlikely and any effect would be imperceptible and temporary in nature**.

The Sonnagh Old Wind Farm turbines are similar to those installed at Derrybrien and the nine turbines have a rated output of 7.65MW. Assuming an average capacity factor of 32% the Sonnagh wind farm generates circa 22,000 MWh of renewable electricity each year. **Along with other wind farms in operation nationally the cumulative effect with Sonnagh wind farm would have been positive, of moderate significance and medium term in nature**.

The cumulative impact of the operation of Derrybrien and Sonnagh Old Wind Farms on the transboundary aspects of air quality through emission reduction of air pollutants by the displacement of fossil fuel combustion would **have been positive, slight and medium term.**

12.5.1.4 Keeldeery Wind Farm:

Keelderry Wind Farm site is located approximately 3km to the west of the Derrybrien Wind Farm site in an unforested area of Slieve Aughty Mountain. However, the wind farm was never developed although some initial construction works were undertaken (see Chapter 1). On foot of planning permission granted, internal access roads were constructed circa 2007 but the rest of the development was never constructed. Subsequent to this an application for a redesigned wind farm layout, with fewer, larger wind turbines, was refused on appeal by An Bord Pleanála and no further development occurred on the Keelderry site. No significant cumulative impact with Derrybrien wind farm would have occurred during construction and no cumulative impact occurred during the operational phase.

12.5.1.5 Forestry

As described in Chapter 1, Section 1.5.1.3 the Slieve Aughty Mountains and particularly the Derrybrien area has extensive commercial coniferous forest cover. This commercial forest cover undergoes periodic clear felling and replanting in the normal lifecycle of such forests.

Clearfelling and product harvesting will give rise to some localised air quality impact from harvesting and transport vehicles during the operational life of the Derrybrien wind farm. **The impacts will be localised, imperceptible and temporary in nature.**

Clearfelling associated with the construction and initial operation of Derrybrien wind farm would have been cumulative with the normal planned lifecycle operations of commercial forestry. The carbon costs of the Derrybrien wind farm site forest clearfelling has been accounted for in the carbon payback period. In the normal lifecycle of commercial forestry in Ireland the impact would **be neutral in the medium term**.

12.5.1.6 Areas planted in lieu of felling

Felling Licence 2003

Coillte replanted 119.3 hectares of forest on circa 150 ha of sites in counties Roscommon and Tipperary. The total site areas include access tracks, fire breaks and some natural unplanted areas. The trees were planted primarily on acid mineral soils with only a very small proportion being planted on peat soil and carbon sequestration by the growing plantation would have commenced without significant loss of carbon dioxide from land use change. The carbon sequestration of the 119.3 ha of forest plantation planted in lieu of the felling at Derrybrien has reduced the net loss of forest plantation overall see Section 12.4.6.1 above) and the effect has been **positive, significant and long term**.

12.5.1.7 Overhead Transmission Lines

The Moneypoint - Oldstreet 400 kV Overhead Line (OHL) (commissioned in 1984, is 102.5 km long, and runs from the Moneypoint substation in Kilrush, Co. Clare to the Oldstreet substation in Portumna, Co. Galway) was developed prior to the development of the Derrybrien Wind Farm Project. **No cumulative impact** during the construction stage of Derrybrien would have occurred.

The Ennis - Shannonbridge 110kV Overhead Line was installed in 1952 with some further structures installed in 1968. Construction works on this line did not coincide with the Derrybrien grid connection works. However, the construction of Agannygal Substation resulted in the line being split into two circuits: Agannygal - Shannonbridge (Galway West) and Agannygal - Ennis (Galway West). This would have required temporary diversion of the line and the installation of new tower structures which would have given rise to **insignificant air quality cumulative effects of short duration** from dust generation.

12.5.1.8 Gort Regional Water Supply Scheme

The Gort Regional Supply Scheme extracts water for treatment and public supply from the Gort/ Cannahowna River. There are no emissions to air associated with this scheme and **no cumulative impact** with Derrybrien Wind Farm has or will occur.

12.5.1.9 Flood Relief Schemes

A number of flood relief schemes have either been implemented or planned in the general area. These include the OPW flood relief scheme in Gort completed in 1997 the local flood relief works at Kiltartan completed in 2012 by Galway County Council, temporary flood relief works at Kinvarra in December 2015 and the proposed Gort Lowlands Flood Relief Scheme, which is currently at preliminary engineering and feasibility stage in advance of planning. Given the location of these schemes and distance to Derrybrien Wind Farm **no cumulative impact** has occurred or is likely to occur in the future.

12.5.1.10 M18 Motorway Project

The M18 motorway project was planned and constructed after the Derrybrien Wind Farm Project was developed. **No cumulative impacts** occurred during the construction phase of the Derrybrien Wind Farm Project. Construction of the M18 was ongoing up until September 2018 during which time the Derrybrien wind farm was operational and **no cumulative impacts on air** quality would have occurred given the large separation distance to the M18.

12.5.1.11 Quarries/Sand extraction

There are a number of quarry/sand extraction activities located in the general vicinity of Derrybrien Wind with potential for cumulative effects to occur.

Planning permission for sand extraction at Cloghvoley was granted (GCC Ref. Ref. 08/1664) in May 2008 after the wind farm project was developed. **No cumulative** impact with this quarry occurred.

The Coillte Quarry, located just east of the junction between the R353 and the Black Road, to the south-east of the project site, was registered in 2005 with Galway County Council and is a relatively small (1.8 ha) aggregate quarry with an extraction area of 1.3 ha. Some aggregate from this quarry may have been used historically on the Derrybrien wind farm site. During the construction period there would have been potential for **cumulative insignificant negative localised air quality effects** form the quarries operation.

Ballinakill Quarry is operated by Ballinakill Quarries Ltd at Cregg on the R353 in accordance with its substitute consent permission granted by An Bord Pleanála for works and operations undertaken prior to August 2012 (Ref. 07.SU0038). A rEIS and rNIS were submitted with the application setting out mitigation measures to ensure no significant adverse impacts from the quarries operation occurs and which are required to be implemented as part of the permission. **No significant cumulative impacts** with Derrybrien Wind Farm during the operational phase is likely to have occurred or will occur in the future. Although it supplied material for construction of the Derrybrien wind farm **no significant cumulative impacts** with this quarry will have occurred during the construction phase given the separation distance from the project to the quarry site.

12.5.1.12 Works to Beagh Bridge

Repair works to the privately owned four-span Beagh Bridge at the outlet of Lough Cutra were undertaken in January 2005. This bridge is located circa 11.8km to the southwest of the windfarm boundary and given the large separation distance **no significant cumulative impact on air or climate** would have occurred during the Derrybrien construction phase.

12.5.2 Cumulative impacts which are occurring

12.5.2.1 Turbary within and immediately adjacent to the wind farm

Domestic turf cutting (peat extraction) under turbary rights is ongoing during the operational phase of the wind farm but as the project has paid back its carbon cost budget there is **no cumulative impact** with the Project.

12.5.2.2 Peat extraction outside Project site

Peat extraction outside the Project site is also occurring **but no cumulative impact** is occuring.

12.5.2.3 Wind farms in the Slieve Aughty Mountains

Sonnagh Old Wind Farm:

The cumulative impact of the operation of Derrybrien and Sonnagh Old Wind Farms reducing Greenhouse Gas emissions is cumulatively **positive and moderate in the medium term**.

Similarly with respect to transboundary aspects of air quality the cumulative impact is **positive, slight and medium term.**

Keeldeery Wind Farm:

As the Keelderry Wind Farm was never developed to operational stage no cumulative impacts are occuring.

12.5.2.4 Forestry

No clearfelling of forests to facilitate the current operation of Derrybrien wind farm is required and **no negative cumulative impact** from such clearfell will occur.

Carbon sequestration is continuing in the forest plantations in the general area of Derrybrien which is **cumulatively positive moderate in nature**.

12.5.2.5 12.5.1.6 Overhead Transmission Lines

No overhead line refurbishment works are currently underway although refurbishment works are planned to be undertaken on the Moneypoint - Oldstreet 400 kV Overhead Line (OHL) in 2020. No cumulative impact is occurring.

12.5.2.6 Gort Regional Water Supply Scheme

No cumulative impacts with the Gort Regional Supply Scheme are occurring.

12.5.2.7 Flood Relief Schemes

No cumulative impacts with Flood Relief Schemes are occurring.

12.5.2.8 M18 Motorway Project

No cumulative impacts on air quality are likely to occur given the large separation distance to the M18.

12.5.2.9 Quarries/Sand extraction

No cumulative impact with this Cloghvoley quarry is occurring.

It is **unlikely that any cumulative** impacts from the operation of the Coillte Quarry is occuring with the operation of the Project given its small scale.

12.5.2.10 Works to Beagh Bridge

No cumulative impact Beagh Bridge location is occurring from any works undertaken at this bridge site.

12.5.3 Conclusion on Cumulative impacts which are occuring

Cumulative positive effects on reduction of emissions of transboundary air pollutants and displacement of fossil fuel electricity generation with consequent reduction in emissions of greenhouse gases are occuring.

The effect of cumulative operation is positive, ongoing and moderate in nature.

12.5.4 Cumulative impacts which are likely to occur

12.5.4.1 Turbary within and immediately adjacent to the wind farm

Domestic turf cutting (peat extraction) under turbary rights is likely to continue during the operational phase to circa 2040 and during the decommissioning phase to circa 2042 but as the project would have paid back its carbon cost budget there would be **no cumulative impact** with the Project.

12.5.4.2 Peat extraction outside Project site

Peat extraction outside the Project site would also likely occur for the remainder of the Project lifecycle **but no cumulative impact** is likely to occur.

12.5.4.3 Wind farms in the Slieve Aughty Mountains

Sonnagh Old Wind Farm:

The cumulative impact of the operation of Derrybrien and Sonnagh Old Wind Farms reducing Greenhouse Gas emissions will continue to be cumulatively **positive and moderate in the medium term**.

Similarly with respect to transboundary aspects of air quality the cumulative impact will continue to be **positive, slight and medium term.**

Keeldeery Wind Farm:

As the Keelderry Wind Farm was never developed to operational stage no cumulative impacts will occur.

12.5.4.4 Forestry

Clearfelling of forests to facilitate the operation of Derrybrien wind farm will not be required to the end of circa 2040 and **no negative cumulative impact** from such clearfell will occur.

Carbon sequestration will continue in the forest plantations in the general area of Derrybrien which will be **cumulatively positive moderate in nature and** for the operational period of the wind farm.

12.5.4.5 12.5.1.6 Overhead Transmission Lines

Refurbishment works are planned to be undertaken on the Moneypoint - Oldstreet 400 kV Overhead Line (OHL) in 2020 on foot of planning permissions received from Clare County Council (CCC) (Reference 16/1011) and Galway County Council (GCC) (Reference 16/1747). All structures on the overhead line will be refurbished. The Derrybrien-Agannygal 110kV OHL passes under the Moneypoint to Woodlands 400kV OHL at co-ordinates Easting - 562119, Northing -700626 and there is therefore some potential for cumulative effect during the refurbishment works, such as a temporary brief outage of the Derrybrien grid connection to accommodate works, leading to a brief curtailment of the wind farm operation. The effect will be **slightly negative, insignificant and brief in duration**.

The Ennis – Agannygal 110kV circuit is scheduled to be refurbished in 2023/2024 and a planning application for the works will be made in advance of the works. Refurbishment will likely require a temporary line outage and could negatively affect the export of renewable electricity from Derrybrien Wind Farm into the national grid but this would be **slightly negative of short duration and insignificant** in effect overall.

12.5.4.6 Gort Regional Water Supply Scheme

No cumulative impacts with the Gort Regional Supply Scheme are likely to occur.

12.5.4.7 Flood Relief Schemes

No cumulative impacts with Flood Relief Schemes are likely to occur

12.5.4.8 M18 Motorway Project

No cumulative impacts on air quality are likely to occur given the large separation distance to the M18.

12.5.4.9 Quarries/Sand extraction

No cumulative impact with this Cloghvoley quarry is likely to occur

It is **unlikely that any cumulative** impacts from the operation of the Coillte Quarry will occur with the continued operation of the Project given its small scale.

Given the distance of the Project to the Ballinakill Quarry it is **unlikely that any** cumulative impacts on air quality during the decommissioning phase of the project will occur

12.5.4.10 Works to Beagh Bridge

Given the distance from the Project to the Beagh Bridge location **no cumulative** impact would likely occur from any works undertaken at this bridge site up to circa 2040.

12.5.5 Conclusion on Cumulative impacts which are likely to occur

Cumulative positive effects on reduction of emissions of transboundary air pollutants and displacement of fossil fuel electricity generation with consequent reduction in emissions of greenhouse gases will continue until the wind farm is decommissioned.

The effect of cumulative operation will be positive, medium term and moderate in nature.

12.6 Remedial (Mitigation) Measures and Monitoring

12.6.1 Remedial Measures/Monitoring for significant effects

Following the SF_6 leakage in 2015, the switchgear was replaced. There has been no further loss of SF_6. Routine maintenance checks will be made on this equipment to minimise the potential for leakages of SF_6 in future.

12.6.2 Mitigation Measures for non-significant effects

Decommissioning mitigation measures to prevent airborne dust will be put in place such as road and stockpile dampening and minimising the area of exposed stockpiles of demolition materials.

A dust management plan will also be developed in advance of the site decommissioning and be implemented.

Decommissioning will also be undertaken under a Health & Safety Plan with all employees provided with the appropriate PPE.

12.7 Residual Impacts

Given the large distances to the nearest occupied dwellings and the mitigation measures proposed to control dust during decommissioning no significant residual impacts will occur.

The Derrybrien wind farm has fully paid back the carbon cost of constructing the wind farm since circa mid- 2013. It annually produces circa 121,800 MWh of renewable electricity continuing to displace fossil fuel generators on the system reducing greenhouse gas and transboundary air pollutant emissions and avoiding the need to import fossil fuel and its associated costs. The residual impact can therefore be said to be **positive, of moderate significance and medium term in duration**.

12.8 Conclusion

During the construction phase of the Project, including the period when the peat slide event occurred, localised air quality impacts would likely have occurred from dust generation and from vehicle emission exhausts at the construction sites at the wind farm itself, along the overhead line route and at the Agannygal Substation site. However, these would have been of short duration and given the distances from construction activity locations to the nearest occupied dwellings **no significant impacts** are predicted to have occurred.

In terms of greenhouse gas emissions and climate change, the carbon costs of constructing the wind farm have been estimated at **227,688 tons of CO_2** largely due to carbon losses from peat displaced or drainage requirement and forest felling required for construction. Based on the annual renewable electricity production of Derrybrien Wind Farm and the estimated annual carbon fossil fuel electricity generation displacement saving the carbon costs required circa 7.4 years of operation to offset. The Derrybrien wind farm has fully paid back the carbon cost of constructing the wind farm since circa mid- 2013. It annually produces circa 121,500 MWh of renewable electricity continuing to displace fossil fuel generators on the system reducing greenhouse gas and transboundary air pollutant emissions and avoiding the need to import fossil fuel and its associated costs. The overall impact can therefore be said to be **positive, of moderate significance and medium term** in duration.

In terms of cumulative impact with other projects no significant negative impacts have been identified. Cumulatively with Sonnagh Old windfarm and other operational wind farms in Ireland the Project will continue to contribute to the positive significant impact in the medium term on air quality and greenhouse gas emission reduction through displacement of fossil fuel electricity generation. This will continue until such time as it is decommissioned, circa 2040.

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