Cover

CARBON CALCULATOR TOOL v . .

Help About...

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The Scottish Government Application Status Control

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Start Carbon Calculator

This tool calculates payback time for windfarm sited on peatlands using methods given in Nayak et al, 2008 (http://www.gov.scot/Publications/2008/06/25114657/0) and revised equations for GHG emissions (Nayak, D.R., Miller, D., Nolan, A., Smith, P. and Smith, J.U., 2010, Calculating carbon budgets of wind farms on Scottish peatland. Mires and Peat 4: Art. 9. Online: http://mires-and-peat.net/pages/volumes/map04/map0409.php

Admin

CARBON CALCULATOR TOOL v . . - APPLICATION STATUS CONTROL

Help

Reference Code: Search

Windfarm Name	Version	Methodology used for calculating emission factors	Status Date	Status
No data available in table				

PreviousNext

Selected:

Saved Signed-off Received Consented Refused Withdrawn
Revert to original status

Start

CARBON CALCULATOR TOOL v . .

- Will the site be drained on construction of the windfarm?
- Is the soil at the site highly organic?
- Does windfarm construction require a significant amount of deforestation?
  i.e. is removal in excess of keyholing the turbines within the forest boundary?

If you already have an Application Reference, type it here (or paste it in the first box):

Search

New application

CoreInput

Core input data
1. Windfarm characteristics 2. Peatland 3. Bog plants 4. Forestry Plantation 5. Emission factors 6. Borrow pits 7. Foundations and hard-standing 8. Access tracks 9. Cable trenches 10. Additional peat 11. Improvement actions 12. Restoration after decomissioning 13. Methodology & application details
Forestry input data
Construction input data

Save ☐ Signed off for submission

Note: Results are only available once ALL data are correct and complete, and a new version will be created.

New app...

Ref: MPRJ-W5M3-2KPG v

MENU≡

Help

Core input data | Forestry input data | Construction input data

Windfarm characteristics Page 1 of 12

Expected values	Minimum	Maximum
Dimensions		
Number of Turbines		
5		
Chapter 2 Project Description	5	5
Duration of consent (years)		
35		
Chapter 2 Project Description	35	35
Performance		
Power rating of 1 turbine (MW)		
5,6		
Chapter 2 Project Description	5,6	6,6
Capacity factor		
Direct input (% estimated capacity factor)	Direct input (% estimated capacity factor)	Direct input (% estimated capacity factor)
35		
Chapter 10 Air and Climate	34	36
Backup		
Fraction of output to backup (%)		
5		
SNH Calculator Guidance	5	5

Payback Time

1. Windfarm CO2 emission saving over...	Exp.	Min.	Max.
...coal-fired electricity generation (t CO2 / yr)	86,020	83,562	104,277
...grid-mix of electricity generation (t CO2 / yr)	16,601	16,127	20,125
...fossil fuel-mix of electricity generation (t CO2 / yr)	37,086	36,027	44,958
Energy output from windfarm over lifetime (MWh)	3,004,680	2,918,832	3,642,408

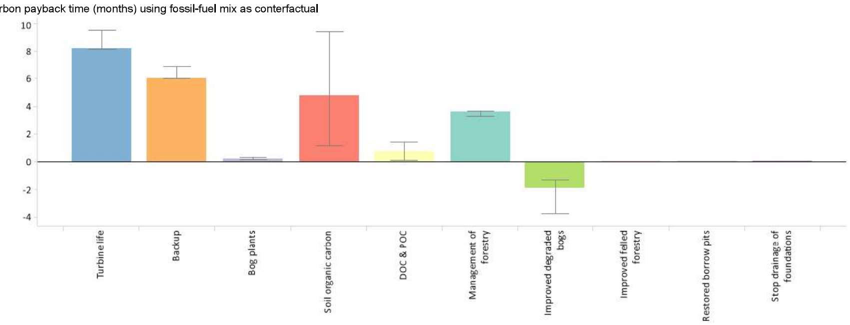
Total CO2 losses due to wind farm (tCO2 eq.)	Exp.	Min.	Max.
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	25,341	25,246	30,329
3. Losses due to backup	18,543	18,543	21,854
4. Lossess due to reduced carbon fixing potential	731	498	1,003
5. Losses from soil organic matter	14,691	3,801	32,121
6. Losses due to DOC & POC leaching	2,216	416	4,875
7. Losses due to felling forestry	11,074	10,331	11,396
Total losses of carbon dioxide	72,597	58,834	101,578

8. Total CO2 gains due to improvement of site (t CO2 eq.)	Exp.	Min.	Max.
8a. Change in emissions due to improvement of degraded bogs	-5,709	0	-7,612
8b. Change in emissions due to improvement of felled forestry	0	0	0
8c. Change in emissions due to restoration of peat from borrow pits	0	0	0
8d. Change in emissions due to removal of drainage from foundations & hardstanding	0	0	0
Total change in emissions due to improvements	-5,709	0	-7,612

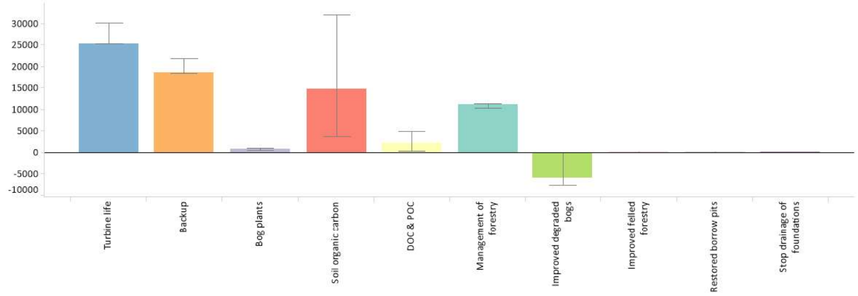
RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide (t CO2 eq.)	66,888	51,222	101,578
Carbon Payback Time			
...coal-fired electricity generation (years)	0.8	0.5	1.2
...grid-mix of electricity generation (years)	4.0	2.5	6.3
...fossil fuel-mix of electricity generation (years)	1.8	1.1	2.8
Ratio of soil carbon loss to gain by restoration (not used in Scottish applications)	2.96	0.55	No gains!
Ratio of CO2 eq. emissions to power generation (g/kWh) (for info. only)	22.26	14.06	34.80

Payback Time - Charts

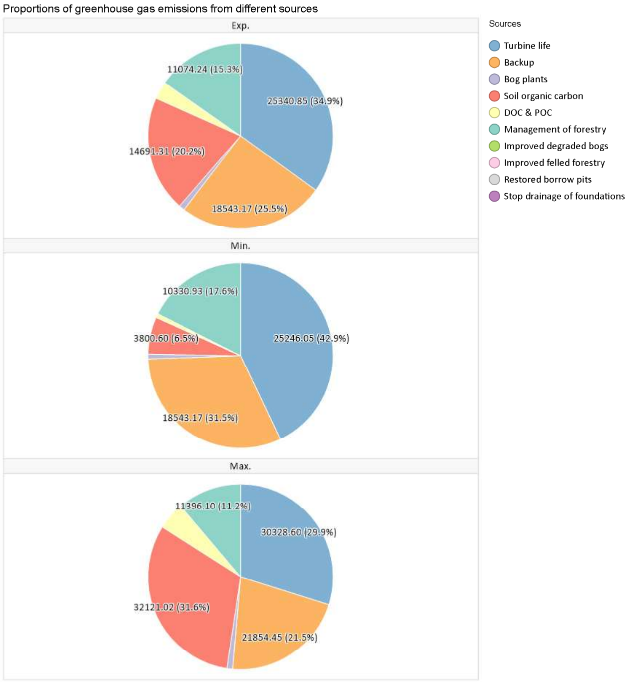
Carbon payback time (months) using fossil-fuel mix as conterfactual



Greenhouse gas emissions (t CO2 eq,)



Proportions of greenhouse gas emissions from different sources



View

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Carbon Calculator v1.7.0
Inchamore Wind Farm Location: 51.949379 -9.269362
Inchamore Wind DAC

Core input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm characteristics				
Dimensions				
No. of turbines	5	5	5	Chapter 2 Project Description
Duration of consent (years)	35	35	35	Chapter 2 Project Description
Performance				
Power rating of 1 turbine (MW)	5.6	5.6	6.6	Chapter 2 Project Description
Capacity factor	35	34	36	Chapter 10 Air and Climate
Backup				
Fraction of output to backup (%)	5	5	5	SNH Calculator Guidance
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10	10	10	Fixed
Total CO2 emission from turbine life (tCO2 MW^{-1}) (eg. manufacture, construction, decommissioning)	Calculate wrt installed capacity	Calculate wrt installed capacity	Calculate wrt installed capacity	
Characteristics of peatland before windfarm development				
Type of peatland	Acid bog	Acid bog	Acid bog	Chapter 5: Biodiversity
Average annual air temperature at site (°C)	9.975	9.7	10	Chapter 10 Air and Climate
Average depth of peat at site (m)	0.53	0	1.4	Chapter 8 Soils & Geology
C Content of dry peat (% by weight)	55	50	60	Default Value
Average extent of drainage around drainage features at site (m)	7.5	5	10	Chapter 9 Hydrology and Hydrogeology
Average water table depth at site (m)	0.5	0.1	1	Chapter 9 Hydrology & Hydrogeology
Dry soil bulk density (g cm^{-3})	0.1	0.09	0.11	Default Values
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	10	5	15	Best Practice from Bog Restoraton Ireland
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.25	0.24	0.26	Default Values
Input data / Forestry Plantation Characteristics	Expected value	Minimum value	Maximum value	Source of data
Area of forestry plantation to be felled (ha)	23.97	23	24	Chapter 2 Project Description
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	3.6	3.5	3.7	Cannell, 1999
Counterfactual emission factors				
Coal-fired plant emission factor (t CO2 MWh^{-1})	1.002	1.002	1.002	
Grid-mix emission factor (t CO2 MWh^{-1})	0.19338	0.19338	0.19338	
Fossil fuel-mix emission factor (t CO2 MWh^{-1})	0.432	0.432	0.432	
Borrow pits				
Number of borrow pits	1	1	1	Chapter 2: Project Description
Average length of pits (m)	414	413	415	Chapter 2: Project Description
Average width of pits (m)	93.41	92	93.41	Chapter 2: Project Description

5. Loss of soil CO2 (a, b)

Emissions due to loss of soil organic carbon
Loss of C stored in peatland is estimated from % site lost by peat removal (table 5a), CO2 loss from removed peat (table 5b), % site affected by drainage (table 5c), and the CO2 loss from drained peat (table 5d).

5. Loss of soil C02

	Exp.	Min.	Max.
CO2 loss from removed peat (t CO2 equiv.)	8408.28	154.75	22723.5
CO2 loss from drained peat (t CO2 equiv.)	6283.03	3645.85	9397.52
RESULTS			
Total CO2 loss from peat (removed + drained) (t CO2 equiv.)	14691.31	3800.6	32121.02
Additional CO2 payback time of windfarm due to loss of soil C...			
...coal-fired electricity generation (months)	2.05	0.55	3.7
...grid-mix of electricity generation (months)	10.62	2.83	19.15
...fossil fuel - mix of electricity generation (months)	4.75	1.27	8.57

CO_2 loss from removed peats
If peat is treated in such a way that it is permanently restored, so that less than 100% of the C is lost to the atmosphere, a lower percentage can be entered in cell C10.

5b. CO2 loss from removed peat

	Exp.	Min.	Max.
CO2 loss from removed peat (t CO2)	16204.00	6598.90	31756.41
CO2 loss from undrained peat left in situ (t CO2)	7795.72	6444.16	9032.91
RESULTS			
CO2 loss atributable to peat removal only (t CO2)	8408.28	154.75	22723.50

Volume of Peat Removed
% site lost by peat removal is estimated from peat removed in borrow pits, turbine foundations, hard-standing and access tracks. If peat is removed for any other reason, this must be added in as additional peat excavated in the core input data entry.

5a. Volume of peat removed

	Exp.	Min.	Max.
Peat removed from borrow pits			
Area of land lost in borrow pits (m2)	38671.74	37996	38765.15
Volume of peat removed from borrow pits (m3)	48339.68	18998	77530.3
Peat removed from turbine foundations			
Area of land lost in foundation (m2)	1890	1760	2167.5
Volume of peat removed from foundation area (m3)	567	176	1083.75
Peat removed from hard-standing			
Area of land lost in hard-standing (m2)	23700	18000	23750
Volume of peat removed from hard-standing area (m3)	14220	3600	33250
Peat removed from access tracks			
Area of land lost in floating roads (m2)	0	0	0
Volume of peat removed from floating roads (m3)	0	0	0
Area of land lost in excavated roads (m2)	17775	17770	21336
Volume of peat removed from excavated roads (m3)	10665	10662	12801.6
Area of land lost in rock-filled roads (m2)	0	0	0
Volume of peat removed from rock-filled roads (m3)	0	0	0
Total area of land lost in access tracks (m2)	17775	17770	21336
Total volume of peat removed due to access tracks (m3)	10665	10662	12801.6
RESULTS			
Total area of land lost due to windfarm construction (m2)	92966.74	86455	96948.65
Total volume of peat removed due to windfarm construction (m3)	80349.68	39993	131223.65

5. Loss of soil CO2 (c,d,e)

Volume of peat drained
Extent of site affected by drainage is calculated assuming an average extent of drainage around each drainage feature as given in the input data.

5c. Volume of peat drained

	Exp.	Min.	Max.
Total area affected by drainage around borrow pits (m2)	7836.15	5150	10568.2
Total volume affected by drainage around borrow pits (m3)	4897.59	1287.5	10568.2
Peat affected by drainage around turbine foundation and hardstanding			
Total area affected by drainage of foundation and hardstanding area (m2)	20167.5	12400	27750
Total volume affected by drainage of foundation and hardstanding area (m3)	6050.25	1240	19425
Peat affected by drainage of access tracks			
Total area affected by drainage of access track(m2)	53325	35540	71120
Total volume affected by drainage of access track(m3)	15997.5	10662	21336
Peat affected by drainage of cable trenches			
Total area affected by drainage of cable trenches(m2)	0	0	0
Total volume affected by drainage of cable trneches(m3)	0	0	0
Drainage around additional peat excavated			
Total area affected by drainage (m2)	2956.28	1931.5	4020.24
Total volume affected by drainage (m3)	1773.77	1158.72	2412.37
RESULTS			
Total area affected by drainage due to windfarm (m2)	84284.93	55021.5	113458.44
Total volume affected by drainage due to windfarm (m3)	28719.11	14348.22	53741.57

CO_2 loss due to drainage
Note, CO2 losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new equations have been derived directly from experimental data for acid bogs and fens (see Nayak et al, 2008 - Final report).

5d. CO2 loss from drained peat

	Exp.	Min.	Max.
Calculations of C Loss from Drained Land if Site is NOT Restored after Decomissioning			
Total GHG emissions from Drained Land (t CO2 equiv.)	5791.74	2367.48	13005.58
Total GHG emissions from Undrained Land (t CO2 equiv.)	3066.07	1253.31	6884.98
Calculations of C Loss from Drained Land if Site IS Restored after Decomissioning			
Losses if Land is Drained			
CH4 emissions from drained land (t CO2 equiv.)	0	0	0
CO2 emissions from drained land (t CO2)	13350.73	7747.03	19968.69
Total GHG emissions from Drained Land (t CO2 equiv.)	13350.73	7747.03	19968.69
Losses if Land is Undrained			
CH4 emissions from undrained land (t CO2 equiv.)	227.74	132.15	340.63
CO2 emissions from undrained land (t CO2)	6839.96	3969.02	10230.53
Total GHG emissions from Undrained Land (t CO2 equiv.)	7067.71	4101.18	10571.16
RESULTS			
Total GHG emissions due to drainage (t CO2 equiv.)	6283.03	3645.85	9397.52

Emission rates from soils
Note, CO2 losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new equations have been thoroughly tested against experimental data (see Nayak et al, 2008 - Final report).

5e. Emission rates from soils

	Exp.	Min.	Max.
Calculations following IPCC default methodology			
Flooded period (days/year)	178	178	178
Annual rate of methane emission (t CH4-C/ha year)	0.04	0.04	0.04
Annual rate of carbon dioxide emission (t CO2/ha year)	35.2	35.2	35.2
Calculations following ECOSSE based methodology			
Total area affected by drainage due to wind farm construction (ha)	8.43	5.5	11.35

7. Forestry CO2 loss

CO_2 loss from forests - calculation using detailed management information
Forest carbon calculator (Perks et al, 2009)

Total potential carbon squestration loss due to felling of forestry for the wind farm (t CO2)	
Total emissions due to cleared land (t CO2)	
Emissions due to harvesting operations (t CO2)	
Fossil fuel equivalent saving from use of felled forestry as biofuel (t CO2)	
Fossil fuel equivalent saving from use of replanted forestry as biofuel (t CO2)	
RESULTS	
Total carbon loss associated with forest management(t CO2)	

Emissions due to forest felling - calculation using simple management data
Emissions due to forestry felling are calculated from the reduced carbon sequestered per crop rotation. If the forestry was due to be removed before the planned development, this C loss is not attributable to the wind farm and so the area of forestry to be felled should be entered as zero.

	Exp.	Min.	Max.
Area of forestry plantation to be felled (ha)	23.97	23	24
Carbon sequestered (t C ha-1 yr-1)	3.6	3.5	3.7
Lifetime of windfarm (years)	35	35	35
Carbon sequestered over the lifetime of the windfarm (t C ha-1)	126	122.5	129.5
RESULTS			
Total carbon loss due to felling of forestry (t CO2)	11074.24	10330.93	11396.1
Additional CO2 payback time of windfarm due to management of forestry			
...coal-fired electricity generation (months)	1.54	1.48	1.31
...grid-mix of electricity generation (months)	8	7.69	6.8
...fossil fuel - mix of electricity generation (months)	3.58	3.44	3.04

8. CO2 gain - site improvement

Gains due to site improvement
Note, CO2 losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new equations have been thoroughly tested against experimental data (see Nayak et al, 2008 - Final report).

Degraded Bog

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	11	0	11
Depth of peat above water table before improvement (m)	0.16	0	0.25
Depth of peat above water table after improvement (m)	0.1	0	0.05
2. Losses with improvement			
Improved period (years)	15	20	5
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.04	0.04	0.04
CH4 emissions from improved land (t CO2 equiv.)	99.075	0	132.1
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0	0	0
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	99.075	0	132.1
3. Losses without improvement			
Improved period (years)	15	20	5
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0	0	0
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	35.2	35.2	35.2
CO2 emissions from unimproved land (t CO2 equiv.)	5808	0	7744

Felled Forestry

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	0	0	0
Depth of peat above water table before improvement (m)	0	0	0
Depth of peat above water table after improvement (m)	0	0	0
2. Losses with improvement			
Improved period (years)	15	25	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.04	0.04	0.04
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0	0	0
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	0
3. Losses without improvement			
Improved period (years)	15	25	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0	0	0
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	35.2	35.2	35.2
CO2 emissions from unimproved land (t CO2 equiv.)	0	0	0

Borrow Pits

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	0	0	0
Depth of peat above water table before improvement (m)	0	0	0
Depth of peat above water table after improvement (m)	0	0	0
2. Losses with improvement			
Improved period (years)	24	29	18
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.04	0.04	0.04
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0	0	0
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	0
3. Losses without improvement			
Improved period (years)	24	29	18
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0	0	0
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	35.2	35.2	35.2
CO2 emissions from unimproved land (t CO2 equiv.)	0	0	0

Foundations & Hardstanding

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	0	0	0
Depth of peat above water table before improvement (m)	0	0	0
Depth of peat above water table after improvement (m)	0	0	0
2. Losses with improvement			
Improved period (years)	32.5	34.9	30
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.04	0.04	0.04
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0	0	0
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	0
3. Losses without improvement			
Improved period (years)	32.5	34.9	30
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0	0	0
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	35.2	35.2	35.2
CO2 emissions from unimproved land (t CO2 equiv.)	0	0	0

3. CO2 loss backup

Emissions due to backup power generation
CO2 loss due to back up is calculated from the extra capacity required for backup of the windfarm given in the input data.

Wind generated electricity is inherently variable, providing unique challenges to the electricity generating industry for provision of a supply to meet consumer demand (Netz, 2004). Backup power is required to accompany wind generation to stabilise the supply to the consumer. This backup power will usually be obtained from a fossil fuel source. At a high level of wind power penetration in the overall generating mix, and with current grid management techniques, the capacity for fossil fuel backup may become strained because it is being used to balance the fluctuating consumer demand with a variable and highly unpredictable output from wind turbines (White, 2007). The Carbon Trust (Carbon Trust/DTI, 2004) concluded that increasing levels of intermittent generation do not present major technical issues at the percentages of renewables expected by 2010 and 2020, but the UK renewables target at the time of that report was only 20%. When national reliance on wind power is low (less than ~20%), the additional fossil fuel generated power requirement can be considered to be insignificant and may be obtained from within the spare generating capacity of other power sectors (Dale et al, 2004). However, as the national supply from wind power increases above 20%, without improvements in grid management techniques, emissions due to backup power generation may become more significant. The extra capacity needed for backup power generation is currently estimated to be 5% of the rated capacity of the wind plant if wind power contributes more than 20% to the national grid (Dale et al 2004). Moving towards the SG target of 50% electricity generation from renewable sources, more short-term capacity may be required in terms of pumped-storage hydro-generated power, or a better mix of offshore and onshore wind generating capacity. Grid management techniques are anticipated to reduce this extra capacity, with improved demand side management, smart meters, grid reinforcement and other developments. However, given current grid management techniques, it is suggested that 5% extra capacity should be assumed for backup power generation if wind power contributes more than 20% to the national grid. At lower contributions, the extra capacity required for backup should be assumed to be zero. These assumptions should be revisited as technology improves.

Assumption: Backup assumed to be by fossil-fuel-mix of electricity generation. Note that hydroelectricity may also be used for backup, so this assumption may make the value for backup generation too high. These assumptions should be revisited as technology develops.

	Exp.	Min.	Max.
Reserve energy (MWh/yr)	12,264	12,264	14,454
Annual emissions due to backup from fossil fuel-mix of electricity generation (tCO2/yr)	530	530	624
RESULTS			
Total emissions due to backup from fossil fuel-mix of electricity generation (tCO2)	18,543	18,543	21,854

1. CO2 emission saving

Emissions due to turbine life
The carbon payback time of the windfarm due to turbine life (eg. manufacture, construction, decomissioning) is calculated by comparing the emissions due to turbine life with carbon-savings achieved by the windfarm while displacing electricity generated from coal-fired capacity or grid-mix.

Capacity factor calculated from forestry data

Area name	Value type	Capacity factor (%)	Wind speed ratio	Average site windspeed (m/s)	Annual theoretical energy output (MW / turbine yr)

Capacity factor - Direct input

	Exp.	Min.	Max.
Capacity factor (%)	35.0	34.0	36.0

	Exp.	Min.	Max.
Annual energy output from windfarm (MW/yr)			
RESULTS			
Emissions saving over coal-fired electricity generatio...	86,020	83,562	104,277
Emissions saving over grid-mix of electricity generati...	16,601	16,127	20,125
Emissions saving over fossil fuel - mix of electricity g...	37,086	36,027	44,958

2. CO2 loss turbine life

Emissions due to turbine life

The carbon payback time of the windfarm due to turbine life (eg. manufacture, construction, decomissioning) is calculated by comparing the emissions due to turbine life with carbon-savings achieved by the windfarm while displacing electricity generated from coal-fired capacity or grid-mix.

Calculation of emissions with relation to installed capacity

	Exp.	Min.	Max.
Emissions due to turbine frome energy output (t CO2)	4765	4765	5699
Emissions due to cement used in construction (t CO2)	1517	1422	1833

Direct input of emissions due to turbine life

	Exp.	Min.	Max.
Emissions due to turbine life (tCO2/windfarm)			

RESULTS

	Exp.	Min.	Max.
Losses due to turbine life (manufacture, construction, etc.) (t CO2)	25341	25246	30329
Additional CO2 payback time of windfarm due to turbine life			
...coal-fired electricity generation (months)	4	4	3
...grid-mix of electricity generation (months)	18	19	18
...fossil fuel - mix of electricity generation (months)	8	8	8

4. Loss CO2 fixing pot.

Emissions due to loss of bog plants
Annual C fixation by the site is calculated by multiplying area of the windfarm by the annual C accumulation due to bog plant fixation.

	Exp.	Min.	Max.
Area where carbon accumulation by bog plants is lost (ha)	17.73	14.15	21.04
Total loss of carbon accumulation up to time of restoration (tCO2 eq./ha)	41	35	48
RESULTS			
Total loss of carbon fixation by plants at the site (t CO2)	731	498	1003
Additional CO2 payback time of windfarm due to loss of CO2 fixing potential			
...coal-fired electricity generation (months)	0	0	0
...grid-mix of electricity generation (months)	1	0	1
...fossil fuel - mix of electricity generation (months)	0	0	0

6. CO2 loss DOC & POC

Emissions due to loss of DOC and POC
Note, CO2 losses from DOC and POC are calculated using a simple approach derived from generic estimates of the percentage of the total CO2 loss that is due to DOC or POC leaching.

No POC losses for bare soil included yet. If extensive areas of bare soil is present at site need modified calculation (Birnie et al, 1991)

	Exp.	Min.	Max.
Gross CO2 loss from restored drained land (t CO2)	6510.77	3778.00	9738.15
Gross CH4 loss from restored drained land (t CO2 equiv.)	0.00	0.00	0.00
Gross CO2 loss from improved land (t CO2)	0.00	0.00	0.00
Gross CH4 loss from improved land (t CO2 equiv.)	99.07	0.00	132.10
Total gaseous loss of C (t C)	1777.91	1030.26	2658.83
Total C loss as DOC (t C)	462.26	72.12	1063.53
Total C loss as POC (t C)	142.23	41.21	265.88
RESULTS			
Total CO2 loss due to DOC leaching (t CO2)	1694.96	264.44	3899.65
Total CO2 loss due to POC leaching (t CO2)	521.52	151.11	974.91
Total CO2 loss due to DOC & POC leaching (t CO2)	2216.48	415.54	4874.56
Additional CO2 payback time of windfarm due to DOC & POC			
...coal-fired electricity generation (months)	0	0	1
...grid-mix of electricity generation (months)	2	0	3
...fossil fuel - mix of electricity generation (months)	1	0	1

Cover

CARBON CALCULATOR TOOL v . .

Help About...

Scottish Government and SEPA users only:

The Scottish Government
Application Status Control
Enter password
Sign in
Start Carbon Calculator

This tool calculates payback time for windfarm sited on peatlands using methods given in Nayak et al, 2008 (http://www.gov.scot/Publications/2008/06/25114657/0) and revised equations for GHG emissions (Nayak, D.R., Miller, D., Nolan, A., Smith, P. and Smith, J.U., 2010, Calculating carbon budgets of wind farms on Scottish peatland. Mires and Peat 4: Art. 9. Online: http://mires-and-peat.net/pages/volumes/map04/map0409.php

Admin

CARBON CALCULATOR TOOL v . . - APPLICATION STATUS CONTROL

Help

Reference Code: Search

Windfarm Name	Version	Methodology used for calculating emission factors	Status Date	Status
No data available in table				

PreviousNext

Selected:

Saved Signed-off Received Consented Refused Withdrawn
Revert to original status

Start

CARBON CALCULATOR TOOL v . .

- Will the site be drained on construction of the windfarm?
- Is the soil at the site highly organic?
- Does windfarm construction require a significant amount of deforestation?
  i.e. is removal in excess of keyholing the turbines within the forest boundary?

If you already have an Application Reference, type it here (or paste it in the first box):

Search

New application

CoreInput

Core input data
1. Windfarm characteristics 2. Peatland 3. Bog plants 4. Forestry Plantation 5. Emission factors 6. Borrow pits 7. Foundations and hard-standing 8. Access tracks 9. Cable trenches 10. Additional peat 11. Improvement actions 12. Restoration after decomissioning 13. Methodology & application details
Forestry input data
Construction input data

Save ☐ Signed off for submission

Note: Results are only available once ALL data are correct and complete, and a new version will be created.

New app...

Ref: MPRJ-W5M3-2KPG v

MENU≡

Help

Core input data | Forestry input data | Construction input data

Windfarm characteristics Page 1 of 12

Expected values	Minimum	Maximum
Dimensions		
Number of Turbines		
5		
Chapter 2 Project Description	5	5
Duration of consent (years)		
35		
Chapter 2 Project Description	35	35
Performance		
Power rating of 1 turbine (MW)		
6,6		
Chapter 2 Project Description	5,6	6,6
Capacity factor		
Direct input (% estimated capacity factor)	Direct input (% estimated capacity factor)	Direct input (% estimated capacity factor)
35		
Chapter 10 Air and Climate	34	36
Backup		
Fraction of output to backup (%)		
5		

Payback Time

1. Windfarm CO2 emission saving over...	Exp.	Min.	Max.
...coal-fired electricity generation (t CO2 / yr)	101,380	83,562	104,277
...grid-mix of electricity generation (t CO2 / yr)	19,566	16,127	20,125
...fossil fuel-mix of electricity generation (t CO2 / yr)	43,709	36,027	44,958
Energy output from windfarm over lifetime (MWh)	3,541,230	2,918,832	3,642,408

Total CO2 losses due to wind farm (tCO2 eq.)	Exp.	Min.	Max.
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	30,013	25,246	30,329
3. Losses due to backup	21,854	18,543	21,854
4. Lossess due to reduced carbon fixing potential	731	498	1,003
5. Losses from soil organic matter	14,691	3,801	32,121
6. Losses due to DOC & POC leaching	2,216	416	4,875
7. Losses due to felling forestry	11,074	10,331	11,396
Total losses of carbon dioxide	80,580	58,834	101,578

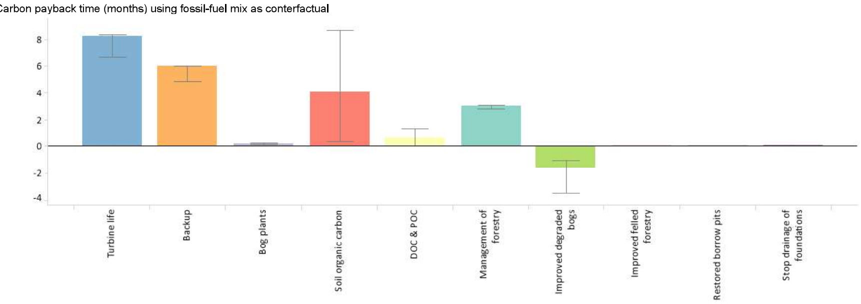
8. Total CO2 gains due to improvement of site (t CO2 eq.)	Exp.	Min.	Max.
8a. Change in emissions due to improvement of degraded bogs	-5,709	0	-7,612
8b. Change in emissions due to improvement of felled forestry	0	0	0
8c. Change in emissions due to restoration of peat from borrow pits	0	0	0
8d. Change in emissions due to removal of drainage from foundations & hardstanding	0	0	0
Total change in emissions due to improvements	-5,709	0	-7,612

RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide (t CO2 eq.)	74,871	51,222	101,578
Carbon Payback Time			
...coal-fired electricity generation (years)	0.7	0.5	1.2
...grid-mix of electricity generation (years)	3.8	2.5	6.3
...fossil fuel-mix of electricity generation (years)	1.7	1.1	2.8
Ratio of soil carbon loss to gain by restoration (not used in Scottish applications)	2.96	0.55	No gains!
Ratio of CO2 eq. emissions to power generation (g/kWh) (for info. only)	21.14	14.06	34.80

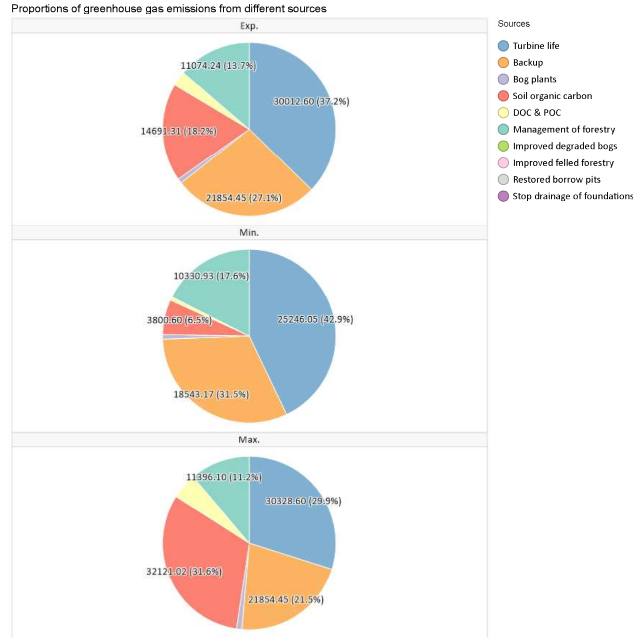
Payback Time - Charts

Payback Time
Payback Time - ChartsInput Data
1. Windfarm CO2 emission saving 2. CO2 loss due to turbine life 3. CO2 loss due to backup 4. Loss of CO2 fixing potential 5. Loss of soil CO2 (a-b) 5. Loss of soil CO2 (c-d-e) 6. CO2 loss by DOC & POC loss 7. Forestry CO2 loss 8. CO2 gain - site improvement

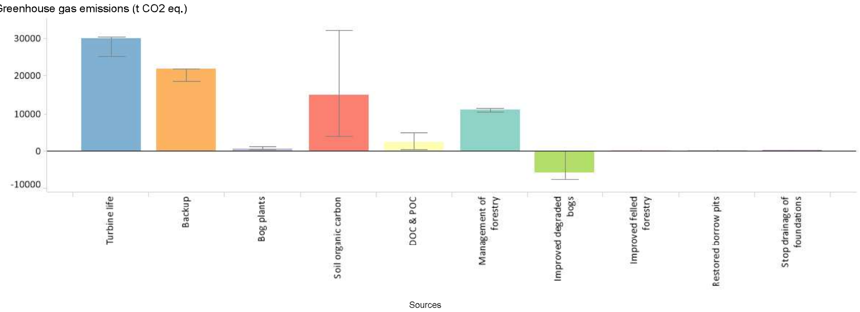
Carbon payback time (months) using fossil-fuel mix as conterfactual



Proportions of greenhouse gas emissions from different sources



Greenhouse gas emissions (t CO2 eq.)



View

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Carbon Calculator v1.7.0

Inchamore Wind Farm   Location: 51.949379 -9.269362

Inchamore Wind DAC

Core input data

Input data	Expected value	Minimum value	Maximum value	Source of data
Windfarm characteristics				
Dimensions				
No. of turbines	5	5	5	Chapter 2 Project Description
Duration of consent (years)	35	35	35	Chapter 2 Project Description
Performance				
Power rating of 1 turbine (MW)	6.6	5.6	6.6	Chapter 2 Project Description
Capacity factor	35	34	36	Chapter 10 Air and Climate
Backup				
Fraction of output to backup (%)	5	5	5	SNH Calculator Guidance
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10	10	10	Fixed
Total CO2 emission from turbine life (tCO2 MW^{-1}) (eg. manufacture, construction, decommissioning)	Calculate wrt installed capacity	Calculate wrt installed capacity	Calculate wrt installed capacity	
Characteristics of peatland before windfarm development				
Type of peatland	Acid bog	Acid bog	Acid bog	Chapter 5: Biodiversity
Average annual air temperature at site (°C)	9.975	9.7	10	Chapter 10 Air and Climate
Average depth of peat at site (m)	0.53	0	1.4	Chapter 8 Soils & Geology
C Content of dry peat (% by weight)	55	50	60	Default Value
Average extent of drainage around drainage features at site (m)	7.5	5	10	Chapter 9 Hydrology and Hydrogeology
Average water table depth at site (m)	0.5	0.1	1	Chapter 9 Hydrology & Hydrogeology
Dry soil bulk density (g cm^{-3})	0.1	0.09	0.11	Default Values
Characteristics of bog plants				
Time required for regeneration of bog plants after restoration (years)	10	5	15	Best Practice from Bog Restoraton Ireland
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.25	0.24	0.26	Default Values
Forestry Plantation Characteristics				
Input data	Expected value	Minimum value	Maximum value	Source of data
Area of forestry plantation to be felled (ha)	23.97	23	24	Chapter 2 Project Description
Average rate of carbon sequestration in timber (tC ha^{-1} yr^{-1})	3.6	3.5	3.7	Cannell, 1999
Counterfactual emission factors				
Coal-fired plant emission factor (t CO2 MWh^{-1})	1.002	1.002	1.002	
Grid-mix emission factor (t CO2 MWh^{-1})	0.19338	0.19338	0.19338	
Fossil fuel-mix emission factor (t CO2 MWh^{-1})	0.432	0.432	0.432	
Borrow pits				
Number of borrow pits	1	1	1	Chapter 2: Project Description

5. Loss of soil CO2 (a, b)

Emissions due to loss of soil organic carbon
Loss of C stored in peatland is estimated from % site lost by peat removal (table 5a), CO2 loss from removed peat (table 5b), % site affected by drainage (table 5c), and the CO2 loss from drained peat (table 5d).

5. Loss of soil C02

	Exp.	Min.	Max.
CO2 loss from removed peat (t CO2 equiv.)	8408.28	154.75	22723.5
CO2 loss from drained peat (t CO2 equiv.)	6283.03	3645.85	9397.52
RESULTS			
Total CO2 loss from peat (removed + drained) (t CO2 equiv.)	14691.31	3800.6	32121.02
Additional CO2 payback time of windfarm due to loss of soil C...			
...coal-fired electricity generation (months)	1.74	0.55	3.7
...grid-mix of electricity generation (months)	9.01	2.83	19.15
...fossil fuel - mix of electricity generation (months)	4.03	1.27	8.57

CO_2 loss from removed peats
If peat is treated in such a way that it is permanently restored, so that less than 100% of the C is lost to the atmosphere, a lower percentage can be entered in cell C10.

5b. CO2 loss from removed peat

	Exp.	Min.	Max.
CO2 loss from removed peat (t CO2)	16204.00	6598.90	31756.41
CO2 loss from undrained peat left in situ (t CO2)	7795.72	6444.16	9032.91
RESULTS			
CO2 loss atributable to peat removal only (t CO2)	8408.28	154.75	22723.50

Volume of Peat Removed
% site lost by peat removal is estimated from peat removed in borrow pits, turbine foundations, hard-standing and access tracks. If peat is removed for any other reason, this must be added in as additional peat excavated in the core input data entry.

5a. Volume of peat removed

	Exp.	Min.	Max.
Peat removed from borrow pits			
Area of land lost in borrow pits (m2)	38671.74	37996	38765.15
Volume of peat removed from borrow pits (m3)	48339.68	18998	77530.3
Peat removed from turbine foundations			
Area of land lost in foundation (m2)	1890	1760	2167.5
Volume of peat removed from foundation area (m3)	567	176	1083.75
Peat removed from hard-standing			
Area of land lost in hard-standing (m2)	23700	18000	23750
Volume of peat removed from hard-standing area (m3)	14220	3600	33250
Peat removed from access tracks			
Area of land lost in floating roads (m2)	0	0	0
Volume of peat removed from floating roads (m3)	0	0	0
Area of land lost in excavated roads (m2)	17775	17770	21336
Volume of peat removed from excavated roads (m3)	10665	10662	12801.6
Area of land lost in rock-filled roads (m2)	0	0	0
Volume of peat removed from rock-filled roads (m3)	0	0	0
Total area of land lost in access tracks (m2)	17775	17770	21336
Total volume of peat removed due to access tracks (m3)	10665	10662	12801.6
RESULTS			
Total area of land lost due to windfarm construction (m2)	92966.74	86455	96948.65
Total volume of peat removed due to windfarm construction (m3)	80349.68	39993	131223.65

5. Loss of soil CO2 (c,d,e)

Volume of peat drained
Extent of site affected by drainage is calculated assuming an average extent of drainage around each drainage feature as given in the input data.

5c. Volume of peat drained

	Exp.	Min.	Max.
Total area affected by drainage around borrow pits (m2)	7836.15	5150	10568.2
Total volume affected by drainage around borrow pits (m3)	4897.59	1287.5	10568.2
Peat affected by drainage around turbine foundation and hardstanding			
Total area affected by drainage of foundation and hardstanding area (m2)	20167.5	12400	27750
Total volume affected by drainage of foundation and hardstanding area (m3)	6050.25	1240	19425
Peat affected by drainage of access tracks			
Total area affected by drainage of access track(m2)	53325	35540	71120
Total volume affected by drainage of access track(m3)	15997.5	10662	21336
Peat affected by drainage of cable trenches			
Total area affected by drainage of cable trenches(m2)	0	0	0
Total volume affected by drainage of cable trneches(m3)	0	0	0
Drainage around additional peat excavated			
Total area affected by drainage (m2)	2956.28	1931.5	4020.24
Total volume affected by drainage (m3)	1773.77	1158.72	2412.37
RESULTS			
Total area affected by drainage due to windfarm (m2)	84284.93	55021.5	113458.44
Total volume affected by drainage due to windfarm (m3)	28719.11	14348.22	53741.57

CO_2 loss due to drainage
Note, CO2 losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new equations have been derived directly from experimental data for acid bogs and fens (see Nayak et al, 2008 - Final report).

5d. CO2 loss from drained peat

	Exp.	Min.	Max.
Calculations of C Loss from Drained Land if Site is NOT Restored after Decomissioning			
Total GHG emissions from Drained Land (t CO2 equiv.)	5791.74	2367.48	13005.58
Total GHG emissions from Undrained Land (t CO2 equiv.)	3066.07	1253.31	6884.98
Calculations of C Loss from Drained Land if Site IS Restored after Decomissioning			
Losses if Land is Drained			
CH4 emissions from drained land (t CO2 equiv.)	0	0	0
CO2 emissions from drained land (t CO2)	13350.73	7747.03	19968.69
Total GHG emissions from Drained Land (t CO2 equiv.)	13350.73	7747.03	19968.69
Losses if Land is Undrained			
CH4 emissions from undrained land (t CO2 equiv.)	227.74	132.15	340.63
CO2 emissions from undrained land (t CO2)	6839.96	3969.02	10230.53
Total GHG emissions from Undrained Land (t CO2 equiv.)	7067.71	4101.18	10571.16
RESULTS			
Total GHG emissions due to drainage (t CO2 equiv.)	6283.03	3645.85	9397.52

Emission rates from soils
Note, CO2 losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new equations have been thoroughly tested against experimental data (see Nayak et al, 2008 - Final report).

5e. Emission rates from soils

	Exp.	Min.	Max.
Calculations following IPCC default methodology			
Flooded period (days/year)	178	178	178
Annual rate of methane emission (t CH4-C/ha year)	0.04	0.04	0.04
Annual rate of carbon dioxide emission (t CO2/ha year)	35.2	35.2	35.2
Calculations following ECOSSE based methodology			

7. Forestry CO2 loss

CO_2 loss from forests - calculation using detailed management information
Forest carbon calculator (Perks et al, 2009)

Total potential carbon squestration loss due to felling of forestry for the wind farm (t CO2)
Total emissions due to cleared land (t CO2)
Emissions due to harvesting operations (t CO2)
Fossil fuel equivalent saving from use of felled forestry as biofuel (t CO2)
Fossil fuel equivalent saving from use of replanted forestry as biofuel (t CO2)
RESULTS
Total carbon loss associated with forest management(t CO2)

Emissions due to forest felling - calculation using simple management data
Emissions due to forestry felling are calculated from the reduced carbon sequestered per crop rotation. If the forestry was due to be removed before the planned development, this C loss is not attributable to the wind farm and so the area of forestry to be felled should be entered as zero.

	Exp.	Min.	Max.
Area of forestry plantation to be felled (ha)	23.97	23	24
Carbon sequestered (t C ha-1 yr-1)	3.6	3.5	3.7
Lifetime of windfarm (years)	35	35	35
Carbon sequestered over the lifetime of the windfarm (t C ha-1)	126	122.5	129.5
RESULTS			
Total carbon loss due to felling of forestry (t CO2)	11074.24	10330.93	11396.1
Additional CO2 payback time of windfarm due to management of forestry			
...coal-fired electricity generation (months)	1.31	1.48	1.31
...grid-mix of electricity generation (months)	6.79	7.69	6.8
...fossil fuel - mix of electricity generation (months)	3.04	3.44	3.04

8. CO2 gain - site improvement

Gains due to site improvement
Note, CO2 losses are calculated using two approaches: IPCC default methodology and more site specific equations derived for this project. The IPCC methodology is included because it is the established approach, although it contains no site detail. The new equations have been thoroughly tested against experimental data (see Nayak et al, 2008 - Final report).

Degraded Bog

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	11	0	11
Depth of peat above water table before improvement (m)	0.16	0	0.25
Depth of peat above water table after improvement (m)	0.1	0	0.05
2. Losses with improvement			
Improved period (years)	15	20	5
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.04	0.04	0.04
CH4 emissions from improved land (t CO2 equiv.)	99.075	0	132.1
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0	0	0
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	99.075	0	132.1
3. Losses without improvement			
Improved period (years)	15	20	5
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0	0	0
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	35.2	35.2	35.2

Felled Forestry

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	0	0	0
Depth of peat above water table before improvement (m)	0	0	0
Depth of peat above water table after improvement (m)	0	0	0
2. Losses with improvement			
Improved period (years)	15	25	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.04	0.04	0.04
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0	0	0
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	0
3. Losses without improvement			
Improved period (years)	15	25	0
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0	0	0
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	35.2	35.2	35.2

Borrow Pits

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	0	0	0
Depth of peat above water table before improvement (m)	0	0	0
Depth of peat above water table after improvement (m)	0	0	0
2. Losses with improvement			
Improved period (years)	24	29	18
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.04	0.04	0.04
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0	0	0
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	0
3. Losses without improvement			
Improved period (years)	24	29	18
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0	0	0
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	35.2	35.2	35.2

Foundations & Hardstanding

	Exp.	Min.	Max.
1. Description of site			
Area to be improved (ha)	0	0	0
Depth of peat above water table before improvement (m)	0	0	0
Depth of peat above water table after improvement (m)	0	0	0
2. Losses with improvement			
Improved period (years)	32.5	34.9	30
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0.04	0.04	0.04
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	0	0	0
CO2 emissions from improved land (t CO2 equiv.)	0	0	0
Total GHG emissions from improved land (t CO2 eqiv.)	0	0	0
3. Losses without improvement			
Improved period (years)	32.5	34.9	30
Selected annual rate of methane emissions (t CH4-C ha-1 yr-1)	0	0	0
CH4 emissions from improved land (t CO2 equiv.)	0	0	0
Selected annual rate of carbone dioxide emissions (t CO2 ha-1 yr-1)	35.2	35.2	35.2

3. CO2 loss backup

Emissions due to backup power generation
CO_2 loss due to back up is calculated from the extra capacity required for backup of the windfarm given in the input data.

Wind generated electricity is inherently variable, providing unique challenges to the electricity generating industry for provision of a supply to meet consumer demand (Netz, 2004). Backup power is required to accompany wind generation to stabilise the supply to the consumer. This backup power will usually be obtained from a fossil fuel source. At a high level of wind power penetration in the overall generating mix, and with current grid management techniques, the capacity for fossil fuel backup may become strained because it is being used to balance the fluctuating consumer demand with a variable and highly unpredictable output from wind turbines (White, 2007). The Carbon Trust (Carbon Trust/DTI, 2004) concluded that increasing levels of intermittent generation do not present major technical issues at the percentages of renewables expected by 2010 and 2020, but the UK renewables target at the time of that report was only 20%. When national reliance on wind power is low (less than ~20%), the additional fossil fuel generated power requirement can be considered to be insignificant and may be obtained from within the spare generating capacity of other power sectors (Dale et al, 2004). However, as the national supply from wind power increases above 20%, without improvements in grid management techniques, emissions due to backup power generation may become more significant. The extra capacity needed for backup power generation is currently estimated to be 5% of the rated capacity of the wind plant if wind power contributes more than 20% to the national grid (Dale et al 2004). Moving towards the SG target of 50% electricity generation from renewable sources, more short-term capacity may be required in terms of pumped-storage hydro-generated power, or a better mix of offshore and onshore wind generating capacity. Grid management techniques are anticipated to reduce this extra capacity, with improved demand side management, smart meters, grid reinforcement and other developments. However, given current grid management techniques, it is suggested that 5% extra capacity should be assumed for backup power generation if wind power contributes more than 20% to the national grid. At lower contributions, the extra capacity required for backup should be assumed to be zero. These assumptions should be revisited as technology improves.

Assumption: Backup assumed to be by fossil-fuel-mix of electricity generation. Note that hydroelectricity may also be used for backup, so this assumption may make the value for backup generation too high. These assumptions should be revisited as technology develops.

	Exp.	Min.	Max.
Reserve energy (MWh/yr)	14,454	12,264	14,454
Annual emissions due to backup from fossil fuel-mix of electricity generation (tCO_2/yr)	624	530	624
RESULTS			
Total emissions due to backup from fossil fuel-mix of electricity generation (tCO_2)	21,854	18,543	21,854

1. CO2 emission saving

Emissions due to turbine life

The carbon payback time of the windfarm due to turbine life (eg. manufacture, construction, decomissioning) is calculated by comparing the emissions due to turbine life with carbon-savings achieved by the windfarm while displacing electricity generated from coal-fired capacity or grid-mix.

Capacity factor calculated from forestry data

Area name	Value type	Capacity factor (%)	Wind speed ratio	Average site windspeed (m/s)	Annual theoretical energy output (MW / turbine yr)

Capacity factor - Direct input

	Exp.	Min.	Max.
Capacity factor (%)	35.0	34.0	36.0

	Exp.	Min.	Max.
Annual energy output from windfarm (MW/yr)			
RESULTS			
Emissions saving over coal-fired electricity generatio...	101,380	83,562	104,277
Emissions saving over grid-mix of electricity generati...	19,566	16,127	20,125
Emissions saving over fossil fuel - mix of electricity g...	43,709	36,027	44,958

2. CO2 loss turbine life

Payback Time
Payback Time - ChartsInput Data
1. Windfarm CO2 emission saving 2. CO2 loss due to turbine life 3. CO2 loss due to backup 4. Loss of CO2 fixing potential 5. Loss of soil CO2 (a,b) 5. Loss of soil CO2 (c,d,e) 6. CO2 loss by DOC & POC loss 7. Forestry CO2 loss 8. CO2 gain - site improvement

Emissions due to turbine life

The carbon payback time of the windfarm due to turbine life (eg. manufacture, construction, decomissioning) is calculated by comparing the emissions due to turbine life with carbon-savings achieved by the windfarm while displacing electricity generated from coal-fired capacity or grid-mix.

Calculation of emissions with relation to installed capacity

	Exp.	Min.	Max.
Emissions due to turbine frome energy output (t CO2)	5699	4765	5699
Emissions due to cement used in construction (t CO2)	1517	1422	1833

Direct input of emissions due to turbine life

	Exp.	Min.	Max.
Emissions due to turbine life (tCO2/windfarm)			

RESULTS

	Exp.	Min.	Max.
Losses due to turbine life (manufacture, construction, etc.) (t CO2)	30013	25246	30329
Additional CO2 payback time of windfarm due to turbine life			
...coal-fired electricity generation (months)	4	4	3
...grid-mix of electricity generation (months)	18	19	18
...fossil fuel - mix of electricity generation (months)	8	8	8

4. Loss CO2 fixing pot.

Emissions due to loss of bog plants
Annual C fixation by the site is calculated by multiplying area of the windfarm by the annual C accumulation due to bog plant fixation.

	Exp.	Min.	Max.
Area where carbon accumulation by bog plants is lost (ha)	17.73	14.15	21.04
Total loss of carbon accumulation up to time of restoration (tCO2 eq./ha)	41	35	48
RESULTS			
Total loss of carbon fixation by plants at the site (t CO2)	731	498	1003
Additional CO2 payback time of windfarm due to loss of CO2 fixing potential			
...coal-fired electricity generation (months)	0	0	0
...grid-mix of electricity generation (months)	0	0	1
...fossil fuel - mix of electricity generation (months)	0	0	0

6. CO2 loss DOC & POC

Emissions due to loss of DOC and POC
Note, CO_2 losses from DOC and POC are calculated using a simple approach derived from generic estimates of the percentage of the total CO_2 loss that is due to DOC or POC leaching.

No POC losses for bare soil included yet. If extensive areas of bare soil is present at site need modified calculation (Birnie et al, 1991)

	Exp.	Min.	Max.
Gross CO2 loss from restored drained land (t CO2)	6510.77	3778.00	9738.15
Gross CH4 loss from restored drained land (t CO2 equiv.)	0.00	0.00	0.00
Gross CO2 loss from improved land (t CO2)	0.00	0.00	0.00
Gross CH4 loss from improved land (t CO2 equiv.)	99.07	0.00	132.10
Total gaseous loss of C (t C)	1777.91	1030.26	2658.83
Total C loss as DOC (t C)	462.26	72.12	1063.53
Total C loss as POC (t C)	142.23	41.21	265.88
RESULTS			
Total CO2 loss due to DOC leaching (t CO2)	1694.96	264.44	3899.65
Total CO2 loss due to POC leaching (t CO2)	521.52	151.11	974.91
Total CO2 loss due to DOC & POC leaching (t CO2)	2216.48	415.54	4874.56
Additional CO2 payback time of windfarm due to DOC & POC			
...coal-fired electricity generation (months)	0	0	1
...grid-mix of electricity generation (months)	1	0	3
...fossil fuel - mix of electricity generation (months)	1	0	1

Appendix 11.1: Photos of noise monitors in-situ

Location H4: Towards house and towards wind farm

Location H3: Towards house and towards wind farm


Location H18: Towards house and towards wind farm


Location H2: Towards house and towards wind farm

Location H2: Rain gauge

Appendix 11.2: Methodology for calculating wind shear from different hub heights calculating to hub height and standardising to 10m height wind speed

Supplementary Guidance Note 4: Wind Shear Equations

a) **<u>Standardising from hub height (hh) to 10m</u>**

$v_{10} = v_{hh}$ * (LN(10/0.05)/LN(hh/0.05)) [EQUATION 1]

v_{10} = Standardised 10m wind speed

v_{hh} = Hub height wind speed   Hub heights (hh) = 102.5m and 110.5m

0.05 = Standard ground roughness length which remains constant (fixed)

b) Calculating from different heights

$v_1 = v_2 * (h1/h_2)$^m [EQUATION 2]

v_1 = wind speed at h_1

v_2 = Wind speed at h_2

h_2 = 10m

m = Wind shear

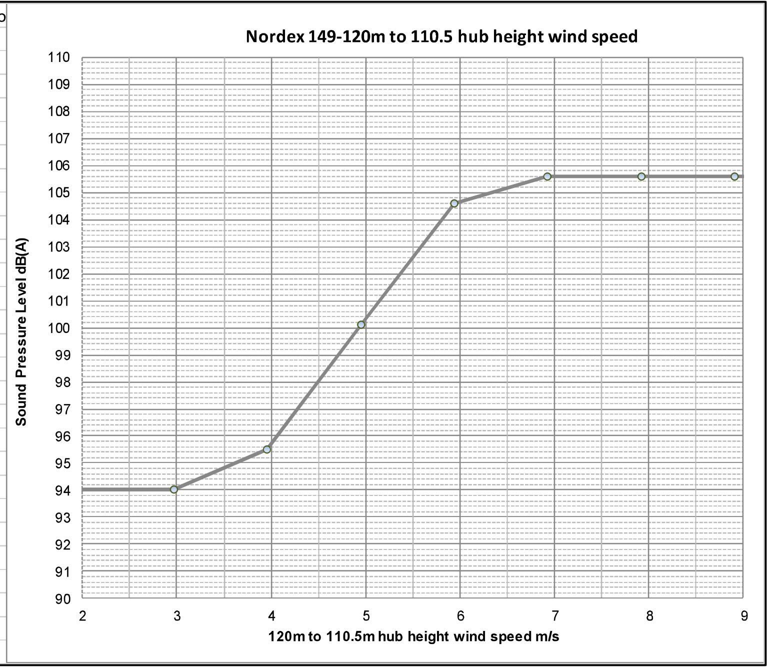
c) Equation **b** can be re-arranged to determine wind shear exponent ‘m’ based on known data at two different Met mast heights (80m and 61m). With wind shear calculated this can be applied to the wind speed at higher (differing) height of 80m to determine hub height wind speed (higher hub height being 110.5m).

m = LN(v_2/v_1) / LN(h_2/h_1) [EQUATION 3]

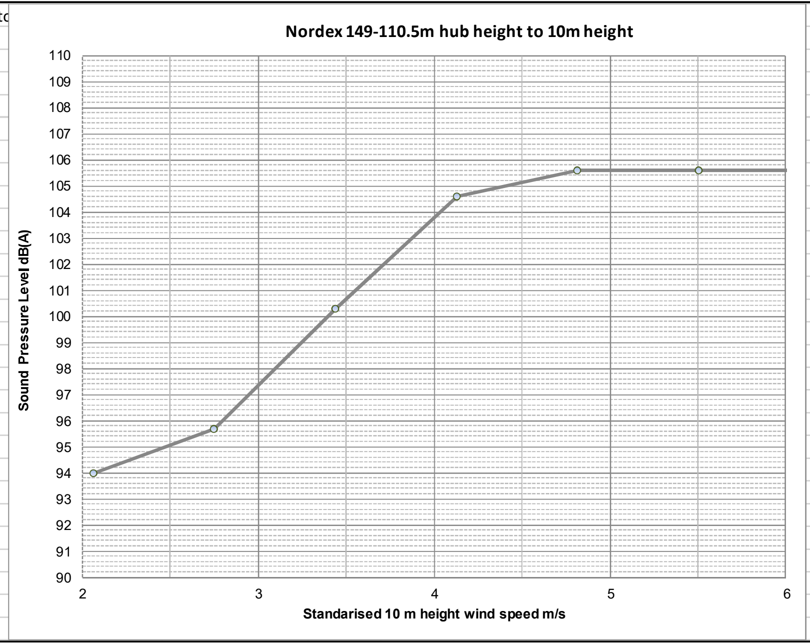
The calculations for hub height 102.5m was derived using equation **<u>a</u>** (from hub height of 105m in manufactures specification and then standardised).

The calculations for hub height 110.5m was derived using equation **<u>a</u>** (from hub height of 120m in manufactures specification and then standardised).

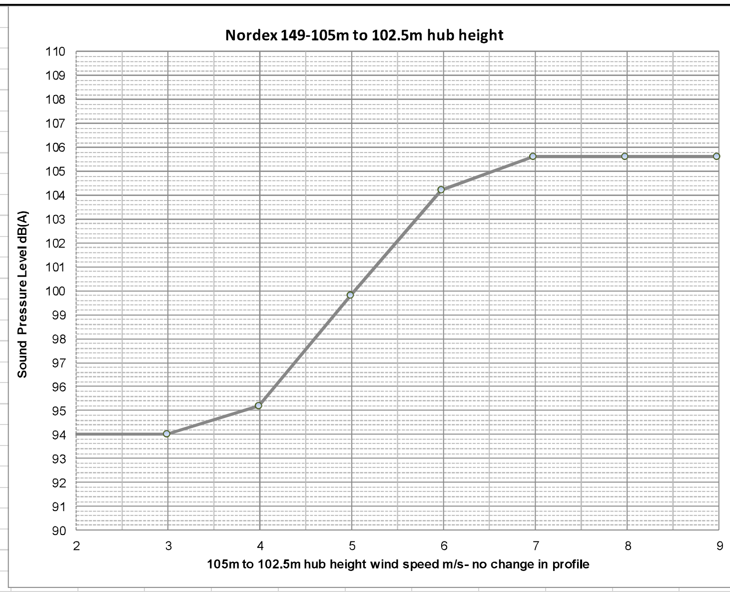
Hub height 120m values		Wind 120m Mean	120m to 110.5	120m to 110.5 values
94.0		2.0	**2.0**	
94		3.0	**3.0**	94
95.5		4.0	**4.0**	95.7
100.1		5.0	**4.9**	100.3
104.6		6.0	**5.9**	104.6
105.6		7.0	**6.9**	105.6
105.6		8.0	**7.9**	105.6
105.6		9.0	**8.9**	105.6
105.6		10.0	**9.9**	105.6
105.6		11.0	**10.9**	105.6
105.6		12.0	**11.9**	105.6
105.6		13.0	**12.9**	
105.6		14.0	**13.9**	
105.6		15.0	**14.8**	
105.6		16.0	**15.8**	
105.6		17.0	**16.8**	
105.6		18.0	**17.8**	
105.6		19.0	**18.8**	
105.6		20.0	**19.8**	
105.6		21.0	**20.8**	
105.6		22.0	**21.8**	
105.6		23.0	**22.8**	
105.6		24.0	**23.7**	
105.6		25.0	**24.7**	
		26.0	**25.7**	



Hub height 110.5 values	Wind 110.5m Mean	**110.5 to 10m**	110.5m to 10m values
	2.0	**1.4**	
94	3.0	**2.1**	97.4
95.7	4.0	**2.8**	103.8
100.3	5.0	**3.4**	105.6
104.6	6.0	**4.1**	105.6
105.6	7.0	**4.8**	105.6
105.6	8.0	**5.5**	105.6
105.6	9.0	**6.2**	105.6
105.6	10.0	**6.9**	105.6
105.6	11.0	**7.6**	105.6
105.6	12.0	**8.3**	105.6
105.6	13.0	**8.9**	
105.6	14.0	**9.6**	
105.6	15.0	**10.3**	
105.6	16.0	**11.0**	
105.6	17.0	**11.7**	
105.6	18.0	**12.4**	
105.6	19.0	**13.1**	
105.6	20.0	**13.8**	
105.6	21.0	**14.4**	
105.6	22.0	**15.1**	
105.6	23.0	**15.8**	
105.6	24.0	**16.5**	
105.6	25.0	**17.2**	
	26.0	**17.9**	

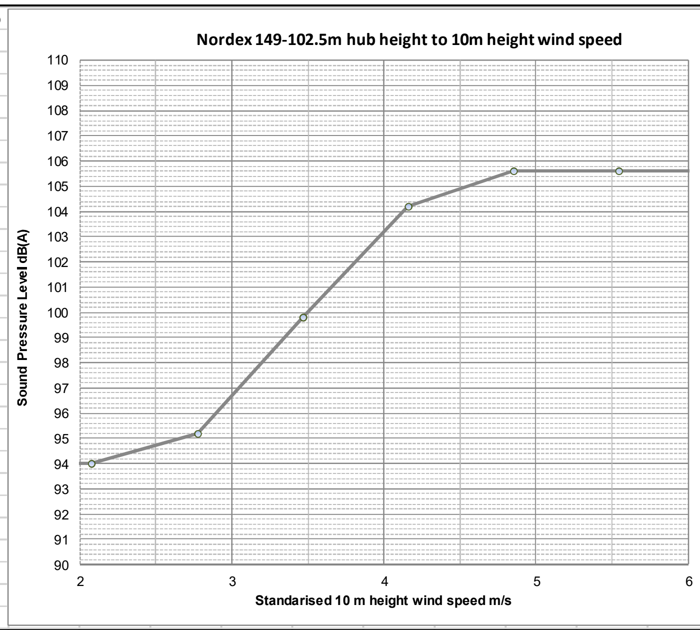


Hub height 105m values		Wind 105.0m Mean	105m 10 102.5m	105m to to values
94.0		2.0	**2.0**	
94		3.0	**3.0**	94.0
95.2		4.0	**4.0**	95.2
99.8		5.0	**5.0**	99.8
104.2		6.0	**6.0**	104.2
105.6		7.0	**7.0**	105.6
105.6		8.0	**8.0**	105.6
105.6		9.0	**9.0**	105.6
105.6		10.0	**10.0**	105.6
105.6		11.0	**11.0**	105.6
105.6		12.0	**12.0**	105.6
105.6		13.0	**13.0**	
105.6		14.0	**14.0**	
105.6		15.0	**15.0**	
105.6		16.0	**15.9**	
105.6		17.0	**16.9**	
105.6		18.0	**17.9**	
105.6		19.0	**18.9**	
105.6		20.0	**19.9**	
105.6		21.0	**20.9**	
105.6		22.0	**21.9**	
105.6		23.0	**22.9**	
105.6		24.0	**23.9**	
105.6		25.0	**24.9**	
		26.0	**25.9**	



NB: There is no change in sound power levels from 105m to 102.5m hub height over range of wind speeds

Hub height 102.5m values	Wind 102.5.0m Mean	102m to 10m		102.5m to 10m values
94.0	2.0	**1.4**	1.4	
94	3.0	**2.1**	2.1	96.6
95.2	4.0	**2.8**	2.8	103.1
99.8	5.0	**3.5**	3.5	105.6
104.2	6.0	**4.2**	4.2	105.6
105.6	7.0	**4.8**	4.8	105.6
105.6	8.0	**5.5**	5.5	105.6
105.6	9.0	**6.2**	6.2	105.6
105.6	10.0	**6.9**	6.9	105.6
105.6	11.0	**7.6**	7.6	105.6
105.6	12.0	**8.3**	8.3	105.6
105.6	13.0	**9.0**	9.0	
105.6	14.0	**9.7**	9.7	
105.6	15.0	**10.4**	10.4	
105.6	16.0	**11.1**	11.1	
105.6	17.0	**11.8**	11.8	
105.6	18.0	**12.5**	12.5	
105.6	19.0	**13.2**	13.2	
105.6	20.0	**13.9**	13.9	
105.6	21.0	**14.5**	14.5	
105.6	22.0	**15.2**	15.2	
105.6	23.0	**15.9**	15.9	
105.6	24.0	**16.6**	16.6	
105.6	25.0	**17.3**	17.3	
	26.0	**18.0**	18.0	



Appendix 11.3: Calibration certificates of noise instruments used

MTS Calibration

MTS Calibration Ltd,
The Grange Business Centre,
Belasis Avenue,
Billingham TS23 1LG,
England
Telephone: 01624 876 410

CERTIFICATE OF CALIBRATION

Page 1 of 11 pages

Approved Signatory:

Tony Sherris

Issued by: **MTS Calibration Ltd**

Date of Issue: **24 January 2019** **Certificate Number:** **32818**

Sound Level Meter

Sound Level Meter Periodic Tests to EN 61672-3: 2013 Class 1

Client: Environmental Measurements on behalf of Brendan O'Reilly
Unit 12, Tallaght Business Centre
Whitestown Business Park
Co.Dublin 24, Ireland

Instrument Make: Larson Davis
Instrument Model: LxT1L
Serial Number: 0004643

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Associated Equipment	Make	Model	Serial number
Preamplifier	PCB	PRMLxT1L	042742
Microphone	PCB	377B02	173111
Calibrator	Larson Davis	CAL200	9175
Calibrator supplied by	by MTS for this calibration		

Test results summary, detailed results are shown on subsequent pages.

Periodic tests were performed in accordance with procedures from IEC 61672-3:2013 Class 1

Tests performed	Section	Results of test	Page	Comments
Calibration Certificate	22		1	
Additional information			2	
Indication with Calibrator Supplied	10	No Limit	3	
Self-Generated Noise	11	No Limit	3	
Frequency and Time-weightings at 1kHz	14	Complies	3	
Long term stability	15	Complies	3	
High stability	21	Complies	3	
Acoustic Tests	12	Complies	4	
Frequency Weighting A	13	Complies	5	
Frequency Weighting C	13	Complies	6	
Frequency Weighting Z	13	Complies	7	
Level Linearity	16	Complies	8	
Level Linearity Range Control	17		n/a	Only one range
Tone-burst Response	18	Complies	9	
Peak C sound level	19	Complies	10	
Overload indication	20	Complies	11	
Additional tests performed				
Microphone		32820		See additional certificate
Filter, third octave or octave		32818F		See additional certificate

The instrument was within the above specification as received - no modifications were made

The sound level meter submitted for testing has successfully completed the periodic tests of IEC 61672-3: 2013 for the environmental conditions under which the tests were performed. As evidence was publicly available, from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2: 2013, to demonstrate that the model of sound level meter fully conformed to the Class 1 specifications in IEC 61672-1: 2013, the sound level meter submitted for testing conforms to the Class 1 specifications of IEC 61672-1: 2013

MTS Calibration Ltd,
The Grange Business Centre,
Belasis Avenue,
Billingham TS23 1LG,
England
Telephone: 01624 876 410

CERTIFICATE OF CALIBRATION

Approved Signatory:

Tony Sherris

Issued by: **MTS Calibration Ltd**

Date of Issue: **25 January 2019** **Certificate Number:** **32815**

Sound Level Meter

Sound Level Meter Periodic Tests to EN 61672-3: 2013 Class 1

Client: Environmental Measurements on behalf of Brendan O'Reilly
Unit 12, Tallaght Business Centre
Whitestown Business Park
Co.Dublin 24, Ireland

Instrument Make: Larson Davis
Instrument Model: LxT1L
Serial Number: 0004647

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Associated Equipment	Make	Model	Serial number
Preamplifier	PCB	PRMLxT1L	042725
Microphone	PCB	377B02	171552
Calibrator	Larson Davis	CAL200	9175
Calibrator supplied by	by MTS for this calibration		

Test results summary, detailed results are shown on subsequent pages.

Periodic tests were performed in accordance with procedures from IEC 61672-3:2013 Class 1

Tests performed	Section	Results of test	Page	Comments
Calibration Certificate	22		1	
Additional information			2	
Indication with Calibrator Supplied	10	No Limit	3	
Self-Generated Noise	11	No Limit	3	
Frequency and Time-weightings at 1kHz	14	Complies	3	
Long term stability	15	Complies	3	
High stability	21	Complies	3	
Acoustic Tests	12	Complies	4	
Frequency Weighting A	13	Complies	5	
Frequency Weighting C	13	Complies	6	
Frequency Weighting Z	13	Complies	7	
Level Linearity	16	Complies	8	
Level Linearity Range Control	17		n/a	Only one range
Tone-burst Response	18	Complies	9	
Peak C sound level	19	Complies	10	
Overload indication	20	Complies	11	
Additional tests performed				
Microphone		32817		See additional certificate
Filter, third octave or octave		32815F		See additional certificate

The instrument was within the above specification as received - no modifications were made

The sound level meter submitted for testing has successfully completed the periodic tests of IEC 61672-3: 2013 for the environmental conditions under which the tests were performed. As evidence was publicly available, from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2: 2013, to demonstrate that the model of sound level meter fully conformed to the Class 1 specifications in IEC 61672-1: 2013, the sound level meter submitted for testing conforms to the Class 1 specifications of IEC 61672-1: 2013

MTS Calibration Ltd,
The Grange Business Centre,
Belasis Avenue,
Billingham TS23 1LG,
England
Telephone: 01624 876 410

CERTIFICATE OF CALIBRATION

Approved Signatory:

Tony Sherris

Issued by: **MTS Calibration Ltd**

Date of Issue: **25 January 2019** **Certificate Number:** **32812**

Sound Level Meter

Sound Level Meter Periodic Tests to EN 61672-3: 2013 Class 1

Client: Environmental Measurements on behalf of Brendan O'Reilly
Unit 12, Tallaght Business Centre
Whitestown Business Park
Co.Dublin 24, Ireland

Instrument Make: Larson Davis
Instrument Model: LxT1L
Serial Number: 0004570

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Associated Equipment	Make	Model	Serial number
Preamplifier	PCB	PRMLxT1L	036058
Microphone	PCB	377B02	152974
Calibrator	Larson Davis	CAL200	9175
Calibrator supplied by	by MTS for this calibration		

Test results summary, detailed results are shown on subsequent pages.

Periodic tests were performed in accordance with procedures from IEC 61672-3:2013 Class 1

Tests performed	Section	Results of test	Page	Comments	
Calibration Certificate	22		1		
Additional information			2		
Indication with Calibrator Supplied	10	No Limit	3		
Self-Generated Noise	11	No Limit	3		
Frequency and Time-weightings at 1kHz	14	Complies	3		
Long term stability	15	Complies	3		
High stability	21	Complies	3		
Acoustic Tests	12	Complies	4		
Frequency Weighting A	13	Complies	5		
Frequency Weighting C	13	Complies	6		
Frequency Weighting Z	13	Complies	7		
Level Linearity	16	Complies	8		
Level Linearity Range Control	17		n/a	Only one range	
Tone-burst Response	18	Complies	9		
Peak C sound level	19	Complies	10		
Overload indication	20	Complies	11		
Additional tests performed					
Microphone		32814			See additional certificate
Filter, third octave or octave		32812F			See additional certificate

The instrument was within the above specification as received - no modifications were made

The sound level meter submitted for testing has successfully completed the periodic tests of IEC 61672-3: 2013 for the environmental conditions under which the tests were performed. As evidence was publicly available, from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2: 2013, to demonstrate that the model of sound level meter fully conformed to the Class 1 specifications in IEC 61672-1: 2013, the sound level meter submitted for testing conforms to the Class 1 specifications of IEC 61672-1: 2013

Calibration Certificate

Certificate Number 2019012216
Customer:
Environmental Measurement
Unit 12
Dublin, 24, Ireland

Model Number	LxT SE	*Procedure Number*	D0001.8384		
Serial Number	0005990	*Technician*	Ron Harris		
Test Results	**Pass**	*Calibration Date*	1 Oct 2019		
Initial Condition	As Manufactured	*Calibration Due*			
		Temperature	23.6	°C	± 0.25 °C
Description	Sound Expert LxT Class 1 Sound Level Meter Firmware Revision: 2.402	*Humidity*	49.6	%RH	± 2.0 %RH
		Static Pressure	85.93	kPa	± 0.13 kPa

Evaluation Method — *Tested with:*

Larson Davis PRMLxT1L. S/N 055804
PCB 377B02. S/N 316349
Larson Davis CAL200. S/N 9079
Larson Davis CAL291. S/N 0108

Data reported in dB re 20 μPa.

Compliance Standards — Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001.8378:

IEC 60651:2001 Type 1	ANSI S1.4-2014 Class 1
IEC 60804:2000 Type 1	ANSI S1.4 (R2006) Type 1
IEC 61252:2002	ANSI S1.11 (R2009) Class 1
IEC 61260:2001 Class 1	ANSI S1.25 (R2007)
IEC 61672:2013 Class 1	ANSI S1.43 (R2007) Type 1

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2005.

Test points marked with a ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.

The quality system is registered to ISO 9001:2015.

This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances would be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

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Correction data from Larson Davis LxT Manual for SoundTrack LxT & SoundExpert Lxt, I770.01 Rev J Supporting Firmware Version 2.301, 2015-04-30

Calibration Certificate

Certificate Number 2019012218

Customer:

Environmental Measurement
Unit 12
Dublin, 24, Ireland

Model Number	LxT SE	*Procedure Number*	D0001.8384		
Serial Number	0005992	*Technician*	Ron Harris		
Test Results	**Pass**	*Calibration Date*	1 Oct 2019		
Initial Condition	As Manufactured	*Calibration Due*			
		Temperature	23.64	°C	± 0.25 °C
Description	Sound Expert LxT Class 1 Sound Level Meter Firmware Revision: 2.402	*Humidity*	49.5	%RH	± 2.0 %RH
		Static Pressure	85.93	kPa	± 0.13 kPa

Evaluation Method — *Tested with:*
Larson Davis PRMLxT1L. S/N 055806
PCB 377B02. S/N 316352
Larson Davis CAL200. S/N 9079
Larson Davis CAL291. S/N 0108

Data reported in dB re 20 μPa.

Compliance Standards — Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001.8378:

IEC 60651:2001 Type 1	ANSI S1.4-2014 Class 1
IEC 60804:2000 Type 1	ANSI S1.4 (R2006) Type 1
IEC 61252:2002	ANSI S1.11 (R2009) Class 1
IEC 61260:2001 Class 1	ANSI S1.25 (R2007)
IEC 61672:2013 Class 1	ANSI S1.43 (R2007) Type 1

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2005.

Test points marked with a ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.

The quality system is registered to ISO 9001:2015.

This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances would be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

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Correction data from Larson Davis LxT Manual for SoundTrack LxT & SoundExpert Lxt, I770.01 Rev J Supporting Firmware Version 2.301, 2015-04-30

Calibration Certificate

Certificate Number 2020009385

Customer:
Environmental Measurement
Unit 12 Tallaght Business Centre
Whitestown Business Park
Dublin, 24, Ireland

Model Number	CAL200	***Procedure Number***	D0001.8386
Serial Number	18140	***Technician***	Scott Montgomery
Test Results	**Pass**	***Calibration Date***	26 Aug 2020
Initial Condition	As Manufactured	***Calibration Due***	
		Temperature	23 °C ± 0.3 °C
Description	Larson Davis CAL200 Acoustic Calibrator	***Humidity***	35 %RH ± 3 %RH
		Static Pressure	101.2 kPa ± 1 kPa

Evaluation Method The data is aquired by the insert voltage calibration method using the reference microphone's open circuit sensitivity. Data reported in dB re 20 µPa.

Compliance Standards Compliant to Manufacturer Specifications per D0001.8190 and the following standards:
IEC 60942:2017 ANSI S1.40-2006

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the SI through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2017.
Test points marked with a ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.

The quality system is registered to ISO 9001:2015.

This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances would be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

Standards Used

Description	Cal Date	Cal Due	Cal Standard
Agilent 34401A DMM	08/04/2020	08/04/2021	001021
Larson Davis Model 2900 Real Time Analyzer	04/02/2020	04/02/2021	001051
Microphone Calibration System	03/03/2020	03/03/2021	005446
1/2" Preamplifier	09/17/2019	09/17/2020	006506
Larson Davis 1/2" Preamplifier 7-pin LEMO	08/06/2020	08/06/2021	006507
1/2 inch Microphone - RI - 200V	12/06/2019	12/06/2020	006511
Pressure Transducer	10/18/2019	10/18/2020	007204

Appendix 11.4: Candidate turbine manufacturer's noise emission data

NORDEX

Third octave sound power levels

Nordex N149/5.X

Mode 0

hub height 105 m – 105.6 dB(A)

third octave sound power levels [dB(A)] at standardized wind speeds v_s										
Frequency	3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s
10 Hz	37.6	38.8	42.3	46.7	48.1	48.5	48.5	48.5	48.5	48.4
12.5 Hz	42.4	43.6	47.2	51.6	53.0	53.3	53.3	53.3	53.3	53.3
16 Hz	47.0	48.2	51.8	56.2	57.6	57.9	57.9	57.9	57.9	57.9
20 Hz	51.4	52.6	56.1	60.5	61.9	62.3	62.3	62.3	62.3	62.3
25 Hz	55.8	57.0	60.5	64.9	66.3	66.2	66.2	66.2	66.2	66.2
31.5 Hz	59.9	61.1	65.0	69.4	70.8	71.7	71.7	71.7	71.7	71.7
40 Hz	65.8	67.0	69.4	73.8	75.2	75.3	75.3	75.3	75.3	75.3
50 Hz	67.0	68.2	72.7	77.1	78.5	80.4	80.4	80.4	80.4	80.4
63 Hz	71.9	73.1	75.2	79.6	81.0	81.7	81.7	81.7	81.7	81.7
80 Hz	74.8	76.0	78.9	83.3	84.7	84.5	84.5	84.5	84.5	84.5
100 Hz	75.8	77.0	80.9	85.3	86.7	89.2	89.2	89.2	89.2	89.2
125 Hz	78.0	79.2	81.9	86.3	87.7	87.7	87.7	87.7	87.7	87.7
160 Hz	81.3	82.5	84.9	89.3	90.7	89.0	89.0	89.0	89.0	89.0
200 Hz	80.4	81.6	84.9	89.3	90.7	90.3	90.3	90.3	90.3	90.3
250 Hz	81.7	82.9	86.4	90.8	92.2	91.2	91.2	91.2	91.2	91.2
315 Hz	82.9	84.1	88.0	92.4	93.8	94.5	94.5	94.5	94.5	94.5
400 Hz	83.3	84.5	88.3	92.7	94.1	94.1	94.1	94.1	94.1	94.1
500 Hz	82.0	83.2	88.0	92.4	93.8	94.3	94.3	94.3	94.3	94.3
630 Hz	83.2	84.4	89.6	94.0	95.4	96.3	96.3	96.3	96.3	96.3
800 Hz	82.5	83.7	89.2	93.6	95.0	95.4	95.4	95.4	95.4	95.4
1000 Hz	83.8	85.0	90.6	95.0	96.4	96.2	96.2	96.2	96.2	96.2
1250 Hz	83.4	84.6	90.1	94.5	95.9	95.5	95.5	95.5	95.5	95.5
1600 Hz	82.9	84.1	89.8	94.2	95.6	94.5	94.5	94.5	94.5	94.5
2000 Hz	81.4	82.6	88.1	92.5	93.9	93.3	93.3	93.3	93.3	93.3
2500 Hz	79.1	80.3	85.7	90.1	91.5	91.3	91.3	91.3	91.3	91.3
3150 Hz	76.9	78.1	81.5	85.9	87.3	88.6	88.6	88.6	88.6	88.6
4000 Hz	76.8	78.0	76.7	81.1	82.5	84.6	84.6	84.6	84.6	84.6
5000 Hz	72.2	73.4	74.3	78.7	80.1	79.8	79.8	79.8	79.8	79.8
6300 Hz	68.5	69.7	72.7	77.1	78.5	79.6	79.6	79.6	79.6	79.6
8000 Hz	66.6	67.8	70.6	75.0	76.4	77.7	77.7	77.7	77.7	77.7
10000 Hz	62.7	63.9	66.7	71.1	72.5	73.5	73.5	73.5	73.5	73.5
Total sound power level	94.0	95.2	99.8	104.2	105.6	105.6	105.6	105.6	105.6	105.6

hub height 120 m – 105.6 dB(A)

third octave sound power levels [dB(A)] at standardized wind speeds v_s										
Frequency	3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s
10 Hz	37.6	39.1	42.6	47.1	48.1	48.5	48.5	48.5	48.5	48.4
12.5 Hz	42.4	43.9	47.5	52.0	53.0	53.3	53.3	53.3	53.3	53.3
16 Hz	47.0	48.5	52.1	56.6	57.6	57.9	57.9	57.9	57.9	57.9
20 Hz	51.4	52.9	56.4	60.9	61.9	62.3	62.3	62.3	62.3	62.3
25 Hz	55.8	57.3	60.8	65.3	66.3	66.2	66.2	66.2	66.2	66.2
31.5 Hz	59.9	61.4	65.3	69.8	70.8	71.7	71.7	71.7	71.7	71.7
40 Hz	65.8	67.3	69.7	74.2	75.2	75.3	75.3	75.3	75.3	75.3
50 Hz	67.0	68.5	73.0	77.5	78.5	80.4	80.4	80.4	80.4	80.4
63 Hz	71.9	73.4	75.5	80.0	81.0	81.7	81.7	81.7	81.7	81.7
80 Hz	74.8	76.3	79.2	83.7	84.7	84.5	84.5	84.5	84.5	84.5
100 Hz	75.8	77.3	81.2	85.7	86.7	89.2	89.2	89.2	89.2	89.2
125 Hz	78.0	79.5	82.2	86.7	87.7	87.7	87.7	87.7	87.7	87.7
160 Hz	81.3	82.8	85.2	89.7	90.7	89.0	89.0	89.0	89.0	89.0
200 Hz	80.4	81.9	85.2	89.7	90.7	90.3	90.3	90.3	90.3	90.3
250 Hz	81.7	83.2	86.7	91.2	92.2	91.2	91.2	91.2	91.2	91.2
315 Hz	82.9	84.4	88.3	92.8	93.8	94.5	94.5	94.5	94.5	94.5
400 Hz	83.3	84.8	88.6	93.1	94.1	94.1	94.1	94.1	94.1	94.1
500 Hz	82.0	83.5	88.3	92.8	93.8	94.3	94.3	94.3	94.3	94.3
630 Hz	83.2	84.7	89.9	94.4	95.4	96.3	96.3	96.3	96.3	96.3
800 Hz	82.5	84.0	89.5	94.0	95.0	95.4	95.4	95.4	95.4	95.4
1000 Hz	83.8	85.3	90.9	95.4	96.4	96.2	96.2	96.2	96.2	96.2
1250 Hz	83.4	84.9	90.4	94.9	95.9	95.5	95.5	95.5	95.5	95.5
1600 Hz	82.9	84.4	90.1	94.6	95.6	94.5	94.5	94.5	94.5	94.5
2000 Hz	81.4	82.9	88.4	92.9	93.9	93.3	93.3	93.3	93.3	93.3
2500 Hz	79.1	80.6	86.0	90.5	91.5	91.3	91.3	91.3	91.3	91.3
3150 Hz	76.9	78.4	81.8	86.3	87.3	88.6	88.6	88.6	88.6	88.6
4000 Hz	76.8	78.3	77.0	81.5	82.5	84.6	84.6	84.6	84.6	84.6
5000 Hz	72.2	73.7	74.6	79.1	80.1	79.8	79.8	79.8	79.8	79.8
6300 Hz	68.5	70.0	73.0	77.5	78.5	79.6	79.6	79.6	79.6	79.6
8000 Hz	66.6	68.1	70.9	75.4	76.4	77.7	77.7	77.7	77.7	77.7
10000 Hz	62.7	64.2	67.0	71.5	72.5	73.5	73.5	73.5	73.5	73.5
Total sound power level	**94.0**	**95.5**	**100.1**	**104.6**	**105.6**	**105.6**	**105.6**	**105.6**	**105.6**	**105.6**

Cumulative Turbines Operating: All turbines are Vestas V90-3MW except Kilgarvin which 6 turbines, V52 0.85MW.

PUBLIC

Class 1
Document no.: 0005-5233 V01
2010-02-09

1/1 Octaves According to General Specification V90–3.0 MW

VCS, 50 Hz

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3.1.2 1/1 Octaves

V90-3.0 MW-VCS-50 Hz-Mode 0 - Hub Height 80 m											
Wind speed 10 m	3	4	5	6	7	8	9	10	11	12	13
Power	97	282.9	572.4	1023.3	1599.6	2200.8	2699.9	2955.4	2996.6	3000	3000
1/1 octaves	LWA	LWA	LWA	LWA	LWA	LWA	LWA	LWA	LWA	LWA	LWA
[Hz]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]
16	64.1	65.2	60.5	60.5	62.3	67.1	67.1	66.5	67.6	67.7	67.8
31.5	69.1	67.1	70.0	76.6	80.8	83.2	83.5	82.3	82.6	82.7	82.8
63	78.9	76.6	82.1	85.7	89.7	91.8	92.3	91.3	91.0	91.1	91.2
125	87.0	84.6	86.9	90.9	93.3	94.0	94.2	93.0	92.6	92.7	92.8
250	89.1	89.3	91.5	94.0	96.1	97.3	96.9	95.5	95.2	95.3	95.4
500	91.1	91.7	93.5	96.5	98.3	99.6	99.5	98.2	97.9	98.0	98.1
1000	92.3	92.3	95.9	99.1	100.8	101.8	101.7	100.4	100.1	100.2	100.3
2000	91.1	91.1	94.6	98.2	100.1	100.5	100.4	99.2	98.6	98.7	98.8
4000	86.6	86.8	90.5	94.3	96.2	96.7	96.4	94.9	94.2	94.3	94.4
8000	75.5	75.2	79.1	83.7	85.7	86.7	86.6	85.0	84.2	84.3	84.4
Spectra Value	97.9	97.9	100.9	104.2	106.1	107.0	106.9	105.6	105.2	105.3	105.4

Table 3-2: Octaves for V90-3.0 MW-VCS-50 Hz-mode 0, hub height = 80 m.

V90-3.0 MW-VCS-50 Hz-Mode 0 - Hub Height 105 m											
Wind speed 10 m	3	4	5	6	7	8	9	10	11	12	13
Power	114.4	316.4	647.8	1142.5	1756.4	2364.6	2835.3	2978.1	2999.4	3000	3000
1/1 octaves	LWA	LWA	LWA	LWA	LWA	LWA	LWA	LWA	LWA	LWA	LWA
[Hz]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]
16	64.2	64.3	60.6	61.3	65.9	66.5	67.4	66.3	67.6	67.8	67.9
31.5	69.3	67.3	70.8	77.8	80.9	83.2	83.5	82.0	82.7	82.8	82.9
63	79.1	77.2	82.8	86.6	89.5	92.0	92.1	91.0	90.9	91.2	91.3
125	86.8	84.7	87.6	91.8	92.9	94.1	94.1	92.7	92.6	92.8	92.9
250	89.4	89.5	92.1	94.8	96.5	97.2	96.7	95.2	95.2	95.4	95.5
500	91.4	91.8	94.2	97.3	99.1	99.6	99.3	97.9	97.9	98.1	98.2
1000	92.6	92.7	96.6	99.9	101.4	101.8	101.5	100.1	100.1	100.3	100.4
2000	91.5	91.5	95.4	99.0	99.9	100.5	100.2	99.0	98.6	98.8	98.9
4000	86.9	87.2	91.2	95.1	95.9	96.7	96.1	94.6	94.2	94.4	94.5
8000	75.7	75.7	80.0	84.6	85.6	86.7	86.3	84.7	84.2	84.4	84.5
Spectra Value	98.2	98.2	101.6	105.0	106.4	107.0	106.7	105.3	105.2	105.4	105.5

Table 3-3: Octaves for V90-3.0 MW-VCS-50 Hz-mode 0, hub height = 105 m.

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V90-3.0 MW-VCS-50 Hz-Mode 0 - Hub Height 90 m											
Wind speed 10 m	3	4	5	6	7	8	9	10	11	12	13
Power	104.6	297.4	603.4	1074.9	1667.6	2271.7	2758.6	2969.4	2997.8	3000	3000
1/1 octaves	LWA	LWA	LWA	LWA	LWA	LWA	LWA	LWA	LWA	LWA	LWA
[Hz]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]
16	64.0	64.2	60.4	60.8	63.8	66.8	67.3	66.4	67.6	67.7	67.8
31.5	69.1	67.1	70.5	77.1	80.8	83.2	83.6	82.1	82.6	82.7	82.8
63	78.9	77.0	82.5	86.0	89.6	91.9	92.3	91.1	90.9	91.1	91.2
125	86.7	84.5	87.3	91.3	93.1	94.0	94.3	92.8	92.6	92.7	92.8
250	89.2	89.3	91.8	94.3	96.2	97.3	96.9	95.3	95.2	95.3	95.4
500	91.2	91.7	93.9	96.8	98.6	99.6	99.5	98.0	97.9	98.0	98.1
1000	92.4	92.4	96.3	99.4	101.1	101.8	101.7	100.2	100.1	100.2	100.3
2000	91.3	91.3	95.1	98.5	100.0	100.5	100.4	99.0	98.6	98.7	98.8
4000	86.7	87.0	90.9	94.6	96.0	96.7	96.4	94.7	94.2	94.3	94.4
8000	75.5	75.5	79.7	84.0	85.6	86.7	86.5	84.8	84.2	84.3	84.4
Spectra Value	98.0	98.0	101.3	104.5	106.2	107.0	106.9	105.4	105.2	105.3	105.4

Table 3-4: Octaves for V90-3.0 MW-VCS-50 Hz-mode 0, hub height = 90 m.

Class 1
Document no. 946506 V10
2008-10-08

General Specification Vestas V52-850 kW 50/60 Hz

OptiSpeed® – Wind Turbine

WWW.VESTAS.COM

Vestas Wind Systems A/S · Alsvej 21 · 8940 Randers SV· Denmark · www.vestas.com

1.1 OptiSpeed® Description

OptiSpeed®, also called **V**estas **C**onverter **S**ystem (VCS), ensures a steady and stable electric power supply from the turbine.

VCS consists of

- an effective asynchronous generator with wound rotor and sliprings.
- a power converter with *Insulated Gate Bipolar Transistor* (IGBT) switches.
- contactors and protection.

VCS enables variable speed operation in a range of approx. 60 % of nominal RPM. VCS along with the pitch regulation OptiTip®, ensures energy optimisation, low noise operation and reduction of loads on the gearbox and other vital components.

VCS controls the current in the rotor circuit in the generator. This gives precise control of the reactive power and gives an accurate and precise connection between the generator and the grid.

1.2 Type Approvals

The V52-850 kW OptiSpeed® turbine is currently approved according to the following standards:

Country	Design criteria	Conditions	Hub height [m]
Denmark	DS472 + Teknisk Grundlag	Roughness Class 0, 1, 2, 3	40, 44, 49, 55, 60, 65, 74
Germany	DIBt	Zone III	60, 65
		Zone II	60, 65, 74, 86
Holland	NVN11400/0	Class II_A	36.5, 40, 44, 49, 55, 60, 65, 70
IEC	IEC 61400-1	Class I_A	40, 44, 49, 55, 60, 65
IEC		Class II_A	55, 60, 65, 74

1.3 Climatic Conditions

The V52-850 kW OptiSpeed® turbine is as standard designed for operation in ambient temperatures ranging from -20°C to +40°C. The turbine will be put in PAUSE-mode outside these temperatures. Restart-temperatures after stop on lower/upper ambient temperature limit are -20°C and +38°C accordingly.
Special precautions must be taken outside the standard operating temperatures. See section 1.7 "General Reservations" as well as Low Temperature (LT) appendix (Vestas doc. no. 946507) and High Temperature (HT) appendix (Vestas doc. no. 951614).

The turbines can be placed in wind farms with a distance of at least five times the rotor diameter (260 m) between the turbines. If the turbines are placed in one row, perpendicular to the predominant wind direction, the distance between turbines must be at least 4 rotor diameters (208 m).

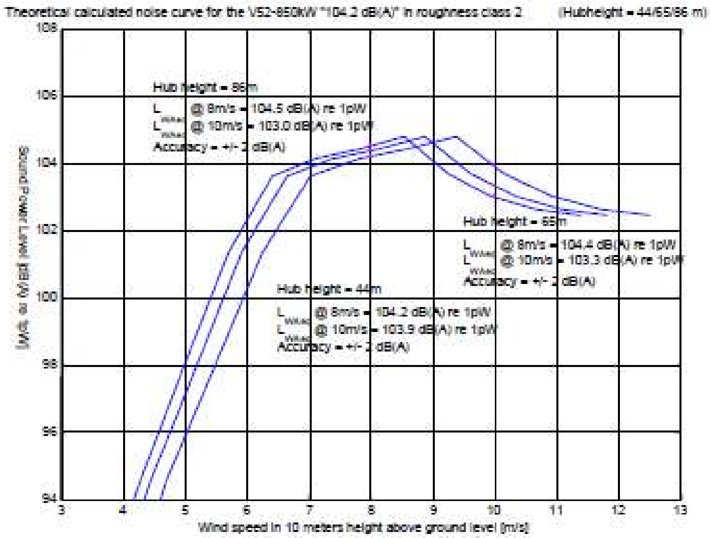
A relative humidity of 100 % is acceptable max. 10 % of the time.

<u>General corrosion classes, nacelle:</u>

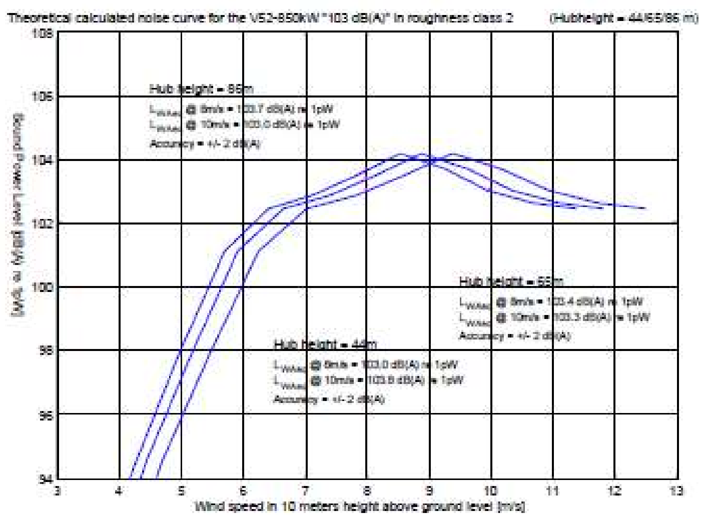
Protection against internal corrosion, according to ISO 12944, Class C3/High.

2.4 Noise Emission Plots

2.4.1 104.2 dB(A)



2.4.2 103.0 dB(A)



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Appendix 11.5: Predicted noise levels for 102.5m hub height

Table A.1: Predicted noise levels at varying wind speeds for hub height of 102.5m at standardised to 10m height wind speed

	ITM	ITM	3m/s	4m/s	5m/s	6m/s	7m/s	8m/s	9+m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA	dBA
H1	512160	578211	30.7	37.2	39.7	39.7	39.7	39.7	39.7
H2	513445	578031	31.1	37.6	40.1	40.1	40.1	40.1	40.1
H3	513072	579801	30.4	36.9	39.4	39.4	39.4	39.4	39.4
H4	514329	579384	30	36.5	39	39	39	39	39
H5	514339	577982	28.2	34.7	37.2	37.2	37.2	37.2	37.2
H6	514756	578856	28	34.5	37	37	37	37	37
H7	513435	577744	28.6	35.1	37.6	37.6	37.6	37.6	37.6
H8	512511	577570	26.9	33.4	35.9	35.9	35.9	35.9	35.9
H9	513762	577696	27.6	34.1	36.6	36.6	36.6	36.6	36.6
H10	513449	577603	27.4	33.9	36.4	36.4	36.4	36.4	36.4
H11	513566	577655	27.6	34.1	36.6	36.6	36.6	36.6	36.6
H12	514700	579510	26.3	32.8	35.3	35.3	35.3	35.3	35.3
H13	513505	577609	27.3	33.8	36.3	36.3	36.3	36.3	36.3
H14	513565	577612	27.3	33.8	36.3	36.3	36.3	36.3	36.3
H15	512009	577691	25.9	32.4	34.9	34.9	34.9	34.9	34.9
H16	513794	577514	26.1	32.6	35.1	35.1	35.1	35.1	35.1
H17	511756	577894	25.8	32.3	34.8	34.8	34.8	34.8	34.8
H18	511689	577885	25.3	31.8	34.3	34.3	34.3	34.3	34.3
H19	513838	580300	25.2	31.7	34.2	34.2	34.2	34.2	34.2
H20	513548	577431	25.9	32.4	34.9	34.9	34.9	34.9	34.9
H21	514950	577873	23.6	30.1	32.6	32.6	32.6	32.6	32.6
H22	515053	579406	24.1	30.6	33.1	33.1	33.1	33.1	33.1
H23	513747	577308	24.7	31.2	33.7	33.7	33.7	33.7	33.7
H24	514759	577513	22.9	29.4	31.9	31.9	31.9	31.9	31.9
H25	513572	577269	24.7	31.2	33.7	33.7	33.7	33.7	33.7
H26	513974	577197	23.6	30.1	32.6	32.6	32.6	32.6	32.6
H27	515322	579275	22.6	29.1	31.6	31.6	31.6	31.6	31.6
H28	513631	577179	24.1	30.6	33.1	33.1	33.1	33.1	33.1
H29	515488	579130	21.8	28.3	30.8	30.8	30.8	30.8	30.8
H30	514568	577209	22	28.5	31	31	31	31	31

	ITM	ITM	3m/s	4m/s	5m/s	6m/s	7m/s	8m/s	9+m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA	dBA
H31	514413	577149	22.2	28.7	31.2	31.2	31.2	31.2	31.2
H32	511831	577246	22.5	29	31.5	31.5	31.5	31.5	31.5
H33	515603	579094	21.1	27.6	30.1	30.1	30.1	30.1	30.1
H34	512444	580689	22.7	29.2	31.7	31.7	31.7	31.7	31.7
H35	515614	578103	20.5	27	29.5	29.5	29.5	29.5	29.5
H36	515672	578122	20.2	26.7	29.2	29.2	29.2	29.2	29.2
H37	515646	578046	20.2	26.7	29.2	29.2	29.2	29.2	29.2
H38	515525	579630	20.7	27.2	29.7	29.7	29.7	29.7	29.7
H39	515332	577403	19.9	26.4	28.9	28.9	28.9	28.9	28.9

Table A2: Margin between predicted cumulative noise levels, LA 90, 40dB limit at less than 5m/s and LA90, 43dB for all other wind speeds

	ITM	ITM	3m/s	4m/s	5m/s	6m/s	7m/s	8m/s	9+m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA	dBA
H1	512160	578211	-9.3	-5.8	-3.3	-3.3	-3.3	-3.3	-3.3
H2	513445	578031	-8.9	-5.4	-2.9	-2.9	-2.9	-2.9	-2.9
H3	513072	579801	-9.6	-6.1	-3.6	-3.6	-3.6	-3.6	-3.6
H4	514329	579384	-10	-6.5	-4	-4	-4	-4	-4
H5	514339	577982	-11.8	-8.3	-5.8	-5.8	-5.8	-5.8	-5.8
H6	514756	578856	-12	-8.5	-6	-6	-6	-6	-6
H7	513435	577744	-11.4	-7.9	-5.4	-5.4	-5.4	-5.4	-5.4
H8	512511	577570	-13.1	-9.6	-7.1	-7.1	-7.1	-7.1	-7.1
H9	513762	577696	-12.4	-8.9	-6.4	-6.4	-6.4	-6.4	-6.4
H10	513449	577603	-12.6	-9.1	-6.6	-6.6	-6.6	-6.6	-6.6
H11	513566	577655	-12.4	-8.9	-6.4	-6.4	-6.4	-6.4	-6.4
H12	514700	579510	-13.7	-10.2	-7.7	-7.7	-7.7	-7.7	-7.7
H13	513505	577609	-12.7	-9.2	-6.7	-6.7	-6.7	-6.7	-6.7
H14	513565	577612	-12.7	-9.2	-6.7	-6.7	-6.7	-6.7	-6.7
H15	512009	577691	-14.1	-10.6	-8.1	-8.1	-8.1	-8.1	-8.1
H16	513794	577514	-13.9	-10.4	-7.9	-7.9	-7.9	-7.9	-7.9
H17	511756	577894	-14.2	-10.7	-8.2	-8.2	-8.2	-8.2	-8.2
H18	511689	577885	-14.7	-11.2	-8.7	-8.7	-8.7	-8.7	-8.7

	ITM	ITM	3m/s	4m/s	5m/s	6m/s	7m/s	8m/s	9+m/s
House ID	Easting	Northing	dBA	dBA	dBA	dBA	dBA	dBA	dBA
H19	513838	580300	-14.8	-8.3	-8.8	-8.8	-8.8	-8.8	-8.8
H20	513548	577431	-14.1	-7.6	-8.1	-8.1	-8.1	-8.1	-8.1
H21	514950	577873	-16.4	-9.9	-10.4	-10.4	-10.4	-10.4	-10.4
H22	515053	579406	-15.9	-9.4	-9.9	-9.9	-9.9	-9.9	-9.9
H23	513747	577308	-15.3	-8.8	-9.3	-9.3	-9.3	-9.3	-9.3
H24	514759	577513	-17.1	-10.6	-11.1	-11.1	-11.1	-11.1	-11.1
H25	513572	577269	-15.3	-8.8	-9.3	-9.3	-9.3	-9.3	-9.3
H26	513974	577197	-16.4	-9.9	-10.4	-10.4	-10.4	-10.4	-10.4
H27	515322	579275	-17.4	-10.9	-11.4	-11.4	-11.4	-11.4	-11.4
H28	513631	577179	-15.9	-9.4	-9.9	-9.9	-9.9	-9.9	-9.9
H29	515488	579130	-18.2	-11.7	-12.2	-12.2	-12.2	-12.2	-12.2
H30	514568	577209	-18	-11.5	-12	-12	-12	-12	-12
H31	514413	577149	-17.8	-11.3	-11.8	-11.8	-11.8	-11.8	-11.8
H32	511831	577246	-17.5	-11	-11.5	-11.5	-11.5	-11.5	-11.5
H33	515603	579094	-18.9	-12.4	-12.9	-12.9	-12.9	-12.9	-12.9
H34	512444	580689	-17.3	-10.8	-11.3	-11.3	-11.3	-11.3	-11.3
H35	515614	578103	-19.5	-13	-13.5	-13.5	-13.5	-13.5	-13.5
H36	515672	578122	-19.8	-13.3	-13.8	-13.8	-13.8	-13.8	-13.8
H37	515646	578046	-19.8	-13.3	-13.8	-13.8	-13.8	-13.8	-13.8
H38	515525	579630	-19.3	-12.8	-13.3	-13.3	-13.3	-13.3	-13.3
H39	515332	577403	-20.1	-13.6	-14.1	-14.1	-14.1	-14.1	-14.1

APPENDIX 12.1

12.1a Visual Receptor Sensitivity

12.1b Magnitude of Visual Impacts at Representative Viewpoint Locations

12.1a Visual Receptor Sensitivity

Visual sensitivity is a two-sided analysis of receptor susceptibility (people or groups of people) versus the value of the view on offer at a particular location. To assess the susceptibility of viewers and the amenity value of views, the assessor uses a range of criteria and provides a four point weighting scale to indicate how strongly the viewer/view is associated with each of the criterion identified in **Section 12.2.6.1** of Chapter 12.

Table A12.1: Visual Receptor Sensitivity

Scale of Value for each criterion

Strong association	Moderate association	Mild association	Negligible association

N = Negligible; **L** = low sensitivity; **ML** = medium-low sensitivity **M** = medium sensitivity; **HM** = High-medium sensitivity; **H** = high sensitivity; **VH** = very high sensitivity

Values associated with the view	VP1	VP2	VP3	VP4	VP5	VP6	VP7	VP8	VP9	VP10
Susceptibility of viewers to changes in views										
Recognised scenic value of the view										
Views from within highly sensitive landscape areas										
Primary views from residences										
Intensity of use, popularity (number of viewers)										
Viewer connection with the landscape										
Provision of vast, elevated panoramic views										
Sense of remoteness / tranquillity at the viewing location										
Degree of perceived naturalness										
Presence of striking or noteworthy features										
Sense of Historical, cultural and / or spiritual significance										
Rarity or uniqueness of the view										
Integrity of the landscape character within the view										
Sense of place at the viewing location										
Sense of awe										
Overall sensitivity assessment	**M**	**M**	**HM**	**HM**	**ML**	**ML**	**HM**	**ML**	**ML**	**VH**

N = Negligible; **L** = low sensitivity; **ML** = medium-low sensitivity **M** = medium sensitivity; **HM** = High-medium sensitivity; **H** = high sensitivity; **VH** = very high sensitivity

Values associated with the view	VP11	VP12	VP13	VP14	VP15	VP16	VP17	VP18	VP19	VP20
Susceptibility of viewers to changes in views										
Recognised scenic value of the view										
Views from within highly sensitive landscape areas										
Primary views from residences										
Intensity of use, popularity (number of viewers)										
Viewer connection with the landscape										
Provision of vast, elevated panoramic views										
Sense of remoteness / tranquillity at the viewing location										
Degree of perceived naturalness										
Presence of striking or noteworthy features										
Sense of Historical, cultural and / or spiritual significance										
Rarity or uniqueness of the view										
Integrity of the landscape character within the view										
Sense of place at the viewing location										
Sense of awe										
Overall sensitivity assessment		**H**	**VH**	**VH**	**M**	**ML**	**H**	**H**	**ML**	**M**

Values associated with the view	VP21	VP22	VP23	VP24	VP25
Susceptibility of viewers to changes in views					
Recognised scenic value of the view					
Views from within highly sensitive landscape areas					
Primary views from residences					
Intensity of use, popularity (number of viewers)					
Viewer connection with the landscape					
Provision of vast, elevated panoramic views					
Sense of remoteness / tranquillity at the viewing location					
Degree of perceived naturalness					
Presence of striking or noteworthy features					
Sense of Historical, cultural and / or spiritual significance					
Rarity or uniqueness of the view					
Integrity of the landscape character within the view					
Sense of place at the viewing location					
Sense of awe					
Overall sensitivity assessment	**M**	**HM**	**ML**	**M**	**ML**

12.1b Magnitude of Visual Effects at Viewshed Reference Points

The assessment of visual impacts at each of the selected viewpoints is aided by spatially accurate wireframe images and photomontages that have been produced in accordance with Scottish Natural Heritage (SNH) Visual representation of wind farms: Best Practice Guidelines (version 2.2 - 2017). The presented images for each viewpoint include:

1. Existing View (Contextual 90° included angle)
2. Wireframe view - proposed and cumulative turbines (Contextual 90° included angle)
3. Wireframe view (53.5° included angle)
4. Montage View (53.5° included angle)

VP No.	Existing View	VP Sensitivity	Visual Impact Magnitude	Significance / Quality / Duration of Impact
VP1	**Local Road at Gortnagross** This is a broad and elevated views across the landscape of the central study area where such open views are not frequent. It takes in a rugged landscape of rolling hills covered in a grainy texture of marginal farmland, reverting scrub, commercial forestry and patches of woodland. Rising above the complex skyline ridge in the distance are the turbines from the wind farms on the Kerry side of the Cork / Kerry border. There are very few dwellings in view and a general sense of rural tranquillity	**Medium**	The proposed turbines present in an exemplary manner from this direction and in this context (in accordance with WEDG). They are seen at a noticeable, but not dominating scale at this distance and within a broad landform and land use where they are well assimilated. The turbines are fully revealed with an even spacing and a profile than mimics the underlying terrain making it a highly legible view . They sit largely within a commercial forest plantation and marginal farmland in a landscape already characterised by turbines. However, the turbines also represent further built development in this upland rural scene and they contribute to a greater proportion of the surrounding ridge system containing turbines in a cumulative sense. On balance of the reasons outlined above, the magnitude of visual impact is deemed to be Medium-low	**Moderate-slight/** **Negative/** **Long-term**
VP2	**Local Road at Coolea Village** This is a view from the western edge of Coolea Village across a mixed foreground of marginal paddocks, a storage yard and residential dwellings amongst various patches of scrub and tree lines. The view is contained in the middle distance by farmed and forested slopes leading to a rolling ridge that hosts around a dozen modest scale wind turbines to the west.	**Medium**	All five of the proposed turbines are visible from here rising above the ridgeline to the northeast on alignment with the road that runs in the same direction out of the village. They are seen at a relatively prominent, but not excessive scale in this context, albeit there is a minor degree of scale conflict with dwellings on the slopes beneath the site. The broad forested slopes and ridges in which the turbines sit are more assimilative in terms of both scale and productive upland rural context. From this angle there are overlapping clusters of two pairs of turbines with a single turbine between. The latter provides some balance and legibility to the array which is otherwise cluttered. The turbines will form a backdrop feature to the Village but one that is clearly contained within its rural hinterland in a patter that is already familiar. Overall, the magnitude of visual impact is deemed to be Medium.	**Moderate/** **Negative/** **Long-term**
VP3	**Local road west of Coolea**	**High-medium**	Although this view is only a short distance west of Coolea Village, the more open rural context and altered viewing	**Moderate/**

VP No.	Existing View	VP Sensitivity	Visual Impact Magnitude	Significance / Quality / Duration of Impact
	This is a relatively broad and open view from the valley floor just to the west of the village of Coolea. The foreground consists of marginal damp ground followed by improved pasture with a combination of rough grazing, pasture and forestry on the rising slopes beyond. A small section of moorland ridge can be seen to the north, whilst small wind turbines rise above a vegetated ridgeline further to the northwest.		angle results in a much more legible view of the proposed turbines than from VP2. The clusters of two pairs of turbines at either end of the scheme still occur, but the degree of overlapping is less and there is a stronger sense of where each of the turbines is placed within the rolling forested site. The development is well assimilated within this context in terms of scale and function. Overall, the magnitude of impact is deemed to be Medium-low.	**Negative/** **Long-term**
VP4	**Local road at Lumnagh** This is a down-valley view to the north from a slightly elevated location, which is relatively contained in the foreground but vegetation and landform, but opens up across the valley beyond. The land cover of the valley consists of a combination of farmed fields on low and rising ground with forestry scrub and moorland on the higher slopes and ridges.	**High-medium**	As with VP1, this is an exemplary view of the proposed wind farm with the turbines presenting an even spacing and profile that matches the underling topography. They are seen in a broad landform and land cover context where they do not appear over-scaled and they are well assimilated with the productive upland rural setting. This is balanced against the increase in built development within that rural setting. Overall, the magnitude of visual impact is deemed to be Medium-low.	**Moderate/** **Negative/** **Long-term**
VP5	**Local road at Inchamore** The subject view to the northeast is a contained uphill one across farmland and then forestry covering a domed ridgeline. More expansive views are afforded across the upland valley in the opposite direction to the south.	**Medium-low**	Four of the five proposed turbines are visible from here to varying degrees just over the forested spur ridge to the northeast. Only the full blade sets of two of the turbines will be revealed above the forest with partial blade sets and blade tips revealed for the other three. Whilst this is not an ideal scenario from an aesthetics and legibility perspective, it represents a reasonable degree of screening and the turbines do not appear excessive in terms of scale in this context. They do represent a noticeable increase in the scale of built development in this remote rural context. Overall, the magnitude of visual impact is deemed to be Medium	**Moderate/** **Negative/** **Long-term**

VP No.	Existing View	VP Sensitivity	Visual Impact Magnitude	Significance / Quality / Duration of Impact
VP6	**Local road at Laharan East** This is a strongly enclosed view within an upland area that is contained in commercial forestry that appears to be around mid-rotation in terms of its size. It may have been that this section of scenic route was designated at a point of time when the landscape was more open and broad elevated views to the south were likely to have been afforded along it. Currently and for the next decade or so, the scenic designation is less warranted and this is reflected in the sensitivity rating. The view in question is along the road in a northernly direction.	**Medium-low**	This is an illustrative view from the S25 scenic route that highlights the degree of enclosure form both localised landform (roadside embankment and forestry. The proposed turbines will not be visible from here due to screening and the magnitude of visual impact will be Negligible by default.	**Imperceptible/** **Neutral**
VP7	**Local road at Caraghnacaha** This is a vast elevated view, but not in the direction of the site. Whilst the subject view to the north is substantially truncated at a short distance by forestry, it is the view to the south that is channelled through an upland valley towards distant lowland farmland (Not depicted). The view to the north does allow a brief window through the forest plantation towards forested slopes and a distant mountain ridgeline.	**High-medium**	One of the turbines and the blade tips of another will be visible from here through a gap in the foreground forestry plantation and rising above another forested ridge. In the context of the broader view afforded in the opposite direction which is framed by much closer turbines from the Derragh Wind Farm, the proposed turbines are unlikely to be noticed by a casual observer. Furthermore, the consequence of seeing them will have little bearing on visual amenity. Thus, the magnitude of visual impact is deemed to be Low-negligible.	**Slight-imperceptible/** **Negative/** **Long-term**
VP8	**Local road at Milleeny** This elevated viewpoint affords views across an upland context of good and marginal grazing in the foreground that is flanked and interspersed with conifers. A more consistent blanket of forestry occupies the slopes and ridges beyond.	**Medium-low**	Four of the proposed turbines will be clearly visible from here rising above the nearby forested ridge, but divided by a clump of foreground conifers. These same conifers substantially screen one of the remaining turbines whilst a foreground plantation to the right screens the other. It is a relatively clear and unambiguous view of the turbines within a broad upland setting that assimilates them well in terms of scale and function. At the same time, the turbines represent a notable increase to the scale and intensity of built development within this relatively undeveloped rural context. On balance, the magnitude of impact is deemed to be High-medium.	**Moderate/** **Negative/** **Long-term**

VP No.	Existing View	VP Sensitivity	Visual Impact Magnitude	Significance / Quality / Duration of Impact
VP9	**Local road at Bardinch** This is a cross-valley view to the north from a slightly elevated location, which affords slightly filtered views between fore-to-middle ground trees and treelines, but opens up across the valley beyond. The land cover of the distant slopes and ridges is a combination of forestry, scrub and moorland.	**Medium-low**	All of the proposed turbines are present to the viewer from here in a clear and comprehensible manner rising above the middle distance forested ridgeline. They are seen in two groups with near perfect spacing within each cluster. The development presents at a prominent scale but is not overbearing in terms of the viewer or over-scaled in terms of the receiving landscape context. Aside from introducing a heightened scale and intensity of built development into this upland rural scene, the wind farm appears well assimilated. Overall, the magnitude of visual impact is deemed to be Medium.	**Moderate-slight/** **Negative/** **Long-term**
VP10	**Summit of Crohane Mountain** This is a vast mountaintop view from the summit of Crohane Mountain, which is the easternmost peak in the Mangerton range. The summit is generally reached from the northern side via a road along the eastern edge of the scenic Lough Guitane. It is a steep and challenging climb and a lesser known trail than others in the Mangerton range, so it is not a highly frequented location and generally by fit and experienced hill walkers. Whilst the view to the north takes in Lough Guitane and Killarney lakes national park, the view in question, to the south, covers a sparsely populated upland area. This is a fissured plateau of upland ridges and valleys contained in a regular and balanced mix of patchwork farmland and scrubby woodland in the valleys with rocky moorland, commercial forestry and wind turbines occupying the higher slopes and ridges. Lowland farmland can be seen in the far distance to the southeast. In terms of wind energy development, the upland area to the south of the Mangerton range has a high stocking of wind turbines	**Very High**	The proposed turbines will rise at a noticeable scale above a forested ridge within the lower Derrynasaggart range revealing the full blade set of each turbine. The turbines have a relatively even spacing that avoids overlap and the profile of the development is consistent with the underlying terrain. Within the wider wind energy context of this vista the proposed turbines serve as a visual link between the 'Kilgarvan' group of wind farms to the south and the Millstreet group of wind farms further to the east. In cumulative impact terms, this is more an effect of broadening dissemination of wind farms within different parts of the view. The proposed development remains relatively isolated from the nearest developments as a modest and discrete development within a vast context where wind energy is a characteristic feature. Overall, the magnitude of visual impact is deemed to be Low-negligible.	**Moderate-slight/** **Negative/** **Long-term**

VP No.	Existing View	VP Sensitivity	Visual Impact Magnitude	Significance / Quality / Duration of Impact
VP11	**N22 at Direenaling** This is an elevated view to the south afforded from a small cul-de-sac immediately adjacent to the N22, which affords clearer views that from most of the major road / scenic route and should be considered a worst-case-scenario. The view in question takes in nearby slopes of marginal farmland and forestry to the southwest. However, in this instance the eye is generally drawn down-valley to the southeast where a lowland farming landscape can be seen in the far distance and it is considered that this is the key aspect of visual amenity relating to the scenic route designation.	**High-medium**	The partial blade sets of three of the proposed turbines and blade tips of the other two will be revealed from here above the nearby forested ridgeline to the southwest. They present at a prominent scale and will introduce an increased scale and intensity of built development within the upland rural scene. The blade sets will rotate on the skyline which is not as aesthetically desirable as if they rotated freely above it. The turbines do not appear excessive in this broad upland context The proposed turbines are contextually integrated into this productive upland landscape, which already contains wind turbines to the south and they will not obstruct or unduly intrude on the long distance down valley views to the south east, which are the key source of visual amenity at this location which is also a busy arterial route. Overall, the magnitude of impact is deemed to be High-medium	**Substantial-moderate/** **Negative/** **Long-term**
VP12	**Local road at Coomnagire** This is a broad elevated view from a local road that runs across the lower south-western slopes of Kilcaskan Mountain. It takes in a folding upland landscape that varies in landcover between marginal and good quality grazing, commercial forestry and reverting scrub. It is dotted occasionally with rural dwellings and farmsteads. There is also a series of wind turbines from the Derragh and Cleanrath wind Farms lining distant ridges to the southwest and smaller turbines on the distant ridges to the west.	**High**	All of the proposed turbines will rise above a middle distance forested ridge to the west and consequently they are peripheral in this vast southerly vista. Nonetheless, they present at a noticeable scale, but with a low degree of contrast against the sky. The arrangement of the turbines is cluttered with one pair and a group of three heavily overlapped. This is offset slightly by a less ambiguous view of the remaining turbine to the left with a similar gap as that between the clusters. The turbines will not look out of place in this productive upland rural context where wind turbines are a characteristic feature. Overall, the magnitude of visual impact is deemed to be Low.	**Moderate-slight/** **Negative/** **Long-term**
VP13	**Western Summit of 'the Paps of Anu'** This is a vast mountaintop view in all directions, but this summit and the adjacent summit, which are together	**Very high**	All of the proposed turbines will be visible from here rising with full blade sets above a middle distance ridge against a backcloth of diminishing ridgelines beyond. They are seen at a modest scale and as this is a southerly view,	**Moderate/** **Negative/**

VP No.	Existing View	VP Sensitivity	Visual Impact Magnitude	Significance / Quality / Duration of Impact
	known as 'the Paps of Anu' have particular heritage value as they are both topped by Iron Age cairns suggesting they were an important part of ancient rituals / worship for the inhabitants of this area. The view in question, to the south, takes in the steeply ascending moorland slopes of the Paps followed by an upland terrace of ridges and valleys contained in large tracts of commercial forestry, some patchwork farmland and a relatively extensive scattering of wind turbines. Although the latter consists of a number of sperate developments, they tend to run together in perspective in this elevated oblige view and trail along the higher slopes and ridges.		they will be predominantly cast in shadow, which reduces their visual contrast against the terrain (compared to in silhouette against the sky). Despite the rugged and naturalistic foreground spurs, the turbines are seen in a broad and productive upland rural context of forestry, farmland and wind energy development with which they are well assimilated in terms of scale and function. Nonetheless, they will be the closest turbines to this viewpoint. On balance of the reasons outlined above, the magnitude of visual impact is deemed to be Low.	**Long-term**
VP14	**Summit of Mangerton Mountain** This is a vast mountain-top view from the peak that lends its name to the Mangerton range. Though slightly less iconic than the MacGillycuddy Reeks further to the west, the Mangerton range and chiefly Mangerton Mountain provide part of the dramatic backdrop to Killarney Town and the Killarney Lakes National Park, both of which lie outside of the study area and visibility potential from the proposed development further to the northwest. By way of finer context, Mangerton Mountain is reached via the popular Devil's Punchbowl walking loop which begins just outside of Killarney. However, the broad peak of Mangerton Mountain is not actually on that loop and is likely to be visited by only a fraction of those embarking on the Devil's Punchbowl circuit. The south-easterly vista in question is dominated for some distance by the plateau brow of Mangerton Mountain itself, which limits the visibility of much of the lower middle-distance landscape beyond. A more distant band of rolling ridges emerges beyond the brow, cloaked in a combination of mountain moorland on higher slopes, forestry and marginal farmland on mid-	**Very High**	All of the proposed turbines can be seen from here at a small scale due to the considerable viewing distance. They will rise above a distant forested ridge with a low degree of contrast against a backdrop of very distant lowland farmland. Two pairs of turbines are heavily overlapped, but such aesthetic effects have less of a bearing on distant views of wind farms in terms of generating visual clutter. Notwithstanding the viewing distance and vast scale of the view, they will be one of the more prominent individual wind energy developments as they are more isolated between larger groups of turbines to the southeast and further to the east. In this respect they serve as something of a visual link between the two larger groups and add to the sense of wind energy dissemination throughout the view. They will not appear at all ambiguous in this upland rural setting which is already influenced by wind turbines. Overall, the magnitude of visual impact is deemed to be Low-negligible.	**Moderate-slight/** **Negative/** **Long-term**

VP No.	Existing View	VP Sensitivity	Visual Impact Magnitude	Significance / Quality / Duration of Impact
	slopes and more arable farmland in the sheltered valley between. Dozens of turbines from predominantly the Grousemount and Inchincoosh Wind Farms can also be made out on higher ground within the distant upland setting			
VP15	**N72 east of Kilarney** This is a pleasant and slightly elevated vista across a valley of lowland agriculture defined by treelined hedgerows, which has a dramatic backdrop of the rugged Mangerton range to the south. There is a low section in the range to the southeast though which the lower hills of the Derrynasaggart range can be glimpsed between sections of foreground vegetation.	**Medium**	Only three of the proposed turbines are potentially visible from here rising above the skyline of the distant Derrynasaggart range. One of the turbines will be near fully revealed while the other two present partial blade sets above the skyline ridge. In this regard they appear as the outliers of a larger development that occurs beyond the ridge and out of view and they are also the only turbines visible from this location. However, they are a distant background feature within a less dramatic section of this vista, which is also from a busy road lined by residential development. For the reasons outlined above, the magnitude of visual impact is deemed to be Low.	**Slight/** **Negative/** **Long-term**
VP16	**Local road at Coumaclovane** This upland context view is from an elevated section of local road where a fore-to-middle ground of scrub and grazing sweeps towards a containing slope of rocky moorland.	**Medium-low**	All of the proposed turbines are potentially visible from here rising to differing degree above the rugged moorland ridge to the north. They will present full and partial blade sets above the skyline ridge and one of the turbines rises in a gap beyond the eastern end of the ridge. Thus, the array does not have a clear and legible arrangement within this scene and some of the blade sets will rotate against the skyline ridge in silhouette which can generate a degree of visual irritation. At the same time, the view of turbines within this productive upland rural scene is not ambiguous. Overall, the magnitude of visual impact is deemed to be Medium.	**Moderate-slight/** **Negative/** **Long-term**
VP17	**Local road at Gortnahoughtee** The is a vast elevated view across the upland context of the study area principally comprising of a series of	**High**	The proposed turbines are only partially visible presenting less than full blade sets beyond the distant skyline ridge to the northwest. They will be seen with low degree of contrast against the sky and are much less prominent than	**Slight/** **Negative/**

VP No.	Existing View	VP Sensitivity	Visual Impact Magnitude	Significance / Quality / Duration of Impact
	folding, elongated ridges and valleys cloaked in marginal farmland and scrubby woodland at lower elevations and forestry and moorland at higher elevations. There is a loose scattering of dwellings visible and a prominent feature of the foreground is an ancient ringfort. Lough Allua can be glimpsed in the lower middle distance and the turbines of the Cleanrath and Derragh Wind Farms occupy different sections of ridgeline beyond		the five Derragh turbines that on a similar alignment on a nearer ridge. Indeed, the only aesthetic issue is the potential for visual clutter or scale/distance confusion with these nearer turbines through which the proposed turbines are seen. Because the bases of the Derragh turbines are visible on the nearer ridge, the legibility of separation distance between the developments is maintained. For the reasons outlined above, the magnitude of visual impact is deemed to be Low-negligible	**Long-term**
VP18	**Local road at Kilbarry** Similar in nature to VP17, this is a vast elevated view across rugged, but consistent height hills and valleys of the study area. Whilst the foreground setting is that of pastoral farming, the background is more heavily vegetated with scrub, woodland patches and forestry. There are a series of undulating ridgelines, but the skyline is a relatively horizontal blend of them. In the central middle distance, turbines from the Cleanrath Wind Farm can be seen merging with turbines from the Derragh Wind Farm just beyond	**High**	The proposed turbines will be visible as a small scale cluster rising with a low degree of contrast above the distant skyline ridge. Aside from one instance of turbine overlap, the scheme is well presented in a legible manner. The proposed turbines are considerably less noticeable within this broad vista than the nearer Cleanrath and Derragh turbines further to the south (left). Overall, the magnitude of visual impact is deemed to be Low-negligible.	**Slight/** **Negative/** **Long-term**
VP19	**N22 at Ballymakeery** This is a channelled view from the N22 on approach to the settlements of Ballymakeery and Ballyvourney. The view is flanked by vegetation in the foregrounds and a low vegetated ridge truncates the view on alignment with the road in the middle distance.	**Medium-low**	Only the hubs and blades of the proposed turbines will be visible from here above the vegetated skyline ridge, but on almost direct alignment with the road. Consequently, they will be noticed but not as prominent features of the view and they are also legibly contained in the upland rural context beyond the settlement. Notably, the view from the settlement within more contained lower ground is likely to be considerably less. There is a slight degree of clutter and ambiguity associated with the overlapping blade sets rotating amongst the skyline treetops.	**Slight/** **Negative/** **Long-term**

VP No.	Existing View	VP Sensitivity	Visual Impact Magnitude	Significance / Quality / Duration of Impact
			Overall, the magnitude of visual impact is deemed to be Low.	
VP20	**N22 at Inchinlinane** This is a pleasant view from the N22 road corridor across a foreground of flat pastoral farmland in the base of the valley giving way to middle distance slopes of farmland and woodland. The view is contained at a modest distance by an undulating, vegetated ridge and mature trees line the road ahead for west bound road users	**Medium**	The proposed turbines will not be visible from here due to screening by foreground roadside vegetation and this continues to be the case heading west along the road for at least the depicted section. The magnitude of visual impact will be Negligible.	**Imperceptible/** **Neutral**
VP21	**Local road near Kilnamartyra** This is a broad elevated vista from just above the settlement of Kilnamartyra, the houses, commercial buildings and playing pitches of which can be seen in the fore-to-middle ground wrapped by a hinterland of pastoral farmland. Whilst the middle distance landscape remains predominantly farmland, scrub, forestry and rugged moorland can be seen on the slopes and ridges beyond, which extend to a relatively horizontal skyline in the distance. The turbines from the Cleanrath and Derragh Wind Farms can be seen rising at a modest scale above closely associated, but discrete, sections of ridgeline in the distant middle ground (not depicted)	**Medium**	The proposed turbines will all be visible above a domed section of the skyline ridge to the northwest. They present at a modest scale in a tight but relatively even spaced group from this distance and their profile reflects that of the underlying terrain, They will not intrude on any views of distinctive background peaks and appear well assimilated in this view alongside broad tracts of forestry and other sporadic wind energy developments. Overall, the magnitude of visual impact is deemed to be Low.	**Slight/** **Negative/** **Long-term**
VP22	**R582 at Gortavranner** This is a pleasant pastoral scene that takes in rolling farmland in the foreground backed by a woodland hill and a moorland ridge in the distance. There is also an array of farm structures and utility poles as well as several turbines above the distant skyline ridge.	**High-medium**	This is a potential brief glimpse of the proposed turbines through a vegetated saddle in the middle distance ridgeline. Only the blade tips of the proposed turbines will be potentially discernible above the distant skyline and they will be so small and faint that they are unlikely to be noticed by a casual observer. There will be no consequence for visual amenity so the impact is Negligible.	**Imperceptible/** **Neutral**

VP No.	Existing View	VP Sensitivity	Visual Impact Magnitude	Significance / Quality / Duration of Impact
VP23	**Local road at Dangansallagh** This is a slightly elevated view across rolling farmland and woodland on lower ground with forestry and moorland covering upper slopes and ridges. The foreground has a series of farm structures and dwellings.	**Medium-low**	Similar to the view from VP22, the partial blade sets of the proposed turbines are likely to be just visible with a low degree of contrast above a lower section of the vegetated skyline ridge and at a considerable distance. Whilst potentially discernible and not presenting in a particularly legible manner, the proposed turbines will not have a notable effect on visual amenity at this location. For these reasons, the magnitude of visual impact is deemed to be Low-negligible.	**Slight-imperceptible/** **Negative/** **Long-term**
VP24	**Local road at Reananerree** This is a relatively contained and slightly uphill view across a farmed field towards a dwelling and coniferous treeline that serve to truncate it at a relatively short distance.	**Medium**	Whilst potentially visible in a bare-ground scenario, the proposed turbines will be fully screened from this section of designated scenic view. The magnitude of visual impact is therefore Negligible by default.	**Imperceptible/** **Neutral**
VP25	**N22 Bypass above Ballyvourney** This elevated viewpoint is located just below the new bypass road to the east of Ballyvourney and the image was captured during the latter part of its construction. The view to the west is a pleasant one across rolling wooded slopes with the village of Ballyvourney visible in the lower middle ground. There are wind turbines visible at a small-scale above the distant skyline ridges	**Medium-low**	The proposed turbines will all be visible above one of the nearer wooded ridges in the middle distance. They are seen at a modest, but noticeable scale with a limited lateral extent and they will present with a low degree of visual contrast against the sky. Aside from one instance of heavy overlapping, the turbines have a regular spacing and are generally seen in an unambiguous manner (ignore the foreground utility pole at this precise location). They will contribute to a minor increase in the intensity of built development within this scene but in the context of a busy national route and settlement. Overall, the magnitude of visual impact is deemed to be Low.	**Slight / Negative**

APPENDIX 12.2

Cumulative Impact Analysis at Viewpoints

Nature of Cumulative Visibility

The nature of cumulative visibility within the study area is analysed in Table 12.1A below using the same viewpoints that are used for the main visual impact assessment. The results are then summarized within the Chapter in Section 12.6.1.

Table 12.1A: Nature of Cumulative Visibility

VRP Ref.	Number of other wind farms potentially visible	Nearer or further than the Proposed Development	Combined View (within a single viewing arc - 90°)	Succession View (within a series of viewing arcs from the same location)	Sequential View (view of different developments moving along a linear receptor)
VP1	5+	Similar and further	Yes	Yes	No
VP2	4	Further	Yes	Yes	No
VP3	1	Further	Yes	No	No
VP4	1	Further	Yes	No	No
VP5	-	-	-	-	-
VP6	-	-	-	-	-
VP7	3	Nearer	Yes	Yes	No
VP8	5+	Further	Yes	Yes	No
VP9	-	-	-	-	-
VP10	10+	Nearer and Further	Yes	Yes	No
VP11	-	-	-	-	-
VP12	5+	Nearer and Further	Yes	Yes	No
VP13	10+	Further	Yes	Yes	No
VP14	10+	Nearer and Further	Yes	Yes	No
VP15	-	-	-	-	-
VP16	-	-	-	-	-
VP17	5+	Nearer and Further	Yes	Yes	No
VP18	5+	Nearer and Further	Yes	Yes	No
VP19	-	-	-	-	-
VP20	-	-	-	-	-
VP21	5+	Nearer and Further	Yes	Yes	No
VP22	1	Further	Yes	No	Yes

VP23	2	Further	Yes	No	No
VP24	-	-	-	-	-
VP25	5	Similar and Further	Yes	No	Yes