Hare Hill Windfarm Repowering and Extension

Environmental Impact Assessment Report

Volume 3

Technical Appendix 14.2: Carbon Balance

Input Data	Expected Value	Minimum	Maximum
Windfarm characteristics			
Dimensions			
No. of turbines	23	23	23
Lifetime of windfarm (years)	40	40	40
Performance			
Power rating of turbines (turbine capacity) (MW)	5.5	4.5	6.2
Capacity factor			
Enter estimated capacity factor (percentage efficiency)	26.3	23.5	32.7
Backup			
Extra capacity required for backup (%)	5	5	5
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10	10	10
Carbon dioxide emissions from turbine life - (eg. manufacture, construction, decommissioning)	Calculate wrt installed capacity		
Characteristics of peatland before windfarm development			
Type of peatland	Acid Fen		
Average annual air temperature at site (°C)	8.04	4.35	11.73
Average depth of peat at site (m)	0.48	0.47	0.49
C Content of dry peat (% by weight)	40	25	52
Average extent of drainage around drainage features at site (m)	20.00	10.00	30.00
Average water table depth at site (m)	0.40	0.20	0.60
Dry soil bulk density (g cm^{-3})	0.35	0.25	0.45
Characteristics of bog plants			
Time required for regeneration of bog plants after restoration (years)	15	10	20
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha^{-1} yr^{-1})	0.25	0.12	0.31
Forestry Plantation Characteristics			
Method used to calculate CO_2 loss from forest felling	Enter Simple Data		
Area of forestry plantation to be felled (ha)	0	0	0
Average rate of carbon sequestration in timber (tC ha-1 yr-1)	3.60	3.60	3.60
Counterfactual emission factors			
Coal-fired plant emission factor (t CO_2 MWh^{-1})	1.046	0.994	1.046
Grid-mix emission factor (t CO_2 MWh^{-1})	0.171	0.171	0.191
Fossil fuel-mix emission factor (t CO_2 MWh^{-1})	0.437	0.437	0.44
Borrow pits			
Number of borrow pits	4	4	4
Average length of pits (m)	215.5	170	277
Average width of pits (m)	130	111	156
Average depth of peat removed from pit (m)	0.29	0.27	0.30
Foundations and hard-standing area associated with each turbine			
Method used to calculate CO_2 loss from foundations and hard-standing	Rectangular with vertical walls		

Average length of turbine foundations (m)	36	31	39
Average width of turbine foundations (m)	36	31	39
Average depth of peat removed from turbine foundations (m)	0.43	0.35	0.5
Average length of hard-standing (m)	240	240	240
Average width of hard-standing (m)	42	38	46
Average depth of peat removed from hard-standing (m)	0.40	0.39	0.41
Access tracks			
Total length of access track (m)	31930	28737	35123
Existing track length (m)	7170	7170	7170
Length of access track that is floating road (m)	4010	3609	4411
Floating road width (m)	24.5	22.5	25.5
Floating road depth (m)	0.80	0.80	0.80
Length of floating road that is drained (m)	3920	3500	4400
Average depth of drains associated with floating roads (m)	0.80	0.80	0.80
Length of access track that is excavated road (m)	21020	18918	23122
Excavated road width (m)	23.48	21.59	24.48
Average depth of peat excavated for road (m)	0.37	0.30	0.45
Length of access track that is rock filled road (m)	0	0	0
Rock filled road width (m)	0	0	0
Rock filled road depth (m)	0	0	0
Length of rock filled road that is drained (m)	0	0	0
Average depth of drains associated with rock filled roads (m)	0	0	0
Cable Trenches			
Length of any cable trench on peat that does not follow access tracks and is lined with a permeable medium (eg. sand) (m)	0	0	0
Average depth of peat cut for cable trenches (m)	0.38	0.00	2.51
Additional peat excavated (not already accounted for above)			
Volume of additional peat excavated (m^3)	15473.65	11957.575	21607.6
Area of additional peat excavated (m^2)	42721.0	36469.0	53481.0
Peat Landslide Hazard			
Weblink: Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments			
Improvement of C sequestration at site by blocking drains, restoration of habitat etc			
Improvement of degraded bog			
Area of degraded bog to be improved (ha)			
Water table depth in degraded bog before improvement (m)			
Water table depth in degraded bog after improvement (m)			
Time required for hydrology and habitat of bog to return to its previous state on improvement (years)			
Period of time when effectiveness of the improvement in degraded bog can be guaranteed (years)			
Improvement of felled plantation land			
Area of felled plantation to be improved (ha)			
Water table depth in felled area before improvement (m)			

Water table depth in felled area after improvement (m)			
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)			
Period of time when effectiveness of the improvement in felled plantation can be guaranteed (years)			
Restoration of peat removed from borrow pits			
Area of borrow pits to be restored (ha)			
Depth of water table in borrow pit before restoration with respect to the restored surface (m)			
Depth of water table in borrow pit after restoration with respect to the restored surface (m)			
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)			
Period of time when effectiveness of the restoration of peat removed from borrow pits can be guaranteed (years)			
Early removal of drainage from foundations and hardstanding			
Water table depth around foundations and hardstanding before restoration (m)	0.5	0.3	0.7
Water table depth around foundations and hardstanding after restoration (m)	0.3	0.1	0.5
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	3	2	5
Restoration of site after decommissioning			
Will the hydrology of the site be restored on decommissioning?	Yes	Yes	Yes
Will you attempt to block any gullies that have formed due to the windfarm?	Yes	Yes	Yes
Will you attempt to block all artificial ditches and facilitate rewetting?	Yes	Yes	Yes
Will the habitat of the site be restored on decommissioning?			
Will the habitat of the site be restored on decommissioning?	No	No	No
Will you control grazing on degraded areas?	No	No	No
Will you manage areas to favour reintroduction of species	Yes	Yes	Yes

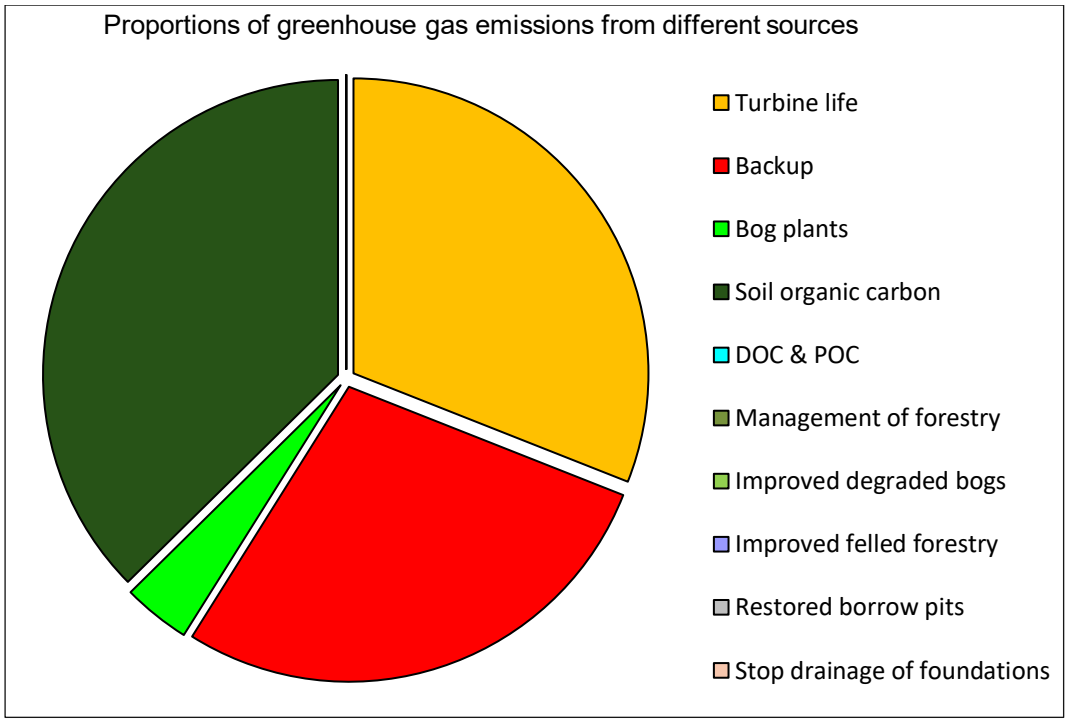
Results

PAYBACK TIME AND CO_2 EMISSIONS

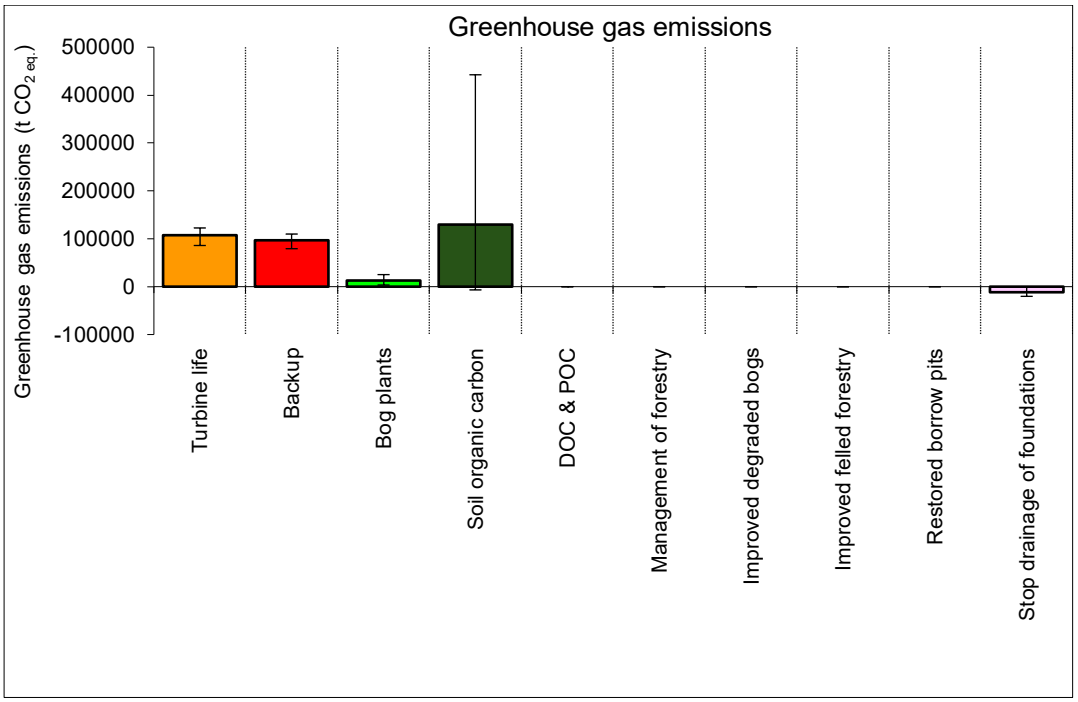
Note: The carbon payback time of the windfarm is calculated by comparing the loss of C from the site due to windfarm development with the carbon-savings achieved by the windfarm while displacing electricity generated from coal-fired capacity or grid-mix.

	Exp.	*Min.*	*Max.*
1. Windfarm CO_2 emission saving over…			
…coal-fired electricity generation (tCO_2 yr^{-1})	305311	211787	427271
…grid-mix of electricity generation (tCO_2 yr^{-1})	49912	36434	78020
…fossil fuel - mix of electricity generation (tCO_2 yr^{-1})	127553	93109	179731
Energy output from windfarm over lifetime (MWh)	11675363	8522604	16339222
Total CO_2 losses due to wind farm (t CO_2 eq.)			
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	107442	85952	122485
3. Losses due to backup	96851	79242	109927
4. Losses due to reduced carbon fixing potential	12817	3426	25155
5. Losses from soil organic matter	129612	-6836	442381
6. Losses due to DOC & POC leaching	0	0	9
7. Losses due to felling forestry	0	0	0
Total losses of carbon dioxide	346722	161784	699957
8. Total CO_2 gains due to improvement of site (t CO_2 eq.)			
8a. Change in emissions due to improvement of degraded bogs	0	0	0
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	-11643	0	-20237
Total change in emissions due to improvements	-11643	0	-20237

RESULTS	*Exp.*	*Min.*	*Max.*
Net emissions of carbon dioxide (t $CO_{2\ eq.}$)	**335079**	**141547**	**699957**
Carbon Payback Time			
…coal-fired electricity generation (years)	1.1	0.3	3.3
…grid-mix of electricity generation (years)	6.7	1.8	19.2
…fossil fuel - mix of electricity generation (years)	**2.6**	**0.8**	**7.5**
Ratio of soil carbon loss to gain by restoration (TARGET ratio (Natural Resources Wales) < 1.0)	**No gains!**	**No gains!**	**No gains!**
Ratio of CO_2 eq. emissions to power generation (g / kWh) (TARGET ratio by 2030 (electricity generation) < 50 g /kWh)	**29**	**9**	**82**


Proportions of greenhouse gas emissions from different sources
Turbine life
Backup
Bog plants
Soil organic carbon
DOC & POC
Management of forestry
Improved degraded bogs
Improved felled forestry
Restored borrow pits
Stop drainage of foundations

Greenhouse gas emissions			
	Exp.	*Min*	*Max*
Turbine life	107442	21490	15043
Backup	96851	17609	13076
Bog plants	12817	9390	12339
Soil organic carbon	129612	136448	312769
DOC & POC	0	0	9
Management of forestry	0	0	0
Improved degraded bogs	0	0	0
Improved felled forestry	0	0	0
Restored borrow pits	0	0	0
Stop drainage of foundations	0	0	0



Data used in barchart of carbon payback time using fossil-fuel mix as counterfactual

Greenhouse gas emission				**Carbon payback time (months)**		
	Exp.	***Min.***	***Max.***	***Exp.***	***Min.***	***Max.***
Turbine life	107442	21490	15043	10	3	1
Backup	96851	17609	13076	9	2	1
Bog plants	12045	8649	10528	1	1	1
Soil organic carbon	139921	136601	274086	13	18	18
DOC & POC	0	0	9	0	0	0
Management of forestry	4108	412	380	0	0	0
Improved degraded bogs	0	0	0	0	0	0
Improved felled forestry	0	0	0	0	0	0
Restored borrow pits	0	0	0	0	0	0
Stop drainage of foundations	-11643	-11643	-8594	-1	-2	-1
	348724			**33**