Derrinlough Wind Farm: Carbon Balance Calculation

1. Technology Lifecycle Emissions

	Value	Unit
Turbine No.	21	
Turbine Size	4.2	MW
Capacity factor*	31.7	%
Curtailment	4	%
Operational life	30	years
Annual Output - no curt.	239,781	MWh/a
Annual Output - with curt.	230,190	MWh/a
Total Output	6,905,691	MWh
Wind lifecycle emissions	9.37	kg CO2/MWh

2. Additional System Cycling Emissions

	Value	Unit
Carbon emissions from natural gas	56.9	kg CO2/GJ
CCGT emissions at 54% design efficiency	379.3	kg CO2/MWh
CCGT efficiency at Min Stable Generation	48.6	%
Demand Following: 18hrs@53%; 6 hrs@MSG		
Average efficiency from demand following	51.90	%
CCGT emissions at 51.9% efficiency	394.7	kg CO2/MWh
CCGT efficiency at low wind	46	%
CCGT emissions at 46% efficiency	448.9	kg CO2/MWh
CCGT efficiency at high wind	44	%
CCGT emissions at 44% efficiency	464.9	kg CO2/MWh
Additional emissions from wind cycling	16.05	kg CO2/MWh

3. Additional Peatland Disturbance Emissions

	Value	Unit
Peat disturbed	24.22	ha
Net change in emissions	8.14	t CO2/ha/a

4. Fossil Fuel Emissions Displaced

SEM mid-merit emissions	744.5	kg CO2/MWh
EU Fossil Fuel Comparator	658.8	kg CO2/MWh
'Demand Following' CCGT unit	394.7	kg CO2/MWh

1. Total Technology Lifecycle emissions

Annual output	230,190	MWh
Lifespan	30	years
Lifecycle emissions	9.37	kg CO2/MWh
Total emissions	**76,173**	**tonnes CO2**

2. Total Additional Cycling Emissions

Annual output	230,190	MWh
Lifespan	30	years
Cycling emissions	16.05	kg CO2/MWh
Total emissions	**110,811**	**tonnes CO2**

3. Total Additional Peatland Disturbance Emissions

Respread area	23.26	ha
Lifespan	30	years
Emissions increase	8.14	t CO2/ha/a
Total emissions	**5,681**	**tonnes CO2**

4. Carbon Balance

Windfarm Lifetime Emissions		
- technology	76,173	
- cycling	110,811	
- peat	5,681	
Total:	**192,665**	**t CO2**

Windfarm Lifetime Savings	**(t CO2)**	**Payback (yrs)**
Against SEM mid-merit	5,141,287	1.12
Against EU FFC	4,549,469	1.27
Against 'Demand Following' CCGT	2,725,552	2.12

Assumptions Underlying the Analysis

	Sources
Wind Farm Carbon Emissions	
Wind turbine lifecycle emissions - includes turbine, transport, all civil works, operation and also decommissioning	
LCA emissions are taken as an average of turbine supplier embodied carbon data: = 8.64 kg CO2/MWh	
System Cycling - additional emissions	
Carbon emissions from natural gas - from 'Energy in Ireland 1990-2014' = 56.9 t CO2/TJ	
CCGT Design efficiency: 54%	
Irish CCGT units on a system without intermittent wind would still operate in a 'load following' mode	
Average emissions from load-following CCGTS at high wind: 464.92 kg CO2/MWh; Average CCGT efficiency: 44%	SEMO
Average emissions from load-following CCGTS at low wind: 448.87 kg CO2/MWh; Average CCGT efficiency: 46%	SEMO
Additional emissions from cycling: 16.05 kg CO2/MWh	
Emissions from Peatland Disturbance	
Total volume of peat excavated for roads, turbine bases, substation etc = 232,644m3	
Excavated peat respread 1 m depth at all locations	
Total area of respread peat = 23.26 ha	
Assume that all areas excavated have a carbon emission factor of zero t CO2/ha/a	
Assume respread areas are recolonised with rushes & birch/willow scrub - with net emissions of 19.25 t CO2/ha/a - and that no vegetation management is carried out.	CARBAL FINAL REPORT; industrial cutaway peatlands
Fossil Fuel Emissions Displaced	
Wind displaces fossil electricity generated from thermal plants up to the system non-synchronous penetration limit	
On the Irish Grid - taken as SEM Reference mid-merit plant (SEM/13/006) = 744.5 kg CO2/MWh	
In the EU Single Electricity Market - COM(2016)767 - the Fossil Fuel Comparator is 183 gCO2/MJ = 658.8 kg CO2/MWh	Recast of RED; See Annex VI
For a displaced 'Demand Following' CCGT unit = 379.3 kg CO2/MWh	