

Appendix C GHG calculations

Turbine Fabrication

Parameter	Value	Unit	Comments
Turbine Steel	868.3	tonnes/turbine	Based on weights provided in Description of an 8 MW Reference Wind Turbine - Journal of Physics , 2016
Turbine Fiberglas	129.7	tonnes/turbine	Based on weights provided in Description of an 8 MW Reference Wind Turbine - Journal of Physics , 2016

Emission Factors

Parameter	Value	Unit	Comments
general steel	1.5	TCO2e/T	source: Inventory of Carbon and Energy v2.0 for a mixture of steel types
fiberglas	5	TCO2e/T	source: The Environmental Impact of wind turbine blades - 37th Int'l Symposium on Materials Science - 2016
Emissions	95596.55	TCO2e	(B4*B8)+(B5*B9)*49

Turbine Transportation

Parameter	Value	Unit	Comments
heavy duty truck (diesel)	1	ea	
distance travelled	130,340	km	from Busan South Korea to dockside and Sheet Harbour NS to wind turbine laydown areas (all components)
freight weight	52.5	tonnes	estimate of each component, 998 tonnes/19 components per WT
Marine Cargo and Containers (diesel)			
distance travelled	929,326	km	from Busan South Korea to Sheet Harbour NS (includes 49 WT)
freight weight	998	tonnes	cells B3 and B4

Emission Factors

Parameter	Value	Unit	Comments
heavy duty truck (diesel)	135	g CO2e/T.km	Freight emissions for calculating GHGs from freight shipment(GHG Genius v5.0d)
conversion factor	0.000001	T CO2e/T.km	1 g = 0.000001 tonnes
Emissions	923.7848	T CO2e	B14*B15*B21*B22
Marine Cargo and Containers (diesel)	15.1	g CO2e/T.km	Freight emissions for calculating GHGs from freight shipment(GHG Genius v5.0d)
conversion factor	0.000001	T CO2e/T.km	1 g = 0.000001 tonnes
Emissions	14004.76	T CO2e	B17*B18*B24*B25
Total WT Transportation Emissions	14928.54	T CO2e	B23+B26

Concrete Foundation

Parameter	Value	Unit	Comments
Concrete Production Quantity	5681	tonne	based on a volume of 2367 m3 per WT pad and density of 2.4 T/m3 source Nordex
Concrete transport	16.8	T	16.8 tonnes /truck
Concrete truck	338	ea	
Distance travelled (freight)	15	km	based on one way trip from concrete batch plant to each WT pad
Distance travelled (no freight)	15	km	based on one way trip from each WT pad to concrete batch plant
steel rebar quantity	425	tonne	based on an average steel content per base of 7% rebar , pipe , screws source: Nordex
rebar transport	21.25	T	21.25 tonnes /truck
rebar truck	20	ea	
Distance travelled (freight)	140	km	based on a one way trip from the rebar supplier to each WT pad
Distance travelled (no freight)	140	km	based on a one way trip from each WT pad to rebar supplier

Emission Factors

Parameter	Value	Unit	Comments
concrete production	300	g CO2e/kg	source GHGenius v 5.0d
general steel	1.5	TCO2e/T	source: Inventory of Carbon and Energy v2.0 for a mixture of steel types
concrete truck (freight)	135	g CO2e/T.km	Freight emissions for calculating GHGs from freight shipment(GHG Genius v5.0d)
concrete truck (no freight)	1,106	g CO2e/km	Emissions for calculating GHGs where the volume of fuel consumed is unknown but the distance travelled is known source: GHGenius v5.0d
steel truck (freight)	135	g CO2e/T.km	Freight emissions for calculating GHGs from freight shipment(GHG Genius v5.0d)
steel truck (no freight)	1,106	g CO2e/km	Emissions for calculating GHGs where the volume of fuel consumed is unknown but the distance travelled is known source: GHGenius v5.0d
conversion factor	0.000001	T CO2e/T.km	1 g = 0.000001 tonnes
concrete production emissions	83510.7	T CO2e	B30*1000*B42*B48*49(WT)
steel production emissions	31237.5	T CO2e	B35*B43*49
Concrete truck (freight) emissions	563.44	t CO2e	B31*B32*B33*B44*B48*49
Concrete truck (no freight) emissions	274.7636	T CO2e	B32*B34*B45*B48*49
steel truck (freight) emissions	393.5925	T CO2e	B36*B37*B38*B46*B48*49
steel truck (no freight) emissions	151.7432	T CO2e	B37*B39*B47*B48*49
Total WT Foundation Emissions	116131.74	T CO2e	B49+B50+B51+B52+B53+B54
Total Emissions Turbines and Bases	226656.83	T CO2e	B10+B27+B55

Electrical Infrastructure

Parameter	Value	Unit	Comments
substation transformers steel	37	tonnes	typical for a 50 MVA transformer source ABB.com
substation transformers copper	9	tonnes	typical for a 50 MVA transformer source ABB.com
substation transformers oil	17	tonnes	typical for a 50 MVA transformer source ABB.com
substation transformer pad concrete	16.1	tonnes	based on a volume of 6.7 m3 per pad and density of 2.4 T/m3 source ABB.com
substation transformer pad rebar	1.1	tonnes	based on an average steel content per pad of 7% rebar
copper carbon intensity	4.1	TCO2E/T	source: Copper Environmental profile - International Copper Association , copperalliance.org
mineral oil carbon intensity	0.00189	TCO2e/litre	source: BEES carbon footprint calculator
mineral oil density	830	kg/1000 litres	source: Wikipedia
remaining substation steel	272	tonnes	circuit breakers , relays, switches, cabling, supports, lighting, lightning protection, fencing, control building, transmission bus, pad rebar
remaining substation concrete	56.4	tonnes	remaining equipment and building pads
aluminum carbon intensity	4.8	TCO2E/T	source: carbonchain.com for aluminum produced in Canada.
switching station steel	272	tonnes	circuit breakers , relays, switches, cabling, supports, lighting, lightning protection, fencing, pad rebar
switching station concrete	56.4	tonnes	equipment pads
345 kv transmission tower steel	14	tonnes	typical for a 33m high guyed portal tangent steel lattice design (36 assumed)
345 kv transmission tower steel	30	tonnes	typical for a 33m high freestanding steel lattice design (4 assumed)
guyed tower concrete	6220.8	tonnes	4m2 x 2m deep (typ for 3 per tower) (36 towers assumed)
freestanding tower concrete	307.2	tonnes	4m2 x 2m deep (typ for 4 per tower) (4 towers assumed)
34.5 kv acsr distribution cable steel	121.7	tonnes	total cable length estimate is 675 km for 15 circuits. 495 km at 163 kg/km and 180 km at 228 kg/km steel
34.5 kv acsr distribution cable aluminum	833.4	tonnes	total cable length estimate is 675 km for 15 circuits. 495 km at 1119 kg/km and 180 km at 1553 kg/km aluminum
345 kv acsr transmission cable steel	15.6	tonnes	total cable length estimate is for 2 10.1 km transmission lines in parallel with a 10% allowance . 233 kg/km steel
345 kv acsr transmission cable aluminum	104.4	tonnes	total cable length estimate is for 2 10.1 km transmission lines in parallel with a 10% allowance . 1556 kg/km aluminum
steel production emissions	2358	T CO2e	((B61*7)+(B65*7)+B69+B72+(B74*36)+(B75*4)+B78+B80)*B43
Concrete production emissions	2026.05	T CO2e	((B64*7)+B70+B73+B76+B77)*B42
Copper production emissions	258.3	T CO2e	B62*B66*7
Mineral oil production emissions	270.98	T CO2e	((B63*1000)/B68)*B67*7*1000
aluminum production emissions	4501.44	T CO2e	(B79+B81)*B71
metal truck loads	103	ea	Assume all metal components are shipped by truck from Dartmouth 140 km each way, max load 25 T
mineral oil loads	5	ea	assume all mineral oil is shipped by truck from Dartmouth 140 km each way, max load 25 T
concrete truck loads	402	ea	((B64*7)+B70+B73+B76+B77)/B31
metal truck (freight) emissions	48.63	T CO2e	B38*B46*B48*25*B88
metal truck (no freight) emissions	15.93	T CO2e	B39*B47*B48*B88
oil truck (freight) emissions	2.25	T CO2e	B38*B46*B48*25*B89
oil truck (no freight) emissions	0.74	T CO2e	B39*B47*B48*B89
Concrete truck (freight) emissions	13.68	T CO2e	B31*B33*B44*B48*B90
Concrete truck (no freight) emissions	6.67	T CO2e	B34*B45*B48*B90

Total Emissions Electrical Infrastructure	9502.66	T CO2e	B82+B83+B84+B85+B86+B91+B92+B93+B94+B95+B96
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Total emissions	236159.49	T CO2e	B57+B98
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