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SiteLCA

Of Poysdorf-Wilfersdorf V 16.8MW wind plant of V150-4.2MW WTGs

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Executive Summary

SiteLCA of Electricity Production from Poysdorf-Wilfersdorf V 16.8MW wind plant comprising of four V150-4.2MW WTGs

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Executive summary

The present Life cycle assessment (LCA) is the final reporting for the electricity produced from the 16.8MW onshore wind power plant composed of four Vestas V150-4.2 MW turbines at Poysdorf-Wilfersdorf V project. Vestas Wind Systems A/S has prepared the report and the underlying LCA model.

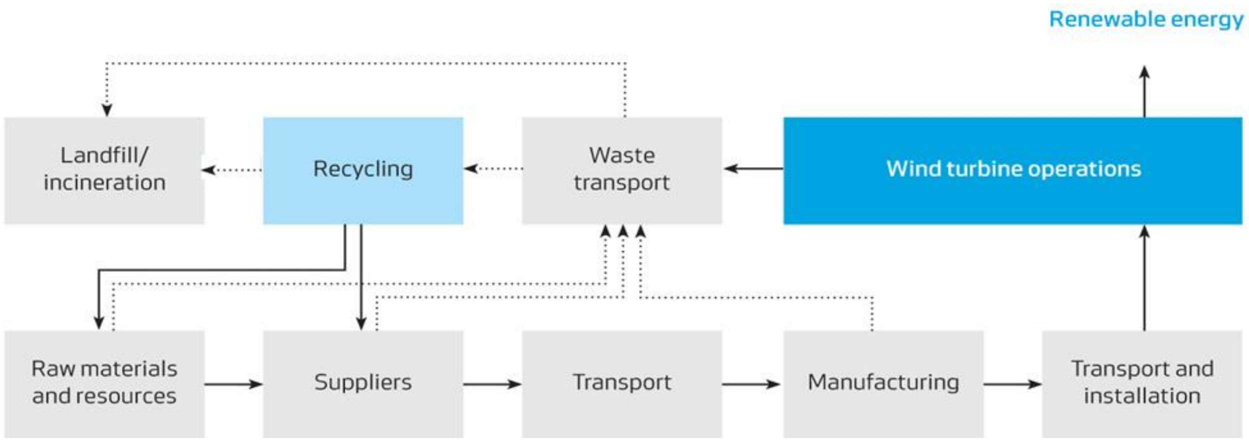
Context

This LCA of the V150-4.2 MW power plant has assessed the turbine's entire bill-of-materials accounting for around 10,000 parts that make up the turbine. The complete wind power plant is assessed up to the point of the electricity grid, including the turbine itself, foundations, site cabling that connects the turbines together and other site parts such as the transformer station and site switchgear.

This LCA has evaluated over 99.9% of the total mass of the turbine itself, and over 99.95% of the entire mass of the power plant. Missing information relates to parts where the material was not identified.

Each part of the wind plant is assessed over the entire life cycle from cradle to grave, as shown below in the life-cycle figure. The potential environmental impacts are calculated for each turbine component relating to the specific material grade of the part, generic manufacturing processes, part maintenance, and estimated disposal and recycling steps at end-of-life. This provides a comprehensive view of the environmental performance.

Life cycle of the wind power plant



Wind plant specification

The Table below gives an overview of the baseline wind power plant assessed in this life cycle assessment.

Baseline wind plant assessed

Description	Unit	Quantity
Lifetime	years	20
Rating per turbine	MW	4.2
Generator type	-	Induction
Turbines per power plant	pieces	4
Plant size	MW	16.8
Hub height	m	166
Rotor diameter	m	150
Wind class	-	DIBt WZ2 (S)
Tower type	-	Standard steel
Foundation type		Low ground water level (LGWL)
Gross electricity production per turbine^	MWh per year	13707
Electricity production per turbine @ approved bottleneck performance P75^	MWh per year	11891
Total cable length	km	8.8
Plant location	-	Austria
Vestas production location	-	Global average

^Annual energy data are consolidated from the Audit report - identification and evaluation of the site-specific wind potential and energy yield (EWS, 2019)

The environmental performance of the wind plant is assessed per 1 kWh of electricity delivered to the grid by the 16.8MW wind power plant at Poysdorf-Wilfersdorf V.

Environmental impacts summary

The Table below presents the total potential environmental impacts of a 16.8MW onshore wind power plant of V150-4.2 MW turbines, covering the entire power plant over the life cycle, per kWh of electricity delivered to the grid.

The results show that raw material and component production dominate the environmental impacts of the power plant (e.g. 71% of total CO_2 emissions), while other phases influence to a lesser extent. Of the raw material production and manufacturing phases, the tower, nacelle, blades and foundations contribute most significantly to all studied environmental impact indicators. Vestas factories contribute between 1% and 2% across all impact categories. Transport of the turbine components contributes between around 1% and 72% across all impact categories, and 23% to the total global warming potential impacts[1]. The impacts from transportation are associated primarily to the shipping of tower and hub components over a long distance.

Whole-life environmental impacts of V150-4.2 MW plant (shown in g, mg or MJ per functional unit of 1kWh)

Environmental impact categories:	Unit	Quantity
Abiotic resource depletion (ADP elements)	mg Sb-e	0.12
Abiotic resource depletion (ADP fossils)	MJ	0.16
Acidification potential (AP)	mg SO2-e	100
Eutrophication potential (EP)	mg PO4-e	11
Freshwater aquatic ecotoxicity potential (FAETP)	mg DCB-e	80
Global warming potential (GWP)	g CO2-e	12.0
Human toxicity potential (HTP)	mg DCB-e	7684
Marine aquatic ecotoxicity potential (MAETP)	g DCB-e	1240
Photochemical oxidant creation potential (POCP)	mg Ethene	5.8
Terrestrial ecotoxicity potential (TETP)	mg DCB-e	54

Note: impact indicators are based on CML impact assessment method Version 2016 (CML, 2016)

Refer to Section 5.2 and Annex A4 of the main report for further description of the impact categories and the wind plant components and substances that contribute to these.

The Table below shows the other environmental indicators assessed, including return-on energy, recyclability and estimated circularity of the wind plant.

Whole-life environmental indicators of V150-4.2 MW (units shown in g or MJ per kWh)

Non-impact indicators:	Unit	Quantity
*Primary energy from renewable raw materials	MJ	0.02
*Primary energy from non-renewable resources	MJ	0.20
**AWARE water scarcity footprint	g	382
Blue water consumption	g	21
***Return-on energy	Number of times	18
****Turbine recyclability (not life cycle based, turbine only)	% (w/w)	88.9%
******Turbine circularity (not life cycle based, turbine only)	-	0.63

* *Net calorific value*

[1] Transport refers to the aggregated impacts covering all transport stages in the life cycle.

*** Based on WULCA model for water scarcity footprint that assesses available water remaining water (Boulay, 2018)*
**** Based on 'Net energy' calculation defined in Section 6*
***** Rounded up or down to the nearest half percentage point.*
****** Refer to Section 5.3.5*
******* Based on Circularity indicator calculation defined in section 5.3.6*

Improvement potentials for CO_2 reduction

Sensitivity analyses and improvement potential scenarios were evaluated for this siteLCA.

Summary of estimated improvement potential from the various scenarios assessed

Improvement option	Reduction potential	grams CO_2 per kWh
Baseline CO_2		12.0
Increased wind plant lifetime	20%	9.6
Grid capacity increase	13%	10.4
*Five years at bottleneck grid capacity and twenty years at full grid capacity	29%	8.5
Reduced transport distance	18%	9.8
Low CO_2 concrete	7%	11.1
Electric cranes	5%	11.4
Electric vehicles	0.5%	11.9
Change to concrete-hybrid towers	11%	10.6
Repair and replacement parts	0.8%	11.9

Note: savings cannot be directly added together to show total CO_2 reduction. Formula for CO_2 per kWh = Total tonnes CO_2 / Total MWh, over lifetime. If all of the above were implemented, then the minimum CO_2 based on above estimated reduction potentials is around 4.8 grams CO_2 per kWh versus to baseline performance of 12.0 grams CO_2 per kWh.

**Note: an alternate scenario is of the plant operation for twenty five years, where the plant runs at bottleneck grid capacity for the first five years (11891MWh) and at full grid capacity for the next twenty years (13740 MWh). The global warming potential in this scenario is calculated to be 8.5 grams per kWh. This is a reduction of 29% from the baseline scenario. With the implementation of this scenario, the minimum CO_2 based on the above estimated reduction potentials is around 4.9 grams CO_2 per kWh versus the baseline performance for 12.0 grams CO_2 per kWh.*

<u>Transport</u>

The impacts of transport of the turbine from Vestas production locations to the wind plant erection site are very significant, contributing 23% to total global warming potential. This is due to long shipping distances for the Hub (from China) and Tower (from Vietnam). Assuming a scenario where these components were transported from Denmark by truck to Austria, then an improvement of 18% total global warming potential is possible.

<u>Grid Capacity</u>

Operating the turbines at full grid capacity has a considerable impact on the total global warming potential, when referenced to the functional unit of 1 kWh of delivered electricity to the grid. At full grid capacity all potential environmental impacts decrease in the range of -13% compared to the baseline.

An alternate scenario is of the plant operation for twenty five years where the plant runs at bottleneck grid capacity for the first five years (11891MWh) and at full grid capacity for the next twenty years

(13740 MWh). The global warming potential in this scenario is calculated to be 8.5 grams per kWh. This is a reduction of 29% from the baseline scenario.

Lifetime

The power plant lifetime is also a dominant factor when determining the impacts of the electricity production per kWh. This LCA assumes a lifetime of 20 years which matches the standard design life. However, increasing the turbine lifetime from 20 years to 25 years has the impact to improve global warming potential by 20%.

Electric vehicles

A scenario has been assessed where electric cranes will be used for installation and decommissioning. Converting to electric service vehicles does not have a significant impact on the life cycle environmental impacts. Converting to electric cranes have a small environmental benefit in the life cycle of 5%. However, viewing these changes from the point of view of decarbonising the transport sector should be considered.

Tower and Foundation

Sensitivity analyses have also been conducted to evaluate the impact of low CO2 intensive concrete, as well as the impacts from concrete-hybrid towers. Clinker substitution in cement or the use of cement free concrete present scenarios where 50% to 60% lowering of CO2 intensity is observed for the foundation itself. The equates to 7% reduction at plant level. Similarly, converting to concrete hybrid towers have an effect to reduce global warming potential by 30% for foundation and tower combined, which equates to 11% reduction at plant level.

Conclusions

Overall, the study represents a robust and detailed reflection of the potential environmental impacts of a 16.8 MW onshore wind power plant consisting of four V150-4.2 MW turbines at Poysdorf-Wilfersdorf V, Austria. The LCA is based upon accurate product knowledge, site-specific data collection for the wind plant design, performance and construction operations, as well as state-of-the-art LCA software modelling and methodologies to evaluate a range of environmental impacts.

Furthermore, significant CO_2 reductions potentials have been identified for the Poysdorf-Wilfersdorf V wind plant.

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