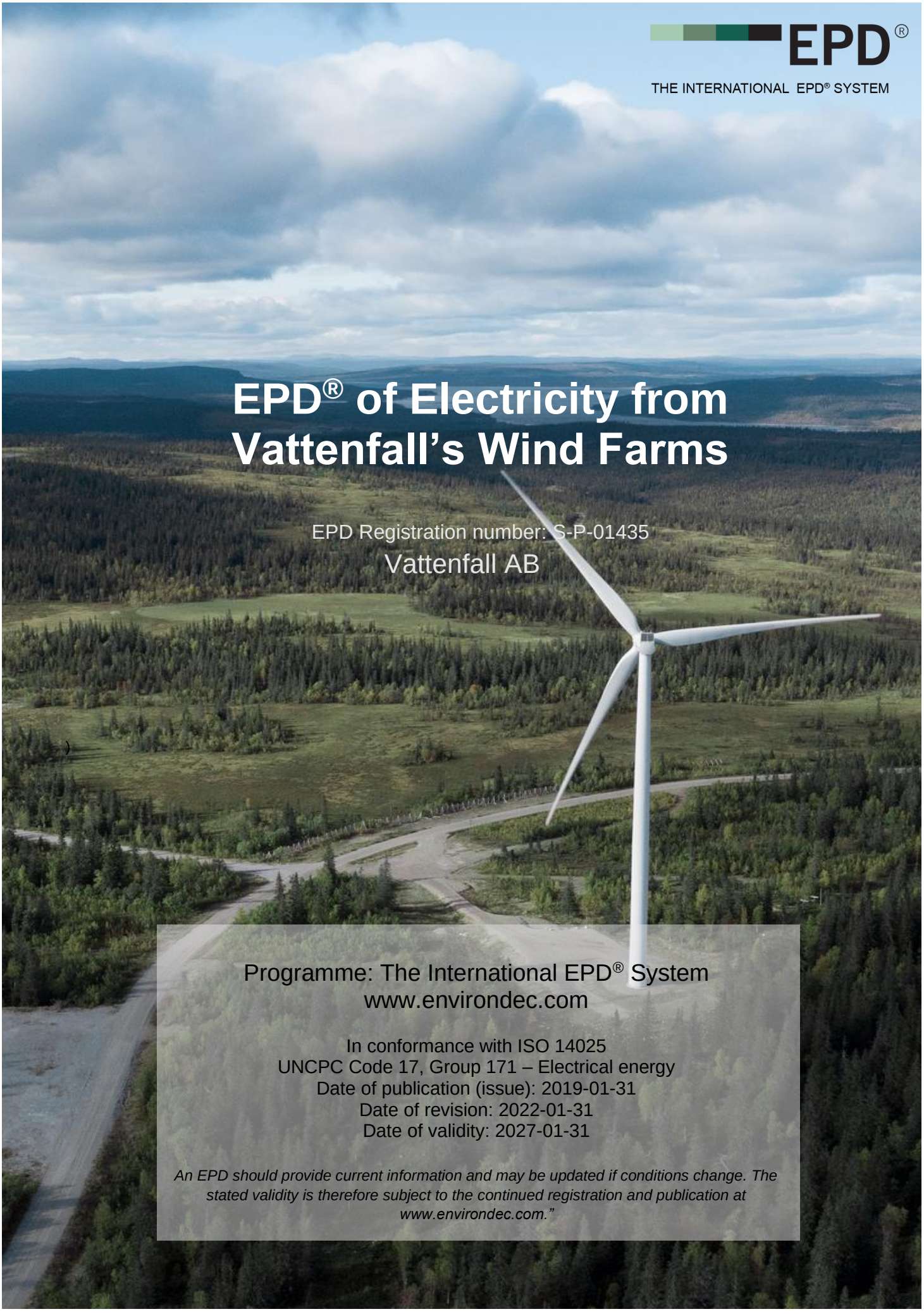

EPD®

THE INTERNATIONAL EPD® SYSTEM

EPD® of Electricity from Vattenfall's Wind Farms

EPD Registration number: S-P-01435

Vattenfall AB

Programme: The International EPD® System
www.environdec.com

In conformance with ISO 14025
UNCPC Code 17, Group 171 – Electrical energy
Date of publication (issue): 2019-01-31
Date of revision: 2022-01-31
Date of validity: 2027-01-31

An EPD should provide current information and may be updated if conditions change. The stated validity is therefore subject to the continued registration and publication at www.environdec.com."

VATTENFALL

Summary

PRODUCER
Vattenfall Business Area (BA) Wind is responsible for the electricity generation in all Vattenfall's wind farms in Europe. Vattenfall Business Area Wind is part of Vattenfall AB, SE–169 92 Stockholm, telephone +46 8 739 50 00, www.vattenfall.com. Vattenfall BA Wind has a management system for quality, environment and health & safety certified according to ISO 9001:2015, ISO 14001:2015 and OHSAS 18001:2008 implemented.

PRODUCT AND FUNCTIONAL UNIT
Electricity belongs to the product category UNCPC Code 17, Group 171 – Electrical energy. The functional unit is defined as 1 kWh net of electricity generated and thereafter distributed to a customer connected to the medium voltage grid.
Vattenfall's average annual wind power generation is close to 9 TWh of electricity (net).

Country	Installed capacity 2020 [MW]		Net average generation [GWh/year]		Total net average generation [GWh/year]
	Offshore	Onshore	Offshore	Onshore	
Sweden[1]	110	148	327	382	709
Denmark	502	233	1 869	629	2 498
UK	613	391	1 845	1 079	2 924
Germany	294	12	1 307	20	1 327
Netherlands	0	501	0	1 420	1 420
Total[1]	**1 518**	**1 285**	**5 348**	**3 530**	**8 878**

[1] Note that these values do not include the wind farm Blakliden Fäbodberget, since it is being constructed in 2021

THE INTERNATIONAL EPD®SYSTEM
The International EPD® system is administrated by EPD International AB and based on ISO 14025, Type III Environmental Declarations. The relevant governing documents in hierarchical order are: PCR CPC171 version 4.2, General Programme Instructions for an environmental product declaration EPD®, Version 3.01, ISO 14025, ISO 14040, ISO 14044.

ENVIRONMENTAL PERFORMANCE - BASED ON LCA
See section 3 of the complete EPD® documentation.

System boundaries
The EPD® comprises the generation of electricity in the wind farms, upstream processes (production of auxiliary substances) and downstream processes (distribution of electricity). Further, construction and dismantling of the wind farms has been included. The use stage of electricity at the consumer is not included. The technical service life is estimated to 25 years for Horns Rev 3, Blakliden Fäbodberget and Princess Ariane. For the rest of the farms it is estimated to be 20 years.

The complete certified declaration also contains descriptions of environmental risks, land use and impacts on biodiversity in accordance with the EPD®system instructions.

Environmental information
A short summary of compiled data is presented below per generated and distributed kWh electricity. The results are presented for the following lifecycle modules:

Upstream	Production of oils, and fuels for maintenance and inspection trips.
Core	Operation of wind farm, i.e. emissions from inspection trips. Incineration or deposit of operational waste
Core – infrastructure	Construction and decommissioning of wind farms, including foundation, tower, nacelle, hub, rotor blades etc. Reinvestment of gearbox, generator, transformer and more.
Downstream	Operation of electricity networks, i.e. emissions from inspection trips, production and emissions of oils. Losses in the networks.
Downstream – infrastructure	Construction and decommissioning of the transmission grids and distribution networks.

Distribution of electricity implies grid losses, which is compensated for by increased generation. The losses are different in different countries and often higher in the countryside. The grid loss to an average large industrial customer connected to the regional network is set to 5% of generated electricity. This loss is assumed to be compensated for by increased generation in the wind farms and is included in the downstream column in the table below.

Environmental impact categories		Unit/kWh	Upstream	Core	Core - infra.	Total - generated	Down-stream[1]	Downstream - infra.	Total - distributed
Global warming potential (GWP)	Fossil	g CO_2-eq. (100years)	0.0748	0.419	11.6	**12.1**	0.691	1.34	**14.2**
	Biogenic	g CO_2-eq. (100years)	0.00177	0.00151	0	**0.00329**	0.00173	0.0159	**0.0209**
	Luluc[2] (deforestation)	g CO_2-eq. (100years)	0	0	0.944	**0.944**	0.0472	0.445	**1,44**
	Total	g CO_2-eq. (100years)	0.0766	0.420	12.6	**13.1**	0.739	1.80	**15,6**
Acidification potential (AP)		**g SO_2-eq.**	2.20E-04	0.00350	0.0361	**0.0398**	0.00217	0.00248	**0.0445**
Eutrophication potential (EP)		**g PO_4^{3-}-eq.**	2.03E-04	6.85E-04	0.00703	**0.00792**	4.36E-04	0.00272	**0.0111**
Photochemical oxidant formation potential (POFP)		**g NMVOC-eq.**	6.76E-04	0.00498	0.0310	**0.0367**	0.00231	0.00590	**0.0449**
Particulate matter		**g PM2.5-eq.**	6.39E-05	5.59E-04	0.00916	**0.00979**	5.40E-04	6.45E-04	**0.0110**
Abiotic depletion potential - Elements		**g Sb-eq.**	3.23E-07	4.61E-08	1.72E-04	**1.73E-04**	8.66E-06	5.56E-05	**2.37E-04**
Abiotic depletion potential - Fossil fuels		**MJ, net cal. value**	0.00617	1.40E-04	0.130	**0.136**	0.00744	0.0179	**0.161**
Water scarcity footprint		**m^3 H_2O-eq.**	1.13E-05	3.79E-06	0.300	**0.300**	0.0150	9.87E-04	**0.316**

[1] Distribution losses of 5% of generated electricity are included in the downstream column.
[2] The indicator GWP Luluc entails emissions of greenhouse gases related to activities leading to land use and land use change.

Resource use and emissions related to handling and treatment of the lifecycle waste through incineration or deposition are included in the Environmental impact i.e., no crediting has been performed.

Conclusions of the LCA

The major environmental impact per kWh from wind power is attributable to the activities in the Core - infrastructure process, i.e., the construction of wind farms. Emissions of greenhouse gases emanate mainly from the combustion of fossil fuels as a part of the energy supply for manufacturing processes, here the majority comes from the production of steel for the turbine towers and foundations. Offshore wind sites require more steel mainly due to the larger towers

and underwater construction, in comparison with onshore sites. This causes the lifecycle emissions of greenhouse gases from offshore sites in general to be higher than for onshore sites, although the higher production from offshore sites partly decreases the impact per kWh.

In this version, emissions as a result of deforestation (Luluc) are included, which increases the total global warming potential results compared to the previous version. When excluding GWP-Luluc, the GWP results are however lower than in the previous update of the EPD. This indicates a significant decrease in GWP because new factors have been included in this EPD version that could have increased the GWP. This is mainly related to factors such as the inclusion of demolition of previously modelled substations, the increase in core result due to increased offshore maintenance trips (where emissions from combustion of marine diesel is a dominating contributor) and a decrease in average energy production for Lyngsmose, Horns Rev 1, Bajlum, Kentish Flats and Pen y Cymoedd. Global warming potential (GWP) excluding Luluc has decreased due to Vattenfall's wind farm portfolio's higher ratio of modern wind farms with generally lower GWP per produced kWh and longer lifetime expectancy.

In this version of the EPD, water scarcity footprint (AWARE) is a new impact category. The water scarcity footprint is a regionalised approach which quantifies the relative available water remaining per (specified) area after satisfying the demand of aquatic ecosystems and anthropogenic activities. The impact category considers the water scarcity in the region where the water is consumed, so that water which is consumed in a scarce region is weighted higher. The dominating contribution to water scarcity is related to the construction of turbines (Core - infrastructure), approximately 95 %. Water is mainly used in supplier processes and material production. The impact of distribution losses is driven by the impact of core – infrastructure.

ADDITIONAL ENVIRONMENTAL INFORMATION

Land use and impact on biodiversity

Vattenfall's method for land use and biodiversity is used to quantify changes in land use when wind power is built, and to look at impact on biodiversity from those changes as well as from operations of the wind farms. In the table below the identified changes are shown. See section 4.1 for the complete results.

Land cover	Area before (m^2)	Area after (m^2)	Land use change (m^2)
1. Artificial Surfaces	8.93E+05	1.09E+07	9.99E+06
2. Agricultural areas	1.06E+06	7.20E+04	-9.84E+05
3. Forest and seminatural areas	8.46E+07	7.67E+07	-7.94E+06
4. Wetlands	1.44E+07	1.33E+07	-1.06E+06
5. Water bodies	2.79E+08	2.79E+08	0

Environmental risk assessment

The conclusion is that over a longer period of time the environmental risks due to undesired events are considerably smaller than those emanating from normal operation. The main risks are connected to diesel/oil/gasoline leakages. See chapter 4.4 of the complete EPD® documentation.

Noise

Measurements show that Vattenfall's wind farms operate below limits in present regulations.

Mandatory statements

References

Jacket foundation at Ormonde offshore windfarm (photo: Tony West)

1. Information from the independent verification, the Certification Body and Mandatory Statements

1.1. Information on the independent verification and certification of this EPD

This EPD® has been verified within Vattenfall's EPD® Management Process. The independent verifiers Caroline Setterwall (Hitachi Energy Sweden AB),Lasse Kyläkorpi (Vattenfall AB) and confirm that the product fulfils relevant process- and product-related laws and regulations and certify that this EPD® follows and fulfils all rules and requirements of the EPD® system managed by EPD International AB, General Programme Instructions, version 3.01 (GPI) and Product Category Rules CPC 171 version 4.2. This certification is valid until 2027-01-31.

1.2. Information from the Certification Body on the verification of Vattenfall's EPD® Management Process

Vattenfall's EPD® management process is third party verified annually, last review was made 2021-11-25. Bureau Veritas Certification, accredited by SWEDAC, the Swedish Board for Accreditation and Conformity Assessment, hereby confirms that Vattenfall's EPD® Management Process follows the requirements of EPD® International expressed in GPI and the Process Certification Clarification (PCC) for the International EPD® system

1.3. Mandatory Statements

1.3.1. General

To be noted: EPD®s from different EPD® programmes may not be comparable. When comparisons are made between different products in this product category it should be noted that energy can be supplied through different energy carriers like heat/steam or electricity, but the amount of kWh needed will differ with different energy carriers due to different energy quality and conversion/distribution efficiencies.

1.3.2. Omissions of life cycle stages

The use stage of produced electricity has been omitted in accordance with the PCR since the use of electricity fulfils various functions in different contexts.

1.3.3. Means of obtaining explanatory materials

ISO 14025 prescribes that explanatory material must be available if the EPD® is communicated to final consumers. This EPD® is aimed for industrial customers and not meant for private customer communication.

7.3.4. Information on verification

EPD® programme:

The International EPD®system is managed by EPD International AB , www.environdec.com

Product Category Rules:

Product Category Rules, CPC 171 Electrical Energy, CPC 173 Steam and Hot Water, version 4.2

PCR review, was conducted by:

The Technical Committee of the International EPD®system. Chair: Claudia A. Peña. Contact via info@environdec.com

Independent third-party verification of the declaration and data, according to ISO 14025:2006

EPD® Process Certification

has been performed within Vattenfall's certified EPD® Management process.

Third party verification of Vattenfall´s EPD Management process has been conducted by the accredited Certification body: Bureau Veritas Certification

External verifier: **Camilla Landén** **This EPD® is valid until: 2027-01-31**

Internal and external verifiers**: Caroline Setterwall, Hitachi Energy Sweden AB, Lasse Kyläkorpi, Vattenfall AB**

Procedure for follow-up of data during EPD validity involves third-party verifier

No