

EPD[®] of Electricity from Vattenfall's Nuclear Power Plants

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Vattenfall AB

Programme: The International EPD[®] System
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In conformance with ISO 14025
UNCPC Code 17, Group 171 – Electrical energy
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Summary of certified Environmental Product Declaration EPD® of electricity
from Vattenfall's nuclear power plants

UNCPC Code 17, Group 171 – Electrical energy

The International EPD® system

Summary

PRODUCER. Forsmarks Kraftgrupp AB (hereafter called Forsmark) and Ringhals AB (hereafter called Ringhals) are responsible for the electricity generation in Vattenfall’s nuclear power sites. The sites are located north of Östhammar on the Swedish East coast and north of Varberg on the Swedish West coast. The companies are partly owned by Vattenfall AB SE–162 87 Stockholm, telephone +46 8 739 50 00, www.vattenfall.com. Both Forsmark and Ringhals have environmental and health and safety management systems certified and registered according to ISO 14001 and ISO 45001.

PRODUCT AND DECLARED UNIT. Electricity belongs to the product category UNCPC Code 17, Group 171 – Electrical energy. The declared unit is defined as 1 kWh net of electricity generated and thereafter distributed to a customer connected to the Swedish regional grid (70/130 kV). The two sites have together three Boiling Water Reactors (BWR) and two Pressurised-Water Reactors (PWR) with a common generating capacity of about 5500 MW. On an average year they generate approximately 40 TWh of electricity. The reactors are of type generation II and once-through fuel cycles are applied, i.e. there is no reprocessing of fuel. Both Forsmark and Ringhals are base load plants.

THE INTERNATIONAL EPD® SYSTEM

The international EPD® system, administrated by EPD International AB, is based on ISO 14025, Type III Environmental Declarations. The relevant governing documents in hierarchical order are: Product Category Rules UN CPC 171 and 173, 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 below for a summary of methods and results. For more information, see section 3 in the complete EPD® Report.

System Boundaries. The EPD® comprises the generation of electricity in the nuclear power plant; Upstream processes i.e. uranium fuel production and production of auxiliary supplies; and Downstream processes i.e. distribution of electricity. Further construction and dismantling of the nuclear power plant and the facilities for radioactive waste handling have been included in Core – Infrastructure, while the annual operation of all plants is included in Core. The use stage of electricity at the consumer level is not included. The geographical scope for electricity generation and management of spent nuclear fuel and radioactive waste is within Sweden, whilst the nuclear fuel is produced world-wide.

Environmental Information. A short summary of compiled data are presented below, per generated and distributed kWh electricity. The results are presented for the life cycle modules described in the table below.

Upstream	Mining & milling, refinery and conversion, enrichment and fabrication of nuclear fuel. Production of auxiliary substances and chemicals for nuclear power plant operations and radioactive waste treatment.
Core	Operation of nuclear power plants and facilities for handling radioactive waste and spent nuclear fuel. Incineration or deposit of conventional waste from operations.
Core – Infrastructure	Construction and decommissioning of the nuclear power plants and radioactive waste facilities, including necessary reinvestments.
Downstream	Operation of electricity networks, i.e. emissions from inspection trips, production and emissions of oils. Extra generation in nuclear power plants to compensate for losses in the distribution system.
Downstream – Infrastructure	Construction and decommissioning of the transmission grids and distribution networks.

Distribution of electricity implies losses, which must be compensated for by increased generation. The loss to an average large industrial customer connected to the regional distribution network (70-130 kV) is set to 4 %. The losses

are different for different types of customers and often higher in the countryside. The average loss to a household customer varies between 7-8 %.

In the table below, the calculated environmental impact per life cycle module is presented. *Total – generated* summarizes the impacts from producing 1 kWh electricity from Vattenfall's nuclear power, while *Total – distributed* presents the entire impacts as per functional unit: *1 kWh distributed to an industrial customer during an average year*. The industrial customer is connected to the regional distribution network.

Environmental impact categories

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)	1.60	0.214	0.433	2.25	0.168	1.62	4.04
	Biogenic	g CO ₂ -eq. (100years)	0.0442	0.0811	0.0940	0.219	0.0094	0.0188	0.248
	Luluc ² (deforestation)	g CO ₂ -eq. (100years)	0	0	0.00821	0.00821	3.28E-04	1.41	1.42
	Total	g CO ₂ -eq. (100years)	1.65	0.296	0.535	2.48	0.177	3.05	5.71
Acidification potential (AP)		g SO ₂ -eq.	0.00511	0.00137	0.00242	0.00890	4.46E-04	0.0104	0.0198
Eutrophication potential (EP)		g PO ₄ ³⁻ -eq.	0.00327	7.11E-04	4.30E-04	0.00441	1.94E-04	0.00533	0.00993
Photochemical oxidant formation potential (POFP)		g NMVOC-eq.	0.00731	0.00184	0.00197	0.0111	7.59E-04	0.00741	0.0193
Particulate matter		g PM _{2.5} -eq.	0.00320	3.58E-04	6.43E-04	0.00420	1.86E-04	0.00414	0.00853
Abiotic depletion potential - Elements		g Sb-eq.	2.81E-05	5.28E-08	7.24E-06	3.54E-05	1.42E-06	2.28E-05	5.97E-05
Abiotic depletion potential - Fossil fuels		MJ, net cal. value	0.0267	6.73E-04	0.00408	0.0314	0.00190	0.0197	0.0530
Water scarcity footprint		m ³ H ₂ O-eq.	0.0685	0.00562	0.328	0.402	0.0161	0.199	0.618

¹ Distribution losses of 4 % 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 from nuclear power generation, concerning the herein assessed impact categories, is attributable to the activities in the upstream processes, especially during mining of uranium where the biggest contributions come from the uranium extraction activity and electricity consumption. All in all, upstream processes contribute to about 11-50 % of the impact depending on impact category. When looking at the distribution of electricity as well, the environmental impact from nuclear power is mainly caused by construction and decommissioning of the grid for distribution of the electricity generated. The downstream processes contribute to about 35-57 % of the total impact, depending on impact category. See section 3.4.8. in the complete EPD[®] Report for a more detailed dominance analysis of the results.

In contrast to the previous version of this EPD[®], greenhouse gas emissions as a result of deforestation (GWP Luluc) are now included. The greenhouse gas emissions from generation and distribution of electricity are around 5.7 g CO₂e per kWh delivered to customer, which is somewhat higher compared to last update of the EPD[®] and much due to the inclusion of GWP Luluc. When excluding GWP Luluc, the GWP results are however somewhat lower than in the previous update of the EPD[®]. See section 5.1 in the complete EPD[®] Report for more descriptions of the differences towards the previous EPD[®].

ADDITIONAL ENVIRONMENTAL INFORMATION

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

Land use and Impact on Biodiversity

Vattenfall's method for Land use and biodiversity impacts is used to quantify impacts on biodiversity as a direct consequence of the utilisation of land and water for economic activities. Affected areas are categorised into the Corine Land Classes. In the table and figure below the identified biotope changes are shown. See section 4.1. in the complete EPD® Report for more information.

Land cover	Before (m²)	After (m²)	Land use change (m²)
1. Artificial Surfaces	1 730 000	90 500 000	88 700 000
2. Agricultural areas	513 000	0	-513 000
3. Forest and seminatural areas	107 000 000	30 100 000	-76 500 000
4. Wetlands	10 200 000	4 050 000	-6 180 000
5. Water bodies	36 100 000	30 600 000	-5 560 000

Safety, Barriers and Radiation

The nuclear power industry is strictly regulated and closely monitored by authorities. The operator of a nuclear power plant is the owner of and responsible for the nuclear fuel from mining to final repository. In addition to strict design criteria including redundant control systems there are safety considerations at three levels. See section 4.2. in the complete EPD® Report for more information.

Radioactive substances in various forms are handled during normal operation by facilities in the nuclear fuel cycle. These substances emit ionizing radiation that may result in doses to the people working in the facility and to people outside the facility, dose to third party.

Occupational dose. The table below show the average annual dose to personnel at the different facilities in the nuclear fuel life cycle.

	Unit	Upstream facilities	Nuclear power plants - operations	Nuclear waste handling
Average annual individual dose	mSv	0.02 – 1.9	0.95 – 1.1	0.25 – 1.5

Dose to representative individual is an assessed dose (mSv) that is received by an individual living in the vicinity of the facility. This is commonly a hypothetical individual that is assumed to represent a person that is more exposed due to its habits and consumption pattern, the representative individual may be defined differently between countries due to the type of facility, the emissions as well as the surrounding environment.

Maximum calculated annual effective dose 2021 from Forsmark and Ringhals was 0.00012 and 0.00079 mSv respectively. For comparison, if you live in Sweden the annual radiation dose is about 0.6 mSv from naturally occurring radioactive substances in soil and building materials. The annual dose to people in Sweden varies, but the average is about 4 mSv including for instance medical radiation and radon in homes.

Environmental Risk Assessment

The conclusion is that environmental risks in the nuclear fuel chain have low probability according to acceptance criteria set by the regulatory body. See chapter 4.4 in the complete EPD® Report for more information.

Mandatory Information

Information on the Independent Verification of this EPD®

This EPD® has been verified within Vattenfall's EPD® Management Process. The independent verifiers Caroline Setterwall (Hitachi Energy), Håkan Stripplé (IVL), and Lasse Kyläkorpi (Vattenfall), 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 International EPD® system managed by EPD International AB (General Programme Instructions (GPI), version 3.01, 2017-12-11, and Product Category Rules (PCR) CPC 171 version 4.0, 2020-03-16). This certification is valid until 2027-12-31.

Verification of Vattenfall's EPD® Management Process

Vattenfall's EPD® management process is third party verified on annual bases, the last review was made 2022-03-28. 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 in the GPI and the Process Certification Clarification (PCC) for the International EPD® system.

Mandatory Statements

General

To be noted: EPD®s within the same product category but 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.

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.

Means of Obtaining Explanatory Materials

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

Information on Verification

EPD® programme: The International EPD® system managed by EPD International AB, Box 210 60, SE-100 31 Stockholm, Sweden. E-mail: info@environdec.com, www.environdec.com

Product Category Rules: Product Category Rules, CPC 171 Electrical Energy, version 4.2

PCR review was conducted by: The Technical Committee of the International EPD® system. Chair: Massimo Marine. EPD International AB. Full list of TC members available on www.environdec.com/TC

Independent verification of the declaration and data, according to ISO 14025, has been performed within Vattenfall's certified EPD® Management process.

X Internal (EPD process certification)

Internal and external verifiers: Caroline Setterwall, Hitachi Energy, Håkan Stripplé, IVL Swedish Environmental Research Institute, and Lasse Kyläkorpi, Vattenfall AB

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: 2027-12-31