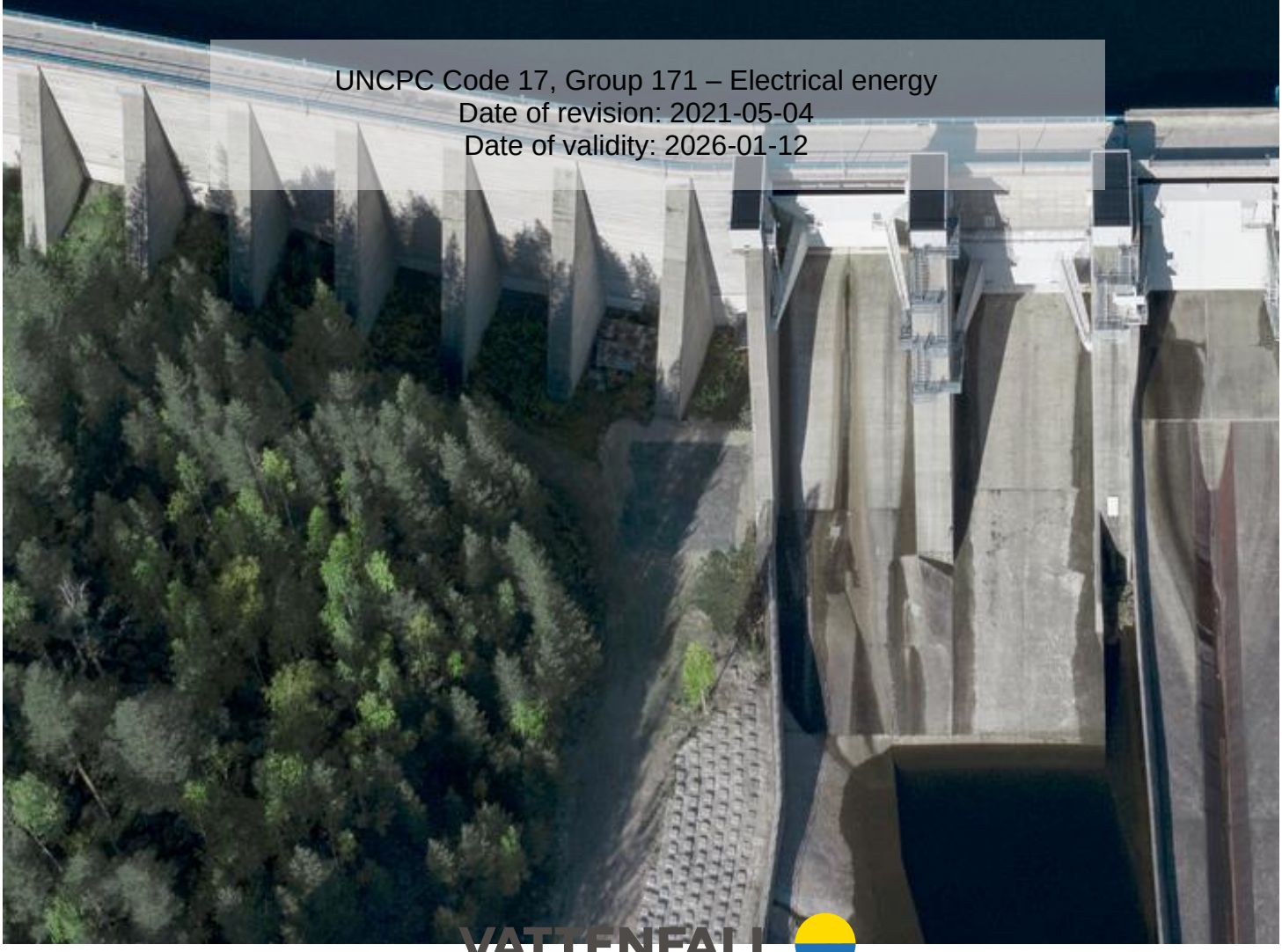
EPD®
THE INTERNATIONAL EPD® SYSTEM

Summary of EPD® of Electricity from Vattenfall's Nordic Hydropower

EPD® registration number: S-P 00088
The International EPD® System

Vattenfall AB

Confidentiality class: None (C1)



UNCPC Code 17, Group 171 – Electrical energy
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VATTENFALL

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Vattenfall AB
Summary of certified Environmental Product Declaration EPD® of Electricity from Vattenfall's Nordic Hydropower UNCPC Code 17, Group 171 – Electrical energy

Cover page: Vattenfall Tuggen power station (cropped image, photo: Jennie Pettersson)

Summary

PRODUCER, Vattenfall Business Unit Hydro Nordic is responsible for Vattenfall AB's hydropower generation in the Nordic countries. BU Hydro Nordic is part of Vattenfall AB, SE-169 92 Stockholm, Sweden. Phone: +46 8 739 50 00; www.vattenfall.se and www.vattenfall.com. BU Hydro Nordic implements a certified work environment and environmental management system. This system is based on the standards ISO 14001:2015 and OHSAS 18001:2007 as well as the provision AFS 2001:1.

PRODUCT AND DECLARED UNIT, Electricity belongs to the product category UNCPC Code 17, Group 171 – Electrical energy. The declared unit is 1 kWh electricity net generated and thereafter distributed to a customer connected to the Swedish regional grid (70/130 kV) and represents an average for hydro power Vattenfall. Vattenfall AB owns or has majority share in 56 large-scale hydropower plants in the Nordic countries and 32 small-scale stations. The hydropower generation that BU Hydro Nordic disposes from majority owned plants during an average year is 31 TWh which corresponds to about half of the total hydro power production in Sweden. Several reservoirs enable the generation to follow the load curve, and electricity can be delivered without backup sources.

THE INTERNATIONAL EPD® SYSTEM, managed by EPD International AB as a subsidiary to IVL Swedish Environmental Research Institute, is based on ISO 14025, Type III Environmental Declarations. The relevant governing documents in hierarchical order are: PCR-CPC171, version 4.11; General Programme Instructions for an environmental product declaration, EPD® version 3.01; ISO 14025; ISO 14040, and ISO 14044.

Environmental Performance

System Boundaries, The EPD® describes the core process, i.e. the generation of electricity in Vattenfall's Nordic hydropower plants, upstream process comprising production of auxiliary supplies, and downstream process including distribution of electricity. The core - infrastructure comprising construction of power plants, dams and waterways is also included. Decommissioning has not been included but the technical lifetime has been set at a level that provides for complete replacement of the power plant through reinvestments. Technical lifetime for machinery in power plants has been set to 60 years and for buildings, dams and waterways 100 years. Construction and decommissioning of infrastructure in downstream process have been included. The use of electricity at the consumer has been excluded. Nordic hydropower plants, majority and wholly owned by Vattenfall AB, have been selected for the study to be representative regarding location, physical geography regions, and type and size of station. The stations are located in different river regions. The selected stations have a third of Vattenfall's installed capacity and generate a third of Vattenfall's hydropower. For more information about the selection of hydropower plants, see appendix *Beskrivning av valda anläggningar* (in Swedish).

This certified declaration also contains descriptions of environmental risks and impacts on biodiversity in accordance with the EPD® system instructions.

Table 1 Operations in the different phases of the life cycle

Upstream	Production of oils, chemicals and fuels for operation of the plant and for vehicles and reserve power.
Core	Operation of power plant, i.e. emissions from inspection trips, emissions of oil to water and ground, incineration or deposit of operational waste.
Core – infrastructure	Construction and reinvestments in machinery, dams and waterways. Emissions from land inundated by reservoirs.
Downstream	Operation of electricity networks, i.e. emissions from inspection trips, production and emissions of oils. Additional generation in Vattenfall's hydropower plants to compensate for losses in the networks.
Downstream – infrastructure	Construction and decommissioning of the transmission grid and distribution networks.

Environmental Performance based on LCA

A short summary of compiled data is presented below per generated and distributed kWh of electricity. For more information see section 3 of the complete EPD report. Distribution of electricity implies losses, which is compensated for by increased generation. The loss to an average large industrial customer connected to the regional distribution network (70/130 kV) amounts to 4% (included in the downstream column below). The losses are different for different types of customers and often higher in the countryside. The average loss to a household customer is around 8%.

Table 2 Environmental impacts

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. (100yrs)	$7,45*10^{-3}$	$3,83*10^{-2}$	1,36	**1,40**	$1,40*10^{-1}$	1,44	**2,99**
	Biogenic	g CO_2-eq. (100yrs)	$4,04*10^{-5}$	$1,91*10^{-3}$	$2,34*10^{-2}$	**$2,54*10^{-2}$**	$1,02*10^{-3}$	0,00	**$2,64*10^{-2}$**
	Luluc[2] (inundation)	g CO_2-eq. (100yrs)	0,00	0,00	$7,98\text{^}10^{-1}$	**$7,98\text{^}10^{-1}$**	$3,19*10^{-2}$	0,00	**$8,30\text{^}10^{-1}$**
	Luluc (deforestation)	g CO_2-eq. (100yrs)	0,00	0,00	2,11	**2,11**	$8,42*10^{-2}$	1,22	**3,41**
	Total	g CO_2-eq. (100yrs)	$6,78*10^{-3}$	$4,02*10^{-2}$	4,29	**4,33**	$2,57*10^{-1}$	2,68	**7,26**
Acidification potential (AP)		g SO_2-eq.	$6,59*10^{-5}$	$5,42*10^{-5}$	$5,15*10^{-3}$	**$5,27*10^{-3}$**	$3,74\times10^{-4}$	$7,84*10^{-3}$	**$1,35*10^{-2}$**
Eutrophication potential (EP)[3]		g PO_4^{3-}-eq.	$1,83*10^{-5}$	$1,59*10^{-5}$	$1,50*10^{-2}$	**$1,50*10^{-2}$**	$6,41*10^{-4}$	$3,51*10^{-3}$	**$1,92*10^{-2}$**
Photochemical oxidant formation potential (POFP)		g NMVOC-eq.	$4,82*10^{-5}$	$1,23\times10^{-4}$	$4,52*10^{-3}$	**$4,69*10^{-3}$**	$6,66\times10^{-4}$	$6,90*10^{-3}$	**$1,23*10^{-2}$**
Particulate matter		g PM2.5-eq.	$1,80*10^{-5}$	$1,94*10^{-5}$	$1,91*10^{-3}$	**$1,94*10^{-3}$**	$1,35*10^{-4}$	$3,12*10^{-3}$	**$5,20*10^{-3}$**
Abiotic depletion potential - Elements		g Sb-eq.	$4,98*10^{-8}$	$3,20*10^{-9}$	$1,09*10^{-5}$	**$1,09*10^{-5}$**	$4,62*10^{-7}$	$2,38*10^{-5}$	**$3,51*10^{-5}$**
Abiotic depletion potential - Fossil fuels		MJ, net cal. Value	$5,89\times10^{-4}$	$5,65*10^{-6}$	$1,43*10^{-2}$	**$1,49*10^{-2}$**	$1,23*10^{-3}$	$1,85*10^{-2}$	**$3,46*10^{-2}$**
Water scarcity footprint		m^3 H_2O-eq.	$3,17*10^{-7}$	$1,76*10^{-7}$	$5,48*10^{-4}$	**$5,48*10^{-4}$**	$2,28*10^{-5}$	$3,12*10^{-4}$	**$8,83*10^{-4}$**

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.
3 Over 98% emanates from COD and inundation of land; this is calculated in accordance with the methodology described in the PCR

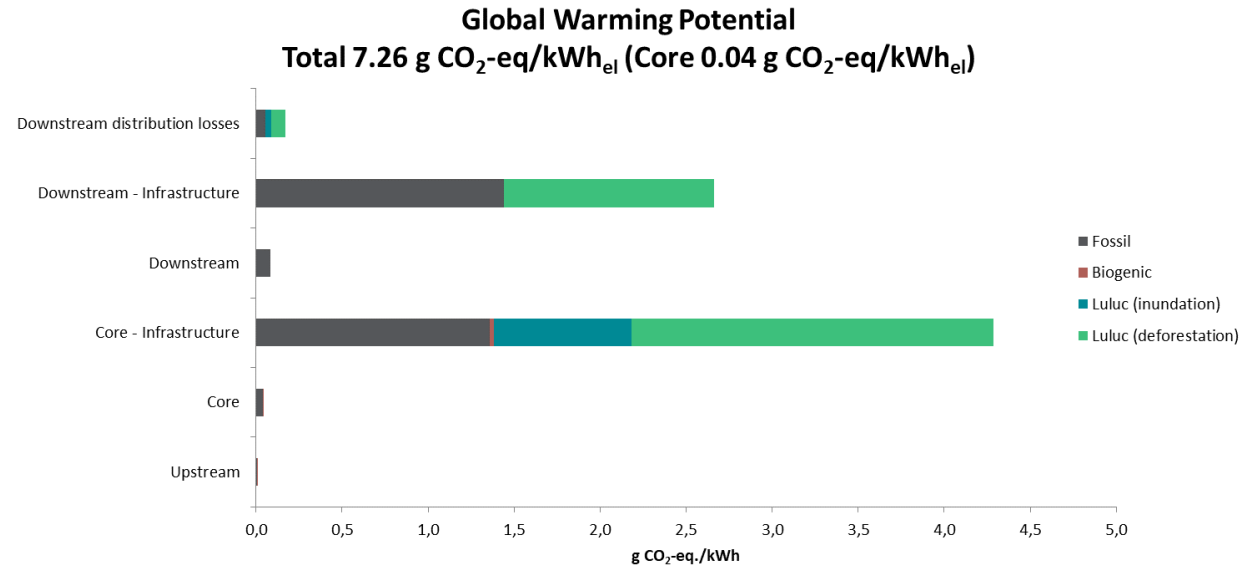

Figure 1 Potential emissions of greenhouse gases

The main contributions to the emission categories in the table above occur in the construction phase of the hydropower plants (core-infrastructure) as well as power networks (downstream-infrastructure), and mainly relate to the use of material for construction and reinvestment. Operation contributes less than 1% in the majority of the assessed impact categories.

With regards to the impact categories Eutrophication Potential and Global Warming Potential, the emissions in core-infrastructure are dominated by activities related to land use change, where inundation in reservoirs is the single most significant contributor to emissions of eutrophying substances and greenhouse gases. Deforestation, as a result of the construction of water reservoirs (dams) and power network infrastructure, also has a significant contribution to the emissions of greenhouse gases in both core- and downstream-infrastructure.

If the facilities were to be used beyond the assumed 100 years, the emission per generated kWh would decrease since there would be the same amount of carbon released due to land use change, but a larger amount of kWh generated.

Additional Environmental Information

Land use and Impact on Biodiversity

Vattenfall´s Biotope Method 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 Critical biotope, Rare biotope, General biotope and Technotope. The 14 selected hydropower stations occupy an area of in total about 74 000 hectares, predominantly river-, lake, and annual reservoirs. This reservoir area constitutes 40% of Vattenfall's total reservoir area and the 14 stations generate 31% of Vattenfall's hydropower.

The table below shows the aggregated change of biotope categories caused by the construction of the 14 stations. The specific values in the table give a rough approximation of the direct biotope changes caused by Vattenfall's Nordic hydropower. Data should be interpreted based on the whole chapter on land use and biodiversity – see chapter 4.1 in the EPD report.

Out of the allocated area about 56% is assessed at the highest methodological level (A) and 44% at the next highest level (B). This gives the study an overall quality level of B and therefore the results are given with a two-digit accuracy.

Table 3 Biotope change

Category	Biotope change (ha)	Biotope change per kWh (m^2/kWh)
Critical biotope	-34 000	$-3{,}1*10^{-4}$
Rare biotope	-15 000	$-1{,}4*10^{-4}$
General biotope	30 000	$2{,}8*10^{-4}$
Technotope	18 000	$1{,}7*10^{-4}$

Environmental Risk Assessment

The risk assessment shows that, allocated over a long period of time, emissions of carbon dioxide, dust and carbon monoxide related to accidents and breakdowns are smaller than emissions occurring under normal conditions. The difference between the environmental risk assessment and the LCI for oil/diesel/petrol is not significant. Emissions of gasified copper and SF_6 are on the same order of magnitude in both assessments. However, the absolute volumes are small for these parameters. See chapter 4.3 in the EPD report for more information on risks.

Noise

The most notable noise outdoors is the sound from water running through above-ground power plants. The noise levels are however lower than before the construction of the hydro power plants.

Information from the Certification Body and Mandatory Statements

Information from the Certification Body

This EPD® has been verified within Vattenfall's EPD® Management Process. The independent verifiers Caroline Setterwall, Hitachi ABB Power Grids, Martin Erlandsson, IVL and Lasse Kyläkorpi, Vattenfall AB, confirm that the product does not violate 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 2019-09-18, and Product Category Rules (PCR) CPC 171 version 4.11, 2020-03-16). This certification is valid until 2026-01-12.

Verification of Vattenfall's EPD® Management Process

Vattenfall's EPD® management process is third party verified annually, last review was made 2020-10-19. 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 AB expressed in the GPI and the Process Certification Clarification (PCC) for the International EPD® system.

Mandatory Statements

1.1.1. 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.

1.1.2. 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.

1.1.3. 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.

1.1.4. Information on Verification

EPD® programme: **The EPD® system managed by EPD International AB as a subsidiary to IVL Swedish Environmental Research Institute, www.environdec.com**	
Product Category Rules: **Electricity, steam and hot water generation and distribution, version 4.11, CPC 171 Electrical Energy**	
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 **X EPD® Process Certification** **has been performed within Vattenfall's certified EPD® Management process.**	
Internal and external verifiers: **Caroline Setterwall, Hitachi ABB Power Grids, Lasse Kyläkorpi, Vattenfall AB and Martin Erlandsson, IVL**	
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: 2026-01-12**
Procedure for follow-up of data during EPD validity involves third-party verifier **X No**	