ENVIRONMENTAL PRODUCT DECLARATION

EPD®
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The Norwegian EPD Foundation

According to ISO 14025

Registered under the scope of mutual recognition between The International EPD® System and The Norwegian EPD Foundation

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Registration number: S-P-01085
Issue date: 2016-06-21
Valid to: 2021-06-21

Hydroelectricity from Skjerka power station

Agder Energi AS

Foto: Anders Martinsen

General information

Product

Hydroelectricity from Skjerka power station.

Owner of the declaration

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Declaration number

NEPD-449-300-EN

Place of production:

Skjerkevatn, Åseral kommune, Norway

This declaration is based on Product Category Rules:

PCR for electricity, steam and hot and cold water generation and distribution. PCR 2007:08, version 3.0. Dated 2015-02-05. There are a few deviations according to format required by EPD Norway

Management system:

Statements:

The owner of the declaration shall be liable for the underlying information and evidence.
EPD Norway shall not be liable with respect to manufacturer, life cycle assessment data and evidences.

Organisation no:

NO 981 952 324

Issue date

21.06.2016

Valid to

21.06.2021

Declared unit:

1 kWh of electricity produced by hydropower technology.

Year of study:

2015

Declared unit with option:

1 kWh of electricity produced by hydropower technology, and thereafter distributed.

Comparability:

EPDs from other programmes than the Norwegian EPD foundation may not be comparable.

Functional unit:

The EPD has been worked out by:

Ellen Soldal

Østfoldforskning

Verification:

Independent verification of the declaration and data, according to ISO14025:2010

☐ internal ☑ external

Third party verifier:

sign
PhD Andreas Brekke
(Independent verifier approved by EPD Norway)

Approved

Håkon Hauan
Managing Director of EPD-Norway

Key environmental indicators	Declared unit		
	1 kWh electricity produced and ready to be distributed, excl. emissions from inundated land	1 kWh electricity produced and ready to be distributed	0.88 kWh produced and distributed
Global warming	0.9 g CO_2-eq/DU	2.8 g CO_2-eq/DU	4.2 g CO_2-eq/DU
Use of primary energy resources	3.27 MJ/DU	3.27 MJ/DU	3.29 MJ/DU
Renewable energy share	100 %	100 %	99 %

Product

Product description:
110 kV hydroelectricity produced at Skjerka power station. The power station is located in Åseral municipality in southern parts of Norway. The owner of the power station is Agder Energi, which can cover 5 % of the total national energy demand.

Technical data:
High voltage (110 kV) hydroelectricity.

Market:
Europe

LCA: Calculation rules

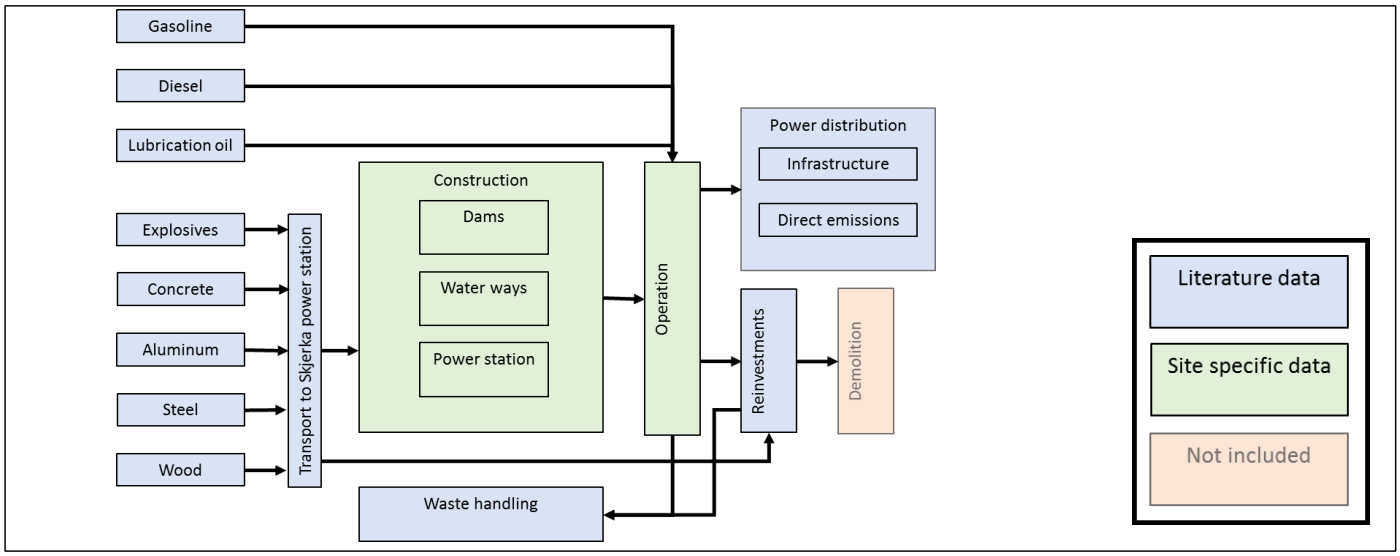
Declared unit:
1 kWh of hydropower produced, ready for distribution on the transmission network, at 110 kV.

Distribution of the electricity is included as an option. The loss of energy at during distribution is based on Ecoinvent (Weidema et al. 2013). The declared unit is still 1 kWh produced because the distribution is not relevant for the target audience for this EPD.

System boundary:
The total contribution to environmental impacts for electricity ready for delivery to the electricity grid, including raw material extraction and production (Figure 1). 100 % reinvestment of all installations are included, divided over the technical life time of the installations. The environmental impacts from dams, gates and roads upstream and at Skjerka are allocated to Skjerka power station and to Håverstad power station, which is downstream Skjerka power station. The allocation is based on annual electricity production and Skjerka is thus given 70 % of the load.

Energy loss due to distribution			
Voltage	Loss in %	Loss in kWh	Source
High	3,16 %	0.032 kWh	Weidema et al. 2013
Medium	3,56 %	0.034 kWh	Weidema et al. 2013
Low	5,51 %	0.051 kWh	Weidema et al. 2013

Figure 1 System boundaries for the environmental analysis of electricity produced by Skjerka hydropower station, and thereafter distributed. The "Dams" include four upstream dams that provide benefit to the electricity production at Skjerka hydropower station.



Data quality:
Information on material flows are based upon site specific data. The data was collected in 2015, and is relevant to time, geography and technology. The production of raw materials used are based on generic data from the Ecoinvent database, version 3 (Weidema et al. 2013).

Cut-off criteria:
All major raw materials and all the essential energy is included. In this analysis, no data obtained has been omitted. All data and processes have been considered relevant, and all the data attained has been analysed.

Allocation:
The allocation is made in accordance with the provisions of ISO 14025. Effects of primary production of recycled materials allocated to the main product in which the material was used. The recycling process and transportation of the material is allocated to this analysis. The environmental impacts from dams, gates and roads upstream and at Skjerka are allocated to Skjerka power station and to Håverstad power station, which is downstream Skjerka power station. The allocation is based on annual electricity production and Skjerka has 70 % of the load.

LCA: Scenarios and additional technical information

Distribution of electricity is included (A4). The reults for A1-A3 are given for the production of 1 kWh electricity. The reults A1-A4 are, thus, given for delivery of 1 kWh less loss due to distribution. This equals delivery of 0.88 kWh.

LCA: Results

For the production of 1 kWh electricity, emissions of GHG from inundated land is the single most important contribution to GWP and EP. Annual reinvestments are important in all impact categories. Amongst the infrastructure components roads and dams are important. Emissions due to distribution are domiant.

System boundaries (X=included, MND=module not declared, MNR=module not relevant)

Product stage			Assembly stage		Use stage							End of life stage				Beyond the system boundaries
Raw materials	Transport	Manufacturing	Transport	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

Environmental impact

Parameter	Unit	A1-A2	A3	A1-A3	A4
GWP*	kg CO_2 -eqv	8,49E-04	1,97E-03	2,82E-03	1,41E-03
ODP	kg CFC11-eqv	4,80E-11	1,36E-11	6,16E-11	8,57E-11
POCP	kg C_2H_4 -eqv	1,81E-07	1,55E-08	1,97E-07	2,20E-06
AP	kg SO_2 -eqv	3,09E-06	4,48E-07	3,53E-06	5,10E-05
EP	kg PO_4^{3-}-eqv	1,09E-06	1,93E-05	2,04E-05	3,88E-05
ADPM	kg Sb-eqv	5,60E-09	1,11E-11	5,61E-09	4,03E-07
ADPE	MJ	5,69E-03	1,04E-03	6,73E-03	1,50E-02
WSI (Pfister)**	m^3-eqv	4,72E-06	7,31E-05	7,78E-05	1,65E-05
WSI (Boulay)***	m^3-eqv	5,29E-06	5,15E-08	5,34E-06	1,85E-05

*GWP include 1.9 g CO2-eq./kWh due to inundation of land.

**Water Scarcity Index by use of the Pfister et al. (2009) method. This method is based on a withdrawal-to-availability (WTA) ratio.

***Water Scarcity Index by use of the Boulay et al. (2011) method. This method is based on a consumption-to-availability (CTA) ratio.

GWP Global warming potential; ODP Depletion potential of the stratospheric ozone layer; POCP Formation potential of tropospheric photochemical oxidants; AP Acidification potential of land and water; EP Eutrophication potential; ADPM Abiotic depletion potential for non fossil resources; ADPE Abiotic depletion potential for fossil resources; WSI Water scarcity index

Resource use					
Parameter	**Unit**	**A1-A2**	**A3**	**A1-A3**	**A4**
RPEE	MJ	3,26E+00	4,36E-06	3,26E+00	3,38E-03
RPEM	MJ	9,87E-05	1,03E-06	9,97E-05	1,50E-03
TPE	MJ	3,26E+00	5,39E-06	3,26E+00	4,88E-03
NRPE	MJ	6,45E-03	1,05E-03	7,50E-03	1,66E-02
NRPM	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00
TRPE	MJ	6,45E-03	1,05E-03	7,50E-03	1,66E-02
SM	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00
W(a)*	m^3	1,09E-05	1,01E-07	1,10E-05	1,95E-05
W(b)**	m^3	0,00E+00	8,75E-04	8,75E-04	0,00E+00
W	m^3	1,09E-05	8,75E-04	8,86E-04	1,95E-05

*W(a) is use of net fresh water, excluding net evaporation/evapotranspiration from reservoir and inundated area.

**W(b) is net evaporation/evapotranspiration from reservoir and inundated area. These numbers are seldom included in LCAs of hydropower (Bakken, Modahl, Engeland, Raadal and Arnøy, 2015). Evaporation/evapotranspiration data have been calculated by Tor Haakon Bakken (CEDREN memo dated 29th January 2016). The calculation has been based on a number of factors, such as precipitation, temperature, humidity, radiation, wind speed, land use types and inundated area. A Penman-Monteith model has been used, using meteorological data with daily time step for the period 2007-2014. A net value methodology has been used. The increased (net) water losses has been calculated for the planned situation in 2018 from the non-regulated system (some time before 1930).

RPEE Renewable primary energy resources used as energy carrier; RPEM Renewable primary energy resources used as raw materials; TPE Total use of renewable primary energy resources; NRPE Non renewable primary energy resources used as energy carrier; NRPM Non renewable primary energy resources used as materials; TRPE Total use of non renewable primary energy resources; SM Use of secondary materials; RSF Use of renewable secondary fuels; NRSF Use of non renewable secondary fuels; W Use of net fresh water

End of life - Waste					
Parameter	**Unit**	**A1-A2**	**A3**	**A1-A3**	**A4**
HW	kg	1,39E-05	3,14E-10	1,39E-05	4,18E-08
NHW	kg	3,96E-04	2,62E-06	3,98E-04	5,70E-03
RW*	kg	INA	INA	INA	INA

*Radioactive waste disposed is assessed in volume, not in weight. The amount is given in the LCA-report (Soldal and Modahl, 2016).

HW Hazardous waste disposed; NHW Non hazardous waste disposed; RW Radioactive waste disposed

End of life - Output flow					
Parameter	**Unit**	**A1-A2**	**A3**	**A1-A3**	**A4**
CR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MR	kg	6,22E-04	0,00E+00	6,22E-04	0,00E+00
MER	kg	1,44E-06	0,00E+00	1,44E-06	0,00E+00
EEE	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00
ETE	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00

CR Components for reuse; MR Materials for recycling; MER Materials for energy recovery; EEE Exported electric energy; ETE Exported thermal energy

Reading example: 9.0 E-03 = $9.0*10^{-3}$ = 0.009

Additional environmental information

Agder Energi's hydropower plants are not located in protected areas or in protected water ways. Their power installations and activities do not have a bigger impact on nature or society than is usual for this kind of business. Within the framework of Agder Energi's existing licenses, various statutory and voluntary measures are taken to reduce the negative environmental impacts. These measures include releasing water to entice fish to swim up rivers and building salmon ladders, putting out fish and roe in reservoirs, and actions for reduction of Eurasian eagle-owl death by power lines (Agder energi 2015).
In order to reduce the risk of flooding in relation to the new dam constructed at Lake Skjerkevatn, Agder Energi is building a spillway, as well as a diversion tunnel with outlet gates to ensure that flood water is safely diverted.
The PCR, chapter 9.4, asks for LCI data for emissions of various substances. These data are omitted here for the EPD to better conform with the standard format of EPD Norway and to avoid the reader focusing on substances with little or no relevance to the product system. LCI data on emissions are available in the LCA report (Soldal and Modahl, 2016).

Additional Norwegian requirements

Greenhous gas emission from the use of electricity in the manufacturing phase

The following data is used for national production mix from import, low voltage (production of transmission lines, in addition to direct emissions and losses in grid) of applied electricity for the manufacturing prosess (A3): Electricity, low voltage {NO}| market for | Alloc Rec, U (Weidema et al. 2013).

Data source	Amount	Unit
Econinvent v3 (june 2014)	25,3	g CO_2-eqv/kWh

Dangerous substances

- ☑ The product contains no substances given by the REACH Candidate list (The European parliament 2006, European Chemicals Agency, 2015) or the Norwegian priority list (Norwegian Environment Agency, 2015).
- ☐ The product contains substances given by the REACH Candidate list or the Norwegian priority list that are less than 0,1 % by weight.
- ☐ The product contain dangerous substances, more then 0,1% by weight, given by the REACH Candidate List or the Norwegian
- ☐ The product contains no substances given by the REACH Candidate list or the Norwegian priority list. The product is

Indoor environment

Not relevant as the product does not affect indoor climate.

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