ENGINEERING TOMORROW

Environmental **Product Declaration**

VLT® AQUA/HVAC/Refrigeration Drive FC-202/FC-102/FC-103 series D Frame Size

EPD issued	2024-04-11
EPD expires	2029-04-11
EPD author	Danfoss Power Electronics & Drives A/S
EPD type	Cradle-to-grave
Declared unit	One product over its Reference Service Life
Product included	FC-102N315T4E2MH4BGC3 (134U2562)
Products covered by EPD	All D-frames in the VLT® FC-102. FC-103 and FC-202 range
Manufacturing Location	Loves Park, USA
Use Location	Europe
Application	Water/Waste water e.g. HVAC, Refrigeration etc.
Mass	231,1 kg without packaging 300,6 kg with packaging
Dimensions (H×W×D)	1931 x 420 x 386 mm without packaging
Verification	[ ] External [X] Internal [ ] None
Produced to	Danfoss Product Category Rules (2022-09)
Internal independent verifier	Danfoss Climate Solutions

DISCLAIMER
This EPD was prepared to the best of knowledge of Danfoss A/S. The life cycle assessment calculations were performed in accordance with ISO 14040 & 14044 and EN15804+A2.
All results were internally reviewed by independent experts. While this declaration has followed the guidance of ISO 14025, it has not been externally verified or registered by an EPD programme and therefore does not fully comply with the ISO 14025 standard.
This EPD has been published by Danfoss A/S on Danfoss Product Store and Danfoss Website. For questions, feedback or requests please contact your Danfoss sales representative.

Product Description

This Environmental Product Declaration (EPD) follows the Danfoss Product Category Rules (PCR) (2022-09-20). These rules provide a consistent framework for calculating and reporting the environmental performance of Danfoss' products and is aligned with relevant international standards, particularly ISO 14025:2006, EN 15804+A2:2019 and EN 50598-3:2015.

This document has been produced by Danfoss A/S following an internal verification process, but it is not a third-party verified document.

What is an EPD?

An EPD is a document used to communicate transparently, the quantified environmental impacts of a product over its lifecycle stages. This quantification is done by performing a Life Cycle Assessment (LCA) in line with a consistent set of rules known as a PCR (Product Category Rules).

An EPD provides:

- A product's carbon footprint together with other relevant environmental indicators, including air pollution, water use, energy consumption and waste, over its own life cycle (Modules A-C), as well as the expected benefits of reuse and recycling in reducing the impact of future products (Module D). See Table 1 for module descriptions.
- Environmental data allowing customers to calculate LCAs and produce EPDs for their own products.

Type of EPD

This EPD is of the type 'cradle-to-grave' and includes all relevant modules: production (A1-A3), shipping (A4) and installation (A5); operational energy use (B6); deconstruction (C1), waste collection and transport (C2), treatment (C3) and disposal (C4). It also includes potential net benefits to future products from recycling or reusing post-consumer waste (D). The codes in brackets are the module labels from EN 15804+A2. Modules concerning use, maintenance, repair, replacement, refurbishment (B1-B5) and operational water use (B7) are excluded, following the cut-off rules from EN 15804.

Table 1: Modules of the product's life cycle included in the EPD

Product stage			Installation		Use stage							End-of-life stage				Benefits
Raw materials	Transport	Manufacture	Transport	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-install.	Transport	Waste processing	Disposal	Benefits and loads outside system boundaries
A1	**A2**	**A3**	**A4**	**A5**	B1	B2	B3	B4	B5	**B6**	B7	**C1**	**C2**	**C3**	**C4**	**D**
X	**X**	**X**	**X**	**X**	MNR	MNR	MNR	MNR	MNR	**X**	MNR	**X**	**X**	**X**	**X**	**X**

(X = declared module; MNR = module not relevant)

Product Description

The reference product used for this EPD is representative of Danfoss VLT® HVAC Frequency Converter D7H frame size (Model Code: FC-102N315T4E2MH4BGC3). The EPD covers all products in the VLT® FC-102, FC-103, and FC-202 range within the D frame range since the reference product is the biggest and most powerful frequency converter in this range, therefore representing a conservative scenario. This assumption is based on the mass, material composition and power of the product. The products in this range have weights between 62 kg and 232 kg and power outputs between 55 kW and 315 kW. The production location is the Danfoss plant in Loves Park, USA. See more information on Danfoss Store.

The VLT® Frequency Converter represents a single drive concept that controls the entire range of operations from ordinary to servo-like applications on any machine or production line.

Figure 1: The VLT® HVAC Frequency Converter D7H frame size.

Reference Service Life

For the purpose of this EPD the reference service life (RSL) of the product is considered to be 10 years. However, with the correct maintenance, the lifetime of the product can reach over 20 years.

Intended market

The intended market of this study is Europe, and the baseline scenario involves the distribution, installation, and end-of-life in Europe. With regards to the use stage and the end-of-life stage, this EPD is not representative of regions other than Europe.

Product Description

Table 2: Product composition

Material	Mass (kg)	%
Metals	**182,1**	**78,8%**
Steel	95,8	41,4%
Aluminium and its alloys	63,0	27,3%
Copper and its alloys	20,8	9,0%
Other metals	2,52	1,1%
Plastics	**14,0**	**6,1%**
Polycarbonate	7,46	3,2%
Other plastics	6,56	2,8%
Electrical/electronic	**35,0**	**15,1%**
Product Total	**231,1**	**100%**
Wood	59,0	84,9%
Plastic	1,22	1,8%
Cardboard	8,94	12,9%
Paper (documentation)	0,30	0,4%
Packaging Total	**69,5**	**100%**
Total (Product + Packaging)	**300,6**	

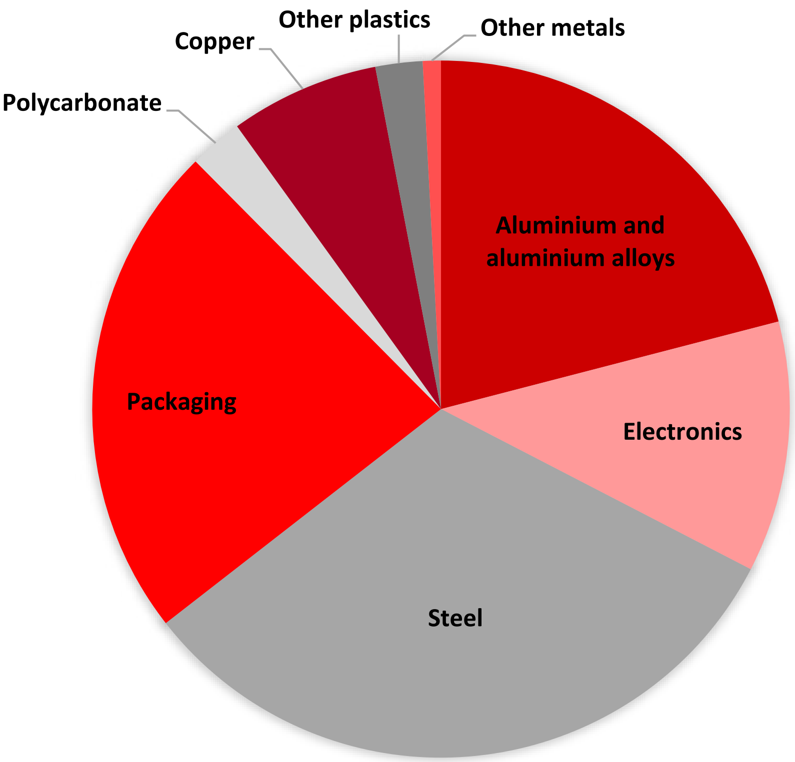

Figure 2: Material Composition Overview

Overview of LCA study

Data quality

Data quality of the selected datasets is generally assessed as good and very good in terms of geographical, time and technology representativeness and applicability. Background data is from LCA for Experts (Sphera) database version 2023.2.

Allocation and cut-off criteria

The allocation is made in accordance with the provisions of EN 15804+A2. All major raw materials and all the essential energy are included. All hazardous materials and substances are considered in the inventory. Data sets within the system boundary are complete and fulfil the criteria for the exclusion of inputs and output criteria.

System boundaries

The results in this EPD are split into life cycle modules following EN 15804 (Figure 1): production (A1-A3), distribution (A4), use (B6) and the end of the product's life (C1-C4). Module D represents environmental benefits and loads that occur beyond the system boundary (i.e., in future products).

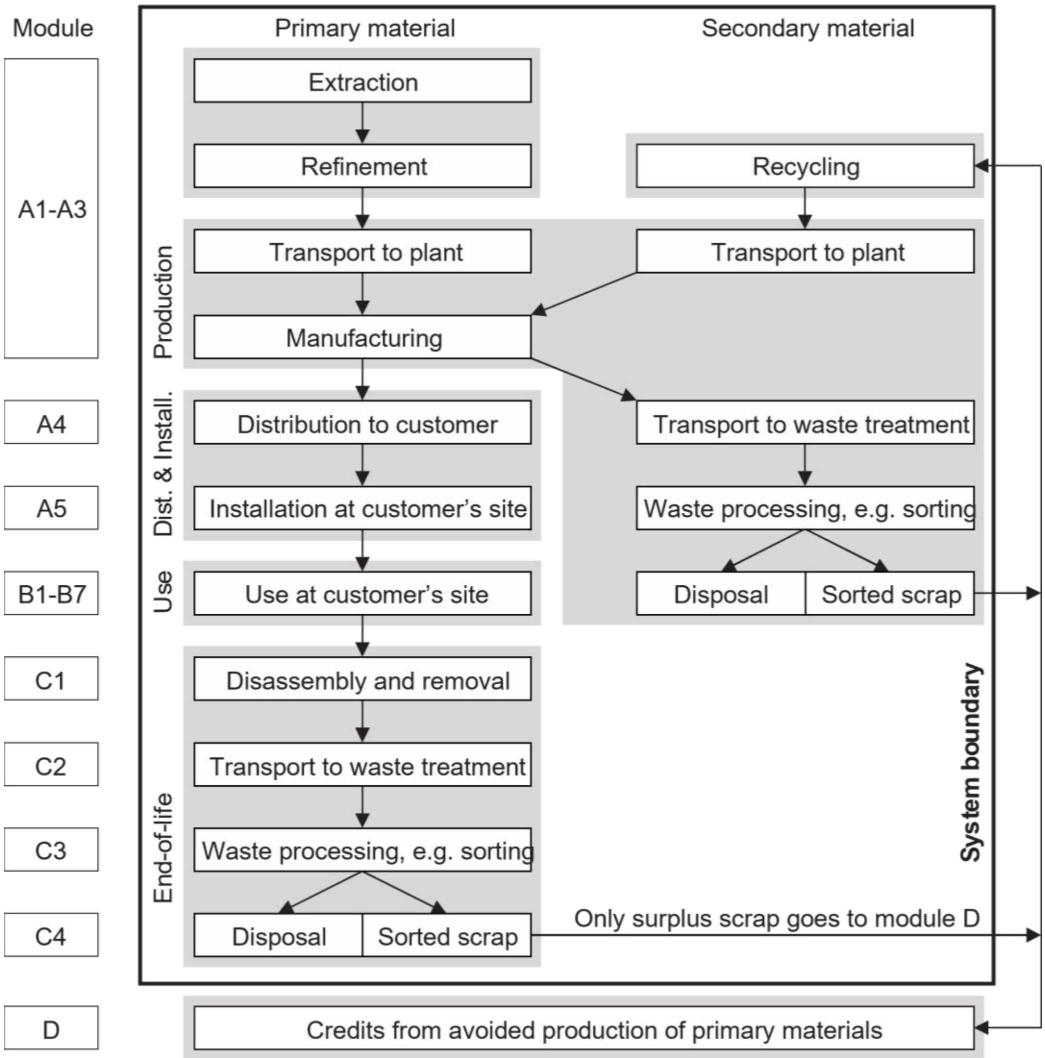

Figure 3: Modular structure used in this EPD (following EN 15804+A2)

Overview of LCA study

Product and packaging manufacture (A1-A3)

Final manufacturing occurs in the Danfoss Loves Park plant, USA. The facility is compliant to IATF 16949 and certified according to ISO 14001, and ISO 9001. Where waste generated on-site is recyclable, it is separated and recycled. For further information, see here. The product is shipped in the packaging as described in Table 1. All packaging materials can be safely recycled or incinerated if appropriate local facilities are available. The on-site data was gathered for 2023.

Table 3: Biogenic carbon content in product and packaging

	Total (excluding recycling)
Biogenic carbon content in product [kg]	-
Biogenic carbon content in accompanying packaging [kg]	15,8

Note: 1 kg biogenic carbon is equivalent to 44/12 kg of CO_2.

Shipping and installation (A4-A5)

Distribution is assumed to occur to customers in Europe from the production site in the USA. Therefore, a flight distance of 6850 km is assumed between the factory and the final customer, as well as an additional 2000 km by truck (following EN 50598-3, section 7.11 on default distance assumptions), which accounts for any transportation occurring within Europe to transport the drive to the final customer.

Module A5 includes disposal of packaging materials only, the benefits from e.g., energy recovered after plastic incineration are allocated to module D. The product is assumed to be installed by hand. Energy use in handheld tools during installation is not included as it falls under the cut-off criteria.

Use phase (B1-B6)

The electricity consumption by the drive during the use phase (B6) can vary based on application. The use scenario considered here is an average scenario to represent a range of industrial applications, developed according to Danfoss Power Electronics & Drives Segment global applications experts and internal sales data. The use phase results covered in this EPD are based on a VLT® FC-102 Frequency Converter, D7H frame size, and are therefore only valid for this specific product. The other products covered by this EPD have a similar or smaller energy consumption than this reference product.

The energy consumption is calculated considering an efficiency of 97,8%. Only the loss from the frequency converter is assigned as energy consumption of the inverter module. The remaining energy is allocated to the motor and is out of the scope of this EPD. The drive is in active mode on average for 6000 hours/year which results in 60.000 hours over 10 years lifetime or 16,44 hours per day. An average load of 80% is applied. For the remaining hours, the drive is either in standby mode or turned off completely. Standby mode is 2500 hours per year and during the remaining 260 hours the drive is turned off. This therefore results in 25.000 hours over 10 years or 6,85 hours per day, in standby mode.

The scope of this study is targeted for the European market; therefore, the product under study is sold and used in Europe. Sales also occur outside of Europe, which is important to note considering the impact the electricity grid mix can have on the emissions in the use phase. However, for the purpose of this assessment, an average EU-27 CO_2 factor from Sphera database (2023.2) is applied. This factor will differ, depending on the country and share of renewables and fossil energy sources in the corresponding local electricity grid. For that reason, two scenarios are additionally applied to demonstrate the impact of the results: USA and China.

Table 4: CO2 emissions per use phase location

Location of use	Use phase, kgCO2eq
Europe, EU-27 (Baseline scenario)	1,04E05
USA	1,58E05
China	2,66E05

The major limitation of the impact calculations for the use phase is that the electricity grid mix in use is assumed to remain at the same carbon intensity over time. Following the plans for the decarbonization of the grid across EU, the environmental impacts are expected to decrease over time within the course of the next 10 years. However, as decarbonization will occur in the future and as the pace of decarbonization is uncertain, the use of the emission intensity of today's grid should prove to be a "worst-case", conservative assumption.

End-of-life (C1-C4)

The standard end-of-life procedure from EN 50598-3 has been applied:

- Manual dismantling is used to separate recyclable bulk materials, e.g. bulk metals and plastics.
- Shredding is used for the remaining parts, such as printed circuit board assemblies.
- Ferrous metals, non-ferrous metals and bulk plastics are recovered through recycling.
- The remaining materials go to either energy recovery or landfill.

In line with EN 15804+A2, only the 'net scrap' (i.e., the leftover recyclable materials remaining after inputs of recycled content required in the manufacturing phase are first satisfied) is used to calculate the benefits and loads beyond the system boundary (Module D).

For this EPD an average scenario has been assumed with 50% of the product being send to recycling and 50% of the product being send to landfill (C3, C4, D).

This scenario is designed to represent an average end-of-life scenario as it is assumed that it represents the majority of cases on average.

1. Recycling scenario with 100% of the product sent to recycling at the end-of-life, excluding fractions that cannot be recycled or incinerated (e.g., glass reinforcing in glass-filled plastics) and are sent to landfill.

This scenario illustrates best case performance. It assumes a 100% collection rate and best available recycling technologies. Under this scenario electrical cables, and all metals, flat glass and unreinforced plastics found within the body and chassis of the product are recycled. Printed circuit board assemblies are incinerated, and the copper and precious metals (gold, silver, palladium, and platinum) are recycled.

2. Landfill scenario with 100% of the product sent to landfill.

This scenario assumes that the whole product, including its packaging, is landfilled. It is designed to represent a poor end of-life-route where valuable resources are lost.

Overview of LCA study

Benefits and loads beyond the system boundary (D)

Module D considers the net benefit of recycling (including energy recovery) of materials in the product and packaging, taking account of losses in the recycling process and the recycled material used in the production of the product. Module D covers the average end-of-life scenario, as described above.

Environmental performance

This section presents the environmental performance of one VLT® FC-102 Frequency Converter, D7H frame size. Figure 4 presents the environmental impact of the VLT® FC-102 Frequency Converter D7H across a number of environmental impact categories (following EN 15804+A2:2019) per life cycle stage, over its full 10-year life cycle, including Global Warming Potential.

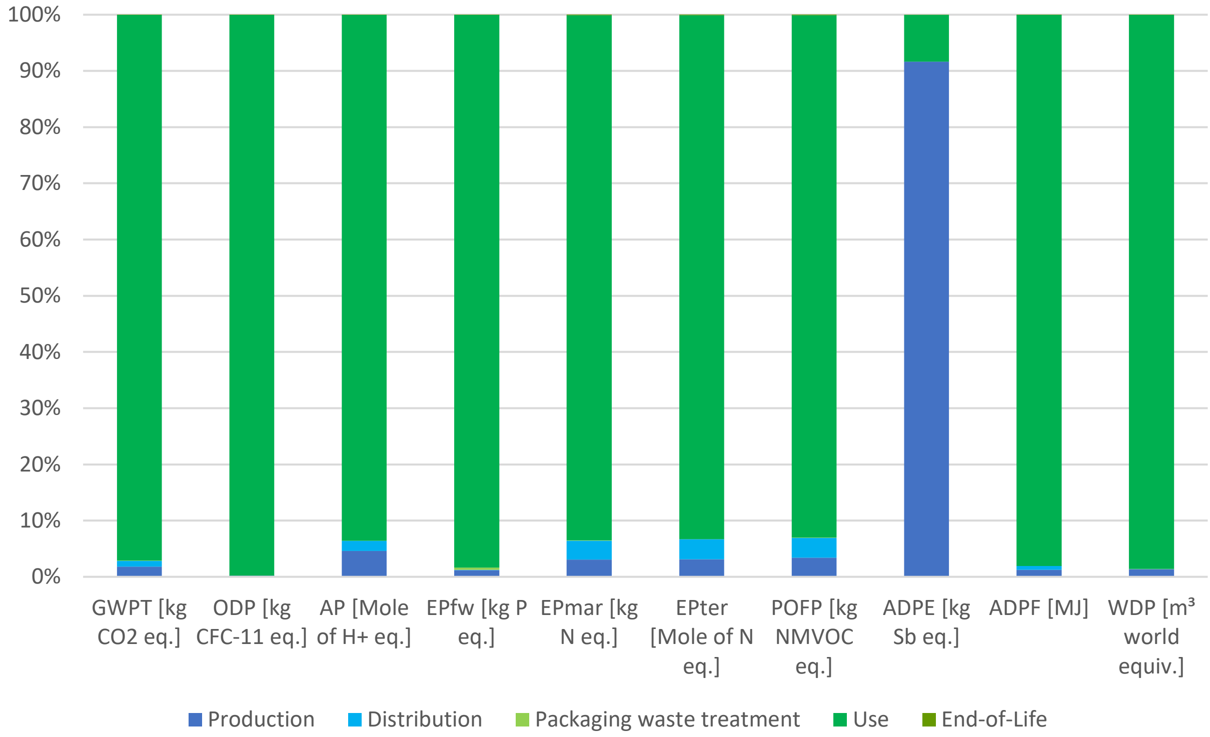

Figure 4: Breakdown of environmental impacts by life cycle stages (see Table 6 for descriptions of environmental impact indicators).

Table 5: Environmental impact indicators results per declared unit

	Production	Distribution	Packaging waste treatment	Use	End-of-Life				(not included in Figure 4)
Life cycle stages based on EN 15804+A2	**A1-A3**	**A4**	**A5**	**B6**	**C1**	**C2**	**C3**	**C4**	**D**
Description / **Environmental Impact Indicators**	Manufacture of the product from 'cradle-to-gate'	Transport of the product to the customer	Installation of the product and disposal of used packaging	Use of the product over its lifetime e.g. 10 years	Deinstallation of the product from the site	Transport of the product to waste treatment	Processing waste for recycling	Disposal of waste that cannot be recycled (through landfill and incineration)	Potential benefits and loads beyond the system boundary due to reuse, recycling, and energy recovery
GWPT [kg CO2 eq.]	1,93E03	1,13E03	6,62E01	1,04E05	0,00E00	2,34E00	1,30E01	1,72E01	-5,87E02
GWPF [kg CO2 eq.]	1,99E03	1,13E03	8,36E00	1,03E05	0,00E00	2,34E00	1,29E01	1,71E01	-5,87E02
GWPB [kg CO2 eq.]	-5,78E01	0,00E00	5,78E01	8,99E02	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00
GWPLULUC [kg CO2 eq.]	2,24E00	4,71E-01	3,66E-03	1,13E01	0,00E00	5,71E-05	1,03E-01	5,73E-03	-3,24E-01
ODP [kg CFC-11 eq.]	4,56E-09	6,50E-11	6,38E-12	1,91E-06	0,00E00	2,76E-16	3,46E-11	9,95E-12	-1,69E-09
AP [Mole of H+ eq.]	1,08E01	4,27E00	1,98E-02	2,20E02	0,00E00	3,24E-03	7,39E-02	3,05E-02	-2,85E00
EPfw [kg P eq.]	4,55E-03	3,56E-04	1,47E-03	3,87E-01	0,00E00	5,12E-07	4,75E-05	8,15E-05	-2,80E-04
EPmar [kg N eq.]	1,72E00	1,92E00	1,66E-02	5,27E01	0,00E00	1,29E-03	3,52E-02	1,18E-02	-3,37E-01
EPter [Mole of N eq.]	1,85E01	2,10E01	7,27E-02	5,51E02	0,00E00	1,42E-02	3,89E-01	1,31E-01	-3,63E00
POFP [kg NMVOC eq.]	5,18E00	5,31E00	4,19E-02	1,41E02	0,00E00	3,07E-03	6,75E-02	2,89E-02	-1,13E00
ADPE [kg Sb eq.]	1,75E-01	1,42E-05	1,11E-07	1,60E-02	0,00E00	8,41E-08	1,02E-06	1,47E-07	-4,17E-02
ADPF [MJ]	2,70E04	1,55E04	5,86E01	2,17E06	0,00E00	3,41E01	1,89E02	6,04E01	-7,18E03
WDP [m^3 world equiv.]	3,16E02	2,13E00	2,43E-01	2,27E04	0,00E00	3,99E-03	5,30E-01	3,08E00	-4,92E01

How to read scientific numbers:

e.g. 2,05E02 = $2,05 \times 10^2 = 205$

2,04E-01 = $2,04 \times 10^{-1} = 0,204$

Table 6: Environmental impact indicator descriptions

Acronym	Unit	Indicator
GWPT	kg CO_2 eq.	Carbon footprint (Global Warming Potential) – total
GWPF	kg CO_2 eq.	Carbon footprint (Global Warming Potential) – fossil
GWPB	kg CO_2 eq.	Carbon footprint (Global Warming Potential) – biogenic
GWPLULUC	kg CO_2 eq.	Carbon footprint (Global Warming Potential) – land use and land use change
ODP	kg CFC-11 eq.	Depletion potential of the stratospheric ozone layer
AP	Mole H+ eq.	Acidification potential
EPfw	kg P eq.	Eutrophication potential – aquatic freshwater
EPmar	kg N eq.	Eutrophication potential – aquatic marine
EPter	Mole of N eq.	Eutrophication potential – terrestrial
POFP	kg NMVOC eq.	Summer smog (photochemical ozone formation potential)
ADPE*	kg Sb eq.	Depletion of abiotic resources – minerals and metals
ADPF*	MJ	Depletion of abiotic resources – fossil fuels
WDP*	m^3 world eq.	Water deprivation potential (deprivation-weighted water consumption)

Results for module A1-A3 are specific to the product. All results from module A4 onwards should be considered as scenarios that represent one possible outcome. The true environmental performance of the product will depend on actual use.

The results in this section are relative expressions only and do not predict actual impacts, the exceeding of thresholds, safety margins, or risks. EPDs from others may not be comparable.

Carbon footprint

The GWPF, cradle-to-grave, of the product is **1,06E05 kg CO2-eq (A1-C4)**, based on the baseline use phase scenario. The GWPF of production of this product, cradle-to-gate, is **1,99E03 kg CO2-eq (A1-A3)**.

Table 7: Resource use results per declared unit

	A1-A3	A4	A5	B6	C1	C2	C3	C4	D
PERE [MJ]	8,66E03	9,64E01	5,21E00	1,30E06	0,00E00	1,12E-01	3,36E01	7,02E00	-1,67E03
PERM [MJ]	4,50E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00
PERT [MJ]	8,67E03	9,64E01	5,21E00	1,30E06	0,00E00	1,12E-01	3,36E01	7,02E00	-1,67E03
PENRE [MJ]	2,67E04	1,55E04	5,88E01	2,17E06	0,00E00	3,41E01	1,90E02	6,05E01	-7,24E03
PENRM [MJ]	3,56E02	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00
PENRT [MJ]	2,71E04	1,55E04	5,88E01	2,17E06	0,00E00	3,41E01	1,90E02	6,05E01	-7,24E03
SM [kg]	1,55E01	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00
RSF [MJ]	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00
NRSF [MJ]	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00
FW [m3]	1,49E01	1,21E-01	7,57E-03	1,04E03	0,00E00	1,81E-04	3,02E-02	7,38E-02	-3,90E00

Table 7: Resource use indicator descriptions

Acronym	Unit	Indicator
PERE	MJ	Use of renewable primary energy excluding renewable primary energy resources used as raw materials
PERM	MJ	Use of renewable primary energy resources used as raw materials
PERT	MJ	Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)
PENRE	MJ	Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials
PENRM	MJ	Use of non-renewable primary energy resources used as raw materials
PENRT	MJ	Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials)
SM	kg	Use of secondary material
RSF	MJ	Use of renewable secondary fuels
NRSF	MJ	Use of non-renewable secondary fuels
FW	m^3	Net use of fresh water

Table 8: Waste categories and output flows results per declared unit

	A1-A3	A4	A5	B6	C1	C2	C3	C4	D
HWD [kg]	8,54E-05	3,08E-08	4,77E-09	-1,69E-04	0,00E00	2,35E-10	-2,48E-09	1,38E-09	-3,56E-05
NHWD [kg]	3,25E02	1,44E00	5,51E01	1,59E03	0,00E00	3,41E-03	5,09E-02	1,21E02	-9,16E01
RWD [kg]	9,45E-01	1,43E-02	6,75E-04	3,44E02	0,00E00	3,65E-05	6,27E-03	8,61E-04	-3,85E-01
CRU [kg]	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00
MFR [kg]	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	9,92E01	0,00E00
MER [kg]	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00
EEE [MJ]	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	2,83E01	0,00E00
EET [MJ]	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	0,00E00	5,32E01	0,00E00

Table 9: Waste category and output flow descriptions

Acronym	Unit	Indicator
HWD	kg	Hazardous waste disposed
NHWD	kg	Non-hazardous waste disposed
RWD	kg	Radioactive waste disposed
CRU	kg	Components for reuse
MFR	kg	Materials for recycling
MER	kg	Materials for energy recovery
EEE	kg	Exported energy (electrical)
EET	kg	Exported energy (thermal)

Table 10: Additional indicators* results per declared unit

	A1-A3	A4	A5	B6	C1	C2	C3	C4	D
PM [Disease incidences]	1,20E-04	1,41E-05	1,94E-07	1,85E-03	0,00E00	4,50E-08	4,83E-07	3,08E-07	-3,47E-05
IRP [kBq U235 eq.]	1,48E02	1,95E00	9,95E-02	5,72E04	0,00E00	5,18E-03	1,04E00	1,21E-01	-8,06E01
ETPfw [CTUe]	1,10E04	1,10E04	6,93E01	6,03E05	0,00E00	2,50E01	1,19E02	4,34E01	-3,16E03
HTPc [CTUh]	1,53E-06	2,01E-07	3,18E-09	3,19E-05	0,00E00	4,60E-10	2,77E-09	3,21E-09	-5,02E-07
HTPnc [CTUh]	3,54E-05	6,43E-06	2,84E-07	5,08E-04	0,00E00	1,50E-08	1,07E-07	2,78E-07	-7,47E-06
SQP [Pt]	3,72E04	3,14E02	5,58E00	8,54E05	0,00E00	8,72E-02	7,83E01	9,06E00	-5,67E02
GWP-GHG [kg CO2 eq.]	1,99E03	1,13E03	8,37E00	1,03E05	0,00E00	2,34E00	1,30E01	1,72E01	-5,87E02

Table 11: Additional indicator descriptions

Acronym	Unit	Indicator
PM	Disease incidence	Potential incidence of disease due to particulate matter emissions
IRP**	kBq U235 eq.	Potential human exposure efficiency relative to U235
ETPfw*	CTUe	Potential Comparative Toxic Unit for ecosystems (fresh water)
HTPc*	CTUh	Potential Comparative Toxic Unit for humans (cancer)
HTPnc*	CTUh	Potential Comparative Toxic Unit for humans (non-cancer)
SQP*	Dimensionless	Potential soil quality index
GWP-GHG	kg CO2 eq.	Carbon footprint – greenhouse gases

**Disclaimer for ADPE, ADPF, WDP, ETPfw, HTPc, HTPnc, SQP:* The results of these environmental impact indicators shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator. ***Disclaimer for ionizing radiation:* This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.

References

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