GAMESA ELECTRIC SAU

ENVIRONMENTAL PRODUCT DECLARATION

PROTEUS PV INVERTERS

(Proteus PV 4100, Proteus PV 4300, Proteus PV 4500, Proteus PV 4700)

Calle del Mar Mediterráneo, 14-16. 28830 San Fernando de Henares, Madrid, Spain

In accordance with ISO 14025 and EN 50693

Program Operator	EPDItaly
Publisher	EPDItaly

Declaration number	GAM-EPD01
Registration number	EPDITALY0837

Issue date	12/11/2024
Valid to	12/11/2029

General information

Programme operator

Programme:	EPD Italy
Address:	Via Gaetano De Castilla, 10 – 21124 Milano, Italy
Website:	www.epditaly.it
E-mail:	info@epditaly.it

EPD owner

Company name	Gamesa Electric SAU
Registered office	Parque Tecnológico de Bizkaia, Edificio 206, 48179 Zamudio, Bizkaia, Spain info@siemensgamesa.com
Contacts for information on the EPD	Cristina Arribas Gozalo (cristina.arribas@siemensgamesa.com) Calle del Mar Mediterráneo, 14-16. 28830 San Fernando de Henares, Madrid, Spain

EPD & Product information

EPD type	Product specific
Product name	Proteus PV Inverter
Product codes included	Proteus PV 4100 Proteus PV 4300 Proteus PV 4500 Proteus PV 4700
Production site	Calle del Mar Mediterráneo, 14-16. 28830 San Fernando de Henares, Madrid, Spain
Intended use	The function of Proteus PV Inverters are to convert the voltage generated in direct current by photovoltaic solar panels into alternating current for the main electricity supply, since direct current cannot be carried the long distances of the electrical supply grid.
Product standards	IEC 62109-1, IEC 62109-2, IEC 61000-6-2/4, IEEE 1547, EN 55011, IEC 62920. EN 50530, IEC 62116, IEC 61683, IEEE 519, IEC 60529, IEC 61727, NTS 631 v1.1 SENP & v2.1 SEPE, UL 1741-SA, CSA C22.2, NEC 2020, CEA 2007, Rule 14, Rule 21, PRC 024 AND UL 62109-1.
CPC Code	4612, "Electrical Transformers, static converters and inductors"
LCA Consultant	Ingurumenaren Kideak Ingenieria (IK Ingenieria) Website: www.ik-ingenieria.com/ Contact: ik@ik-ingenieria.com

Verification information

Product category rules (PCR)	• Core PCR EPDItaly007:20 Electronic and Electrical Products and Systems revision 3, January 2023 • Sub-PCR EPDItaly032: Electronic and Electrical Products and Systems: Power Inverter revision 0, 22/12/2022
EPDItaly regulations	• Regulations of the EPDItaly Programme rev. 6.0, 30/10/2023
LCA project report	This EPD study is based on the LCA study described in the LCA report – Proteus PV Inverters.
Independent verification	Independent third-party verification of the declaration and data, according to ISO 14025:2006: ☒ External ☐ Internal Third-party verification carried out by: ICMQ S.p.A., via Gaetano de Castillia n ° 10 - 20124 Milan, Italy. Accredited by Accredia.
Comparability statement	Environmental statements published within the same product category, but from different programs may not be comparable.
Liability statement	The EPD Owner releases EPDItaly from any non-compliance with environmental legislation. The holder of the declaration will be responsible for the information and supporting evidence. EPDItaly disclaims any responsibility for the information, data and results provided by the EPD Owner for life cycle assessment.

The EPD owner has the sole ownership, liability and responsibility for the EPD.

EPDs within the same product category but registered in different EPD programmes, or not compliant with EN 50693, may not be comparable. For two EPDs to be comparable, they must be based on the same PCR (including the same version number) or be based on fully-aligned PCRs or versions of PCRs; cover products with identical functions, technical performances and use (e.g. identical declared/functional units); have equivalent system boundaries and descriptions of data; apply equivalent data quality requirements, methods of data collection, and allocation methods; apply identical cut-off rules and impact assessment methods (including the same version of characterization factors); have equivalent content declarations; and be valid at the time of comparison. For further information about comparability, see EN 50693 and ISO 14025.

Company information

Owner of the EPD:

Gamesa Electric SAU

Description of the organisation:

Gamesa Electric SAU is a worldwide leader in the design and manufacturing of electrical equipment, with extensive experience in photovoltaics, hydro-electric energy, marine propulsion, wind power and energy storage applications, among others.

From the merge of Gamesa with Siemens Wind to form Siemens Gamesa Renewable Energy in 2017, Gamesa Electric as a subsidiary of this merged company has put its cutting-edge technology and innovation at service of renewable energies and environment, contributing with flexible complete solutions to make clean energy more affordable and reliable. Gamesa Electric´s target is leading the global renewable energy industry driving the transition towards a sustainable world.

For us, our people are our energy. In their continuous work, our team shapes a renewable, clean and reliable energy in our way to a more sustainable word. This philosophy is reflected in our work towards our customers through honesty, professional responsibility and transparency.

As a sign of Gamesa Electric´s commitment to sustainability and social responsibility, Gamesa Electric is dedicated to driving the United Nations´ 2030 agenda and contributing to reaching the UN Sustainable Development Goals (SDGs) targets.

As a first step, our company achieved carbon neutrality in 2019 verified by the Science Based Target Initiative (SBTi). Our aim is to become climate positive by 2040, meaning that by this stage we will be removing more CO2 from the atmosphere than we emit.

Currently, our production centres hold the standards ISO 9001, ISO 14001 and OHSAS 45001 certificates.


Certificate

Standard ISO 9001:2015

Certificate Holder: SIEMENS GAMESA RENEWABLE ENERGY, S.A.
Parque Tec. de Zamudio Edif. 222
48170 Zamudio
Spain
including the branch offices according to annex

Scope: Sales, design, development, procurement and manufacturing of wind turbines and other mechanical and electrical components for wind and non-wind applications. Project development & execution, construction, installation and service of wind turbines.

Proof has been furnished by means of an audit that the requirements of ISO 9001:2015 are met.

Validity: The certificate is valid from 2021-07-14 until 2024-07-13.
First certification 2012

2021-07-02


Certificate

Standard ISO 14001:2015

Certificate Holder: SIEMENS GAMESA RENEWABLE ENERGY, S.A.
Parque Tec. de Zamudio Edif. 222
48170 Zamudio
Spain
including the branch offices according to annex

Scope: Sales, design, development, procurement and manufacturing of wind turbines and other mechanical and electrical components for wind and non-wind applications. Project development & execution, construction, installation and service of wind turbines.

Proof has been furnished by means of an audit that the requirements of ISO 14001:2015 are met.

Validity: The certificate is valid from 2021-07-14 until 2024-07-13.
First certification 2002

2021-07-02


Certificate

Standard ISO 45001:2018

Certificate Holder: SIEMENS GAMESA RENEWABLE ENERGY, S.A.
Parque Tec. de Zamudio Edif. 222
48170 Zamudio
Spain
including the branch offices according to annex

Scope: Sales, design, development, procurement and manufacturing of wind turbines and other mechanical and electrical components for wind and non-wind applications. Project development & execution, construction, installation and service of wind turbines.

Proof has been furnished by means of an audit that the requirements of ISO 45001:2018 are met.

Validity: The certificate is valid from 2021-07-16 until 2024-07-15.
First certification BS OSHAS 18001:2007 from 2013

2021-07-03

Name and location of production site(s):

Gamesa Electric Madrid

Calle del Mar Mediterráneo, 14-16. 28830 San Fernando de Henares, Madrid, Spain.

Contact:

Cristina Arribas Gozalo. Email: cristina.arribas@siemensgamesa.com

More information on www.gamesaelectric.com.

Product information

Product name:

Proteus PV Inverters (Proteus PV 4100, Proteus PV 4300, Proteus PV 4500, Proteus PV 4700)

Product description:

This Environmental Product Declaration covers the life cycle analysis carried out on a Proteus PV Inverter manufactured by Gamesa Electric. The power output for these inverters can range from 4,100 kW to 4,700 kW, and, consequently, the environmental impacts have been calculated for each possible configuration.

The characteristics of the Proteus PV Inverters are shown below:

Type of inverter:	Central inverter
Nominal PV input voltage:	835 – 1,500 V
Nominal AC voltage:	600 – 690 V
Max AC output current:	3,940 Arms [40ºC/104ºF]
Topology:	Triphase
Power use consumption:	4,100 – 4,700 kW
Standby power use consumption:	< 200 W
Dimensions:	4,325 x 2,250 x 1,022 mm
Energy efficiency:	99.14%
Country of geographic cluster in which the product is to be installed and operated:	Global

UN CPC code: 4612 "Electrical Transformers, static converters and inductors".

Life Cycle Assessment information

Functional unit: The functional unit of the study is **a single power inverter transformerless converting the variable DC voltage generated by a photovoltaic solar panel into a commercial frequency alternating current (AC), during a reference service life of 25 years.**

The reference flows for all the products are 4,551.26 kg.

Reference service life: A lifetime of 25 years has been considered for these products, as stated by the sub-PCR.

Geographical scope: The geographical scope of this EPD is **Global**.

Time representativeness: The data collection from factory (primary data) and electricity mix are from 01/01/2022 to 31/12/2022. In this study, no dataset older than 10 years was used.

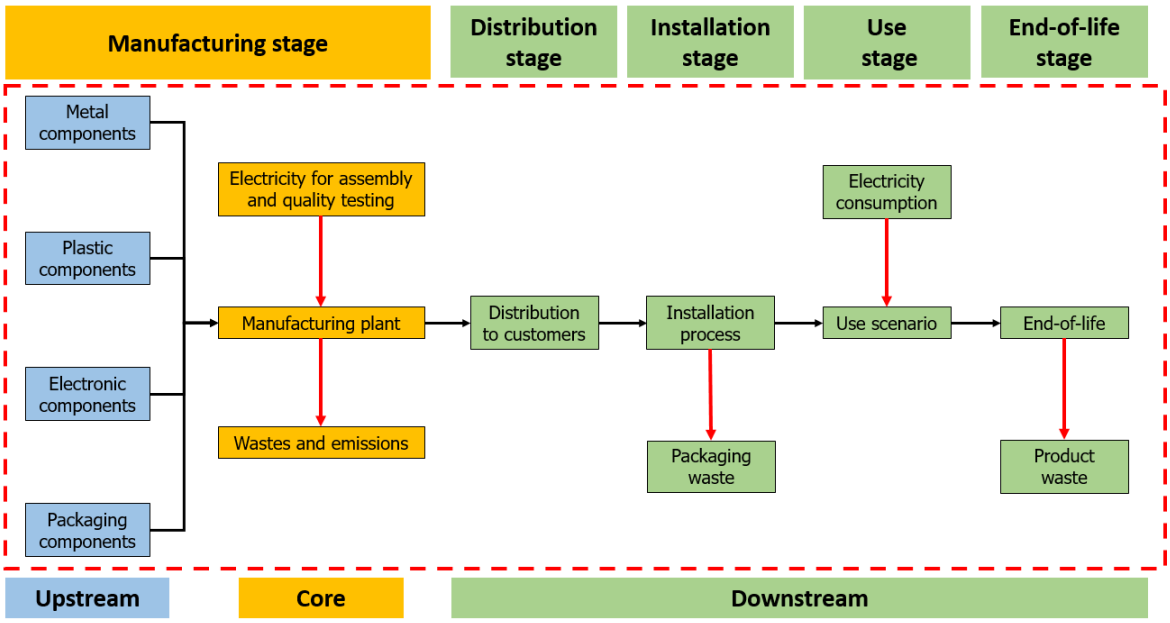
Database(s) and LCA software: All data used for the Life Cycle Inventory and to model the process is specific and have been obtained from Gamesa Electric´s internal system and measurements carried out during 2022 year.

Ecoinvent database 3.9 version has been used due to the characteristics of the study and the analysed product as this database contains the most extensive and updated information and its scope coincides with the geographical, technological and temporal area of the project. The Life Cycle Assessment was modelled with Simapro software version 9.5.0.1.

System boundaries: The life cycle analysis is from cradle to grave, including upstream, core and downstream modules.

Modules	**Upstream**	**Core**	**Downstream**				**Benefits and loads beyond the system**
Stages	**Manufacturing**		**Distribution**	**Installation**	**Use & Maintenance**	**End-of-life**	
Processes	Extraction of raw materials and processing of semi-finished products. Transport of raw materials to production unit.	Product assembly and testing; Transport and treatment of manufacturing waste.	Transport of the product to the installation place; Transport and treatment of packaging components; Electricity consumption of the products during its service lifetime; Transport and treatment of the product at its end-of-life.				Reuse-recovery-recycling potential
Declared modules	X	X	X	X	X	X	Not included
Geography	ES	ES	GLO	GLO	GLO	GLO	-

System diagram:



Data quality: The environmental impact of the inverters has been calculated. This study is based on the international standards established for the development of environmental product declarations: ISO 14025 for the preparation of the environmental product declaration, ISO 14040 and ISO 14044 for the development of the life cycle analysis, and standard EN 50693 and the product category rules of EPDItaly programme (Core-PCR EPDItaly007 and Sub-PCR EPDItaly032) for the definition of the study rules.

Data has been collected for 2022 year and is representative of that year. Data for raw material supply, transport from suppliers to fabrication plant and production is based on specific data for Gamesa Electric´s plant in Madrid. Generic background datasets and representative scenarios were used for downstream processes.

Assumptions:

The modularity principle, as well as the polluter-payer principle have been followed for the development of the study. The following assumptions have been followed:

- The impacts related to the production, transportation and installation of capital goods (buildings, infrastructure, machinery and internal transport packing); the general operations (staff travel, marketing and communication actions); and the infrastructure for general management (office, laboratory and headquarters operations) have been excluded from the system boundaries.
- An allocation of the electricity consumption required by Gamesa electric to manufacture and test Proteus PV Inverters has been made based on the consumption of the business sector of the manufacturing plant and the total electricity consumed by the company in 2022.
- The processes associated with the production of fuels and emissions are intrinsically included in the indicators of the Ecoinvent 3.9 database.
- The environmental impact of external transport has been calculated using trucks from the Ecoinvent 3.9 database. Those trucks have been chosen to reflect the most realistic scenario possible.

Cut-off rules:

The ISO 14025 standard and the Core-PCR EPDItaly007 Electronic and electrical products systems indicate that the life cycle inventory data must include a minimum of 95% of the total inputs (material and energy). In this study, this criterion has been fulfilled.

Allocation:

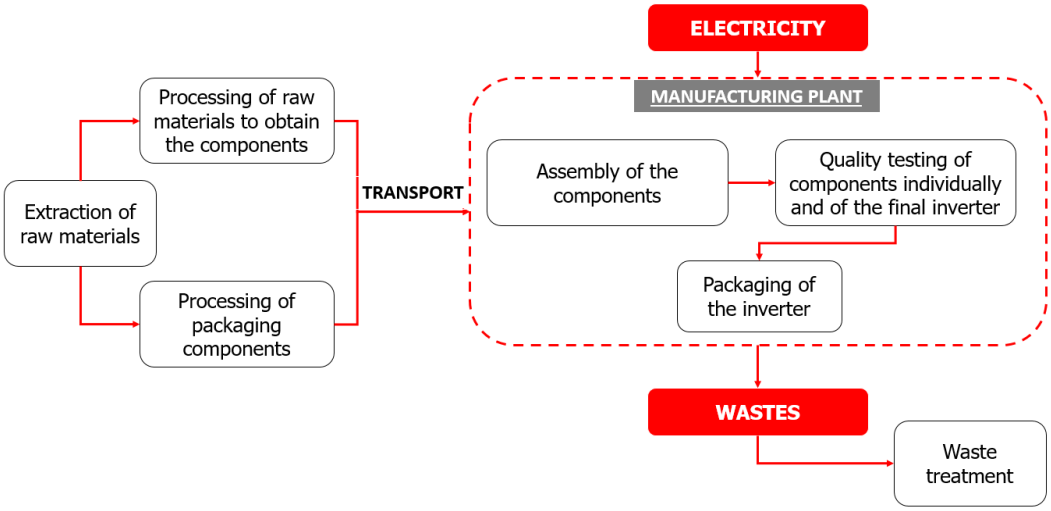
It has not been necessary to make any load allocation between products and co-products. The electricity consumption required for manufacturing and quality testing the analysed products have been allocated for each inverter produced.

Life Cycle Assessment scenarios and additional information

Manufacturing stage

This stage includes the production, industrial transformation, manufacturing processes and transportation of raw materials and components making up the Proteus inverters. All the components making up Proteus PV Inverters are received from suppliers ready-to-be-used practically without packaging. After testing their correct condition and status, they are conveniently stored to be used at the right time.

Initially, several components are pre-assembled and the electronics within the inverters are integrated and interconnected. Then, a connection and power tests are applied to the inverters. Finally, the equipment is closed, cleaned and packed for shipping to customers.



Distribution stage

Proteus PV inverters, once packaged, are distributed directly from the manufacturing plant to the end customers located throughout the world.

Installation stage

This module includes impacts arising from the installation of the power inverter in the operational site. The installation process of Proteus PV Inverters doesn't require any additional material and only the end-of-life of packaging are included in this stage, as well as their transportation to the waste manager.

The EoL scenario of the packaging materials has been obtained from different resources depending on the place of installation: Eurostat data about the treatment method of packaging for European customers, United States Environmental Protection Agency data about Advancing Sustainable Materials Management for US customers and default EoL values of standard EN 50693 for the rest of the customers.

Use & Maintenance stage

The impacts related to the energy used by the power inverter to operate during its entire reference service life are considered. Use stage considers only the electricity dissipated by the power inverter to keep converting electricity from DC to AC frequency.

The calculation of the electricity consumption of the inverters during the product´s service life has been carried out with the formula from the sub-PCR EPDItaly – Power Inverters:

$$E_{Use}\ [kWh] = Output\ rated\ AC\ Active\ power * Average\ local\ annual\ sunshine * (1 - average\ energy\ effiiency) * RSL$$

Output rated AC active power of the inverter	Electricity consumption during the service lifetime (kWh)
4,100 kW	2,717,263.58
4,300 kW	2,704,414.40
4,500 kW	2,708,472.04
4,700 kW	2,733,494.13

Ordinary maintenance is not contemplated due to the high reliability of these power inverters. For this reason, maintenance interventions are exclusively related to extraordinary maintenance. In the case of Proteus inverters, no extraordinary maintenance operations have been considered as these products don't require substitution of components during the 25 years of lifetime considered by the sub-PCR.

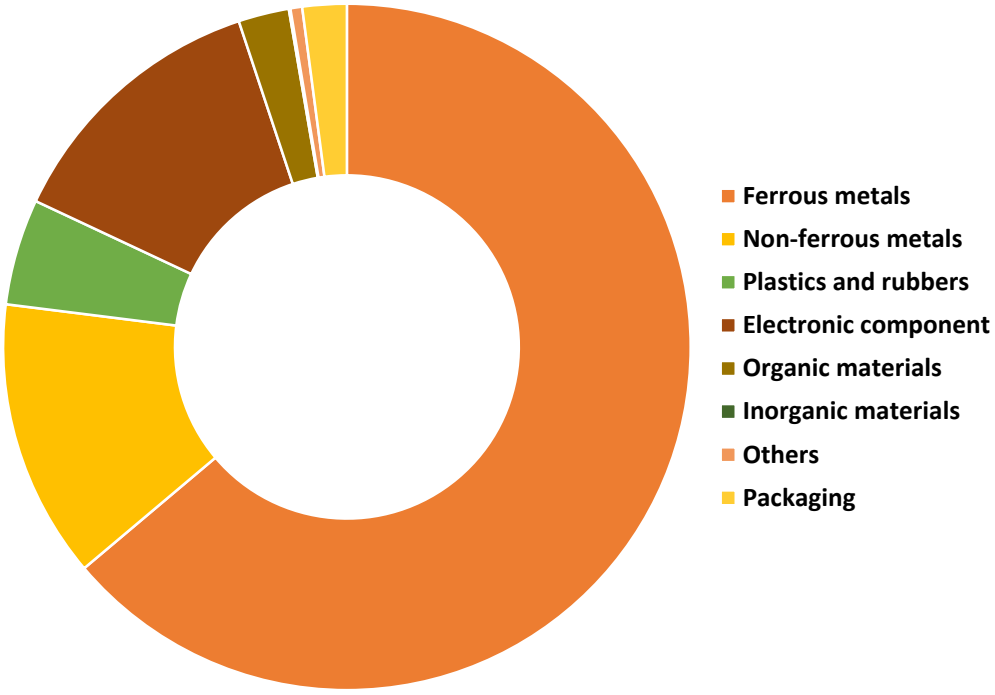
End-of-life stage

As Proteus inverters are innovative products placed on the market for few years, no information about their EoL has been obtained. For this reason, the EoL parameters collected by Table G.4 of the standard EN 50693 have been used in order to estimate the treatment provided to each type of material of the Proteus PV inverters. In addition, this stage also includes the transportation process to the waste manager (considered by lorry along 1,000 km) and disassembly operations.

Content declaration

The four configurations of Proteus PV Inverters have the same components (consequently, the same content declaration) and they are programmed in order to supply the required power output according to the customers´ needs.

Type of material	Weight (kg)	Percentage (%)
Ferrous metals	2,905.68	63.84%
Non-ferrous metals	598.24	13.14%
Electronic component	588.18	12.92%
Plastics and rubbers	227.47	5.00%
Organic materials	108.50	2.38%
Inorganic materials	3.44	0.08%
Others	25.09	0.55%
Packaging	94.66	2.08%
Total weight of the product	**4,456.60**	**97.92%**
Total packaging of the product	**94.66**	**2.08%**
Total weight of one product with packaging material	**4,551.26**	**100.00%**



The product is transported to the customer in pallets and packed with protective plastic films and foams, and cardboard corners.

Environmental impacts

The environmental impacts are shown below depending on the output power of the equipment (i.e. 4,100, 4,300, 4,500 and 4,700 kW):

- **For Proteus PV Inverter with an output power of 4,100 kW:**

Potential environmental impacts – Environmental impact descriptive parameters:

Category	Unit	TOTAl	Manufacturing stage	Distribution stage	Installation stage	Use & Maintenance stage	End-of-life stage
GWP – Total	Kg CO_2 eq.	1.26E+06	3.19E+04	8.58E+02	5.79E+01	1.23E+06	1.66E+03
GWP – Biogenic	Kg CO_2 eq.	1.24E+06	3.18E+04	8.57E+02	2.34E+01	1.21E+06	1.67E+03
GWP – Luluc	Kg CO_2 eq.	1.54E+04	1.43E+00	2.22E-01	3.45E+01	1.53E+04	-7.92E+00
GWP – Fossil	Kg CO_2 eq.	4.17E+03	8.83E+01	5.13E-01	9.75E-03	4.08E+03	1.19E+00
ODP	Kg CFC-11 eq.	9.40E-03	1.11E-03	1.49E-05	3.29E-07	8.21E-03	6.01E-05
AP	mol H^+ eq.	5.52E+03	4.21E+02	1.22E+01	7.08E-02	5.08E+03	3.51E+00
EP – Freshwater	Kg P eq.	8.72E+01	4.04E+00	5.79E-03	1.80E-04	8.32E+01	2.50E-02
EP – Marine aquatic	Kg N eq.	6.88E+02	4.47E+01	3.19E+00	3.79E-02	6.39E+02	9.63E-01
EP - Terrestrial	mol N eq.	8.02E+03	5.70E+02	3.51E+01	2.52E-01	7.40E+03	1.11E+01
POCP	Kg NMVOC eq.	3.02E+03	1.83E+02	1.04E+01	1.01E-01	2.83E+03	4.00E+00
ADP – Minerals & metals	Kg Sb eq.	2.04E+01	9.41E+00	1.71E-03	5.99E-05	1.09E+01	3.10E-03
ADP - Fossil	MJ	2.25E+07	4.23E+05	1.17E+04	2.67E+02	2.21E+07	1.18E+04
WDP	m^3 eq.	3.32E+05	1.02E+04	4.61E+01	1.63E+00	3.22E+05	1.61E+02
Acronyms	GWP-fossil = Global Warming Potential fossil fuels; GWP-biogenic = Global Warming Potential biogenic; GWP-luluc = Global Warming Potential land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment; EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment; EP-terrestrial = Eutrophication potential, Accumulated Exceedance; POCP = Formation potential of tropospheric ozone; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion for fossil resources potential; WDP = Water (user) deprivation potential, deprivation-weighted water consumption						

Potential environmental impacts – Parameters describing resource use:

Category	Unit	TOTAl	Manufacturing stage	Distribution stage	Installation stage	Use & Maintenance stage	End-of-life stage
PERE	MJ	3.63E+06	4.63E+04	1.32E+02	3.85E+00	3.58E+06	6.24E+02
PERM	MJ	1.44E+03	1.44E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	3.63E+06	4.78E+04	1.32E+02	3.85E+00	3.58E+06	6.24E+02
PENRE	MJ	2.25E+07	4.15E+05	1.17E+04	2.67E+02	2.21E+07	1.18E+04
PENRM	MJ.	8.10E+03	8.10E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	2.25E+07	4.23E+05	1.17E+04	2.67E+02	2.21E+07	1.18E+04
SM	kg	0.00E+00	0.00E+00	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	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	9.80E+03	3.13E+02	1.51E+00	5.38E-02	9.48E+03	4.55E+00
Acronyms	PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy re-sources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water						

Potential environmental impacts – Waste production parameters:

Category	Unit	TOTAl	Manufacturing stage	Distribution stage	Installation stage	Use & Maintenance stage	End-of-life stage
Hazardous landfill waste	Kg	3.84E+02	1.24E+01	6.75E-02	1.70E-03	4.86E+01	3.23E+02
Non-hazardous waste disposed	Kg	9.27E+04	8.00E+03	6.59E+02	4.52E+01	8.25E+04	1.58E+03
Radioactive waste disposed	Kg	1.10E+02	9.75E-01	2.44E-03	6.60E-05	1.09E+02	5.54E-03
Components for reuse	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for energy recovery	Kg	2.88E+03	5.75E+01	0.00E+00	4.94E+01	0.00E+00	2.78E+03
Materials for recycling	Kg	8.53E+02	0.00E+00	0.00E+00	1.29E+01	0.00E+00	8.41E+02
Exported energy, electricity	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy, thermal	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

- **For Proteus PV Inverter with an output power of 4,300 kW:**

Potential environmental impacts – Environmental impact descriptive parameters:

Category	Unit	TOTAl	Manufacturing stage	Distribution stage	Installation stage	Use & Maintenance stage	End-of-life stage
GWP – Total	Kg CO_2 eq.	1.26E+06	3.19E+04	8.58E+02	5.79E+01	1.22E+06	1.66E+03
GWP – Biogenic	Kg CO_2 eq.	1.24E+06	3.18E+04	8.57E+02	2.34E+01	1.20E+06	1.67E+03
GWP – Luluc	Kg CO_2 eq.	1.53E+04	1.43E+00	2.22E-01	3.45E+01	1.53E+04	-7.92E+00
GWP – Fossil	Kg CO_2 eq.	4.15E+03	8.83E+01	5.13E-01	9.75E-03	4.06E+03	1.19E+00
ODP	Kg CFC-11 eq.	9.36E-03	1.11E-03	1.49E-05	3.29E-07	8.17E-03	6.01E-05
AP	mol H^+ eq.	5.49E+03	4.21E+02	1.22E+01	7.08E-02	5.06E+03	3.51E+00
EP – Freshwater	Kg P eq.	8.68E+01	4.04E+00	5.79E-03	1.80E-04	8.28E+01	2.50E-02
EP – Marine aquatic	Kg N eq.	6.85E+02	4.47E+01	3.19E+00	3.79E-02	6.36E+02	9.63E-01
EP - Terrestrial	mol N eq.	7.98E+03	5.70E+02	3.51E+01	2.52E-01	7.37E+03	1.11E+01
POCP	Kg NMVOC eq.	3.01E+03	1.83E+02	1.04E+01	1.01E-01	2.81E+03	4.00E+00
ADP – Minerals & metals	Kg Sb eq.	2.03E+01	9.41E+00	1.71E-03	5.99E-05	1.09E+01	3.10E-03
ADP - Fossil	MJ	2.24E+07	4.23E+05	1.17E+04	2.67E+02	2.20E+07	1.18E+04
WDP	m^3 eq.	3.31E+05	1.02E+04	4.61E+01	1.63E+00	3.20E+05	1.61E+02
Acronyms	GWP-fossil = Global Warming Potential fossil fuels; GWP-biogenic = Global Warming Potential biogenic; GWP-luluc = Global Warming Potential land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment; EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment; EP-terrestrial = Eutrophication potential, Accumulated Exceedance; POCP = Formation potential of tropospheric ozone; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion for fossil resources potential; WDP = Water (user) deprivation potential, deprivation-weighted water consumption						

Potential environmental impacts – Parameters describing resource use:

Category	Unit	TOTAl	Manufacturing stage	Distribution stage	Installation stage	Use & Maintenance stage	End-of-life stage
PERE	MJ	3.61E+06	4.63E+04	1.32E+02	3.85E+00	3.57E+06	6.24E+02
PERM	MJ	1.44E+03	1.44E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	3.61E+06	4.78E+04	1.32E+02	3.85E+00	3.57E+06	6.24E+02
PENRE	MJ	2.24E+07	4.15E+05	1.17E+04	2.67E+02	2.20E+07	1.18E+04
PENRM	MJ.	8.10E+03	8.10E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	2.24E+07	4.23E+05	1.17E+04	2.67E+02	2.20E+07	1.18E+04
SM	kg	0.00E+00	0.00E+00	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	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	9.75E+03	3.13E+02	1.51E+00	5.38E-02	9.43E+03	4.55E+00

Potential environmental impacts – Waste production parameters:

Category	Unit	TOTAl	Manufacturing stage	Distribution stage	Installation stage	Use & Maintenance stage	End-of-life stage
Hazardous landfill waste	Kg	3.84E+02	1.24E+01	6.75E-02	1.70E-03	4.84E+01	3.23E+02
Non-hazardous waste disposed	Kg	9.23E+04	8.00E+03	6.59E+02	4.52E+01	8.21E+04	1.58E+03
Radioactive waste disposed	Kg	1.10E+02	9.75E-01	2.44E-03	6.60E-05	1.09E+02	5.54E-03
Components for reuse	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for energy recovery	Kg	2.88E+03	5.75E+01	0.00E+00	4.94E+01	0.00E+00	2.78E+03
Materials for recycling	Kg	8.53E+02	0.00E+00	0.00E+00	1.29E+01	0.00E+00	8.41E+02
Exported energy, electricity	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy, thermal	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

- **For Proteus PV Inverter with an output power of 4,500 kW:**

Potential environmental impacts – Environmental impact descriptive parameters:

Category	Unit	TOTAl	Manufacturing stage	Distribution stage	Installation stage	Use & Maintenance stage	End-of-life stage
GWP – Total	Kg CO_2 eq.	1.26E+06	3.19E+04	8.58E+02	5.79E+01	1.22E+06	1.66E+03
GWP – Biogenic	Kg CO_2 eq.	1.24E+06	3.18E+04	8.57E+02	2.34E+01	1.20E+06	1.67E+03
GWP – Luluc	Kg CO_2 eq.	1.53E+04	1.43E+00	2.22E-01	3.45E+01	1.53E+04	-7.92E+00
GWP – Fossil	Kg CO_2 eq.	4.16E+03	8.83E+01	5.13E-01	9.75E-03	4.07E+03	1.19E+00
ODP	Kg CFC-11 eq.	9.37E-03	1.11E-03	1.49E-05	3.29E-07	8.19E-03	6.01E-05
AP	mol H^+ eq.	5.50E+03	4.21E+02	1.22E+01	7.08E-02	5.06E+03	3.51E+00
EP – Freshwater	Kg P eq.	8.70E+01	4.04E+00	5.79E-03	1.80E-04	8.29E+01	2.50E-02
EP – Marine aquatic	Kg N eq.	6.86E+02	4.47E+01	3.19E+00	3.79E-02	6.37E+02	9.63E-01
EP - Terrestrial	mol N eq.	8.00E+03	5.70E+02	3.51E+01	2.52E-01	7.38E+03	1.11E+01
POCP	Kg NMVOC eq.	3.02E+03	1.83E+02	1.04E+01	1.01E-01	2.82E+03	4.00E+00
ADP – Minerals & metals	Kg Sb eq.	2.03E+01	9.41E+00	1.71E-03	5.99E-05	1.09E+01	3.10E-03
ADP - Fossil	MJ	2.24E+07	4.23E+05	1.17E+04	2.67E+02	2.20E+07	1.18E+04
WDP	m^3 eq.	3.31E+05	1.02E+04	4.61E+01	1.63E+00	3.21E+05	1.61E+02

Acronyms	GWP-fossil = Global Warming Potential fossil fuels; GWP-biogenic = Global Warming Potential biogenic; GWP-luluc = Global Warming Potential land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment; EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment; EP-terrestrial = Eutrophication potential, Accumulated Exceedance; POCP = Formation potential of tropospheric ozone; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion for fossil resources potential; WDP = Water (user) deprivation potential, deprivation-weighted water consumption

Potential environmental impacts – Parameters describing resource use:

Category	Unit	TOTAl	Manufacturing stage	Distribution stage	Installation stage	Use & Maintenance stage	End-of-life stage
PERE	MJ	3.62E+06	4.63E+04	1.32E+02	3.85E+00	3.57E+06	6.24E+02
PERM	MJ	1.44E+03	1.44E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	3.62E+06	4.78E+04	1.32E+02	3.85E+00	3.57E+06	6.24E+02
PENRE	MJ	2.24E+07	4.15E+05	1.17E+04	2.67E+02	2.20E+07	1.18E+04
PENRM	MJ.	8.10E+03	8.10E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	2.24E+07	4.23E+05	1.17E+04	2.67E+02	2.20E+07	1.18E+04
SM	kg	0.00E+00	0.00E+00	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	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	9.77E+03	3.13E+02	1.51E+00	5.38E-02	9.45E+03	4.55E+00

Potential environmental impacts – Waste production parameters:

Category	Unit	TOTAl	Manufacturing stage	Distribution stage	Installation stage	Use & Maintenance stage	End-of-life stage
Hazardous landfill waste	Kg	3.84E+02	1.24E+01	6.75E-02	1.70E-03	4.85E+01	3.23E+02
Non-hazardous waste disposed	Kg	9.25E+04	8.00E+03	6.59E+02	4.52E+01	8.22E+04	1.58E+03
Radioactive waste disposed	Kg	1.10E+02	9.75E-01	2.44E-03	6.60E-05	1.09E+02	5.54E-03
Components for reuse	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for energy recovery	Kg	2.88E+03	5.75E+01	0.00E+00	4.94E+01	0.00E+00	2.78E+03
Materials for recycling	Kg	8.53E+02	0.00E+00	0.00E+00	1.29E+01	0.00E+00	8.41E+02
Exported energy, electricity	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy, thermal	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

- **For Proteus PV Inverter with an output power of 4,700 kW:**

Potential environmental impacts – Environmental impact descriptive parameters:

Category	Unit	TOTAl	Manufacturing stage	Distribution stage	Installation stage	Use & Maintenance stage	End-of-life stage
GWP – Total	Kg CO_2 eq.	1.27E+06	3.19E+04	8.58E+02	5.79E+01	1.24E+06	1.66E+03
GWP – Biogenic	Kg CO_2 eq.	1.25E+06	3.18E+04	8.57E+02	2.34E+01	1.22E+06	1.67E+03
GWP – Luluc	Kg CO_2 eq.	1.55E+04	1.43E+00	2.22E-01	3.45E+01	1.54E+04	-7.92E+00
GWP – Fossil	Kg CO_2 eq.	4.19E+03	8.83E+01	5.13E-01	9.75E-03	4.10E+03	1.19E+00
ODP	Kg CFC-11 eq.	9.45E-03	1.11E-03	1.49E-05	3.29E-07	8.26E-03	6.01E-05
AP	mol H^+ eq.	5.55E+03	4.21E+02	1.22E+01	7.08E-02	5.11E+03	3.51E+00
EP – Freshwater	Kg P eq.	8.77E+01	4.04E+00	5.79E-03	1.80E-04	8.37E+01	2.50E-02
EP – Marine aquatic	Kg N eq.	6.92E+02	4.47E+01	3.19E+00	3.79E-02	6.43E+02	9.63E-01
EP - Terrestrial	mol N eq.	8.06E+03	5.70E+02	3.51E+01	2.52E-01	7.45E+03	1.11E+01
POCP	Kg NMVOC eq.	3.04E+03	1.83E+02	1.04E+01	1.01E-01	2.84E+03	4.00E+00
ADP – Minerals & metals	Kg Sb eq.	2.04E+01	9.41E+00	1.71E-03	5.99E-05	1.10E+01	3.10E-03
ADP - Fossil	MJ	2.26E+07	4.23E+05	1.17E+04	2.67E+02	2.22E+07	1.18E+04
WDP	m^3 eq.	3.34E+05	1.02E+04	4.61E+01	1.63E+00	3.24E+05	1.61E+02
Acronyms	GWP-fossil = Global Warming Potential fossil fuels; GWP-biogenic = Global Warming Potential biogenic; GWP-luluc = Global Warming Potential land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment; EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment; EP-terrestrial = Eutrophication potential, Accumulated Exceedance; POCP = Formation potential of tropospheric ozone; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion for fossil resources potential; WDP = Water (user) deprivation potential, deprivation-weighted water consumption						

Potential environmental impacts – Parameters describing resource use:

Category	Unit	TOTAl	Manufacturing stage	Distribution stage	Installation stage	Use & Maintenance stage	End-of-life stage
PERE	MJ	3.65E+06	4.63E+04	1.32E+02	3.85E+00	3.60E+06	6.24E+02
PERM	MJ	1.44E+03	1.44E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	3.65E+06	4.78E+04	1.32E+02	3.85E+00	3.60E+06	6.24E+02
PENRE	MJ	2.26E+07	4.15E+05	1.17E+04	2.67E+02	2.22E+07	1.18E+04
PENRM	MJ.	8.10E+03	8.10E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	2.26E+07	4.23E+05	1.17E+04	2.67E+02	2.22E+07	1.18E+04
SM	kg	0.00E+00	0.00E+00	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	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	9.85E+03	3.13E+02	1.51E+00	5.38E-02	9.54E+03	4.55E+00

Potential environmental impacts – Waste production parameters:

Category	Unit	TOTAl	Manufacturing stage	Distribution stage	Installation stage	Use & Maintenance stage	End-of-life stage
Hazardous landfill waste	Kg	3.84E+02	1.24E+01	6.75E-02	1.70E-03	4.89E+01	3.23E+02
Non-hazardous waste disposed	Kg	9.32E+04	8.00E+03	6.59E+02	4.52E+01	8.29E+04	1.58E+03
Radioactive waste disposed	Kg	1.11E+02	9.75E-01	2.44E-03	6.60E-05	1.10E+02	5.54E-03
Components for reuse	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for energy recovery	Kg	2.88E+03	5.75E+01	0.00E+00	4.94E+01	0.00E+00	2.78E+03
Materials for recycling	Kg	8.53E+02	0.00E+00	0.00E+00	1.29E+01	0.00E+00	8.41E+02
Exported energy, electricity	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy, thermal	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

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Life Cycle Assessment Report- Proteus PV Inverters