epd-norway
Global Program Operator

Environmental Product Declaration

In accordance with 14025 and EN15804 +A2

FUxxxM Silk® Nova / FUxxxMV Silk® Nova

Owner of the declaration:
FuturaSun srl

Product name:
FUxxxM Silk® Nova / FUxxxMV Silk® Nova

Declared unit:
1m^2 of manufactured photovoltaic module

Product category /PCR:
NPCR 029:2022 Part B for photovoltaic modules 1.2

Program holder and publisher:
The Norwegian EPD foundation

Declaration number:
NEPD-6641-5880-EN

Registration number:
NEPD-6641-5880-EN

Issue date: 21.05.2024

Valid to: 21.05.2029

ver-280524

The Norwegian
EPD Foundation

General information

Product:
Mono-crystalline Single glass, N-Type, solar photovoltaic modules

Program operator:
The Norwegian EPD Foundation
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Declaration number:
NEPD-6641-5880-EN

This declaration is based on Product Category Rules:
NPCR 029:2022 Part B for photovoltaic modules 1.2

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 evidence. EPD of construction products may not be comparable if they do not comply with EN 15804. This is a specific EPD, not average.

Declared unit:
1m^2 of manufactured photovoltaic module

Functional unit:
1 Wp of manufactured photovoltaic module, from cradle-to-grave and module D, with activities needed for a study period for a defined reference service life (≥80% of the labelled power output)

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

internal ☐ external ☒

Independent verifier approved by EPD Norway

Owner of the declaration:
FuturaSun srl
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Manufacturer:
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Place of production:
China

Management system:
ISO 14001, ISO 9001, IEC 61216 and 61730, ISO 45001

Organisation no:
IT04635940283

Issue date:
21.05.2024

Valid to:
21.05.2029

Year of study:
2024

Comparability:
EPDs from other programs than The Norwegian EPD Foundation may not be comparable.

The EPD has been worked out by:
Juliette Leroy
Kapstan

Approved

Manager of EPD Norway

Product

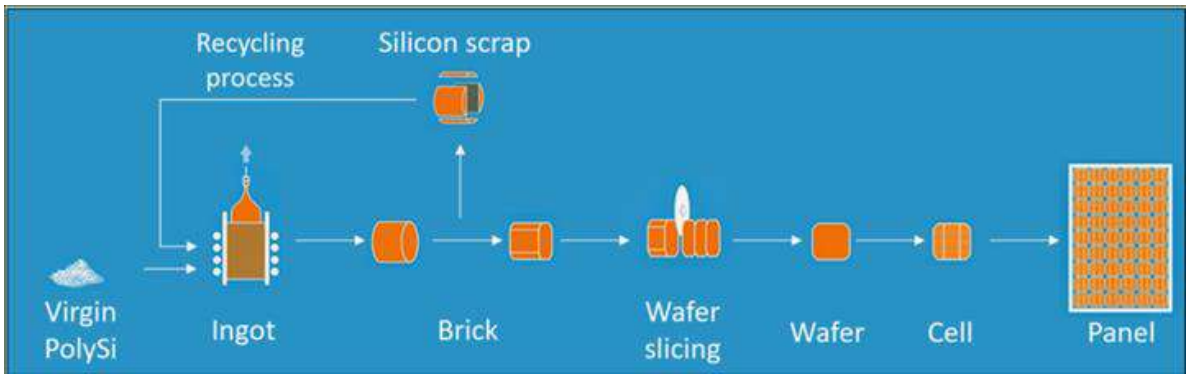
Product description:

580 Wp mono-crystalline solar photovoltaic module, designed to be installed on roofs or as stand-alone systems for local power production. Solar cells are assembled together with the backsheet, EVA, glass, frame and electrical connections to produce the finished solar module in the production factory in China.

This EPD represents multiples modules with small variations over the size, the number of cells, power… (see table of module characteristics in "Technical data"). The results are calculated based on the maximum inventory amongst the modules. The variation between each module results is lower than 10 %.

Production process:

The solar module production from silicon is explained in the figure below:



Step 1 - **PolySi**: The raw material used to produce the cells is a high purity silicon called "Solar grade silicon" or "PolySi".

Step 2 - **Ingot**: The PolySi is transformed into a monocrystalline ingot by heating up the silicon with a process called "Czochralski process".

Step 3 - **Wafer**: the ingot is then cut into bricks and sliced into wafers by diamond wire slicing.

Step 4 - **Solar cell**: the wafer is transformed into a cell through chemical treatments and screen-printing wiring.

Step 5 - **Solar module**: the cells are combined, 144 half-cut cells per FUxxxMV Silk® Nova module. The different components of the panel are given below. Standard panels are made with a 3.2mm glass front and a plastic backsheet.

Product specification:

Sold as individual panels, with an effective surface area of 2.58m^2 and a weight of 28.20 kg. The packaging consists of LDPE, HDPE and a cardboard box, and the panels are delivered on a wooden pallet.

Materials	KG/DU	%
Cells	**2.9E-01**	3%
Glass	**7,9E+00**	73%
EVA	**1,1E+00**	10%
Aluminium frame	**1,1E+00**	8%
Junction box	**1.1E-01**	1%
String connector	**2,5E-02**	0%
Cell connector	**8,1E-02**	1%
Silicone	**1.5-01**	1%
Soldering flux	**9,2E-03**	0%
Packaging	**KG/DU**	**%**
Wooden pallet	**4,4E-01**	4%
Cardboard	**1.6E-01**	1%
Low density PE	**8,1E-03**	0%
PP	**2,7E-03**	0%
Paper	**7,1E-05**	0%
Packaging from raw materials	**5,9E-01**	5%

Technical data:

The modules are tested according to the following norms: IEC 61215 and IEC 61730.

This EPD is valid for the following module types:

- FUxxxM Silk® Nova
- FUxxxMV Silk® Nova

Characteristics	FUxxxM Silk® Nova	FUxxxMV Silk® Nova
Height [m]	1,722	2,278
Width [m]	1,134	1,134
Area [m^2]	1,953	2,583
Wafer size[1]	182 x 182	182 x 182
Power [Wp][2]	Min : 420 Max : 440	Min : 570 Max : 580
Bifacial	No	No
Lifetime [year]	25	25
Yearly degradation	0,40%	0,40%
Nb. of cells [pcs]	54	72
Cell technology	n-type	n-type

This study has been conducted according to the requirements of:

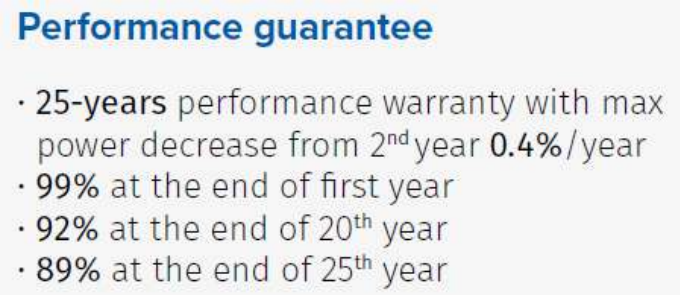
- ISO 14044;
- ISO 14025;
- EN15804+A2:2019;
- NPCR part A "Construction products and services" version 2.0;
- NPCR part B "for photovoltaic modules used in the building and construction industry, including production of cell, wafer, ingot block, solar grade silicon, solar substrates, solar superstrates and other solar grade semiconductor materials" version 1.1.

Market:

World

Reference service life, product:

25 years



[1] This EPD is also valid for wafer sizes 182.2x182.2 and 182.2x183.75.
[2] This EPD certificate is also valid for powers lower or higher than those indicated. Extrapolation rules are detailed p20.

LCA: Calculation rules

Declared unit:

1m^2 of manufactured photovoltaic module

Data quality:

Specific data comes from actual consumption of the module assembly factory (January 2023 – December 2023). This data has been collected by the manufacturer and checked by the LCA practitioner.

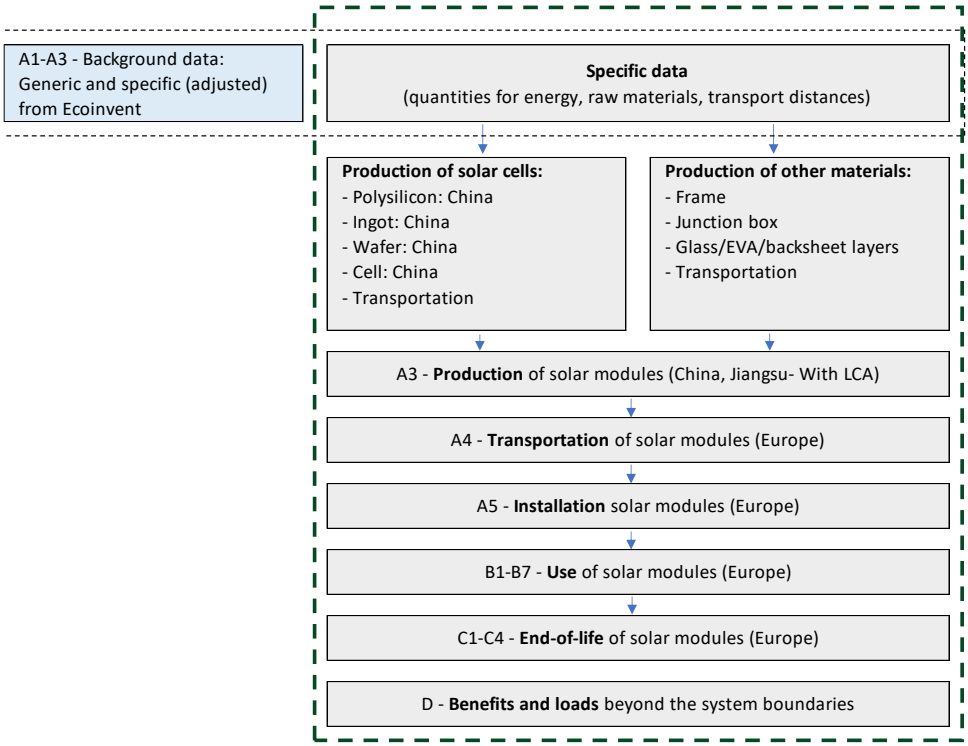
Generic data is from Ecoinvent v3.8 and Simapro v9. Characterization factors from EN15804:2012 + A2: 2019. Generic data <10 years old. Ecoinvent system model used: cut-off.

Allocation:

The allocation is made in accordance with the provisions of ISO 14025. Incoming energy and water and waste production in-house is allocated equally among all products through surface allocation. 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.

System boundary:

The study is based on a cradle to grave analysis i.e., from raw material extraction to the disposal of waste. A summary of what is included and excluded is shown below:



The PolySi, ingots, wafers, cells and modules are manufactured in China. The supply chain is shown below:

Production	Site
Virgin Polysi	China
Ingot/brick	China
Wafer	China
Recycled Polysi	China
Cells	Anhui province, China
Modules	Jiangsu province, China

Cut-off criteria:

No known significant flows have been excluded from the study.

LCA: Scenarios and additional technical information

The following information describes the scenarios in the different modules of the EPD. All data is provided per functional unit.

Transport from production place to assembly/user (A4)

The transport step A4 covers the transport from the factory in China to the installation site in Europe by sea and road. The delivery port used for calculations in Europe is Rotterdam.

Transport from production place to assembly/user (A4)	Capacity utilisation (incl. return) %	Distance (km)	Fuel/Energy consumption	Unit	Value
Truck	50%	400	Diesel (4.44E-2 L/tkm)	tkm	3.96
Ship	50%	19000	Heavy fuel (2.63E-3 L/tkm)	tkm	211.89
Truck	50%	1000	Diesel (4.44E-2 L/tkm)	tkm	11.15

The calculation of fuel consumption is based on the weight of the product and packaging. It includes return freight.

Assembly (A5)

The modules are installed by hand. The screwdriver electricity consumption is neglected. As in PCR part B, the fasteners (screws) are not included in the LCA. The only impact is the packaging waste given in the table below:

Packaging	Unit	Value
Wooden pallet	Kg	4,37E-01
Cardboard	Kg	1,61E-01
Low density PE	Kg	8,12E-03
PP	Kg	2,68E-03
Plastics	Kg	0,00E+00
Plastic film	Kg	0,00E+00
Paper	Kg	7,11E-05
Polyester film	Kg	0,00E+00
Transportation in lorry (Capacity utilisation incl. return: 50%)	Tkm	6.09E-01

Use (B1)

Photovoltaic modules harness solar energy throughout their entire lifecycle via the photovoltaic effect. The amount of electricity they produce is directly influenced by solar irradiance. The electricity production is calculated as below:

$$E_{year\ i} = I_{sun} \times S_{1kWp} \times Eff_{panel} \times PR \times D_{panel} \times (1 + b)$$

Where:

- I_{sun} is the sun irradiation received by the module in kWh. m^{-2}.$year^{-1}$, which depends on the site location.

- PR, or Performance Ratio, is the ratio between the energy produced by the panel and the final energy at the output of the photovoltaic system in order to take into account the various losses (cables, inverter, etc.).
- Eff_{panel}, or panel efficiency, is the ratio between the energy produced and the solar radiation received.
- b is the bifacial gain (5% if bifacial and 0% if monofacial)
- S_{1kWp} is the surface area to get 1 kWp.
- D_{panel} corresponds to the degradation of the panel in year i. This degradation is 1% the first year and then 0.4% per year. $D_{panel}=0.99 \times (1-0.4\%)^{i-1}$

As a result, the following chart illustrates the electricity produced by the modules after 25 years:

Solar irradiance for electricity production	Unit	Value
1000 kWh/m²/year	kWh/m² (25 years)	3 966
1100 kWh/m²/year	kWh/m² (25 years)	4 759
1200 kWh/m²/year	kWh/m² (25 years)	5 155
1300 kWh/m²/year	kWh/m² (25 years)	5 155
1400 kWh/m²/year	kWh/m² (25 years)	5 552
1500 kWh/m²/year	kWh/m² (25 years)	5 948
1600 kWh/m²/year	kWh/m² (25 years)	6 345
1700 kWh/m²/year	kWh/m² (25 years)	6 742

Maintenance (B2)/Repair (B3)/Replacement (B4)/Refurbishment (B5)

The modules are considered as self-cleaning materials. No maintenance, repair, replacement, or refurbishment is required during the module lifetime.

Operational energy (B6) and water consumption (B7)

The products do not require any energy or water consumption.

End of Life (C1, C3, C4)

The modules are considered as removed by hand. Waste scenarios follow PCR part B standards for C3 and C4.

Waste process	Unit	Value
Recycling	Kg	2.38E+01
Incineration and energy recovery	Kg	1.36E+00

Transport to waste processing (C2)

It has been assumed that the modules are collected by truck and sent for recycling. 50 km is considered from the site to the recycling factory as proposed in PCR part B.

Type	Capacity utilisation (incl. return) %	Type of vehicle	Distance (km)	Fuel/Energy consumption	Value (tkm)
Truck	50%	16-32 metric ton lorry, EURO5	50	Diesel (4.44E-2 l/tkm)	6.19E-01

Benefits and loads beyond the system boundaries (D)

Benefits and loads have been based on glass and aluminium frame recycling only. Energy recovery from A4-A5 and C1-C4 modules is included.

The benefits of exported energy from energy recovery in a treatment facility is calculated with substitution of Norwegian electricity market mix and heat production from wood chip burning plants in Norway. Conversion factors for efficiencies and losses from waste to delivered energy are included.

Item	Unit	Value
Glass	Kg	-7.94E+00
Aluminium	Kg	-2.82E-01
Substitution of electrical energy	MJ	-1,21E+00
Substitution of thermal energy	MJ	-4,29E+01

LCA: Results

The LCA results show the environmental impacts and resource input and output flows calculated according to ISO 14025 and EN 15804 +A2. The results are shown per functional unit, which for this declaration is 1Wp, as well as per declared unit, which for this declaration is 1 m^2. The LCA results have been calculated using the LCA software SimaPro 9.

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

Product stage			Assembly stage		Use stage							End of life stage				Benefits & loads beyond system boundary
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	X	X	X	X	X	X	X	X	X	X	X	X	X

Classification of disclaimers to the declaration of core and additional environmental impact indicators

ILCD classification	Indicator	Disclaimer
ILCD type / level 1	Global warming potential (GWP)	None
	Depletion potential of the stratospheric ozone layer (ODP)	None
	Potential incidence of disease due to PM emissions (PM)	None
ILCD type / level 2	Acidification potential, Accumulated Exceedance (AP)	None
	Eutrophication potential, Fraction of nutrients reaching marine end compartment (EP-marine)	None
	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	None
	Formation potential of tropospheric ozone (POCP)	None
	Potential Human exposure efficiency relative to U235 (IRP)	1
ILCD type / level 3	Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	2
	Abiotic depletion potential for fossil resources (ADP-fossil)	2
	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	2
	Potential Comparative Toxic Unit for ecosystems (ETP-fw)	2
	Potential Comparative Toxic Unit for humans (HTP-c)	2
	Potential Comparative Toxic Unit for humans (HTP-nc)	2
	Potential Soil quality index (SQP)	2

Disclaimer 1 – 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.

Disclaimer 2 – The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator

Results presented per functional unit-Wp

Core environmental impact indicators (per functional unit-Wp)

Parameter	Unit	A1-A3	A4	A5	B1 - B7	C1	C2	C3	C4	D
GWP-total	kg CO2 eq	5,91E-01	2,02E-02	5,43E-03	0,00E+00	0,00E+00	2,50E-04	3,28E-03	5,99E-04	-2,70E-02
GWP-fossil	kg CO2 eq	5,92E-01	2,02E-02	1,86E-03	0,00E+00	0,00E+00	2,50E-04	3,27E-03	5,98E-04	-2,66E-02
GWP-biogenic	kg CO2 eq	-1,39E-03	6,77E-06	3,57E-03	0,00E+00	0,00E+00	9,96E-08	3,34E-06	9,23E-07	-2,91E-04
GWP-luluc	kg CO2 eq	3,82E-04	1,10E-05	2,07E-07	0,00E+00	0,00E+00	8,99E-08	5,45E-07	3,43E-07	-8,96E-05
ODP	kg CFC11 eq	2,87E-07	4,35E-09	1,16E-10	0,00E+00	0,00E+00	5,97E-11	3,10E-11	3,54E-11	-1,50E-09
AP	mol H+ eq	3,53E-03	3,35E-04	2,65E-06	0,00E+00	0,00E+00	1,04E-06	2,59E-06	1,93E-06	-1,92E-04
EP-freshwater	kg P eq	2,50E-04	1,05E-06	1,33E-07	0,00E+00	0,00E+00	1,56E-08	2,72E-07	3,36E-06	-8,43E-06
EP-marine	kg N eq	8,99E-04	8,49E-05	9,85E-07	0,00E+00	0,00E+00	3,18E-07	1,10E-06	5,60E-07	-3,44E-05
EP-terrestial	mol N eq	7,38E-03	9,40E-04	9,73E-06	0,00E+00	0,00E+00	3,48E-06	1,06E-05	6,28E-06	-3,90E-04
POCP	kg NMVOC eq	2,06E-03	2,51E-04	2,76E-06	0,00E+00	0,00E+00	1,12E-06	2,44E-06	1,63E-06	-1,03E-04
ADP-M&M[2]	kg Sb eq	2,16E-05	5,14E-08	1,82E-09	0,00E+00	0,00E+00	5,75E-10	3,59E-09	1,77E-09	9,25E-08
ADP-fossil[2]	MJ	6,26E+00	2,84E-01	7,72E-03	0,00E+00	0,00E+00	3,90E-03	3,75E-03	3,68E-03	-3,04E-01
WDP[2]	m3	-1,95E-01	6,91E-04	2,02E-04	0,00E+00	0,00E+00	1,30E-05	4,92E-04	7,42E-05	-2,97E-03

GWP-total: *Global Warming Potential;* ***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; See "additional requirements" for indicator given as PO4 eq.* ***EP-marine:*** *Eutrophication potential, fraction of nutrients reaching freshwater end compartment;* ***EP-terrestial:*** *Eutrophication potential, Accumulated Exceedance;* ***POCP****: Formation potential of tropospheric ozone;* ***ADP-M&M****: Abiotic depletion potential for non-fossil resources (minerals and metals);* ***ADP-fossil:*** *Abiotic depletion potential for fossil resources;* ***WDP:*** *Water deprivation potential, deprivation weighted water counsumption*

Additional environmental impact indicators (per functional unit-Wp)

Parameter	Unit	A1-A3	A4	A5	B1 - B7	C1	C2	C3	C4	D
PM	Disease incidence	4,26E-08	1,05E-09	3,80E-11	0,00E+00	0,00E+00	2,26E-11	2,41E-11	1,68E-11	-2,32E-09
IRP	kBq U235 eq.	2,13E-02	1,36E-03	3,85E-05	0,00E+00	0,00E+00	1,97E-05	6,55E-05	1,78E-05	-1,03E-03
ETP-fw	CTUe	3,05E+01	2,06E-01	1,24E-02	0,00E+00	0,00E+00	3,05E-03	1,85E-02	4,74E-02	-8,70E-01
HTP-c	CTUh	2,43E-09	9,66E-12	5,69E-13	0,00E+00	0,00E+00	8,43E-14	1,09E-12	2,56E-11	-3,40E-11
HTP-nc	CTUh	9,30E-08	1,85E-10	2,02E-11	0,00E+00	0,00E+00	3,33E-12	3,53E-11	1,38E-10	-6,37E-10
SQP	Dimensionless	4,78E+00	1,78E-01	7,57E-03	0,00E+00	0,00E+00	6,87E-03	5,92E-03	7,61E-03	-1,09E+00

PM: *Particulate matter emissions;* ***IRP:*** *Ionising radiation, human health;* ***ETP-fw:*** *Ecotoxicity (freshwater);* ***ETP-c:*** *Human toxicity, cancer effects;* ***HTP-nc:*** *Human toxicity, non-cancer effects;* ***SQP:*** *Land use related impacts / soil quality*

Resource use (per functional unit-Wp)

Parameter	Unit	A1-A3	A4	A5	B1 - B7	C1	C2	C3	C4	D
RPEE	MJ	7,42E-01	3,05E-03	1,25E-04	0,00E+00	0,00E+00	4,96E-05	1,25E-02	1,63E-04	-1,41E-01
RPEM	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
TPE	MJ	7,42E-01	3,05E-03	1,25E-04	0,00E+00	0,00E+00	4,96E-05	1,25E-02	1,63E-04	-1,41E-01
NRPE	MJ	6,26E+00	2,84E-01	7,72E-03	0,00E+00	0,00E+00	3,90E-03	3,72E-03	3,68E-03	-3,04E-01
NRPM	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
TRPE	MJ	6,26E+00	2,84E-01	7,72E-03	0,00E+00	0,00E+00	3,90E-03	3,72E-03	3,68E-03	-3,04E-01
SM	kg	0,00E+00	0,00E+00	0,00E+00	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	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	0,00E+00	0,00E+00	0,00E+00
W	m^3	-4,21E-03	2,19E-05	3,78E-06	0,00E+00	0,00E+00	4,20E-07	9,74E-05	1,89E-06	-2,19E-04

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 (per functional unit-Wp)

Parameter	Unit	A1-A3	A4	A5	B1 - B7	C1	C2	C3	C4	D
HW	KG	3,97E-02	2,46E-04	7,29E-04	0,00E+00	0,00E+00	2,70E-06	1,63E-03	3,62E-03	-4,17E-03
NHW	KG	6,53E-01	1,05E-02	4,30E-04	0,00E+00	0,00E+00	3,85E-04	2,82E-04	1,57E-04	-1,91E-02
RW	KG	8,71E-06	1,93E-06	4,90E-08	0,00E+00	0,00E+00	2,64E-08	2,07E-08	1,72E-08	-5,50E-07

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

End of life – output flow (per functional unit-Wp)

Parameter	Unit	A1-A3	A4	A5	B1 - B7	C1	C2	C3	C4	D
CR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,06E-01	0,00E+00	0,00E+00
MER	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,06E-03	0,00E+00	0,00E+00
EEE	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,65E-03	0,00E+00	0,00E+00
ETE	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,30E-01	0,00E+00	0,00E+00
Exported energy - gas and process	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	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

Information describing the biogenic carbon content at the factory gate (per functional unit-Wp)

Biogenic carbon content	Unit	Value
Biogenic carbon content in product	kg C	0,00E+00
Biogenic carbon content in the accompanying packaging	kg C	9,73E-04

Results presented per declared unit

Core environmental impact indicators (per declared unit-m^2)

Parameter	Unit	A1-A3	A4	A5	B1 - B7	C1	C2	C3	C4	D
GWP-total	kg CO2 eq	1,33E+02	4,54E+00	1,22E+00	0,00E+00	0,00E+00	5,62E-02	7,36E-01	1,34E-01	-6,05E+00
GWP-fossil	kg CO2 eq	1,33E+02	4,54E+00	4,18E-01	0,00E+00	0,00E+00	5,62E-02	7,35E-01	1,34E-01	-5,97E+00
GWP-biogenic	kg CO2 eq	-3,13E-01	1,52E-03	8,01E-01	0,00E+00	0,00E+00	2,24E-05	7,50E-04	2,07E-04	-6,54E-02
GWP-LULUC	kg CO2 eq	8,57E-02	2,46E-03	4,66E-05	0,00E+00	0,00E+00	2,02E-05	1,22E-04	7,70E-05	-2,01E-02
ODP	kg CFC11 eq	6,45E-05	9,76E-07	2,59E-08	0,00E+00	0,00E+00	1,34E-08	6,96E-09	7,95E-09	-3,37E-07
AP	mol H+ eq	7,92E-01	7,52E-02	5,96E-04	0,00E+00	0,00E+00	2,34E-04	5,81E-04	4,34E-04	-4,30E-02
EP-freshwater	kg P eq	5,61E-02	2,36E-04	2,98E-05	0,00E+00	0,00E+00	3,50E-06	6,10E-05	7,55E-04	-1,89E-03
EP-marine	kg N eq	2,02E-01	1,91E-02	2,21E-04	0,00E+00	0,00E+00	7,15E-05	2,47E-04	1,26E-04	-7,72E-03
EP-terrestial	mol N eq	1,66E+00	2,11E-01	2,18E-03	0,00E+00	0,00E+00	7,82E-04	2,38E-03	1,41E-03	-8,76E-02
POCP	kg NMVOC eq	4,62E-01	5,63E-02	6,21E-04	0,00E+00	0,00E+00	2,52E-04	5,47E-04	3,67E-04	-2,32E-02
ADP-M&M	kg Sb eq	4,86E-03	1,15E-05	4,09E-07	0,00E+00	0,00E+00	1,29E-07	8,05E-07	3,97E-07	2,08E-05
ADP-fossil	MJ	1,41E+03	6,37E+01	1,73E+00	0,00E+00	0,00E+00	8,76E-01	8,43E-01	8,26E-01	-6,83E+01
WDP	m3 depriv.	-4,37E+01	1,55E-01	4,53E-02	0,00E+00	0,00E+00	2,93E-03	1,10E-01	1,67E-02	-6,68E-01

GWP-total: *Global Warming Potential;* ***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; See "additional requirements" for indicator given as PO4 eq.* ***EP-marine:*** *Eutrophication potential, fraction of nutrients reaching freshwater end compartment;* ***EP-terrestial:*** *Eutrophication potential, Accumulated Exceedance;* ***POCP****: Formation potential of tropospheric ozone;* ***ADP-M&M****: Abiotic depletion potential for non-fossil resources (minerals and metals);* ***ADP-fossil:*** *Abiotic depletion potential for fossil resources;* ***WDP:*** *Water deprivation potential, deprivation weighted water counsumption*

Additional environmental impact indicators (per declared unit-m^2)

Parameter	Unit	A1-A3	A4	A5	B1 - B7	C1	C2	C3	C4	D
PM	Disease incidence	9,56E-06	2,36E-07	8,53E-09	0,00E+00	0,00E+00	5,07E-09	5,41E-09	3,76E-09	-5,20E-07
IRP	kBq U235 eq.	4,78E+00	3,05E-01	8,65E-03	0,00E+00	0,00E+00	4,43E-03	1,47E-02	4,01E-03	-2,31E-01
ETP-fw	CTUe	6,84E+03	4,63E+01	2,78E+00	0,00E+00	0,00E+00	6,84E-01	4,15E+00	1,07E+01	-1,95E+02
HTP-c	CTUh	5,46E-07	2,17E-09	1,28E-10	0,00E+00	0,00E+00	1,89E-11	2,45E-10	5,76E-09	-7,63E-09
HTP-nc	CTUh	2,09E-05	4,15E-08	4,54E-09	0,00E+00	0,00E+00	7,48E-10	7,93E-09	3,10E-08	-1,43E-07
SQP	Dimensionless	1,07E+03	3,99E+01	1,70E+00	0,00E+00	0,00E+00	1,54E+00	1,33E+00	1,71E+00	-2,44E+02

PM: *Particulate matter emissions;* ***IRP:*** *Ionising radiation, human health;* ***ETP-fw:*** *Ecotoxicity (freshwater);* ***ETP-c:*** *Human toxicity, cancer effects;* ***HTP-nc:*** *Human toxicity, non-cancer effects;* ***SQP:*** *Land use related impacts / soil quality*

Resource use (per declared unit-m^2)

Parameter	Unit	A1-A3	A4	A5	B1 - B7	C1	C2	C3	C4	D
RPEE	MJ	1,67E+02	6,84E-01	2,81E-02	0,00E+00	0,00E+00	1,11E-02	2,81E+00	3,67E-02	-3,17E+01
RPEM	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
TPE	MJ	1,67E+02	6,84E-01	2,81E-02	0,00E+00	0,00E+00	1,11E-02	2,81E+00	3,67E-02	-3,17E+01
NRPE	MJ	1,41E+03	6,37E+01	1,73E+00	0,00E+00	0,00E+00	8,76E-01	8,35E-01	8,26E-01	-6,83E+01
NRPM	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
TRPE	MJ	1,40E+03	6,37E+01	1,73E+00	0,00E+00	0,00E+00	8,75E-01	8,35E-01	8,25E-01	-6,82E+01
SM	kg	0,00E+00	0,00E+00	0,00E+00	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	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	0,00E+00	0,00E+00	0,00E+00
W	m^3	-9,46E-01	4,92E-03	8,48E-04	0,00E+00	0,00E+00	9,44E-05	2,19E-02	4,24E-04	-4,91E-02

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 (per declared unit-m^2)

Parameter	Unit	A1-A3	A4	A5	B1 - B7	C1	C2	C3	C4	D
HW	KG	8,91E+00	5,52E-02	1,64E-01	0,00E+00	0,00E+00	6,06E-04	3,65E-01	8,13E-01	-9,36E-01
NHW	KG	1,47E+02	2,36E+00	9,66E-02	0,00E+00	0,00E+00	8,64E-02	6,34E-02	3,51E-02	-4,29E+00
RW	KG	1,95E-03	4,32E-04	1,10E-05	0,00E+00	0,00E+00	5,93E-06	4,65E-06	3,85E-06	-1,23E-04

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

End of life – output flow (per declared unit-m^2)

Parameter	Unit	A1-A3	A4	A5	B1 - B7	C1	C2	C3	C4	D
CR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,38E+01	0,00E+00	0,00E+00
MER	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,36E+00	0,00E+00	0,00E+00
EEE	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	8,20E-01	0,00E+00	0,00E+00
ETE	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,92E+01	0,00E+00	0,00E+00
Exported energy - gas and process	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	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

Information describing the biogenic carbon content at the factory gate (per declared unit-m^2)

Biogenic carbon content	Unit	Value
Biogenic carbon content in product	kg C	0.00E+00
Biogenic carbon content in the accompanying packaging	kg C	2,19E-01

Additional requirements

Location based electricity mix from the use of electricity in manufacturing

Regional market for and medium voltage (production of transmission lines, in addition to direct emissions and losses in grid) electricity dataset has been used for the module manufacturing process (foreground/core) per functional unit.

National market for mix of electricity have been used for all other industrial stages (PolySi, Ingot, Wafer, Cells).

Regional electricity grid	A3 (kWh/m^2)	Value (kgCO2eq/kWh)
FUTURASUN_Electricity, medium voltage {CN-JS}| market for | Cut-off, U	5,6E+00	1.10

Guarantees of origin from the use of electricity in the manufacturing phase

In the context of China, a market-based approach is not applicable due to the absence of a Guarantee of Origin system. Therefore, a location-based approach is employed to assess the environmental impact of electricity in this EPD.

Additional environmental impact indicators required for construction products (Wp)

In order to increase the transparency of biogenic carbon contribution to climate impact, the indicator GWP-IOBC is required as it declares climate impacts calculated according to the principle of instantanious oxidation. GWP-IOBC is also reffered to as GWP-GHG in context to Swedish public procurement legislation.

Parameter	Unit	A1-A3	A4	A5	B1 - B7	C1	C2	C3	C4	D
GWP-IOBC	kg CO2 eq.	5,92E-01	2,02E-02	1,86E-03	0,00E+00	0,00E+00	2,50E-04	3,27E-03	5,98E-04	-2,66E-02

GWP-IOBC *Global warming potential calculated according to the principle of instantaneous oxidation.*

Hazardous substances

The declaration is based upon reference to threshold values and/or test results and/or material safety data sheets provided to EPD verifiers. Documentation available upon request to EPD owner.

- ➔ The product contains no substances given by the REACH Candidate list or the Norwegian priority list.
- ➔ The product contains substances given by the REACH Candidate list that are less than 0,1 % by weight.

Indoor environment

No tests have been carried out on the product concerning indoor climate.

Carbon footprint

The carbon footprint per kWh with a production in Norway (I_{rad}=1000 kWh. m^{-2}.$year^{-1}$) is 35,14

gCO2-eq / kWh.

The carbon footprint per kWh with a production in Italy (I_{rad}=1600 kWh. m^{-2}.$year^{-1}$) is 21,96 gCO2-eq / kWh.

This carbon footprint corresponds to the total GWP and all the stages of the life cycle (A1-C4) have been taken into account. The impact of the module has been converted into kgCO2/kWh using the amount of electricity the module is expected to produce over its lifetime with an irradiance equal to I_{rad} (see section "Use (B1) on page 9).

Extrapolation rules

Power peak

The environmental impacts are given for a specific module power peak. For example, $Wp/area_{EPD}$ = 225Wp/m^2 for the EPD based on module **FUxxxMV Silk® Nova.**

For a different Wp (for example $Wp_{project}$ = 236Wp/m^2 for module FUxxxMV Silk® Nova), the impacts can be re-calculated by applying to each impact the following ratio: $Wp/area_{EPD}$ / $Wp/area_{Project}$ = 225 Wp/m^2 / 236 Wp/m^2.

Therefore:

$$Impacts_{project\ (per\ Wp)} = \frac{impact_{per\ m^2}}{236} = \frac{Impact_{per\ m^2}}{225} \times \frac{225}{236} = Impacts_{EPD\ (per\ Wp)} \times \frac{225}{236}$$

		EPD 1	EPD 1
		FUxxxM Silk® Nova	FUxxxMV Silk® Nova
Module area	m²	1,953	2,583
Power	Wp	440	580
Power/Area	Wp/m2	225,32	224,52

Bibliography

ISO 14025:2010	Environmental labels and declarations - Type III environmental declarations - Principles and procedures
ISO 14044:2006	Environmental management - Life cycle assessment - Requirements and guidelines
EN 15804:2012+A2:2019	Sustainability of construction works - Environmental product declaration - Core rules for the product category of construction products
ISO 21930:2007	Sustainability in building construction - Environmental declaration of building products
LCA report	FUTURASUN_EPD_report_15042024_v1.1
NPCR	Part A "Construction products and services" version 2.0 Part B "for photovoltaic modules used in the building and construction industry, including production of cell, wafer, ingot block, solar grade silicon, solar substrates, solar superstrates and other solar grade semiconductor materials" version 1.2
Simapro	Version 9
Ecoinvent	Ecoinvent v3.8

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