

ENVIRONMENTAL PRODUCT DECLARATION

in accordance with ISO 14025, ISO 21930 and EN 15804

Owner of the declaration:	NorSun AS
Program operator:	The Norwegian EPD Foundation
Publisher:	The Norwegian EPD Foundation
Declaration number:	NEPD-2651-1357-EN
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Issue date:	03.02.2021
Valid to:	03.02.2026

NorSun mono-crystalline silicon wafer

NorSun AS



www.epd-norge.no



Foto: Copyright NorSun

General information

Product:

NorSun mono-crystalline silicon wafer

Program operator:

The Norwegian EPD Foundation
 Postboks 5250 Majorstuen, 0303 Oslo
 Phone: +47 23 08 82 92
 e-mail: post@epd-norge.no

Declaration number:

NEPD-2651-1357-EN

ECO Platform reference number:
This declaration is based on Product Category Rules:

EN 15804:2012+A1:2013 and NPCR PART A: Construction Products and Services, 07.04.2017, serves as core PCR

NPCR 029, v1.1, 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

Statement of liability:

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

Declared unit:

1 m² of manufactured mono-crystalline silicon wafer, 133 µm thickness in 125 mm pseudo square format

Declared unit with option:

Cradle to gate A1-A3 + option A4

Functional unit:

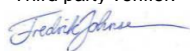
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Verification:

The CEN Norm EN 15804 serves as the core PCR. Independent verification of the declaration and data, according to ISO14025:2010

internal external

Third party verifier:



Fredrik Moltu Johnsen, NORSUS
 (Independent verifier approved by EPD Norway)

Owner of the declaration:

NorSun AS
 Contact person: Carsten Rohr
 Phone: +47-95901965
 e-mail: carsten.rohr@norsun.no

Manufacturer:

NorSun AS
 Karenslyst Allé
 NO-0278 Oslo, Norway

Place of production:

Årdal, Norway

Management system:

No

Organisation no:

989 186 493

Issue date:

03.02.2021

Valid to:

03.02.2026

Year of study:

LCA conducted 2020. Data from Norsun Årdal wafer production 01.01.2019 - 31.12.2019

Comparability:


EPD of construction products may not be comparable if they do not comply with EN 15804 and are seen in a building context.

The EPD has been worked out by:

Oddbjørn Dahlstrøm Andvik
 Asplan Viak AS


asplan viak

Approved



Håkon Hauan
 Managing Director of EPD-Norway

Product

Product description:

A wafer is a thin slice of semiconductor, such as crystalline silicon (c-Si), used for the fabrication of solar cells.

Wafers manufactured by NorSun are made of monocrystalline silicon material of premium quality, using the Czochralski process for producing monocrystalline silicon ingots which are sliced with diamond wire into wafers.

Product specification:

Wafer formats: 125mm pseudo-square, M2, M3, M4, M6 formats (sidelength of 125mm, 156.75mm, 158.75mm, 161.7mm and 166mm respectively)

Wafer thickness: 130-180 ±15 µm

Technical data:

n-type (P) or p-type (B)
 Resistivity from 0.5 Ω cm
 High minority carrier lifetime
 Interstitial oxygen < 18 ppma
 Substitutional carbon < 3 ppma
 130-180 ±15 µm thickness
 TTV < 25 µm, Bow < 50 µm, Saw mark depth < 15 µm, Chipping < 300 µm
 No microcracks, stains, or pinholes

Reference service life, product:

Not Declared

Market:

Global

Table 1: Product composition

Mono-crystalline silicon wafer	Declared thick.		Standard thicknesses						Comment		
	133 µm		130 µm		150 µm		170 µm			180 µm□	
Total consumption of Si ingot	0,854		0,834		1,044		1,083		1,147	kg Si/m ² wafer	
Internally sourced recycled Si ingot	0,28	33 %	0,30	36 %	0,43	41 %	0,43	39 %	0,45	39 %	kg Si/m ² wafer
Externally sourced recycled Si ingot	-	0 %	-	0 %	-	0 %	-	0 %	-	0 %	kg Si/m ² wafer
Total mass wafer (excluding packaging)	0,337		0,303		0,350		0,396		0,419	kg Si/m ² wafer	
Packaging: styrofoam inlays					0,028					kg/m ² wafer	
Packaging: cardboard and paper					0,028					kg/m ² wafer	
Packaging: pallet, wood					0,001					kg/m ² wafer	
Total mass: Including packaging	0,393		0,359		0,406		0,452		0,475	kg/m ² wafer	

Table 2: Product dimensions

Wafer format	Side length (mm)	Diameter (mm)	Area (mm ²)	Wafers per m ²
125	125	166	15,506	64,49
M2	157	210	24,432	40,93
M3	159	211	25,015	39,98
M4	162	211	25,825	38,72
M6	166	223	27,415	36,48

Table 3: Conversion factors for cradle-to-gate carbon footprint for all wafer thicknesses

For modules A1-A3 (cradle-to-gate), ~90% of the Global Warming Potential (GWP) is caused by the consumption of Si ingot. A conversion factor based on Si consumption (kg) per m² wafer can be used to obtain approximate carbon footprints for different thicknesses.

Wafer thickness	133 µm	130 µm	150 µm	170 µm	180 µm□	Comment
Conversion factor	1	0,98	1,22	1,27	1,34	factor * results

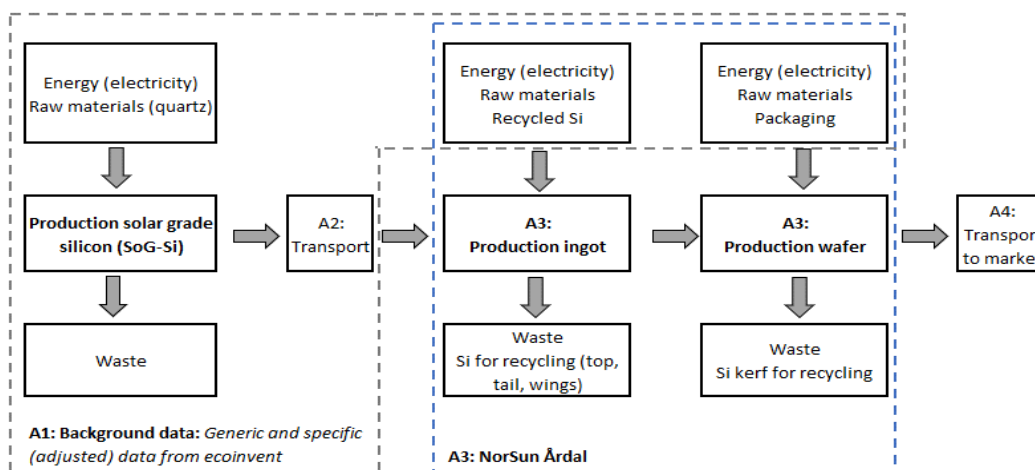
LCA: Calculation rules

Declared unit:

1 m² of manufactured mono-crystalline silicon wafer, 133 μm thickness in 125 mm pseudo square format

System boundary:

The flow chart for the production of wafer is shown in the figure below. Additionally, transport to market (A4) has been added to show the importance of this transport.



Data quality:

Data for production of mono-crystalline silicon ingot and wafer, A1-A3, is based on specific consumption data for NorSun Årdal, Norway 2019. Norsun Årdal produces around 1 500 tonnes of ingot and 1,7 million m² wafer annually.

For solar grade silicon, SoG-Si, electricity consumption in generic SoG-Si production is adjusted to represent national grid mix, including imports, in the country of production (USA and DE).

Generic data is from Ecoinvent v3.6 and SimaPro v9. Characterization factors from or in line with EN15804:2012 + A1: 2013. Generic data <10 years old.

Allocation:

The allocation is made in accordance with the provisions of EN 15804. Incoming energy, water and waste production in-house are allocated among all products through economic allocation for wafer, kerf and off-spec material.

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.

Cut-off criteria:

All major raw materials and all the essential energy is included. The production process for raw materials and energy flows that are included with very small amounts (<1%) are not included. This cut-off rule does not apply for hazardous materials or substances.

LCA: Scenarios and additional technical information

The following information describes the scenarios in the different modules of the EPD.

This declaration is based on a "cradle to gate" (A1-A3) assessment. Additionally, transportation (A4) to a relevant market for the product has been added, to show the importance of this transport.

Transport from production site to a relevant market:

A4a: Transport to Shanghai, China

A4b: Transport to Europe, Germany

A4c: Transport to Kuala Lumpur, Malaysia

Transport from production place to user (A4a: Transport to Shanghai, China)

Type	Capacity utilisation (incl. return) %	Type of vehicle	Distance km	Fuel/Energy consumption	
Truck	36,67 %	16-32 t, EURO 6	500 km	0,044 l/tkm	22,02 l/t
Transoceanic ship	70 %	Transoceanic ship	20 000 km	0,003 l/tkm	55,56 l/t

Transport from production place to user (A4b: Transport to Europe, Germany)

Type	Capacity utilisation (incl. return) %	Type of vehicle	Distance km	Fuel/Energy consumption	
Truck	36,67 %	16-32 t, EURO 6	1 500 km	0,044 l/tkm	66,07 l/t

Transport from production place to user (A4c: Transport to Kuala Lumpur, Malaysia)

Type	Capacity utilisation (incl. return) %	Type of vehicle	Distance km	Fuel/Energy consumption	
Truck	36,67 %	16-32 t, EURO 6	500 km	0,044 l/tkm	22,02 l/t
Air freight, intercont.	-	Global average	9 740 km	0,356 l/tkm	3463,11 l/t

LCA: Results

The LCA results show environmental impacts, resource use and outflows calculated according to EN 15804: 2012 + A1: 2013. The results are per m² of manufactured mono-crystalline silicon wafer (133 µm thickness in 125 mm pseudo square format). Transport A4 is to a relevant market. Results for A1-A3 without solar grade silicon are given in the column "A1-A3 w/o SoG-Si" to enable users to input other values for SoG-Si ingot production and transportation. The resulting values represent an approximation of A1-A3 of wafer production by NorSun in ..

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-A3	A4a: Shanghai	A4b: Germany	A4c: Kuala Lumpur	A1-A3 w/o SoG-Si
GWP	kg CO ₂ -ekv	3,54E+01	1,20E-01	9,50E-02	4,28E+00	1,38E+00
ODP	kg CFC11-ekv	3,00E-06	2,00E-08	1,76E-08	7,87E-07	1,09E-07
POCP	kg C ₂ H ₄ -ekv	7,37E-03	6,50E-05	1,45E-05	6,83E-04	1,08E-03
AP	kg SO ₂ -ekv	1,25E-01	1,94E-03	2,27E-04	1,60E-02	7,01E-03
EP	kg PO ₄ ³⁻ -ekv	2,50E-02	1,73E-04	3,05E-05	2,73E-03	2,28E-03
ADPM	kg Sb-ekv	4,34E-05	1,17E-07	2,91E-07	5,30E-07	1,78E-05
ADPE	MJ	5,31E+02	1,76E+00	1,46E+00	6,09E+01	2,31E+01

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

Resource use

Parameter	Unit	A1-A3	A4a: Shanghai	A4b: Germany	A4c: Kuala Lumpur	A1-A3 w/o SoG-Si
RPEE	MJ	3,58E+02	3,21E-02	1,37E-02	2,40E-01	3,88E+01
RPEM	MJ	1,46E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00
TPE	MJ	3,58E+02	3,21E-02	1,37E-02	2,40E-01	3,88E+01
NRPE	MJ	5,17E+02	1,79E+00	1,48E+00	6,28E+01	2,40E+01
NRPM	MJ	1,28E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
TRPE	MJ	5,18E+02	1,79E+00	1,48E+00	6,28E+01	2,40E+01
SM	kg	3,10E-01	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
NRSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
W	m ³	1,49E+00	3,51E-04	2,68E-04	7,41E-03	1,10E+00

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-A3	A4a: Shanghai	A4b: Germany	A4c: Kuala Lumpur	A1-A3 w/o SoG-Si
HW	kg	1,55E-03	1,07E-06	9,34E-07	1,96E-05	1,20E-04
NHW	kg	3,58E+00	2,55E-02	7,03E-02	5,53E-02	5,09E-01
RW	kg	1,85E-03	1,16E-05	9,91E-06	4,43E-04	7,33E-05

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

End of life - Output flow

Parameter	Unit	A1-A3	A4a: Shanghai	A4b: Germany	A4c: Kuala Lumpur	A1-A3 w/o SoG-Si
CR	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MR	kg	7,02E-01	0,00E+00	0,00E+00	0,00E+00	7,02E-01
MER	kg	3,98E-02	0,00E+00	0,00E+00	0,00E+00	3,98E-02
EEE	MJ	0,00E+00	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	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 = $9,0 \cdot 10^{-3}$ = 0,009

Additional Norwegian requirements

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

National production mix with import, on low voltage (included production of transmission lines, in addition to direct emissions and losses in grid) is applied for electricity in the manufacturing process.

Data source	Process	Amount	Unit
Norway: (ingot and wafer production), Ecoinvent v3.6	Medium voltage, NO	0,025	kg CO ₂ -ekv/kWh
USA: (solar grade silicon production), Ecoinvent v3.6	Medium voltage, US	0,654	kg CO ₂ -ekv/kWh
Germany: (solar grade silicon production), Ecoinvent v3.6	Medium voltage, DE	0,640	kg CO ₂ -ekv/kWh

Dangerous substances

- 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 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 Priority list, see table.
- The product contains no substances given by the REACH Candidate list or the Norwegian priority list. The product is classified as hazardous waste (Avfallsforkiften, Annex III), see table.

Transport

Transport from production site to market according to scenario A4:

A4a: Transport to Shanghai, China

A4b: Transport to Europe, Germany

A4c: Transport to Kuala Lumpur, Malaysia

Assumptions for transport are described in detail in scenario description for A4, page 4.

Indoor environment




Not relevant, product is not used in indoor environment.

Carbon footprint

A specific Carbon footprint declaration is not provided in this declaration. For the carbon footprint value of the product, please see environmental impacts result parameter "GWP".

Bibliography

NS-EN ISO 14025:2010	<i>Environmental labels and declarations - Type III environmental declarations - Principles and procedures</i>
NS-EN ISO 14044:2006	<i>Environmental management - Life cycle assessment - Requirements and guidelines</i>
NS-EN 15804:2012+A1:2013	<i>Sustainability of construction works - Environmental product declaration - Core rules for the product category of construction products</i>
ISO 21930:2007	<i>Sustainability in building construction - Environmental declaration of building products</i>
Ecoinvent v3.6	<i>Allocation, cut-off by classification, Swiss Centre of Life Cycle Inventories.</i> https://www.ecoinvent.org/
Simapro	<i>LCA software, developed by PRé Sustainability</i> https://simapro.com/
NPCR Part A, 2017	<i>The Norwegian EPD Foundation, 07.04.2017. Construction Products and Services.</i>
NPCR 029, v1.1, Part B	<i>NPCR 029, v1.1, 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</i>
Andvik, Oddbjørn Dahlstrøm et al. (2020)	<i>LCA Rapport: NorSun mono-crystalline silicon wafer.</i>

 epd-norge.no The Norwegian EPD Foundation	Program operator The Norwegian EPD Foundation Post Box 5250 Majorstuen, 0303 Oslo Norway	Tlf: +47 23 08 80 00 e-post: post@epd-norge.no web: www.epd-norge.no
 NorSun	Owner of the declaration NorSun AS Karenslyst Allé NO-0278 Oslo, Norway	Tlf: +47-95901965 e-post: carsten.rohr@norsun.no web:
 asplan viak	Author of the Life Cycle Assessment Asplan Viak AS Oddbjørn Dahlstrøm Andvik Kjørboveien 20, 1337 Sandvika, Norway	Tlf: +47 417 99 417 e-post: Oddbjorn.Dahlstrom@asplanviak.no web: www.asplanviak.no