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The Norwegian EPD Foundation

ENVIRONMENTAL PRODUCT DECLARATION

in accordance with ISO 14025, ISO 21930, ISO 14044 and EN 15804

Owner of the declaration:	REC Solar Norway AS
Program operator:	The Norwegian EPD Foundation
Publisher:	The Norwegian EPD Foundation
Declaration number:	NEPD-2682-1371-EN
Registration number:	NEPD-2682-1371-EN
ECO Platform reference number:	-
Issue date:	12.02.2021
Valid to:	12.02.2026

REC Solar multicrystalline silicon block

REC Solar Norway AS

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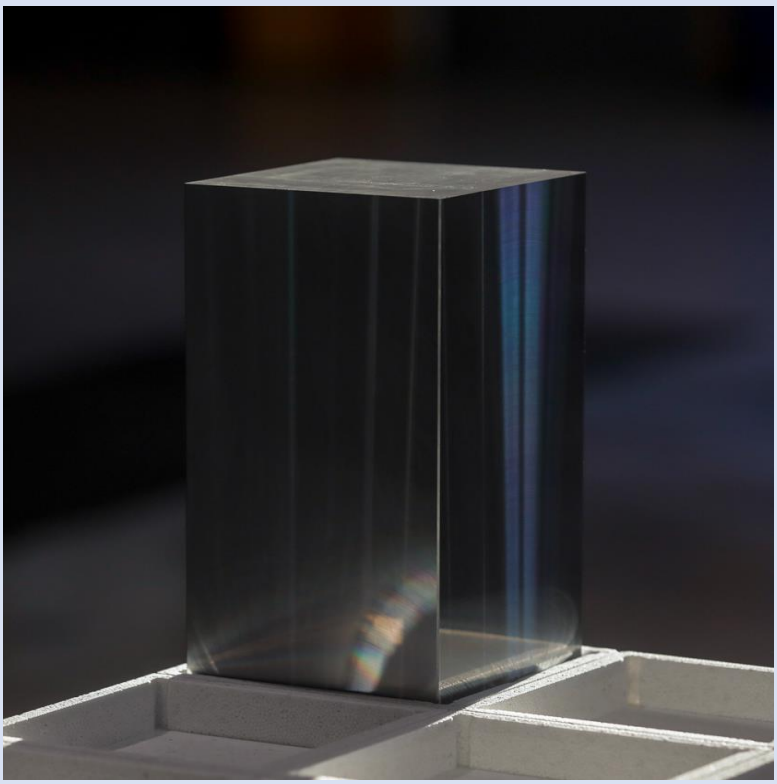

Photo: REC Solar

General information

Product:
REC Solar multicrystalline silicon block

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Manufacturer:
REC Solar Norway AS

Declaration number:
NEPD-2682-1371-EN

Place of production:
Herøya, Porsgrunn, Norway

ECO Platform reference number:

Management system:
RBS (REC Business System). In the phase of being certified according to NS-EN ISO 9001:2015.

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 029:2020 Part B for photovoltaic modules

Organisation no:
986 707 328

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.

Issue date:
12.02.2021

Valid to:
12.02.2026

Declared unit:
1 kg of manufactured multicrystalline silicon block

Year of study:
LCA conducted 2020. Data from REC Fiskå (solar grade silicon, SoG-Si) 01.01.18 - 31.12.18, data from REC Herøya (block) 01.01.18 - 31.05.18.

Declared unit with option:
Cradle-to-gate A1-A3, + A4

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

Functional unit:
-

The EPD has been worked out by:
Oddbjørn Dahlstrøm Andvik
Asplan Viak AS

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:
Julie Lyslo Skullestad
(Independent verifier approved by EPD Norway)

Approved
Håkon Hauan
Managing Director of EPD-Norway

Product

Product description:

Mulitcrystaline block is a silicon piece created when polysilicon is melted and crystallized in a furnace. Multicrystalline blocks are made when an ingot is sliced into blocks in a block saw and further processed to meet the given tolerances. Blocks are further processing into wafers, solar cells and modules.

Technical data:

Oxygen concentration < 4 x 10^{17}
Carbone concentration < 5 x 10^{17}
Dislocation Density < 6 x 10^{5}
Average Resistivity between 0.8 Ohm cm - 1.3 Ohm cm depending on specification
Lifetime > 5μ sec

Product specification:

A typical size for multicrystalline blocks is 680 x 680 mm with a weight of 570-670 kg. Multicrystalline blocks are silicon blocks with a typical size of 156-157.2mm by 156-157,2mm and height of 300 -355mm and a weight between 17 - 20,3 kg.

Market:

Norway, Europe, World

Total mass of multicrystalline block, 25 pcs a 157x157x324mm		
Excluding packaging	1,00	kg
Including packaging	1,17	kg
Consumption of SoG-Si related to declared unit	1,41	kg SoG-Si/kg block
Internally sourced recycled content*	25 %	kg
Externally sourced recycled content*	0 %	kg

* Not included recycled content in solar grade silicon upstream ingot production.

Reference service life, product:

Not Declared

Substance	kg	%
Block	1,00E+00	85,6 %
Packaging: polystyrene	5,08E-03	0,4 %
Packaging: pallet, wood	5,61E-02	4,8 %
Packaging: pure wooden box	1,07E-01	9,2 %
Total mass: Including packaging	1,17E+00	100 %

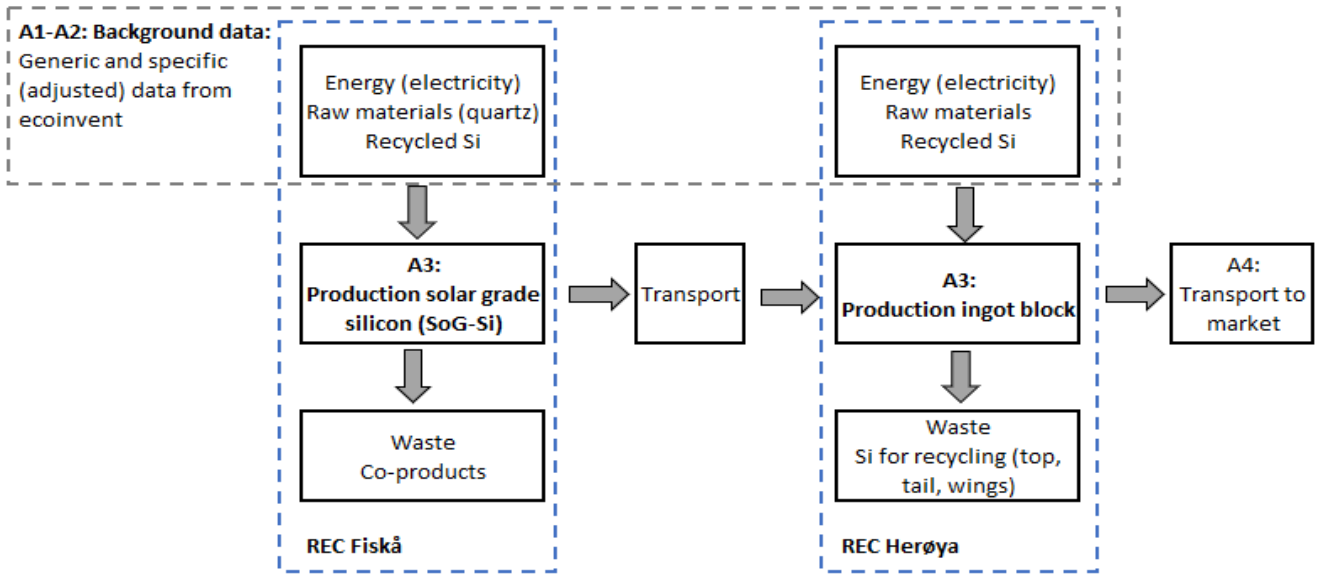
LCA: Calculation rules

Declared unit:

1 kg of manufactured multicrystalline silicon block

System boundary:

The flow chart for the production of ingot block 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 solar grade silicon, SoG-Si, (REC Fiskå) and ingot block (REC Herøya), A1-A3, is based on specific consumption data for REC Fiskå and REC Herøya 2018. REC Herøya produces around 4 000 tonnes of ingot block annually.

Data for production of solar grade silicon from REC Fiskå is based on specific data for REC Solar AS, also available as an EPD. For solar grade silicon not from REC Fiskå, electricity consumption in generic SoG-Si production is adjusted to represent FBR production technology and national grid mix, including imports, in country of production (USA).

Generic data is from Ecoinvent v3.6 and SimaPro v9. Characterization factors from 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 equally among all products through mass allocation (ingot block production).
For production of solar grade silicon (Fiskå): Incoming energy, water and waste production in-house are allocated among all products through economic allocation for solar grade silicon and B-quality products for sale.

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-A) assessment. Aditionally, a 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

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	0,0028 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

LCA: Results

The LCA results show environmental impacts, resource use and outflows calculated according to EN 15804: 2012 + A1: 2013. The results are per kg of manufactured multicrystalline silicon ingot block. Transport A4 is to a relevant market.

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

Product stage			Assemby 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
GWP	kg CO_2-ekv	1,60E+01	3,05E-01	2,42E-01
ODP	kg CFC11-ekv	1,09E-06	5,09E-08	4,47E-08
POCP	kg C_2H_4-ekv	2,64E-03	1,65E-04	3,68E-05
AP	kg SO_2-ekv	6,37E-02	4,93E-03	5,78E-04
EP	kg PO_4^{3-}-ekv	1,04E-02	5,43E-04	1,31E-04
ADPM	kg Sb-ekv	3,01E-05	2,97E-07	7,40E-07
ADPE	MJ	1,96E+02	4,48E+00	3,71E+00

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
RPEE	MJ	2,04E+02	8,16E-02	3,50E-02
RPEM	MJ	4,35E+01	0,00E+00	0,00E+00
TPE	MJ	2,48E+02	8,16E-02	3,50E-02
NRPE	MJ	1,51E+02	4,54E+00	3,77E+00
NRPM	MJ	6,90E+01	0,00E+00	0,00E+00
TRPE	MJ	2,20E+02	4,54E+00	3,77E+00
SM	kg	4,08E-01	0,00E+00	0,00E+00
RSF	MJ	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ	0,00E+00	0,00E+00	0,00E+00
W	m^3	1,61E+00	8,94E-04	6,83E-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

Parameter	Unit	A1-A3	A4a: Shanghai	A4b: Germany
HW	kg	1,80E-03	2,71E-06	2,38E-06
NHW	kg	4,62E+00	6,50E-02	1,79E-01
RW	kg	6,02E-04	2,96E-05	2,52E-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
CR	kg	0,00E+00	0,00E+00	0,00E+00
MR	kg	8,96E-01	0,00E+00	0,00E+00
MER	kg	0,00E+00	0,00E+00	0,00E+00
EEE	MJ	0,00E+00	0,00E+00	0,00E+00
ETE	MJ	0,00E+00	0,00E+00	0,00E+00

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

Reading example: 9,0 E-03 = $9,0*10^{-3}$ = 0,009

Additional Norwegian requirements

Greenhous gas emission from the use of electricity in the manufacturing phase
National production mix with import, on low woltage (included production of transmission lines, in addition to direct emissions and losses in grid) is applied for electricity in the manufacturing prosess (A3).

Data source	Process	Amount	Unit
Norway: (SoG-Si and block production), Ecoinvent v3.6	Medium voltage, NO	0,025	kg CO_2-ekv/kWh
USA: (SoG-Si production, USA), Ecoinvent v3.6	Medium voltage, US	0,654	kg CO_2-ekv/kWh

Dangerous substances

[X] The product contains no substances given by the REACH Candidate list or the Norwegian priority list[1]
[1]No substances as given by REACH are used or have been added to the production.

[ ] 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 (Avfallsforskiften, Annex III), see table.

Transport

Transport from production site to a construction site according to scenario A4:
A4a: Transport to Shanghai, China
A4b: Transport to Europe, Germany

Assumtions 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

Carbon footprint has not been worked out for the product

Bibliography

NS-EN ISO 14025:2010	*Environmental labels and declarations - Type III environmental declarations - Principles and procedures*
NS-EN ISO 14044:2006	*Environmental management - Life cycle assessment - Requirements and guidelines*
NS-EN 15804:2012+A1:2013	*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*
Ecoinvent v3.6	*Allocation, cut-off by classification, Swiss Centre of Life Cycle Inventories. https://www.ecoinvent.org/*
SimaPro	*LCA software, developed by PRé Sustainability https://simapro.com/*
NPCR Part A, 2017	*The Norwegian EPD Foundation, 07.04.2017. Construction Products and Services.*
NPCR 029, v1.1, Part B	*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*
Andvik, Oddbjørn Dahlstrøm et al (2020)	*LCA Rapport, 629959-01 Asplan Viak AS, REC Solar grade silicon, Ingot block*

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