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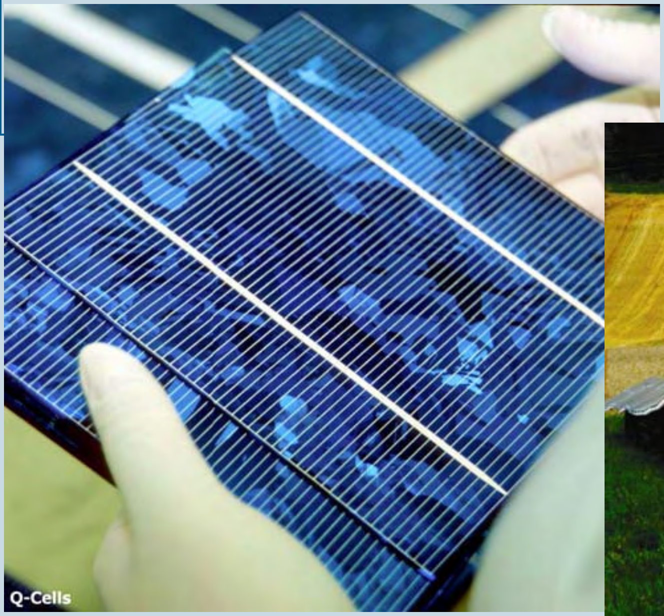
Life Cycle Inventories and Life Cycle Assessments of Photovoltaic Systems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PHOTOVOLTAIC
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PROGRAMME

Report IEA-PVPS T12-04:2015

INTERNATIONAL ENERGY AGENCY
PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

Life Cycle Inventories and Life Cycle Assessments of Photovoltaic Systems

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Operating agent:
Garvin Heath, National Renewable Energy Laboratory, Golden, CO, USA
Carol Olson, Energy Research Center of the Netherlands, Petten, The Netherlands

Authors:
Rolf Frischknecht, René Itten, Parikhit Sinha, Mariska de Wild-Scholten, Jia Zhang

Other Sections Previously Published by

Operating agent:

Vasilis Fthenakis, Brookhaven National Laboratory
Upton, New York, USA

Authors:

Vasilis Fthenakis, Hyung Chul Kim, Rolf Frischknecht, Marco Raugei, Parikhit Sinha and Matthias Stucki

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Executive Summary

Life Cycle Assessment (LCA) is a structured, comprehensive method of quantifying material- and energy-flows and their associated impacts in the life cycles of products (i.e., goods and services). One of the major goals of IEA PVPS Task 12 is to provide guidance on assuring consistency, balance, transparency and quality of LCA to enhance the credibility and reliability of the results. The current report presents the latest consensus LCA results among the authors, PV LCA experts in North America, Europe and Asia. At this time consensus is limited to five technologies for which there are well-established and up-to-date LCI data: mono- and multi-crystalline Si, CdTe CIGS, and high concentration PV (HCPV) using III/V cells. The LCA indicators shown herein include Energy Payback Times (EPBT), Greenhouse Gas emissions (GHG), criteria pollutant emissions, and heavy metal emissions.

Life Cycle Inventories (LCIs) are necessary for LCA and the availability of such data is often the greatest barrier for conducting LCA. The Task 12 LCA experts have put great efforts in gathering and compiling the LCI data presented in this report. These include detailed inputs and outputs during manufacturing of cell, wafer, module, and balance-of-system (i.e., structural- and electrical- components) that were estimated from actual production and operation facilities. In addition to the LCI data that support the LCA results presented herein, data are presented to enable analyses of various types of PV installations; these include operational data of rooftop and ground-mount PV systems and country-specific PV-mixes. The LCI datasets presented in this report are the latest that are available to the public describing the status in 2011 for crystalline Si, 2010-2011 for CdTe, 2010 for CIGS, and 2010 for HCPV technology.

This report provides an update of the life cycle inventory data in Section 5 of the previous report:
V. Fthenakis, H. C. Kim, R. Frischknecht, M. Raugei, P. Sinha, M. Stucki , 2011, Life Cycle Inventories and Life Cycle Assessment of Photovoltaic Systems, International Energy Agency(IEA) PVPS Task 12, Report T12-02:2011.

Updates are provided for the crystalline silicon PV global supply chain (Section 5.1), thin film PV module manufacturing (Sections 5.2-5.3), PV mounting structures (Section 5.5), and country-specific electricity grid mixes (Section 5.9). Other sections of this report are the same as in the previous report. Electronic versions of the updated tables in Section 5 are available at IEA PVPS (http://www.iea-pvps.org; select Task 12 under Archive) and treeze Ltd (http://treeze.ch; under Publications).

Foreword

The IEA PVPS is one of the collaborative R&D Agreements established within the IEA, and was established in 1993. The overall programme is headed by an Executive Committee composed of representatives from each participating country and/or organisation, while the management of individual research projects (Tasks) is the responsibility of Operating Agents. By early 2015, fifteen Tasks were established within the PVPS programme, of which six are currently operational.

The IEA PVPS Implementing Agreement presently has 29 members and covers the majority of countries active in photovoltaics, both in R&D, production and installation. The programme deals with the relevant applications of photovoltaics, both for on-grid and off-grid markets. It operates in a task-shared mode whereby member countries and/or organisations contribute with their experts to the different Tasks. The co-operation deals with both technical and non-technical issues relevant to a wide-spread use of photovoltaics in these different market segments.

The mission of the IEA PVPS programme is: “To enhance the international collaborative efforts which facilitate the role of photovoltaic solar energy as a cornerstone in the transition to sustainable energy systems.” The underlying assumption is that the market for PV systems is rapidly expanding to significant penetrations in grid-connected markets in an increasing number of countries, connected to both the distribution network and the central transmission network. At the same time, the market is gradually shifting from a policy to a business driven approach.

Task 12 aims at fostering international collaboration in safety and sustainability that are crucial for assuring that PV growth to levels enabling it to make a major contribution to the needs of the member countries and the world.

The overall objectives of Task 12 are to accomplish the following:

1. Quantify the environmental profile of PV in comparison to other energy- technologies;

2. Define and address environmental health & safety and sustainability issues that are important for market growth.

The first objective of this task is well served by life cycle assessments (LCAs) that describe the energy-, material-, and emission-flows in all the stages of the life of PV. The second objective will be addressed by assisting the collective action of PV companies in defining material availability and product-recycling issues, and on communicating "lessons learned" from incidents or potential ones in PV- production facilities. A third objective (i.e., dissemination) will be accomplished by presentations to broad audiences, producing simple fact sheets documented by comprehensive reports, and engaging industrial associations and the media in the spreading this information.

Within Task 12, there are three targets of Subtask 20 “Life Cycle Assessment”: To quantify the environmental profile of electricity produced with PV systems (compared to that from other sources); to show trends in the improvement of PV’s environmental profile; and, to assess this profile with the help of "external" costs, and other life-cycle-impact assessment methods.

Task 12 was initiated by Brookhaven National Laboratory under the auspices of the U.S. Department of Energy and is now operated jointly by the National Renewable Energy Laboratory (NREL) and Energy Center

of the Netherlands (ECN). Support from DOE and ECN are gratefully acknowledged. Further information on the activities and results of the Task can be found at: http://www.iea-pvps.org.

1. Introduction

Life Cycle Assessment (LCA) enables us to take into account the entire life cycle stages, from cradle to grave, in measuring environmental and resource sustainability. There has been continuous and remarkable progress in photovoltaic (PV) technologies during the last decade as governments and the industry stepped up investments in solar energy. Economies of scale and improvements in material utilization and process and module efficiencies have contributed to drastic reductions in production costs and to lower environmental footprints. In this report, we present major life cycle impact metrics (e.g., energy payback time and life cycle emissions) of commercial PV technologies for which detailed data are available. This report also includes the life cycle inventory data that were the building block of the reported LCA results. The results pertain to mono-and multi-crystalline Si, CdTe and high concentration (HC) PV for which up-to-date analyses have been performed. We also include in the report additional inventory data describing different mounting and system options. LCA results related to a-Si and CIGS technologies were not included as there are no LCI data available in the public domain supporting such. The LCA indicators we present in this report are: Energy Payback Times (EPBT), Greenhouse Gas (GHG) emissions, SO2, NOX and heavy metal emissions. Other indicators (e.g. resource availability, toxicity indicators) are relatively uncertain and lack consensus in the LCA community.

2. Life Cycle Assessment Overview

2.1 Life Cycle of PV

The life-cycle of photovoltaics starts from the extraction of raw materials (cradle) and ends with the disposal (grave) or recycling and recovery (cradle) of the PV components (Figure 1).

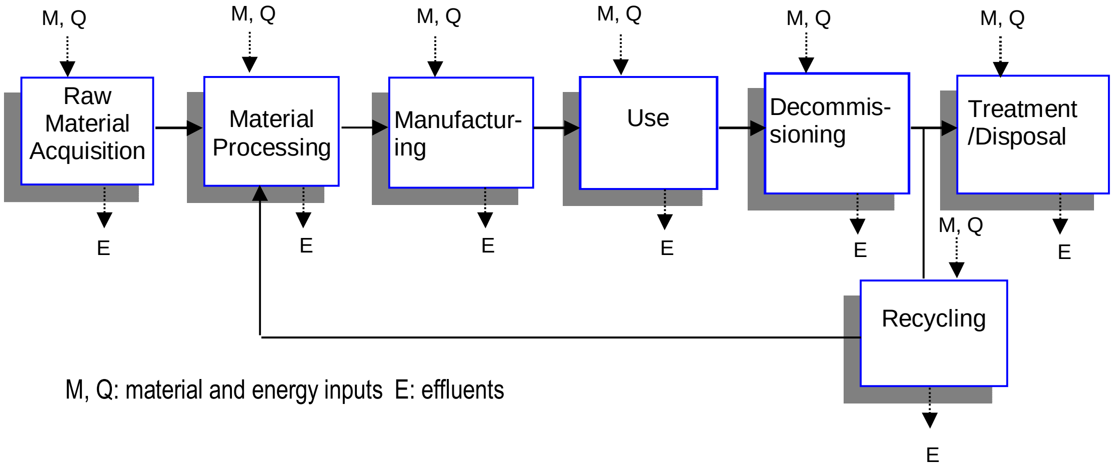

Figure 1: Flow of the life-cycle stages, energy, materials, and effluents for PV systems

The mining of raw materials, for example, quartz sand for silicon PVs, is followed by further processing and purification stages, to achieve the required high purities, which typically entails a large amount of energy consumption. The silica in the quartz sand is reduced in an arc furnace to metallurgical-grade silicon, which must be purified further into solar grade silicon (>99.9999%), typically through a modified-Siemens process. Metal-grade cadmium and tellurium for CdTe PV is primarily obtained as a byproduct of zinc and copper smelters respectively, and further purification is required for solar-grade purity (>99.999%). Similarly, metals used in CIGS PV are recovered as byproducts; indium and gallium are byproducts of zinc mining while selenium is mostly recovered from copper production.

The raw materials include those for encapsulations and balance-of-system components, for example, silica for glass, copper ore for cables, and iron and zinc ores for mounting structures. The manufacture of a bulk silicon PV device is divided into several steps, that is, wafer, cell, and module. In the wafer stage, solar-grade polycrystalline or single-crystal silicon ingots are sliced into ~0.2 mm thick wafers. During the cell stage, a p-n junction is formed by dopant diffusion and electric circuit is created by applying and sintering metallization pastes. In the module stage, cells are connected physically and electronically, and encapsulated by glasses and plastics. The manufacturing stage is relatively simple for thin-film PVs which typically rely on a series of semiconductor layer deposition followed by module fabrication steps (e.g., encapsulation) similar to those for silicon PVs. During the PV system installation stage, support structures are erected, PV systems are mounted, and PV modules, cables, and power conditioning equipment are integrated. At the end of their lifetime, PV systems are decommissioned and disposed with valuable parts and materials recycled.

2.2 *Life Cycle Assessment Indicators and Interpretation*

2.2.1 Primary Energy Demand

This is the cumulative primary energy demand throughout the life cycle of a PV system. Primary energy is defined as the energy embodied in natural resources (e.g., coal, crude oil, natural gas, uranium) that has not undergone any anthropogenic conversion and needs to be converted and transported to become usable energy [1].

2.2.2 Energy Payback Time

Energy payback time is defined as the period required for a renewable energy system to generate the same amount of energy (in terms of primary energy equivalent) that was used to produce the system itself.

Energy Payback Time (EPBT) = $(E_{mat}+E_{manuf}+E_{trans}+E_{inst}+E_{EOL}) / ((E_{agen} / \ _{G}) - E_{aoper})$
where,
E_{mat} : Primary energy demand to produce materials comprising PV system
E_{manuf} : Primary energy demand to manufacture PV system
E_{trans} : Primary energy demand to transport materials used during the life cycle

E_{inst} : Primary energy demand to install the system
E_{EOL} : Primary energy demand for end-of-life management
E_{agen} : Annual electricity generation
E_{aoper} : Annual energy demand for operation and maintenance in primary energy terms
$_{G}$: Grid efficiency, the average primary energy to electricity conversion efficiency at the demand side

Calculating the primary energy equivalent requires knowledge of the country-specific, energy-conversion parameters for fuels and technologies used to generate energy and feedstock. In the results presented in this report, the annual electricity generation (E_{agen}) is converted to the primary energy equivalent by means of the average conversion efficiency of 0.29 for the United States and 0.31 for Western Europe [2, 3].

2.2.3 Greenhouse Gas Emissions

The greenhouse gas (GHG) emissions during the life cycle stages of a PV system are estimated as an equivalent of CO2 using an integrated time horizon of 100 years; the major emissions included as GHG emissions are CO2 (GWP =1), CH4 (GWP=25), N2O (GWP=298) and chlorofluorocarbons (GWP=4750-14400) [4].

2.3 Literature Review

In early life-cycle studies, researchers estimated a wide range of primary energy consumption for Si-PV modules [5]: 2400-7600 and 5300-16500 MJ/m2 for multi-crystalline silicon (multi-Si) and mono-crystalline silicon (mono-si) modules. Besides the uncertainty in the data, these differences are due to different assumptions and allocation rules for modeling the purification and crystallization stages of silicon [5, 6]. Reject electronic-grade silicon collected during the Siemens process which produces silicon of over nine 9s purity (i.e. >99.9999999%), was often used for PV wafer manufacturing. This route was replaced by a dedicated solar-grade silicon purification process called modified-Siemens process in early 2000s, which requires far less energy than the former process. Allocating environmental burdens between off-spec electronic grade and on-spec solar grade silicon is debatable when both types of silicon are used in PV wafer. Selecting only those process steps needed to produce solar-grade silicon, Alsema estimated 4200 and 5700 MJ/m2 for multi- and mono-Si modules, respectively [5]. These values correspond to an energy payback time (EPBT, see section 2.1 for definition) of 2.5 and 3.1 years, and life-cycle GHG emissions of 46 and 63 g CO2-eq./kWh for rooftop mounted multi- Si PV with 13% efficiency and mono-Si with 14% efficiency, respectively, under Southern European (Mediterranean) conditions: insolation of 1700 kWh/m2/yr, and a performance ratio of 0.75. Meijer et al. [7] reported a slightly higher energy demand of 4900 MJ/m2 to produce a multi-Si module assuming that wafer is produced from electronic-grade silicon. With 14.5% cell efficiency, their corresponding EPBT estimate for the module was 3.5 years under the solar irradiation in the Netherlands (1000 kWh/m2/yr).

Jungbluth [8] reported the life-cycle metrics of various PV systems under environmental conditions in Switzerland assuming that the source of silicon materials was 50% from solar-grade silicon and 50% from electronic grade-silicon. For 300 µm-thick multi-Si and mono-Si PV modules with 13.2% and 14.8% conversion efficiency, respectively, this study arrived at 39-110 g CO2-eq./kWh of GHG emissions and 3-6 years of EPBT for the Swiss average insolation of 1100 kWh/m2/yr [6, 8], depending on configuration of PV systems (i.e., façade, slanted-roof, and flat-roof).

With material-inventory data from industry, Alsema and de Wild-Scholten [6] demonstrated that the life-cycle primary energy and greenhouse gas emission of complete rooftop Si-PV systems are much lower than those reported in earlier studies. Primary energy consumption is 3700 and 4200 MJ/m2, respectively, for multi- and mono- Si modules. Fthenakis and Alsema also report that the GHG emissions of multi- and mono-Si modules corresponding to 2004-2005 production are within a 37 and 45 g CO2-eq./kWh , with an EPBT of 2.2 and 2.7 years for a rooftop application under Southern European insolation of 1700 kWh/m2/yr and a performance ratio (PR) of 0.75 [9]. We note that in these estimates, the BOS for rooftop application accounts for 4.5-5 g CO2-eq./kWh of GHG emissions and 0.3 years of EPBT. De wild-Scholten [10] recently updated these estimates based on thinner modules and more efficient processes, reporting an EPBT of ~1.8 yrs and GHG emissions of ~30 g CO2-eq./kWh for both multi- and mono-Si PVs. Note that these figures include the effect of “take back and recycling” of PV modules but do not take into account the frame which is typically required for structural integrity in single glass modules.

There are fewer life-cycle studies of thin film PV technologies. Kato et al. (2001) in an early energy study of CdTe life cycle forecasted energy burdens of 1523, 1234, and 992 MJ/m2 for CdTe PV frameless modules with annual capacities of 10, 30, and 100 MWp , respectively[11]. However, these earlier estimates fall far short of present-day commercial-scale CdTe PV production that, unlike previously, now encompasses many large-scale production plants. Fthenakis and Kim (2006) estimated a life cycle energy consumption of 1200 MJ/m2, based on the actual 2005 production from First Solar’s 25 MWp prototype plant in Ohio, United States [9, 12]. The greenhouse-gas emissions (GHG) and energy payback time (EPBT) of ground-mounted CdTe PV modules under the average US insolation condition, 1800 kWh/m2/yr, were determined to be 24 g CO2-eq./kWh and 1.1 years, correspondingly. These estimates include 6 g CO2-eq./kWh of GHG and 0.3 year of EPBT contribution from the ground-mounted BOS [13]. Raugei et al. [14] estimated a lower primary energy consumption, ~1100 MJ/m2, and thereby less GHG emissions and lower EPBT than ours, based on the data of the year 2002 from Antec Solar’s 10 MWp plant in Germany. However, the latter estimates are obsolete as their plant ceased producing CdTe PV. Fthenakis et al. [18] recently updated these estimates based on data from First Solar’s plant in Frankfurt-Oder, Germany, reporting an EPBT of ~0.87 yrs and GHG emissions of ~18 g CO2-eq/kWh.

Amorphous silicon (a-Si) PV has been installed mostly as building integrated configuration. An early study by Lewis and Keoleian (1999) reported that for a-Si thin-film PV integrated in a building, the life cycle GHG emissions corresponded to 187.8 g CO2/kWh while the EPBT was 5.14 yrs [15]. This study assumed a 20-yr lifetime operation under the condition of Detroit, MI with a zero tilt angle that receives 1400 kWh/m2/yr of solar irradiation. Pacca et al (2007) recently assessed the life cycle environmental impact of a-Si PV systems on a rooftop in Ann Arbor, Michigan [16]. The installed a-Si PV array facing the south with a 12° tilt angle receives a solar irradiation of 1359 kWh/m2/yr in this location. The life cycle CO2 emissions from the a-Si PV module with 6.3% efficiency corresponded to 34.3 g/kWh over a 20-yr lifetime. Note that this estimate takes into account an assumed degradation of module efficiency of 1.1% per year.

Note that this picture is not a static one and it is expected that improvements in material and energy utilization and recycling will continue to improve the environmental profiles. For example, a recently introduced recycling process for the sawing slurry used in the wafer cutting recovers 80-90% of the silicon carbide and polyethylene glycol [17]. Also, any increases in the electric-conversion efficiencies of the modules will entail a proportional improvement of the EPBT.

3. LCA of Current PV Technologies

With continuing efficiency growth and reduction of electricity use in the new production lines, Fthenakis et al (2009) updated CdTe PV's environmental indicators using new data from the plant in Perrysburg Ohio, and two studies based on data from the plant in Frankfurt-Oder, Germany [18]. Besides raising conversion efficiency, efforts have been made in reducing the thickness of silicon wafer used in PV modules to save expensive high grade silicon materials. De Wild-Scholten (2009) recently updated the EPBT and GHG emissions of bulk silicon PVs based on a new investigation under the Crystal Clear project [10]. In this study, the reduced thickness, enhanced conversion efficiency, and novel silicon feedstock and wafer processes were evaluated.

3.1 Energy Payback Time

Figure 2 presents the energy payback times (EPBTs) estimated from the currently-available in the public domain life cycle inventory (LCI) data (mostly 2006 status); these are shown in Tables 5.1.1 to 5.2.3 for modules and frames and in Tables 5.4.1 and 5.5.1.1 to 5.5.1.4 for balance of system (BOS) components. However, these LCI data do not represent the up-to-date EPBT status. For example, current technologies offer mono- and multi - Si wafers with a thickness of around 200 µm, while the 2006 LCI data describe wafers with 270-and 240-µm thicknesses, respectively. Figure 3 gives the latest EPBT estimates of three major commercial PV module types, i.e. mono-Si, multi-Si, and cadmium telluride (CdTe), by Fthenakis et al (2009) and de Wild Scholten (2009) [10, 18]. The LCI data corresponding to the new mono- and multi-Si PVs are not in the public domain. The poly silicon purification and multi-Si wafer production stage data are from REC Solar and may not be representative of industry averages. The wafer thickness for the analyzed system represents state-of-the-art designs corresponding to 180 and 200 µm for mono- and multi-crystalline Si. For CdTe, the estimate is an average of two studies based on data from First Solar's plant in Frankfurt-Oder, Germany. First Solar is by far the biggest CdTe PV manufacturer and therefore, their data are currently representative of the entire CdTe PV industry;

note that the current module efficiency (11.7%) is higher than the efficiency corresponding to figures 2 and 3. The ribbon-Si estimates were removed from the latest comparison lacking verified data. Take back and recycling stages have not been included. The latest EPBT typical rooftop installation in south Europe, (i.e., irradiation of 1700 kWh/m2/yr), correspond to 1.7, 1.7 and 0.8 yrs for mono-Si, multi-Si, and CdTe PV technologies, respectively.

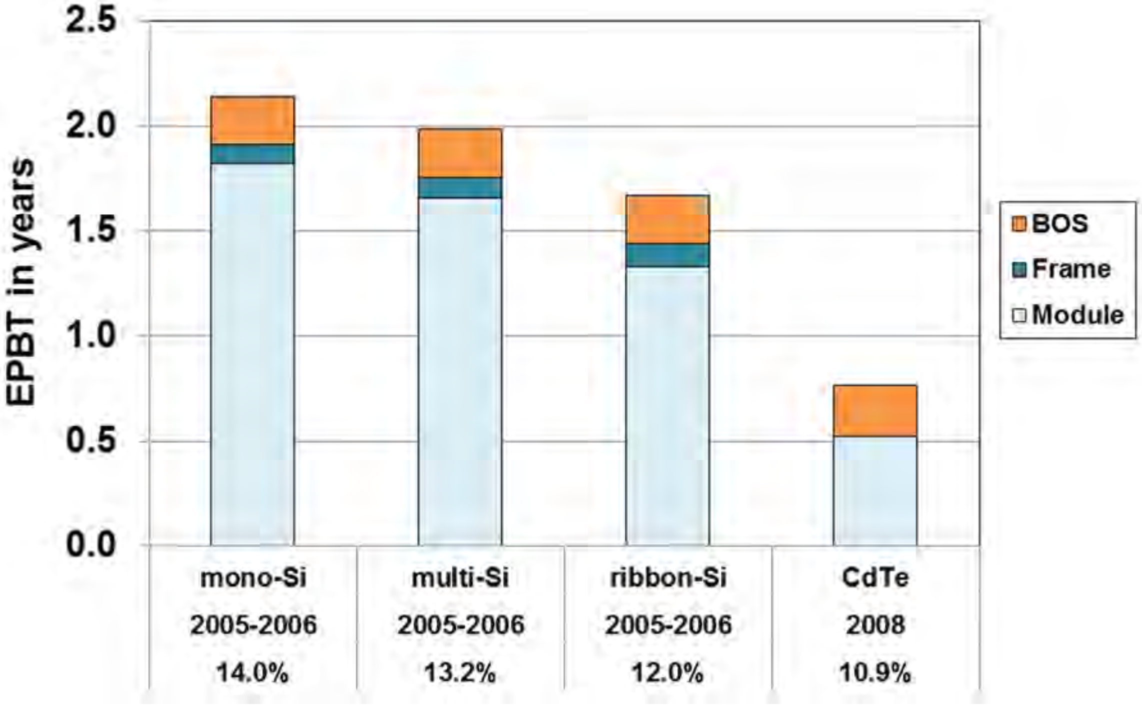

Figure 2: Energy payback time (EPBT) of rooftop mounted PV systems estimated from the currently available LCI data for European production and installation. The estimates are based on Southern European irradiation of 1700 kWh/m2/yr and performance ratio of 0.75. See Tables 5.1.1-5.2.3, 5.4.1, and 5.5.1.1-5.5.1.4 for the corresponding LCI data.

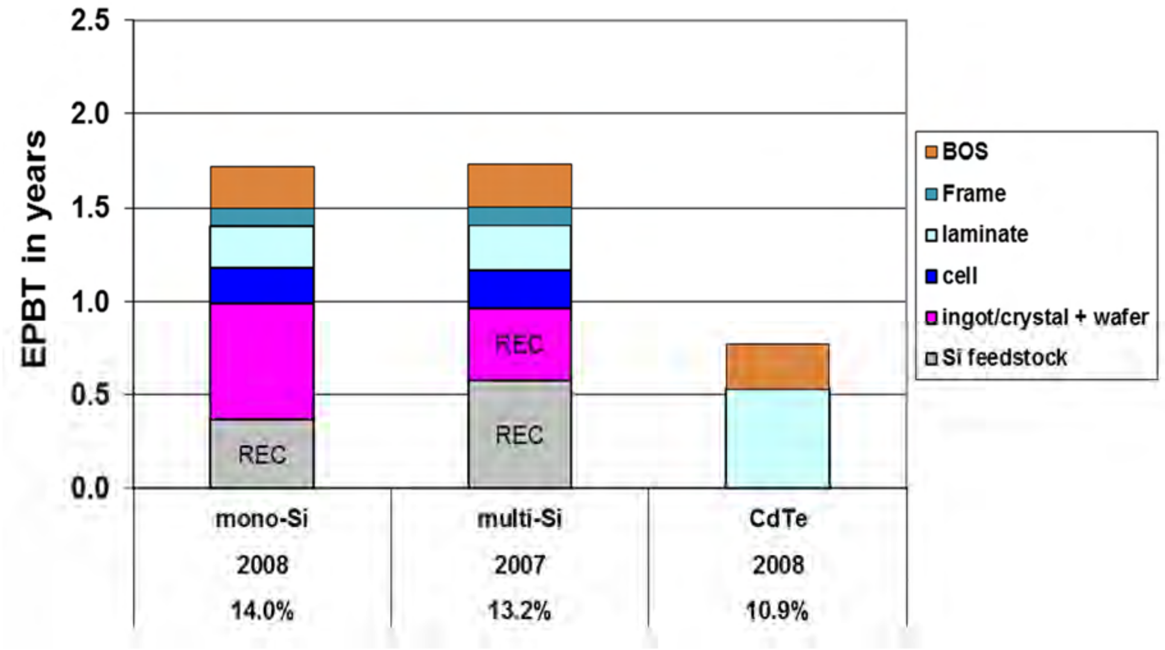

Figure 3: Energy payback time (EPBT) of rooftop mounted PV systems for European production and installation under Southern European irradiation of 1700 kWh/m2/yr and performance ratio of 0.75. Data adapted from de Wild Scholten (2009) and Fthenakis et al. (2009) [6, 18]. They were harmonized for system boundary and performance ratios, according to IEA Task 12 LCA Methodology Guidelines. REC corresponds to REC product-specific Si production; the corresponding LCI data are not publically available.

3.2 *Greenhouse Gas Emissions*

Figure 4 presents the GHG emissions per kWh generated for crystalline silicon and CdTe PV technologies estimated based on the same available LCI data under the same condition as for Figure 2, with an expected lifetime of 30 yrs [10, 18]. Note that the GHG estimates of 30-37 g CO2-eq./kWh for Si PV technologies do not represent the current level of carbon footprint for the same reason described above. Figure 5 gives the latest estimates by Fthenakis et al (2009) and de Wild Scholten (2009) [10, 18], which are 29, 28 and 18 g CO2-eq./kWh for mono-Si, multi-Si and CdTe respectively. These figures indicate that for silicon PV, 30-40% reductions in EPBT and GHG emissions from the previous estimates by Fthenakis and Alsema (2006) and Fthenakis et al (2008) [9, 12]. For CdTe, the EPBT is 35% lower while the GHG emissions are 30% lower than the previous estimates by Fthenakis and Kim (2006), reflecting the efficiency growth and reduction of electricity use in the new production lines [19].

Since the major parameters of the PV technologies including conversion efficiency, wafer thickness, material utilization are continuously improving, even the latest estimates in Figures 3 and 5 may not represent the current data, warranting timely updates of these indicators.

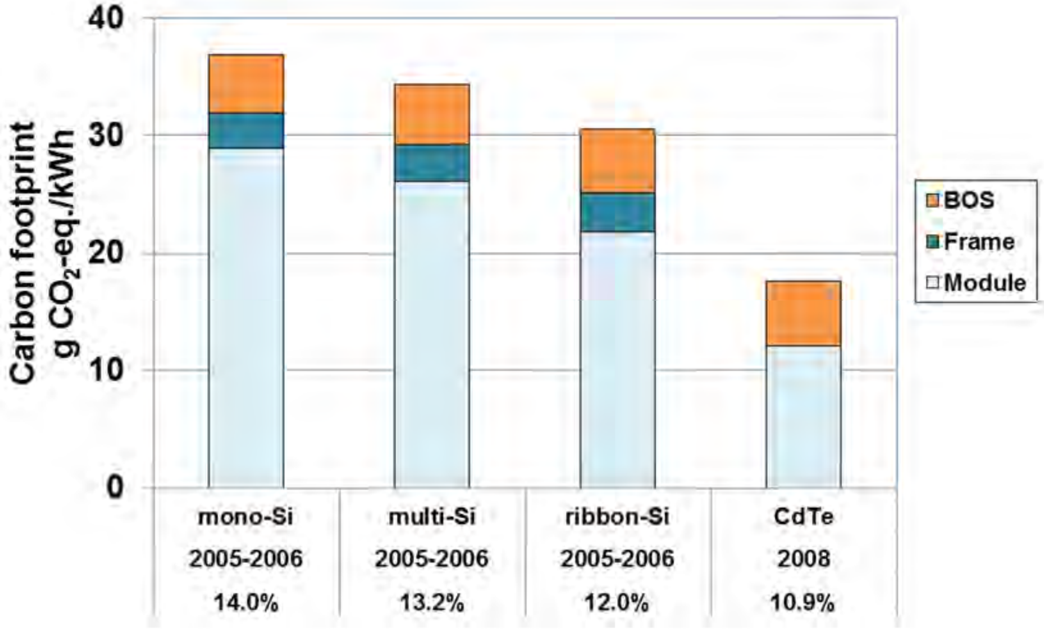

Figure 4: Greenhouse gas (GHG) emissions of rooftop mounted PV systems estimated from the currently available LCI data for European production and installation. The estimates are based on Southern European irradiation of 1700 kWh/m2/yr and performance ratio of 0.75. See Tables 5.1.1-5.2.3, 5.4.1, and 5.5.1.1-5.5.1.4 for the corresponding LCI data.

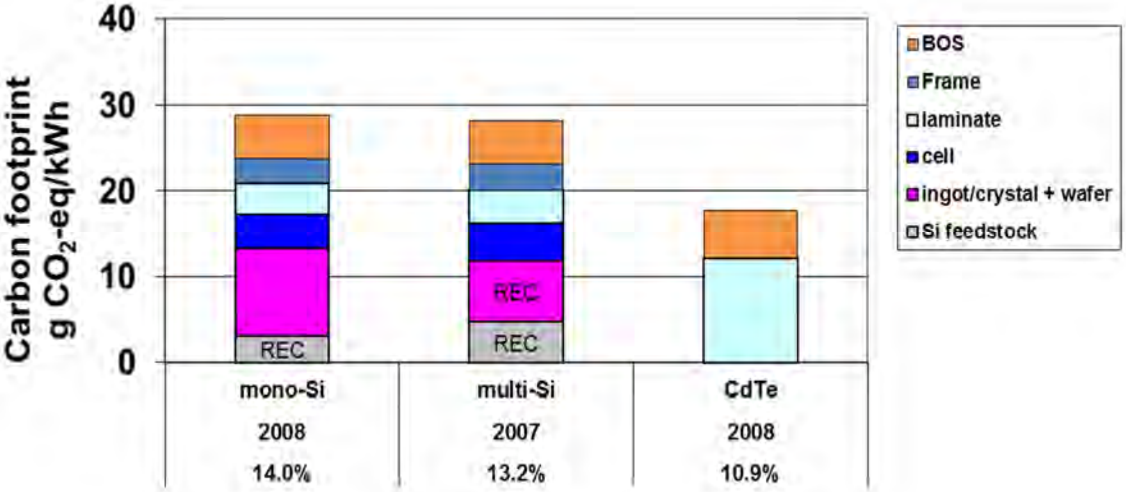

Figure 5: Life cycle GHG emissions from rooftop mounted PV systems for European production and installation under Southern European irradiation of 1700 kWh/m2/yr, performance ratio of 0.75, and lifetime of 30 yrs. Data adapted from de Wild Scholten (2009) and Fthenakis et al (2009) [10, 18]. They were harmonized for system boundary and performance ratios, according to IEA Task 12 LCA Methodology Guidelines. REC corresponds to REC product-specific Si production; the corresponding LCI data are not publically available.

It is noted that all these indicators strongly depend on the location of the PV system operation and the locations of the supply chain. For operation in the US-South west (e.g., irradiation 2400 kWh/m2/yr), all indicators per kWh would be lower, whereas for operation in central Europe (e.g., irradiation 1100 kWh/m2/yr), they will be higher.

The Sustainability Working Group of the European Photovoltaic Industry Association (EPIA) develops fact sheets aiming at dissemination of factual information on the contribution of PV to sustainable development. At the time of publication of this report, the Working Group had developed two fact sheets, one related to the Energy Payback Time [20] and one related to Greenhouse Gas Emissions [21].

3.3 Criteria Pollutant Emissions

The emissions of criteria pollutants (e.g., SO_2, NO_x, particulates) during the life cycle of a PV system are largely proportional to the amount of fossil fuel burned during its various phases, in particular, PV material processing and manufacturing; therefore, the emission profiles are close to those of the greenhouse gas emissions. Figure 6 shows the life-cycle NOx emissions of three major technologies and Figure 7 Shows the corresponding SO2 emissions. Toxic gases and heavy metals can be emitted directly from material processing and PV manufacturing, and indirectly from generating the energy used at both stages.

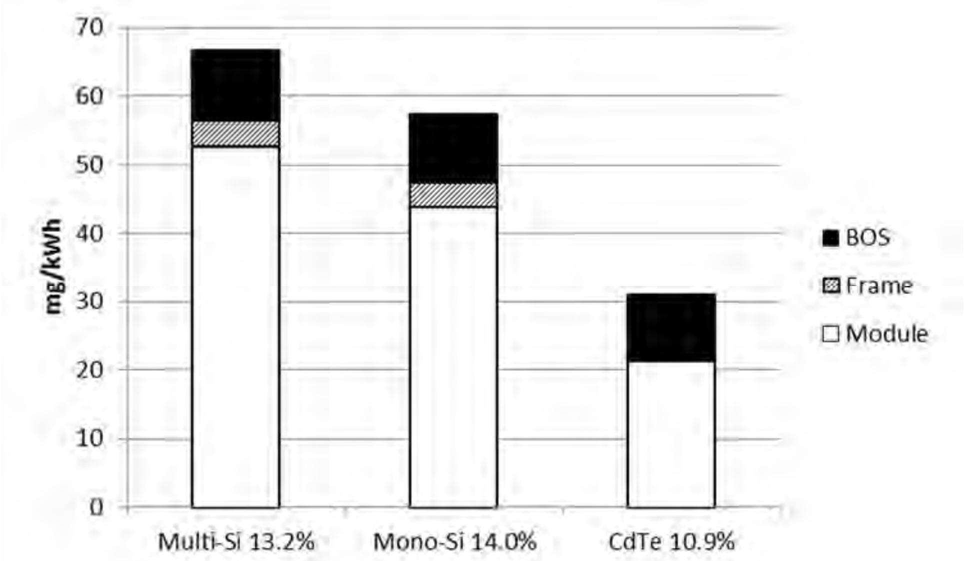

Figure 6: Life-cycle NO_x emissions from silicon and CdTe PV modules, wherein BOS is the Balance of System (i.e., module supports, cabling and power conditioning). The estimates are based on rooftop-mount installation, Southern European insolation, 1700 kWh/m2/yr, a performance ratio of 0.75, and a lifetime of 30 years. It is assumed that the electricity supply for all the PV system is from the European Network of Transmission System Operators for Electricity (ENTSO-E, former UCTE) grid.

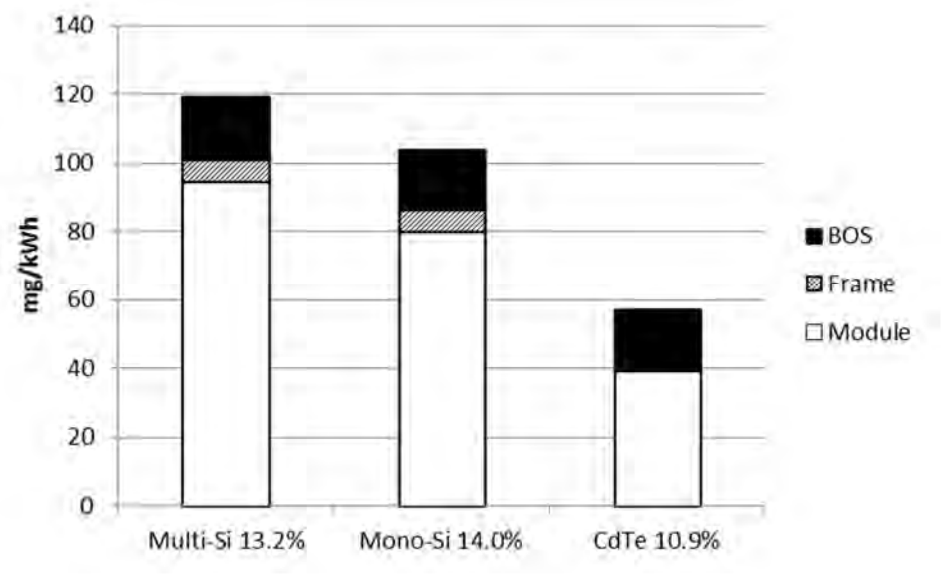

Figure 7: Life-cycle SO_2 emissions from silicon and CdTe PV modules, wherein BOS is the Balance of System (i.e., module supports, cabling and power conditioning). The estimates are based on rooftop-mount installation, Southern European insolation, 1700 kWh/m2/yr, a performance ratio of 0.75, and a lifetime of 30 years. It is assumed that the electricity supply for all the PV system is from the ENTSO-E grid.

Accounting for all the emissions is necessary to create a complete picture of the environmental impact of a technology. An interesting example of accounting for the total emissions is that of cadmium flows in CdTe and other PV technologies, as discussed next.

3.4 Heavy Metal Emissions

3.4.1 Direct Emissions

Direct emissions of heavy metals could occur during the mining and processing of precursor materials and during manufacturing of PV modules. Such emissions of cadmium in the life cycle of CdTe PV have been studied in detail by Fthenakis [19]. Cadmium is a byproduct of zinc and lead, and is collected from emissions and waste streams during the production of these major metals. The largest fraction of cadmium, with ~99.5% purity, is in the form of a sponge from the electrolytic recovery of zinc. This sponge is transferred to a cadmium-recovery facility, and is further processed through oxidation and leaching to generate a new electrolytic solution. After selectively precipitating the major impurities, cadmium of 99.99% purity is recovered by electrowinning. It is further purified by vacuum distillation to the five 9s purity required for CdTe PV manufacturing. The emissions during each of these steps are detailed elsewhere [22]. They total to 0.02 g per GWh of PV-produced electricity under Southern European condition. Gaseous cadmium emissions during the lifespan of a finished CdTe module are negligible; the only conceivable pathway of release is if a fire breaks out. Experiments at Brookhaven

National Laboratory that simulated fire conditions revealed that CdTe is effectively contained within the glass-to-glass encapsulation during the fire, and only minute amounts (0.4-0.6%) of Cd are released [23].

3.4.2 Indirect Emissions

The indirect emissions here are those emissions associated with the production of energy used in mining and industrial processes in the PV life cycle. Reporting indirect emissions separately from direct ones not only improves transparency in analyses but also allows calculating emissions for a certain mix of energy options as shown in a recent study by Reich et al (2011) [24]. Coal and oil-fired power plants routinely generate Cd during their operation, as it is a trace element in both fuels. According to the US Electric Power Research Institute's (EPRI's) data, under the best/optimized operational and maintenance conditions, burning coal for electricity releases between 2 to 7 g of Cd/GWh into the atmosphere [25]. In addition, 140 g/GWh of Cd inevitably collects as fine dust in boilers, baghouses, and electrostatic precipitators (ESPs). Furthermore, a typical US coal-powered plant emits per GWh about 1000 tons of CO_2, 8 tons of SO_2, 3 tons of NO_x, and 0.4 tons of particulates. The emissions of Cd from heavy-oil burning power plants are 12-14 times higher than those from coal plants, even though heavy oil contains much less Cd than coal (~0.1 ppm), because these plants do not have particulate-control equipment. Cadmium emissions also are associated with natural gas and nuclear fuel life-cycles because of the energy used in the associated fuel processing and material productions [2].

We accounted for Cd emissions in generating the electricity used in producing a CdTe PV system [32]. The assessment of electricity demand for PV modules and BOS was based on the life cycle inventory of each module and the electricity input data for producing BOS materials. Then, Cd emissions from the electricity demand for each module were assigned, assuming that the life-cycle electricity for the silicon- and CdTe-PV modules was supplied by the European Network of Transmission System Operators for Electricity (ENTSO-E) grid. The indirect Cd emissions from electricity usage during the life-cycle of CdTe PV modules (i.e., 0.2 g/GWh) are an order-of- magnitude greater than the direct ones (routine and accidental) (i.e., 0.016 g/GWh).

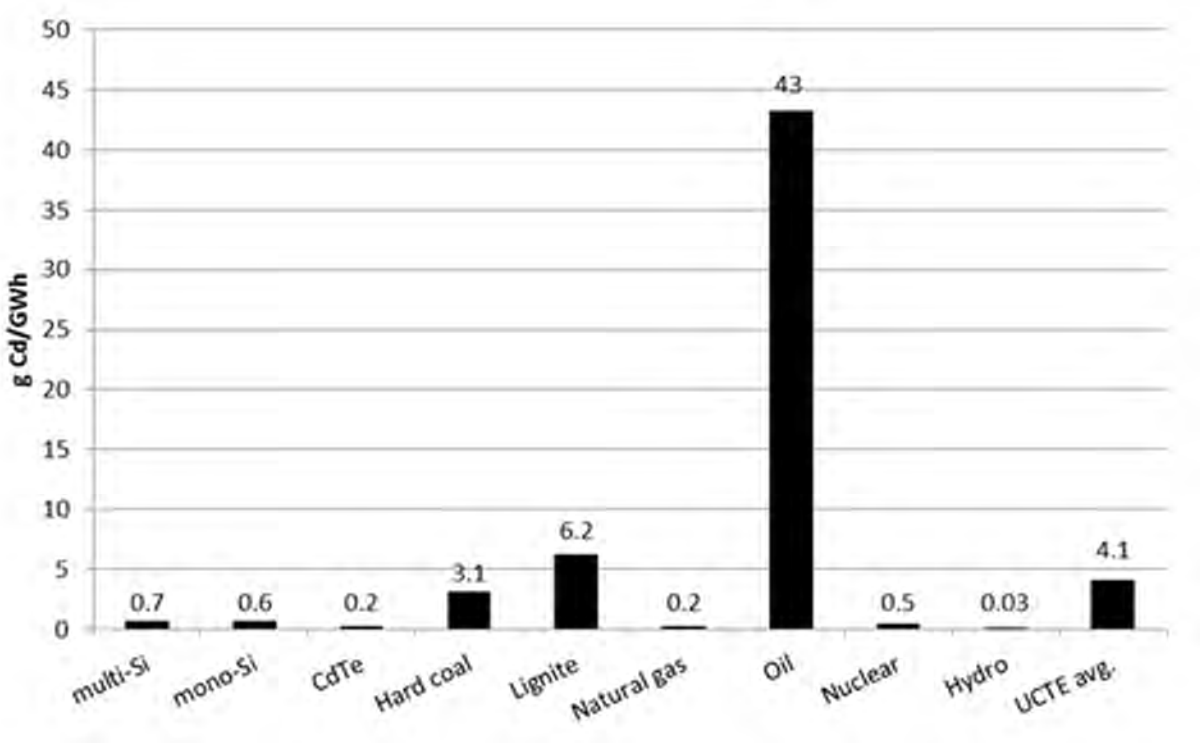

Figure 8: Life cycle atmospheric Cd emissions for PV systems from electricity and fuel consumption, normalized for a Southern Europe average insolation of 1700 kWh/m2/yr, performance ratio of 0.8, and lifetime of 30 yrs. A ground-mounted BOS is assumed for all PV systems [12].

The complete life-cycle atmospheric Cd emissions, estimated by adding those from the electricity and fuel demand associated with manufacturing and materials production for various PV modules and Balance of System (BOS), are compared with the emissions from conventional electricity generating technologies (Figure 8) [12]. Undoubtedly, displacing fossil-fuel-based power generation with Cd PV solar farms lowers the amount of Cd released into the air. Thus, every GWh of electricity generated by CdTe PV modules can prevent around 4 g of Cd air emissions if they are used instead of, or as a supplement to, the ENTSO-E grid. Also, the direct emissions of Cd during the life-cycle of CdTe PV are 10 times lower than the indirect ones due to electricity and fuel use in the same life-cycle, and about 30 times less than those indirect emissions from crystalline photovoltaics [9]. Furthermore, we examined the indirect heavy metal emissions in the life-cycle of the three silicon technologies discussed earlier, finding that, among PV technologies; CdTe PV with the lowest energy payback time has the fewest heavy metal emissions (Figure 9) [12].

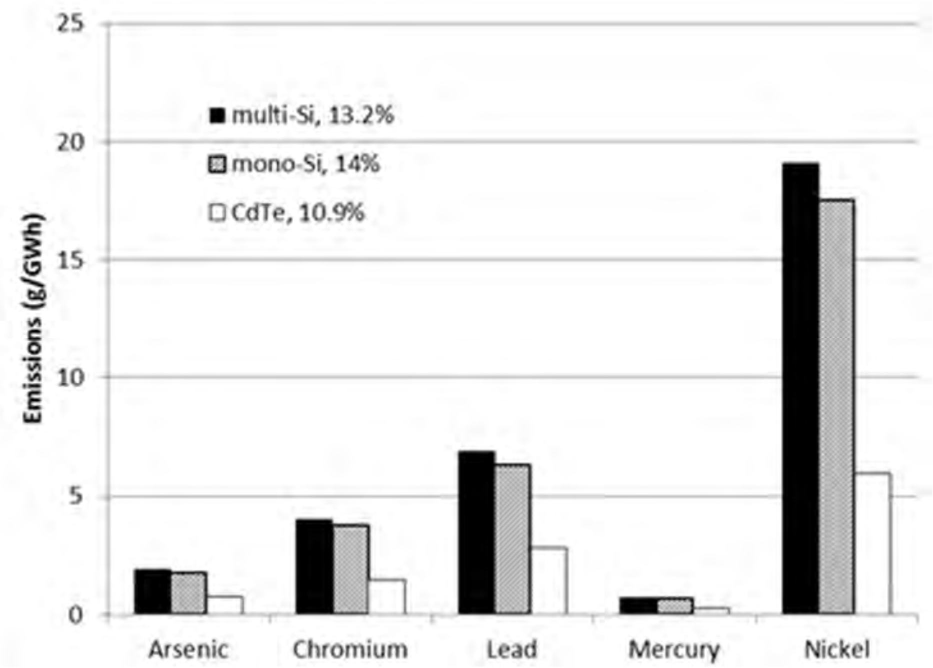

Figure 9: Emissions of heavy metals due to electricity use, based on European ENTSO-E average (ecoinvent database). Emissions are normalized for Southern European average insolation of 1700 kWh/m2/yr, performance ratio of 0.8, and lifetime of 30 yrs. Each PV system is assumed to include the ground-mounted BOS (Mason et al. [13]).

4. Life Cycle Inventories

4.1 Overview

The Life cycle inventory phase of LCA involves data compilation of materials and energy inputs, and emissions and product outputs for the complete life cycle of the system under analysis. For PV LCA these data are separately collected or modeled for the modules and the balance of system (BOS).

4.2 Modules

The material and energy inputs and outputs during the life cycles of Si PVs, viz., multi-Si, mono-Si, and also thin-film CdTe PV, were investigated in detail based on actual measurements from PV production plants. Alsema and de Wild-Scholten recently updated the life cycle inventory (LCI) for the technology for producing crystalline silicon modules in Western Europe under the framework of the Crystal Clear project, an European Integrated Project focusing on crystalline silicon technology, co-funded by the European Commission and the participating countries [6, 26].

The typical thickness of multi- and mono-Si PV is 200 and 180 µm, respectively; 60 individual cells of 243 cm2 (156 mm x156 mm) comprise a module of 1.6 m2 for all Si PV types. The conversion efficiency of multi- and mono-Si module is taken as 13.2%, and 14.0%, respectively. On the other hand, as of 2009, First Solar manufactures frameless, double-glass, CdTe modules of 1.2 m by 0.6 m, which are rated at 10.9% photon-to-electricity conversion efficiency with ~3 µm thick active layer. In 2010, conversion efficiency increased to 14.2%, 14.5%, and 11.3% for multi-Si, mono-Si, and CdTe modules, respectively.[1]

The data for Si PVs extend from the production stage of solar-grade Si to the module manufacturing stage, and those for CdTe PV correspond to the production of 99.999% CdTe, deposition of the CdTe film and the module's manufacturing stages.

4.2.1 Crystalline–Si PV

Detailed LCI of crystalline silicon modules for polycrystalline silicon feedstock purification, crystallization, wafering, cell processing, and module assembly for the status of 2005/2006 in Western Europe was completed within the "CrystalClear" European Commission project. The sources of LCI data for this project include 11 commercial European and U.S. photovoltaic module manufacturing companies supplemented by numbers from the literature. Such data are presented in this report (section 5. Life Cycle Inventory Data). However, we note that they do not represent the state-of-the art Si modules with a wafer thickness of ~200 µm.

The metallurgical-grade silicon that is extracted from quartz is purified into solar-grade polysilicon by either a silane (SiH4) or trichlorosilane (SiHCl3)-based process. The energy requirement for this purification step is significant for crystalline Si PV modules, accounting for ~30% of the primary energy used for fabricating multi-Si modules [27]. Two technologies are currently employed for producing polysilicon from silicon gases: the Siemens reactor method and the fluidized bed reactor (FBR) method. In the former, which accounts for the majority (~90% in 2004) of solar-grade silicon production in the US, silane- or trichlorosilane-gas is introduced into a thermal decomposition furnace (reactor) with high temperature (~1100-1200 °C) polysilicon rods [28-30]. The silicon rods grow as silicon atoms in the gas deposit onto them, up to 150 mm in diameter and up to 150 cm in length [27]. The data on Si PVs in Section 5.1 are based on averages over standard and modified Siemens reactors. The scenario involving the scrap silicon from electronic-grade silicon production is not considered as the market share of this material accounts for only 5% in 2005 [31].

4.2.2 CdTe PV

The LCI data were obtained at First Solar's CdTe PV manufacturing plant in Perrysburg, OH with a 25-MW production capacity for the period of Jan 1 - May 31, 2005 [19]. The electricity usage was updated in 2008 from data obtained at First Solar's plant in Frankfurt, Germany [18]. Chemicals and water data have also been updated since the first data collection. The CdTe module electricity conversion efficiency

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[1] Source for Si PV: Mehta, S. 2010. PV Technology, Production and Cost Outlook: 2010 – 2015. GTM Research; Source for CdTe PV: First Solar. 2011. Key Quarterly Financial Data. (Available at: www.firstsolar.com)

was 9% in yr 2005, and 11% in 2010. The cadmium telluride (CdTe) absorber layer and cadmium sulfide (CdS) window layer in First Solar's production scheme are laid down by vapor transport deposition (VTD), based on subliming the powders and condensing the vapors on glass substrates. A stream of inert carrier gas guides the sublimed dense vapor cloud to deposit the films on glass substrates at 500–600 °C. Depositing layers of common metals followed by series of scribing and heat treatment forms interconnections and back contacts.

4.3 High Concentration PV (HCPV)

The LCI data for Amonix 7700 HCPV was compiled on February 2010 updating the previous LCI of previous 25 kW Amonix system. The Amonix 7700 HCPV system consists of seven concentrating module units called MegaModules mounted on a two-axis tracker. Sunlight is concentrated on to 7560 focal spots at a rate of 500:1. This system uses multi-junction GaInP/GaInAs/Ge cells grown on a germanium substrate rated at 37% efficiency under the test condition of $50W/cm^2$, 25°C, and AM 1.5D. With an aperture area of 267 m^2, the capacity of this unit corresponds to 53 kW_p AC power. While the measurements of the mass of manufactured parts were taken directly from the assembly line, the quantity of concrete used was calculated by the dimensions of the foundation. The detailed material compositions of electrical parts, i.e., motor, transformer, and inverter, were estimated from Mason et al (2006) [13]. The LCI includes materials used in scheduled maintenance over an expected lifetime of 30 years which include changing the hydraulic- and bearing-oils, cleaning the lens, and changing the air- and oil-filters.

4.4 Balance of System (BOS)

Little attention has been paid to the LCA studies of the balance of system (BOS), and so inventory data are scarce. Depending on the application, solar cells are either rooftop- or ground-mounted, both operating with a proper balance of system (BOS). Silicon modules need an aluminum frame of 2.6 kg per m2 for structural robustness and easy installation, while a glass backing performs the same functions for the CdTe PV produced in the US [6, 19]. For a rooftop PV application, the BOS typically includes inverters, mounting structures, cable and connectors. Large-scale ground-mounted PV installations require additional equipment and facilities, such as grid connections, office facilities, and concrete.

4.4.1 Mounting structures

Life cycle inventory datasets of the following types of photovoltaic mounting systems are established in compliance with the ecoinvent quality guidelines v2.2 as part of the Swiss contribution to the IEA PVPS Task 12:

- *Mounting on façade*
- *Integrating in façade*
- *Mounting on flat roof*
- *Mounting on slanted roof*
- *Integrating in slanted roof*
- *Mounting on open ground*

The inventory data are based on manufacturer information and literature. The amount of materials of each type of mounting system is weighted based on the average mass per type calculated from a European market overview in 2008. The open ground mounting systems considered have a foundation of profiles that are piled into the ground and not a concrete foundation [32]. The inventory data in this report are slightly simplified and do not reflect one-to-one the original ecoinvent datasets. In case of any uncertainties it is recommended to apply the original ecoinvent datasets.

4.4.2 Complete roof-top BOS

The LCI data of Balance-of-System components for year 2006 was collected by the project "Technologie-en Milieuverkenningen" with ECN project number 7.4750 financed by the Ministry of Economic Affairs, the Netherlands. De Wild-Scholten et al.[33] studied two classes of rooftop mounting systems based on a mc-Si PV system called SolarWorld SW220 with dimensions of 1001 mm x 1675 mm, 220 Wp: they are used for on-roof mounting where the system builds on existing roofing material, and in-roof mounting where the modules replace the roof tiles. The latter case is credited in terms of energy and materials use because roof tile materials then are not required. Section 5.4 details the LCI of several rooftop mounting systems, cabling, and inverters. Two types (500 and 2500 W) of small inverters adequate for rooftop PV design were inventoried. A transformer is included as an electronic component for both models. The amount of control electronics will become less significant for inverters with higher capacity (> 10 kW), resulting in less material use per PV capacity.

4.4.3 Complete ground mount BOS

A recent analysis of a large PV installation at the Springerville Generating Station in Arizona, USA [13] affords a detailed materials- and energy-balance for a ground-mounted BOS. The Springerville PV plant at the time of data collection had 4.6 MWp of installed PV modules, of which 3.5 MW were mc-Si PV modules. For this study, Tucson Electric Power (TEP) prepared the BOS bill of materials- and energy-consumption data for their mc-Si PV installations. The life expectancy of the PV metal support structures is assumed to be 60 years. Inverters and transformers are considered to last for 30 years, but parts must be replaced every 10 years, amounting to 10% of their total mass, according to well-established data from the power industry on transformers and electronic components. The inverters are utility-scale, Xantrex PV-150 models with a wide-open frame, allowing failed parts to be easily replaced. The life-cycle inventory includes the office facility's materials and energy use for administrative, maintenance, and security staff, as well as the operation of maintenance vehicles. Aluminum frames are shown separately, since they are part of the module, not of the BOS inventory; there are both framed and frameless modules on the market.

4.5 Medium-Large PV Installations in Europe

Within the framework of the ecoinvent database and the Swiss contribution to the IEA PVPS Task 12, life cycle inventory datasets of the following real photovoltaic installations are established:

- *93 kWp slanted-roof installation, single-Si laminates, Switzerland*
- *280 kWp flat-roof installation, single-Si panels, Switzerland*
- *156 kWp flat-roof installation, multi-Si panels, Switzerland*
- *1.3 MWp slanted-roof installation, multi-Si panels, Switzerland*
- *324 kWp flat-roof installation, single-Si panels, Germany*
- *450 kWp flat- roof installation, single-Si panels, Germany*
- *569 kWp open ground installation, multi-Si panels, Spain*
- *570 kWp open ground installation, multi-Si panels, Spain*

The inventory data are based on information from installers, operators, and literature. The inventories can be combined with information about mounting systems and silicon modules presented in this report [32]. The inventory data in this report are slightly simplified and do not reflect one-to-one the original ecoinvent datasets. In case of any uncertainties it is recommended to apply the original ecoinvent datasets.

4.6 Country specific photovoltaic mixes

Life cycle inventory datasets of 25 country specific photovoltaic electricity are established within the framework of the ecoinvent database and the Swiss contribution to the IEA PVPS Task 12. These are based on national and international statistics about the shares of different module technologies; the shares of different mounting systems, the share of centralized/decentralized installations, and country specific electricity yields that are dependent on solar irradiation[32].

The inventory data in this report are slightly simplified and do not reflect one-to-one the original ecoinvent datasets. In case of any uncertainties it is recommended to apply the original ecoinvent datasets.

5. Life Cycle Inventory Data

These data update those in section 5 of the report:
V. Fthenakis, H. C. Kim, R. Frischknecht, M. Raugei, P. Sinha, M. Stucki , 2011, Life Cycle Inventories and Life Cycle Assessment of Photovoltaic Systems, International Energy Agency(IEA) PVPS Task 12, Report T12-02:2011.

Updates are provided for the crystalline silicon PV global supply chain (Section 5.1), thin film PV module manufacturing (Sections 5.2-5.3), PV mounting structures (Section 5.5), and country-specific electricity grid mixes (Section 5.9). Electronic versions of the updated tables in Section 5 are available at IEA PVPS (http://www.iea-pvps.org; select Task 12 under Archive) and treeze Ltd (http://treeze.ch; under Publications).

Authors:
Rolf Frischknecht and René Itten, treeze Ltd., Uster, Switzerland, frischknecht@treeze.ch,
Parikhit Sinha, First Solar, Tempe, AZ, USA parikhit.sinha@firstsolar.com
Mariska de Wild-Scholten, SmartGreenScans, Groet, The Netherlands, mariska@smartgreenscans.nl
Jia Zhang, Institute of Electrical Engineering, Chinese Academy of Sciences, Beijing, China, zhangjia@mail.iee.ac.cn

Operating agents:
Garvin Heath, National Renewable Energy Laboratory, Golden, CO, USA, garvin.heath@nrel.gov
Carol Olson, Energy Research Center of the Netherlands, Petten, The Netherlands, olson@ecn.nl

Disclaimer:
The authors have assembled this LCI data set to the best of their knowledge and in their opinion it gives a reliable representation of photovoltaic module production technology. Although we have cross-checked the data from different users we cannot guarantee that it does not contain any errors. Therefore we cannot accept any responsibility for the use of these data.

5.1 Crystalline Si PV

5.1.1 Description of the supply chain

Figure shows the supply chain of photovoltaic electricity production according to Jungbluth et al. (2012) [38]. The already existing supply chains for Europe and China (Bauer et al. 2012 [36], Jungbluth et al. 2012 [38]) are extended with two more world regions, namely North America (US) and Asia & Pacific (APAC). Furthermore, world markets are introduced on the level of the production of polysilicon, the wafer production and the panel production. Additional descriptions of specific manufacturers in the crystalline Si PV supply chain and their manufacturing processes are available in de Wild-Scholten (2014) [40].

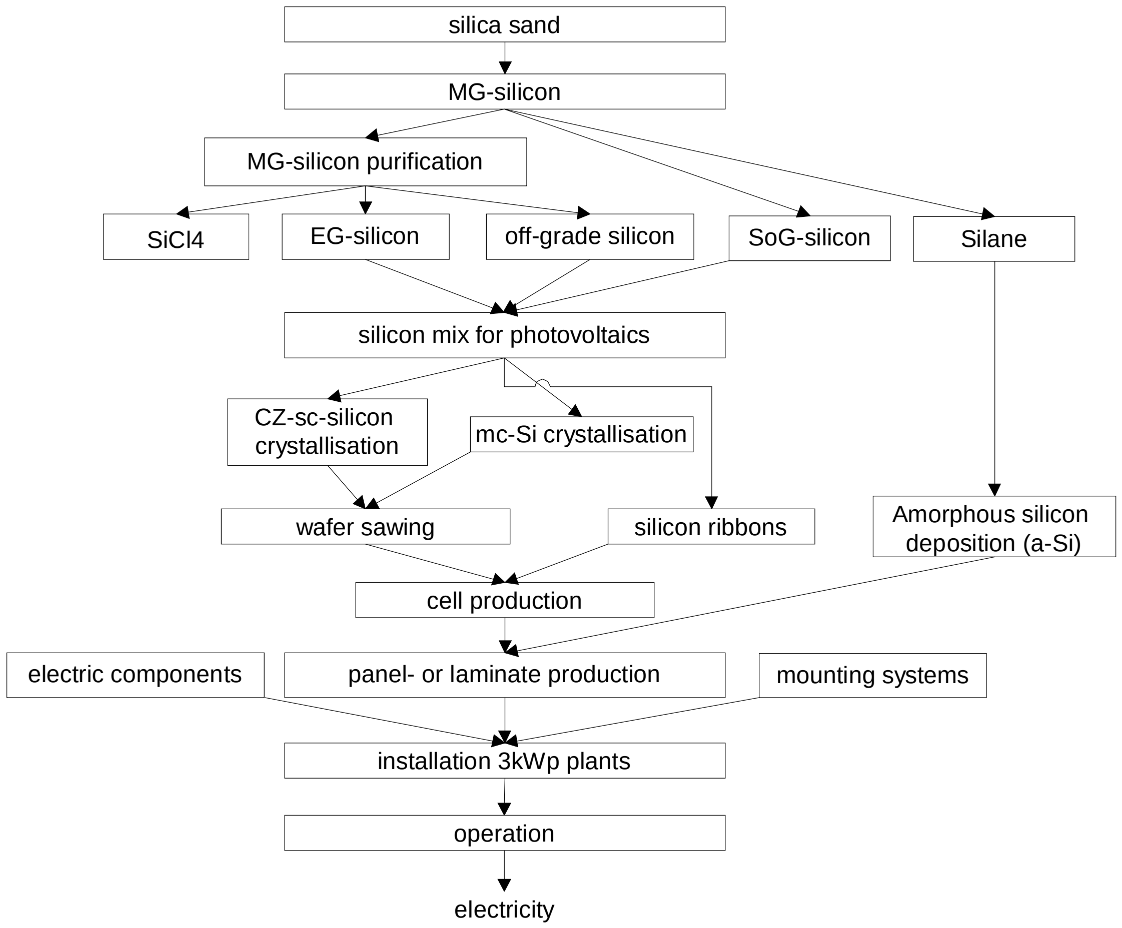
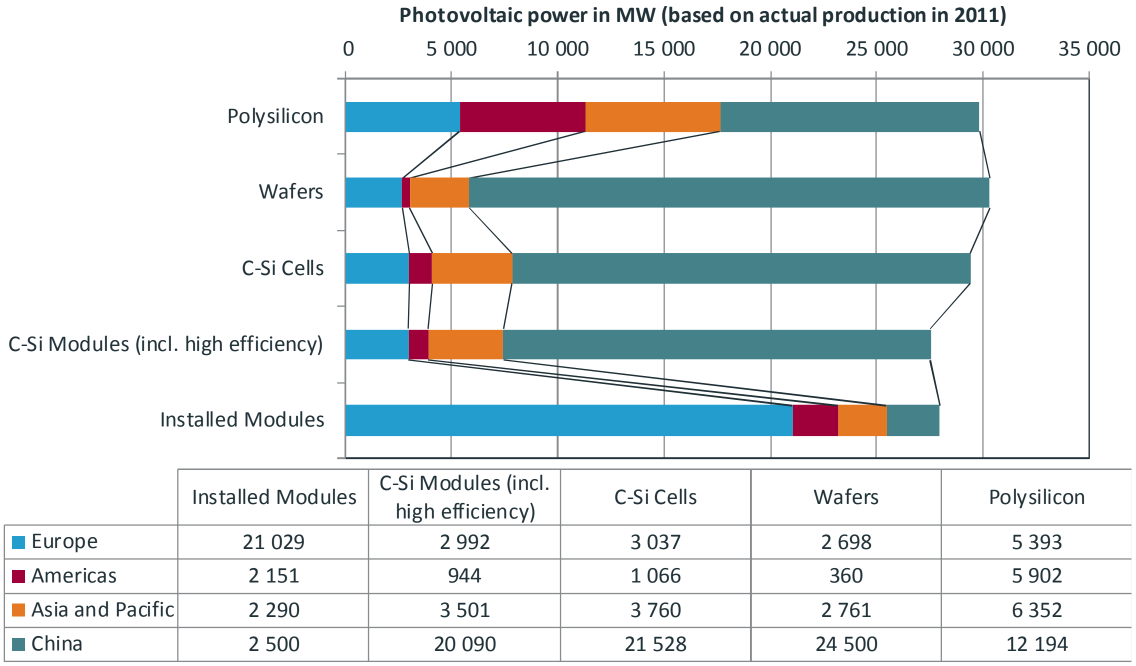


Figure 10 Supply chain of silicon based photovoltaic electricity production. MG-silicon: metallurgical grade silicon; EG-silicon: electronic grade silicon; SoG-silicon: solar-grade silicon; a-Si: amorphous silicon; CZ: Czochralsky; kWp: kilowatt peak (according to Jungbluth et al. (2012) [38]).

5.1.2 Market Mixes

Figure 11 shows the market shares of the four world regions on the different levels of the supply chain. The production is given in MW of photovoltaic power and based on the 2012 market report of the photovoltaic power systems programme (IEA-PVPS 2013 [37]). The amount of silicon in tonnes is converted to MW based on an average consumption of about 6’900 kg of polysilicon per MW of photovoltaic power capacity using supply chain data published in Jungbluth et al. (2012) [38]. The market shares of the different regions of the world have been cross-checked with the global market shares reported by EPIA (EPIA 2013 [39]). The values of the IEA-PVPS programme have been used for the actual calculation of the market shares, since this source provides absolute numbers on the market shares on all levels of the supply chain. The data are given on the country level and aggregated to the four world regions.

The polysilicon production is spread rather evenly across the four world regions with China having the highest share. China and Asia & Pacific contribute more than 60 % to the world market of polysilicon. Wafers, cells and modules are mainly produced in China (with a share of between 73% and 81 % of the world production) with Europe and Asia and Pacific each producing about 9 % of these products. The production in the Americas is of minor importance (about 1 % to 4 %). In contrast to production, which mainly takes place in China, photovoltaic modules are still mainly installed in Europe (>75 %), followed by China (9 %), Asia and Pacific (8 %) and the Americas (8 %).



	Installed Modules	C-Si Modules (incl. high efficiency)	C-Si Cells	Wafers	Polysilicon
🟦 Europe	21 029	2 992	3 037	2 698	5 393
🟥 Americas	2 151	944	1 066	360	5 902
🟧 Asia and Pacific	2 290	3 501	3 760	2 761	6 352
🟩 China	2 500	20 090	21 528	24 500	12 194

Figure 11 Market shares of the four world regions on polysilicon, wafer production, crystalline silicon cells and modules manufacture, and installed crystalline silicon modules, in MW power capacity

Tab. and Tab. 5.1.2.3 show the supply volumes and market shares derived from the information shown in Figure 11. The market shares are determined with the simplifying assumption that production volumes in Europe, the Americas, and Asia and Pacific are fully absorbed by the subsequent production step in the same region. Furthermore, it is assumed that the missing supply volumes are imported from China first and then from Asia & Pacific. Excess production is shipped to China in case of polysilicon and to the European Market in case of the (installed) modules.

Tab. shows the supply volumes and market mixes of polysilicon used in wafer production in China, the Americas, Asia and Pacific and Europe. All regions except China rely on their own production. The Chinese polysilicon supply mix corresponds to the surplus production volumes from the other regions available for export after covering their domestic demand.

Tab. 5.1.2.1Supply volumes and market mixes of polysilicon used in wafer production in China, the Americas, Asia and Pacific and Europe, and wafer production volumes as reported in EPIA (2013) [37]

	China		Americas		Asia and Pacific		Europe		Total
	MW	%	MW	%	MW	%	MW	%	MW
Europe	2 695	11.2%	0	0.0%	0	0.0%	2 698	100.0%	5 393
Asia and Pacific	3 591	14.9%	0	0.0%	2 761	100.0%	0	0.0%	6 352
Americas	5 542	23.1%	360	100.0%	0	0.0%	0	0.0%	5 902
China	12 194	50.8%	0	0.0%	0	0.0%	0	0.0%	12 194
Total	24 021	100.0%	360	100.0%	2 761	100.0%	2 698	100.0%	29 840
Wafer production	24 500	102.0%	360	100.0%	2 761	100.0%	2 698	100.0%	30 319

Tab. 5.1.2.2 shows the supply volumes and market mixes of wafers used in cell production in China, the Americas, Asia & Pacific and Europe. All wafers required in Chinese cell production are produced domestically. One third of the American wafer demand (as a feedstock to cell production in the Americas) is covered by American production. The remaining two thirds are imported from China. Three quarter of the wafer demand in Asia & Pacific are covered by domestic production. The remaining quarter is imported from China. In Europe wafer production covers 88.8 % of the demand. 11.2 % of the European wafer demand is imported from China to complement the domestic supply.

Tab. 5.1.2.2 Supply volumes and market mixes of wafers used in cell production in China, the Americas, Asia and Pacific and in Europe and production volume of cells

	China		Americas		Asia and Pacific		Europe		Total
	MW	%	MW	%	MW	%	MW	%	MW
Europe	0	0.0 %	0	0.0 %	0	0.0 %	2 698	88.8 %	2 698
Asia and Pacific	0	0.0 %	0	0.0 %	2 761	73.4 %	0	0.0 %	2 761
Americas	0	0.0 %	360	33.8 %	0	0.0 %	0	0.0 %	360
China	22 456	100 %	706	66.2 %	999	26.6 %	339	11.2 %	24 500
Cell production	21 528	95.9 %	1 066	100.0 %	3 760	100.0 %	3 037	100.0 %	29 391

Tab. 5.1.2.3 shows the supply volumes and market mixes of panels installed in China, the Americas, Asia & Pacific and Europe. Panels installed in Europe are produced in China (78 %), Europe (14 %) and Asia & Pacific (6 %). There is a slight deficit in modules produced in 2011. All panels installed in China are produced domestically. The same holds true for panels mounted in Asia & Pacific. In the Americas somewhat less than half of the installed modules are produced domestically, the rest is imported from China.

Tab. 5.1.2.3 Supply volumes and market mixes of panels installed in China, the Americas, Asia and Pacific and Europe.

	China		Americas		Asia and Pacific		Europe		Total
	MW	%	MW	%	MW	%	MW	%	MW
Europe	0	0.0 %	0	0.0 %	0	0.0 %	2 992	14.2 %	2 992
Asia and Pacific	0	0.0 %	0	0.0 %	2 291	100.0 %	1 210	5.8 %	3 501
Americas	0	0.0 %	944	43.9 %	0	0.0 %	0	0.0 %	944
China	2 500	100.0 %	1 207	56.1 %	0	0.0 %	16 383	77.9 %	20 090
Panels installed	2 500	100.0 %	2 151	100.0 %	2 291	100.0 %	20 586	97.9 %	27 527

5.1.3 General approach

The existing datasets describing the photovoltaic supply chain in Europe and China (Jungbluth et al. 2012) [38] are used as a basis for the life cycle inventories of the supply chain of the two new regions Americas and Asia & Pacific. The electricity consumption on all process levels is modelled with specific electricity mixes corresponding to these two world regions. The supply chains of the regions are modelled based on the market shares describe in Subchapter 5.1.2. All other inputs and outputs are not changed because of lacking information about the material, energy and environmental efficiencies of the production in the different world regions.

In addition, the LCI data of the single-crystalline silicon production, the multi-crystalline silicon production, the silicon wafer production, the silicon cell production, the silicon module production, the CIGS cell production and the CIGS module production are updated based on recent information published by de Wild-Scholten (2014) [40].

5.1.4 Basic silicon products

5.1.4.1 Metallurgical grade silicon

The first level in the photovoltaic supply chain is the production of metallurgical grade silicon (MG-silicon). Tab. 5.1.4.1.1 shows the unit process data of the MG-Silicon production in Europe (NO), China (CN), North America (US) and Asia & Pacific (APAC). European MG-silicon factories are located in Norway, which implies the Norwegian electricity mix. The South Korean electricity mix is selected for the APAC region, because South Korea produces the highest share of MG-Silicon in the APAC region. The US electricity mix is used to model electricity consumption in the North American production.

All other data about material and energy consumption as well as about emissions correspond to the life cycle inventory data of MG-silicon published by Jungbluth et al. (2012) [38].

Tab. 5.1.4.1.1 Unit process data of MG-Silicon production in Europe (NO), China (CN), North America (US) and Asia & Pacific (APAC).

	Name	Location	InfrastructureProcess	Unit	MG-silicon, at plant	MG-silicon, at plant	MG-silicon, at plant	MG-silicon, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				NO	CN	US	APAC			
	InfrastructureProcess				0	0	0	0			
	Unit				kg	kg	kg	kg			
product	MG-silicon, at plant	NO	0	kg	1	0	0	0			
	MG-silicon, at plant	CN	0	kg	0	1	0	0			
	MG-silicon, at plant	US	0	kg	0	0	1	0			
	MG-silicon, at plant	APAC	0	kg	0	0	0	1			
technosphere	electricity, medium voltage, at grid	NO	0	kWh	1.10E+1	0	0	0	1	1.10	(2,2,2,1,1,3); Literature, lower range to account for heat recovery
	electricity, medium voltage, at grid	CN	0	kWh	0	1.10E+1	0	0	1	1.10	(2,2,2,1,1,3); Literature, lower range to account for heat recovery
	electricity, medium voltage, at grid	US	0	kWh	0	0	1.10E+1	0	1	1.10	(2,2,2,1,1,3); Literature, lower range to account for heat recovery
	electricity, medium voltage, at grid	KR	0	kWh	0	0	0	1.10E+1	1	1.10	(2,2,2,1,1,3); Literature, lower range to account for heat recovery
	wood chips, mixed, u=120%, at forest	RER	0	m3	3.25E-3	3.25E-3	3.25E-3	3.25E-3	1	1.10	(2,2,2,1,1,3); Literature, 1.35 kg
	hard coal coke, at plant	RER	0	MJ	2.31E+1	2.31E+1	2.31E+1	2.31E+1	1	1.10	(2,2,2,1,1,3); Literature, coal
	graphite, at plant	RER	0	kg	1.00E-1	1.00E-1	1.00E-1	1.00E-1	1	1.10	(2,2,2,1,1,3); Literature, graphite electrodes
	charcoal, at plant	GLO	0	kg	1.70E-1	1.70E-1	1.70E-1	1.70E-1	1	1.10	(2,2,2,1,1,3); Literature
	petroleum coke, at refinery	RER	0	kg	5.00E-1	5.00E-1	5.00E-1	5.00E-1	1	1.10	(2,2,2,1,1,3); Literature
	silica sand, at plant	DE	0	kg	2.70E+0	2.70E+0	2.70E+0	2.70E+0	1	1.10	(2,2,2,1,1,3); Literature
	oxygen, liquid, at plant	RER	0	kg	2.00E-2	2.00E-2	2.00E-2	2.00E-2	1	1.29	(3,4,3,3,1,5); Literature
	disposal, slag from MG silicon production, 0% water, to inert material landfill	CH	0	kg	2.50E-2	2.50E-2	2.50E-2	2.50E-2	1	1.10	(2,2,2,1,1,3); Literature
	silicone plant	RER	1	unit	1.00E-11	1.00E-11	1.00E-11	1.00E-11	1	3.05	(1,2,2,1,3,3); Estimation
	transport, transoceanic freight ship	OCE	0	tkm	2.55E+0	2.55E+0	2.55E+0	2.55E+0	1	2.09	(4,5,na,na,na,na); Charcoal from Asia 15000km
	transport, lorry >16t, fleet average	RER	0	tkm	1.56E-1	1.56E-1	1.56E-1	1.56E-1	1	2.09	(4,5,na,na,na,na); Standard distance 50km, 20km for sand
	transport, freight, rail	RER	0	tkm	6.90E-2	6.90E-2	6.90E-2	6.90E-2	1	2.09	(4,5,na,na,na,na); Standard distance 100km
emission air, low population density	Heat, waste	-	-	MJ	7.13E+1	7.13E+1	7.13E+1	7.13E+1	1	1.10	(2,2,2,1,1,3); Calculation based on fuel and electricity use minus 25 MJ/kg
	Arsenic	-	-	kg	9.42E-9	9.42E-9	9.42E-9	9.42E-9	1	5.09	(3,4,3,3,1,5); Literature, in dust
	Aluminium	-	-	kg	1.55E-6	1.55E-6	1.55E-6	1.55E-6	1	5.09	(3,4,3,3,1,5); Literature, in dust
	Antimony	-	-	kg	7.85E-9	7.85E-9	7.85E-9	7.85E-9	1	5.09	(3,4,3,3,1,5); Literature, in dust
	Boron	-	-	kg	2.79E-7	2.79E-7	2.79E-7	2.79E-7	1	5.09	(3,4,3,3,1,5); Literature, in dust
	Cadmium	-	-	kg	3.14E-10	3.14E-10	3.14E-10	3.14E-10	1	5.09	(3,4,3,3,1,5); Literature, in dust
	Calcium	-	-	kg	7.75E-7	7.75E-7	7.75E-7	7.75E-7	1	5.09	(3,4,3,3,1,5); Literature, in dust
	Carbon monoxide, biogenic	-	-	kg	6.20E-4	6.20E-4	6.20E-4	6.20E-4	1	5.09	(3,4,3,3,1,5); Literature
	Carbon monoxide, fossil	-	-	kg	1.38E-3	1.38E-3	1.38E-3	1.38E-3	1	5.09	(3,4,3,3,1,5); Literature
	Carbon dioxide, biogenic	-	-	kg	1.61E+0	1.61E+0	1.61E+0	1.61E+0	1	1.10	(2,2,2,1,1,3); Calculation, biogenic fuels
	Carbon dioxide, fossil	-	-	kg	3.58E+0	3.58E+0	3.58E+0	3.58E+0	1	1.10	(2,2,2,1,1,3); Calculation, fossil fuels
	Chromium	-	-	kg	7.85E-9	7.85E-9	7.85E-9	7.85E-9	1	5.09	(3,4,3,3,1,5); Literature, in dust
	Chlorine	-	-	kg	7.85E-8	7.85E-8	7.85E-8	7.85E-8	1	1.61	(3,4,3,3,1,5); Literature
	Cyanide	-	-	kg	6.87E-6	6.87E-6	6.87E-6	6.87E-6	1	1.61	(3,4,3,3,1,5); Estimation
	Fluorine	-	-	kg	3.88E-8	3.88E-8	3.88E-8	3.88E-8	1	1.61	(3,4,3,3,1,5); Literature, in dust
	Hydrogen sulfide	-	-	kg	5.00E-4	5.00E-4	5.00E-4	5.00E-4	1	1.61	(3,4,3,3,1,5); Estimation
	Hydrogen fluoride	-	-	kg	5.00E-4	5.00E-4	5.00E-4	5.00E-4	1	1.61	(3,4,3,3,1,5); Estimation
	Iron	-	-	kg	3.88E-6	3.88E-6	3.88E-6	3.88E-6	1	5.09	(3,4,3,3,1,5); Literature, in dust
	Lead	-	-	kg	3.44E-7	3.44E-7	3.44E-7	3.44E-7	1	5.09	(3,4,3,3,1,5); Literature, in dust
	Mercury	-	-	kg	7.85E-9	7.85E-9	7.85E-9	7.85E-9	1	5.09	(3,4,3,3,1,5); Literature, in dust
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	9.60E-5	9.60E-5	9.60E-5	9.60E-5	1	1.61	(3,4,3,3,1,5); Literature
	Nitrogen oxides	-	-	kg	9.74E-3	9.74E-3	9.74E-3	9.74E-3	1	1.52	(3,2,2,1,1,3); Calculation based on environmental report
	Particulates, > 10 um	-	-	kg	7.75E-3	7.75E-3	7.75E-3	7.75E-3	1	1.52	(3,2,2,1,1,3); Calculation based on environmental report
	Potassium	-	-	kg	6.20E-5	6.20E-5	6.20E-5	6.20E-5	1	5.09	(3,4,3,3,1,5); Literature, in dust
	Silicon	-	-	kg	7.51E-3	7.51E-3	7.51E-3	7.51E-3	1	5.09	(3,4,3,3,1,5); Literature, SiO2 in dust
	Sodium	-	-	kg	7.75E-7	7.75E-7	7.75E-7	7.75E-7	1	5.09	(3,4,3,3,1,5); Literature, in dust
	Sulfur dioxide	-	-	kg	1.22E-2	1.22E-2	1.22E-2	1.22E-2	1	1.13	(3,2,2,1,1,3); Calculation based on environmental report
	Tin	-	-	kg	7.85E-9	7.85E-9	7.85E-9	7.85E-9	1	5.09	(3,4,3,3,1,5); Literature, in dust

5.1.4.2 Electronic grade silicon

al. (2012) [38]. The European (DE) and Chinese (CN) production of solar and electronic grade silicon remain unchanged.

Tab. 5.1.4.2.1 and Tab. 5.1.4.2.2 show the unit process data of the electronic grade silicon production in China (CN), North America (US), Asia & Pacific (APAC) and Europe (DE). The South Korean electricity mix is selected for the APAC region, because South Korea produces the highest share of electronic grade silicon in the APAC region. The US electricity mix is used to model electricity consumption in the North American production.

All other data about material and energy consumption as well as about emissions correspond to the life cycle inventory data of electronic grade (and off-grade) silicon published by Jungbluth et al. (2012) [38]. The European (DE) and Chinese (CN) production of solar and electronic grade silicon remain unchanged.

Tab. 5.1.4.2.1 Unit process data of electronic grade silicon production in China (CN) and North America (US)

	Name	Location	InfrastructureProcess	Unit	silicon, electronic grade, at plant	silicon, electronic grade, off-grade, at plant	silicon, electronic grade, at plant	silicon, electronic grade, off-grade, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CN	CN	US	US			
	InfrastructureProcess				0	0	0	0			
	Unit				kg	kg	kg	kg			
	silicon, electronic grade, at plant	CN	0	kg	1	0	0	0			
	silicon, electronic grade, off-grade, at plant	CN	0	kg	0	1	0	0			
	silicon, electronic grade, at plant	US	0	kg	0	0	1	0			
	silicon, electronic grade, off-grade, at plant	US	0	kg	0	0	0	1			
resource, in water	Water, cooling, unspecified natural origin	-	-	m3	6.23E+1	1.66E+1	6.23E+1	1.66E+1	1	1.34	(4,4,3,3,1,5); Literature 1997
	MG-silicon, at plant	CN	0	kg	1.05E+0	1.05E+0	0	0	1	1.26	(3,1,3,1,1,5); Literature 1998
	MG-silicon, at plant	US	0	kg	0	0	1.05E+0	1.05E+0	1	1.26	(3,1,3,1,1,5); Literature 1997
	polyethylene, HDPE, granulate, at plant	RER	0	kg	6.79E-4	1.81E-4	6.79E-4	1.81E-4	1	1.69	(4,4,4,3,4,5); Literature, Hagedorn, different plastics
	hydrochloric acid, 30% in H2O, at plant	RER	0	kg	1.43E+0	3.82E-1	1.43E+0	3.82E-1	1	1.11	(3,na,1,1,1,na); Estimation, produced on site
	hydrogen, liquid, at plant	RER	0	kg	8.97E-2	2.39E-2	8.97E-2	2.39E-2	1	1.34	(4,4,3,3,1,5); Literature 1997, produced on site
	tetrafluoroethylene, at plant	RER	0	kg	6.39E-4	1.70E-4	6.39E-4	1.70E-4	1	1.69	(4,4,4,3,4,5); Hagedorn 1992, fittings
	sodium hydroxide, 50% in H2O, production mix, at plant	RER	0	kg	4.63E-1	1.24E-1	4.63E-1	1.24E-1	1	1.34	(4,4,3,3,1,5); Literature 1997, neutralization of wastes
	graphite, at plant	RER	0	kg	7.10E-4	1.89E-4	7.10E-4	1.89E-4	1	1.69	(4,4,4,3,4,5); Hagedorn 1992, graphite
transport	transport, lorry >16t, fleet average	RER	0	tkm	2.15E+0	2.15E+0	2.15E+0	2.15E+0	1	2.09	(4,5,na,na,na,na); Standard distances 100km, MG-Si 2000km
	transport, freight, rail	RER	0	tkm	9.31E-2	2.48E-2	9.31E-2	2.48E-2	1	2.09	(4,5,na,na,na,na); Standard distances 200km
	water, completely softened, at plant	RER	0	kg	1.85E+1	4.94E+0	1.85E+1	4.94E+0	1	1.22	(2,2,1,1,3,3); Environmental report 2002
energy	heat, at cogen 1MWe lean burn, allocation exergy	RER	0	MJ	1.74E+2	4.65E+1	1.74E+2	4.65E+1	1	1.59	(3,1,3,1,1,5); Literature 1997, basic uncertainty = 1.5
	electricity, at cogen 1MWe lean burn, allocation exergy	RER	0	kWh	0	0	0	0	1	1.59	(3,1,3,1,1,5); Literature 1997, basic uncertainty = 1.5
	electricity, hydropower, at run-of-river power plant	RER	0	kWh	0	0	0	0	1	1.59	(3,1,3,1,1,5); Literature 1997, basic uncertainty = 1.5
	electricity, medium voltage, at grid	CN	0	kWh	1.63E+2	4.35E+1	0	0	1	1.59	(3,1,3,1,1,5); Literature 1997, basic uncertainty = 1.5
	electricity, medium voltage, at grid	US	0	kWh	0	0	1.63E+2	4.35E+1	1	1.59	(3,1,3,1,1,5); Literature 1997, basic uncertainty = 1.5
	electricity, medium voltage, at grid	KR	0	kWh	0	0	0	0	1	1.59	(3,1,3,1,1,5); Literature 1997, basic uncertainty = 1.5
waste	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	0	kg	1.32E-3	3.52E-4	1.32E-3	3.52E-4	1	1.69	(4,4,4,3,4,5); Hagedorn 1992
	silicone plant	RER	1	unit	1.07E-11	2.84E-12	1.07E-11	2.84E-12	1	3.05	(1,1,1,1,3,3); Estimation
emission air, high population density	Heat, waste	-	-	MJ	3.92E+2	1.05E+2	3.92E+2	1.05E+2	1	3.05	(1,2,1,1,3,3); Calculation with electricity use minus 180 MJ per kg produced silicon
emission water, river	AOX, Adsorbable Organic Halogen as Cl	-	-	kg	1.26E-5	3.37E-6	1.26E-5	3.37E-6	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	BOD5, Biological Oxygen Demand	-	-	kg	2.05E-4	5.46E-5	2.05E-4	5.46E-5	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	COD, Chemical Oxygen Demand	-	-	kg	2.02E-3	5.39E-4	2.02E-3	5.39E-4	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Chloride	-	-	kg	3.60E-2	9.60E-3	3.60E-2	9.60E-3	1	3.05	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Copper, ion	-	-	kg	1.02E-7	2.73E-8	1.02E-7	2.73E-8	1	5.06	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Nitrogen	-	-	kg	2.08E-4	5.53E-5	2.08E-4	5.53E-5	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Phosphate	-	-	kg	2.80E-6	7.48E-7	2.80E-6	7.48E-7	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Sodium, ion	-	-	kg	3.38E-2	9.01E-3	3.38E-2	9.01E-3	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Zinc, ion	-	-	kg	1.96E-6	5.23E-7	1.96E-6	5.23E-7	1	5.06	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Iron, ion	-	-	kg	5.61E-6	1.50E-6	5.61E-6	1.50E-6	1	5.06	(1,2,1,1,3,3); Environmental report 2002, average Si product
	DOC, Dissolved Organic Carbon	-	-	kg	9.10E-4	2.43E-4	9.10E-4	2.43E-4	1	5.06	(1,2,1,1,3,3); Environmental report 2002, average Si product
	TOC, Total Organic Carbon	-	-	kg	9.10E-4	2.43E-4	9.10E-4	2.43E-4	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product

Tab. 5.1.4.2.2 Unit process data of electronic grade silicon production in Asia & Pacific (APAC) and Europe (DE)

	Name	Location	InfrastructureProcess	Unit	silicon, electronic grade, at plant	silicon, electronic grade, off-grade, at plant	silicon, electronic grade, at plant	silicon, electronic grade, off-grade, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				APAC	APAC	DE	DE			
	InfrastructureProcess				0	0	0	0			
	Unit				kg	kg	kg	kg			
products	silicon, electronic grade, at plant	DE	0	kg	0	0	1.00E+00	0			
	silicon, electronic grade, off-grade, at plant	DE	0	kg	0	0	0	1.00E+00			
	silicon, electronic grade, at plant	APAC	0	kg	1.00E+00	0	0	0			
	silicon, electronic grade, off-grade, at plant	APAC	0	kg	0	1.00E+00	0	0			
resource, in water	Water, cooling, unspecified natural origin	-	-	m3	6.23E+1	1.66E+1	6.23E+01	1.66E+01	1	1.34	(4,4,3,3,1,5); Literature 1997
technosphere	MG-silicon, at plant	NO	0	kg	0	0	1.05E+00	1.05E+00	1	1.26	(3,1,3,1,1,5); Literature 1997
	MG-silicon, at plant	APAC	0	kg	1.05E+0	1.05E+0	0	0	1	1.26	(3,1,3,1,1,5); Literature 1998
	polyethylene, HDPE, granulate, at plant	RER	0	kg	6.79E-4	1.81E-4	6.79E-04	1.81E-04	1	1.69	(4,4,4,3,4,5); Literature, Hagedorn, different plastics
	hydrochloric acid, 30% in H2O, at plant	RER	0	kg	1.43E+0	3.82E-1	1.43E+00	3.82E-01	1	1.11	(3,na,1,1,1,na); Estimation, produced on site
	hydrogen, liquid, at plant	RER	0	kg	8.97E-2	2.39E-2	8.97E-02	2.39E-02	1	1.34	(4,4,3,3,1,5); Literature 1997, produced on site
	tetrafluoroethylene, at plant	RER	0	kg	6.39E-4	1.70E-4	6.39E-04	1.70E-04	1	1.69	(4,4,4,3,4,5); Hagedorn 1992, fittings
	sodium hydroxide, 50% in H2O, production mix, at plant	RER	0	kg	4.63E-1	1.24E-1	4.63E-01	1.24E-01	1	1.34	(4,4,3,3,1,5); Literature 1997, neutralization of wastes
	graphite, at plant	RER	0	kg	7.10E-4	1.89E-4	7.10E-04	1.89E-04	1	1.69	(4,4,4,3,4,5); Hagedorn 1992, graphite
transport	transport, lorry >16t, fleet average	RER	0	tkm	2.15E+0	2.15E+0	2.15E+00	2.15E+00	1	2.09	(4,5,na,na,na,na); Standard distances 100km, MG-Si 2000km
	transport, freight, rail	RER	0	tkm	9.31E-2	2.48E-2	9.31E-02	2.48E-02	1	2.09	(4,5,na,na,na,na); Standard distances 200km
	water, completely softened, at plant	RER	0	kg	1.85E+1	4.94E+0	1.85E+01	4.94E+00	1	1.22	(2,2,1,1,3,3); Environmental report 2002
energy	heat, at cogen 1MWe lean burn, allocation exergy	RER	0	MJ	1.74E+2	4.65E+1	1.74E+02	4.65E+01	1	1.59	(3,1,3,1,1,5); Literature 1997, basic uncertainty = 1.5
	electricity, at cogen 1MWe lean burn, allocation exergy	RER	0	kWh	0	0	1.24E+02	3.31E+01	1	1.59	(3,1,3,1,1,5); Literature 1997, basic uncertainty = 1.5
	electricity, hydropower, at run-of-river power plant	RER	0	kWh	0	0	3.92E+01	1.05E+01	1	1.59	(3,1,3,1,1,5); Literature 1997, basic uncertainty = 1.5
	electricity, medium voltage, at grid	CN	0	kWh	0	0	0.00E+00	0.00E+00	1	1.59	(3,1,3,1,1,5); Literature 1997, basic uncertainty = 1.5
	electricity, medium voltage, at grid	US	0	kWh	0	0	0.00E+00	0.00E+00	1	1.59	(3,1,3,1,1,5); Literature 1997, basic uncertainty = 1.5
	electricity, medium voltage, at grid	KR	0	kWh	1.63E+2	4.35E+1	0.00E+00	0.00E+00	1	1.59	(3,1,3,1,1,5); Literature 1997, basic uncertainty = 1.5
waste	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	0	kg	1.32E-3	3.52E-4	1.32E-03	3.52E-04	1	1.69	(4,4,4,3,4,5); Hagedorn 1992
	silicone plant	RER	1	unit	1.07E-11	2.84E-12	1.07E-11	2.84E-12	1	3.05	(1,1,1,1,3,3); Estimation
emission air, high population density	Heat, waste	-	-	MJ	3.92E+2	1.05E+2	3.92E+02	1.05E+02	1	3.05	(1,2,1,1,3,3); Calculation with electricity use minus 180 MJ per kg produced silicon
emission water, river	AOX, Adsorbable Organic Halogen as Cl	-	-	kg	1.26E-5	3.37E-6	1.26E-05	3.37E-06	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	BOD5, Biological Oxygen Demand	-	-	kg	2.05E-4	5.46E-5	2.05E-04	5.46E-05	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	COD, Chemical Oxygen Demand	-	-	kg	2.02E-3	5.39E-4	2.02E-03	5.39E-04	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Chloride	-	-	kg	3.60E-2	9.60E-3	3.60E-02	9.60E-03	1	3.05	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Copper, ion	-	-	kg	1.02E-7	2.73E-8	1.02E-07	2.73E-08	1	5.06	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Nitrogen	-	-	kg	2.08E-4	5.53E-5	2.08E-04	5.53E-05	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Phosphate	-	-	kg	2.80E-6	7.48E-7	2.80E-06	7.48E-07	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Sodium, ion	-	-	kg	3.38E-2	9.01E-3	3.38E-02	9.01E-03	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Zinc, ion	-	-	kg	1.96E-6	5.23E-7	1.96E-06	5.23E-07	1	5.06	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Iron, ion	-	-	kg	5.61E-6	1.50E-6	5.61E-06	1.50E-06	1	5.06	(1,2,1,1,3,3); Environmental report 2002, average Si product
	DOC, Dissolved Organic Carbon	-	-	kg	9.10E-4	2.43E-4	9.10E-04	2.43E-04	1	5.06	(1,2,1,1,3,3); Environmental report 2002, average Si product
	TOC, Total Organic Carbon	-	-	kg	9.10E-4	2.43E-4	9.10E-04	2.43E-04	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product

5.1.4.3 Solar grade silicon

Tab.5.1.4.3.1 shows the unit process data of solar grade silicon production in Europe (RER), China (CN), North America (US) and Asia & Pacific (APAC). The South Korean electricity mix is selected for the APAC region, because South Korea produces the highest share of solar grade silicon in the APAC region. Electricity from hydro power is chosen to model electricity consumption in the North American production, since one of the most important North American producers mainly relies on hydroelectric power.

All other data about material and energy consumption as well as about emissions correspond to the life cycle inventory data of solar grade silicon published by Jungbluth et al. (2012) [38].

Tab.5.1.4.3.1 Unit process data of solar grade silicon production in Europe (RER), China (CN), North America (US) and Asia & Pacific (APAC).

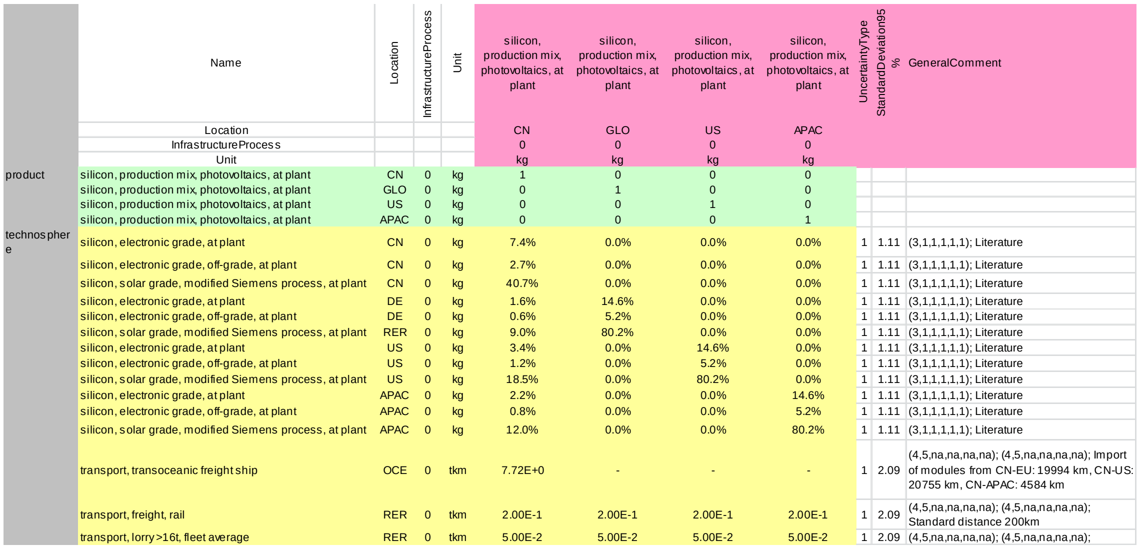
	Name	Location	InfrastructureProcess	Unit	silicon, solar grade, modified Siemens process, at plant	silicon, solar grade, modified Siemens process, at plant	silicon, solar grade, modified Siemens process, at plant	silicon, solar grade, modified Siemens process, at plant	Uncertainty	StandardDeviation95%	GeneralComment
	Location				RER	CN	US	APAC			
	InfrastructureProcess				0	0	0	0			
	Unit				kg	kg	kg	kg			
product	silicon, solar grade, modified Siemens process, at plant	RER	0	kg	1	0	0	0			
product	silicon, solar grade, modified Siemens process, at plant	CN	0	kg	0	1	0	0			
product	silicon, solar grade, modified Siemens process, at plant	US	0	kg	0	0	1	0			
product	silicon, solar grade, modified Siemens process, at plant	APAC	0	kg	0	0	0	1			
technosphere	MG-silicon, at plant	NO	0	kg	1.13E+0	0	0	0	1	1.10	(2,3,1,2,1,3); Literature
	MG-silicon, at plant	CN	0	kg	0	1.13E+0	0	0	1	1.10	(2,3,1,2,1,3); Literature
	MG-silicon, at plant	US	0	kg	0	0	1.13E+0	0	1	1.10	(2,3,1,2,1,3); Literature
	MG-silicon, at plant	APAC	0	kg	0	0	0	1.13E+0	1	1.10	(2,3,1,2,1,3); Literature
	hydrochloric acid, 30% in H2O, at plant	RER	0	kg	1.60E+0	1.60E+0	1.60E+0	1.60E+0	1	1.14	(3,3,1,2,1,3); de Wild 2007, share of NaOH, HCl and H2 estimated with EG-Si data
	hydrogen, liquid, at plant	RER	0	kg	5.01E-2	5.01E-2	5.01E-2	5.01E-2	1	1.14	(3,3,1,2,1,3); de Wild 2007, share of NaOH, HCl and H2 estimated with EG-Si data
	sodium hydroxide, 50% in H2O, production mix, at plant	RER	0	kg	3.48E-1	3.48E-1	3.48E-1	3.48E-1	1	1.14	(3,3,1,2,1,3); de Wild 2007, share of NaOH, HCl and H2 estimated with EG-Si data
	transport, lorry >16t, fleet average	RER	0	tkm	2.66E+0	2.66E+0	2.66E+0	2.66E+0	1	2.09	(4,5,na,na,na,na); Distance 2000km plus 100 km for chemicals
	transport, freight, rail	RER	0	tkm	2.40E+0	2.40E+0	2.40E+0	2.40E+0	1	2.09	(4,5,na,na,na,na); 600km for chemicals including solvent
	transport, transoceanic freight ship	OCE	0	tkm	5.30E+0	0	0	0	1	2.06	(2,3,2,2,3,2); Transport of REC silicon from US to European market
	electricity, at cogen 1MWe lean burn, allocation exergy	RER	0	kWh	3.58E+1	0	0	0	1	1.10	(2,3,1,2,1,3); on-site plant of Wacker in Germany
	electricity, hydropower, at run-of-river power plant	RER	0	kWh	6.17E+1	0	1.10E+2	0	1	1.10	(2,3,1,2,1,3); production of REC and of Wacker's hydropower plant
	electricity, medium voltage, at grid	NO	0	kWh	1.25E+1	0	0	0	1	1.10	(2,3,1,2,1,3); production of Elkem in Norway
	electricity, medium voltage, at grid	CN	0	kWh	0	1.10E+2	0	0	1	1.10	(2,3,1,2,1,3); production in China
	electricity, medium voltage, at grid	US	0	kWh	0	0	0	0	1	1.10	(2,3,1,2,1,3); production in US
	electricity, medium voltage, at grid	KR	0	kWh	0	0	0	1.10E+2	1	1.10	(2,3,1,2,1,3); production in Asia and Pacific
	heat, at cogen 1MWe lean burn, allocation exergy	RER	0	MJ	1.85E+2	1.85E+2	1.85E+2	1.85E+2	1	1.10	(2,3,1,2,1,3); literature, for process heat
	silicone plant	RER	1	unit	1.00E-11	1.00E-11	1.00E-11	1.00E-11	1	3.05	(1,3,1,2,3,3); Estimation
emission air	Heat, waste	-	-	MJ	3.51E+2	3.51E+2	3.51E+2	3.51E+2	1	1.10	(2,3,1,2,1,3); Calculation
emission water, river	AOX, Adsorbable Organic Halogen as Cl	-	-	kg	1.26E-5	1.26E-5	1.26E-5	1.26E-5	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	BOD5, Biological Oxygen Demand	-	-	kg	2.05E-4	2.05E-4	2.05E-4	2.05E-4	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	COD, Chemical Oxygen Demand	-	-	kg	2.02E-3	2.02E-3	2.02E-3	2.02E-3	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Chloride	-	-	kg	3.60E-2	3.60E-2	3.60E-2	3.60E-2	1	3.05	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Copper, ion	-	-	kg	1.02E-7	1.02E-7	1.02E-7	1.02E-7	1	5.06	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Nitrogen	-	-	kg	2.08E-4	2.08E-4	2.08E-4	2.08E-4	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Phosphate	-	-	kg	2.80E-6	2.80E-6	2.80E-6	2.80E-6	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Sodium, ion	-	-	kg	3.38E-2	3.38E-2	3.38E-2	3.38E-2	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Zinc, ion	-	-	kg	1.96E-6	1.96E-6	1.96E-6	1.96E-6	1	5.06	(1,2,1,1,3,3); Environmental report 2002, average Si product
	Iron, ion	-	-	kg	5.61E-6	5.61E-6	5.61E-6	5.61E-6	1	5.06	(1,2,1,1,3,3); Environmental report 2002, average Si product
	DOC, Dissolved Organic Carbon	-	-	kg	9.10E-4	9.10E-4	9.10E-4	9.10E-4	1	5.06	(1,2,1,1,3,3); Environmental report 2002, average Si product
	TOC, Total Organic Carbon	-	-	kg	9.10E-4	9.10E-4	9.10E-4	9.10E-4	1	1.56	(1,2,1,1,3,3); Environmental report 2002, average Si product

5.1.5 Silicon production mix

Tab. 5.1.5.1 shows the unit process data of the silicon production mixes of global and European production (GLO), China (CN), North America (US) and Asia & Pacific (APAC). The shares of the different world regions are based on the production volumes shown in Tab. . The shares of the different silicon qualities used in producing polysilicon, electronic grade (14.6 %), off-grade (5.2 %) and solar grade

(80.2 %) according to Jungbluth et al. (2012) [38], are assumed to be the same in all four world regions. The shares shown in Tab. are multiplied with the shares of the different silicon qualities according to Jungbluth et al. (2012) [38], resulting in the shares given in Tab. 5.1.5.1.

Tab. 5.1.5.1 Unit process data of the silicon production mixes of global and European production (GLO), China (CN), North America (US) and Asia & Pacific (APAC).



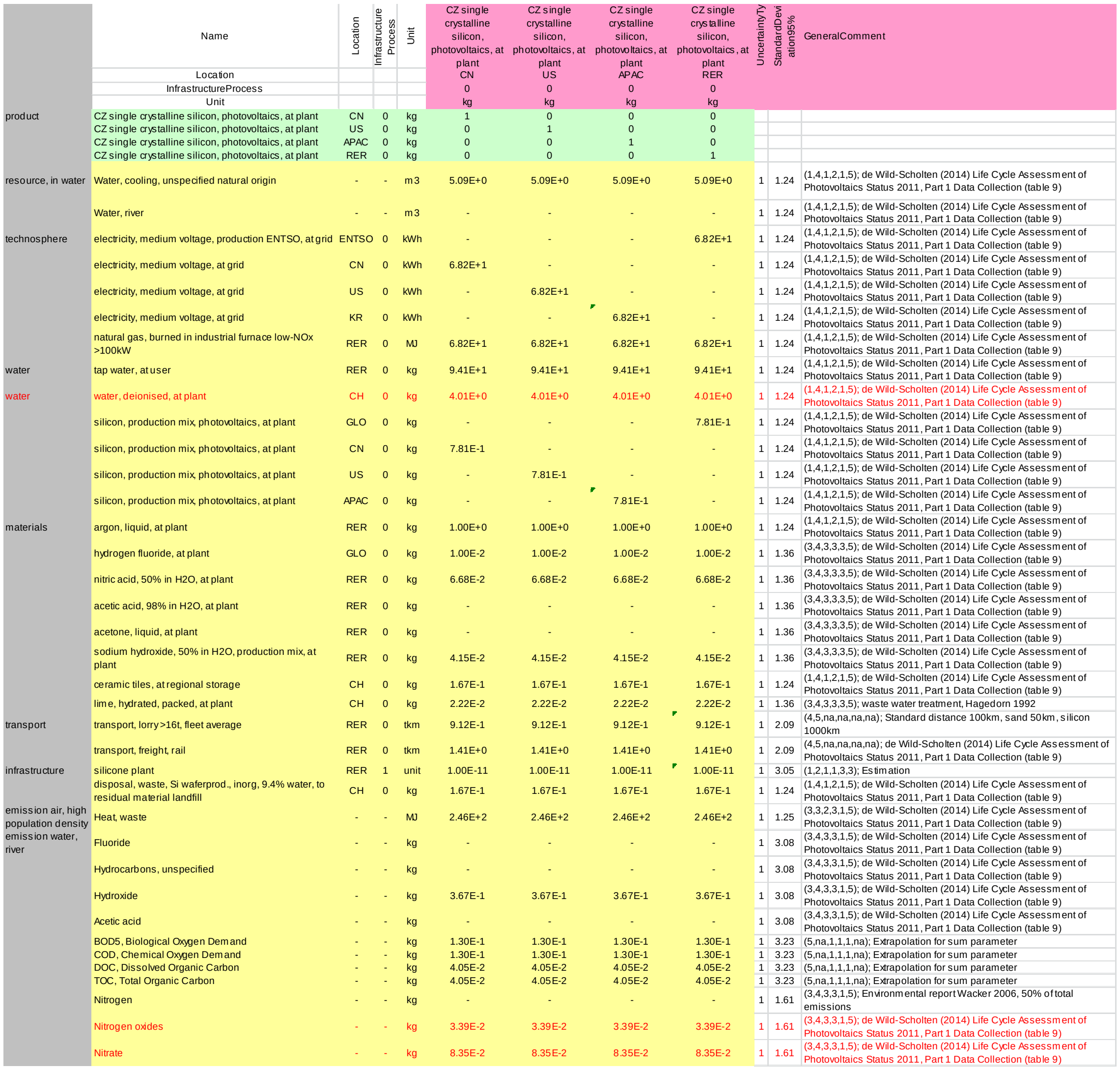
	Name	Location	InfrastructureProcess	Unit	silicon, production mix, photovoltaics, at plant	silicon, production mix, photovoltaics, at plant	silicon, production mix, photovoltaics, at plant	silicon, production mix, photovoltaics, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CN	GLO	US	APAC			
	InfrastructureProcess				0	0	0	0			
	Unit				kg	kg	kg	kg			
product	silicon, production mix, photovoltaics, at plant	CN	0	kg	1	0	0	0			
	silicon, production mix, photovoltaics, at plant	GLO	0	kg	0	1	0	0			
	silicon, production mix, photovoltaics, at plant	US	0	kg	0	0	1	0			
	silicon, production mix, photovoltaics, at plant	APAC	0	kg	0	0	0	1			
technosphere	silicon, electronic grade, at plant	CN	0	kg	7.4%	0.0%	0.0%	0.0%	1	1.11	(3,1,1,1,1,1); Literature
	silicon, electronic grade, off-grade, at plant	CN	0	kg	2.7%	0.0%	0.0%	0.0%	1	1.11	(3,1,1,1,1,1); Literature
	silicon, solar grade, modified Siemens process, at plant	CN	0	kg	40.7%	0.0%	0.0%	0.0%	1	1.11	(3,1,1,1,1,1); Literature
	silicon, electronic grade, at plant	DE	0	kg	1.6%	14.6%	0.0%	0.0%	1	1.11	(3,1,1,1,1,1); Literature
	silicon, electronic grade, off-grade, at plant	DE	0	kg	0.6%	5.2%	0.0%	0.0%	1	1.11	(3,1,1,1,1,1); Literature
	silicon, solar grade, modified Siemens process, at plant	RER	0	kg	9.0%	80.2%	0.0%	0.0%	1	1.11	(3,1,1,1,1,1); Literature
	silicon, electronic grade, at plant	US	0	kg	3.4%	0.0%	14.6%	0.0%	1	1.11	(3,1,1,1,1,1); Literature
	silicon, electronic grade, off-grade, at plant	US	0	kg	1.2%	0.0%	5.2%	0.0%	1	1.11	(3,1,1,1,1,1); Literature
	silicon, solar grade, modified Siemens process, at plant	US	0	kg	18.5%	0.0%	80.2%	0.0%	1	1.11	(3,1,1,1,1,1); Literature
	silicon, electronic grade, at plant	APAC	0	kg	2.2%	0.0%	0.0%	14.6%	1	1.11	(3,1,1,1,1,1); Literature
	silicon, electronic grade, off-grade, at plant	APAC	0	kg	0.8%	0.0%	0.0%	5.2%	1	1.11	(3,1,1,1,1,1); Literature
	silicon, solar grade, modified Siemens process, at plant	APAC	0	kg	12.0%	0.0%	0.0%	80.2%	1	1.11	(3,1,1,1,1,1); Literature
	transport, transoceanic freight ship	OCE	0	tkm	7.72E+0	-	-	-	1	2.09	(4,5,na,na,na,na); (4,5,na,na,na,na); Import of modules from CN-EU: 19994 km, CN-US: 20755 km, CN-APAC: 4584 km
	transport, freight, rail	RER	0	tkm	2.00E-1	2.00E-1	2.00E-1	2.00E-1	1	2.09	(4,5,na,na,na,na); (4,5,na,na,na,na); Standard distance 200km
	transport, lorry >16t, fleet average	RER	0	tkm	5.00E-2	5.00E-2	5.00E-2	5.00E-2	1	2.09	(4,5,na,na,na,na); (4,5,na,na,na,na);

5.1.6 Single and multi-crystalline silicon

Tab. 5.1.6.1 U and Tab. 5.1.6.2 show the unit process data of the single- and multi-crystalline silicon production in Europe (RER), China (CN), North America (US) and Asia & Pacific (APAC). The South Korean electricity mix is selected for the APAC region, because South Korea produces the highest share of single-and multi-crystalline silicon in the APAC region. The US electricity mix is chosen to model electricity consumption in the North American production.

The LCI data on material and energy consumption as well as about emissions are updated based on LCI data of single- and multi-crystalline silicon published by de Wild-Scholten (2014) [40].

Tab. 5.1.6.1 Unit process data of the single-crystalline silicon production in Europe (RER), China (CN), North America (US) and Asia & Pacific (APAC); red added exchanges compared to Jungbluth et al. (2012).



	Name	Location	Infrastructure Process	Unit	CZ single crystalline silicon, photovoltaics, at plant	CZ single crystalline silicon, photovoltaics, at plant	CZ single crystalline silicon, photovoltaics, at plant	CZ single crystalline silicon, photovoltaics, at plant	UncertaintyTy	StandardDeviation95%	GeneralComment
	Location				CN	US	APAC	RER			
	InfrastructureProcess				0	0	0	0			
	Unit				kg	kg	kg	kg			
product	CZ single crystalline silicon, photovoltaics, at plant	CN	0	kg	1	0	0	0			
	CZ single crystalline silicon, photovoltaics, at plant	US	0	kg	0	1	0	0			
	CZ single crystalline silicon, photovoltaics, at plant	APAC	0	kg	0	0	1	0			
	CZ single crystalline silicon, photovoltaics, at plant	RER	0	kg	0	0	0	1			
resource, in water	Water, cooling, unspecified natural origin	-	-	m3	5.09E+0	5.09E+0	5.09E+0	5.09E+0	1	1.24	(1,4,1,2,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	Water, river	-	-	m3	-	-	-	-	1	1.24	(1,4,1,2,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	-	-	-	6.82E+1	1	1.24	(1,4,1,2,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	electricity, medium voltage, at grid	CN	0	kWh	6.82E+1	-	-	-	1	1.24	(1,4,1,2,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	electricity, medium voltage, at grid	US	0	kWh	-	6.82E+1	-	-	1	1.24	(1,4,1,2,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	electricity, medium voltage, at grid	KR	0	kWh	-	-	6.82E+1	-	1	1.24	(1,4,1,2,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	natural gas, burned in industrial furnace low-NOx >100kW	RER	0	MJ	6.82E+1	6.82E+1	6.82E+1	6.82E+1	1	1.24	(1,4,1,2,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
water	tap water, at user	RER	0	kg	9.41E+1	9.41E+1	9.41E+1	9.41E+1	1	1.24	(1,4,1,2,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
water	water, deionised, at plant	CH	0	kg	4.01E+0	4.01E+0	4.01E+0	4.01E+0	1	1.24	(1,4,1,2,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	silicon, production mix, photovoltaics, at plant	GLO	0	kg	-	-	-	7.81E-1	1	1.24	(1,4,1,2,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	silicon, production mix, photovoltaics, at plant	CN	0	kg	7.81E-1	-	-	-	1	1.24	(1,4,1,2,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	silicon, production mix, photovoltaics, at plant	US	0	kg	-	7.81E-1	-	-	1	1.24	(1,4,1,2,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	silicon, production mix, photovoltaics, at plant	APAC	0	kg	-	-	7.81E-1	-	1	1.24	(1,4,1,2,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
materials	argon, liquid, at plant	RER	0	kg	1.00E+0	1.00E+0	1.00E+0	1.00E+0	1	1.24	(1,4,1,2,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	hydrogen fluoride, at plant	GLO	0	kg	1.00E-2	1.00E-2	1.00E-2	1.00E-2	1	1.36	(3,4,3,3,3,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	nitric acid, 50% in H2O, at plant	RER	0	kg	6.68E-2	6.68E-2	6.68E-2	6.68E-2	1	1.36	(3,4,3,3,3,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	acetic acid, 98% in H2O, at plant	RER	0	kg	-	-	-	-	1	1.36	(3,4,3,3,3,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	acetone, liquid, at plant	RER	0	kg	-	-	-	-	1	1.36	(3,4,3,3,3,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	sodium hydroxide, 50% in H2O, production mix, at plant	RER	0	kg	4.15E-2	4.15E-2	4.15E-2	4.15E-2	1	1.36	(3,4,3,3,3,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	ceramic tiles, at regional storage	CH	0	kg	1.67E-1	1.67E-1	1.67E-1	1.67E-1	1	1.24	(1,4,1,2,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	lime, hydrated, packed, at plant	CH	0	kg	2.22E-2	2.22E-2	2.22E-2	2.22E-2	1	1.36	(3,4,3,3,3,5); waste water treatment, Hagedorn 1992
transport	transport, lorry >16t, fleet average	RER	0	tkm	9.12E-1	9.12E-1	9.12E-1	9.12E-1	1	2.09	(4,5,na,na,na,na); Standard distance 100km, sand 50km, silicon 1000km
	transport, freight, rail	RER	0	tkm	1.41E+0	1.41E+0	1.41E+0	1.41E+0	1	2.09	(4,5,na,na,na,na); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
infrastructure	silicone plant	RER	1	unit	1.00E-11	1.00E-11	1.00E-11	1.00E-11	1	3.05	(1,2,1,1,3,3); Estimation
	disposal, waste, Si waferprod., inorg, 9.4% water, to residual material landfill	CH	0	kg	1.67E-1	1.67E-1	1.67E-1	1.67E-1	1	1.24	(1,4,1,2,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
emission air, high population density	Heat, waste	-	-	MJ	2.46E+2	2.46E+2	2.46E+2	2.46E+2	1	1.25	(3,3,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
emission water, river	Fluoride	-	-	kg	-	-	-	-	1	3.08	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	Hydrocarbons, unspecified	-	-	kg	-	-	-	-	1	3.08	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	Hydroxide	-	-	kg	3.67E-1	3.67E-1	3.67E-1	3.67E-1	1	3.08	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	Acetic acid	-	-	kg	-	-	-	-	1	3.08	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	BOD5, Biological Oxygen Demand	-	-	kg	1.30E-1	1.30E-1	1.30E-1	1.30E-1	1	3.23	(5,na,1,1,1,na); Extrapolation for sum parameter
	COD, Chemical Oxygen Demand	-	-	kg	1.30E-1	1.30E-1	1.30E-1	1.30E-1	1	3.23	(5,na,1,1,1,na); Extrapolation for sum parameter
	DOC, Dissolved Organic Carbon	-	-	kg	4.05E-2	4.05E-2	4.05E-2	4.05E-2	1	3.23	(5,na,1,1,1,na); Extrapolation for sum parameter
	TOC, Total Organic Carbon	-	-	kg	4.05E-2	4.05E-2	4.05E-2	4.05E-2	1	3.23	(5,na,1,1,1,na); Extrapolation for sum parameter
	Nitrogen	-	-	kg	-	-	-	-	1	1.61	(3,4,3,3,1,5); Environmental report Wacker 2006, 50% of total emissions
	Nitrogen oxides	-	-	kg	3.39E-2	3.39E-2	3.39E-2	3.39E-2	1	1.61	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)
	Nitrate	-	-	kg	8.35E-2	8.35E-2	8.35E-2	8.35E-2	1	1.61	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 9)

25 % of the solar grade silicon input is recycled silicon in case of the CZ single crystalline silicon production. This corresponds to an input of 0.26 kg recycled silicon per kg of CZ single crystalline silicon. The input of recycled silicon is not listed in Tab. 5.1.6.1 U. It is assumed that recycled silicon mainly arises from the cutting losses of the round single-crystalline ingot to the rectangular wafers.

Further details on the recycling shares and the recycling processes can be found in de Wild-Scholten (2014) [40]

Tab. 5.1.6.2 Unit process data of the multi-crystalline silicon production in Europe (RER), China (CN), North America (US) and Asia & Pacific (APAC) ; red added exchanges compared to Jungbluth et al. (2012).

	Name	Location	InfrastructureProcess	Unit	silicon, multi-Si, casted, at plant	silicon, multi-Si, casted, at plant	silicon, multi-Si, casted, at plant	silicon, multi-Si, casted, at plant	UncertaintyType	StandardDeviation95 %	GeneralComment
	Location				CN	US	APAC	RER			
	InfrastructureProcess				0	0	0	0			
	Unit				kg	kg	kg	kg			
product	silicon, multi-Si, casted, at plant	CN	0	kg	1	0	0	0			
	silicon, multi-Si, casted, at plant	US	0	kg	0	1	0	0			
	silicon, multi-Si, casted, at plant	APAC	0	kg	0	0	1	0			
	silicon, multi-Si, casted, at plant	RER	0	kg	0	0	0	1			
resource, in water	Water, cooling, unspecified natural origin	-	-	m3	9.43E-1	9.43E-1	9.43E-1	9.43E-1	1	1.26	(3,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 12)
	tap water, at user	RER	0	kg	-	-	-	-	1	1.25	(3,3,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 12)
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	-	-	-	1.55E+1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 12)
	electricity, medium voltage, at grid	CN	0	kWh	1.55E+1	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 12)
	electricity, medium voltage, at grid	US	0	kWh	-	1.55E+1	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 12)
	electricity, medium voltage, at grid	KR	0	kWh	-	-	1.55E+1	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 12)
	argon, liquid, at plant	RER	0	kg	2.52E-1	2.52E-1	2.52E-1	2.52E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 12)
	helium, at plant	GLO	0	kg	7.76E-5	7.76E-5	7.76E-5	7.76E-5	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 12)
	sodium hydroxide, 50% in H2O, production mix, at plant	RER	0	kg	5.00E-3	5.00E-3	5.00E-3	5.00E-3	1	1.25	(3,3,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 12)
	nitrogen, liquid, at plant	RER	0	kg	3.04E-2	3.04E-2	3.04E-2	3.04E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 12)
	ceramic tiles, at regional storage	CH	0	kg	2.14E-1	2.14E-1	2.14E-1	2.14E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 12)
	silicon, production mix, photovoltaics, at plant	GLO	0	kg	-	-	-	7.00E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 12)
	silicon, production mix, photovoltaics, at plant	CN	0	kg	7.00E-1	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 12)
	silicon, production mix, photovoltaics, at plant	US	0	kg	-	7.00E-1	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 12)
	silicon, production mix, photovoltaics, at plant	APAC	0	kg	-	-	7.00E-1	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (table 12)
	transport, lorry >16t, fleet average	RER	0	tkm	7.25E-1	7.25E-1	7.25E-1	7.25E-1	1	2.09	(4,5,na,na,na,na); Standard distances 50km, silicon 1000km
	transport, freight, rail	RER	0	tkm	1.55E-1	1.55E-1	1.55E-1	1.55E-1	1	2.09	(4,5,na,na,na,na); Standard distances 100km
	silicone plant	RER	1	unit	1.00E-11	1.00E-11	1.00E-11	1.00E-11	1	3.05	(1,2,1,1,3,3); Estimation
emission air	Heat, waste	-	-	MJ	5.58E+1	5.58E+1	5.58E+1	5.58E+1	1	1.25	(3,3,2,3,1,5); Calculation

30 % of the solar grade silicon input is recycled silicon in case of the multi-crystalline silicon production. This corresponds to an input of 0.3 kg recycled silicon per kg of multi-crystalline silicon. The input of recycled silicon is not listed in Tab. 5.1.6.2 . It is assumed that recycled silicon mainly arises from the cutting losses of the round single-crystalline ingot to the rectangular wafers (and is used as input for the multi-crystalline silicon casting).

Further details on the recycling shares and the recycling processes can be found in de Wild-Scholten (2014) [40].

5.1.7 Silicon wafer production

The LCI data on material and energy consumption as well as about emissions are updated based on LCI data of single- and multi-crystalline silicon published by de Wild-Scholten (2014) [40], including typical kerf loss for slurry based sawing of 145 micron [41].

Tab. 5.1.7.1 and Tab. 5.1.7.2 show the unit process data of the single- and multi-crystalline silicon wafer production in Europe (RER), China (CN), North America (US) and Asia & Pacific (APAC). The Japanese electricity mix is selected for the APAC region, because Japan produces the highest share of the single- and multi-crystalline wafers in the APAC region. The US electricity mix is chosen to model electricity consumption in the North American production.

The LCI data on material and energy consumption as well as about emissions are updated based on LCI data of single- and multi-crystalline silicon published by de Wild-Scholten (2014) [40], including typical kerf loss for slurry based sawing of 145 micron [41].

Tab. 5.1.7.1 Unit process data of the single- and multi-crystalline silicon wafer production in China (CN) and North America (US); red added exchanges compared to Jungbluth et al. (2012) [38].

	Name	Location	InfrastructureProcess	Unit	single-Si wafer, photovoltaics, at plant	multi-Si wafer, at plant	single-Si wafer, photovoltaics, at plant	multi-Si wafer, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CN	CN	US	US			
	InfrastructureProcess				0	0	0	0			
	Unit				m2	m2	m2	m2			
product	multi-Si wafer, at plant	CN	0	m2	0	1	0	0			
	single-Si wafer, photovoltaics, at plant	CN	0	m2	1	0	0	0			
	multi-Si wafer, at plant	US	0	m2	0	0	0	1			
	single-Si wafer, photovoltaics, at plant	US	0	m2	0	0	1	0			
	multi-Si wafer, at plant	APAC	0	m2	0	0	0	0			
	single-Si wafer, photovoltaics, at plant	APAC	0	m2	0	0	0	0			
product	single-Si wafer, photovoltaics, at plant	RER	0	m2	0	0	0	0			
	single-Si wafer, electronics, at plant	RER	0	m2	0	0	0	0			
	multi-Si wafer, at plant	RER	0	m2	0	0	0	0			
	multi-Si wafer, ribbon, at plant	RER	0	m2	0	0	0	0			
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	-	-	-	-	1	2.07	(3,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	electricity, medium voltage, at grid	CN	0	kWh	2.57E+1	2.08E+1	-	-	1	2.07	(3,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	electricity, medium voltage, at grid	US	0	kWh	-	-	2.57E+1	2.08E+1	1	2.07	(3,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	electricity, medium voltage, at grid	JP	0	kWh	-	-	-	-	1	2.07	(3,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	natural gas, burned in industrial furnace low-NOx >100kW	RER	0	MJ	4.00E+0	4.00E+0	4.00E+0	4.00E+0	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
water	tap water, at user	RER	0	kg	6.00E-3	1.64E+2	6.00E-3	1.64E+2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	water, completely softened, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	water, deionised, at plant	CH	0	kg	1.80E+1	-	1.80E+1	-	1	1.26	(3,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
material	silicon, multi-Si, casted, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	CZ single crystalline silicon, photovoltaics, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	silicon, multi-Si, casted, at plant	CN	0	kg	-	1.02E+0	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	CZ single crystalline silicon, photovoltaics, at plant	CN	0	kg	1.58E+0	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	silicon, multi-Si, casted, at plant	US	0	kg	-	-	-	1.02E+0	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	CZ single crystalline silicon, photovoltaics, at plant	US	0	kg	-	-	1.58E+0	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	silicon, multi-Si, casted, at plant	APAC	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	CZ single crystalline silicon, photovoltaics, at plant	APAC	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	silicon, production mix, photovoltaics, at plant	GLO	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	silicon carbide, at plant	RER	0	kg	6.20E-1	6.20E-1	6.20E-1	6.20E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	silicon carbide, recycling, at plant	RER	0	kg	1.41E+0	1.41E+0	1.41E+0	1.41E+0	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
auxiliary material	graphite, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	flat glass, uncoated, at plant	RER	0	kg	9.99E-3	4.08E-2	9.99E-3	4.08E-2	2	1.26	(3,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	argon, liquid, at plant	RER	0	kg	-	-	-	-	1	1.26	(3,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	sodium hydroxide, 50% in H2O, production mix, at plant	RER	0	kg	1.50E-2	1.50E-2	1.50E-2	1.50E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	hydrochloric acid, 30% in H2O, at plant	RER	0	kg	2.70E-3	2.70E-3	2.70E-3	2.70E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	acetic acid, 98% in H2O, at plant	RER	0	kg	3.90E-2	3.90E-2	3.90E-2	3.90E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	nitric acid, 50% in H2O, at plant	RER	0	kg	-	-	-	-	1	1.58	(5,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	triethylene glycol, at plant	RER	0	kg	2.18E-1	2.18E-1	2.18E-1	2.18E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	triethylene glycol, recycling, at plant	RER	0	kg	1.95E+0	1.95E+0	1.95E+0	1.95E+0	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	dipropylene glycol monomethyl ether, at plant	RER	0	kg	3.00E-1	3.00E-1	3.00E-1	3.00E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	alkylbenzene sulfonate, linear, petrochemical, at plant	RER	0	kg	2.40E-1	2.40E-1	2.40E-1	2.40E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	acrylic binder, 34% in H2O, at plant	RER	0	kg	2.00E-3	3.85E-3	2.00E-3	3.85E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	glass wool mat, at plant	CH	0	kg	-	-	-	-	1	1.07	(2,2,1,1,1,na); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	paper, woodfree, coated, at integrated mill	RER	0	kg	-	-	-	-	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	polystyrene, high impact, HIPS, at plant	RER	0	kg	-	-	-	-	1	1.34	(4,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	packaging film, LDPE, at plant	RER	0	kg	-	-	-	-	1	1.34	(4,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	brass, at plant	CH	0	kg	7.44E-3	7.44E-3	7.44E-3	7.44E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	steel, low-alloyed, at plant	RER	0	kg	7.97E-1	7.97E-1	7.97E-1	7.97E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	wire drawing, steel	RER	0	kg	8.05E-1	8.05E-1	8.05E-1	8.05E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
wastes	disposal, waste, silicon wafer production, 0% water, to underground deposit	DE	0	kg	1.10E-1	1.70E-1	1.10E-1	1.70E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	disposal, municipal solid waste, 22.9% water, to sanitary landfill	CH	0	kg	-	-	-	-	1	1.24	(2,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	disposal, waste, Si waferprod., inorg, 9.4% water, to residual material landfill	CH	0	kg	-	-	-	-	1	1.24	(2,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
transport	transport, lorry >16t, fleet average	RER	0	tkm	9.29E-1	8.46E-1	9.29E-1	8.46E-1	1	2.09	(4,5,na,na,na,na); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	transport, freight, rail	RER	0	tkm	3.84E+0	3.86E+0	3.84E+0	3.86E+0	1	2.09	(4,5,na,na,na,na); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
infrastructure	wafer factory	DE	1	unit	4.00E-6	4.00E-6	4.00E-6	4.00E-6	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
emission air	Heat, waste	-	-	MJ	9.25E+1	7.49E+1	9.25E+1	7.49E+1	1	1.26	(3,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Nitrogen oxides	-	-	kg	-	-	-	-	1	1.58	(2,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
emission water, river	AOX, Adsorbable Organic Halogen as Cl	-	-	kg	-	-	-	-	1	1.58	(2,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Cadmium, ion	-	-	kg	-	-	-	-	1	3.06	(2,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Chromium, ion	-	-	kg	-	-	-	-	1	3.06	(2,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	COD, Chemical Oxygen Demand	-	-	kg	2.95E-2	2.95E-2	2.95E-2	2.95E-2	1	1.58	(2,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Copper, ion	-	-	kg	-	-	-	-	1	3.06	(2,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Lead	-	-	kg	-	-	-	-	1	5.07	(2,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Mercury	-	-	kg	-	-	-	-	1	5.07	(2,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Nickel, ion	-	-	kg	-	-	-	-	1	5.07	(2,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Nitrogen	-	-	kg	-	-	-	-	1	1.58	(2,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Phosphate	-	-	kg	-	-	-	-	1	1.58	(2,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	BOD5, Biological Oxygen Demand	-	-	kg	2.95E-2	2.95E-2	2.95E-2	2.95E-2	1	1.59	(3,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	DOC, Dissolved Organic Carbon	-	-	kg	1.11E-2	1.11E-2	1.11E-2	1.11E-2	1	1.59	(3,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	TOC, Total Organic Carbon	-	-	kg	1.11E-2	1.11E-2	1.11E-2	1.11E-2	1	1.59	(3,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)

Tab. 5.1.7.2 Unit process data of the single- and multi-crystalline silicon wafer production in Europe (RER) and Asia & Pacific (APAC); red added exchanges compared to Jungbluth et al. (2012) [38].

	Name	Location	InfrastructureProcess	Unit	single-Si wafer, photovoltaics, at plant	multi-Si wafer, at plant	single-Si wafer, photovoltaics, at plant	multi-Si wafer, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				APAC	APAC	RER	RER			
	InfrastructureProcess				0	0	0	0			
	Unit				m2	m2	m2	m2			
product	multi-Si wafer, at plant	CN	0	m2	0	0	0	0			
	single-Si wafer, photovoltaics, at plant	CN	0	m2	0	0	0	0			
	multi-Si wafer, at plant	US	0	m2	0	0	0	0			
	single-Si wafer, photovoltaics, at plant	US	0	m2	0	0	0	0			
	multi-Si wafer, at plant	APAC	0	m2	0	1	0	0			
	single-Si wafer, photovoltaics, at plant	APAC	0	m2	1	0	0	0			
product	single-Si wafer, photovoltaics, at plant	RER	0	m2	0	0	1	0			
	single-Si wafer, electronics, at plant	RER	0	m2	0	0	0	0			
	multi-Si wafer, at plant	RER	0	m2	0	0	0	1			
	multi-Si wafer, ribbon, at plant	RER	0	m2	0	0	0	0			
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	-	-	2.57E+1	2.08E+1	1	2.07	(3,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	electricity, medium voltage, at grid	CN	0	kWh	-	-	-	-	1	2.07	(3,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	electricity, medium voltage, at grid	US	0	kWh	-	-	-	-	1	2.07	(3,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	electricity, medium voltage, at grid	JP	0	kWh	2.57E+1	2.08E+1	-	-	1	2.07	(3,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	natural gas, burned in industrial furnace low-NOx >100kW	RER	0	MJ	4.00E+0	4.00E+0	4.00E+0	4.00E+0	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
water	tap water, at user	RER	0	kg	6.00E-3	1.64E+2	6.00E-3	1.64E+2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	water, completely softened, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	water, deionised, at plant	CH	0	kg	1.80E+1	-	1.80E+1	-	1	1.26	(3,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
material	silicon, multi-Si, casted, at plant	RER	0	kg	-	-	-	1.02E+0	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	CZ single crystalline silicon, photovoltaics, at plant	RER	0	kg	-	-	1.58E+0	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	silicon, multi-Si, casted, at plant	CN	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	CZ single crystalline silicon, photovoltaics, at plant	CN	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	silicon, multi-Si, casted, at plant	US	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	CZ single crystalline silicon, photovoltaics, at plant	US	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	silicon, multi-Si, casted, at plant	APAC	0	kg	-	1.02E+0	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	CZ single crystalline silicon, photovoltaics, at plant	APAC	0	kg	1.58E+0	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	silicon, production mix, photovoltaics, at plant	GLO	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	silicon carbide, at plant	RER	0	kg	6.20E-1	6.20E-1	6.20E-1	6.20E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	silicon carbide, recycling, at plant	RER	0	kg	1.41E+0	1.41E+0	1.41E+0	1.41E+0	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
auxiliary material	graphite, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	flat glass, uncoated, at plant	RER	0	kg	9.99E-3	4.08E-2	9.99E-3	4.08E-2	1	1.26	(3,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	argon, liquid, at plant	RER	0	kg	-	-	-	-	1	1.26	(3,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	sodium hydroxide, 50% in H2O, production mix, at plant	RER	0	kg	1.50E-2	1.50E-2	1.50E-2	1.50E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	hydrochloric acid, 30% in H2O, at plant	RER	0	kg	2.70E-3	2.70E-3	2.70E-3	2.70E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	acetic acid, 98% in H2O, at plant	RER	0	kg	3.90E-2	3.90E-2	3.90E-2	3.90E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	nitric acid, 50% in H2O, at plant	RER	0	kg	-	-	-	-	1	1.58	(5,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	triethylene glycol, at plant	RER	0	kg	2.18E-1	2.18E-1	2.18E-1	2.18E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	triethylene glycol, recycling, at plant	RER	0	kg	1.95E+0	1.95E+0	1.95E+0	1.95E+0	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	dipropylene glycol monomethyl ether, at plant	RER	0	kg	3.00E-1	3.00E-1	3.00E-1	3.00E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	alkylbenzene sulfonate, linear, petrochemical, at plant	RER	0	kg	2.40E-1	2.40E-1	2.40E-1	2.40E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	acrylic binder, 34% in H2O, at plant	RER	0	kg	3.85E-3	3.85E-3	2.00E-3	3.85E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	glass wool mat, at plant	CH	0	kg	-	-	-	-	1	1.07	(2,2,1,1,1,na); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	paper, woodfree, coated, at integrated mill	RER	0	kg	-	-	-	-	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	polystyrene, high impact, HIPS, at plant	RER	0	kg	-	-	-	-	1	1.34	(4,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	packaging film, LDPE, at plant	RER	0	kg	-	-	-	-	1	1.34	(4,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	brass, at plant	CH	0	kg	7.44E-3	7.44E-3	7.44E-3	7.44E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	steel, low-alloyed, at plant	RER	0	kg	7.97E-1	7.97E-1	7.97E-1	7.97E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	wire drawing, steel	RER	0	kg	8.05E-1	8.05E-1	8.05E-1	8.05E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
wastes	disposal, waste, silicon wafer production, 0% water, to underground deposit	DE	0	kg	1.70E-1	1.70E-1	1.10E-1	1.70E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	disposal, municipal solid waste, 22.9% water, to sanitary landfill	CH	0	kg	-	-	-	-	1	1.24	(2,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	disposal, waste, Si waferprod., inorg, 9.4% water, to residual material landfill	CH	0	kg	-	-	-	-	1	1.24	(2,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
transport	transport, lorry >16t, fleet average	RER	0	tkm	9.29E-1	8.46E-1	9.29E-1	8.46E-1	1	2.09	(4,5,na,na,na,na); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	transport, freight, rail	RER	0	tkm	3.84E+0	3.86E+0	3.84E+0	3.86E+0	1	2.09	(4,5,na,na,na,na); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
infrastructure	wafer factory	DE	1	unit	4.00E-6	4.00E-6	4.00E-6	4.00E-6	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
emission air	Heat, waste	-	-	MJ	9.25E+1	7.49E+1	9.25E+1	7.49E+1	1	1.26	(3,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Nitrogen oxides	-	-	kg	-	-	-	-	1	1.58	(2,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
emission water, river	AOX, Adsorbable Organic Halogen as Cl	-	-	kg	-	-	-	-	1	1.58	(2,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Cadmium, ion	-	-	kg	-	-	-	-	1	3.06	(2,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Chromium, ion	-	-	kg	-	-	-	-	1	3.06	(2,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	COD, Chemical Oxygen Demand	-	-	kg	2.95E-2	2.95E-2	2.95E-2	2.95E-2	1	1.58	(2,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Copper, ion	-	-	kg	-	-	-	-	1	3.06	(2,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Lead	-	-	kg	-	-	-	-	1	5.07	(2,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Mercury	-	-	kg	-	-	-	-	1	5.07	(2,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Nickel, ion	-	-	kg	-	-	-	-	1	5.07	(2,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Nitrogen	-	-	kg	-	-	-	-	1	1.58	(2,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	Phosphate	-	-	kg	-	-	-	-	1	1.58	(2,4,1,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	BOD5, Biological Oxygen Demand	-	-	kg	2.95E-2	2.95E-2	2.95E-2	2.95E-2	1	1.59	(3,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	DOC, Dissolved Organic Carbon	-	-	kg	1.11E-2	1.11E-2	1.11E-2	1.11E-2	1	1.59	(3,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)
	TOC, Total Organic Carbon	-	-	kg	1.11E-2	1.11E-2	1.11E-2	1.11E-2	1	1.59	(3,4,2,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 19,25)

Tab. 5.1.7.3 shows the unit process data of the silicon wafer market mixes in Europe (RER), North America (US) and Asia & Pacific (APAC). The values correspond to the shares given in Tab. 5.1.2.2. The

transport distances with freight ships depend on the world region. Distances of 19’994 km, 20’755 km and 4584 km are assumed for the transport from China (Shanghai) to Europe (Rotterdam), from China (Shanghai) to North America (New York) and from China (Shanghai) to APAC (Port Klang), respectively. Furthermore, 50 km transport by lorry and 200 km transport by train are assumed independent of the region.

Tab. 5.1.7.3 Unit process data of the silicon wafer market mixes in Europe (RER), North America (US) and Asia & Pacific (APAC).

	Name	Location	Infrastructure Process	Unit	multi-Si wafer, at regional storage	single-Si wafer, photovoltaics, at regional storage	multi-Si wafer, at regional storage	single-Si wafer, photovoltaics, at regional storage	multi-Si wafer, at regional storage	single-Si wafer, photovoltaics, at regional storage	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	US	US	APAC	APAC			
	InfrastructureProcess				0	0	0	0	0	0			
	Unit				m2	m2	m2	m2	m2	m2			
	multi-Si wafer, at regional storage	RER	0	m2	1	0	0	0	0	0			
	single-Si wafer, photovoltaics, at regional storage	RER	0	m2	0	1	0	0	0	0			
	multi-Si wafer, at regional storage	US	0	m2	0	0	1	0	0	0			
	single-Si wafer, photovoltaics, at regional storage	US	0	m2	0	0	0	1	0	0			
	multi-Si wafer, at regional storage	APAC	0	m2	0	0	0	0	1	0			
	single-Si wafer, photovoltaics, at regional storage	APAC	0	m2	0	0	0	0	0	1			
modules	multi-Si wafer, at plant	RER	0	m2	8.88E-1	-	-	-	-	-	1	1.56	(5,1,1,1,1,5); Market shares European wafers
	single-Si wafer, photovoltaics, at plant	RER	0	m2	-	8.88E-1	-	-	-	-	1	1.56	(5,1,1,1,1,5); Market shares European wafers
	multi-Si wafer, at plant	CN	0	m2	1.12E-1	-	6.62E-1	-	2.66E-1	-	1	1.56	(5,1,1,1,1,5); Market shares Chinese wafers
	single-Si wafer, photovoltaics, at plant	CN	0	m2	-	1.12E-1	-	6.62E-1	-	2.66E-1	1	1.56	(5,1,1,1,1,5); Market shares Chinese wafers
	multi-Si wafer, at plant	US	0	m2	-	-	3.38E-1	-	-	-	1	1.56	(5,1,1,1,1,5); Market shares US wafers
	single-Si wafer, photovoltaics, at plant	US	0	m2	-	-	-	3.38E-1	-	-	1	1.56	(5,1,1,1,1,5); Market shares US wafers
	multi-Si wafer, at plant	APAC	0	m2	-	-	-	-	7.34E-1	-	1	1.56	(5,1,1,1,1,5); Market shares APAC wafers
	single-Si wafer, photovoltaics, at plant	APAC	0	m2	-	-	-	-	-	7.34E-1	1	1.56	(5,1,1,1,1,5); Market shares APAC wafers
transport	transport, transoceanic freight ship	OCE	0	tkm	2.23E+0	2.23E+0	1.37E+1	1.37E+1	1.22E+0	1.22E+0	1	2.09	(4,5,na,na,na,na); Import of modules from CN-EU: 19994 km, CN-US: 20755 km, CN-APAC: 4584 km
	transport, freight, rail	RER	0	tkm	2.00E-1	2.00E-1	2.00E-1	2.00E-1	2.00E-1	2.00E-1	1	2.09	(4,5,na,na,na,na); Standard distance 200km
	transport, lorry >16t, fleet average	RER	0	tkm	5.00E-2	5.00E-2	5.00E-2	5.00E-2	5.00E-2	5.00E-2	1	2.09	(4,5,na,na,na,na); Standard distance 50km

5.1.8 Photovoltaic cell, laminate and panel production

5.1.8.1 Photovoltaic cells

The LCI data on material and energy consumption as well as about emissions are updated based on LCI data of single- and multi-crystalline cells published by de Wild-Scholten (2014) [40]. Data on “tap water, at user” refers to city water for facility and manufacturing process use.

Tab. 5.1.8.1.1 and Tab. 5.1.8.1.2 show the unit process data of the photovoltaic cell production in Europe (RER), China (CN), North America (US) and Asia & Pacific (APAC). The Japanese electricity mix is selected for the APAC region, because Japan produces the highest share of single-and multi-crystalline cells in the APAC region. The US electricity mix is chosen to model electricity consumption in the North American production.

The LCI data on material and energy consumption as well as about emissions are updated based on LCI data of single- and multi-crystalline cells published by de Wild-Scholten (2014) [40]. Data on “tap water, at user” refers to city water for facility and manufacturing process use.

Tab. 5.1.8.1.1 Unit process data of the photovoltaic cell production in China (CN) and North America (US); red added exchanges compared to Jungbluth et al. (2012) [38].

	Name	Location	InfrastructureProcess	Unit	photovoltaic cell, single-Si, at plant	photovoltaic cell, multi-Si, at plant	photovoltaic cell, single-Si, at plant	photovoltaic cell, multi-Si, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CN	CN	US	US			
	InfrastructureProcess				0	0	0	0			
	Unit				m2	m2	m2	m2			
	photovoltaic cell, multi-Si, at plant	CN	0	m2	0	1	0	0			
	photovoltaic cell, single-Si, at plant	CN	0	m2	1	0	0	0			
	photovoltaic cell, multi-Si, at plant	US	0	m2	0	0	0	1			
	photovoltaic cell, single-Si, at plant	US	0	m2	0	0	1	0			
	photovoltaic cell, multi-Si, at plant	APAC	0	m2	0	0	0	0			
	photovoltaic cell, single-Si, at plant	APAC	0	m2	0	0	0	0			
product	photovoltaic cell, single-Si, at plant	RER	0	m2	0	0	0	0			
	photovoltaic cell, multi-Si, at plant	RER	0	m2	0	0	0	0			
	photovoltaic cell, ribbon-Si, at plant	RER	0	m2	0	0	0	0			
resource, in water	Water, cooling, unspecified natural origin	-	-	m3	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	tap water, at user	RER	0	kg	1.71E+2	2.51E+2	1.71E+2	2.51E+2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
technosphere	electricity, medium voltage, at grid	CN	0	kWh	1.44E+1	1.44E+1	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
technosphere	electricity, medium voltage, at grid	US	0	kWh	-	-	1.44E+1	1.44E+1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
technosphere	electricity, medium voltage, at grid	JP	0	kWh	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	natural gas, burned in industrial furnace low-NOx >100kW	RER	0	MJ	6.08E-2	2.47E-1	6.08E-2	2.47E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	light fuel oil, burned in industrial furnace 1MW, non-modulating	RER	0	MJ	-	2.70E-3	-	2.70E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
infrastructure	photovoltaic cell factory	DE	1	unit	4.00E-7	4.00E-7	4.00E-7	4.00E-7	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
wafers	multi-Si wafer, at regional storage	RER	0	m2	-	-	-	-	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	single-Si wafer, photovoltaics, at regional storage	RER	0	m2	-	-	-	-	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	multi-Si wafer, ribbon, at plant	RER	0	m2	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	multi-Si wafer, at plant	CN	0	m2	-	1.04E+0	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	single-Si wafer, photovoltaics, at plant	CN	0	m2	1.03E+0	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	multi-Si wafer, at regional storage	US	0	m2	-	-	-	1.04E+0	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	single-Si wafer, photovoltaics, at regional storage	US	0	m2	-	-	1.03E+0	-	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	multi-Si wafer, at regional storage	APAC	0	m2	-	-	-	-	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	single-Si wafer, photovoltaics, at regional storage	APAC	0	m2	-	-	-	-	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
materials	metallization paste, front side, at plant	RER	0	kg	5.75E-3	9.12E-3	5.75E-3	9.12E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	metallization paste, back side, at plant	RER	0	kg	3.84E-3	5.34E-3	3.84E-3	5.34E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	metallization paste, back side, aluminium, at plant	RER	0	kg	5.59E-2	5.96E-2	5.59E-2	5.96E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
chemicals	ammonia, liquid, at regional storehouse	RER	0	kg	2.19E-2	8.92E-3	2.19E-2	8.92E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	phosphoric acid, fertiliser grade, 70% in H2O, at plant	GLO	0	kg	-	8.63E-3	-	8.63E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	phosphoryl chloride, at plant	RER	0	kg	1.33E-2	2.74E-2	1.33E-2	2.74E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	titanium dioxide, production mix, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	ethanol from ethylene, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	isopropanol, at plant	RER	0	kg	1.77E-1	8.10E-4	1.77E-1	8.10E-4	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	solvents, organic, unspecified, at plant	GLO	0	kg	-	1.13E-2	-	1.13E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	silicone product, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	sodium silicate, spray powder 80%, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	calcium chloride, CaCl2, at regional storage	CH	0	kg	-	3.15E-2	-	3.15E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	acetic acid, 98% in H2O, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	hydrochloric acid, 30% in H2O, at plant	RER	0	kg	6.29E-4	8.59E-3	6.29E-4	8.59E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	hydrogen fluoride, at plant	GLO	0	kg	6.45E-4	4.03E-1	6.45E-4	4.03E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	nitric acid, 50% in H2O, at plant	RER	0	kg	-	2.93E-1	-	2.93E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	sodium hydroxide, 50% in H2O, production mix, at plant	RER	0	kg	6.04E-1	7.07E-2	6.04E-1	7.07E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	lime, hydrated, packed, at plant	CH	0	kg	1.51E-2	2.18E-1	1.51E-2	2.18E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	hydrogen peroxide, 50% in H2O, at plant	RER	0	kg	-	4.52E-4	-	4.52E-4	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	sulphuric acid, liquid, at plant	RER	0	kg	-	1.01E-1	-	1.01E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	refrigerant R134a, at plant	RER	0	kg	3.12E-5	2.73E-5	3.12E-5	2.73E-5	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	potassium hydroxide, at regional storage	RER	0	kg	-	3.00E-2	-	3.00E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	ammonium sulphate, as N, at regional storehouse	RER	0	kg	-	2.10E-2	-	2.10E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
gases	argon, liquid, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	oxygen, liquid, at plant	RER	0	kg	-	8.22E-3	-	8.22E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	nitrogen, liquid, at plant	RER	0	kg	1.15E+0	1.35E+0	1.15E+0	1.35E+0	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	tetrafluoroethylene, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	silicon tetrahydride, at plant	RER	0	kg	2.91E-3	2.61E-3	2.91E-3	2.61E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
packaging	polystyrene, expandable, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	transport, lorry >16t, fleet average	RER	0	tkm	2.74E-1	5.22E-1	2.74E-1	5.22E-1	1	2.09	(4,5,na,na,na,na); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	transport, freight, rail	RER	0	tkm	1.52E+0	3.94E-1	1.52E+0	3.94E-1	1	2.09	(4,5,na,na,na,na); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	water, completely softened, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	treatment, PV cell production effluent, to wastewater treatment, class 3	CH	0	m3	1.59E-1	7.89E-2	1.59E-1	7.89E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	disposal, waste, Si waferprod., inorg, 9.4% water, to residual material landfill	CH	0	kg	2.33E+0	2.74E+0	2.33E+0	2.74E+0	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	disposal, solvents mixture, 16.5% water, to hazardous waste incineration	CH	0	kg	1.72E-1	1.08E-2	1.72E-1	1.08E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	transport, transoceanic freight ship	OCE	0	tkm	3.06E-2	-	3.06E-2	-	1	2.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
emission air, high population density	Heat, waste	-	-	MJ	5.18E+1	5.18E+1	5.18E+1	5.18E+1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Aluminium	-	-	kg	7.73E-6	7.73E-6	7.73E-6	7.73E-6	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Ethane, hexafluoro-, HFC-116	-	-	kg	-	-	-	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Hydrogen chloride	-	-	kg	-	-	-	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Hydrogen fluoride	-	-	kg	1.38E-4	6.90E-4	1.38E-4	6.90E-4	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Lead	-	-	kg	7.73E-6	7.73E-6	7.73E-6	7.73E-6	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	-	-	-	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Nitrogen oxides	-	-	kg	-	-	-	-	1	1.61	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Methane, tetrafluoro-, R-14	-	-	kg	-	-	-	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Particulates, < 2.5 um	-	-	kg	-	-	-	-	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Silicon	-	-	kg	3.17E-8	3.17E-8	3.17E-8	3.17E-8	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Silver	-	-	kg	7.73E-6	7.73E-6	7.73E-6	7.73E-6	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Sodium	-	-	kg	-	-	-	-	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Tin	-	-	kg	7.73E-6	7.73E-6	7.73E-6	7.73E-6	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Ammonia	-	-	kg	3.73E-5	5.22E-4	3.73E-5	5.22E-4	1	1.21	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Carbon dioxide, fossil	-	-	kg	1.67E-1	6.82E-1	1.67E-1	6.82E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Chlorine	-	-	kg	4.60E-5	-	4.60E-5	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Hydrogen	-	-	kg	1.10E-2	4.44E-4	1.10E-2	4.44E-4	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	2-Propanol	-	-	kg	1.47E-2	-	1.47E-2	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Acetaldehyde	-	-	kg	6.33E-4	-	6.33E-4	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	3.12E-5	2.73E-5	3.12E-5	2.73E-5	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Silicon	-	-	kg	3.33E-4	1.47E-4	3.33E-4	1.47E-4	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Silicon	-	-	kg	2.63E-3	6.00E-6	2.63E-3	6.00E-6	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.26E-2	3.53E-4	1.26E-2	3.53E-4	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Water	-	-	kg	1.16E+1	5.96E+0	1.16E+1	5.96E+0	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Nitric acid	-	-	kg	-	1.19E-4	-	1.19E-4	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Nitrogen oxides	-	-	kg	-	1.24E-2	-	1.24E-2	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Nitrogen oxides	-	-	kg	-	3.64E-3	-	3.64E-3	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Sodium, ion	-	-	kg	-	-	-	-	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Potassium, ion	-	-	kg	-	-	-	-	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Chloride	-	-	kg	-	-	-	-	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Fluoride	-	-	kg	-	-	-	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Phosphate	-	-	kg	-	-	-	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Ammonium, ion	-	-	kg	-	-	-	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)

Tab. 5.1.8.1.2 Unit process data of the photovoltaic cell production in Europe (RER) and Asia & Pacific (APAC); red added exchanges compared to Jungbluth et al. (2012) [38].

	Name	Location	InfrastructureProcess	Unit	photovoltaic cell, single-Si, at plant	photovoltaic cell, multi-Si, at plant	photovoltaic cell, single-Si, at plant	photovoltaic cell, multi-Si, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				APAC	APAC	RER	RER			
	InfrastructureProcess				0	0	0	0			
	Unit				m2	m2	m2	m2			
	photovoltaic cell, multi-Si, at plant	CN	0	m2	0	0	0	0			
	photovoltaic cell, single-Si, at plant	CN	0	m2	0	0	0	0			
	photovoltaic cell, multi-Si, at plant	US	0	m2	0	0	0	0			
	photovoltaic cell, single-Si, at plant	US	0	m2	0	0	0	0			
	photovoltaic cell, multi-Si, at plant	APAC	0	m2	0	1	0	0			
	photovoltaic cell, single-Si, at plant	APAC	0	m2	1	0	0	0			
product	photovoltaic cell, single-Si, at plant	RER	0	m2	0	0	1	0			
	photovoltaic cell, multi-Si, at plant	RER	0	m2	0	0	0	1			
	photovoltaic cell, ribbon-Si, at plant	RER	0	m2	0	0	0	0			
resource, in water	Water, cooling, unspecified natural origin	-	-	m3	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	tap water, at user	RER	0	kg	1.71E+2	2.51E+2	1.71E+2	2.51E+2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	-	-	1.44E+1	1.44E+1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
technosphere	electricity, medium voltage, at grid	CN	0	kWh	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
technosphere	electricity, medium voltage, at grid	US	0	kWh	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
technosphere	electricity, medium voltage, at grid	JP	0	kWh	1.44E+1	1.44E+1	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	natural gas, burned in industrial furnace low-NOx >100kW	RER	0	MJ	6.08E-2	2.47E-1	6.08E-2	2.47E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	light fuel oil, burned in industrial furnace 1MW, non-modulating	RER	0	MJ	-	2.70E-3	-	2.70E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
infrastructure	photovoltaic cell factory	DE	1	unit	4.00E-7	4.00E-7	4.00E-7	4.00E-7	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
wafers	multi-Si wafer, at regional storage	RER	0	m2	-	-	-	1.04E+0	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	single-Si wafer, photovoltaics, at regional storage	RER	0	m2	-	-	1.03E+0	-	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	multi-Si wafer, ribbon, at plant	RER	0	m2	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	multi-Si wafer, at plant	CN	0	m2	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	single-Si wafer, photovoltaics, at plant	CN	0	m2	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	multi-Si wafer, at regional storage	US	0	m2	-	-	-	-	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	single-Si wafer, photovoltaics, at regional storage	US	0	m2	-	-	-	-	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	multi-Si wafer, at regional storage	APAC	0	m2	-	1.04E+0	-	-	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	single-Si wafer, photovoltaics, at regional storage	APAC	0	m2	1.03E+0	-	-	-	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
materials	metallization paste, front side, at plant	RER	0	kg	5.75E-3	9.12E-3	5.75E-3	9.12E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	metallization paste, back side, at plant	RER	0	kg	3.84E-3	5.34E-3	3.84E-3	5.34E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	metallization paste, back side, aluminium, at plant	RER	0	kg	5.59E-2	5.96E-2	5.59E-2	5.96E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
chemicals	ammonia, liquid, at regional storehouse	RER	0	kg	2.19E-2	8.92E-3	2.19E-2	8.92E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	phosphoric acid, fertiliser grade, 70% in H2O, at plant	GLO	0	kg	-	8.63E-3	-	8.63E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	phosphoryl chloride, at plant	RER	0	kg	1.33E-2	2.74E-2	1.33E-2	2.74E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	titanium dioxide, production mix, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	ethanol from ethylene, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	isopropanol, at plant	RER	0	kg	1.77E-1	8.10E-4	1.77E-1	8.10E-4	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	solvents, organic, unspecified, at plant	GLO	0	kg	-	1.13E-2	-	1.13E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	silicone product, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	sodium silicate, spray powder 80%, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	calcium chloride, CaCl2, at regional storage	CH	0	kg	-	3.15E-2	-	3.15E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	acetic acid, 98% in H2O, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	hydrochloric acid, 30% in H2O, at plant	RER	0	kg	6.29E-4	8.59E-3	6.29E-4	8.59E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	hydrogen fluoride, at plant	GLO	0	kg	6.45E-4	4.03E-1	6.45E-4	4.03E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	nitric acid, 50% in H2O, at plant	RER	0	kg	-	2.93E-1	-	2.93E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	sodium hydroxide, 50% in H2O, production mix, at plant	RER	0	kg	6.04E-1	7.07E-2	6.04E-1	7.07E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	lime, hydrated, packed, at plant	CH	0	kg	1.51E-2	2.18E-1	1.51E-2	2.18E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	hydrogen peroxide, 50% in H2O, at plant	RER	0	kg	-	4.52E-4	-	4.52E-4	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	sulphuric acid, liquid, at plant	RER	0	kg	-	1.01E-1	-	1.01E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	refrigerant R134a, at plant	RER	0	kg	3.12E-5	2.73E-5	3.12E-5	2.73E-5	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	potassium hydroxide, at regional storage	RER	0	kg	-	3.00E-2	-	3.00E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	ammonium sulphate, as N, at regional storehouse	RER	0	kg	-	2.10E-2	-	2.10E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
gases	argon, liquid, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	oxygen, liquid, at plant	RER	0	kg	-	8.22E-3	-	8.22E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	nitrogen, liquid, at plant	RER	0	kg	1.15E+0	1.35E+0	1.15E+0	1.35E+0	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	tetrafluoroethylene, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	silicon tetrahydride, at plant	RER	0	kg	2.91E-3	2.61E-3	2.91E-3	2.61E-3	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
packaging	polystyrene, expandable, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	transport, lorry >16t, fleet average	RER	0	tkm	2.74E-1	5.22E-1	2.74E-1	5.22E-1	1	2.09	(4,5,na,na,na,na); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	transport, freight, rail	RER	0	tkm	1.52E+0	3.94E-1	1.52E+0	3.94E-1	1	2.09	(4,5,na,na,na,na); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	water, completely softened, at plant	RER	0	kg	-	-	-	-	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	treatment, PV cell production effluent, to wastewater treatment, class 3	CH	0	m3	1.59E-1	7.89E-2	1.59E-1	7.89E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	disposal, waste, Si waferprod., inorg, 9.4% water, to residual material landfill	CH	0	kg	2.33E+0	2.74E+0	2.33E+0	2.74E+0	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	disposal, solvents mixture, 16.5% water, to hazardous waste incineration	CH	0	kg	1.72E-1	1.08E-2	1.72E-1	1.08E-2	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	transport, transoceanic freight ship	OCE	0	tkm	3.06E-2	-	3.06E-2	-	1	2.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
emission air, high population density	Heat, waste	-	-	MJ	5.18E+1	5.18E+1	5.18E+1	5.18E+1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Aluminium	-	-	kg	7.73E-6	7.73E-6	7.73E-6	7.73E-6	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Ethane, hexafluoro-, HFC-116	-	-	kg	-	-	-	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Hydrogen chloride	-	-	kg	-	-	-	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Hydrogen fluoride	-	-	kg	1.38E-4	6.90E-4	1.38E-4	6.90E-4	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Lead	-	-	kg	7.73E-6	7.73E-6	7.73E-6	7.73E-6	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	-	-	-	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Nitrogen oxides	-	-	kg	-	-	-	-	1	1.61	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Methane, tetrafluoro-, R-14	-	-	kg	-	-	-	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Particulates, < 2.5 um	-	-	kg	-	-	-	-	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Silicon	-	-	kg	3.17E-8	3.17E-8	3.17E-8	3.17E-8	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Silver	-	-	kg	7.73E-6	7.73E-6	7.73E-6	7.73E-6	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Sodium	-	-	kg	-	-	-	-	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Tin	-	-	kg	7.73E-6	7.73E-6	7.73E-6	7.73E-6	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Ammonia	-	-	kg	3.73E-5	5.22E-4	3.73E-5	5.22E-4	1	1.21	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Carbon dioxide, fossil	-	-	kg	1.67E-1	6.82E-1	1.67E-1	6.82E-1	1	1.07	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Chlorine	-	-	kg	4.60E-5	-	4.60E-5	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Hydrogen	-	-	kg	1.10E-2	4.44E-4	1.10E-2	4.44E-4	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	2-Propanol	-	-	kg	1.47E-2	-	1.47E-2	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Acetaldehyde	-	-	kg	6.33E-4	-	6.33E-4	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	3.12E-5	2.73E-5	3.12E-5	2.73E-5	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Silicon	-	-	kg	3.33E-4	1.47E-4	3.33E-4	1.47E-4	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Silicon	-	-	kg	2.63E-3	6.00E-6	2.63E-3	6.00E-6	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.26E-2	3.53E-4	1.26E-2	3.53E-4	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Water	-	-	kg	1.16E+1	5.96E+0	1.16E+1	5.96E+0	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Nitric acid	-	-	kg	-	1.19E-4	-	1.19E-4	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Nitrogen oxides	-	-	kg	-	1.24E-2	-	1.24E-2	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Nitrogen oxides	-	-	kg	-	3.64E-3	-	3.64E-3	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Sodium, ion	-	-	kg	-	-	-	-	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Potassium, ion	-	-	kg	-	-	-	-	1	5.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Chloride	-	-	kg	-	-	-	-	1	3.00	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Fluoride	-	-	kg	-	-	-	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Phosphate	-	-	kg	-	-	-	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)
	Ammonium, ion	-	-	kg	-	-	-	-	1	1.51	(1,2,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 30,31)

5.1.8.2 Photovoltaic laminate and panels

The LCI data on material and energy consumption as well as about emissions are updated based on LCI data of single- and multi-crystalline modules published by de Wild-Scholten (2014) [40].

Tab5.1.8.2.1 to Tab.5.1.8.2.4 show the unit process data of the photovoltaic laminate and panel production China (CN), North America (US), Asia & Pacific (APAC) and in Europe (RER).

The Japanese electricity mix is selected for the APAC region, because Japan produces the highest share of single-and multi-crystalline laminate and panel in the APAC region. The US electricity mix is chosen to model electricity consumption in the North American production.

The LCI data on material and energy consumption as well as about emissions are updated based on LCI data of single- and multi-crystalline modules published by de Wild-Scholten (2014) [40].

Tab5.1.8.2.1 Unit process data of the photovoltaic laminate and panel production in China (CN) ; red added exchanges compared to Jungbluth et al. (2012) [38].

	Name	Location	InfrastructureProcess	Unit	photovoltaic panel, single-Si, at plant	photovoltaic panel, multi-Si, at plant	photovoltaic laminate, single-Si, at plant	photovoltaic laminate, multi-Si, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CN	CN	CN	CN			
	InfrastructureProcess				1	1	1	1			
	Unit				m2	m2	m2	m2			
product	photovoltaic panel, multi-Si, at plant	CN	1	m2	0	1	0	0			
	photovoltaic panel, single-Si, at plant	CN	1	m2	1	0	0	0			
	photovoltaic laminate, multi-Si, at plant	CN	1	m2	0	0	0	1			
	photovoltaic laminate, single-Si, at plant	CN	1	m2	0	0	1	0			
	photovoltaic panel, multi-Si, at plant	US	1	m2	0	0	0	0			
	photovoltaic panel, single-Si, at plant	US	1	m2	0	0	0	0			
	photovoltaic laminate, multi-Si, at plant	US	1	m2	0	0	0	0			
	photovoltaic laminate, single-Si, at plant	US	1	m2	0	0	0	0			
	photovoltaic panel, multi-Si, at plant	APAC	1	m2	0	0	0	0			
	photovoltaic panel, single-Si, at plant	APAC	1	m2	0	0	0	0			
	photovoltaic laminate, multi-Si, at plant	APAC	1	m2	0	0	0	0			
	photovoltaic laminate, single-Si, at plant	APAC	1	m2	0	0	0	0			
	photovoltaic laminate, single-Si, at plant	RER	1	m2	0	0	0	0			
	photovoltaic panel, single-Si, at plant	RER	1	m2	0	0	0	0			
	photovoltaic laminate, multi-Si, at plant	RER	1	m2	0	0	0	0			
	photovoltaic panel, multi-Si, at plant	RER	1	m2	0	0	0	0			
	photovoltaic laminate, ribbon-Si, at plant	RER	1	m2	0	0	0	0			
	photovoltaic panel, ribbon-Si, at plant	RER	1	m2	0	0	0	0			
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	-	-	-	-	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	electricity, medium voltage, at grid	CN	0	kWh	3.73E+0	3.73E+0	3.73E+0	3.73E+0	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	electricity, medium voltage, at grid	US	0	kWh	-	-	-	-	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	electricity, medium voltage, at grid	JP	0	kWh	-	-	-	-	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	natural gas, burned in industrial furnace low-NOx>100kW	RER	0	MJ	-	-	-	-	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	diesel, burned in building machine	GLO	0	MJ	8.75E-3	8.75E-3	8.75E-3	8.75E-3	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
infrastructure	photovoltaic panel factory	GLO	1	unit	4.00E-6	4.00E-6	4.00E-6	4.00E-6	1	3.02	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	tap water, at user	RER	0	kg	5.03E+0	5.03E+0	5.03E+0	5.03E+0	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	tempering, flat glass	RER	0	kg	8.81E+0	8.81E+0	8.81E+0	8.81E+0	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	wire drawing, copper	RER	0	kg	1.03E-1	1.03E-1	1.03E-1	1.03E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
cells	photovoltaic cell, multi-Si, at plant	RER	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, single-Si, at plant	RER	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, ribbon-Si, at plant	RER	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, multi-Si, at plant	CN	0	m2	-	9.35E-1	-	9.35E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, single-Si, at plant	CN	0	m2	9.35E-1	-	9.35E-1	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, multi-Si, at plant	US	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, single-Si, at plant	US	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, multi-Si, at plant	APAC	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, single-Si, at plant	APAC	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
materials	aluminium alloy, AlMg3, at plant	RER	0	kg	2.13E+0	2.13E+0	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	nickel, 99.5%, at plant	GLO	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	brazing solder, cadmium free, at plant	RER	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	tin, at regional storage	RER	0	kg	1.29E-2	1.29E-2	1.29E-2	1.29E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	lead, at regional storage	RER	0	kg	7.25E-4	7.25E-4	7.25E-4	7.25E-4	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	silver, at regional storage	RER	0	kg	-	-	-	-	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	diode, unspecified, at plant	GLO	0	kg	2.81E-3	2.81E-3	2.81E-3	2.81E-3	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	polyethylene, HDPE, granulate, at plant	RER	0	kg	2.38E-2	2.38E-2	2.38E-2	2.38E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	solar glass, low-iron, at regional storage	RER	0	kg	8.81E+0	8.81E+0	8.81E+0	8.81E+0	1	1.24	(1,4,1,3,3,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	copper, at regional storage	RER	0	kg	1.03E-1	1.03E-1	1.03E-1	1.03E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	glass fibre reinforced plastic, polyamide, injection moulding, at plant	RER	0	kg	2.95E-1	2.95E-1	2.95E-1	2.95E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	ethylvinylacetate, foil, at plant	RER	0	kg	8.75E-1	8.75E-1	8.75E-1	8.75E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	polyvinylfluoride film, at plant	US	0	kg	1.12E-1	1.12E-1	1.12E-1	1.12E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	polyethylene terephthalate, granulate, amorphous, at plant	RER	0	kg	3.46E-1	3.46E-1	3.46E-1	3.46E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	silicone product, at plant	RER	0	kg	1.22E-1	1.22E-1	1.22E-1	1.22E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
auxiliary materials	acetone, liquid, at plant	RER	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	methanol, at regional storage	CH	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	vinyl acetate, at plant	RER	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	lubricating oil, at plant	RER	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	corrugated board, mixed fibre, single wall, at plant	RER	0	kg	7.63E-1	7.63E-1	7.63E-1	7.63E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	1-propanol, at plant	RER	0	kg	1.59E-2	1.59E-2	1.59E-2	1.59E-2	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	EUR-flat pallet	RER	0	unit	5.00E-2	5.00E-2	5.00E-2	5.00E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	hydrogen fluoride, at plant	GLO	0	kg	6.24E-2	6.24E-2	6.24E-2	6.24E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	isopropanol, at plant	RER	0	kg	1.47E-4	1.47E-4	1.47E-4	1.47E-4	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	potassium hydroxide, at regional storage	RER	0	kg	5.14E-2	5.14E-2	5.14E-2	5.14E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	soap, at plant	RER	0	kg	1.16E-2	1.16E-2	1.16E-2	1.16E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
transport	transport, lorry >16t, fleet average	RER	0	tkm	5.85E+0	5.85E+0	5.64E+0	5.64E+0	1	2.09	(4,5,na,na,na,na); Standard distance 100km, cells 500km
	transport, freight, rail	RER	0	tkm	4.25E+1	4.25E+1	4.12E+1	4.12E+1	1	2.09	(4,5,na,na,na,na); Standard distance 600km
disposal	disposal, municipal solid waste, 22.9% water, to municipal incineration	CH	0	kg	3.00E-2	3.00E-2	3.00E-2	3.00E-2	1	1.13	(1,4,1,3,1,3); Alsema (personal communication) 2007, production waste
	disposal, polyvinylfluoride, 0.2% water, to municipal incineration	CH	0	kg	1.12E-1	1.12E-1	1.12E-1	1.12E-1	1	1.13	(1,4,1,3,1,3); Calculation, including disposal of the panel after life time
	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	0	kg	1.64E+0	1.64E+0	1.64E+0	1.64E+0	1	1.13	(1,4,1,3,1,3); Calculation, including disposal of the panel after life time
	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	1.61E-3	1.61E-3	1.61E-3	1.61E-3	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	treatment, sewage, from residence, to wastewater treatment, class 2	CH	0	m3	5.03E-3	5.03E-3	5.03E-3	5.03E-3	1	1.13	(1,4,1,3,1,3); Calculation, water use
emission air	Heat, waste	-	-	MJ	1.34E+1	1.34E+1	1.34E+1	1.34E+1	1	1.29	(3,4,3,3,1,5); Calculation, electricity use
	transport, transoceanic freight ship	OCE	0	tkm	-	-	-	-	1	2.09	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	transport, aircraft, freight	RER	0	tkm	-	-	-	-	1	2.09	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	8.06E-3	8.06E-3	8.06E-3	8.06E-3	1	1.61	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	Carbon dioxide, fossil	-	-	kg	2.18E-2	2.18E-2	2.18E-2	2.18E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)

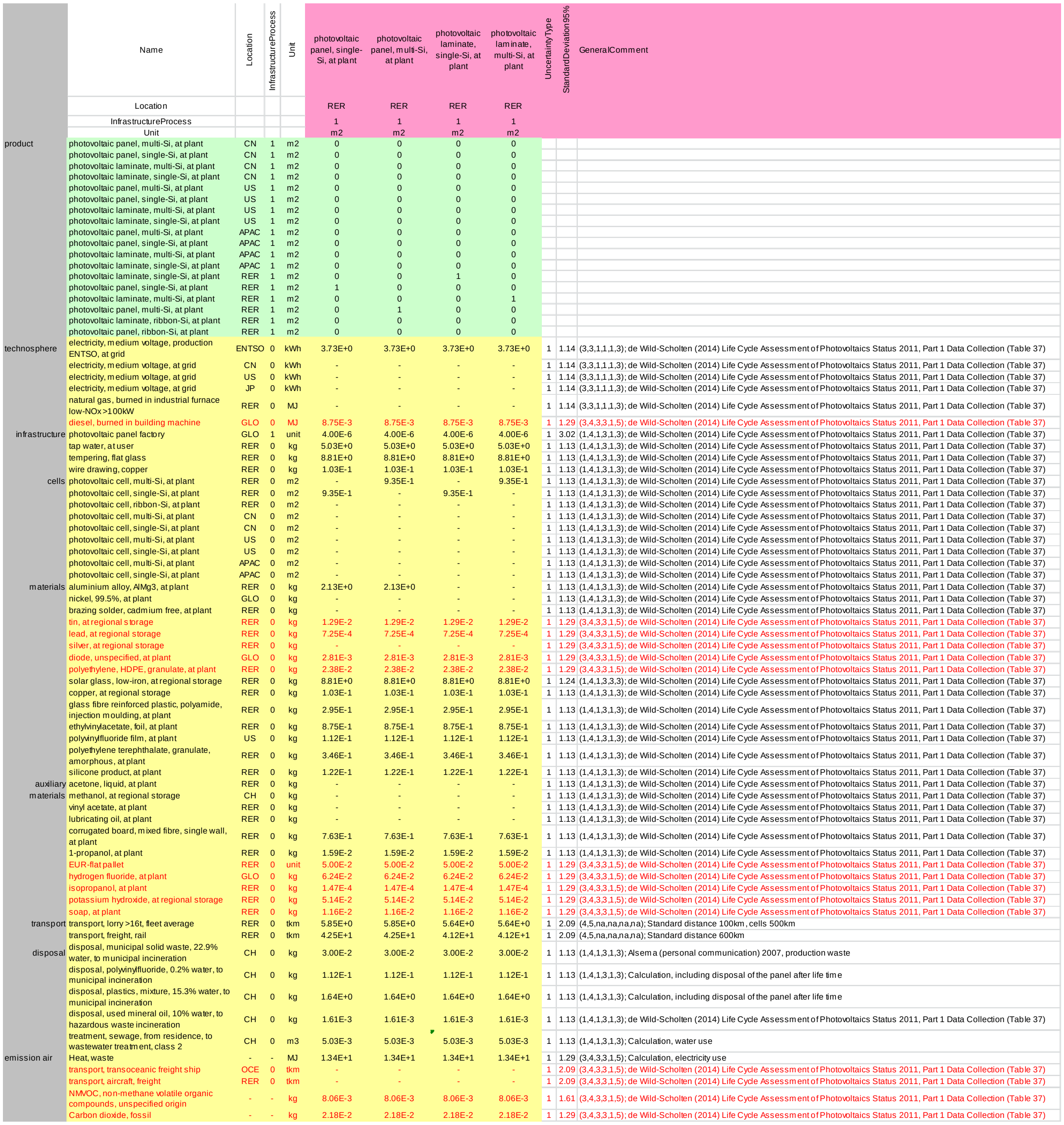
Tab. 5.1.8.2.2 Unit process data of the photovoltaic laminate and panel production in North America (US); red added exchanges compared to Jungbluth et al. (2012) [38].

	Name	Location	InfrastructureProcess	Unit	photovoltaic panel, single-Si, at plant	photovoltaic panel, multi-Si, at plant	photovoltaic laminate, single-Si, at plant	photovoltaic laminate, multi-Si, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				US	US	US	US			
	InfrastructureProcess				1	1	1	1			
	Unit				m2	m2	m2	m2			
product	photovoltaic panel, multi-Si, at plant	CN	1	m2	0	0	0	0			
	photovoltaic panel, single-Si, at plant	CN	1	m2	0	0	0	0			
	photovoltaic laminate, multi-Si, at plant	CN	1	m2	0	0	0	0			
	photovoltaic laminate, single-Si, at plant	CN	1	m2	0	0	0	0			
	photovoltaic panel, multi-Si, at plant	US	1	m2	0	1	0	0			
	photovoltaic panel, single-Si, at plant	US	1	m2	1	0	0	0			
	photovoltaic laminate, multi-Si, at plant	US	1	m2	0	0	0	1			
	photovoltaic laminate, single-Si, at plant	US	1	m2	0	0	1	0			
	photovoltaic panel, multi-Si, at plant	APAC	1	m2	0	0	0	0			
	photovoltaic panel, single-Si, at plant	APAC	1	m2	0	0	0	0			
	photovoltaic laminate, multi-Si, at plant	APAC	1	m2	0	0	0	0			
	photovoltaic laminate, single-Si, at plant	APAC	1	m2	0	0	0	0			
	photovoltaic laminate, single-Si, at plant	RER	1	m2	0	0	0	0			
	photovoltaic panel, single-Si, at plant	RER	1	m2	0	0	0	0			
	photovoltaic laminate, multi-Si, at plant	RER	1	m2	0	0	0	0			
	photovoltaic panel, multi-Si, at plant	RER	1	m2	0	0	0	0			
	photovoltaic laminate, ribbon-Si, at plant	RER	1	m2	0	0	0	0			
	photovoltaic panel, ribbon-Si, at plant	RER	1	m2	0	0	0	0			
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	-	-	-	-	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	electricity, medium voltage, at grid	CN	0	kWh	-	-	-	-	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	electricity, medium voltage, at grid	US	0	kWh	3.73E+0	3.73E+0	3.73E+0	3.73E+0	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	electricity, medium voltage, at grid	JP	0	kWh	-	-	-	-	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	natural gas, burned in industrial furnace low-NOx>100kW	RER	0	MJ	-	-	-	-	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	diesel, burned in building machine	GLO	0	MJ	8.75E-3	8.75E-3	8.75E-3	8.75E-3	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
infrastructure	photovoltaic panel factory	GLO	1	unit	4.00E-6	4.00E-6	4.00E-6	4.00E-6	1	3.02	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	tap water, at user	RER	0	kg	5.03E+0	5.03E+0	5.03E+0	5.03E+0	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	tempering, flat glass	RER	0	kg	8.81E+0	8.81E+0	8.81E+0	8.81E+0	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	wire drawing, copper	RER	0	kg	1.03E-1	1.03E-1	1.03E-1	1.03E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
cells	photovoltaic cell, multi-Si, at plant	RER	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, single-Si, at plant	RER	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, ribbon-Si, at plant	RER	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, multi-Si, at plant	CN	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, single-Si, at plant	CN	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, multi-Si, at plant	US	0	m2	-	9.35E-1	-	9.35E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, single-Si, at plant	US	0	m2	9.35E-1	-	9.35E-1	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, multi-Si, at plant	APAC	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, single-Si, at plant	APAC	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
materials	aluminium alloy, AlMg3, at plant	RER	0	kg	2.13E+0	2.13E+0	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	nickel, 99.5%, at plant	GLO	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	brazing solder, cadmium free, at plant	RER	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	tin, at regional storage	RER	0	kg	1.29E-2	1.29E-2	1.29E-2	1.29E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	lead, at regional storage	RER	0	kg	7.25E-4	7.25E-4	7.25E-4	7.25E-4	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	silver, at regional storage	RER	0	kg	-	-	-	-	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	diode, unspecified, at plant	GLO	0	kg	2.81E-3	2.81E-3	2.81E-3	2.81E-3	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	polyethylene, HDPE, granulate, at plant	RER	0	kg	2.38E-2	2.38E-2	2.38E-2	2.38E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	solar glass, low-iron, at regional storage	RER	0	kg	8.81E+0	8.81E+0	8.81E+0	8.81E+0	1	1.24	(1,4,1,3,3,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	copper, at regional storage	RER	0	kg	1.03E-1	1.03E-1	1.03E-1	1.03E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	glass fibre reinforced plastic, polyamide, injection moulding, at plant	RER	0	kg	2.95E-1	2.95E-1	2.95E-1	2.95E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	ethylvinylacetate, foil, at plant	RER	0	kg	8.75E-1	8.75E-1	8.75E-1	8.75E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	polyvinylfluoride film, at plant	US	0	kg	1.12E-1	1.12E-1	1.12E-1	1.12E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	polyethylene terephthalate, granulate, amorphous, at plant	RER	0	kg	3.46E-1	3.46E-1	3.46E-1	3.46E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	silicone product, at plant	RER	0	kg	1.22E-1	1.22E-1	1.22E-1	1.22E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
auxiliary materials	acetone, liquid, at plant	RER	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	methanol, at regional storage	CH	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	vinyl acetate, at plant	RER	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	lubricating oil, at plant	RER	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	corrugated board, mixed fibre, single wall, at plant	RER	0	kg	7.63E-1	7.63E-1	7.63E-1	7.63E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	1-propanol, at plant	RER	0	kg	1.59E-2	1.59E-2	1.59E-2	1.59E-2	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	EUR-flat pallet	RER	0	unit	5.00E-2	5.00E-2	5.00E-2	5.00E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	hydrogen fluoride, at plant	GLO	0	kg	6.24E-2	6.24E-2	6.24E-2	6.24E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	isopropanol, at plant	RER	0	kg	1.47E-4	1.47E-4	1.47E-4	1.47E-4	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	potassium hydroxide, at regional storage	RER	0	kg	5.14E-2	5.14E-2	5.14E-2	5.14E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	soap, at plant	RER	0	kg	1.16E-2	1.16E-2	1.16E-2	1.16E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
transport	transport, lorry >16t, fleet average	RER	0	tkm	5.85E+0	5.85E+0	5.64E+0	5.64E+0	1	2.09	(4,5,na,na,na,na); Standard distance 100km, cells 500km
	transport, freight, rail	RER	0	tkm	4.25E+1	4.25E+1	4.12E+1	4.12E+1	1	2.09	(4,5,na,na,na,na); Standard distance 600km
disposal	disposal, municipal solid waste, 22.9% water, to municipal incineration	CH	0	kg	3.00E-2	3.00E-2	3.00E-2	3.00E-2	1	1.13	(1,4,1,3,1,3); Alsema (personal communication) 2007, production waste
	disposal, polyvinylfluoride, 0.2% water, to municipal incineration	CH	0	kg	1.12E-1	1.12E-1	1.12E-1	1.12E-1	1	1.13	(1,4,1,3,1,3); Calculation, including disposal of the panel after life time
	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	0	kg	1.64E+0	1.64E+0	1.64E+0	1.64E+0	1	1.13	(1,4,1,3,1,3); Calculation, including disposal of the panel after life time
	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	1.61E-3	1.61E-3	1.61E-3	1.61E-3	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	treatment, sewage, from residence, to wastewater treatment, class 2	CH	0	m3	5.03E-3	5.03E-3	5.03E-3	5.03E-3	1	1.13	(1,4,1,3,1,3); Calculation, water use
emission air	Heat, waste	-	-	MJ	1.34E+1	1.34E+1	1.34E+1	1.34E+1	1	1.29	(3,4,3,3,1,5); Calculation, electricity use
	transport, transoceanic freight ship	OCE	0	tkm	-	-	-	-	1	2.09	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	transport, aircraft, freight	RER	0	tkm	-	-	-	-	1	2.09	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	8.06E-3	8.06E-3	8.06E-3	8.06E-3	1	1.61	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	Carbon dioxide, fossil	-	-	kg	2.18E-2	2.18E-2	2.18E-2	2.18E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)

Tab. 5.1.8.2.3 Unit process data of the photovoltaic laminate and panel production in Asia & Pacific (APAC); red added exchanges compared to Jungbluth et al. (2012) [38].

	Name	Location	InfrastructureProcess	Unit	photovoltaic panel, single-Si, at plant	photovoltaic panel, multi-Si, at plant	photovoltaic laminate, single-Si, at plant	photovoltaic laminate, multi-Si, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				APAC	APAC	APAC	APAC			
	InfrastructureProcess				1	1	1	1			
	Unit				m2	m2	m2	m2			
product	photovoltaic panel, multi-Si, at plant	CN	1	m2	0	0	0	0			
	photovoltaic panel, single-Si, at plant	CN	1	m2	0	0	0	0			
	photovoltaic laminate, multi-Si, at plant	CN	1	m2	0	0	0	0			
	photovoltaic laminate, single-Si, at plant	CN	1	m2	0	0	0	0			
	photovoltaic panel, multi-Si, at plant	US	1	m2	0	0	0	0			
	photovoltaic panel, single-Si, at plant	US	1	m2	0	0	0	0			
	photovoltaic laminate, multi-Si, at plant	US	1	m2	0	0	0	0			
	photovoltaic laminate, single-Si, at plant	US	1	m2	0	0	0	0			
	photovoltaic panel, multi-Si, at plant	APAC	1	m2	0	1	0	0			
	photovoltaic panel, single-Si, at plant	APAC	1	m2	1	0	0	0			
	photovoltaic laminate, multi-Si, at plant	APAC	1	m2	0	0	0	1			
	photovoltaic laminate, single-Si, at plant	APAC	1	m2	0	0	1	0			
	photovoltaic laminate, single-Si, at plant	RER	1	m2	0	0	0	0			
	photovoltaic panel, single-Si, at plant	RER	1	m2	0	0	0	0			
	photovoltaic laminate, multi-Si, at plant	RER	1	m2	0	0	0	0			
	photovoltaic panel, multi-Si, at plant	RER	1	m2	0	0	0	0			
	photovoltaic laminate, ribbon-Si, at plant	RER	1	m2	0	0	0	0			
	photovoltaic panel, ribbon-Si, at plant	RER	1	m2	0	0	0	0			
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	-	-	-	-	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	electricity, medium voltage, at grid	CN	0	kWh	-	-	-	-	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	electricity, medium voltage, at grid	US	0	kWh	-	-	-	-	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	electricity, medium voltage, at grid	JP	0	kWh	3.73E+0	3.73E+0	3.73E+0	3.73E+0	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	natural gas, burned in industrial furnace low-NOx >100kW	RER	0	MJ	-	-	-	-	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	diesel, burned in building machine	GLO	0	MJ	8.75E-3	8.75E-3	8.75E-3	8.75E-3	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
infrastructure	photovoltaic panel factory	GLO	1	unit	4.00E-6	4.00E-6	4.00E-6	4.00E-6	1	3.02	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	tap water, at user	RER	0	kg	5.03E+0	5.03E+0	5.03E+0	5.03E+0	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	tempering, flat glass	RER	0	kg	8.81E+0	8.81E+0	8.81E+0	8.81E+0	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	wire drawing, copper	RER	0	kg	1.03E-1	1.03E-1	1.03E-1	1.03E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
cells	photovoltaic cell, multi-Si, at plant	RER	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, single-Si, at plant	RER	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, ribbon-Si, at plant	RER	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, multi-Si, at plant	CN	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, single-Si, at plant	CN	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, multi-Si, at plant	US	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, single-Si, at plant	US	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, multi-Si, at plant	APAC	0	m2	-	9.35E-1	-	9.35E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, single-Si, at plant	APAC	0	m2	9.35E-1	-	9.35E-1	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
materials	aluminium alloy, AlMg3, at plant	RER	0	kg	2.13E+0	2.13E+0	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	nickel, 99.5%, at plant	GLO	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	brazing solder, cadmium free, at plant	RER	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	tin, at regional storage	RER	0	kg	1.29E-2	1.29E-2	1.29E-2	1.29E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	lead, at regional storage	RER	0	kg	7.25E-4	7.25E-4	7.25E-4	7.25E-4	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	silver, at regional storage	RER	0	kg	-	-	-	-	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	diode, unspecified, at plant	GLO	0	kg	2.81E-3	2.81E-3	2.81E-3	2.81E-3	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	polyethylene, HDPE, granulate, at plant	RER	0	kg	2.38E-2	2.38E-2	2.38E-2	2.38E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	solar glass, low-iron, at regional storage	RER	0	kg	8.81E+0	8.81E+0	8.81E+0	8.81E+0	1	1.24	(1,4,1,3,3,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	copper, at regional storage	RER	0	kg	1.03E-1	1.03E-1	1.03E-1	1.03E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	glass fibre reinforced plastic, polyamide, injection moulding, at plant	RER	0	kg	2.95E-1	2.95E-1	2.95E-1	2.95E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	ethylvinylacetate, foil, at plant	RER	0	kg	8.75E-1	8.75E-1	8.75E-1	8.75E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	polyvinylfluoride film, at plant	US	0	kg	1.12E-1	1.12E-1	1.12E-1	1.12E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	polyethylene terephthalate, granulate, amorphous, at plant	RER	0	kg	3.46E-1	3.46E-1	3.46E-1	3.46E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	silicone product, at plant	RER	0	kg	1.22E-1	1.22E-1	1.22E-1	1.22E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
auxiliary materials	acetone, liquid, at plant	RER	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	methanol, at regional storage	CH	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	vinyl acetate, at plant	RER	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	lubricating oil, at plant	RER	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	corrugated board, mixed fibre, single wall, at plant	RER	0	kg	7.63E-1	7.63E-1	7.63E-1	7.63E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	1-propanol, at plant	RER	0	kg	1.59E-2	1.59E-2	1.59E-2	1.59E-2	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	EUR-flat pallet	RER	0	unit	5.00E-2	5.00E-2	5.00E-2	5.00E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	hydrogen fluoride, at plant	GLO	0	kg	6.24E-2	6.24E-2	6.24E-2	6.24E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	isopropanol, at plant	RER	0	kg	1.47E-4	1.47E-4	1.47E-4	1.47E-4	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	potassium hydroxide, at regional storage	RER	0	kg	5.14E-2	5.14E-2	5.14E-2	5.14E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	soap, at plant	RER	0	kg	1.16E-2	1.16E-2	1.16E-2	1.16E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
transport	transport, lorry >16t, fleet average	RER	0	tkm	5.85E+0	5.85E+0	5.64E+0	5.64E+0	1	2.09	(4,5,na,na,na,na); Standard distance 100km, cells 500km
	transport, freight, rail	RER	0	tkm	4.25E+1	4.25E+1	4.12E+1	4.12E+1	1	2.09	(4,5,na,na,na,na); Standard distance 600km
disposal	disposal, municipal solid waste, 22.9% water, to municipal incineration	CH	0	kg	3.00E-2	3.00E-2	3.00E-2	3.00E-2	1	1.13	(1,4,1,3,1,3); Alsema (personal communication) 2007, production waste
	disposal, polyvinylfluoride, 0.2% water, to municipal incineration	CH	0	kg	1.12E-1	1.12E-1	1.12E-1	1.12E-1	1	1.13	(1,4,1,3,1,3); Calculation, including disposal of the panel after life time
	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	0	kg	1.64E+0	1.64E+0	1.64E+0	1.64E+0	1	1.13	(1,4,1,3,1,3); Calculation, including disposal of the panel after life time
	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	1.61E-3	1.61E-3	1.61E-3	1.61E-3	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	treatment, sewage, from residence, to wastewater treatment, class 2	CH	0	m3	5.03E-3	5.03E-3	5.03E-3	5.03E-3	1	1.13	(1,4,1,3,1,3); Calculation, water use
emission air	Heat, waste	-	-	MJ	1.34E+1	1.34E+1	1.34E+1	1.34E+1	1	1.29	(3,4,3,3,1,5); Calculation, electricity use
	transport, transoceanic freight ship	OCE	0	tkm	-	-	-	-	1	2.09	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	transport, aircraft, freight	RER	0	tkm	-	-	-	-	1	2.09	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	8.06E-3	8.06E-3	8.06E-3	8.06E-3	1	1.61	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	Carbon dioxide, fossil	-	-	kg	2.18E-2	2.18E-2	2.18E-2	2.18E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)

Tab.5.1.8.2.4 Unit process data of the photovoltaic laminate and panel production in Europe (RER); red added exchanges compared to Jungbluth et al. (2012) [38].



	Name	Location	InfrastructureProcess	Unit	photovoltaic panel, single-Si, at plant	photovoltaic panel, multi-Si, at plant	photovoltaic laminate, single-Si, at plant	photovoltaic laminate, multi-Si, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER	RER			
	InfrastructureProcess				1	1	1	1			
	Unit				m2	m2	m2	m2			
product	photovoltaic panel, multi-Si, at plant	CN	1	m2	0	0	0	0			
	photovoltaic panel, single-Si, at plant	CN	1	m2	0	0	0	0			
	photovoltaic laminate, multi-Si, at plant	CN	1	m2	0	0	0	0			
	photovoltaic laminate, single-Si, at plant	CN	1	m2	0	0	0	0			
	photovoltaic panel, multi-Si, at plant	US	1	m2	0	0	0	0			
	photovoltaic panel, single-Si, at plant	US	1	m2	0	0	0	0			
	photovoltaic laminate, multi-Si, at plant	US	1	m2	0	0	0	0			
	photovoltaic laminate, single-Si, at plant	US	1	m2	0	0	0	0			
	photovoltaic panel, multi-Si, at plant	APAC	1	m2	0	0	0	0			
	photovoltaic panel, single-Si, at plant	APAC	1	m2	0	0	0	0			
	photovoltaic laminate, multi-Si, at plant	APAC	1	m2	0	0	0	0			
	photovoltaic laminate, single-Si, at plant	APAC	1	m2	0	0	0	0			
	photovoltaic laminate, single-Si, at plant	RER	1	m2	0	0	1	0			
	photovoltaic panel, single-Si, at plant	RER	1	m2	1	0	0	0			
	photovoltaic laminate, multi-Si, at plant	RER	1	m2	0	0	0	1			
	photovoltaic panel, multi-Si, at plant	RER	1	m2	0	1	0	0			
	photovoltaic laminate, ribbon-Si, at plant	RER	1	m2	0	0	0	0			
	photovoltaic panel, ribbon-Si, at plant	RER	1	m2	0	0	0	0			
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	3.73E+0	3.73E+0	3.73E+0	3.73E+0	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	electricity, medium voltage, at grid	CN	0	kWh	-	-	-	-	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	electricity, medium voltage, at grid	US	0	kWh	-	-	-	-	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	electricity, medium voltage, at grid	JP	0	kWh	-	-	-	-	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	natural gas, burned in industrial furnace low-NOx >100kW	RER	0	MJ	-	-	-	-	1	1.14	(3,3,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	diesel, burned in building machine	GLO	0	MJ	8.75E-3	8.75E-3	8.75E-3	8.75E-3	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
infrastructure	photovoltaic panel factory	GLO	1	unit	4.00E-6	4.00E-6	4.00E-6	4.00E-6	1	3.02	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	tap water, at user	RER	0	kg	5.03E+0	5.03E+0	5.03E+0	5.03E+0	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	tempering, flat glass	RER	0	kg	8.81E+0	8.81E+0	8.81E+0	8.81E+0	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	wire drawing, copper	RER	0	kg	1.03E-1	1.03E-1	1.03E-1	1.03E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
cells	photovoltaic cell, multi-Si, at plant	RER	0	m2	-	9.35E-1	-	9.35E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, single-Si, at plant	RER	0	m2	9.35E-1	-	9.35E-1	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, ribbon-Si, at plant	RER	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, multi-Si, at plant	CN	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, single-Si, at plant	CN	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, multi-Si, at plant	US	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, single-Si, at plant	US	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, multi-Si, at plant	APAC	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	photovoltaic cell, single-Si, at plant	APAC	0	m2	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
materials	aluminium alloy, AlMg3, at plant	RER	0	kg	2.13E+0	2.13E+0	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	nickel, 99.5%, at plant	GLO	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	brazing solder, cadmium free, at plant	RER	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	tin, at regional storage	RER	0	kg	1.29E-2	1.29E-2	1.29E-2	1.29E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	lead, at regional storage	RER	0	kg	7.25E-4	7.25E-4	7.25E-4	7.25E-4	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	silver, at regional storage	RER	0	kg	-	-	-	-	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	diode, unspecified, at plant	GLO	0	kg	2.81E-3	2.81E-3	2.81E-3	2.81E-3	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	polyethylene, HDPE, granulate, at plant	RER	0	kg	2.38E-2	2.38E-2	2.38E-2	2.38E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	solar glass, low-iron, at regional storage	RER	0	kg	8.81E+0	8.81E+0	8.81E+0	8.81E+0	1	1.24	(1,4,1,3,3,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	copper, at regional storage	RER	0	kg	1.03E-1	1.03E-1	1.03E-1	1.03E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	glass fibre reinforced plastic, polyamide, injection moulding, at plant	RER	0	kg	2.95E-1	2.95E-1	2.95E-1	2.95E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	ethylvinylacetate, foil, at plant	RER	0	kg	8.75E-1	8.75E-1	8.75E-1	8.75E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	polyvinylfluoride film, at plant	US	0	kg	1.12E-1	1.12E-1	1.12E-1	1.12E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	polyethylene terephthalate, granulate, amorphous, at plant	RER	0	kg	3.46E-1	3.46E-1	3.46E-1	3.46E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	silicone product, at plant	RER	0	kg	1.22E-1	1.22E-1	1.22E-1	1.22E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
auxiliary materials	acetone, liquid, at plant	RER	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	methanol, at regional storage	CH	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	vinyl acetate, at plant	RER	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	lubricating oil, at plant	RER	0	kg	-	-	-	-	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	corrugated board, mixed fibre, single wall, at plant	RER	0	kg	7.63E-1	7.63E-1	7.63E-1	7.63E-1	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	1-propanol, at plant	RER	0	kg	1.59E-2	1.59E-2	1.59E-2	1.59E-2	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	EUR-flat pallet	RER	0	unit	5.00E-2	5.00E-2	5.00E-2	5.00E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	hydrogen fluoride, at plant	GLO	0	kg	6.24E-2	6.24E-2	6.24E-2	6.24E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	isopropanol, at plant	RER	0	kg	1.47E-4	1.47E-4	1.47E-4	1.47E-4	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	potassium hydroxide, at regional storage	RER	0	kg	5.14E-2	5.14E-2	5.14E-2	5.14E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	soap, at plant	RER	0	kg	1.16E-2	1.16E-2	1.16E-2	1.16E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
transport	transport, lorry >16t, fleet average	RER	0	tkm	5.85E+0	5.85E+0	5.64E+0	5.64E+0	1	2.09	(4,5,na,na,na,na); Standard distance 100km, cells 500km
	transport, freight, rail	RER	0	tkm	4.25E+1	4.25E+1	4.12E+1	4.12E+1	1	2.09	(4,5,na,na,na,na); Standard distance 600km
disposal	disposal, municipal solid waste, 22.9% water, to municipal incineration	CH	0	kg	3.00E-2	3.00E-2	3.00E-2	3.00E-2	1	1.13	(1,4,1,3,1,3); Alsema (personal communication) 2007, production waste
	disposal, polyvinylfluoride, 0.2% water, to municipal incineration	CH	0	kg	1.12E-1	1.12E-1	1.12E-1	1.12E-1	1	1.13	(1,4,1,3,1,3); Calculation, including disposal of the panel after life time
	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	0	kg	1.64E+0	1.64E+0	1.64E+0	1.64E+0	1	1.13	(1,4,1,3,1,3); Calculation, including disposal of the panel after life time
	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	1.61E-3	1.61E-3	1.61E-3	1.61E-3	1	1.13	(1,4,1,3,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	treatment, sewage, from residence, to wastewater treatment, class 2	CH	0	m3	5.03E-3	5.03E-3	5.03E-3	5.03E-3	1	1.13	(1,4,1,3,1,3); Calculation, water use
emission air	Heat, waste	-	-	MJ	1.34E+1	1.34E+1	1.34E+1	1.34E+1	1	1.29	(3,4,3,3,1,5); Calculation, electricity use
	transport, transoceanic freight ship	OCE	0	tkm	-	-	-	-	1	2.09	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	transport, aircraft, freight	RER	0	tkm	-	-	-	-	1	2.09	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	8.06E-3	8.06E-3	8.06E-3	8.06E-3	1	1.61	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)
	Carbon dioxide, fossil	-	-	kg	2.18E-2	2.18E-2	2.18E-2	2.18E-2	1	1.29	(3,4,3,3,1,5); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 37)

Tab. 5.1.8.2.5 and Tab. 5.1.8.2.6 show the unit process data of the photovoltaic laminate and panel market mix in Europe (RER) and North America (US). The market shares for laminate and panels in the different regions of the world are shown in Tab. 5.1.2.3. The European market shares are extrapolated to 100 % because supply in 2011 did not fully match with the installed capacity in the same year.

Tab. 5.1.8.2.5 Unit process data of the photovoltaic laminate and panel market mix in Europe (RER).

	Name	Location	InfrastructureProcess	Unit	photovoltaic laminate, multi-Si, at regional storage	photovoltaic laminate, single-Si, at regional storage	photovoltaic panel, multi-Si, at regional storage	photovoltaic panel, single-Si, at regional storage	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER	RER			
	InfrastructureProcess				1	1	1	1			
	Unit				m2	m2	m2	m2			
	photovoltaic laminate, multi-Si, at regional storage	RER	1	m2	1.00E+0	0	0	0			
	photovoltaic laminate, single-Si, at regional storage	RER	1	m2	0	1.00E+0	0	0			
	photovoltaic panel, multi-Si, at regional storage	RER	1	m2	0	0	1.00E+0	0			
	photovoltaic panel, single-Si, at regional storage	RER	1	m2	0	0	0	1.00E+0			
modules	photovoltaic panel, multi-Si, at plant	RER	1	m2	-	-	1.45E-1	-	1	3.27	(5,1,1,1,1,5); modules produced in Europe
	photovoltaic panel, single-Si, at plant	RER	1	m2	-	-	-	1.45E-1	1	3.27	(5,1,1,1,1,5); modules produced in Europe
	photovoltaic laminate, multi-Si, at plant	RER	1	m2	1.45E-1	-	-	-	1	3.27	(5,1,1,1,1,5); modules produced in Europe
	photovoltaic laminate, single-Si, at plant	RER	1	m2	-	1.45E-1	-	-	1	3.27	(5,1,1,1,1,5); modules produced in Europe
	photovoltaic panel, multi-Si, at plant	US	1	m2	-	-	-	-	1	3.27	(5,1,1,1,1,5); module import from US
	photovoltaic panel, single-Si, at plant	US	1	m2	-	-	-	-	1	3.27	(5,1,1,1,1,5); module import from US
	photovoltaic laminate, multi-Si, at plant	US	1	m2	-	-	-	-	1	3.27	(5,1,1,1,1,5); module import from US
	photovoltaic laminate, single-Si, at plant	US	1	m2	-	-	-	-	1	3.27	(5,1,1,1,1,5); module import from US
	photovoltaic panel, multi-Si, at plant	CN	1	m2	-	-	7.96E-1	-	1	3.27	(5,1,1,1,1,5); module import from China
	photovoltaic panel, single-Si, at plant	CN	1	m2	-	-	-	7.96E-1	1	3.27	(5,1,1,1,1,5); module import from China
	photovoltaic laminate, multi-Si, at plant	CN	1	m2	7.96E-1	-	-	-	1	3.27	(5,1,1,1,1,5); module import from China
	photovoltaic laminate, single-Si, at plant	CN	1	m2	-	7.96E-1	-	-	1	3.27	(5,1,1,1,1,5); module import from China
	photovoltaic panel, multi-Si, at plant	APAC	1	m2	-	-	5.88E-2	-	1	3.27	(5,1,1,1,1,5); module import from APAC
	photovoltaic panel, single-Si, at plant	APAC	1	m2	-	-	-	5.88E-2	1	3.27	(5,1,1,1,1,5); module import from APAC
	photovoltaic laminate, multi-Si, at plant	APAC	1	m2	5.88E-2	-	-	-	1	3.27	(5,1,1,1,1,5); module import from APAC
	photovoltaic laminate, single-Si, at plant	APAC	1	m2	-	5.88E-2	-	-	1	3.27	(5,1,1,1,1,5); module import from APAC
transport	transport, transoceanic freight ship	OCE	0	tkm	2.09E+2	2.09E+2	2.53E+2	2.53E+2	1	2.09	(4,5,na,na,na,na); Import of modules from China: 19994.192 km and Malaysia: 15549.392
	transport, freight, rail	RER	0	tkm	2.49E+0	2.48E+0	3.01E+0	3.01E+0	1	2.09	(4,5,na,na,na,na); Standard distance 200km
	transport, lorry >16t, fleet average	RER	0	tkm	6.22E-1	6.20E-1	7.53E-1	7.52E-1	1	2.09	(4,5,na,na,na,na); Standard distance 50km

Tab. 5.1.8.2.6 Unit process data of the photovoltaic laminate and panel market mix in North America (US).

	Name	Location	InfrastructureProcess	Unit	photovoltaic laminate, multi-Si, at regional storage	photovoltaic laminate, single-Si, at regional storage	photovoltaic panel, multi-Si, at regional storage	photovoltaic panel, single-Si, at regional storage	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				US	US	US	US			
	InfrastructureProcess				1	1	1	1			
	Unit				m2	m2	m2	m2			
	photovoltaic laminate, multi-Si, at regional storage	US	1	m2	1.00E+0	0	0	0			
	photovoltaic laminate, single-Si, at regional storage	US	1	m2	0	1.00E+0	0	0			
	photovoltaic panel, multi-Si, at regional storage	US	1	m2	0	0	1.00E+0	0			
	photovoltaic panel, single-Si, at regional storage	US	1	m2	0	0	0	1.00E+0			
	photovoltaic panel, multi-Si, at plant	RER	1	m2	-	-	-	-	1	3.27	(5,1,1,1,1,5); modules produced in Europe
	photovoltaic panel, single-Si, at plant	RER	1	m2	-	-	-	-	1	3.27	(5,1,1,1,1,5); modules produced in Europe
modules	photovoltaic laminate, multi-Si, at plant	RER	1	m2	-	-	-	-	1	3.27	(5,1,1,1,1,5); modules produced in Europe
	photovoltaic laminate, single-Si, at plant	RER	1	m2	-	-	-	-	1	3.27	(5,1,1,1,1,5); modules produced in Europe
	photovoltaic panel, multi-Si, at plant	US	1	m2	-	-	4.39E-1	-	1	3.27	(5,1,1,1,1,5); module import from US
	photovoltaic panel, single-Si, at plant	US	1	m2	-	-	-	4.39E-1	1	3.27	(5,1,1,1,1,5); module import from US
	photovoltaic laminate, multi-Si, at plant	US	1	m2	4.39E-1	-	-	-	1	3.27	(5,1,1,1,1,5); module import from US
	photovoltaic laminate, single-Si, at plant	US	1	m2	-	4.39E-1	-	-	1	3.27	(5,1,1,1,1,5); module import from US
	photovoltaic panel, multi-Si, at plant	CN	1	m2	-	-	5.61E-1	-	1	3.27	(5,1,1,1,1,5); module import from China
	photovoltaic panel, single-Si, at plant	CN	1	m2	-	-	-	5.61E-1	1	3.27	(5,1,1,1,1,5); module import from China
	photovoltaic laminate, multi-Si, at plant	CN	1	m2	5.61E-1	-	-	-	1	3.27	(5,1,1,1,1,5); module import from China
	photovoltaic laminate, single-Si, at plant	CN	1	m2	-	5.61E-1	-	-	1	3.27	(5,1,1,1,1,5); module import from China
	photovoltaic panel, multi-Si, at plant	APAC	1	m2	-	-	-	-	1	3.27	(5,1,1,1,1,5); module import from APAC
	photovoltaic panel, single-Si, at plant	APAC	1	m2	-	-	-	-	1	3.27	(5,1,1,1,1,5); module import from APAC
	photovoltaic laminate, multi-Si, at plant	APAC	1	m2	-	-	-	-	1	3.27	(5,1,1,1,1,5); module import from APAC
	photovoltaic laminate, single-Si, at plant	APAC	1	m2	-	-	-	-	1	3.27	(5,1,1,1,1,5); module import from APAC
transport	transport, transoceanic freight ship	OCE	0	tkm	1.45E+2	1.45E+2	1.75E+2	1.75E+2	1	2.09	(4,5,na,na,na,na); Import of modules from China: 20755.364 km
	transport, freight, rail	RER	0	tkm	2.49E+0	2.48E+0	3.01E+0	3.01E+0	1	2.09	(4,5,na,na,na,na); Standard distance 200km
	transport, lorry >16t, fleet average	RER	0	tkm	6.22E-1	6.20E-1	7.53E-1	7.52E-1	1	2.09	(4,5,na,na,na,na); Standard distance 50km

5.1.9 LCI of the Chinese multi-crystalline supply chain

Overview

This chapter describes the LCI of the whole multi-crystalline silicon supply chain, photovoltaic cell and photovoltaic module production in China. There are always two data sets for each level of the supply chain including cell and module production, one data set describing the mainstream production and one data set describing the best technology production. The two data sets give an indication on the variability of the data.

The main data sources are Diao & Shi (2011) [42], Institute of Electrical Engineering (IEE) of Chinese Academy of Sciences (CAS)[2], Hou & Zhao (2014) [43] and Wang (2014) [44]. The data sets are based on the data available in Diao & Shi (2011) [42]. These data sets are adjusted with more recent information on specific parameters based on IEE CAS[2], Hou & Zhao (2014) [43] and Wang (2014) [44], if available.

Tab. 5.1.9.1 shows a summary of important parameters of the production of the Chinese multi-Si PV modules for both technology levels according to Diao & Shi (2011) [42].

The supply chain data in this chapter differs from that in preceding chapters in that it is based only data from manufacturing facilities in China, whereas the preceding chapters presented global supply chain data coupled with country-specific electricity mixes.

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[2] Personal communication: 张嘉 (Zhang Jia), Institute of Electrical Engineering (IEE), Chinese Academy of Science (CAS), Beijing China, 01.08.2014

Tab. 5.1.9.1 Important production parameters for both technology levels of the Chinese multi-crystalline supply chain according to Diao & Shi (2011) [42]

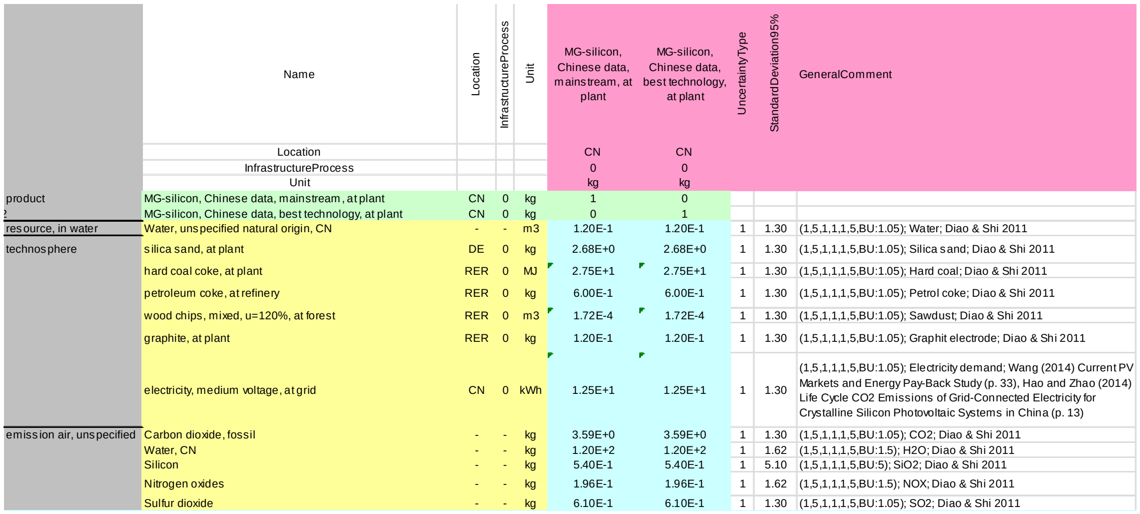
Process	Parameter	Unit	Mainstream technology	Best technology
Silica reduction	Yield	%	80.00%	80%
Solar grade silicon production	Process	-	Siemens modified	Siemens modified
Ingot	Ingot method	-	Coventional Ingot	Coventional Ingot
	Border loss	%	85%	85%
Wafer	Wafer size	-	0.156m x 0.156m	0.156m x 0.156m
	Wafer thickness	um	200	180
	Kerf loss	um	200	200
Surface treatment	Damage layer corrosion, texturing	-	NaOH	NaOH
Diffusion system knot	Semiconductor doping	-	POCL3 Diffusion Furnace	POCL3 Diffusion Furnace
	Back diffusion layer corrosion	-	HF/HNO3	HF/HNO3
	Edge etching	-	CF4 Plasma	CF4 Plasma
Electrode printing	Backside	-	Al	Al
	Back busbar		100%	100%
	Back electrode covering	-	Ag/Al	Ag/Al
	Positive electrode layer	-	Screen printing Ag	Screen printing Ag
	Front metal cover	%	10%	7%
	Front busbar	-	Ag	Ag
Passivation ARC	Passivation methods	-	PECVD of Si3N4	PECVD of Si3N4
Circuit detection	Yield		95%	95%
Module production	Cell components	-	72	72
	Glass thickness	mm	4	3.2
	EVA film thickness	mm	2 x 0.5mm	2 x 0.5mm
	Back film thickness	um	125	125
	PET backplane thickness	mm	0.2	0.2
Component detection	Component dimension	-	992mm x 1956mm	992mm x 1956mm
	Yield	%	99%	99%
	Module efficiency	%	12.40%	14.40%
	Life time	a	25	25

Metallurgical grade silicon

Tab. 5.1.9.2 shows the unit process data of the Chinese production of metallurgical grade silicon (MG-silicon) for both technology levels (mainstream and best technology). There are no significant differences between the mainstream and the best technology in case of the production of MG-silicon.

The LCI remains unchanged as published by Diao & Shi (2011) [42], except in case of the electricity consumption, where more recent data is available in Hou & Zhao (2014) [43] and Wang (2014) [44].

Tab. 5.1.9.2 Unit process data of MG-Silicon production in China (CN) for mainstream and best technology



	Name	Location	InfrastructureProcess	Unit	MG-silicon, Chinese data, mainstream, at plant	MG-silicon, Chinese data, best technology, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CN	CN			
	InfrastructureProcess				0	0			
	Unit				kg	kg			
product	MG-silicon, Chinese data, mainstream, at plant	CN	0	kg	1	0			
	MG-silicon, Chinese data, best technology, at plant	CN	0	kg	0	1			
resource, in water	Water, unspecified natural origin, CN	-	-	m3	1.20E-1	1.20E-1	1	1.30	(1,5,1,1,1,5,BU:1.05); Water; Diao & Shi 2011
technosphere	silica sand, at plant	DE	0	kg	2.68E+0	2.68E+0	1	1.30	(1,5,1,1,1,5,BU:1.05); Silica sand; Diao & Shi 2011
	hard coal coke, at plant	RER	0	MJ	2.75E+1	2.75E+1	1	1.30	(1,5,1,1,1,5,BU:1.05); Hard coal; Diao & Shi 2011
	petroleum coke, at refinery	RER	0	kg	6.00E-1	6.00E-1	1	1.30	(1,5,1,1,1,5,BU:1.05); Petrol coke; Diao & Shi 2011
	wood chips, mixed, u=120%, at forest	RER	0	m3	1.72E-4	1.72E-4	1	1.30	(1,5,1,1,1,5,BU:1.05); Sawdust; Diao & Shi 2011
	graphite, at plant	RER	0	kg	1.20E-1	1.20E-1	1	1.30	(1,5,1,1,1,5,BU:1.05); Graphit electrode; Diao & Shi 2011
	electricity, medium voltage, at grid	CN	0	kWh	1.25E+1	1.25E+1	1	1.30	(1,5,1,1,1,5,BU:1.05); Electricity demand; Wang (2014) Current PV Markets and Energy Pay-Back Study (p. 33), Hao and Zhao (2014) Life Cycle CO2 Emissions of Grid-Connected Electricity for Crystalline Silicon Photovoltaic Systems in China (p. 13)
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	3.59E+0	3.59E+0	1	1.30	(1,5,1,1,1,5,BU:1.05); CO2; Diao & Shi 2011
	Water, CN	-	-	kg	1.20E+2	1.20E+2	1	1.62	(1,5,1,1,1,5,BU:1.5); H2O; Diao & Shi 2011
	Silicon	-	-	kg	5.40E-1	5.40E-1	1	5.10	(1,5,1,1,1,5,BU:5); SiO2; Diao & Shi 2011
	Nitrogen oxides	-	-	kg	1.96E-1	1.96E-1	1	1.62	(1,5,1,1,1,5,BU:1.5); NOX; Diao & Shi 2011
	Sulfur dioxide	-	-	kg	6.10E-1	6.10E-1	1	1.30	(1,5,1,1,1,5,BU:1.05); SO2; Diao & Shi 2011

Solar grade silicon

Tab. 5.1.9.3 shows the unit process data of the Chinese production of solar grade silicon for both technology levels. There are significant differences in the water, hydrogen, steam and electricity demand as well as the emissions of silicon to air and fluoride to water between the mainstream and the best technology in case of the production of solar grade silicon.

The major inputs and emissions are based on data provided by IEE CAS[2] and complemented with data provided by Diao & Shi (2011) [42].

Tab. 5.1.9.3 Unit process data of solar grade silicon production in China (CN) for mainstream and best technology; red: added exchanges (not included in Diao & Shi (2011) [42])

	Name	Location	InfrastructureProcess	Unit	silicon, solar grade, Siemens, Chinese data, mainstream, at plant	silicon, solar grade, Siemens, Chinese data, best tech., at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CN	CN			
	InfrastructureProcess				0	0			
	Unit				kg	kg			
product	silicon, solar grade, Siemens, Chinese data, mainstream, at plant	CN	0	kg	1	0			
	silicon, solar grade, Siemens, Chinese data, best tech., at plant	CN	0	kg	0	1			
resource, in water	Water, unspecified natural origin, CN	-	-	m3	4.54E-1	2.16E-1	1	1.30	(1,5,1,1,1,5,BU:1.05); Cooling water; Diao & Shi 2011
	Water, unspecified natural origin, CN	-	-	m3	1.70E-2	3.80E-4	1	1.30	(1,5,1,1,1,5,BU:1.05); Process water; Diao & Shi 2011
technosphere	MG-silicon, Chinese data, mainstream, at plant	CN	0	kg	1.12E+0	0	1	1.30	(1,5,1,1,1,5,BU:1.05); MG-Si; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	MG-silicon, Chinese data, best technology, at plant	CN	0	kg	0	1.12E+0	1	1.30	(1,5,1,1,1,5,BU:1.05); MG-Si; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	hydrogen, liquid, at plant	RER	0	kg	5.36E-2	4.50E-2	1	1.30	(1,5,1,1,1,5,BU:1.05); H2; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014), LCI Chinese Production, Diao & Shi 2011
	chlorine, liquid, production mix, at plant	RER	0	kg	2.00E-1	2.00E-1	1	1.30	(1,5,1,1,1,5,BU:1.05); Cl2; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	sodium hydroxide, 50% in H2O, production mix, at plant	RER	0	kg	8.70E-1	8.70E-1	1	1.30	(1,5,1,1,1,5,BU:1.05); NaOH; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	limestone, milled, packed, at plant	CH	0	kg	5.80E-1	5.80E-1	1	1.30	(1,5,1,1,1,5,BU:1.05); Lime; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	steam, for chemical processes, at plant	RER	0	kg	6.81E+1	5.50E+1	1	1.30	(1,5,1,1,1,5,BU:1.05); Steam; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014), LCI Chinese Production, Diao & Shi 2011
	electricity, medium voltage, at grid	CN	0	kWh	1.25E+2	1.00E+2	1	1.30	(1,5,1,1,1,5,BU:1.05); Electricity demand; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014), Wang (2014) Current PV Markets and Energy Pay-Back Study (pp. 32-33)
emission air, unspecified	Hydrogen chloride	-	-	kg	9.00E-2	1.20E-1	1	1.62	(1,5,1,1,1,5,BU:1.5); HCL; Diao & Shi 2011
	Silicon tetrafluoride	-	-	kg	8.00E-1	0	1	1.62	(1,5,1,1,1,5,BU:1.5); SiCl4; Diao & Shi 2011
	Silicon	-	-	kg	1.50E-1	4.20E-1	1	5.10	(1,5,1,1,1,5,BU:5); SiO2; Diao & Shi 2011
	Silicon	-	-	kg	8.00E-2	5.00E-2	1	5.10	(1,5,1,1,1,5,BU:5); Silica material; Diao & Shi 2011
emission water, unspecified	COD, Chemical Oxygen Demand	-	-	kg	2.04E-3	2.04E-3	1	1.62	(1,5,1,1,1,5,BU:1.5); COD; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	Chloride	-	-	kg	7.70E-2	7.70E-2	1	3.09	(1,5,1,1,1,5,BU:3); Chloride; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	Fluoride	-	-	kg	5.00E-5	3.00E-5	1	1.62	(1,5,1,1,1,5,BU:1.5); Fluoride; Diao & Shi 2011
	Suspended solids, unspecified	-	-	kg	1.44E-3	1.44E-3	1	1.62	(1,5,1,1,1,5,BU:1.5); Suspended solid; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	Ammonium, ion	-	-	kg	3.47E-5	3.47E-5	1	1.62	(1,5,1,1,1,5,BU:1.5); Ammonia Nitrogen; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)

Silicon ingot and wafers

Tab. 5.1.9.4 shows the unit process data of the Chinese production of silicon ingot and wafers for both technology levels.

There are significant differences in the solar grade silicon, nitrogen and electricity demand as well as the emissions of silicon to air and triethylene glykol and chloride to water between the mainstream and the best technology in case of the production of silicon ingot and wafers.

The major inputs and emissions are based on data provided by IEE CAS[2] and complemented with data provided by Diao & Shi (2011) [42].

Tab. 5.1.9.4 Unit process data of silicon ingot and wafer production in China (CN) for mainstream and best technology; red: added exchanges (not included in Diao & Shi (2011) [42])

	Name	Location	InfrastructureProcess	Unit	silicon ingot, sliced (wafer), Chinese data, mainstream, at plant	silicon ingot, sliced (wafer), Chinese data, best technology, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CN	CN			
	InfrastructureProcess				0	0			
	Unit				unit	unit			
product	silicon ingot, sliced (wafer), Chinese data, mainstream, at plant	CN	0	unit	1	0			
	silicon ingot, sliced (wafer), Chinese data, best technology, at plant	CN	0	unit	0	1			
technosphere	silicon, solar grade, Siemens, Chinese data, mainstream, at plant	CN	0	kg	2.04E-2	0	1	1.30	(1,5,1,1,1,5,BU:1.05); SoG-Si; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	silicon, solar grade, Siemens, Chinese data, best tech., at plant	CN	0	kg	0	1.89E-2	1	1.30	(1,5,1,1,1,5,BU:1.05); SoG-Si; Diao & Shi 2011
	argon, liquid, at plant	RER	0	kg	7.79E-3	7.79E-3	1	1.30	(1,5,1,1,1,5,BU:1.05); Argon; Institute of Electrical Engineering
	triethylene glycol, at plant	RER	0	kg	5.12E-2	7.15E-2	1	1.30	(1,5,1,1,1,5,BU:1.05); Polyethylenegylkol; Diao & Shi 2011
	silicon carbide, at plant	RER	0	kg	6.08E-3	6.08E-3	1	1.30	(1,5,1,1,1,5,BU:1.05); SIC; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	hydrogen fluoride, at plant	GLO	0	kg	2.40E-4	2.40E-4	1	1.30	(1,5,1,1,1,5,BU:1.05); HF; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	hydrochloric acid, 30% in H2O, at plant	RER	0	kg	1.65E-4	1.65E-4	1	1.30	(1,5,1,1,1,5,BU:1.05); HCl; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	sodium hydroxide, 50% in H2O, production mix, at plant	RER	0	kg	5.01E-5	5.01E-5	1	1.30	(1,5,1,1,1,5,BU:1.05); NaOH; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	sulphuric acid, liquid, at plant	RER	0	kg	0	6.00E-5	1	1.30	(1,5,1,1,1,5,BU:1.05); Sulphuric acid; Diao & Shi 2011
	nitrogen, liquid, at plant	RER	0	kg	3.62E-3	6.40E-4	1	1.30	(1,5,1,1,1,5,BU:1.05); Nitrogen (liquid); Diao & Shi 2011
	potassium nitrate, as N, at regional storehouse	RER	0	kg	2.20E-4	6.80E-4	1	1.30	(1,5,1,1,1,5,BU:1.05); Nitrate; Diao & Shi 2011
	potassium hydroxide, at regional storage	RER	0	kg	2.00E-5	2.00E-5	1	1.30	(1,5,1,1,1,5,BU:1.05); KOH; Diao & Shi 2011
	steel, converter, unalloyed, at plant	RER	0	kg	1.58E-2	1.58E-2	1	1.30	(1,5,1,1,1,5,BU:1.05); Steel wire; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	wire drawing, steel	RER	0	kg	1.58E-2	1.58E-2	1	1.30	(1,5,1,1,1,5,BU:1.05); Steel wire; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	acrylic acid, at plant	RER	0	kg	4.60E-5	4.60E-5	1	1.30	(1,5,1,1,1,5,BU:1.05); acrylic acid; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	dipropylene glycol monomethyl ether, at plant	RER	0	kg	6.40E-4	6.40E-4	1	1.30	(1,5,1,1,1,5,BU:1.05); Dipropylene Glycol Monomethyl Ether; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	nitric acid, 50% in H2O, at plant	RER	0	kg	7.80E-4	7.80E-4	1	1.30	(1,5,1,1,1,5,BU:1.05); nitric acid; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	acetic acid, 98% in H2O, at plant	RER	0	kg	5.39E-4	5.39E-4	1	1.30	(1,5,1,1,1,5,BU:1.05); acetic acid; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	solar glass, low-iron, at regional storage	RER	0	kg	9.69E-4	9.69E-4	1	1.30	(1,5,1,1,1,5,BU:1.05); glass; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	silica sand, at plant	DE	0	kg	3.89E-3	3.89E-3	1	1.30	(1,5,1,1,1,5,BU:1.05); quartz crucible; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	electricity, medium voltage, at grid	CN	0	kWh	6.86E-1	3.72E-1	1	1.30	(1,5,1,1,1,5,BU:1.05); Electricity demand; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014), Multi-Si Ingot and Wafer; Wang (2014) Current PV Markets and Energy Pay-Back Study (pp. 32-33)
emission air, unspecified	Silicon	-	-	kg	3.20E-2	4.34E-2	1	5.10	(1,5,1,1,1,5,BU:5); SIC; Diao & Shi 2011
emission water, unspecified	Triethylene glycol	-	-	kg	2.65E-2	2.14E-2	1	3.09	(1,5,1,1,1,5,BU:3); Polyethylenegylkol; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014), Multi-Si Ingot and Wafer; Wang (2014) Current PV Markets and Energy Pay-Back Study (pp. 32-33), Diao & Shi 2011
	Fluoride	-	-	kg	6.21E-5	6.21E-5	1	1.62	(1,5,1,1,1,5,BU:1.5); Fluorid; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	COD, Chemical Oxygen Demand	-	-	kg	1.19E-3	1.19E-3	1	1.62	(1,5,1,1,1,5,BU:1.5); COD; Institute of Electrical Engineering of Chinese Academy of Sciences (IEE CAS, 2014)
	Chloride	-	-	kg	6.20E-4	2.80E-4	1	3.09	(1,5,1,1,1,5,BU:3); Chlorid; Diao & Shi 2011

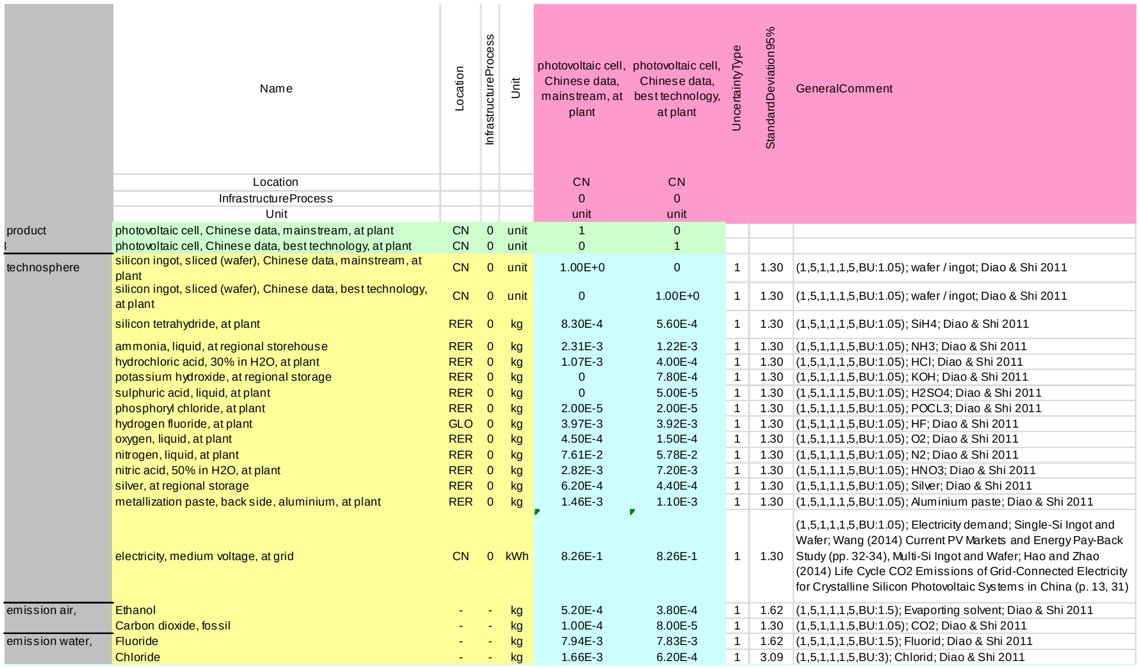
Phovoltaic cells

Tab. 5.1.9.5 shows the unit process data of the Chinese production of multi-crystalline photovoltaic cells for both technology levels.

There are significant differences in all exchanges except POCl3 and HF between the mainstream and the best technology in case of the production of multi-crystalline silicon PV cells.

The major inputs and emissions are based on data provided by by Diao & Shi (2011) [42]. The electricity demand for the cell production is updated based on Hou & Zhao (2014) [43] and Wang (2014) [44].

Tab. 5.1.9.5 Unit process data of photovoltaic cell production in China (CN) for mainstream and best technology



	Name	Location	InfrastructureProcess	Unit	photovoltaic cell, Chinese data, mainstream, at plant	photovoltaic cell, Chinese data, best technology, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CN	CN			
	InfrastructureProcess				0	0			
	Unit				unit	unit			
product	photovoltaic cell, Chinese data, mainstream, at plant	CN	0	unit	1	0			
	photovoltaic cell, Chinese data, best technology, at plant	CN	0	unit	0	1			
technosphere	silicon ingot, sliced (wafer), Chinese data, mainstream, at plant	CN	0	unit	1.00E+0	0	1	1.30	(1,5,1,1,1,5,BU:1.05); wafer / ingot; Diao & Shi 2011
	silicon ingot, sliced (wafer), Chinese data, best technology, at plant	CN	0	unit	0	1.00E+0	1	1.30	(1,5,1,1,1,5,BU:1.05); wafer / ingot; Diao & Shi 2011
	silicon tetrahydride, at plant	RER	0	kg	8.30E-4	5.60E-4	1	1.30	(1,5,1,1,1,5,BU:1.05); SiH4; Diao & Shi 2011
	ammonia, liquid, at regional storehouse	RER	0	kg	2.31E-3	1.22E-3	1	1.30	(1,5,1,1,1,5,BU:1.05); NH3; Diao & Shi 2011
	hydrochloric acid, 30% in H2O, at plant	RER	0	kg	1.07E-3	4.00E-4	1	1.30	(1,5,1,1,1,5,BU:1.05); HCl; Diao & Shi 2011
	potassium hydroxide, at regional storage	RER	0	kg	0	7.80E-4	1	1.30	(1,5,1,1,1,5,BU:1.05); KOH; Diao & Shi 2011
	sulphuric acid, liquid, at plant	RER	0	kg	0	5.00E-5	1	1.30	(1,5,1,1,1,5,BU:1.05); H2SO4; Diao & Shi 2011
	phosphoryl chloride, at plant	RER	0	kg	2.00E-5	2.00E-5	1	1.30	(1,5,1,1,1,5,BU:1.05); POCL3; Diao & Shi 2011
	hydrogen fluoride, at plant	GLO	0	kg	3.97E-3	3.92E-3	1	1.30	(1,5,1,1,1,5,BU:1.05); HF; Diao & Shi 2011
	oxygen, liquid, at plant	RER	0	kg	4.50E-4	1.50E-4	1	1.30	(1,5,1,1,1,5,BU:1.05); O2; Diao & Shi 2011
	nitrogen, liquid, at plant	RER	0	kg	7.61E-2	5.78E-2	1	1.30	(1,5,1,1,1,5,BU:1.05); N2; Diao & Shi 2011
	nitric acid, 50% in H2O, at plant	RER	0	kg	2.82E-3	7.20E-3	1	1.30	(1,5,1,1,1,5,BU:1.05); HNO3; Diao & Shi 2011
	silver, at regional storage	RER	0	kg	6.20E-4	4.40E-4	1	1.30	(1,5,1,1,1,5,BU:1.05); Silver; Diao & Shi 2011
	metallization paste, back side, aluminium, at plant	RER	0	kg	1.46E-3	1.10E-3	1	1.30	(1,5,1,1,1,5,BU:1.05); Aluminium paste; Diao & Shi 2011
	electricity, medium voltage, at grid	CN	0	kWh	8.26E-1	8.26E-1	1	1.30	(1,5,1,1,1,5,BU:1.05); Electricity demand; Single-Si Ingot and Wafer; Wang (2014) Current PV Markets and Energy Pay-Back Study (pp. 32-34), Multi-Si Ingot and Wafer; Hao and Zhao (2014) Life Cycle CO2 Emissions of Grid-Connected Electricity for Crystalline Silicon Photovoltaic Systems in China (p. 13, 31)
emission air,	Ethanol	-	-	kg	5.20E-4	3.80E-4	1	1.62	(1,5,1,1,1,5,BU:1.5); Evaporting solvent; Diao & Shi 2011
	Carbon dioxide, fossil	-	-	kg	1.00E-4	8.00E-5	1	1.30	(1,5,1,1,1,5,BU:1.05); CO2; Diao & Shi 2011
emission water,	Fluoride	-	-	kg	7.94E-3	7.83E-3	1	1.62	(1,5,1,1,1,5,BU:1.5); Fluorid; Diao & Shi 2011
	Chloride	-	-	kg	1.66E-3	6.20E-4	1	3.09	(1,5,1,1,1,5,BU:3); Chlorid; Diao & Shi 2011

Photovoltaic panels

Tab. 5.1.9.6 shows the unit process data of the Chinese production of multi-crystalline photovoltaic panels for both technology levels.

There are significant differences in the solar glass and aluminium demand between the mainstream and the best technology in case of the production of multi-crystalline silicon PV panels.

The major inputs and emissions are based on data provided by by Diao & Shi (2011) [42]. The electricity demand for the cell production is updated based on Hou & Zhao (2014) [43] and Wang (2014) [44].

Tab. 5.1.9.6 Unit process data of photovoltaic module production in China (CN) for mainstream and best technology

	Name	Location	InfrastructureProcess	Unit	photovoltaic panel, Chinese data, mainstream, at plant	photovoltaic panel, Chinese data, best technology, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CN	CN			
	InfrastructureProcess				0	0			
	Unit				unit	unit			
product	photovoltaic panel, Chinese data, mainstream, at plant	CN	0	unit	1	0			
	photovoltaic panel, Chinese data, best technology, at plant	CN	0	unit	0	1			
technosphere	photovoltaic cell, Chinese data, mainstream, at plant	CN	0	unit	7.20E+1	0	1	1.30	(1,5,1,1,1,5,BU:1.05); cells; Diao & Shi 2011
	photovoltaic cell, Chinese data, best technology, at plant	CN	0	unit	0	7.20E+1	1	1.30	(1,5,1,1,1,5,BU:1.05); cells; Diao & Shi 2011
	copper, at regional storage	RER	0	kg	3.60E-2	3.60E-2	1	1.30	(1,5,1,1,1,5,BU:1.05); Copper; Diao & Shi 2011
	solar glass, low-iron, at regional storage	RER	0	kg	1.79E+1	1.43E+1	1	1.30	(1,5,1,1,1,5,BU:1.05); Glass; Diao & Shi 2011
	polyvinylfluoride film, at plant	US	0	kg	2.55E-1	2.55E-1	1	1.30	(1,5,1,1,1,5,BU:1.05); Back film; Diao & Shi 2011
	polyethylene terephthalate, granulate, amorphous, at plant	RER	0	kg	5.20E-1	5.20E-1	1	1.30	(1,5,1,1,1,5,BU:1.05); PET back; Diao & Shi 2011
	silicone product, at plant	RER	0	kg	1.13E-1	1.13E-1	1	1.30	(1,5,1,1,1,5,BU:1.05); Silicone; Diao & Shi 2011
	aluminium alloy, AlMg3, at plant	RER	0	kg	3.40E+0	2.70E+0	1	1.30	(1,5,1,1,1,5,BU:1.05); Aluminium frame; Diao & Shi 2011
	ethylvinylacetate, foil, at plant	RER	0	kg	1.90E+0	1.90E+0	1	1.30	(1,5,1,1,1,5,BU:1.05); EVA; Diao & Shi 2011
	electricity, medium voltage, at grid	CN	0	kWh	3.40E+1	3.40E+1	1	1.30	(1,5,1,1,1,5,BU:1.05); Electricity demand; Single-Si Ingot and Wafer; Wang (2014) Current PV Markets and Energy Pay-Back Study (pp. 32-34), Multi-Si Ingot and Wafer; Hao and Zhao (2014) Life Cycle CO2 Emissions of Grid-Connected Electricity for Crystalline Silicon Photovoltaic Systems in China (p. 13, 31)
	ethylvinylacetate, foil, at plant	RER	0	kg	0	0	1	1.30	(1,5,1,1,1,5,BU:1.05); EVA; Diao & Shi 2011
emission air, unspecified	Silicon	-	-	kg	3.00E-3	3.00E-3	1	5.10	(1,5,1,1,1,5,BU:5); Silicon; Diao & Shi 2011

5.2 CdTe PV

Tab. 5.2.1 shows the unit process data of the CI(G)S photovoltaic laminate and cell production in Europe (Germany, DE).

The data on material, energy consumption and emissions remain unchanged and correspond to the life cycle inventory data of CdTe laminate published by Jungbluth et al. (2012) [38].

Tab. 5.2.1 Unit process data of the CdTe photovoltaic laminate production in Europe (Germany, DE), Asia & Pacific (Malaysia, MY) and North America (United States of America, US)

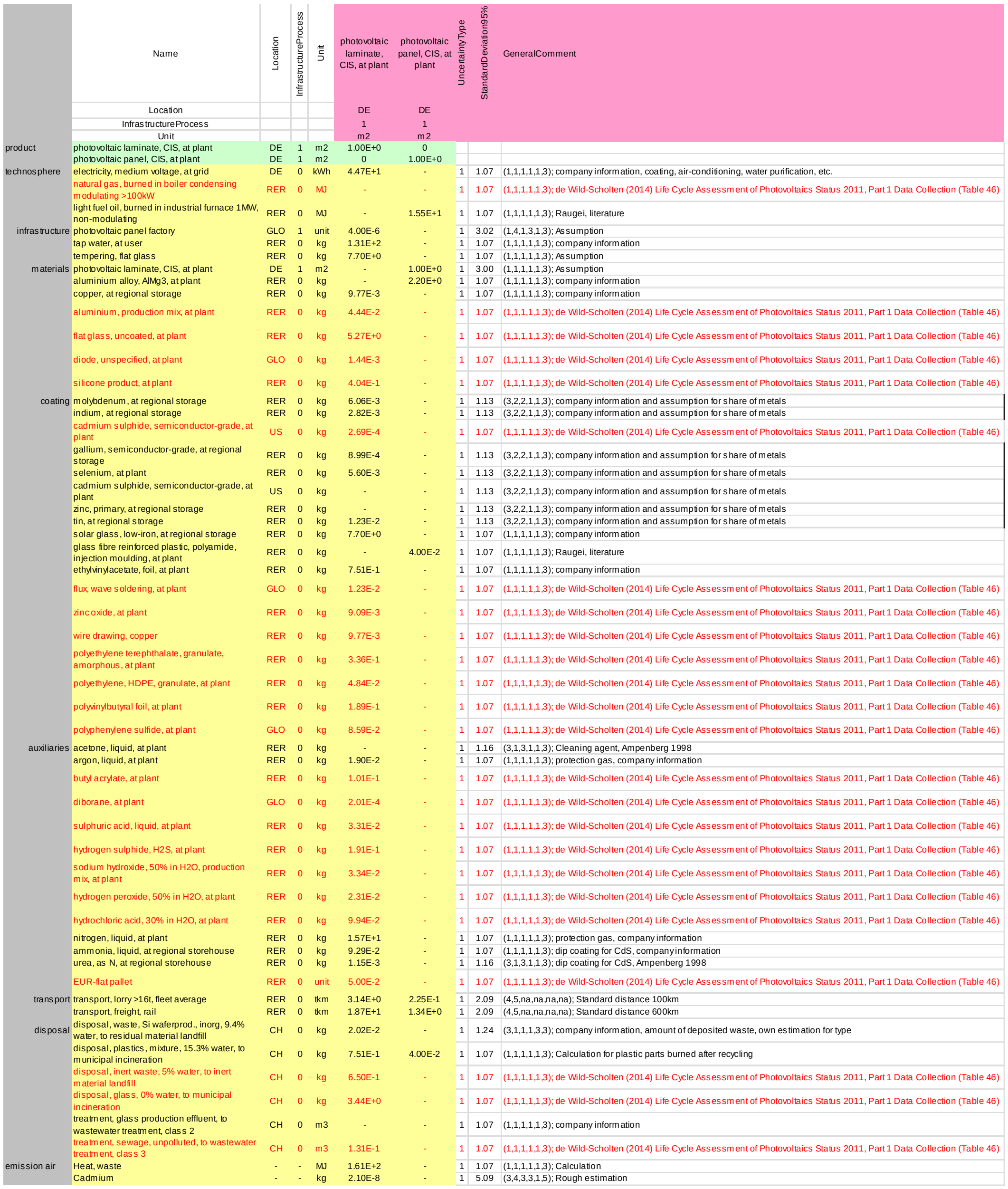
Explanations	Name	Location	Infrastructure-Process	Unit	photovoltaic laminate, CdTe, at plant	photovoltaic laminate, CdTe, at plant	photovoltaic laminate, CdTe, at plant	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				DE	MY	US			
	InfrastructureProcess				1	1	1			
	Unit				m2	m2	m2			
Outputs	photovoltaic laminate, CdTe, at plant	DE	1	m2	1					
	photovoltaic laminate, CdTe, at plant	MY	1	m2		1				
	photovoltaic laminate, CdTe, at plant	US	1	m2			1			
technosphere	electricity, medium voltage, at grid	DE	0	kWh	2.79E+1	-	-	1	1.07	(1,1,1,1,1,3,BU:1.05); 2010 data for First Solar in Germany
04	electricity, medium voltage, at grid	MY	0	kWh	-	3.02E+1	-	1	1.07	(1,1,1,1,1,3,BU:1.05); 2010 data for First Solar in Malaysia
	electricity, medium voltage, at grid	US	0	kWh	-	-	2.95E+1	1	1.07	(1,1,1,1,1,3,BU:1.05); 2011 data for First Solar in US
	natural gas, burned in boiler modulating >100kW	RER	0	MJ	5.50E+0	-	1.16E+1	1	1.07	(1,1,1,1,1,3,BU:1.05); 2010 data for First Solar in US
	photovoltaic panel factory	GLO	1	unit	4.00E-6	4.00E-6	4.00E-6	1	3.04	(3,4,3,1,1,3,BU:3); Assumption
	tap water, at user	RER	0	kg	1.15E+2	2.11E+2	1.32E+2	1	1.07	(1,1,1,1,1,3,BU:1.05); 2010 data for First Solar in US
	tempering, flat glass	RER	0	kg	8.34E+0	8.38E+0	8.47E+0	1	1.07	(1,1,1,1,1,3,BU:1.05); 2010 data for First Solar in US
	copper, at regional storage	RER	0	kg	1.05E-2	1.16E-2	1.10E-2	1	1.07	(1,1,1,1,1,3,BU:1.05); 2010 data for First Solar in US
	silicone product, at plant	RER	0	kg	3.07E-3	3.07E-3	3.07E-3	1	1.08	(1,2,2,3,1,3,BU:1.05); Fthenakis, literature
	solar glass, low-iron, at regional storage	RER	0	kg	8.34E+0	8.38E+0	8.47E+0	1	1.07	(1,1,1,1,1,3,BU:1.05); 2010 data for First Solar in US
	flat glass, uncoated, at plant	RER	0	kg	8.16E+0	8.13E+0	8.25E+0	1	1.07	(1,1,1,1,1,3,BU:1.05); 2010 data for First Solar in US
	glass fibre reinforced plastic, polyamide, injection moulding, at plant	RER	0	kg	1.08E-1	1.08E-1	1.08E-1	1	1.16	(1,4,3,3,1,3,BU:1.05); Fthenakis, literature, sum up of several materials
	ethylvinylacetate, foil, at plant	RER	0	kg	4.77E-1	4.86E-1	4.86E-1	1	1.07	(1,1,1,1,1,3,BU:1.05); 2010 data for First Solar in US
	cadmium telluride, semiconductor-grade, at plant	US	0	kg	2.33E-2	2.34E-2	2.58E-2	1	1.07	(1,1,1,1,1,3,BU:1.05); 2010 data for First Solar in US
	cadmium sulphide, semiconductor-grade, at plant	US	0	kg	3.52E-3	3.52E-3	3.52E-3	1	1.16	(1,4,3,3,1,3,BU:1.05); Fthenakis, literature, incl. Part of Cd compound powder
	nitric acid, 50% in H2O, at plant	RER	0	kg	5.72E-2	5.72E-2	5.72E-2	1	1.16	(1,4,3,3,1,3,BU:1.05); Fthenakis, literature
	sulphuric acid, liquid, at plant	RER	0	kg	3.93E-2	3.93E-2	3.93E-2	1	1.16	(1,4,3,3,1,3,BU:1.05); Fthenakis, literature
	silica sand, at plant	DE	0	kg	4.68E-2	4.68E-2	4.68E-2	1	1.16	(1,4,3,3,1,3,BU:1.05); Fthenakis, literature
	sodium chloride, powder, at plant	RER	0	kg	4.53E-2	4.53E-2	4.53E-2	1	1.16	(1,4,3,3,1,3,BU:1.05); Fthenakis, literature
	hydrogen peroxide, 50% in H2O, at plant	RER	0	kg	1.67E-2	1.67E-2	1.67E-2	1	1.16	(1,4,3,3,1,3,BU:1.05); Fthenakis, literature
	isopropanol, at plant	RER	0	kg	2.08E-3	2.08E-3	2.08E-3	1	1.16	(1,4,3,3,1,3,BU:1.05); Fthenakis, literature
	sodium hydroxide, 50% in H2O, production mix, at plant	RER	0	kg	4.93E-2	4.93E-2	4.93E-2	1	1.16	(1,4,3,3,1,3,BU:1.05); Fthenakis, literature
	chemicals inorganic, at plant	GLO	0	kg	3.76E-2	3.76E-2	3.76E-2	1	1.07	(1,1,1,1,1,3,BU:1.05); 2010 data for First Solar in US
	chemicals organic, at plant	GLO	0	kg	9.74E-3	9.74E-3	9.74E-3	1	1.16	(1,4,3,3,1,3,BU:1.05); Fthenakis, literature, sum up of several chemicals
	nitrogen, liquid, at plant	RER	0	kg	7.32E-2	7.32E-2	7.32E-2	1	1.16	(1,4,3,3,1,3,BU:1.05); Fthenakis, literature
	helium, at plant	GLO	0	kg	3.64E-2	3.64E-2	3.64E-2	1	1.16	(1,4,3,3,1,3,BU:1.05); Fthenakis, literature
	corrugated board, mixed fibre, single wall, at plant	RER	0	kg	5.22E-1	5.22E-1	5.22E-1	1	1.07	(1,1,1,1,1,3,BU:1.05); 2010 data for First Solar in US
	transport, lorry >16t, fleet average	RER	0	tkm	5.87E+0	4.13E-1	7.75E+0	1	2.00	(1,1,1,1,1,3,BU:2); 2010 data for First Solar in US
	transport, freight, rail	RER	0	tkm	-	5.35E+0	-	1	2.00	(1,1,1,1,1,3,BU:2); 2010 data for First Solar in Malaysia
	transport, transoceanic freight ship	OCE	0	tkm	-	2.31E+2	-	1	2.00	(1,1,1,1,1,3,BU:2); 2010 data for First Solar in Malaysia
Waste	disposal, municipal solid waste, 22.9% water, to municipal incineration	CH	0	kg	3.00E-2	3.00E-2	3.00E-2	1	1.16	(1,4,3,3,1,3,BU:1.05); Alsema (personal communication) 2007, production waste
	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	0	kg	7.08E-1	7.08E-1	7.08E-1	1	1.16	(1,4,3,3,1,3,BU:1.05); Calculation
	treatment, sewage, unpolluted, to wastewater treatment, class 3	CH	0	m3	3.41E-2	-	6.16E-2	1	1.07	(1,1,1,1,1,3,BU:1.05); 2010 data for First Solar in US
air, high. pop.	Heat, waste	-	-	MJ	2.09E+2	2.09E+2	2.09E+2	1	1.29	(3,4,3,3,1,5,BU:1.05); Calculation
	Cadmium	-	-	kg	5.34E-9	5.34E-9	5.34E-9	1	5.00	(1,1,1,1,1,3,BU:5); 2010 data for First Solar in US
water, unspecified	Cadmium, ion	-	-	kg	4.43E-7	4.43E-7	4.43E-7	1	3.00	(1,1,1,1,1,3,BU:3); 2010 data for First Solar in US

5.3 CI(G)S modules

Tab. 5.3.1 shows the unit process data of the CI(G)S photovoltaic laminate and cell production in Europe (Germany, DE).

The data on material, energy consumption and emissions correspond to the life cycle inventory data of CI(G)S laminate and panels published by Jungbluth et al. (2012) [38] updated with information published by de Wild-Scholten (2014) [40].

Tab. 5.3.1 Unit process data of the CI(G)S photovoltaic laminate and cell production in Europe (Germany, DE); red added exchanges compared to Jungbluth et al. (2012) [38].



	Name	Location	InfrastructureProcess	Unit	photovoltaic laminate, CIS, at plant	photovoltaic panel, CIS, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				DE	DE			
	InfrastructureProcess				1	1			
	Unit				m2	m2			
product	photovoltaic laminate, CIS, at plant	DE	1	m2	1.00E+0	0			
	photovoltaic panel, CIS, at plant	DE	1	m2	0	1.00E+0			
technosphere	electricity, medium voltage, at grid	DE	0	kWh	4.47E+1	-	1	1.07	(1,1,1,1,1,3); company information, coating, air-conditioning, water purification, etc.
	natural gas, burned in boiler condensing modulating >100kW	RER	0	MJ	-	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	light fuel oil, burned in industrial furnace 1MW, non-modulating	RER	0	MJ	-	1.55E+1	1	1.07	(1,1,1,1,1,3); Raugei, literature
infrastructure	photovoltaic panel factory	GLO	1	unit	4.00E-6	-	1	3.02	(1,4,1,3,1,3); Assumption
	tap water, at user	RER	0	kg	1.31E+2	-	1	1.07	(1,1,1,1,1,3); company information
	tempering, flat glass	RER	0	kg	7.70E+0	-	1	1.07	(1,1,1,1,1,3); Assumption
materials	photovoltaic laminate, CIS, at plant	DE	1	m2	-	1.00E+0	1	3.00	(1,1,1,1,1,3); Assumption
	aluminium alloy, AlMg3, at plant	RER	0	kg	-	2.20E+0	1	1.07	(1,1,1,1,1,3); company information
	copper, at regional storage	RER	0	kg	9.77E-3	-	1	1.07	(1,1,1,1,1,3); company information
	aluminium, production mix, at plant	RER	0	kg	4.44E-2	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	flat glass, uncoated, at plant	RER	0	kg	5.27E+0	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	diode, unspecified, at plant	GLO	0	kg	1.44E-3	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	silicone product, at plant	RER	0	kg	4.04E-1	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
coating	molybdenum, at regional storage	RER	0	kg	6.06E-3	-	1	1.13	(3,2,2,1,1,3); company information and assumption for share of metals
	indium, at regional storage	RER	0	kg	2.82E-3	-	1	1.13	(3,2,2,1,1,3); company information and assumption for share of metals
	cadmium sulphide, semiconductor-grade, at plant	US	0	kg	2.69E-4	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	gallium, semiconductor-grade, at regional storage	RER	0	kg	8.99E-4	-	1	1.13	(3,2,2,1,1,3); company information and assumption for share of metals
	selenium, at plant	RER	0	kg	5.60E-3	-	1	1.13	(3,2,2,1,1,3); company information and assumption for share of metals
	cadmium sulphide, semiconductor-grade, at plant	US	0	kg	-	-	1	1.13	(3,2,2,1,1,3); company information and assumption for share of metals
	zinc, primary, at regional storage	RER	0	kg	-	-	1	1.13	(3,2,2,1,1,3); company information and assumption for share of metals
	tin, at regional storage	RER	0	kg	1.23E-2	-	1	1.13	(3,2,2,1,1,3); company information and assumption for share of metals
	solar glass, low-iron, at regional storage	RER	0	kg	7.70E+0	-	1	1.07	(1,1,1,1,1,3); company information
	glass fibre reinforced plastic, polyamide, injection moulding, at plant	RER	0	kg	-	4.00E-2	1	1.07	(1,1,1,1,1,3); Raugei, literature
	ethylvinylacetate, foil, at plant	RER	0	kg	7.51E-1	-	1	1.07	(1,1,1,1,1,3); company information
	flux, wave soldering, at plant	GLO	0	kg	1.23E-2	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	zinc oxide, at plant	RER	0	kg	9.09E-3	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	wire drawing, copper	RER	0	kg	9.77E-3	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	polyethylene terephthalate, granulate, amorphous, at plant	RER	0	kg	3.36E-1	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	polyethylene, HDPE, granulate, at plant	RER	0	kg	4.84E-2	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	polyvinylbutyral foil, at plant	RER	0	kg	1.89E-1	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	polyphenylene sulfide, at plant	GLO	0	kg	8.59E-2	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
auxiliaries	acetone, liquid, at plant	RER	0	kg	-	-	1	1.16	(3,1,3,1,1,3); Cleaning agent, Ampenberg 1998
	argon, liquid, at plant	RER	0	kg	1.90E-2	-	1	1.07	(1,1,1,1,1,3); protection gas, company information
	butyl acrylate, at plant	RER	0	kg	1.01E-1	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	diborane, at plant	GLO	0	kg	2.01E-4	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	sulphuric acid, liquid, at plant	RER	0	kg	3.31E-2	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	hydrogen sulphide, H2S, at plant	RER	0	kg	1.91E-1	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	sodium hydroxide, 50% in H2O, production mix, at plant	RER	0	kg	3.34E-2	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	hydrogen peroxide, 50% in H2O, at plant	RER	0	kg	2.31E-2	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	hydrochloric acid, 30% in H2O, at plant	RER	0	kg	9.94E-2	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	nitrogen, liquid, at plant	RER	0	kg	1.57E+1	-	1	1.07	(1,1,1,1,1,3); protection gas, company information
	ammonia, liquid, at regional storehouse	RER	0	kg	9.29E-2	-	1	1.07	(1,1,1,1,1,3); dip coating for CdS, company information
	urea, as N, at regional storehouse	RER	0	kg	1.15E-3	-	1	1.16	(3,1,3,1,1,3); dip coating for CdS, Ampenberg 1998
	EUR-flat pallet	RER	0	unit	5.00E-2	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
transport	transport, lorry >16t, fleet average	RER	0	tkm	3.14E+0	2.25E-1	1	2.09	(4,5,na,na,na,na); Standard distance 100km
	transport, freight, rail	RER	0	tkm	1.87E+1	1.34E+0	1	2.09	(4,5,na,na,na,na); Standard distance 600km
disposal	disposal, waste, Si waferprod., inorg, 9.4% water, to residual material landfill	CH	0	kg	2.02E-2	-	1	1.24	(3,1,1,1,3,3); company information, amount of deposited waste, own estimation for type
	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	0	kg	7.51E-1	4.00E-2	1	1.07	(1,1,1,1,1,3); Calculation for plastic parts burned after recycling
	disposal, inert waste, 5% water, to inert material landfill	CH	0	kg	6.50E-1	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	disposal, glass, 0% water, to municipal incineration	CH	0	kg	3.44E+0	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
	treatment, glass production effluent, to wastewater treatment, class 2	CH	0	m3	-	-	1	1.07	(1,1,1,1,1,3); company information
	treatment, sewage, unpolluted, to wastewater treatment, class 3	CH	0	m3	1.31E-1	-	1	1.07	(1,1,1,1,1,3); de Wild-Scholten (2014) Life Cycle Assessment of Photovoltaics Status 2011, Part 1 Data Collection (Table 46)
emission air	Heat, waste	-	-	MJ	1.61E+2	-	1	1.07	(1,1,1,1,1,3); Calculation
	Cadmium	-	-	kg	2.10E-8	-	1	5.09	(3,4,3,3,1,5); Rough estimation

5.4 Amonix 7700 High Concentration PV (HCPV)

Table 5.4.1: LCI for Manufacturing of Amonix 7700 HCPV

Product	**Unit**	**Amount**	**Comment**
Amonix 7700	p	1	aperture area: 267 m^2, capacity: 53 kW$_p$ AC
Component			
Cells	kg	0.16	GaInP/GaInAs/Ge cells grown on a germanium substrate; dimension: 9.5 x 9 x 0.2 mm
Frame	kg	6566	4x12 sections, thickness: 5 mm, material: 18 GA. 55 ksi, G90 Pre-galvanized Steel
Fresnel Lenses	kg	1143	4x6 lenses for submodule; thickness: 4 mm; material: coated acrylic
Heat Sink	kg	3086	aluminum; 3 cm wide rod
Foundation	kg	3126	18’ deep, 42” diameter; concrete basis underground, 3000 PSI concrete
Hydraulic Drive	kg	2724	Steel
Pedestal/Torque tube	kg	11260	Tracker; 18 ft high Pedestal with 30 inch diameter steel pipe with outriggers
Fastener	kg	49	Stainless steel fastener for outriggers
Motor	kg	16	2 horsepower per system.
Inverter	kg	500	
Transformer	kg	100	500 kW
Cables	kg	35	Copper/PVC
Controller	kg	18	
Sensor	kg	1.4	
Anemometer	kg	0.14	
Energy			
Diesel	MJ	126	Used for assembly and installation
Electricity	kWh	1.5	Used for assembly and installation

Table 5.4.2: LCI for Maintenance of Amonix 7700 HCPV

Product	**Unit**	**Amount**	**Comment**
Amonix 7700	p	1	based on 30 yrs of operation and maintenance
Material			
Water	kg	106000	Lens cleaning
Hydraulic Oil	kg	900	
Lubricating Oil	kg	25	For bearing lubrication
Poly carbonate	kg	3	Desiccant Cartridge
Polyester	kg	60	Air filter
Polyurethane	kg	9	Air filter and desiccant cartridge
ABS (co-polymer plastic)	kg	40	Air filter guard
Poly amide	kg	1	Desiccant Cartridge
Silica gel	kg	9	Desiccant Cartridge
Stainless steel	kg	7	Hydraulic pressure filter
Glass fiber	kg	7	Hydraulic pressure filter

5.5 Mounting Structures of PV Modules

Tab. 5.3.1 shows the unit process data of PV mounting systems in Europe. The data correspond to the life cycle inventory data of mounting systems published by Jungbluth et al. (2012) [38]. Data includes materials, packaging, and transport of mounting structures and disposal of packaging materials.

Tab. 5.5.1 Unit process data of different PV mounting systems

	Name	Location	Infrastructure	Unit	facade construction, mounted, at building	facade construction, integrated, at building	flat roof construction, on roof	slanted-roof construction, mounted, on roof	slanted-roof construction, integrated, on roof	open ground construction, on ground	slanted-roof construction, mounted, on roof, Stade de Suisse	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER	RER	RER	RER	CH			
	InfrastructureProcess				1	1	1	1	1	1	1			
	Unit				m2	m2	m2	m2	m2	m2	m2			
technosphere	aluminium, production mix, wrought alloy, at plant	RER	0	kg	2.64E+0	3.27E+0	2.52E+0	2.84E+0	2.25E+0	3.98E+0	2.30E+0	1	2.05	(1,2,1,1,1,na); Literature and own estimations
	corrugated board, mixed fibre, single wall, at plant	RER	0	kg	4.03E-2	-	1.83E-2	1.33E-1	1.14E-1	8.64E-2	1.33E-1	1	2.18	(3,4,3,1,3,5); Schwarz et al. 1992
	polyethylene, HDPE, granulate, at plant	RER	0	kg	7.32E-4	-	1.92E+0	1.40E-3	2.82E-2	9.09E-4	1.40E-3	1	2.05	(1,2,1,1,1,na); Literature and own estimations, recycled PE
	polystyrene, high impact, HIPS, at plant	RER	0	kg	3.66E-3	-	8.30E-3	7.02E-3	6.02E-3	4.55E-3	7.02E-3	1	2.18	(3,4,3,1,3,5); Schwarz et al. 1992
	polyurethane, flexible foam, at plant	RER	0	kg	-	-	-	-	1.84E-2	-	-	1	2.05	(1,2,1,1,1,na); Literature and own estimations
	synthetic rubber, at plant	RER	0	kg	-	-	-	-	1.24E+0	-	-	1	2.05	(1,2,1,1,1,na); Literature and own estimations
	steel, low-alloyed, at plant	RER	0	kg	1.80E+0	-	2.67E-1	1.50E+0	2.00E-1	-	-	1	2.05	(1,2,1,1,1,na); Literature and own estimations
	chromium steel 18/8, at plant	RER	0	kg	-	-	-	-	-	2.47E-1	6.50E-2	1	2.10	(2,3,1,1,1,5); Literature and own estimations
	reinforcing steel, at plant	RER	0	kg	-	-	-	-	-	7.21E+0	-	1	2.10	(2,3,1,1,1,5); Literature and own estimations
	concrete, normal, at plant	CH	0	m3	-	-	-	-	-	5.37E-4	-	1	2.18	(3,4,3,1,3,5); Fence foundation
	section bar extrusion, aluminium	RER	0	kg	2.64E+0	3.27E+0	2.52E+0	2.84E+0	2.25E+0	3.98E+0	2.30E+0	1	2.18	(3,4,3,1,3,5); Estimation
	sheet rolling, steel	RER	0	kg	1.10E-1	-	2.67E-1	1.50E+0	-	-	-	1	2.18	(3,4,3,1,3,5); Estimation
	section bar rolling, steel	RER	0	kg	1.69E+0	-	-	-	2.00E-1	6.15E+0	-	1	2.18	(3,4,3,1,3,5); Brunschweiler 1993
	wire drawing, steel	RER	0	kg	-	-	-	-	-	1.06E+0	-	1	2.18	(3,4,3,1,3,5); Mesh wire fence
	zinc coating, pieces	RER	0	m2	-	-	-	-	-	1.56E-1	-	1	2.18	(3,4,3,1,3,5); Estimation
	zinc coating, coils	RER	0	m2	-	-	-	-	-	1.09E-1	-	1	2.18	(3,4,3,1,3,5); Fence
transport	transport, lorry >16t, fleet average	RER	0	tkm	2.24E-1	1.64E-1	2.56E-1	2.25E-1	2.07E-1	2.17E-1	1.27E-1	1	2.14	(4,5,na,na,na,na); Standard distance 50km
	transport, freight, rail	RER	0	tkm	1.61E+0	6.54E-1	1.05E+0	1.50E+0	8.52E-1	5.14E+0	5.26E-1	1	2.14	(4,5,na,na,na,na); Standard distances 200km, 600km
	transport, van <3.5t	RER	0	tkm	4.44E-1	3.27E-1	4.72E-1	4.34E-1	3.75E-1	1.14E+0	2.37E-1	1	2.18	(3,4,3,1,3,5); 100km to construction place
disposal	disposal, packaging cardboard, 19.6% water, to municipal incineration	CH	0	kg	4.03E-2	-	1.83E-2	1.33E-1	1.14E-1	8.64E-2	1.33E-1	1	2.18	(3,4,3,1,3,5); Calculated with use
	disposal, building, polyethylene/polypropylene products, to final disposal	CH	0	kg	7.32E-4	-	1.92E+0	1.40E-3	1.29E+0	9.09E-4	1.40E-3	1	2.18	(3,4,3,1,3,5); Disposal of plastics parts at end of life
	disposal, building, polystyrene isolation, flame-retardant, to final disposal	CH	0	kg	3.66E-3	-	8.30E-3	7.02E-3	6.02E-3	4.55E-3	7.02E-3	1	2.18	(3,4,3,1,3,5); Disposal of plastics parts at end of life
	Transformation, from pasture and meadow	-	-	m2	-	-	-	-	-	4.72E+0	-	1	2.18	(3,4,3,1,3,5); Tucson Electric Power
	Transformation, to industrial area, built up	-	-	m2	-	-	-	-	-	1.50E+0	-	1	2.15	(1,3,2,3,3,5); Literature and own estimations
	Transformation, to industrial area, vegetation	-	-	m2	-	-	-	-	-	3.22E+0	-	1	2.16	(3,3,2,3,3,5); Literature and own estimations
	Occupation, industrial area, built up	-	-	m2a	-	-	-	-	-	4.50E+1	-	1	2.16	(3,3,2,3,3,5); Assumed life time: 30 a
	Occupation, industrial area, vegetation	-	-	m2a	-	-	-	-	-	9.66E+1	-	1	2.16	(3,3,2,3,3,5); Assumed life time: 30 a
product	facade construction, mounted, at building	RER	1	m2	1.00E+0	0	0	0	0	0	0			
	facade construction, integrated, at building	RER	1	m2	-	1.00E+0	0	0	0	0	0			
	flat roof construction, on roof	RER	1	m2	-	-	1.00E+0	0	0	0	0			
	slanted-roof construction, mounted, on roof	RER	1	m2	-	-	-	1.00E+0	0	0	0			
	slanted-roof construction, integrated, on roof	RER	1	m2	-	-	-	-	1.00E+0	0	0			
	open ground construction, on ground	RER	1	m2	-	-	-	-	0	1.00E+0	0			
	slanted-roof construction, mounted, on roof, Stade de Suisse	CH	1	m2	-	-	-	-	0	0	1.00E+0			
information	total weight, materials			kg	4.5	3.3	4.7	4.5	3.9	11.5	2.5			Sum from the inventory
	total weight, structure			kg	4.4	3.3	4.7	4.3	3.7	11.4	2.4			Sum from the inventory
	panel area			m2	1.0	1.0	1.0	1.0	1.0	1.0	1.0			
	minimum weight, construction			kg		1.5	1.5	1.0	1.0	-	-			Siemer 2008
	maximum, construction			kg		12.5	20.0	20.0	15.0	-	-			Siemer 2008
	number, examples			1		10	34	35	10	-	-			Siemer 2008
	mean, construction, 2008, weighted with the installed capacity			kg	**4.5**	**3.3**	**4.7**	**4.5**	**3.7**	**-**	**-**			Siemer 2008
	standard deviation			kg		1.2	3.1	1.2	2.0	-	-			Siemer 2008
	correction factor			%	0.81	0.96	0.40	1.54	1.32	-	-			Calculated for this study
	mean, construction, 2007, ecoinvent v2.0			kg	4.5	4.0	7.0	4.5	4.0	-	-			Siemer 2007
	mean, construction, 2003, ecoinvent v1.0			kg	4.9		6.2	4.4		**-**	**-**			Siemer 2003

5.6. Electrical Components

5.6.1 Roof Top Installations

Name	**Electrical cabling for module interconnection and AC-interface**
Time period	2006
Geography	Europe, Western
Technology	Average technology
Representativeness	Mixed data
Date	11/6/2006
Collection method	For roof top systems: 4 rows of 13 SolarWorld SW220 poly module with 6 x 10 multicrystalline cells of 156 mm x 156 mm.
Data treatment	Scaled to 1 m2 of module area
Comment	For systems with modules in 150-170 Wp range and dimension of about 1 x 1.3 m2, connected to a 4.6 kW inverter. See ref 1.

Table 5.6.1.1: LCI of DC Cable (1)

Type of system		on-roof or in-roof	ground PhönixSonnenstrom	ground Springerville	
Products	**Unit**	**Amount**	**Amount**	**Amount**	**Comment**
DC Cabling	m2	1	1	1	per m2 module area
Materials/fuels					
copper	kg	0.10	0.62	0.64	2.2 m DC cable and 0.1 m AC cable
TPE = Thermoplastic elastomer	kg	0.06	0.25	0.48	
Electricity					
electricity, medium voltage	kWh	0.0	0.0	0.0	unknown
Emissions					unknown
Waste to treatment					Unknown

Note

1) Typical cable lengths for a roof top system are: 2.2 m DC cable and 0.1 m AC cable per m2 of module/array area

Reference: [33]

Date	9/1/2006
Collection method	http://www.helukabel.de/download.php?lang=en&im=pdf/english/datenblatt/&fid=78990.pdf
Comment	Helukabel Solarflex 101, 4 mm^2, ROHS compliant. In a typical rooftop system, comprising modules of 1x1.7 m2, the DC cable length will be about 2.2 m per m2 of module area

Table 5.6.1.2: LCI of DC Cable (2)

Products	**Unit**	**Amount**	**Comment**
Cable DC 4 mm^2	m	1	
Materials/fuels			
SOLIDS			
copper	kg	0.038	Cu, Sn coated
TPE = Thermoplastic elastomer	kg	0.030	TPE
Electricity			
electricity, medium voltage, total	kWh	0.0	unknown
Emissions			unknown
Waste to treatment			unknown

Reference [33]

Name	**Inverter 500 W-ac**
Time period	2000-2004
Geography	Europe, Western
Technology	Average technology
Representativeness	Data from a specific component
Date	9/21/2006
Collection method	Based on manufacturer specification for PSI 300, extrapolated to values for PSI 500. (Only upscaling of transformers and capacitors).

Table 5.6.1.3: LCI of 500 W-AC Inverter

Products	**Unit**	**Amount**	**Comment**
Inverter	p	1.00	Nominal output 2500 W AC
Materials			
Aluminum	g	682	casing
Polycarbonate	g	68	casing
ABS	g	148	casing
Poly Ethylene	g	1.4	
PVC	g	2	in cable
SAN (Styrene acrylonitrile)	g	2	in cable
copper	g	2	in cable
Steel	g	78	screws and clamps
Printed Circuit Board	cm2	596	double layered board, without components, weight 100 g
connector	g	50	
transformers, wire-wound	g	310	
coils	g	74	
IC's	g	6	
transistor	g	8	
transistor diode	g	10	
capacitor, film	g	72	
capacitor, electrolytic	g	54	
capacitor, CMC	g	4.8	
resistors	g	1	

Name	**Inverter 2500 W-ac**
Time period	2000-2004
Geography	Europe, Western
Technology	Average technology
Representativeness	Data from a specific component
Date	9/21/2006
Collection method	Disassembly of inverter and weighing
Comment	Based on data collected in 2001, based on the Mastervolt Sunmaster 2500

Table 5.6.1.4: LCI of 2500 W-AC Inverter

Products	**Unit**	**Amount**	**Comment**
Inverter	p	1.00	Nominal output 2500 W AC
Materials			
Steel	kg	9.8	casing
Aluminum	kg	1.4	casing
Transformers, wire-wound	kg	5.5	
Printed Circuit Board, with electronic components	kg	1.8	

5.6.2 Ground mount installations

Name	**Inverters + transformers 1 MW**
Time period	2000-2004
Geography	Europe, Western
Technology	Average technology
Representativeness	Data from a specific component
Date	9/21/2006
Data treatment	Data scaled to 1 MW DC
Comment	Based on data collected at the 4.6 MWp Springerville plant (Tucson, USA), scaled to 1 MW DC power. Inverters: Xantrex PV-150. Includes material for step-up transformers. See refs. 1,2 for details

Table 5.6.2.1: LCI of 1 MW Inverters + Transformers for Ground Mount Installation [13, 35]

Products	**Unit**	**Amount**	**Comment**
Inverters + Transformers	p	1.00	Nominal input power 1 MW DC
Materials			
steels	kg	9792	
aluminum	kg	894	
copper	kg	2277	
polyamide injection molded	kg	485	
polyester	kg	300	
Polyethylene, HD	kg	150	
Paint	kg	150	
Transformer oil (vegetable)	kg	6001	

5.7 *Medium-Large PV installations In Europe*

Name	**Real photovoltaic power plants in Europe**
Time period	2004-2009
Geography	Europe
Technology	Mixed data
Representativeness	Individual real installations
Date	09.02.2010
Collection method	Data from system installers, operators and literature.
Comment	Photovoltaic power plants operating in Switzerland, Germany, and Spain Reference [30]

Table 5.7.1: LCI of PV Power Plants in Europe

capacity		93 kWp	280 kWp	156 kWp	1.3 MWp	324 kWp	450 kWp	569 kWp	570 kWp	
type of module		single-Si laminate	single-Si panel	multi-Si panel	multi-Si panel	multi-Si panel	single-Si panel	multi-Si panel	multi-Si panel	
type of mounting system:		Slanted roof integrate	Flat roof mounted	Flat roof mounted	Slanted roof mounted	Flat roof mounted	Flat roof mounted	Open ground	Open ground	
location		Switzerland	Switzerland	Switzerland	Switzerland	Germany	Germany	Spain	Spain	
Products	**Unit**	**Amount**	**Amount**	**Amount**	**Amount**	**Amount**	**Amount**	**Amount**	**Amount**	**Comment**
photovoltaic installation	unit	1	1	1	1	1	1	1	1	Refers to capacity above
electricity yield	kWh/m^2*a	131	155	120	128	141	136	238	198	3.85 MJ converted solar energy per kWh
Components/fuels										
electricity consumption	kWh	7.13E+00	2.15E+01	1.19E+01	1.03E+02	2.48E+01	3.45E+01	3.60E+01	3.60E+01	Erection of plant
diesel consumption	MJ	0	0	0	0	0	0	7.66E+03	7.67E+03	
inverter weight	kg	123	2420	1590	6600	2600	3535	4675	4675	This amount is replaced every 15 years.
mounting system	m2	6.84E+02	2.08E+03	1.17E+03	1.01E+04	2.55E+03	3.38E+03	4.27E+03	4.27E+03	
photovoltaic module	m2	7.05E+02	2.14E+03	1.21E+03	1.04E+04	2.63E+03	3.48E+03	4.29E+03	4.40E+03	Including 2% replaces

										during life time and 1% rejects
Electric installations (excluding inverter)										
copper	kg	7.06E+01	3.18E+02	3.03E+02	3.87E+03	3.77E+02	3.81E+02	7.41E+02	7.41E+02	Drawn to wire
brass	kg	5.46E-01	1.02E+00	6.82E-01	7.50E+00	1.36E+00	1.36E+00	1.36E+00	1.36E+00	
zinc	kg	1.09E+00	2.05E+00	1.36E+00	1.50E+01	2.73E+00	2.73E+00	2.73E+00	2.73E+00	
Steel	kg	2.24E+01	4.12E+01	2.81E+01	2.90E+02	5.29E+01	5.29E+01	5.29E+01	5.29E+01	
nylon 61	kg	6.28E+00	1.18E+01	7.84E+00	8.63E+01	1.57E+01	1.57E+01	1.57E+01	1.57E+01	
polyethylene1	kg	6.07E+01	3.15E+02	2.80E+02	3.73E+03	4.12E+02	4.17E+02	7.09E+02	7.09E+02	
polyvinylchloride1	kg	8.69E-01	2.61E+01	2.17E+01	2.36E+02	4.17E+01	4.35E+01	4.49E+01	4.49E+01	
polycarbonate1	kg	5.46E-02	1.02E-01	6.82E-02	7.50E-01	1.36E-01	1.36E-01	1.36E-01	1.36E-01	
epoxy resin1	kg	5.46E-02	1.02E-01	6.82E-02	7.50E-01	1.36E-01	1.36E-01	1.36E-01	1.36E-01	
Transport	tkm									
lorry	tkm	4.23E+03	1.82E+04	9.64E+03	8.34E+04	2.10E+04	2.96E+04	3.51E+04	3.52E+04	500 km modules
transoceanic freight ship	tkm	1.69E+04	7.28E+04	3.86E+04	3.34E+05	8.14E+04	1.18E+05	1.41E+05	1.41E+05	2’000 km modules
van	tkm	8.91E+02	4.12E+03	2.24E+03	1.80E+04	4.72E+03	6.62E+03	7.96E+03	7.98E+03	100 km system

5.8 Country specific photovoltaic mixes

Name	**Country-specific photovoltaic electricity mixes**
Time period	2005-2009
Geography	World
Technology	Mixed data
Representativeness	Representative for selected countries
Date	9/2/2010
Collection method	National and international statistics.
Comment	Photovoltaic installations on buildings are considered with 3kWp installations, centralized installations are considered with open ground installations

Table 5.8.1: Country-Specific photovoltaic mixes [32]

Country		**Netherlands**	**Norway**	**Portugal**	**Spain**	**Sweden**	**United Kingdom**	**United States**	**Australia**	**Canada**	**Korea, Republic of**	**New Zealand**	**Turkey**
Product	kWh	1	1	1	1	1	1	1	1	1	1	1	1
converted solar energy	MJ	3.85E+0	3.85E+0	3.85E+0	3.85E+0	3.85E+0	3.85E+0	3.85E+0	3.85E+0	3.85E+0	3.85E+0	3.85E+0	3.85E+0
tap water	kg	6.25E-3	6.27E-3	3.90E-3	3.14E-3	6.38E-3	7.04E-3	3.63E-3	4.37E-3	5.11E-3	5.45E-3	4.77E-3	4.05E-3
sewage	m3	6.25E-6	6.27E-6	3.90E-6	3.14E-6	6.38E-6	7.04E-6	3.63E-6	4.37E-6	5.11E-6	5.45E-6	4.77E-6	4.05E-6
569 kWp open ground installation, multi-Si	unit	-	-	2.19E-8	1.61E-8	-	-	-	-	-	-	-	-
570 kWp open ground installation, multi-Si	unit	4.83E-9	-	2.19E-8	1.93E-8	-	-	-	2.04E-9	7.26E-10	5.36E-8	-	-
3.5 MWp open ground installation, multi-Si	unit	-	-	-	-	-	-	1.09E-9	-	-	-	-	-
3kWp facade installation, single-Si, laminated, integrated	unit	1.59E-7	1.54E-7	-	-	1.63E-7	1.91E-7	9.14E-8	1.38E-7	1.40E-7	2.41E-8	1.37E-7	1.24E-7
3kWp facade installation, single-Si, panel, mounted	unit	6.36E-7	6.18E-7	-	-	6.52E-7	7.65E-7	3.65E-7	5.53E-7	5.59E-7	9.64E-8	5.46E-7	4.96E-7
3kWp facade installation, multi-Si, laminated, integrated	unit	2.42E-7	2.35E-7	-	-	2.48E-7	2.91E-7	1.39E-7	2.11E-7	2.13E-7	3.67E-8	2.08E-7	1.89E-7
3kWp facade installation, multi-Si, panel, mounted	unit	9.68E-7	9.41E-7	-	-	9.93E-7	1.17E-6	5.57E-7	8.43E-7	8.52E-7	1.47E-7	8.32E-7	7.55E-7
3kWp flat roof installation, single-Si, on roof	unit	8.77E-7	9.57E-7	-	-	9.68E-7	1.06E-6	4.41E-7	6.07E-7	7.56E-7	1.30E-7	7.09E-7	5.95E-7
3kWp flat roof installation, multi-Si	unit	1.34E-6	1.46E-6	8.90E-8	-	1.48E-6	1.61E-6	6.72E-7	9.24E-7	1.15E-6	1.98E-7	1.08E-6	9.06E-7
3kWp slanted-roof installation, single-Si, laminated, integrated	unit	1.10E-7	1.20E-7	-	-	1.21E-7	1.32E-7	5.52E-8	7.58E-8	9.45E-8	1.62E-8	8.86E-8	7.44E-8
3kWp slanted-roof installation, single-Si, panel, mounted	unit	2.85E-6	3.11E-6	-	-	3.15E-6	3.43E-6	1.43E-6	1.97E-6	2.46E-6	4.21E-7	2.30E-6	1.93E-6
3kWp slanted-roof installation, multi-Si, laminated, integrated	unit	1.67E-7	1.82E-7	-	-	1.84E-7	2.01E-7	8.40E-8	1.15E-7	1.44E-7	2.47E-8	1.35E-7	1.13E-7
3kWp slanted-roof installation, multi-Si, panel, mounted	unit	4.34E-6	4.74E-6	2.66E-7	-	4.79E-6	5.23E-6	2.19E-6	3.00E-6	3.74E-6	6.42E-7	3.51E-6	2.94E-6
3kWp slanted-roof installation, ribbon-Si, panel, mounted	unit	3.67E-7	4.00E-7	-	-	4.05E-7	4.42E-7	1.85E-7	2.54E-7	3.16E-7	5.42E-8	2.96E-7	2.49E-7
3kWp slanted-roof installation, ribbon-Si, laminated, integrated	unit	1.41E-8	1.54E-8	-	-	1.56E-8	1.70E-8	7.10E-9	9.75E-9	1.22E-8	2.09E-9	1.14E-8	9.56E-9
3kWp slanted-roof installation, CdTe, laminated, integrated, on roof	unit	6.12E-7	6.68E-7	-	1.73E-7	6.76E-7	7.38E-7	3.08E-7	4.24E-7	5.28E-7	9.05E-8	4.95E-7	4.15E-7
3kWp slanted-roof installation, CIS, panel, mounted	unit	7.25E-8	7.92E-8	-	-	8.01E-8	8.74E-8	3.65E-8	5.02E-8	6.25E-8	1.07E-8	5.86E-8	4.92E-8
3kWp slanted-roof installation, a-Si, laminated, integrated	unit	2.21E-8	2.41E-8	1.11E-8	-	2.44E-8	2.66E-8	1.11E-8	1.53E-8	1.90E-8	3.26E-9	1.78E-8	1.50E-8
3kWp slanted-roof installation, a-Si, panel, mounted	unit	5.74E-7	6.26E-7	2.37E-8	-	6.34E-7	6.91E-7	2.89E-7	3.97E-7	4.95E-7	8.48E-8	4.64E-7	3.89E-7

Heat, waste	MJ	2.50E-1	2.50E-1	2.50E-1	2.50E-1	2.50E-1	2.50E-1	2.50E-1	2.50E-1	2.50E-1	2.50E-1	2.50E-1	2.50E-1
Global horizontal irradiation	kWh / m2	1045	967	1682	1660	980	955	1816	1686	1273	1215	1412	1697
Annual output, Roof-Top	kWh /kW_p	815	800	1276	1282	791	725	1390	1209	1000	921	1080	1287
Annual output, Facade	kWh /kW_p	562	620	789	813	588	500	839	663	676	620	701	772

Table 5.8.1: Country-Specific PV Electricity Mixes (Continued)

<u>Country</u>		**Austria**	**Belgium**	**Czech Republic**	**Denmark**	**Finland**	**France**	**Germany**	**Greece**	**Hungary**	**Ireland**	**Italy**	**Japan**	**Luxembourg**
<u>Product</u>	kWh	1	1	1	1	1	1	1	1	1	1	1	1	1
converted solar energy	MJ	3.85E+0	3.85E+0	3.85E+0	3.85E+0	3.85E+0	3.85E+0	3.85E+0	3.85E+0	3.85E+0	3.85E+0	3.85E+0	3.85E+0	3.85E+0
tap water	kg	6.25E-3	7.05E-3	6.81E-3	6.48E-3	6.67E-3	5.72E-3	5.85E-3	4.43E-3	5.65E-3	6.80E-3	5.41E-3	5.85E-3	6.45E-3
sewage	m3	6.25E-6	7.05E-6	6.81E-6	6.48E-6	6.67E-6	5.72E-6	5.85E-6	4.43E-6	5.65E-6	6.80E-6	5.41E-6	5.85E-6	6.45E-6
324 kWp flat-roof installation, multi-Si	unit	-	-	-	-	-	5.36E-9	7.16E-9	-	-	-	2.25E-9	-	-
450 kWp flat-roof installation, single-Si	unit	-	-	-	-	-	3.15E-9	4.17E-9	-	-	-	3.33E-9	-	-
570 kWp open ground installation, multi-Si, on open ground	unit	4.25E-9	-	-	-	-	6.60E-9	3.94E-9	-	-	-	2.05E-8	3.02E-10	-
3kWp facade installation, single-Si, laminated, integrated	unit	2.22E-7	1.93E-7	1.90E-7	1.70E-7	1.73E-7	1.93E-7	1.84E-8	1.34E-7	1.59E-7	1.79E-7	7.84E-7	1.64E-7	1.79E-7
3kWp facade installation, single-Si, panel, mounted	unit	8.89E-7	7.72E-7	7.60E-7	6.79E-7	6.92E-7	7.71E-7	7.35E-8	5.38E-7	6.35E-7	7.14E-7	5.03E-7	6.57E-7	7.15E-7
3kWp facade installation, multi-Si, laminated, integrated	unit	2.37E-7	2.94E-7	2.89E-7	2.59E-7	2.63E-7	2.37E-7	2.47E-8	2.05E-7	2.42E-7	2.72E-7	3.81E-7	2.50E-7	2.72E-7
3kWp facade installation, multi-Si, panel, mounted	unit	9.49E-7	1.18E-6	1.16E-6	1.03E-6	1.05E-6	9.46E-7	9.88E-8	8.19E-7	9.67E-7	1.09E-6	2.45E-7	1.00E-6	1.09E-6
3kWp flat roof installation, single-Si	unit	1.17E-6	1.06E-6	1.02E-6	9.80E-7	1.01E-6	5.18E-7	4.37E-7	6.52E-7	8.43E-7	1.03E-6	1.26E-6	8.68E-7	9.66E-7
3kWp flat roof installation, multi-Si	unit	1.25E-6	1.61E-6	1.55E-6	1.49E-6	1.54E-6	6.36E-7	5.87E-7	9.93E-7	1.28E-6	1.56E-6	6.12E-7	1.32E-6	1.47E-6
3kWp slanted-roof installation, single-Si, laminated, integrated	unit	1.47E-7	1.32E-7	1.27E-7	1.22E-7	1.26E-7	9.83E-8	8.17E-8	8.14E-8	1.05E-7	1.28E-7	2.03E-7	1.09E-7	1.21E-7
3kWp slanted-roof installation, single-Si, panel, mounted	unit	3.81E-6	3.43E-6	3.31E-6	3.18E-6	3.28E-6	2.52E-6	3.71E-6	2.12E-6	2.74E-6	3.34E-6	1.87E-6	2.82E-6	3.14E-6
3kWp slanted-roof installation, multi-Si, laminated, integrated	unit	1.57E-7	2.01E-7	1.94E-7	1.87E-7	1.92E-7	1.21E-7	1.10E-7	1.24E-7	1.60E-7	1.96E-7	9.88E-8	1.65E-7	1.84E-7
3kWp slanted-roof installation, multi-Si, panel, mounted	unit	4.07E-6	5.23E-6	5.04E-6	4.85E-6	5.00E-6	3.10E-6	4.98E-6	3.23E-6	4.17E-6	5.08E-6	9.10E-7	4.30E-6	4.78E-6
3kWp slanted-roof installation, ribbon-	unit	-	4.42E-7	4.26E-7	4.10E-7	4.22E-7	3.54E-7	4.30E-7	2.72E-7	3.52E-7	4.29E-7	6.40E-8	3.63E-7	4.04E-7

Si, panel, mounted														
3kWp slanted-roof installation, ribbon-Si, laminated, integrated	unit	-	1.70E-8	1.64E-8	1.58E-8	1.62E-8	1.36E-8	1.66E-8	1.05E-8	1.36E-8	1.65E-8	1.53E-8	1.40E-8	1.55E-8
3kWp slanted-roof installation, CdTe, laminated, integrated	unit	2.39E-7	7.38E-7	7.11E-7	6.84E-7	7.05E-7	5.91E-7	1.46E-7	4.55E-7	5.89E-7	7.17E-7	3.75E-7	6.06E-7	6.75E-7
3kWp slanted-roof installation, CIS, panel, mounted	unit	2.82E-8	8.74E-8	8.42E-8	8.10E-8	8.35E-8	7.00E-8	8.51E-8	5.39E-8	6.97E-8	8.49E-8	4.44E-8	7.18E-8	7.99E-8
3kWp slanted-roof installation, a-Si, laminated, integrated	unit	1.28E-7	2.66E-8	2.56E-8	2.47E-8	2.54E-8	2.13E-8	2.59E-8	1.64E-8	2.12E-8	2.58E-8	7.05E-8	2.18E-8	2.43E-8
3kWp slanted-roof installation, a-Si, panel, mounted	unit	4.94E-9	6.91E-7	6.66E-7	6.41E-7	6.60E-7	5.54E-7	6.73E-7	4.26E-7	5.51E-7	6.72E-7	2.94E-7	5.68E-7	6.32E-7
Heat, waste	MJ	2.50E-1	2.50E-1	2.50E-1	2.50E-1	2.50E-1	2.50E-1	2.50E-1	2.50E-1	2.50E-1	2.50E-1	2.50E-1	2.50E-1	2.50E-1
Global horizontal irradiation	kWh / m2	1108	946	1000	985	956	1204	972	1563	1198	948	1251	1168	1035
Annual output, Roof-Top	kWh/kW$_p$	833	725	752	782	759	905	744	1175	908	746	949	878	793
Annual output, Facade	kWh/kW$_p$	550	496	504	564	554	581	516	712	603	536	622	580	535

5.9 Country specific electricity grid mixes

Tab. 5.3.1 5.9.1-5.9.10 show the electricity grid mixes of the leading PV manufacturing countries globally: China, Japan, Germany, Taiwan, Malaysia, USA, Korea, Spain, India, Mexico (de Wild-Scholten, 2013) [45].

The data correspond to the electricity grid mixes published by Itten et al. (2014) [46], except where indicated otherwise. Entries in red indicate data not available.

Tab.5.9.1 Electricity supply mix of China

China	**Supply Mix**
	%
Fossil fuels	**78.75**
Hard coal	**76.61**
Lignite	**0.00**
Peat	**0.00**
Industrial Gases	**0.61**
Coke gases	***0.00***
Blast furnace gases	***0.00***
Petroleum products	**0.66**
Fuel oil	***0.00***
Diesel	***0.00***
other petroleum products	***0.00***
Natural Gas	**0.88**
Other fossil	**0.00**
Hydro	**18.57**
Reservoir power plants	**13.93**
Run-of-river power plants	**4.64**
Pumped storage power plants	**0.00**
Nuclear	**2.06**
Pressurised-water reactor (PWR)	**2.06**
Boiling-water reactor (BWR)	**0.00**
Renewables	**0.49**
Geothermal	**0.00**
Solar	**0.00**
Photovoltaic	***0.01***
Solar thermal	***0.00***
Wave and tidal energy	**0.00**
Wind	**0.42**
Wood	**0.07**
Biogas	**0.00**
Waste	**0.00**
Municipal waste	**0.00**
Industrial waste	**0.00**
Sewage sludge and landfill gases	**0.00**
Other	**0.00**
Total domestic	**99.88**
Imports	**0.12**
Chinese Taipeh	**0.12**
Total	**100.00**

Tab.5.9.2 Electricity supply mix of Japan

Japan	Supply Mix
	%
Fossil fuels	**65.38**
Hard coal	**24.26**
Lignite	**0.00**
Peat	**0.00**
Industrial Gases	**2.96**
Coke gases	***0.76***
Blast furnace gases	***2.20***
Petroleum products	**12.11**
Fuel oil	***10.03***
Diesel	***0.29***
other petroleum products	***1.78***
Natural Gas	**26.06**
Other fossil	**0.00**
Hydro	**8.07**
Reservoir power plants	**1.48**
Run-of-river power plants	**5.91**
Pumped storage power plants	**0.68**
Nuclear	**23.76**
Pressurised-water reactor (PWR)	**10.36**
Boiling-water reactor (BWR)	**13.40**
Renewables	**2.11**
Geothermal	**0.26**
Solar	**0.21**
Photovoltaic	***0.21***
Solar thermal	***0.00***
Wave and tidal energy	**0.00**
Wind	**0.26**
Wood	**1.39**
Biogas	**0.00**
Waste	**0.67**
Municipal waste	**0.63**
Industrial waste	**0.04**
Sewage sludge and landfill gases	**0.00**
Other	**0.00**
Total domestic	**100.00**
Imports	**0.00**
Total	**100.00**

Tab.5.9.3 Electricity supply mix of Germany [47]

Germany	Supply Mix
	%
Fossil fuels	58.30
Hard coal	18.00
Lignite	25.60
Peat	*0.00*
Industrial Gases	*0.00*
Coke gases	*0.00*
Blast furnace gases	*0.00*
Petroleum products	0.80
Fuel oil	*0.00*
Diesel	*0.00*
other petroleum products	*0.00*
Natural Gas	9.60
Other fossil	4.30
Hydro	3.40
Reservoir power plants	
Run-of-river power plants	
Pumped storage power plants	
Nuclear	15.90
Pressurised-water reactor (PWR)	
Boiling-water reactor (BWR)	
Renewables	21.40
Geothermal	*0.00*
Solar	5.80
Photovoltaic	*5.80*
Solar thermal	*0.00*
Wave and tidal energy	*0.00*
Wind	8.60
Wood	7.00
Biogas	
Waste	1.00
Municipal waste	
Industrial waste	
Sewage sludge and landfill gases	
Other	0.00
Total	100.00

Tab. 5.9.4 Electricity supply mix of Taiwan

Taiwan	Supply Mix
	%
Fossil fuels	**77.35**
Hard coal	**46.82**
Lignite	**4.43**
Peat	**0.00**
Industrial Gases	**0.85**
Coke gases	***0.00***
Blast furnace gases	***0.00***
Petroleum products	**5.94**
Fuel oil	***0.00***
Diesel	***0.00***
other petroleum products	***0.00***
Natural Gas	**19.30**
Other fossil	**0.00**
Hydro	**3.49**
Reservoir power plants	**0.00**
Run-of-river power plants	**3.49**
Pumped storage power plants	**0.00**
Nuclear	**17.43**
Pressurised-water reactor (PWR)	**6.44**
Boiling-water reactor (BWR)	**10.99**
Renewables	**0.49**
Geothermal	**0.00**
Solar	**0.00**
Photovoltaic	***0.00***
Solar thermal	***0.00***
Wave and tidal energy	**0.00**
Wind	**0.27**
Wood	**0.22**
Biogas	**0.00**
Waste	**1.24**
Municipal waste	**1.24**
Industrial waste	**0.00**
Sewage sludge and landfill gases	**0.00**
Other	**0.00**
Total domestic	**100.00**
Imports	**0.00**
Total	**100.00**

Tab. 5.9.5 Electricity supply mix of Malaysia

Malaysia	Supply Mix
	%
Fossil fuels	92.28
Hard coal	26.86
Lignite	0.00
Peat	0.00
Industrial Gases	0.00
Coke gases	*0.00*
Blast furnace gases	*0.00*
Petroleum products	1.89
Fuel oil	*0.00*
Diesel	*0.00*
other petroleum products	*0.00*
Natural Gas	63.52
Other fossil	0.00
Hydro	7.72
Reservoir power plants	7.72
Run-of-river power plants	0.00
Pumped storage power plants	0.00
Nuclear	0.00
Pressurised-water reactor (PWR)	0.00
Boiling-water reactor (BWR)	0.00
Renewables	0.00
Geothermal	0.00
Solar	0.00
Photovoltaic	*0.00*
Solar thermal	*0.00*
Wave and tidal energy	0.00
Wind	0.00
Wood	0.00
Biogas	0.00
Waste	0.00
Municipal waste	0.00
Industrial waste	0.00
Sewage sludge and landfill gases	0.00
Other	0.00
Total domestic	100.00
Imports	0.00
Total	100.00

Tab. 5.9.6 Electricity supply mix of USA

United States of America	Supply Mix
	%
Fossil fuels	**69.31**
Hard coal	**45.62**
Lignite	**1.95**
Peat	**0.00**
Industrial Gases	**0.09**
Coke gases	***0.01***
Blast furnace gases	***0.07***
Petroleum products	**1.30**
Fuel oil	***0.56***
Diesel	***0.19***
other petroleum products	***0.55***
Natural Gas	**20.35**
Other fossil	**0.00**
Hydro	**6.77**
Reservoir power plants	**1.23**
Run-of-river power plants	**4.93**
Pumped storage power plants	**0.61**
Nuclear	**19.10**
Pressurised-water reactor (PWR)	**12.68**
Boiling-water reactor (BWR)	**6.42**
Renewables	**2.75**
Geothermal	**0.40**
Solar	**0.06**
Photovoltaic	***0.04***
Solar thermal	***0.02***
Wave and tidal energy	**0.00**
Wind	**1.35**
Wood	**0.93**
Biogas	**0.02**
Waste	**0.67**
Municipal waste	**0.38**
Industrial waste	**0.12**
Sewage sludge and landfill gases	**0.17**
Other	**0.02**
Total domestic	**98.62**
Imports	**1.38**
Canada	**1.35**
Mexico	**0.03**
Total	**100.00**

Tab. 5.9.7 Electricity supply mix of Korea

South Korea	Supply Mix
	%
Fossil fuels	**64.83**
Hard coal	**39.71**
Lignite	**0.00**
Peat	**0.00**
Industrial Gases	**3.39**
Coke gases	***0.36***
Blast furnace gases	***3.02***
Petroleum products	**3.45**
Fuel oil	***2.59***
Diesel	***0.10***
other petroleum products	***0.76***
Natural Gas	**18.28**
Other fossil	**0.00**
Hydro	**1.30**
Reservoir power plants	**0.14**
Run-of-river power plants	**0.57**
Pumped storage power plants	**0.58**
Nuclear	**33.54**
Pressurised-water reactor (PWR)	**33.54**
Boiling-water reactor (BWR)	**0.00**
Renewables	**0.18**
Geothermal	**0.00**
Solar	**0.06**
Photovoltaic	***0.06***
Solar thermal	***0.00***
Wave and tidal energy	**0.00**
Wind	**0.10**
Wood	**0.01**
Biogas	**0.00**
Waste	**0.14**
Municipal waste	**0.04**
Industrial waste	**0.00**
Sewage sludge and landfill gases	**0.10**
Other	**0.02**
Total domestic	**100.00**
Imports	**0.00**
Total	**100.00**

Tab. 5.9.8 Electricity supply mix of Spain [48]

Spain	Supply Mix
	%
Fossil fuels	36.60
Hard coal	14.60
Lignite	*0.00*
Peat	*0.00*
Industrial Gases	*0.00*
Coke gases	*0.00*
Blast furnace gases	*0.00*
Petroleum products	*0.00*
Fuel oil	*0.00*
Diesel	*0.00*
other petroleum products	*0.00*
Natural Gas	9.50
Other fossil	12.50
Hydro	14.20
Reservoir power plants	
Run-of-river power plants	
Pumped storage power plants	
Nuclear	21.20
Pressurised-water reactor (PWR)	
Boiling-water reactor (BWR)	
Renewables	28.00
Geothermal	*0.00*
Solar	4.80
Photovoltaic	*3.10*
Solar thermal	*1.70*
Wave and tidal energy	*0.00*
Wind	21.20
Wood	2.00
Biogas	*0.00*
Waste	0.00
Municipal waste	*0.00*
Industrial waste	*0.00*
Sewage sludge and landfill gases	*0.00*
Other	0.00
Total	100.00

Tab. 5.9.9 Electricity supply mix of India

India	Supply Mix
	%
Fossil fuels	**80.83**
Hard coal	**64.84**
Lignite	**2.14**
Peat	**0.00**
Industrial Gases	**0.17**
Coke gases	***0.00***
Blast furnace gases	***0.00***
Petroleum products	**4.03**
Fuel oil	***0.00***
Diesel	***0.00***
other petroleum products	***0.00***
Natural Gas	**9.66**
Other fossil	**0.00**
Hydro	**14.28**
Reservoir power plants	**11.01**
Run-of-river power plants	**1.52**
Pumped storage power plants	**1.76**
Nuclear	**1.75**
Pressurised-water reactor (PWR)	**1.63**
Boiling-water reactor (BWR)	**0.12**
Renewables	**1.97**
Geothermal	**0.00**
Solar	**0.00**
Photovoltaic	***0.00***
Solar thermal	***0.00***
Wave and tidal energy	**0.00**
Wind	**1.73**
Wood	**0.23**
Biogas	**0.00**
Waste	**0.00**
Municipal waste	**0.00**
Industrial waste	**0.00**
Sewage sludge and landfill gases	**0.00**
Other	**0.00**
Total domestic	**98.83**
Imports	**1.17**
Bhutan	**1.17**
Total	**100.00**

Tab. 5.9.10 Electricity supply mix of Mexico

Mexico	Supply Mix
	%
Fossil fuels	**77.22**
Hard coal	**8.00**
Lignite	**0.00**
Peat	**0.00**
Industrial Gases	**0.19**
Coke gases	***0.03***
Blast furnace gases	***0.17***
Petroleum products	**18.87**
Fuel oil	***17.77***
Diesel	***0.33***
other petroleum products	***0.77***
Natural Gas	**50.16**
Other fossil	**0.00**
Hydro	**15.73**
Reservoir power plants	**0.00**
Run-of-river power plants	**15.73**
Pumped storage power plants	**0.00**
Nuclear	**3.74**
Pressurised-water reactor (PWR)	**0.00**
Boiling-water reactor (BWR)	**3.74**
Renewables	**3.14**
Geothermal	**2.75**
Solar	**0.00**
Photovoltaic	***0.00***
Solar thermal	***0.00***
Wave and tidal energy	**0.00**
Wind	**0.11**
Wood	**0.28**
Biogas	**0.00**
Waste	**0.03**
Municipal waste	**0.00**
Industrial waste	**0.00**
Sewage sludge and landfill gases	**0.03**
Other	**0.00**
Total domestic	**99.86**
Imports	**0.14**
United States of America	**0.14**
Total	**100.00**

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