BEZIRKSAMT
FRIEDRICHSHAIN-KREUZBERG

SOLAR SUPPLY CHAINS IN FOCUS

UNDERSTAND RISKS, BUY RESPONSIBLY!

Bezirksamt Mitte

BERLIN

PowerShift

A total of 160 solar modules were installed on the roof of the Pablo Neruda district central library in Friedrichshain-Kreuzberg in 2020.

Image: Benjamin Pritzkuleit / Berliner Stadtwerke

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LIST OF ABBREVIATIONS

BMAS	Federal Ministry of Labour and Social Affairs
BMWK	Federal Ministry for Economic Affairs and Climate Protection
CSDDD	EU Corporate Sustainability Due Diligence Directive
CSRD	EU Corporate Sustainability Reporting Directive
DERA	German Raw Materials Agency
ESMC	European Solar Manufacturing Council
Fraunhofer ISE	Fraunhofer Institute for Solar Energy Systems
IEA	International Energy Agency
ILO	International Labour Organization
IRMA	Initiative for Responsible Mining
LkSG	German Supply Chain Due Diligence Act
MGS	Metallurgical Grade Silicon (raw silicon)
RBA	Responsible Business Alliance
SSI	Solar Stewardship Initiative
UFLPA	Uyghur Forced Labour Prevention Act

INTRODUCTION

There is an urgent need to convert energy supplies to renewable energy sources. Accordingly, the German government aims to source 80 per cent of the country's electricity consumption from renewable energy by 2030.[1] For Berlin, this means a massive expansion of photovoltaic systems – after all, there is hardly any open space available for wind power.[2] With its *Solarcity Master Plan*, the city is therefore pursuing the goal of covering a quarter of Berlin's electricity consumption with solar energy.[3]

Around 87% of solar cells and modules imported to Germany in 2022 came from the People's Republic of China.[4] Overall, the People's Republic dominates all stages of the value chain for silicon-based solar modules, with market shares of at least 80 per cent.[i] However, the labour law situation in some regions of China is highly problematic and has worsened in recent years, as various laws have been passed that increasingly restrict the enforcement of labour rights and criminalise activists. In addition, there is no trade union freedom. China has also not ratified several of the core labour standards of the International Labour Organization (ILO)[ii], including the two on freedom of association and collective bargaining.[iii] The International Energy Agency (IEA) also points out that the concentration of a large proportion of jobs in the solar industry in China leads to a considerable risk of poor working conditions and the high level of dependency makes it difficult to ensure compliance with human rights and labour standards.[5]

In addition, China has been heavily criticised for years for its treatment of Uyghurs and other predominantly Muslim ethnic groups in the province of Xinjiang. Since the uncovering of human rights violations in the region, the transparency of supply chains has become

Image: Maryana Serdynska / iStock.com

i As much as 90 per cent of polysilicon is produced in China – with three per cent being produced in each of Europe and Southeast Asia, and two per cent in the USA. The production of ingots and wafers is even more concentrated. China had a market share of 96 per cent in 2023. The final production of the solar modules is also concentrated in China: 81 per cent of silicon-based solar modules were manufactured in China in 2023, 7 per cent in Southeast Asia, 5 per cent in India and 2 per cent each in Europe and the USA. In addition to factors such as strong government support, combined with technological innovation and production scaling through a large domestic market, the low prices for Chinese polysilicon and solar products can also be attributed to comparatively low energy and labour costs. In comparison, the costs for the raw material quartz play a minor role (Wirth, 2024).

ii These include the elimination of forced and child labour as well as freedom of association and the right to collective bargaining (International Labour Organization, 2022).

iii For more details see "Und was ist mit den Menschenrechten? China und die Sorgfaltspflichten" (Ferenschild, 2024).

significantly more important for safeguarding human rights in the solar industry and elsewhere. A report published by Sheffield Hallam University in the summer of 2023 uses concrete analyses to determine which major global companies in the solar industry are most likely to have supply chain connections to the Xinjiang region.[6]

Although China dominates the solar industry in all stages of the supply chain, production in other Asian countries has also gained in importance in recent years, and there are also production capacities in Europe and other regions of the world.

This brochure begins by outlining the fundamental human rights and environmental risks in the supply chain for silicon-based solar modules. The aim is then to identify ways to minimise the likelihood of supply chain links to Xinjiang when purchasing solar modules and to counter the violation of human rights and environmental due diligence obligations that can also occur when sourcing from other countries.

The focus of the analysis is on silicon-based thick-film modules, which have an extremely high global market share due to their high efficiency (studies assume up to 97 per cent in 2023[7]) and are used for roof or balcony constructions in urban areas in particular. Various thin-film modules manage without silicon, but deliver a lower electricity yield per area and are not examined in detail in this brochure.

In addition to silicon, other raw materials that are critical from a human rights and environmental perspective include aluminium, silver and copper. These are also required for the production of silicon-based thick-film modules and are therefore included in the present analysis.

Image: Bjoern Wylezich / iStock.com

Polycrystalline silicon, as seen here, is obtained from raw silicon and is essential for the majority of all solar modules worldwide.

Image: olllo / iStock.com

HUMAN RIGHTS AND ENVIRONMENTAL RISKS IN THE SUPPLY CHAIN OF SILICON-BASED SOLAR MODULES

Silicon

The supply chain for the extraction of the semi-metal silicon from quartz and its further processing into thick-film modules is described below.

Raw material extraction of quartz (processing step 1)

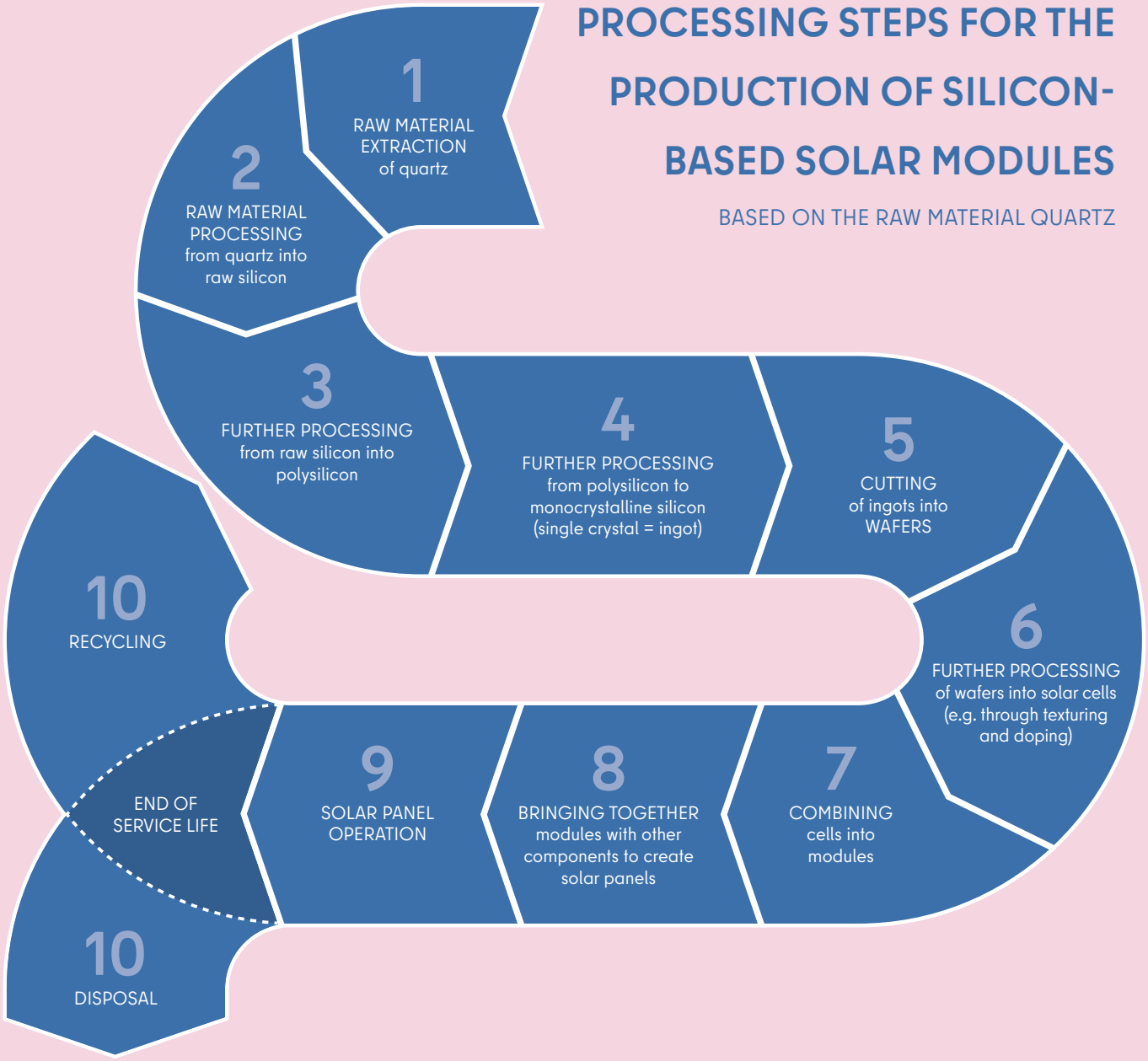
After iron, silicon is the second most abundant element in the Earth's crust – often in combination with oxygen as quartz (silicon dioxide SiO2). Quartz is therefore the starting mineral in the production of silicon. There are many quartz deposits around the world that are generally suitable for mining quartz, from which silicon can be extracted. According to the German Mineral Resources Agency (DERA), there are very large deposits in China, India, Egypt, Uzbekistan, Brazil and Australia, among others. Quartz is also mined in numerous other countries. These include the USA and Canada, Turkey and various countries in Europe – including Norway, Spain, France, Poland, Bosnia -Herzegovina and also Germany (there are deposits in places such as Lower Bavaria and the Bonn vicinity).[8]

Social and environmental risks associated with quartz mining (selection):

- Inhaling the quartz dust that is produced during quartz mining can result in various respiratory diseases – in particular silicosis (quartz dust lung). This risk is particularly high in countries with inadequate occupational health and safety standards or where there is a particularly high risk of labour law violations.[9] This is the case in many of the countries where quartz is mined – including China, India, Egypt, Brazil and Turkey.[10]

PROCESSING STEPS FOR THE PRODUCTION OF SILICON-BASED SOLAR MODULES

BASED ON THE RAW MATERIAL QUARTZ



Sources: Wirth, 2024; DERA, 2023; BMAS, 2023

- In general, a wide range of violations of labour and human rights can occur in these upstream supply chain steps.[11] Numerous cases of forced labour have been documented in China, particularly in the province of Xinjiang (see info box „Zwangsarbeit in Xinjiang“, S. 6).

- Numerous cases of land use conflicts, deforestation and drinking water pollution in quartz mining have also been documented. In addition to the high level of dust pollution, quartz mining is also associated with high water consumption.[12]

Further processing: From quartz to solar module (processing steps 2 to 7)

Raw silicon[i] is obtained by reducing quartz at extremely high temperatures in a smelting reduction furnace using a carbon carrier (usually coal or charcoal)[ii] (step 2). In addition, electricity is required to heat the furnace. It is therefore an extremely energy-intensive process, with the release of emissions being unavoidable.[13]

Polysilicon is produced from the metallurgical silicon in another highly energy-intensive step (step 3), which in turn can be further processed into monocrystalline silicon, which is essential for most solar modules. For this purpose, rods are drawn from hyper-pure silicon – the so-called ingots (step 4). Diamond wire saws then cut these into extremely thin slices, which are known as wafers (step 5). Further processes, including the application of coatings and doping, turn them into solar cells (step 6). These cells are then connected to form the finished solar modules (step 7).[14]

These manufacturing processes for silicon-based solar modules are also associated with social and environmental risks[iii], particularly in the upstream stages of the supply chain. Forced labour, labour law violations and damage to health can also occur here, for example due to the risk of explosions and burns in silicon smelters and the leakage of toxic silicon tetrachloride when silicon is heated[15], with the risks being particularly high in countries with poor occupational health and safety standards. There are particular ecological risks due to the very energy-intensive processes of extracting silicon from quartz and processing it into polysilicon. Large quantities of coal are used in silicon smelters, which is associated with high greenhouse gas emissions.[16] The extraction of the required coal is also often associated with risks. In the case of hard coal from Colombia, which is often used in European silicon smelters, these include intimidation by paramilitary groups, forced evictions from villages due to unpaid protection money, environmental pollution and drinking water shortages, damage to health and increased infant mortality in the local population (due to inhalation of coal dust).[17]

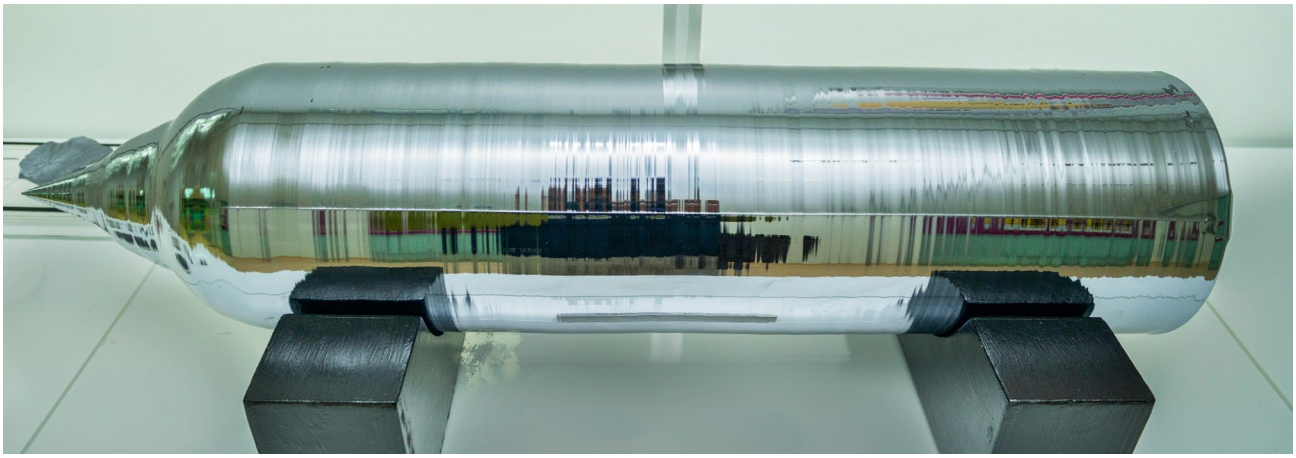


Image: Fhaizal Mazlan / Shutterstock.com

In the next step, an ingot of monocrystalline silicon is cut into wafer-thin solar wafers, which form the basis for solar cells.

i Also known as metallurgical grade silicon and often abbreviated to MGS (Metallurgical Grade Silicon) in English-speaking countries.

ii The fossil energy stored in the carbon carrier accounts for around 60 per cent of the total energy in the reduction process.

iii The publication "Potenzielle menschenrechtliche Risiken entlang der Liefer- und Wertschöpfungsketten" (Potential human rights risks along the supply and value chains) by the Energy Industry Dialogue of the Federal Ministry of Labour and Social Affairs (BMAS) provides a more comprehensive description.

Silver

Due to its electrochemical properties, silver plays an essential role in the production of photovoltaic systems.[25] In 2020, around 10 per cent of global silver demand could be attributed to the production of solar systems. The largest silver-producing countries are Mexico (24.8%), China (13.2%) and Peru (12%), with a large proportion of silver being a by-product of lead-zinc and copper mining.[26] There have been numerous reports of human rights violations in the mining of silver. Prominent examples include the deaths in China's largest silver mine in 2019, which was caused by inadequate safety standards, and the dam burst at the Buenavista del Cobre mine in Mexico in 2014, which destroyed the livelihoods of over 20,000 people due to the negligence of the mine operator.[27] In addition, two thirds of the world's silver is produced in countries with a high or extremely high rate of forced labour.[28] As silver is very expensive, the solar industry is increasingly trying to replace it with copper.

Aluminium and copper

Aluminium and copper are also important metallic raw materials for solar systems. The light metal aluminium is usually used for the frame of a solar module and the installation of a solar system on the roof or balcony. Copper, on the other hand, is particularly relevant due to its electrical conductivity.[i] Extensive environmental damage and social conflicts have also been documented in connection with these two raw materials – including the endangerment of livelihoods (water pollution and declining agricultural yields), land conflicts (land grabbing, forced expropriation, inadequate and non-existent compensation), health risks (e.g. respiratory diseases caused by dust pollution) and the violent suppression of protests.[29]

i Copper strips soldered onto the silicon wafers absorb the energy and transmit it to the inverter (wiring). Copper is also generally essential for the inverter itself and the cabling of the solar system (Carrara et al., 2020).

FORCED LABOUR IN XINJIANG

The Chinese province of Xinjiang (Xinjiang Uyghur Autonomous Region) in the northwest of the country plays a special role for the solar industry, as at least 45 per cent of the polysilicon for the global solar industry comes from there. The province has large quartz deposits[18] and is home to around 40 per cent of the country's coal deposits[19], providing both cheap electricity for the extraction and processing of silicon and the necessary reducing agent. In some other provinces in China, however, the solar industry is increasingly using electricity from renewable energy.[20]

Cheap labour is also available, particularly in Xinjiang, due to the exploitation of Muslim minorities: Numerous reports describe how Uyghurs and other Muslim Turkic peoples such as Kazakhs are oppressed in China and subjected to systematic torture and (sexual) violence in prison camps in Xinjiang. Many people have had to perform forced labour inside and outside these camps. They are then often forced into forced labour in so-called "labour transfer programmes" as "surplus labourers" in companies in Xinjiang or transferred to other parts of the country.[21] The Chinese government provides subsidies and other incentives for companies that take on workers from these programmes. According to studies, around 2.6 million people were affected by these programmes in 2020.[22]

While, according to researchers, these are clearly forced labour programmes, the Chinese government claims that people participate voluntarily and, following this view, even ratified the two key ILO conventions against forced labour in 2022.[23] However, critics primarily see this as a symbolic gesture.[24]

Image: PastryShop / Shutterstock.com

APPROACHES FOR THE DEVELOPMENT OF SOCIALLY RESPONSIBLE AND ECOLOGICAL CRITERIA WHEN PURCHASING SOLAR MODULES

In view of the numerous environmental and human rights risks associated with the extraction and processing of the raw materials required for solar modules, the following section outlines approaches that can help reduce the human rights and ecological risks involved in purchasing these materials.

Diversification of the procurement of solar modules and preliminary products

The EU classifies silicon as a critical and strategic raw material, partly due to low production capacities in the EU and supply risks in connection with China's market power. However, despite China's global market power in the solar industry, there are alternatives. Large solar module manufacturers such as Jinko Solar, Trina Solar, Canadian Solar, Maxeon and REC Solar now have split supply chains: while a significant proportion of production capacity remains in China (often with links to Xinjiang), alternative supply chains are also being established in which links with Xinjiang are to be reduced or eliminated. To this end, the production of ingots, wafers, cells and modules is being relocated, primarily to other countries in Southeast Asia. The metallurgical silicon used in these products is also not from China and is usually processed into polysilicon by the companies Wacker[ii] (in Germany), Hemlock (in the USA) or OCI (in Malaysia).[30]

ii Wacker Chemie AG is the only company that produces polysilicon in Europe and covers a significant portion of its energy requirements with hydropower (Solar Power Europe, n.d.; Wacker Chemie AG, 2024). According to Sheffield Hallam University, since production takes place in Germany and the USA and the raw silicon used is not sourced from China, there are no human rights risks associated with Xinjiang (Crawford & Murphy, 2023).

Although preliminary products for solar modules often come from China, there are also specialised companies in Europe and other regions of the world outside China for every step of the supply chain for silicon-based solar modules.[i] Germany is a frontrunner in the solar industry in Europe: With quartz mining and a silicon smelter[ii], Wacker operates two plants for the production of polysilicon[iii] and several manufacturers have significant production capacities for solar cells and modules[iv], which together account for a significant proportion of Europe's total capacities.[31] There are also efforts to expand production capacities for solar module supply chain steps in Europe, for example via the EU research project PILATUS (for wafers, cells and modules) or, as is the case with the German solar company ENPAL, in cooperation with Chinese technology partners.[32]

Malaysia is also a key producer of metallurgical silicon and polysilicon. Malaysia, Vietnam and Thailand also have significant production capacities for cells and modules.[33] This is specifically due to investments by large Chinese manufacturers, who are aiming to relocate part of their supply chains to other Asian countries. The background to this development is primarily the US import tariffs on Chinese solar cells, as well as the US import ban on products from Xinjiang established in the *Uyghur Forced Labour Prevention Act* (UFLPA)[v].[34] Most manufacturers and operators of production facilities for solar products in Southeast Asia are companies that belong to or are associated with Chinese companies.[35]

The risk of state-imposed forced labour is reduced by shifting supply chains and offers the public sector and private buyers the opportunity to use products that are not associated with the systematic oppression of ethnic minorities. This trend of parallel supply chains of large manufacturers is expected to increase in the coming years when the European Supply Chain Act and the EU Forced Labour Regulation come into force (see „Mehr Nachhaltigkeit in der Solarbranche“, S. 17).

At the same time, however, there are also shortcomings in occupational health and safety in some of the countries to which production is relocated. In Vietnam, Malaysia, Thailand, India and the Philippines, for example, the risks of health and safety violations in the workplace are also assessed as high or very high.[36] Approaches for companies to comply with due diligence obligations must therefore also be identified for these alternative supply chains. Observing ecological criteria, demanding standards, implementing *"beyond auditing"* approaches and engaging in dialogue with companies can represent initial solution strategies, which will be discussed below.

i However, the production capacities of the major Chinese manufacturers exceed those of the larger European solar module manufacturers many times over. The largest solar module manufacturers in the world include the Chinese companies LONGi, Trina, JA Solar and Jinko Solar, with annual production capacities of between 80 and 120 GW.

ii The silicon smelter in Pocking is operated by RW silicium GmbH, using gangue quartz and quartz gravel from Germany, Austria and the Czech Republic as raw materials. Some of the silicon obtained is processed into polysilicon by Wacker. The electricity for the smelter comes mainly from solar energy and a hydroelectric power plant. The required reducing agent is a mix of hard coal (68 per cent; from Colombia), charcoal and wood chips (DERA, 2023).

iii The majority of this is then exported, more than 70 per cent to China, for example.

iv Nevertheless, the nationwide production capacities (around 3.2 to 3.9 GW) are significantly below the annual expansion of solar capacity in Germany (14 GW in 2023) (Federal Network Agency, 2024; Fraunhofer ISE, 2024).

v The UFLPA is a US law that came into force in 2021 and prohibits the import of goods from Xinjiang that have been produced using forced labour. It assumes that all products from this region are associated with forced labour, which means that importers must prove that their goods were not produced under such conditions (reversal of the burden of proof). The law requires companies to comprehensively review their procurement practices. The UFLPA's Entity List registers companies and institutions suspected of being involved in forced labour in the Xinjiang region of China (U.S. Department of Homeland Security).

Consideration of ecological criteria as a starting point

One way to reduce risks and dependencies in the supply chains of silicon-based solar modules is to take ecological criteria into account in procurement.

With regard to ecological aspects, there is also a certain degree of comparability between companies and products[vi], for example in terms of the longevity (the warranty period can be an indicator here) and recyclability of the solar modules, the type of energy used and greenhouse gas emissions and water consumption in production.[vii] There are also companies that strive to ensure the subsequent reusability and recoverability of raw materials from their solar modules and, for example, prepare guidelines for the proper dismantling of modules and lists of material contents in order to increase reusability and improve recycling (these include Solitek and Meyer Burger, for example).

The following sheds a light on the relevance of the adequate circulation of solar modules, as well as the longevity and CO_2 footprint during the entire life cycle.

Circulation

According to the European Environment Agency, 95 per cent of solar systems can be recycled.[37] For the solar modules themselves, the legal requirement is that they must be at least 85 per cent recyclable[viii]. As solar systems have a lifespan of around thirty years and are still a relatively new technology – at least in the mass market – there is not yet a large volume of old appliances. However, huge quantities of this are expected in the coming years; in 2030, around 162,000 tons of aluminium, 99,000 tons of copper and a good 82,000 tons of silicon will be produced across the EU.[38]

Silicon is less easy to recycle than the other raw materials contained in solar systems. The separation of silicon and glass in particular represents a major technical challenge.[39] Accordingly, the recycling targets of 85 per cent are often met without a sufficient amount of the silicon contained being returned to the material cycle.[40] However, it is possible to recycle silicon-based solar cells without any loss of quality if the right infrastructure is provided: There are also companies in Europe that can produce high-purity silicon powder from solar cells, which can be processed into new solar cells.[41] Raw material-specific rules for the recycling of silicon should therefore be included in tender and contract documents.[ix]

In some cases, it may also be worth checking whether solar panels can be sourced second-hand. However, this applies more to balcony power plants, as second-hand modules are somewhat less efficient.

Service life and CO_2 footprint

In addition to a high degree of recycling, a long service life and the purchase of modules with the lowest possible CO_2 emissions during the life cycle also have a positive effect by contributing to a reduction in human rights and ecological risks.

For example, when purchasing solar modules, it makes sense to pay attention to the use of renewable energy throughout the entire production process (including the first supply chain stages from quartz): A 2021 study by the Fraunhofer Institute for Solar Energy Systems (Fraunhofer ISE) concludes that CO_2 emissions are around 40 per cent lower for silicon-based solar module production in the EU compared to production in China. The main reason for this is the energy mix of the different countries.[42] Although several Chinese regions now primarily use renewable energy for the various stages of the solar supply chain, it is not possible to make a general statement about the energy mix used for the

vi When companies publish information about their production, it is usually related to environmental factors.

vii This is generally only measured for final production, i.e. the manufacture of the solar module. Meyer Burger, for example, measures and calculates emissions beyond this.

viii The EU Directive on Waste Electrical and Electronic Equipment (WEEE Directive) stipulates that 85 per cent of waste from photovoltaic modules must be recovered and 80 per cent returned to the material cycle.

ix Adequate recycling is also important due to the lead contained in the modules, as this can be released into the environment or cause damage to human health if silicon-based solar modules are disposed of or recycled improperly. Toxic antimony, which is often used in solar glass to improve light transmission, also poses a challenge when it comes to recycling. The exact antimony content of glass from non-European sources in particular is often unknown, which creates problems with recycling. To improve this, it is recommended that the composition of glass be disclosed transparently, limit values for antimony be set and recycling capacities in Europe be expanded (ESIA, 2023; BMAS, 2023).

entire Chinese solar industry – in Xinjiang, however, the energy required for this is still almost exclusively generated from coal. This leads to the conclusion that a comparatively tiny carbon footprint in the entire production process of a solar module could indicate that the particularly energy-intensive processing steps (steps 2 and 3) did not take place in Xinjiang.[i]

In terms of ecological aspects, modules that are coated with glass on the front and back (known as glass-glass modules) also have a better carbon footprint than modules with backsheets (glass-backsheet modules) – regardless of the country they are produced in.[ii] Glass-glass modules are also considered to be more durable.[43] Although they are often more expensive to purchase initially, it can be worth considering the price per kilowatt hour over the entire lifetime of a system.

Sustainability reports can provide clues for assessing ecological aspects. The solar module manufacturer Meyer Burger, for example, measures and calculates its emissions in the categories Scope 1, 2 and 3.[iii] Fraunhofer ISE has carried out a life cycle analysis of Meyer Burger's solar modules from raw material extraction to recycling and rates the company's environmental balance as comparatively very positive.[iv] The low emissions are attributed in particular to the use of polysilicon from Wacker Chemie AG in Meyer Burger's solar modules.[44]

If companies are to be compared with each other in terms of their carbon footprint, care must be taken to ensure that their sustainability reports or other evidence not only state the emissions from final production, but also those from the entire supply chain, from raw material extraction to recycling, to ensure a comparable data basis.

i However, it should not be forgotten that the labour programmes can also lead to the use of forced labourers in other Chinese provinces.

ii The reason for this is that, unlike glass-foil modules, glass-glass modules do not require an aluminium frame, which takes a lot of energy to produce.

iii Scope 1, 2 and 3 are categories for classifying greenhouse gas emissions in companies: Scope 1 comprises direct emissions from our own sources, such as the combustion of fossil fuels in our own plants. Scope 2 refers to indirect emissions caused by the consumption of purchased energy (electricity). Scope 3 covers all other indirect emissions in the value chain, including the production of raw materials, transportation and use of products.

iv Compared to PERC technology modules from China. The Meyer Burger modules examined achieve CO_2 emissions of between 14.7 g and 17.6 g CO_2 equivalent per kWh over a service life of 25 to 30 years, which Fraunhofer ISE rates as low.

Observance of human rights criteria as a starting point

It is almost impossible to classify corporate actions in terms of human rights due diligence on the basis of publicly available information on the websites of solar module manufacturers. The solar industry is generally very opaque, supply chains are difficult to trace and very few companies provide meaningful documentation. In addition, until now, many of them have hardly been affected by supply chain laws that would require them to comply with human rights and environmental due diligence obligations[v]. In the context of public or private purchasing, other approaches are therefore needed in order to take a step closer to classifying entrepreneurial activity. For example, direct exchange with companies, internet-based research based on specific key questions, and requesting audits[vi] or verification through standards can be considered. Contract monitoring also offers the opportunity to work directly with suppliers in order to minimise human rights risks (see „*Beyond Auditing*-Ansätze, Beschwerdemechanismen und Trainings“, S. 12).

Points of reference for your own research and for dialogue with companies

The following key questions can provide a basis for classifying entrepreneurial activity:

- Is the company or its suppliers (if known) on the Entity List of the US *Uyghur Forced Labour Prevention Act* (UFLPA)? The list contains companies and institutions suspected of being connected to forced labour in Xinjiang.

- In addition, are there any investigations that indicate a high risk of the company or its suppliers (if known) being linked to forced labour in or from Xinjiang?[vii] The extensive list of operators of quartz quarries and producers of raw silicon and polysilicon in Xinjiang compiled in the China country profile in the DERA raw material information document "Raw material risk assessment – silicon and ferrosilicon alloys. Betweenquartz-based products"[45] can serve as a reference point for checking supply chain connections to Xinjiang.

- Are there supply relationships with the USA? This indicates that at least some of the company's products are likely to be manufactured without any proven links to Xinjiang.

v Corporate due diligence refers to the responsibility of companies to take measures to avoid negative impacts on human rights and the environment in their business activities and supply chains. These due diligence obligations include regular reporting, effective risk management, taking preventive measures and establishing grievance mechanisms (Federal Office of Economics and Export Control, 2024).

vi Audits are systematic assessments in which companies, processes or products are checked for compliance with certain standards, guidelines or regulations. In supply chains, audits are often used to assess whether social, environmental and labour standards are being met.

vii In particular, the studies "Over-exposed" (2023) and "In Broad Daylight" (2021) by Sheffield Hallam University, which examine some major solar module manufacturers, should be considered here.

- Does internet-based research provide informationthat serious allegations or incidents of human rights abuses or environmental damage have been made against the company or its suppliers (if known) in recent years?

- Questionnaires can also be used to get a better picture of a company's sustainability efforts. These can focus on areas such as compliance with human and labour rights in the supply chains and the existence and design of grievance mechanisms can be queried. A draft for such a questionnaire can be found under the following link:

www.berlin.de/ba-fk/faire-beschaffung[i]

However, it should be noted that response rates are often low, that the results must be verifiable and that the principle of equal treatment must be upheld when using questionnaires, particularly in the context of procurement procedures.

- Does the company strive for transparency on its website or in communication with potential buyers? This could also be seen as positive. However, it should be noted that the mere provision of information is no guarantee of compliance with due diligence obligations.

- Has the company established effective complaints mechanisms[ii]?

"Beyond auditing" approaches, grievance mechanisms and training

As audits are often not sufficient to identify and effectively address human rights violations, there are alternative approaches that go beyond conventional audits in reviewing and ensuring labour and human rights standards – these are known as *"beyond auditing" approaches*.[46] Their aim is to address human rights due diligence obligations across all sectors in direct cooperation with suppliers. While traditional audits often rely on one-off, pre-announced inspections and standardised checklists, *beyond auditing approaches* aim for long-term, more in-depth and participatory methods in which, for example, workers themselves can participate in monitoring working conditions and report violations, training programmes take place or regular and unannounced inspections are carried out.

Specific measures include the development of *corrective action plans*, discussions with employees and management and *capacity building* through digital learning opportunities that are specifically tailored to production workers in countries of the Global South. Such *beyond auditing* approaches can be implemented in cooperation with providers such as the social enterprise Sustify, which supports corresponding measures on site. Sustify, for example, also offers complaint management systems for China.

Public procurement can therefore examine whether and how companies that carry out complaints management, training and awareness-raising measures can be integrated. In order to ensure effective cooperation with these suppliers, the terms of reference for supply chain management, for example, should stipulate that bidders are obliged to contribute to risk minimisation and, if necessary, to support measures in their own production or with direct or indirect suppliers with increased risk. This also includes disclosing direct suppliers where necessary. The clients and commissioned third parties should be granted access to production facilities if required.

i This questionnaire was created to ask solar module manufacturers about compliance with their due diligence obligations in the course of researching this brochure and was sent on behalf of the district mayors of Friedrichshain-Kreuzberg and Treptow-Köpenick and a district councillor of Neukölln (as of 2024). It has not been reviewed under public procurement law and no evaluation matrix has been created to date.

ii Grievance mechanisms should enable those affected to submit complaints regarding non-compliance with due diligence obligations by companies. According to Section 8 of the Supply Chain Due Diligence Act (LkSG), a complaints procedure is deemed appropriate if it is publicly accessible, is carried out by impartial persons who are obliged to maintain confidentiality, if the information on how to contact them, who is responsible and how the procedure is carried out is made clear, comprehensible and publicly accessible in an appropriate manner, and if the confidentiality of identity is maintained and effective protection against discrimination or punishment on the basis of a complaint is guaranteed.

Image: Blanscape / Shutterstock.com

Overview of industry-relevant standards and certifications and approaches for public procurement

Many companies advertise their efforts towards sustainability (particularly environmental sustainability) on their websites and in public documents, citing which initiatives they are part of and which certifications they have received. Although there are few standards specifically for the solar industry, various certifications and standards are repeatedly mentioned by solar module manufacturers. These relate primarily to ecological and social aspects of individual production sites for the final production of solar modules. Certifications for the responsible sourcing of raw materials[iii], as well as the well-known Fairtrade seal and the Blue Angel, do not appear to be used in theproduction of solar modules.

The standards and norms according to which solar module manufacturers have themselves or their products certified are briefly outlined below with regard to their criteria, certification levels and the processing steps to which they apply.

The important thing is: standards and certifications usually only cover certain environmental or social aspects, do not generally relate to the entire supply chain and are no substitute for laws and regulations. According to various studies[47], standards often fail to ensure comprehensive compliance with environmental and social due diligence obligations.[iv] Nevertheless, when applied in a differentiated manner, they can represent a helpful approach for demanding specific product-related social and environmental criteria, particularly in public procurement.

iii There are standards for aluminium and copper that are intended to ensure a responsible supply and value chain (e.g. the standards of the Aluminium Stewardship Initiative and the Copper Mark Standard), but these have also been the subject of criticism (Sydow et al., 2022). The standard of the Initiative for Responsible Mining (IRMA) is considered a comparatively ambitious standard in mining. There are few copper and silver mining sites that are certified to this standard, and no mining sites for quartz and the ore bauxite, from which aluminium is extracted (IRMA).

iv This is due, for example, to a lack of transparency, a lack of sanction mechanisms for non-compliance and inadequate audits (review mechanisms). Standards should therefore meet various minimum criteria, including multi-stakeholder governance (with equal representation of civil society and the rights holders concerned), the adoption of corrective measures and the establishment of appropriate complaints procedures. The limits of the standards must also be communicated transparently. But even then, they offer no guarantee and cannot replace laws and regulations (Sydow et al., 2022; Lead the Charge, 2024).

ESG Standard and Supply Chain Traceability Standard of the Solar Stewardship Initiative

The Solar Stewardship Initiative (SSI) aims to enable the certification of production facilities in the solar industry according to ESG criteria. Through independent auditors and a planned multi-stakeholder design, in which civil society is also to be represented, the SSI aims to ensure good implementation of its two standards (ESG Standard and Supply Chain Traceability Standard).

Eleven solar module manufacturers are currently members of the SSI and must meet the initiative's ESG standard. These are Chinese manufacturers (including the major manufacturers Trina Solar, JA Solar and Jinko Solar) and European companies, such as RECOM Technologies, based in France, and Solarwatt, based in Germany.[48]

As members have twelve months after joining to undergo a review and the ESG standard was not launched until the beginning of 2024, no results on the ESG standard are yet available (as of October 2024). According to current plans, the Supply Chain Traceability Standard will be launched in 2025, meaning that SSI members will have to have their supply chains certified in accordance with this standard by the end of 2025.

ESG Standard

The ESG Standard initiated by the SSI in 2024 currently requires its members to certify two final production sites[i] according to comprehensive environmental, social and governance criteria[49]. As the SSI currently only requires the certification of two production facilities, human rights violations in non-certified areas may still exist. The exclusion of forced labour in Xinjiang cannot yet be guaranteed due to the focus on the final processing step of solar module production by the SSI ESG Standard. This is one of the reasons why the standard has been criticised by various stakeholders, including the European Solar Manufacturing Council (ESMC).[50]

However, in combination with other evidence that the procured product actually originates from the certified production facility, the standard could provide an approach for the verification of criteria in the final production facilities. As the ESMC also considers the requirements for SSI auditors to be inadequate, consideration could be given to setting additional minimum requirements for the qualifications of the auditors as part of an award process. Furthermore, it should be analysed whether additional requirements should be placed on an effective complaints mechanism, as the SSI requirements are also criticised as inadequate here.

Supply Chain Traceability Standard

The SSI is currently working on the development of a further standard – the Supply Chain Traceability Standard[51] – which aims to extend compliance with the ESG standard to the upstream supply chain steps of at least two production sites by the end of 2025. As of October 2024, the approach provides for three certification levels (Bronze, Silver and Gold), depending on how many requirements of the standard are fully or partially met. The initial focus is on silicon, with plans to extend this to the supply chains of other metallic raw materials that are relevant for solar modules in the future. The various stages will probably require certification of the supply chain up to quartz (Gold), raw silicon (Silver) or polysilicon (Bronze).[ii] SSI is working with independent auditors such as SGS, Kiwa, TÜV Rheinland and TÜV Süd to certify production facilities.[52]

If implemented well, the Supply Chain Traceability Standard could be a first step towards ensuring transparency and compliance with human rights requirements in the upstream solar supply chain.

i The manufacturing members of the SSI ("Manufacturer Members") are currently exclusively solar module manufacturers. They must have two solar module production sites inspected accordingly (processing step 7).

ii Solar module manufacturers can therefore only receive a Gold certificate if supply chain levels 1-7 are considered for at least two production sites. Silver comprises processing steps 2-7 and Bronze steps 3-7.

EPEAT for solar systems

The EPEAT for Solar label is positively emphasised by the Ultra Low Carbon Solar Alliance[iii], the ESMC, and other organisations. This is an eco-label that is managed by the Global Electronics Council organisation. The standard includes requirements[iv] for the avoidance or reduction of emissions with a high global warming potential, information on the recycled content of the product, product return services and compliance with occupational health and safety regulations by the manufacturer.[53] EPEAT evaluates products over their entire life cycle and comprises three certification levels (Bronze, Silver and Gold). To achieve Silver or Gold certification, further optional criteria must be met. These also include social aspects such as compliance with labour rights by direct suppliers or the performance of audits at suppliers that are considered to be at risk.

If social aspects are required as part of an award procedure, which are optionally fulfilled by the company in the case of Silver or Gold certification, it must be demonstrated and proven that the criteria required by the contracting authority are also complied with. To date, Qcells is the only manufacturer of silicon-based solar modules to have been awarded the EPEAT label: It received Bronze certification for a module series that the company manufactures in the USA[v].[54]

Cradle to Cradle Certified Product Standard

The Cradle to Cradle standard is awarded by the Cradle to Cradle Products Innovation Institute for many product groups, whereby the same assessment standard applies to all product groups.[55] It classifies performance in five categories: environmentally safe and healthy materials, recyclability of materials, greenhouse gas emissions and renewable energy, water management and human and workers' rights[vi]. The assessment is carried out by accredited agencies. There are four levels of certification (Bronze, Silver, Gold and Platinum), although the Federal Environment Agency only considers the Gold and Platinum levels to be demanding and advises that the level of certification be observed. Bronze and Silver, on the other hand, merely indicate that a company has initiated a process towards greater sustainability.[56] Products at the Bronze level can be certified for a maximum of four years and must then improve in order to receive a higher rating.

Solarwatt is the first German module manufacturer to receive this certification (Silver)[vii]. Apart from Solarwatt, only two other photovoltaic manufacturers in the world have received this award – the Lithuanian company Solitek (Gold) and the Singapore-based manufacturer Maxeon (Silver, Bronze). All three companies produce silicon-based thick-film modules.

iii The Ultra Low Carbon Solar Alliance is an association of companies from the solar industry that aims to achieve production with low greenhouse gas emissions. Membership of the initiative is not subject to any conditions and no certifications are awarded.

iv The criteria of the "NSF Sustainability Leadership Standard for the Assessment of PV Modules and Inverters" and the EPEAT criteria for the assessment of solar modules with very low CO_2 emissions apply. The list of required minimum criteria and optional criteria for solar modules can be found on the EPEAT website via the product search (Global Electronics Council, 2024). If the minimum criteria are met, the Bronze certification is awarded. The criteria relate to different processing steps.

v In addition, Qcells manufactures solar modules in South Korea, Malaysia and China for which the EPEAT label has not been awarded.

vi For Bronze and Silver certification, one of the following social criteria must be met; two each are required for Gold and Platinum: 1) Audits or certifications are completed for at least 25 per cent of product material by weight, or 2) social issues relevant to the supply chain are comprehensively investigated and a strategy for positive impact is developed, or 3) the company actively implements an innovative social project that positively impacts the lives of employees, the local community, the global community, social aspects of the product's supply chain or recycling/reuse (Cradle to Cradle Products Innovation Institute, 2024).

vii However, Solarwatt's certification expired in June 2024 and has not yet been renewed (as of October 2024).

SA8000

SA8000 from Social Accountability International is a certification standard for social responsibility and is based on international labour standards such as the ILO conventions and the Universal Declaration of Human Rights and covers areas such as child labour, forced labour, health and safety and freedom of association[57]. The main criterion is the continuous improvement of companies. The standard is awarded for individual production sites and therefore does not cover the entire product supply chain. The ESMC positively emphasises the SA8000 as a good standard in the industry.

However, a report by the Worker-Driven Social Responsibility Network, an international association of human rights organisations and workers to combat inhumane working conditions, criticises the certification. These include inadequate monitoring, low wages, lack of employee involvement and conflicts of interest among auditors[58].

For solar module manufacturers, the standard is assigned to individual production sites for final production (processing step 7). Various solar module manufacturers have SA8000-certified production facilities – including Trina Solar, LONGi, DAS Solar and JA Solar[59].

ISO standards

Various solar module manufacturers use the standards ISO 14001 (environmental management systems), 50001 (energy management systems) and 45001 (occupational health and safety management systems) to express their sustainability efforts. However, these standards do not provide any meaningful points of reference, as they do not set absolute requirements for performance, but merely focus on continuous improvement.[60]

Global Compact Initiative

Some solar module manufacturers are members of the United Nations Global Compact Initiative. The prerequisite for this membership is a declaration of commitment in which the company commits itself to the ten principles of the Global Compact on human rights, labour, the environment and anti-corruption and undertakes to clearly express this to stakeholders and the general public and to submit an annual progress report.[61] However, the nature of the declaration of commitment does not go beyond a mere self-declaration, as no external audits by independent third parties are required. It therefore does not provide a meaningful basis for the verification of social and environmental standards. Furthermore, companies whose supply chains can be traced back at least in part to Xinjiang are members of the Global Compact Initiative – these include LONGi, JA Solar, Trina Solar and REC Solar.[62]

Responsible Business Alliance

The Responsible Business Alliance (RBA) is an industry initiative to which more than 250 companies worldwide belong. Members undertake to comply with the RBA Code of Conduct, which sets out standards for working conditions and safety.[63] Compliance with these is verified by independent audits as part of a *Validated Assessment Program*, which companies must complete in order to become full members. Certifications are valid for two years; regular reassessments and corrective measures in the event of non-compliance are required. However, various civil society actors criticise the RBA for failing to sufficiently ensure compliance with social standards by its members and to lead to an actual improvement in working conditions in the participating companies.[64]

As of October 2024, no manufacturer of silicon-based solar modules is a member of the RBA. The solar module manufacturer First Solar is part of the initiative, but it produces cadmium telluride thin-film solar modules.

Image: photoschmidt / iStock.com

MORE SUSTAINABILITY IN THE SOLAR INDUSTRY: STATUS QUO AND OUTLOOK FOR LEGAL REGULATIONS

It can be observed that social and ecological aspects, as well as transparency, are becoming increasingly important in the solar industry. This can be seen, for example, in the fact that industry initiatives such as the Ultra Low Carbon Solar Alliance or the Solar Stewardship Initiative have been founded in recent years to pursue the goals of low-emission production and improved traceability of solar supply chains.

This trend is also based on legal amendments: The UFLPA, which was passed in the US in 2021, prevents the importation of many goods related to forced labour in and associated with Xinjiang into the US. At German federal level, the LkSG, which came into force in 2023, also has a positive impact on supply chains in general – however, German solar module manufacturers are hardly affected by this, as they are not covered by the law if they have fewer than 1,000 employees.[i]

The EU supply chain law – the Corporate Sustainability Due Diligence Directive (CSDDD) – will also apply to companies based in and outside the EU from 2029.[ii] Although many European solar module manufacturers will not fall under this law, the world's largest manufacturers, particularly those based in China, are likely to be affected as they generate relevant sales in the EU. These include LONGi, for example.[65] The EU's Corporate Sustainability Reporting Directive (CSRD) will also oblige many smaller solar companies that have not yet published sustainability reports to do so in the coming years.[66]

i unless they supply other companies based in Germany with more than 1000 employees, who in turn pass on their due diligence obligations to their suppliers. Other companies in the solar supply chains that have more than 1000 employees are also affected by the reporting obligations of the LkSG, e.g. Wacker Chemie AG.

ii Companies based in the EU with at least 1000 employees worldwide and a net turnover of at least 450 million euros must therefore comply with social and environmental due diligence obligations. Companies based in third countries are also affected if they have a net turnover of at least 450 million euros within the EU (European Parliament and Council of the European Union, 2024).

Image: humphery / Shutterstock.com

In particular, the Forced Labour Regulation, which is currently being worked on at EU level[i] and is expected to apply from 2027, is intended to ensure that products with evidence of forced labour in their supply chains may not be imported into the EU. According to the ESMC, this could mean a restructuring of the solar industry, as products from regions or sectors where there is reliable evidence of forced labour will be subject to special scrutiny and a publicly accessible database will be set up to collect information on high-risk products such as metallurgical silicon and polysilicon from Xinjiang[ii], which will speed up the process of banning these products.[67]

In response to or in anticipation of such regulations, many Chinese companies are relocating at least part of their production and establishing two-tier supply chains (see „Diversifizierung des Bezugs von Solarmodulen und Vorprodukten“, S. 7). As the domestic market for solar modules in China itself is considered saturated, the numerous solar module manufacturers now have to adapt in order to continue selling their products on other markets.

i The European Parliament adopted the regulation in spring 2024 and the Council of the European Union plans to decide on it in the autumn of 2024.

ii While companies are only bound by the regulation 36 months after it comes into force, the database is expected to be published after 18 months so that it can serve as a reference point.

The public order office of the Friedrichshain-Kreuzberg district between Bersarinplatz and Frankfurter Tor covers more than a third of its own electricity consumption with its 220 solar modules.

Image: Mathias Völzke / Berliner Stadtwerke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CONCLUSION: TAKING MEASURES TO ASSUME RESPONSIBILITY

Although risks such as the use of forced labour are to be reduced by legal requirements in the coming years, it can be assumed that these can still only cover parts of the supply chain and that the responsible authorities will not always be able to adequately check and ensure compliance with the legal requirements. It will therefore continue to be necessary to make informed decisions based on social and ecological criteria when purchasing solar modules in the future. This brochure has outlined some tips for this.

To avoid risks today, buyers can use the following approaches as a guide:

- **Standards and certifications:** There are several standards that are used in the solar industry. Due to their limitations, however, they should be considered carefully.
- **Xinjiang-free supply chains:** No products should be purchased that are associated with forced labour in or from Xinjiang.
- ***Beyond auditing approaches*:** The provision of complaint management, training and awareness-raising measures in supply chain operations by independent third parties can be an additional approach to reducing risks.
- **Company surveys and transparency:** Interaction with companies, e.g. by means of questionnaires, can help to obtain information on human rights and environmental standards and to assess the company with regard to its efforts.
- **Ecological aspects:** Observing ecological criteria, such as the longevity and recyclability of the modules and, specifically, low CO_2 emissions along the entire supply chain, can also help to reduce risk.

Solar energy is making a decisive contribution to the decarbonisation of our energy production. Solar modules are therefore one of the technologies that we will be using more and more in the future. It is therefore of great importance that the solar industry fulfils its human rights and environmental responsibilities. Many players in this industry are already aware of the various problems. It is now crucial to take appropriate measures. To this end, the existing approaches should also be taken into account in procurement and purchasing processes – this is the only way we can ensure a socially just and sustainable energy transition.

Image: Sven Bock / Berliner Stadtwerke

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Since 2021, the elementary school at Brandburger Tor in the Mitte district has had a solar system that can generate around 86,000 kWh of electricity per year.

Image: Stephan Natz / Berliner Stadtwerke

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