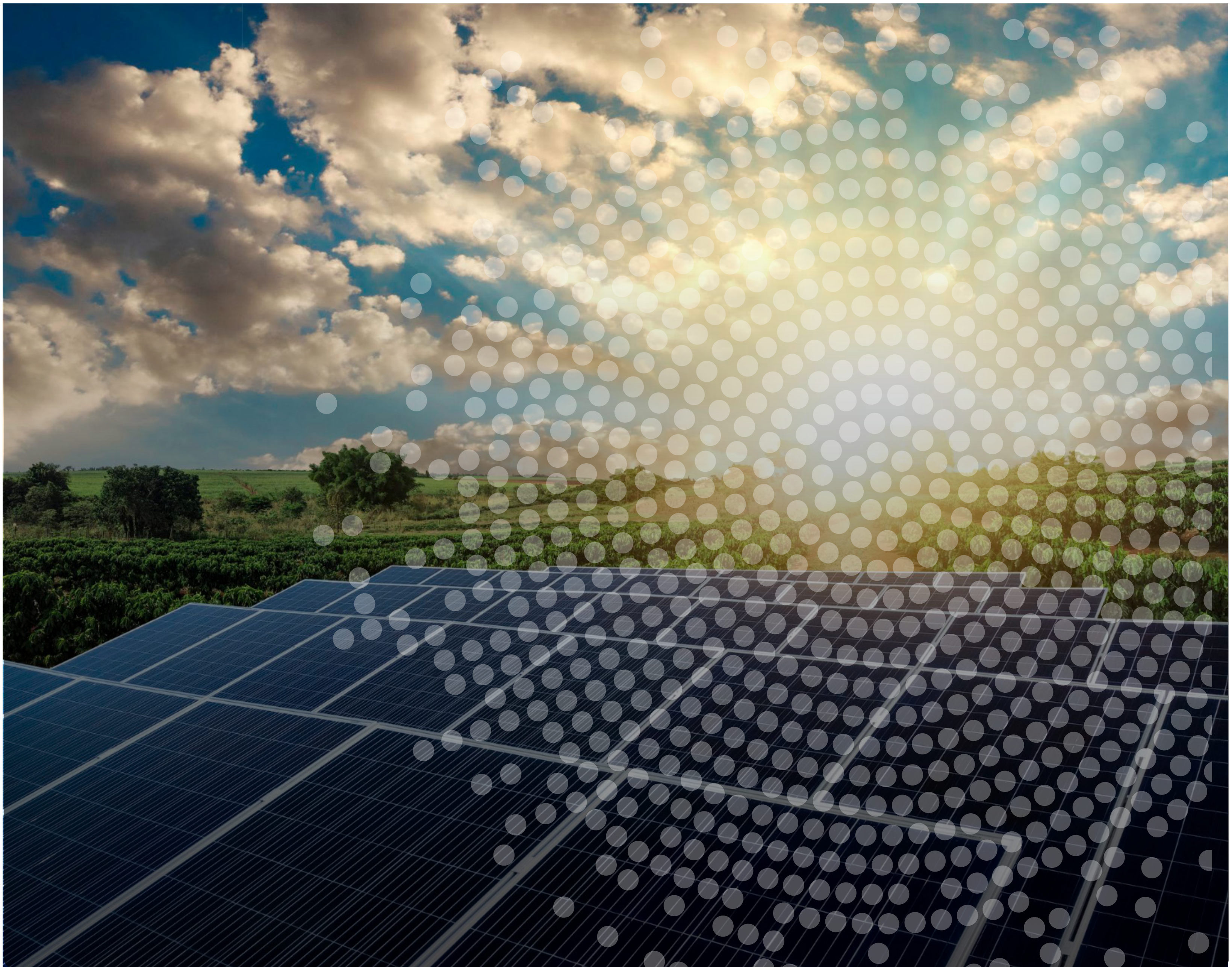

PV SUPPLY CHAIN RESILIENCE & SUSTAINABILITY

India-EU Cooperation

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Supported by: EU-India Clean Energy & Climate Partnership and PwC India

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Executive Summary

To accelerate the worldwide shift towards achieving net zero emissions, it is imperative to accelerate solar deployment. Resilient, diverse, and sustainable supply chains play a crucial role in enabling this transition. The solar photovoltaic (PV) sector is vulnerable to potential disruptions due to its heavy reliance on a single-country supplier, posing various supply chain risks.

Diversifying the supply chain is essential to support the swift deployment and expansion of solar PV, mitigate the risks of material shortages and insufficient manufacturing capacity, as well as, to meet demand and reach net zero targets. As such, India and the European Union (EU) have launched strategies and policies to support their respective domestic manufacturing capacities.

India faces several obstacles when it comes to diversifying its supply chains, including the need for affordable technology for mining critical minerals and processing raw materials, acquiring manufacturing equipment, particularly for ingot/wafer and polysilicon production, and expanding ancillary manufacturing. On the European front, significant challenges include an ongoing manufacturing crisis, high operational costs, difficulties in expanding manufacturing capacities, particularly in the ingot/wafer segment, and the industrialisation of innovations.

Establishing competitive domestic manufacturing capabilities comes with its set of challenges. Therefore, building strategic partnerships is critical to complement and strengthen clean energy industrial policies, and contributing to the diversification of global supply chains.

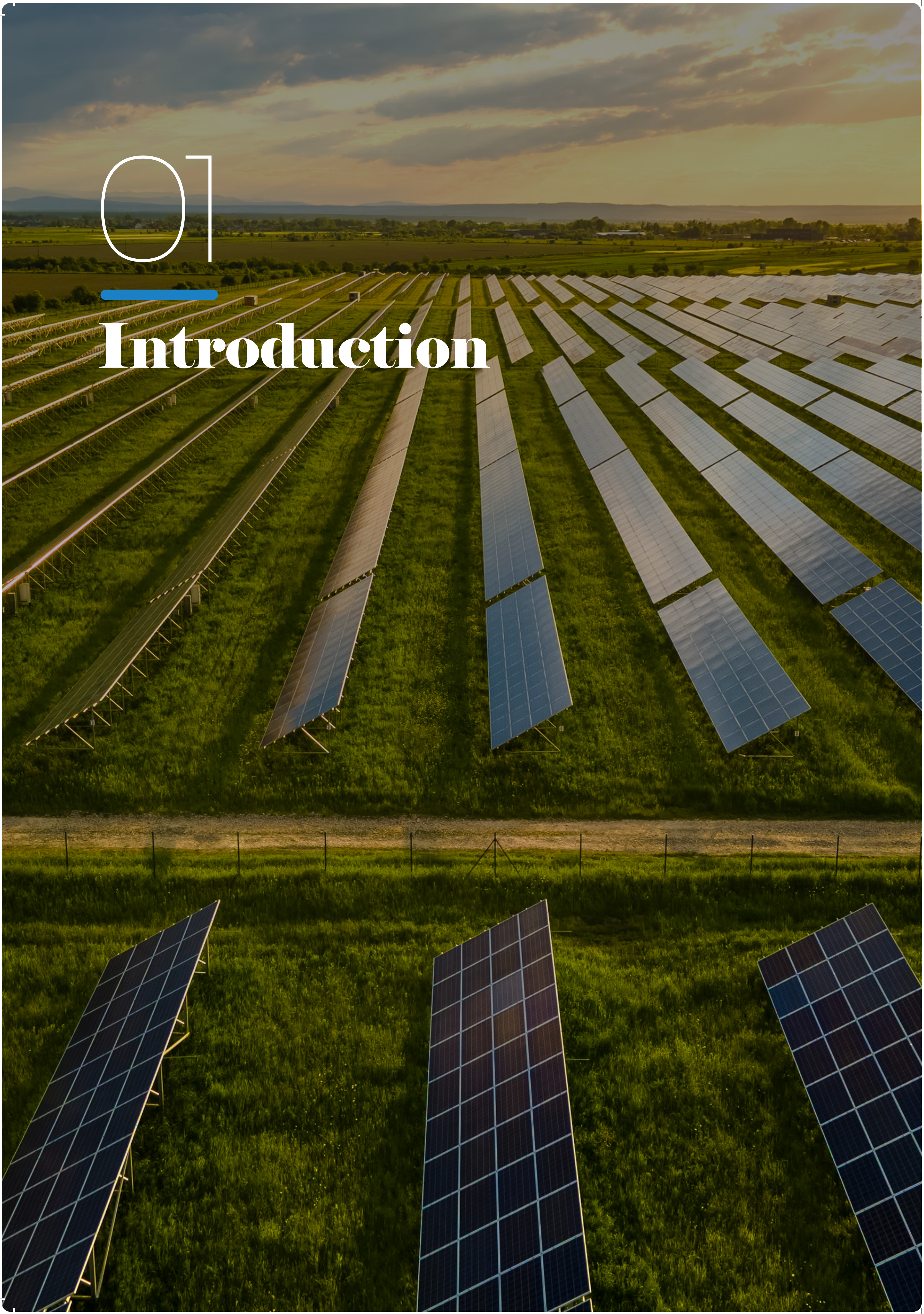
Cooperation between India and the EU in the solar PV sector holds significant promise in various areas, including in the ingot/wafer segment, research and innovation, access to finance, and supply chain transparency. The ingot/wafer segment is challenging for both India and Europe for the manufacturing of equipment and components, thus representing a weak link in the supply chain.

Diversifying the supply chain is essential to support the swift deployment and expansion of solar PV, mitigate the risks of material shortages and insufficient manufacturing capacity, as well as, to meet demand and reach net zero targets.

The Global Gateway should be used to support joint ventures and strategic projects with India in this segment. Critical raw materials, especially silicon sourcing and refining, need diversification through strategic partnerships with countries such as South Africa and Australia, with mining and refining expertise.

Research and development cooperation is crucial for advancing manufacturing capacities and efficient technologies. Leveraging the Horizon Europe programme and bilateral agreements can promote research collaboration in strategic segment of the PV sector. In the context of sustainability, India and the EU should focus on quality assurance, certification processes, and ESG compliance to meet global standards.

Contents



01

Introduction

About the project

This project was launched in the framework and with the support of the EU-India Clean Energy and Climate Partnership through the collaboration between SolarPower Europe and National Solar Energy Federation of India (NSEFI).

This initiative aims to address the critical issue of resilient photovoltaic (PV) supply chains in both the European Union (EU) and India.

The Ministry of New and Renewable Energy of India and the European Union Delegation to India, the International Solar Association (ISA) and PwC also contributed to this project.

The primary objective of this project is to provide an in-depth analysis of the solar supply chain, with a particular emphasis on the silicon cell supply chain encompassing the journey from polysilicon production to module assembly. In addition to this core focus, the analysis encompasses critical information about other key materials and components integral to the solar PV industry, such as solar glass, inverters, and more. This study sheds light on the strengths and opportunities as well as the gaps and weaknesses within the solar PV supply chain in both India and the EU.

Furthermore, this study provides an overview of the global solar value chain before delving into the specifics of the European and Indian solar supply chains. By doing so, it identifies opportunities for synergy and mutual reinforcement between these two vital regions, fostering cooperation in manufacturing and research ecosystems.

To construct this study, a robust methodology was employed, drawing upon the expertise of SolarPower Europe and NSEFI, complemented by valuable insights garnered from member interviews and workshops.

The deliverables of this project encompass this comprehensive study and the formation of the India-EU Task Force, a dynamic working group consisting of members from SolarPower Europe and NSEFI. This collaborative task force benefits from the active participation of the Ministry of New and Renewable Energy of India and the European Union Delegation to India.

The primary objective of this project is to provide an in-depth analysis of the solar supply chain, with a particular emphasis on the silicon cell supply chain encompassing the journey from polysilicon production to module assembly.

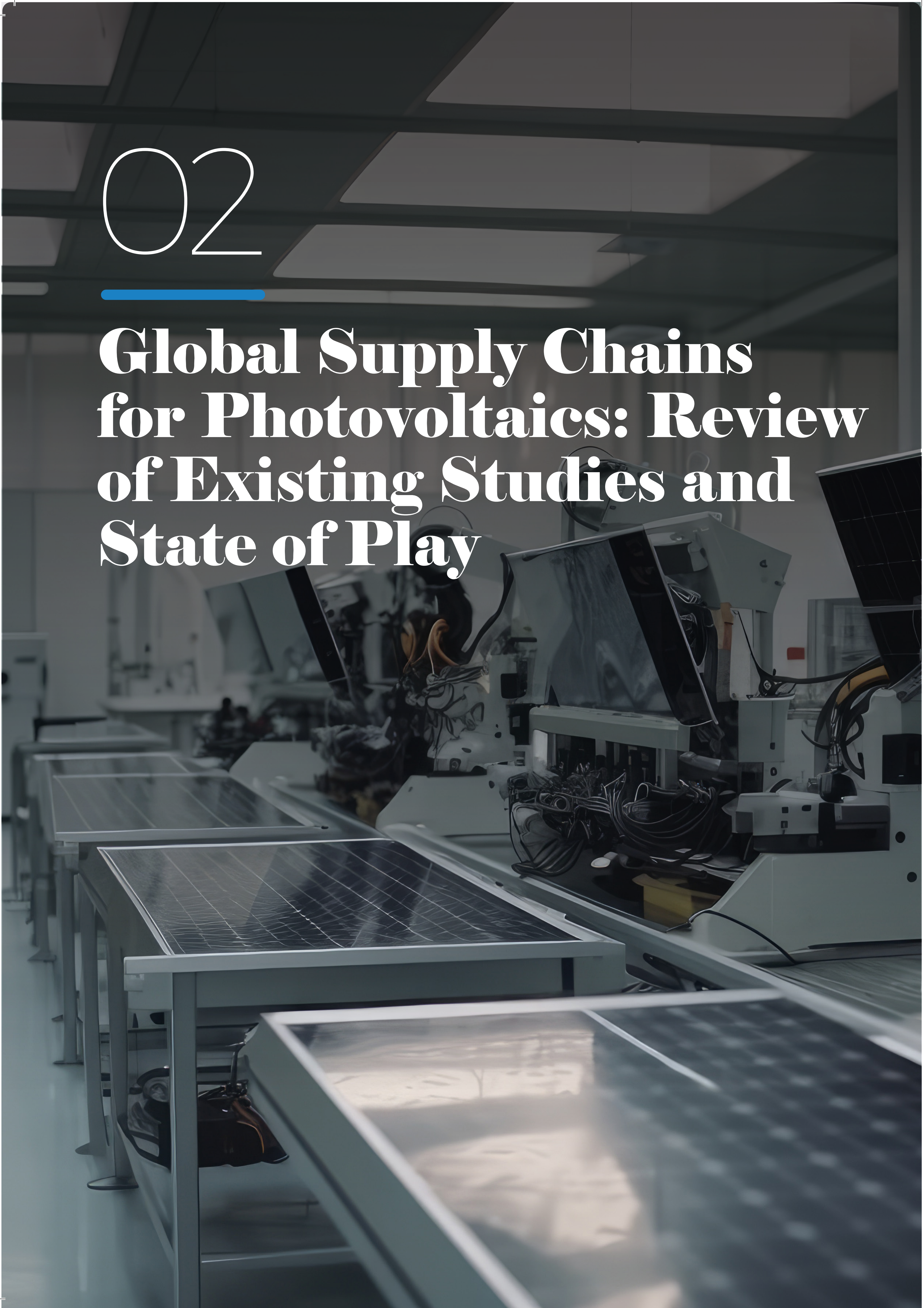
The India-EU Task Force was officially launched on May 16, 2023, during a video conference, where discussions revolved around the unique challenges faced by both the EU and India concerning PV supply chains and the manufacturing and sourcing of solar PV. Preliminary feedback was gathered to inform the preliminary draft of this study.

Subsequently, the second meeting held on September 23, 2023, served as a platform to delve into the preliminary findings of the study and to gather additional feedback, further enhancing the depth and accuracy of the final report.

It is important to note that the findings, conclusions, and recommendations presented in this study are a reflection of the authors' best knowledge at the time of publication and do not necessarily represent the official positions of SolarPower Europe, NSEFI, or their respective members.

02

Global Supply Chains for Photovoltaics: Review of Existing Studies and State of Play



Importance of supply chain diversification

In order to expedite the global transition to net zero emissions, it is imperative to accelerate solar deployment. Resilient, diverse, and sustainable supply chains are pivotal for facilitating this transition. However, the solar PV sector faces susceptibility to disruptions due to its heavy reliance on one single country supplier, i.e. the People's Republic of China, posing various risks. These risks encompass single-point incidents like natural disasters, pandemics, technical issues, as well as shifts in diplomatic relations or policies. Global supply diversification is a vital strategy for mitigating potential vulnerabilities, strengthening supply chain resilience and thus expediting solar PV growth and meeting ambitious net zero objectives.

The state of global PV manufacturing

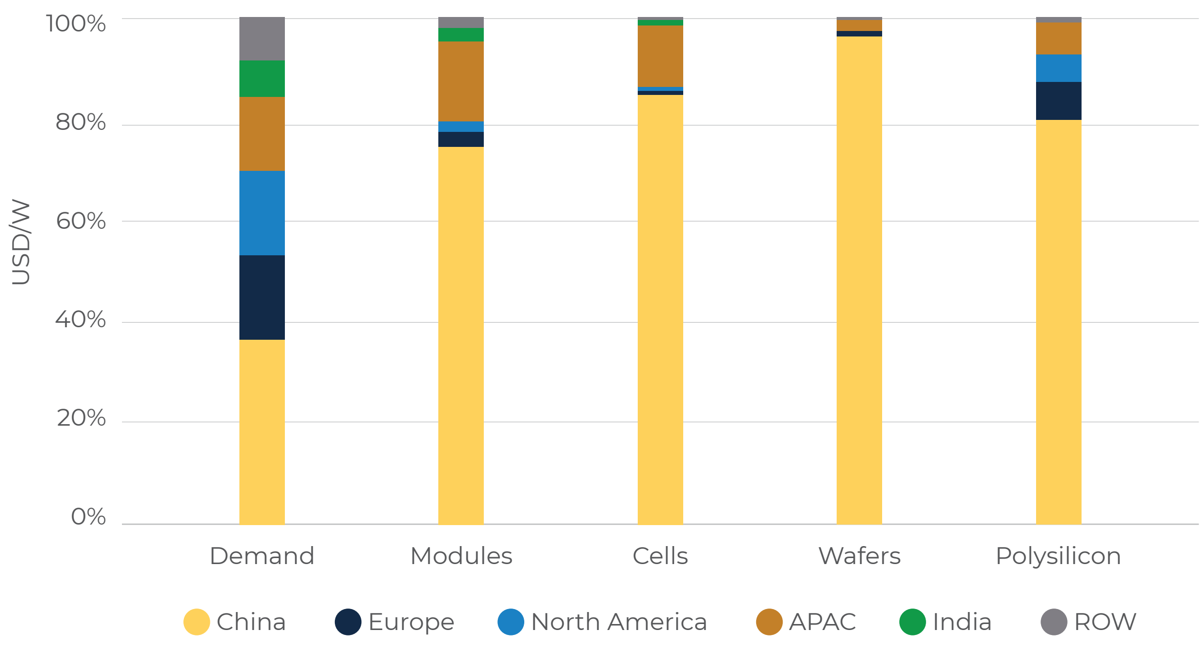
In 2022, global PV manufacturing capacities amounted to around 640 GW, representing a growth of nearly 40% compared to 2021, with 90% of this increase occurring in China.[1] Manufacturing throughout 2022 was around 260 GW, representing a global average utilisation rate of around 40%. According to the IEA, global PV manufacturing capacities are expected to reach almost 1 TW in 2024, which corresponds to global solar market demand in 2030, according to SolarPower Europe market intelligence. While China will continue to dominate the solar market in the short-term, new PV manufacturing project announcements indicate future progress in supply chain diversification.[2]

Solar PV supply chains are highly concentrated in China, which dominates every segment and represents over 80% share in all manufacturing stages.[3] In more details, in 2021, China accounted for 80% of global manufacturing capacity for polysilicon, with Germany, Malaysia and the United States accounting for the remaining market share. Wafers production is heavily concentrated in China, with 97% of market share and the remaining capacity is produced in the Asia-Pacific region. Regarding cells, China accounts for 80% of manufacturing capacity, Southeast Asia and Korea account for 18% and the rest of the world for 2%. For module manufacturing, China accounts for 70% of the production, the rest of the market share include Vietnam (5%), Malaysia (4%), Korea (4%), the USA (4%), Thailand (2%) and Germany (1%). As a result, in all countries, except China, demand largely exceeds manufacturing capacity.

Clean energy transitions also require substantial material inputs. Solar PV necessitate critical materials (silicon, copper), and bulk materials (steel, glass, aluminium, cement, plastic). The production of critical minerals is also highly concentrated geographically, raising concerns about security of supplies. China supplies 60% of rare earth elements and refines 90% of them. China also dominates bulk material supply, accounting for around half of global crude steel, cement and aluminium output, most of it for domestic use. Copper is the most diversified critical mineral, with Chile, Peru and China accounting for less than half of global supplies. Proven reserves for most critical minerals are more geographically widespread than current production. Thus, there is considerable scope for diversification and reducing reliance on a handful of major producers.

[1] IEA (2023), The State of Clean Technology Manufacturing, An Energy Technology Perspectives, Special Briefing, IEA, Paris.
[2] IEA (2023), Renewable Energy Market Update, Outlook for 2023 and 2024, IEA, Paris.
[3] IEA, "Solar PV manufacturing capacity by country and region, 2021," July 2022, https://www.iea.org/data-and-statistics/charts/solar-pv-manufacturing-capacity-by-country-and-region-2021.

Figure 1: Solar PV manufacturing capacity by country and region, compared to demand for solar components (left), 2021 [4]



IEA analytics based on BNEF (2022a), IEA PVPS, SPV Market Research, RTS Corporation and PV InfoLink.

Supply chains concentration and diversification benefits

As a result of this over-concentration in China, solar PV supply chains are susceptible to disruptions. High levels of concentration in a single geographic area, individual facilities and companies, make PV supply chains highly vulnerable to single incidents, including natural disasters, conflicts, pandemics, technical failures, a single company's decision and policy choices. Indeed, around 42% of the global PV manufacturing capacity is concentrated in the Chinese Xinjiang province.[5] These risks have occurred in the past, leading to higher prices and could potentially slow the pace of solar deployment. For instance, in 2020, floods led to the closure of four polysilicon plants, resulting in an estimated 4% decline in annual production and contributing to price increase in 2020-2021. Concentration of production in a single country also exposes supply chains to risks of diplomatic and geopolitical tensions, changes in domestic policies and trade restrictions.[6] As illustrated by China's recent export restriction on critical raw materials, including graphite, gallium and germanium, essential materials to produce batteries for electric vehicles and semiconductors.[7] Market concentration, that is to say the concentration of solar manufacturing capacity in a single or handful of companies exposes the supply chains to risks of collusion, price fixing and dumping. The wafer segment is the most company-concentrated with over 75% of global manufacturing capacity concentrated in the top five companies.

[4] APAC = Asia-Pacific excluding China and India
[5] IEA (2022), Special Report on Solar PV Global Supply Chains, IEA, Paris.
[6] Joint Research Centre (2023), Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study, Publications Office of the European Union, Luxembourg.
[7] Euronews, "Red alert for the EV market: China puts curb on graphite export", 20 October 2023. https://www.euronews.com/2023/10/20/red-alert-for-the-ev-market-china-puts-curb-on-graphite-export

> **The expansion of domestic manufacturing production is beneficial for job creation and innovation. According to the IEA, the solar industry has the potential to create 1300 manufacturing jobs per gigawatt of production capacity.**

Supply chain diversification can provide for the decarbonisation of the PV manufacturing process, enhanced transparency and accountability for environmental and social issues.[8] Solar PV manufacturing is energy-intensive, especially polysilicon production, which accounts for 40% of all energy consumption in PV manufacturing. While 80% of energy needs for the whole manufacturing process are supplied by electricity, coal generates 62% of this electricity. This is the result of manufacturing concentration in China, where coal represents a high share of the energy production, leading to high GHG emissions.[9] Thus, acquiring PV materials from a country with a higher share of electricity generated from renewables has the potential to reduce the carbon footprint of the sector. Module production in the EU or Germany amounts to about 41% and 28% less CO_2 emissions respectively, compared to China.[10]

Additionally, local manufacturing capacities reduce transport emissions. Having said that, even solar PV modules manufactured using coal electricity have a very low carbon footprint as compared to other conventional power generation technologies.

The expansion of domestic manufacturing production is beneficial for job creation and innovation. According to the IEA, the solar industry has the potential to create 1300 manufacturing jobs per gigawatt of production capacity.[11] These jobs are very diverse, ranging from assemblers to engineers. Diversifying supply chains has the potential to foster competition and innovation. Indeed, innovation is crucial to enhance the efficiency of PV modules, reduce costs and diminish dependency on raw materials by making components less material-intensive and easier to recycle.

Given the many benefits of supply chain diversification and the risks associated with over concentration, India and the United States have been deploying incentives to support domestic PV production, through the Production Linked Incentive (PLI) scheme and the Inflation Reduction Act (IRA). According to the IEA, these policies will increase production capacities outside of China and slightly reduce the country's share of manufacturing capacity, from 80-95% to 75-90% depending on the segment.[12] The EU has proposed the Net-Zero Industry Act (NZIA) to increase manufacturing capacity for net-zero technologies, including solar PV. This has been complemented by Germany with a more ambitious EUR 4.1 billion of subsidies to develop local raw materials and solar component manufacturing in 2024.[13]

Overall, supply chain diversification will support the faster deployment and growth of solar PV, avoid risks of material unavailability and insufficient manufacturing capacity to meet demands and reach net zero targets. However, diversification is not without challenges.

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[8] Energy Transitions Commission (2023), Better, Faster, Cleaner: Securing clean energy technology supply chains.
[9] IEA (2022), Special Report on Solar PV Global Supply Chains, IEA, Paris.
[10] Fraunhofer Institute for Solar Energy Systems ISE, "CO_2 Emissions of Silicon Photovoltaic Modules – Impact of module design and production location", 8th World Conference on Photovoltaic Energy Conversion, 26-30 September 2022, Milan Italy.
[11] IEA (2022), Special Report on Solar PV Global Supply Chains, IEA, Paris.
[12] IEA (2022), Renewables 2022, IEA, Paris.
[13] Reuters (2023), "German cabinet approves 58 bln euro green investment plan for 2024". https://www.reuters.com/world/europe/german-cabinet-approves-58-bln-eur-green-investments-plan-2024-2023-08-09/

Key challenges

High investment costs, especially for polysilicon and wafer production, hamper the development of manufacturing capacities outside of China. According to BloombergNEF, polysilicon manufacturing CAPEX requirements are more than three times higher per megawatt in the US and the EU than in China.[14] This difference can be explained by a favourable investment environment in China, with effective support measures and subsidies, complemented by economies of scale and technical expertise. According to the IEA, one-third of manufacturing capacity is at medium or high risk of bankruptcy in the PV sector.[15] The low profitability of the sector can deter investments. High capital requirements increase project risks and reduce their bankability. Integrated PV companies are more economically viable than single segment ones, as they are able to compensate for losses in one segment with profits from another.

High OPEX costs outside of China are another challenge to supply chains diversification. Indeed, China's manufacturing is cost-competitive due to low energy and labour costs. Access to affordable electricity is crucial to develop manufacturing capacities. Energy costs are two times higher in Europe than in China and three times higher than in the USA.[16] In the USA, labour costs represent a considerable part of the final panel price (22%) compared to China (8%), as shown in Figure 7[17]. Without substantial subsidies and dedicated manufacturing support, achieving a reduction in manufacturing costs and ensuring the cost-competitiveness of the sector is challenging.[18] Overall, reaching economies of scale outside of China will be key for new manufacturing production to compete globally.

While expanding domestic manufacturing capacities has a great potential for job creation, efforts will have to be deployed to adequately train workers. Indeed, today, most solar PV skills are concentrated in China and specialisation is limited elsewhere.[19] Providing this new workforce with adequate skills will require crucial additional investments.

Building new mines to extract materials is a lengthy process. Lead times from discovery to the beginning of production takes on average 15.7 years, with variations by mineral, location and mine type.[20] Lead times are long due to risks linked to exploration and capital appraisals, complex engineering and construction, and the necessity to build other infrastructures (roads, power plants, etc). Additionally, long lead time threaten levels of investment, cooperation and coordination of other supply chain segments, increase investment risks and therefore the cost of capital, and imply greater exposure to regulatory, political and market changes.[21]

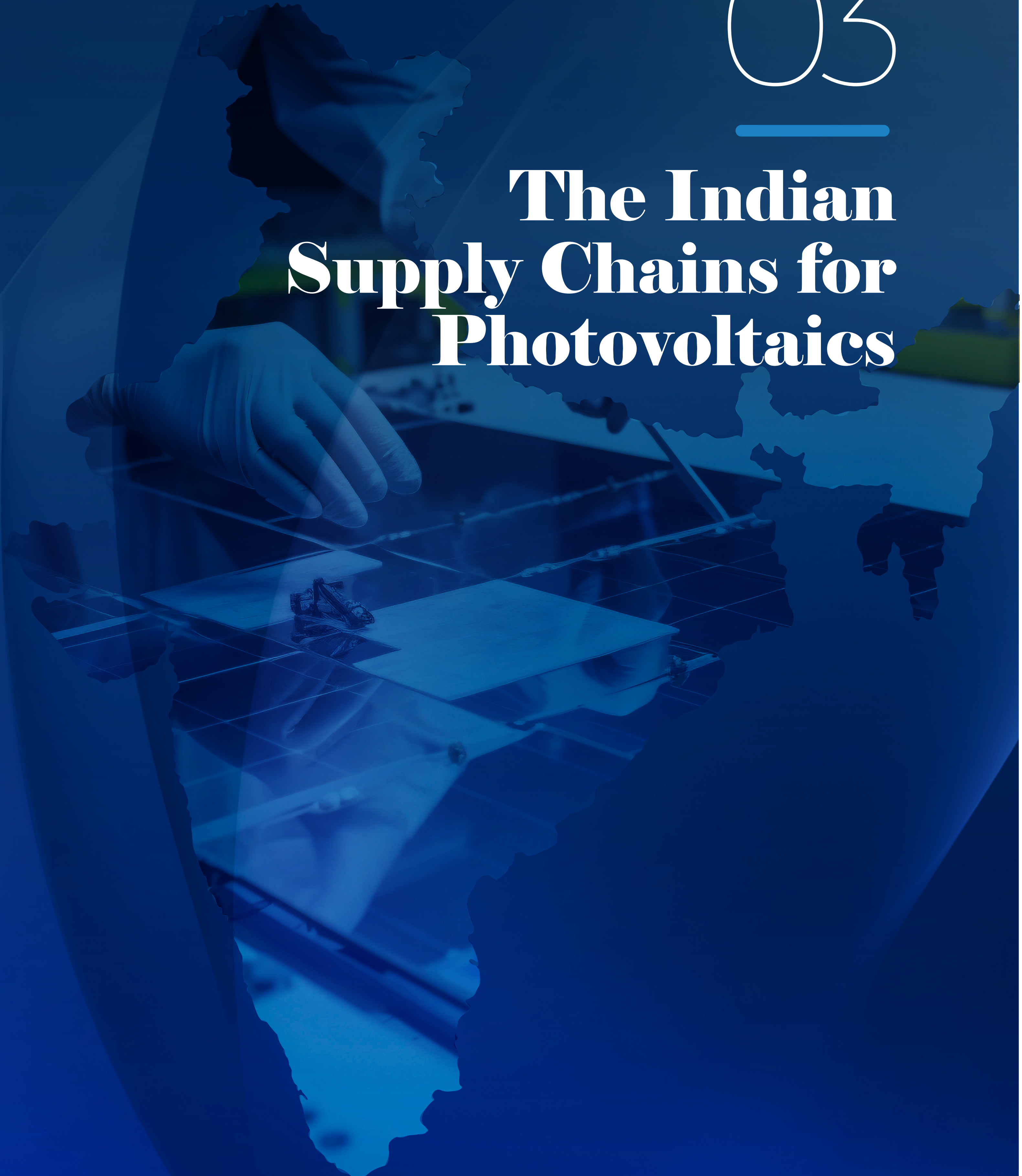
While manufacturing lead times vary depending on segments and location, it takes less time than opening a new mine. Commissioning manufacturing facilities for PV components can take up to five years. For instance, construction of a polysilicon factory takes 12 to 42 months. Building new wafers, cells and modules facilities can take as little as 4 to 24 months. Building new production lines to an existing manufacturing facility is a faster process.

Finally, while Europe, India and the USA have announced plans to increase domestic manufacturing, so has China. The IEA expects China to be able to deploy new capacity quicker than other countries, which would saturate the market and result in low plant utilisation factors. Such supply gut could exacerbate price competition and force investors to cancel announced projects in China and elsewhere. To ensure supply chain diversification, these challenges need to be addressed. If left unresolved, they risk increasing the costs of PV components and delay the pace and scale of solar deployment, putting net zero targets at risk. Supply chain diversification is crucial to avoid disruptions and spread the benefits of the energy transition.

[14] BloombergNEF, (2022), Localizing Clean Energy Value Chains Will Come at a Cost, https://about.bnef.com/blog/localizing-clean-energy-value-chains-will-come-at-a-cost/.
[15] IEA (2022), Special Report on Solar PV Global Supply Chains, IEA, Paris.
[16] IEA (2022), Special Report on Solar PV Global Supply Chains, IEA, Paris.
[17] U.S. Department of Energy (2022), Solar Photovoltaics Supply Chain Deep Dive Assessment.
[18] Becquerel Institute, International Solar Alliance (2023), Building Resilient Global Solar PV Supply Chains.
[19] IEA (2022), Securing Clean Energy Technology Supply Chains, IEA, Paris.
[20] S&P Global, "Discovery to production averages 15.7 years for 127 mines", 6 June 2023, https://www.spglobal.com/marketintelligence/en/news-insights/research/discovery-to-production-averages-15-7-years-for-127-mines
[21] IEA (2023), Energy Technology Perspectives 2023, IEA, Paris.

03

The Indian Supply Chains for Photovoltaics



State of Play

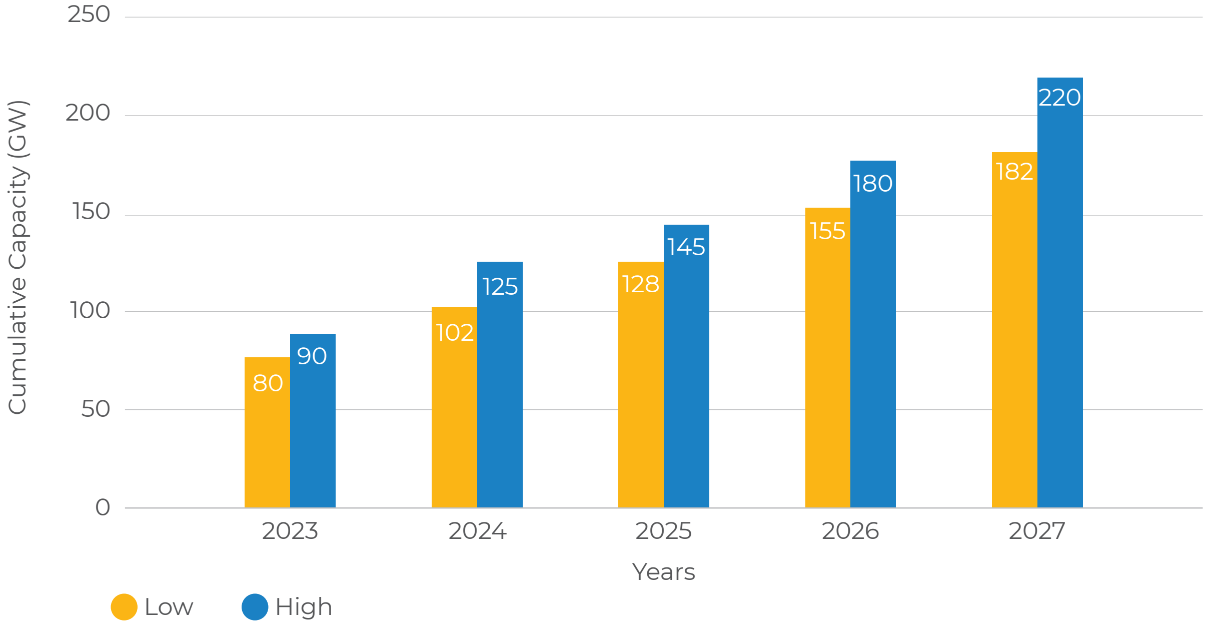
India's PV manufacturing: current scenario and Announcements

In 2010, India launched its National Solar Mission, with an initial target of 20 GW by 2022 which was revised in 2015 to 100 GW by 2022. The country's 2030 targets include 500 GW of RE installations out of which around 280-300 GW will be contributed from solar installations. India's solar installations increased by 17 times from 3 GW in 2012 and today India boasts a capacity of 71.3 GW and is home to the world's 5th largest fleet of solar installations (July 2023).

In April 2023, the Indian Government announced a roadmap to achieve its 2030 solar targets where around 50 GW of solar auctions will be held every year from 2023 till 2028. A quarter-based auction target for FY 23-24 was also released by the Ministry in May 2023. National Solar Energy Federation of India predicts that India will add around 20 GW annually from 2023 and accelerate it to around 30 GW annually by 2025 and crossing 100 GW cumulative installations by mid-2024.

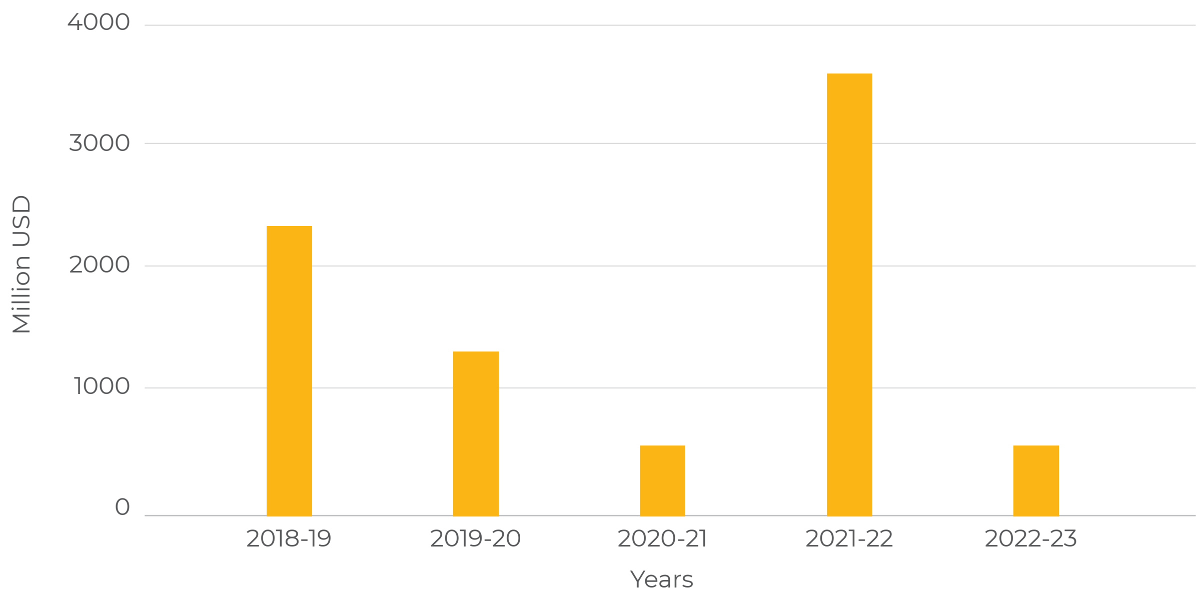
India's domestic manufacturing base for solar PV modules and cells grew steadily in the period between 2008-2011 where India emerged as one of the largest export hubs for solar PV modules in the world, predominantly exporting to the European and American markets. However, in the period of 2011-2021, India's focus shifted on increasing the pace of installations and domestic manufacturing capacity grew at a nominal pace.

Figure 2: India's projected cumulative solar PV capacity (2023-2027)



[22] MNRE Physical Progress (www.mnre.gov.in)

Figure 3: India's Solar Import Value (2018-19 to 2022-23)[23]



On the other hand, India's solar PV module imports soared gradually and in the year 2019-20, India's imports contributed to over 90% of country's solar installation capacity. In 2020, due to the onset of COVID, global supply chains witnessed an unprecedented stress and solar supply chains were one of the largest affected sectors. The Indian Government, realising the necessity to diversify supply chains and make India Self-reliant (Atmanirbhar) announced dedicated schemes along with incentives to promote high efficiency solar manufacturing in India. Since 2021, India's Domestic manufacturing capabilities are increasing manifold and India is expected to emerge as the largest solar manufacturing hub outside China by the end of 2026.

Current and Future Trends in Manufacturing

Indian solar manufacturing grew from a pre-dominantly module-based manufacturing to now a vertically integrated manufacturing ecosystem. As of 2022, India's solar module manufacturing capacity stood at 18 GW with around 4 GW of cell manufacturing. In 2023, India is set to cross 30 GW in module manufacturing capacity while doubling its cell manufacturing to 8 GW.

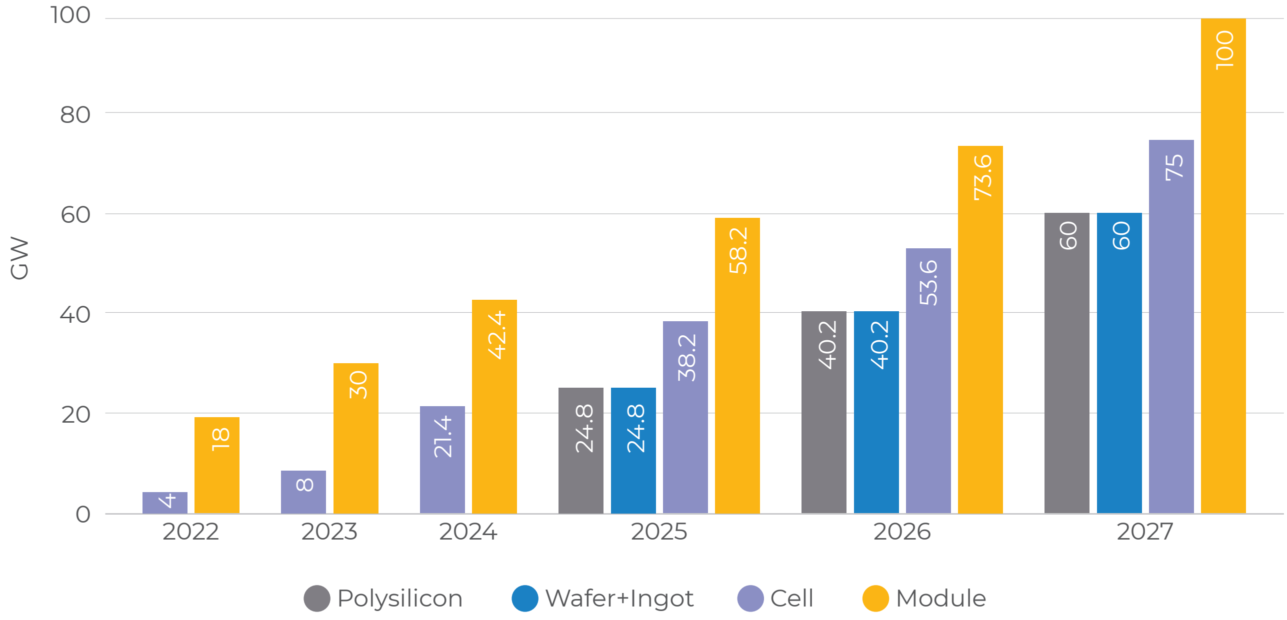
Modules: India currently has the largest solar module manufacturing outside of China. The near mid-term prospects of the industry showcase strong projections with several manufacturers announcing expansion plans. By 2027 the expected capacity of module manufacturing is set to reach 100 GW which would help India to attain the point of self-sufficiency. At the moment 23 companies have proposed to set up GW-scale new module manufacturing capacities.

Cells: As of 2022, the cumulative cell manufacturing capacity was about 4 GW, which increased to about 6.6 GW by March 2023. The expected capacity for cumulative cell manufacturing as of 2024 is estimated to be around 21.4 GW which will reach 75 GW by 2027.

Ingots/wafers: Currently the cumulative wafer manufacturing capacity is concentrated in some countries. India is set to start producing ingots by 2025 and the expected cumulative capacity for ingots/wafers capacity is to stand around 24.8 GW which would subsequently increase to 60 GW by 2027 due to the incentives provided to manufacturing stakeholders under PLI Tranche I and II.

[23] MNRE and Ministry of Commerce, Government of India

Figure 4: India's solar manufacturing base (2023-2027)



Polysilicon: The cumulative capacity for manufacturing of polysilicon in India is going to observe rapid growth with upcoming capacity in 2025 to stand around 24.8 GW which will further see an increase of 35.2 GW and reach 60 GW by 2027.

Challenges

Critical Minerals: While India is accelerating its pace in ensuring the vertical integration of the entire solar PV manufacturing value chain, there is a lack of access to affordable technology for mining Critical Minerals and processing raw materials.[24] While a few Indian companies are able to establish strategic partnerships via Joint ventures with international companies, it is imperative to have a national strategy on developing indigenous technologies that can streamline the processing of raw material.

Manufacturing Equipment: As India looks to accelerate its manufacturing capacity, there is also an immediate requirement of procuring manufacturing equipment, especially for ingot/wafer and polysilicon. India heavily relies on its imports for such equipment where there is an allied duty associated with such imports.

Ancillary (BOM) Manufacturing: India is heavily import-dependent for Ancillaries (Bill of Materials for solar manufacturing) including encapsulant, glass, backsheet/EVA and other allied materials. There is a requirement of creating a resilient and reliable domestic industry to increase production capabilities locally. India is also dependent on inverter imports.

India heavily relies on its imports for such equipment where there is an allied duty associated with such imports.

[24] India possesses resources of Bauxite, Lead, Limestone, Manganese and Zinc. In June 2023, the Ministry of Mines identified a list of 30 Critical Minerals. Ministry of Mines (2023), Critical Minerals for India, Report of the Committee on Identification of Critical Minerals.

Policy landscape and recommendations

Schemes and Incentives

Over the last 5 years, the Indian Government implemented various schemes and initiatives to promote domestic manufacturing while ensuring the import dependency is reduced. Some of the key recent initiatives are:

Basic Customs Duty (BCD): With effect from 1st April 2022, the Indian government has imposed a Basic Customs Duty on import of solar PV cells at 25% and 40% on the import of solar PV modules to reduce the influx of imported PV cells and modules and increase the domestic manufacturing.[25]

Approved List of Models and Manufacturers (ALMM): With the objective of ensuring reliability of solar PV manufacturers and to protect the consumer interests and ensure larger energy security in India, the Ministry of New & Renewable Energy (MNRE), in January 2019, issued Approved Models and Manufacturers of Solar Photovoltaic Modules (Requirements for Compulsory Registration). The order provides for the enlistment of eligible models and manufacturers of solar PV cells and modules complying with the Bureau of Indian Standards and publishes the same in a list called the "Approved List of Models and Manufacturers" (ALMM).[26] The list of manufacturers was recently updated in 2023, with an enlisted capacity of 22 389 MW and more than 70 manufacturers. The module models enlisted on the list are only eligible for use in open access and net metering projects along with government projects, government-assisted projects, and projects under various government schemes and programmes. ALMM acts as a trade barrier that protects the interests of domestic manufacturers since even after applying Basic Customs Duty on imported modules, the current cost differential between a domestic

[25] Ember, India Manufacturing Data Analysis
[26] MNRE

and imported module is negligible. However, the Indian government deferred the implementation of ALMM by 2024 due to the limited availability of high-wattage modules which consequently will lead to a substantial delay in the commissioning of the timeline of multiple solar projects, especially in the utility-scale Solar installations.

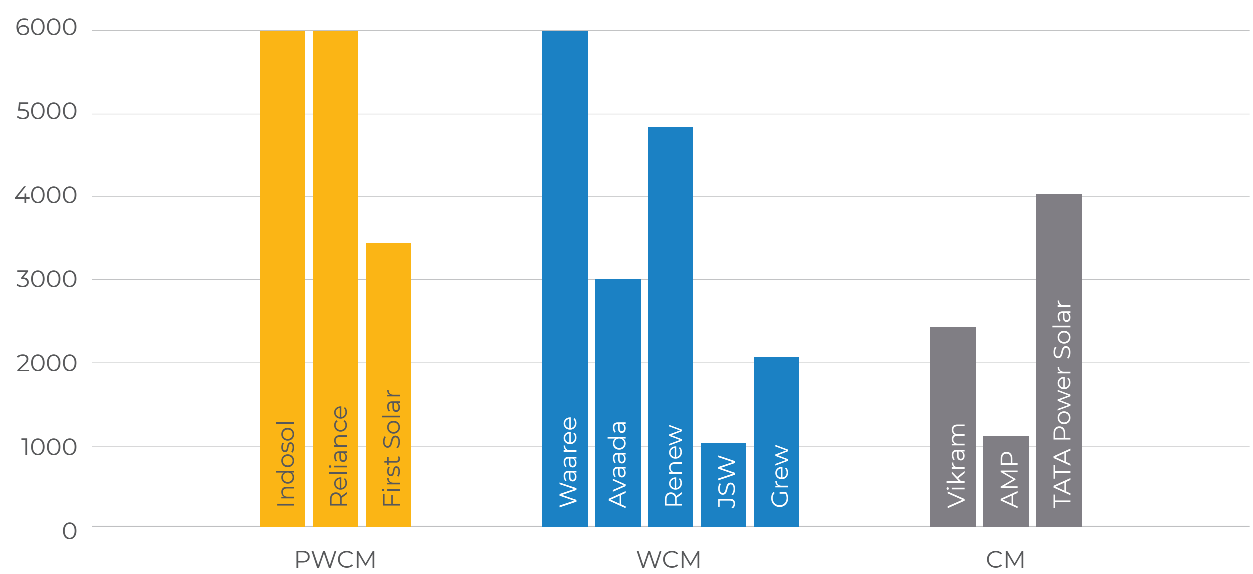
Modified Special Incentive Package Scheme (M-SIPS): In order to promote large-scale manufacturing in India the government had announced the M-SIPS scheme in 2012 under which 20-25% subsidy was provided for investments in capital expenditure for setting up of electronic manufacturing facility. Apart from the subsidy provided for investments a Reimbursement of Countervailing Duty (CVD)/ Excise Duty for capital equipment for the units outside the Special Economic Zone (SEZ) was also implemented. The Scheme inter-alia covered solar PV cells, solar PV modules, EVA, back sheet and solar glass.

Production Linked Incentive Scheme (PLI) Tranche I: The PLI scheme was launched in 2020 by the cabinet for enhancing India's manufacturing capabilities. The First Tranche of the scheme had an outlay of INR 4 500 Crores (circa EUR 500 million) for a total capacity of 10 GW of manufacturing. PLI Tranche I The Indian Renewable Energy Development Agency as the implementing agency on behalf of the MNRE invited bids for the selection of manufacturers for setting up manufacturing capacities for high-efficiency solar modules under Tranche I. This PLI Scheme was oversubscribed by 5.48 times and bidders quoted for a total capacity of 54.8 GW.

Finally, PLI I has been awarded to Reliance New Energy, Shirdi Sai Electricals and Adani for a total capacity of 10 000 MW of polysilicon-ingot-wafer-cell-module manufacturing.

Production Linked Incentive Scheme Tranche II: With the resounding success of PLI I, the Government of India announced a second tranche of PLI Scheme with an increased outlay of INR 19 500 Crores (EUR 1.8 billion). The Government has allocated a total capacity of 39 600 MW of domestic solar PV module manufacturing capacity to 11 companies, with a total outlay of INR 14 007 Crores under the Production Linked Incentive Scheme for high efficiency solar PV modules (Tranche-II). The Tranche-II is expected to bring in an investment of INR 93 041 Crores. It is set to generate a total of 101 487 jobs with 35 010 getting direct employment and 66 477 being indirectly employed.[27]

Figure 5: Capacity awarded under PLI scheme (Tranche II)[28]



[27] PIB, Government of India, https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1911380
[28] PWCM – POLY+WAFER+CELL+MODULE
WCM- WAFER+CELL+MODULE
CM – CELL+MODULE

Recommendations

Manufacturing equipment: India needs to focus on creating dedicated scheme for promoting domestic and indigenous manufacturing technologies and equipment that can help the country achieve its manufacturing targets while significantly reducing the dependency on imports.

Manufacturing hubs: The government can encourage the creation of solar manufacturing parks under the ambit of larger non-fossil fuel energy manufacturing parks. The parks can be divided according to the geography and the particular requirements of the area. Under the manufacturing park, the balance of systems can be carried out in these parks which would reduce the operational cost as well as the transition cost which are higher in the case of India in comparison to other countries. Each hub can be designed to accommodate 4-5 GW of Solar PV manufacturing along with all ancillary industries.

Ancillary manufacturing: A dedicated scheme in the lines of PLI can be created to promote domestic manufacturing of Ancillary/Balance of System materials including Glass, EVA/Backsheet, Encapsulant, Silver Paste etc

Financing for MSMEs: Micro, Small and Medium Industries form backbone to the country's economy and it is essential to promote MSME participation in Solar Manufacturing. Hence, a dedicated Clean Energy Manufacturing Fund can be created to support MSMEs through funds collected through the realization of Basic Customs Duty which would assist MSMEs.

04

The EU Supply Chains for Photovoltaics

State of Play

In recent months, the European solar PV sector has seen a sharp decrease in solar module prices, putting European PV manufacturers in a precarious position, as they were building up their manufacturing capacities encouraged by the broad political support for reshoring a European PV value chain. Module prices have dropped by over 25% since the beginning of the year, making it hard for them to sell their products. This situation raises the risk of insolvency for these companies, as seen with the bankruptcy of Norwegian Crystals in August 2023.

European PV manufacturing: current capacity and announcements

The share of European manufacturing capacities has declined in every segment since the 2010s.[29] In reaction to supply chains disruptions, linked to the COVID-19 pandemic and Russia's war in Ukraine, in light of the REPowerEU plan, and the EU's objective to reach 30 GW of manufacturing capacities across the full value chain by 2030, several European companies have announced investments into manufacturing capacities for various segments of the PV supply chain.

Modules: Module production in Europe stands at 2.8% of global market share, against 12.8% in 2010. The current 9.2 GW capacities are divided among 54 companies in Austria, Belgium, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Italy, Lithuania, Netherlands, Poland, Slovenia, and Spain. New capacity additions amounting to 50 GW are to be expected between 2024 and 2030.

Cells: In 2010, the global cells market was relatively diverse, with Europe accounting for 7.3% of global shares, with Germany dominating the market on the continent, totalling 6% of the global market share. In 2021, Europe accounted for 0.6% of the cells manufacturing sector, with four companies in Finland (Valoe), Germany (Meyer Burger), Hungary (Ecosolifer) and Italy (3Sun), amounting to a total capacity of less than 1 GW. Several new capacity announcements have been made, in France, Germany, Italy, Croatia, Poland, Romania and Spain, for a total capacity of 32 GW by 2030.

Ingot/wafers: European ingot/wafer production stands at 0.5% of global market share, against 3.2% in 2010. In 2023, three companies produced 1.7 GW of wafers in France, EDF Photowatt, and Norway, NorSun and Norwegian Crystal. However, the latter filed for bankruptcy in August 2023. Five companies in Croatia, France, Germany, Spain and Romania have announced developing their wafer manufacturing capacities for a total of at least 27 GW by 2030. Nonetheless, the manufacturing crisis in Europe suggest that these objectives suggests that these announcements will be difficult if not impossible to achieve.

Polysilicon: In 2010, Europe's polysilicon manufacturing capacities accounted for 19.4% of the global market.[30] In 2021, it dropped to 8%, with two companies, Wacker in Germany and REC Solar in Norway, with respectively 20.7 GW and 2.5 GW of polysilicon manufacturing capacities.[31] No new projects are currently being developed.

Ancillary manufacturing: Contrary to other segments, the European inverter manufacturing industry has remained strong with an annual production capacity of nearly 70 GW, accounting for around 24% of global market share. Ten companies produce inverters in Austria (Fronius), Germany (Kaco, Kostal, REFU, SMA, Steca, Sungrow), Italy (Fimer) and Spain (Ingeteam, Power Electronics). With regard to glass, due to the increasing demand, the production capacity is expected to increase in Europe. Backsheets and foils production flexible as it can be used for products beyond solar panels, accordingly, capacity expansion plans are adjusted depending on market demand. The production capacity of backsheets and foils in Europe is therefore sufficient to meet the current demand for PV panels. Encapsulant production is mostly located outside of Europe, notably in China, India and the USA. Similarly, there are few producers of silver paste in Europe.[32]

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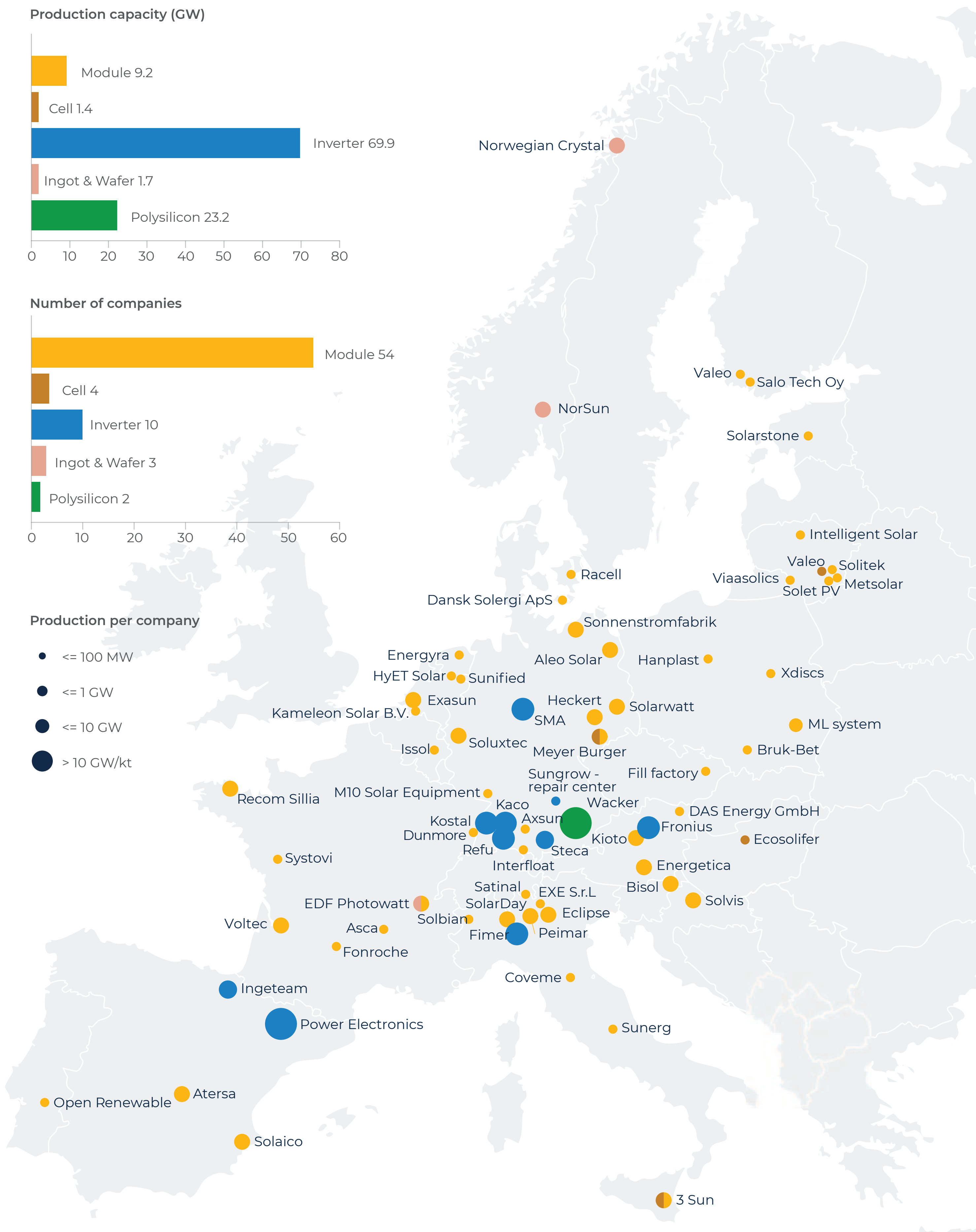
[29] Joint Research Centre, Clean Energy Technology Observatory: Photovoltaics in the European Union – 2022 Status Report on Technology Development, Trends, Value Chains and Markets, Publications Office of the European Union, Luxembourg, 2022.

[30] IEA, "Solar PV manufacturing capacity by country and region, 2010," July 2022, https://www.iea.org/data-and-statistics/charts/solar-pv-manufacturing-capacity-by-country-and-region-2010.

[31] SolarPower Europe, "EU Solar Manufacturing Map," https://www.solarpowereurope.org/insights/interactive-data/solar-manufacturing-map.

[32] ETIP PV (2023), PV Manufacturing in Europe: understanding the value chain for a successful industrial policy, White Paper Industry Working Group.

Figure 6: Production capacity in EU27 countries and Norway, 2022 (GW) (Source: SolarPower Europe)



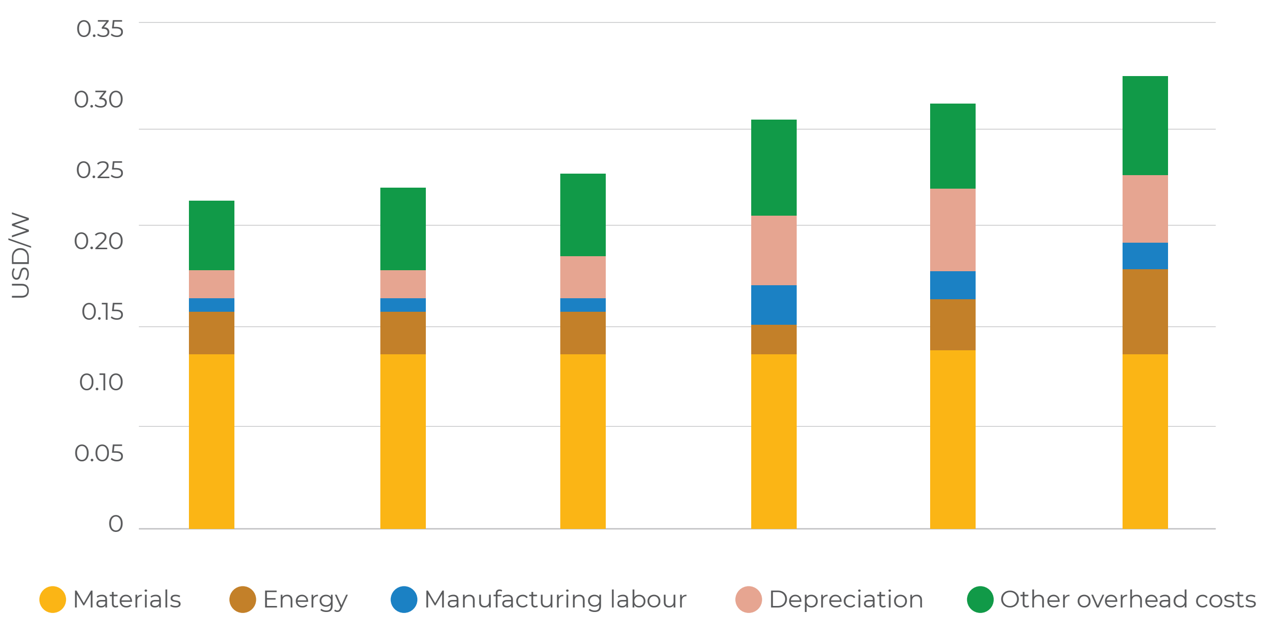
SolarPower Europe estimates a EUR 30-60 billion financing gap including CAPEX and OPEX to reach the 30 GW target of EU manufacturing capacities across the full value chain. Thus, addressing the issue of financing is critical to deploy manufacturing capacities.

Challenges

CAPEX financing: Global oversupply in the solar industry, driven by falling prices, is supporting the adoption of solar energy but negatively affecting the resilience of the European solar supply chain. Structural disadvantages, including higher energy costs, investments, and labour expenses for European manufacturers, a lack of local expertise and economies of scale, creating an uneven playing field. SolarPower Europe estimates a EUR 30-60 billion financing gap including CAPEX and OPEX to reach the 30 GW target of EU manufacturing capacities across the full value chain.[33] Thus, addressing the issue of financing is critical to deploy manufacturing capacities.

OPEX financing: Manufacturing costs are a key challenge in Europe. The cost of production of a PV panel in Europe is around 15-33% higher than in China.[34] Material costs represent most of the cost of a unit and are fairly similar across regions, and labour cost differences are negligible between the two regions compared to energy prices. Energy costs are twice higher in Europe than in China.[35] These challenges lead to European factories currently lacking large, gigawatt-scale production to compete globally.

Figure 7: Breakdown of production costs for mono PERC c-Si solar components by input, 2022



[33] SolarPower Europe, "The Net Zero Industry Act," Position Paper, May 2023.
[34] ETIP PV (2023), PV Manufacturing in Europe: understanding the value chain for a successful industrial policy, White Paper Industry Working Group.
[35] IEA (2022), Special Report on Solar PV Global Supply Chains, IEA, Paris.

Oversupply: The current European PV manufacturing crisis is also exacerbated by rising demand within China and internationally, the Chinese industry is attracting new entrants. Intense domestic competition has led to optimistic forecasts, fearing market share loss. This drives cost-effectiveness and technological advancement, causing rapid devaluation of existing stock. However, increased trade barriers, especially in the USA and India, like import tariffs, anti-dumping measures, taxes, and more, limit sales options. Europe remains the primary export market (56% of 2022 exports). Oversupply in the face of insufficient demand results in plummeting prices and reduced profit margins.

Research and Innovation: The EU has supported the advancement of PV R&I through its Horizon2020 programme (2014-2020), with around EUR 490 million invested in PV-related research projects.[36] Horizon Europe, spanning from 2021 to 2027, commits at least EUR 15 billion to research in areas including "Climate, Energy, and Mobility". These investments have supported research institutes specialised in PV across Europe, including IMEC in Belgium, Fraunhofer ISE, ISC in Germany, CEA-INES and IPVF in France, TNO in the Netherlands, and CSEM in Switzerland, to name a few.

Over the past decades, many key European innovations have contributed to enhancing the competitiveness of PV. Whilst, future key innovative technologies developed in Europe are likely to reach the market, such as tandem cells combining silicon and perovskite, the continent's leadership in the domain is eroding. As the global PV value chain moved outside of Europe, levels of expertise in several PV segments have declined, in particular in the ingot/wafer segment. Indeed, Chinese manufacturers, such as LONGi, Trina Solar, Jinko, JA Solar or Tongwei, have been heavily investing in research and developing their own research centres.

[36] ETIP PV (2023), PV Manufacturing in Europe: understanding the value chain for a successful industrial policy, White Paper Industry Working Group.

Policy landscape and recommendations

European policy framework

REPowerEU Plan: In the aftermath of Russia's aggression on Ukraine and in response to global energy disruptions, the European Commission launched the REPowerEU Plan, in May 2022.[37] It sets ambitious targets for renewables, including over 320 GW of newly installed solar PV by 2025 and almost 600 GW by 2030. As part of the REPowerEU Plan, the EU Solar Strategy led to the creation of a European Solar PV Industry Alliance (ESIA) in December 2022. ESIA's role is foster the growth of the EU solar industry, enhance supply chain security, and promote sustainability and circularity. It brings together public and private entities involved in the solar sector and will execute a Strategic Action Plan around seven key aspects: scaling up, financing, cooperation, international partnerships, circularity and sustainability, skills and research and innovation.

Green Deal Industrial Plan for the Net-Zero Age: To support the green energy transition, reduce dependencies on key products and reach deployment targets, the European Commission presented the Green Deal Industrial Plan for the Net-Zero Age, in February 2023.[38] The Plan aims at providing a European-wide approach to support net-zero industries. It is built around four pillars: a predictable and simplified regulatory environment, access to funding, skills development, and open trade for resilient supply chains.

EU Innovation Fund: The EU Innovation Fund offers another financing avenue for the re-localisation of manufacturing processes, including solar technology. A REPowerEU thematic window within this fund, which became available in November 2022, has doubled funding for large-scale projects,

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reaching 3 billion euros. The Innovation Fund's 3rd call for large-scale projects awarded three projects on PV panels and modules.[39]

Net-Zero Industry Act (NZIA): In March 2023, the European Commission proposed the Net-Zero Industry Act (NZIA) to increase manufacturing capacity for net-zero technologies in the EU.[40] The Act introduces a "Net-Zero Strategic Project" category, streamlining approval processes and funding access for qualifying projects. The proposal aims to ensure that the EU has enough manufacturing capacity for eight strategic net-zero

[37] European Commission, Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, ("REPowerEU Plan"), 18 May 2022, COM(2022)230.
[38] European Commission, Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, ("A Green Deal Industrial Plan for the Net-Zero Age"), 01 February 2023, COM(2023)62.
[39] European Commission, 13 July 2023, "Innovation Fund: EU invests €3.6 billion of emissions trading revenues in innovative clean tech projects", Press release, https://ec.europa.eu/commission/presscorner/detail/en/ip_23_3787.
[40] European Commission, Proposal for a regulation on establishing a framework of measures for strengthening Europe's net-zero technology products manufacturing ecosystem ('Net Zero Industry Act'), 16 March 2023, COM(2023)161.

technologies, with solar PV reaching a benchmark of 40% of the EU's annual deployment needs by 2030. For solar PV specifically, the proposal sets a goal of 30 GW of EU manufacturing capacity by 2030.[41]

Resilience auctions: ESIA is currently developing the concept of resilience auctions for a small but growing segment of public auctions and procurement commensurate with the Union manufactured capacity objectives of 30GW by 2030 across the supply chain. The core of the concept is that these auctions would be reserved for domestically produced solar systems (EU content as a pre-qualification). Once the concept is more widely developed and implemented, it is worth elaborating on how to ensure Indian-produced solar systems could also bid into the resilience auctions and procurement segment. The concept is currently being discussed in Germany.

Corporate Sustainability Due Diligence Directive (CSDDD): The EU has responded to the growing demand for more sustainable products and enhanced environmental, social, and governance (ESG) business performance with several legislative initiatives. The CSDDD, put forward by the European Commission in February 2022, would require companies to take responsibility for human rights abuses and environmental harm throughout their global value chains by conducting due diligence on their own operations as well as their subsidiaries and other entities in their value chains. The CSDD Directive aligns with international human rights and environmental standards, including labour rights and environmental violations. Negotiations are ongoing between the EU institutions, the Directive is not expected to be formally adopted before 2024, and Member States will have two years to implement it into national legislation (with different grace periods depending on company size).[42]

The EU has responded to the growing demand for more sustainable products and enhanced environmental, social, and governance (ESG) business performance with several legislative initiatives.

Solar Stewardship Initiative (SSI): To help companies comply with high ESG standards and upcoming legislation, the Solar Stewardship Initiative (SSI) was launched in September 2022 by SolarPower Europe and Solar Energy UK (SEUK), with over 70 organisations supporting it.[43] The SSI aims to promote responsible production, improve transparency in the solar supply chain and ensure products are manufactured ethically. It has developed a SSI ESG Performance Standard based on international standards, which participating companies are expected to adhere to. The SSI, as a value chain assurance program, with third-party audits, ensures that companies can independently demonstrate commitment to upholding sustainability best practices in their production.

[41] The NZIA proposal is following the EU's legislative process and is currently being discussed in the Committee on Industry, Research and Energy (ITRE) of the European Parliament and in the Council. Legislative Observatory (OEIL), European Parliament, Framework of measures for strengthening Europe's net-zero technology products manufacturing ecosystem (Net-Zero Industry Act), 2023/0081(COD).

[42] European Commission, Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on Corporate Sustainability Due Diligence and amending Directive (EU) 2019/1937, 23 February 2022, COM(2022)71.

[43] Solar Stewardship Initiative, "Our Work," https://www.solarstewardshipinitiative.org/our-work/.

Recommendations

NZIA: The EU should create a Solar Manufacturing Bank for OPEX financing. While the NZIA sets ambitious targets, several challenges remain regarding financing and non-price criteria in public procurement to scale up manufacturing capacities in Europe. The EU updated its State Aid rules under the Temporary Crisis and Transition Framework (TCTF) in March 2023. However, state support is only available for CAPEX. A European-wide financial instrument dedicated to solar PV manufacturing, such as a Solar Manufacturing Bank, akin to the existing Hydrogen Bank, should be established to complement national spending rules under the TCTF and allow for OPEX financing to compensate for energy costs and other structural disadvantages. Non-price criteria in public procurement and auction should also include social and governance criteria to ensure full ESG-based level playing field, including traceability of core and critical raw materials.

Innovation Fund: The potential of the EU Innovation Fund should be maximised to adapt to the needs of the solar industry. It should include a dedicated budget for PV manufacturing and renewable technologies, reward manufacturing projects integrated along the European value chain, simplify the application process and increase CAPEX threshold for large-scale projects.

Sustainability: The EU should back the SSI to advance the effects of the EU Forced Labour Regulation. With the support of the EU, market adoption of the SSI will be expedited.
R&I: The EU should continue to support R&I in the PV sector and endorse its priorities with a particular focus on the development of the next generation of PV cells, the hastening of research into circularity, and the assurance that innovations are effectively introduced to the market.

05

Perspectives for India-EU Cooperation on PV Supply Chain Resilience and Sustainability

This chapter outlines potential future areas of cooperation between India and the EU, particularly regarding ingot/wafer production, research and innovation, financial access, and supply chain transparency. Exploring collaboration opportunities in these domains is crucial to diversify global supply chains. Joint ventures and strategic investments should be pursued.

Cells and modules

Cells and modules manufacturing capacities are easier to deploy and expand compared to more upstream segments of the PV value chain and they can also be developed on a wide range of scales. Cooperation on cells and modules manufacturing is therefore considered by companies to be less critical to contribute to global supply chains diversification. Additionally, cooperation in these segments already exists.

For instance, Reliance Industries, based in India, has acquired, via its subsidiary Reliance New Energy Solar Limited, Norway's REC Group, a PV module manufacturer, for USD 771 million (EUR 725 million). Reliance plans to integrate REC's technology into a vertically integrated silicon-to-module manufacturing site in Jamnagar, India. REC Group, under its new ownership, aims to expand its current 2 GW PV cell and module production capacity in Singapore to 5 GW in the next two to three years, establish a 2 GW cells and module facility in France, and build a 1 GW module facility in the U.S. This acquisition will aid Reliance in its goal to establish a fully integrated PV manufacturing facility at the Dhirubhai Ambani Green Energy Giga Complex in India, starting with 4 GW capacity and expanding to 10 GW. The collaboration aims to replicate similar complexes worldwide, leveraging Reliance's expertise in scale, project execution, and operations.

Ingot/wafer segment

Following the discussions of the Task Force meeting, Indian manufacturers manifested their interest in partnering with European companies, especially in research and technology transfer related to ingot and wafer production. This interest stems from the need to expand manufacturing capacity in India, which currently relies on Chinese machinery. The main challenges faced are capacity expansion bottlenecks with Chinese equipment due to a lack of engineering skills and maintenance issues resulting from travel restrictions on Chinese engineers.

This segment is also challenging for European manufacturers, along with cell production, it represents the weakest links in the EU solar PV supply chain and is falling short of the goal to reshore 30 GW by 2030.

This segment is also challenging for European manufacturers, along with cell production, it represents the weakest links in the EU solar PV supply chain and is falling short of the goal to reshore 30 GW by 2030. The collapse of the European PV industry after 2011 has resulted in a loss of expertise in machine tool production on the continent, especially for the upstream section of PV modules, notably wafers and materials. The EU currently lacks the capacity to upscale equipment manufacturing for ingot pulling and diamond wire saws, as well as for crucial inputs to the PV manufacturing process such as crucibles and diamond wire.[44] Table 2 illustrate technology availability and capacity to scale up in these

[44] ETIP PV (2023), PV Manufacturing in Europe: understanding the value chain for a successful industrial policy, White Paper Industry Working Group.

segments in Europe. The EU's high electricity prices possess a significant barrier to expanding capacity in this segment, due to the high electricity consumption of ingot pulling and wafer cutting processes.

Moreover, international competition coupled with oversupply on the production side and excessive demand in the context of a slowdown in European solar market growth, have created challenging economic conditions for companies. This has led to the bankruptcy of Norwegian Crystals in August 2023 and a substantial reduction in output capacity for Norsun. Additionally, the rapid evolution and development of wafer formats are critical for the competitiveness of upstream solar in Europe. For instance, Norwegian Crystal, before its bankruptcy, had difficulties delivering on modern wafer formats at a competitive price.

Additional players exist on the European market. Companies like NexWafe are in the early stages of technology development for industrial-scale production of their monocrystalline wafer technology. NexWafe has secured financing of EUR 30 million for the construction of its first commercial-scale wafer factory in Bitterfeld, Germany. The Indian company Reliance New Energy Limited is part of the investors.

In Europe, notable manufacturers of ingot pullers include ECM GreenTech and PVA Tepla, producing mono C-Si pullers for the semiconductor industry. EDF Photowatt is another small ingot/wafer manufacturer with an ingot pulling technology used for multi-crystalline solar cells, an outdated technology. However, there's a lack of expertise in wafer cutting, partly because there have been few active PV machine manufacturers in Europe since the 2010s. Additionally, the technology in this field has evolved significantly, with a focus on thinner wafers and reducing kerf losses.

Globally, the segment of ingots and wafers have highest dependency on China. Hence, the segment holds significant promise for collaboration, considering that both India and the EU encounter obstacles in scaling up their manufacturing capacities to meet solar deployment goals. Exploring joint ventures with the mentioned companies and leveraging existing incentives and financing opportunities may be considered to facilitate this cooperation.

***Table 2: equipment and materials for the availability in the EU for PV manufacturing (ETIP PV, Industry White Paper, 2023)*[45]**

Key equipment Wafering	Availability in EU	Scale up capacity in EU
Ingot Puller	✓	Lack of available expertise and capacity to rapidly expand manufacturing for these investments without significant investments.
Cropping–- Squaring–- Polishing	✓✓	
Diamond Wire Saws	✓	
Separation and cleaning	✓✓	
Testing and Sorting	✓✓✓	
Fab Automation	✓✓	
Material for Wafering, Cell & Module production	**Availability in EU**	**Scale up capacity in EU**
Polysilicon	✓✓	Lack of a defined industrial framework for midstream material production towards consumption in the PV manufacturing process in Europe. To expand capacity and drive investment, guarantees as to investment trends in PV in Europe are necessary, as is the definition of added value of European production, notably linked to supply chain circularity.
Crucibles	✓	
Diamond wire	✓	
Chemicals + Gases	✓✓✓	
Ag pastes	✓✓	
Al pastes	✓✓	
Printing screens	✓✓	
Glass (front and rear)	✓✓	
Encapsulants	✓✓	
Frame	✓✓✓	
Ribbon	✓✓	
Junction Box	✓✓	

Research and development

Cooperation in research and development is also a solution to deploy manufacturing capacities and develop efficient technologies in both countries. Such cooperation is possible as India and Europe showcase synergies in their competences. As such, in October 2023, SMA, a German inverter manufacturer, inaugurated its Research and Innovation centre in Bangalore to work on Grid Forming technologies. India represented an ideal choice for this endeavour, owing to its reservoir of skilled engineers, trained in Grid Forming technologies, and the supportive solar incentives established by the Indian government, especially favourable tax policies on software products and office infrastructure.

The project also gathered support from the Indo-German Energy Forum (IGEF) facilitated by the German Chamber of Commerce in India. By year-end, the centre aspires to assemble a team of 40 professionals, with a vision of expanding to over 100 in the future. Their objective is to bring Grid Forming products to the market through SMA's Mumbai office and to deploy their engineers across Europe and the globe.

[45] Orange means basic knowledge of the technology and innovation processes is still available in Europe, Yellow means that there is a need to expand the production. Green means that this equipment and technology is available in Europe, although expansion and new investments in production capacity may remain necessary, depend on yearly installation / production necessary

This venture exemplifies the potential fruitful collaborations between Europe and India. It harnesses the prowess of skilled Indian engineers to meet the evolving demands of European companies and the broader global transition towards sustainable energy solutions. It is important to note that while this research initiative appears ideal, challenges may surface when it comes to establishing manufacturing production lines or research in manufacturing.

Utilising the Horizon Europe programme can serve as a catalyst for promoting EU-India research in the field of PV. Being associated with Horizon Europe is the closest form of collaboration available to non-EU countries, enabling entities from associated nations to participate on equal terms with their EU counterparts. This opportunity extends not only to neighbouring countries but also to any nation globally with a robust research and innovation capacity that shares common values. Hence, India should be associated with the framework. Furthermore, bilateral cooperation through Science and Technology Agreements, such as the one currently in place with India, can facilitate joint efforts in research. To advance the EU's strategic goals and foster a diversified PV supply chain, the EU should establish specific calls aimed at enhancing cooperation with India in the PV sector.

Critical raw materials

During the Task Force discussions, there was an emphasis on ensuring that silicon for PV is not sourced from the Xinjiang region, as it would affect market access in the US for Indian products and potentially access to the EU market in the future. India faces a significant challenge in accessing affordable technology for mining critical minerals and processing raw materials. To address this issue, the EU and India should consider forging strategic partnerships through joint ventures. Additionally, exploring collaboration with South Africa, Australia or other countries in the realm of raw materials and extraction is highly advisable. Australia and South Africa possess extensive expertise in this field, particularly in the processing segment, making them valuable partners for addressing these challenges and contributing to diversification.

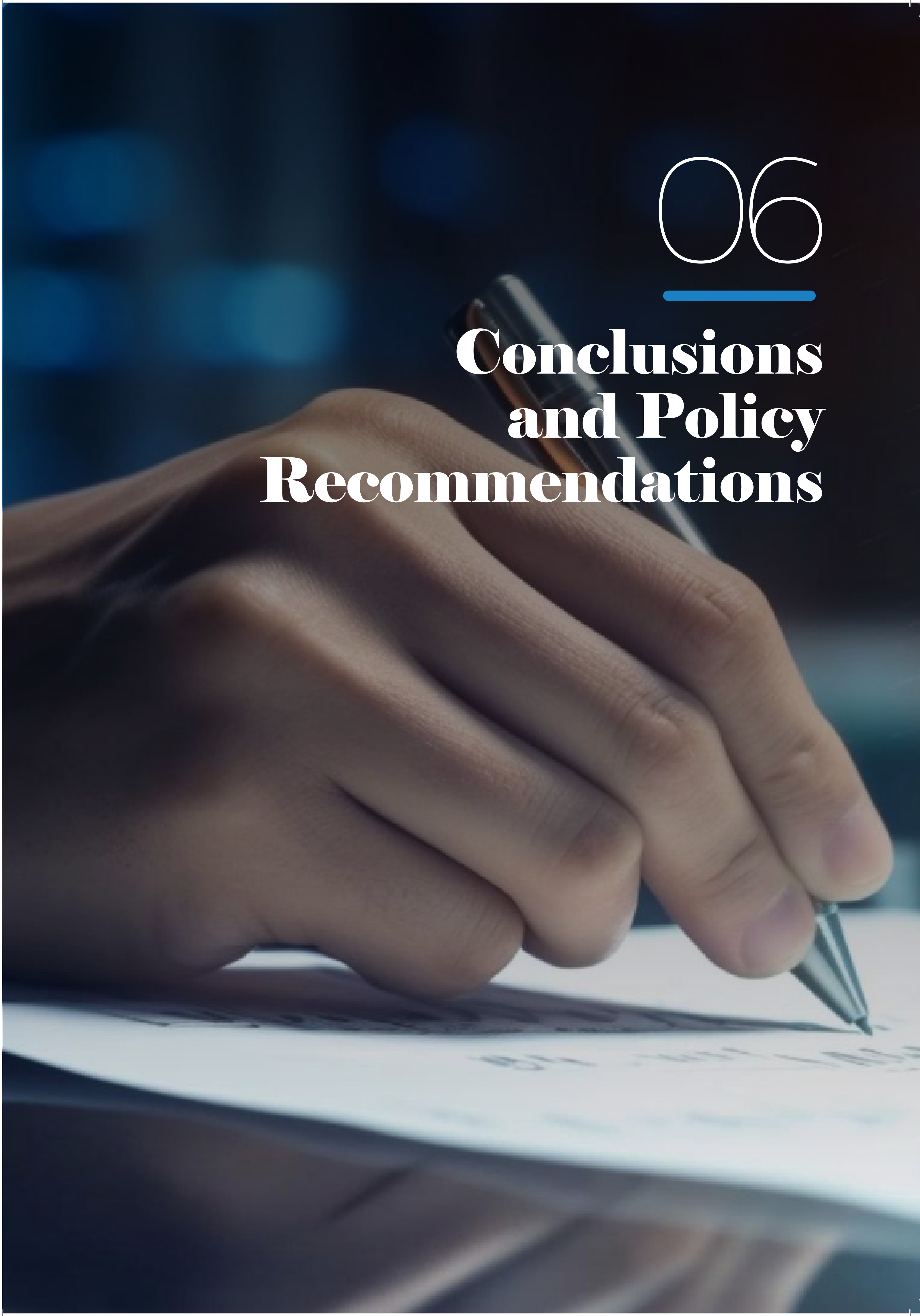
Access to finance

To contribute to diversification and collaboration with India, the EU should utilise initiatives like the Global Gateway and the European Fund for Sustainable Development Plus (EFSD+). The Global Gateway, under a Team Europe initiative, including the EU and its Member States, includes up to EUR 300 billion will be mobilised for sustainable projects from 2021 to 2027. It must be noted that this funding is not for climate and energy only. The EFSD+ with a guaranteed volume of EUR 53 billion for 2021-27 is another important risk-sharing instrument to leverage, potentially generating EUR 232 billion in sustainable investments.

These initiatives should prioritise strategic investments and project proposals that encourage collaboration and innovation in the solar PV sector. Specific funding call aimed at developing PV supply chains diversification projects with India should be developed. By combining resources and expertise, India and Europe can effectively address challenges and capitalise on opportunities to cooperate in the solar sector.

Sustainability

In the context of India's supply chains, there is a policy drive towards self-reliance and reducing dependence on China. Nonetheless, the Task Force discussions showed that Indian manufacturers are keen to export to Europe as well. There is also a demand on India's side to better understand European ESG criteria to be able to meet them. Hence, India-EU cooperation should revolve around quality assurance, certification processes, and maintaining quality throughout production. The EU can provide support for formulating Guidelines for ESG standards for both Indian solar PV manufacturing and EPC installations in line with EU-ESG regulations. Additionally, the introduction of low carbon criteria in the design of PV component should be explored.



06

Conclusions and Policy Recommendations

Key findings and conclusions

To accelerate the worldwide shift towards achieving net zero emissions, it is imperative to accelerate solar deployment. Resilient, diverse, and sustainable supply chains play a crucial role in enabling this transition. The solar PV sector is vulnerable to potential disruptions due to its heavy reliance on a single-country supplier, China, posing various supply chain risks.

Overall, supply chain diversification will support the faster deployment and growth of solar PV, avoid risks of material unavailability and insufficient manufacturing capacity to meet demands and reach net zero targets. Establishing competitive domestic manufacturing capacities is not without challenges. Therefore, building strategic partnerships is crucial to complement and strengthen clean energy industrial policies and contribute to global supply chains diversification.

India faces several challenges in diversifying its supply chains, including the need for affordable technology for mining critical minerals and processing raw materials, acquiring manufacturing equipment, especially for ingot/wafer and polysilicon, and expanding ancillary manufacturing. On the European side, key challenges involve the ongoing manufacturing crisis, high operational costs, difficulties in expanding manufacturing capacities, particularly in the ingot/wafer segment, and the industrialisation of innovations.

Considering the strategic and economic benefits of a more diversified global solar supply chain, policy makers should look for instruments to incentivise local solar manufacturing and build a strong value chain. Additionally, the difficult situation of the European PV manufacturing sector as of late 2023 should prompt European leaders to act quickly and support for reshoring a local PV value chain. Despite the crisis and the plummeting of solar module prices in recent months, establishing trade barriers is not a suitable solution for the current issues facing the European solar industry. There are more effective and notably quicker methods for supporting PV manufacturing, including setting up a Solar Manufacturing Bank on the model of the Hydrogen Bank to support manufacturing, address the inadequacies of the TCTF for State Aid and allow for operational expenditure and advancing the effects of the EU Forced Labour Regulation

> **This segment is also challenging for European manufacturers, along with cell production, it represents the weakest links in the EU solar PV supply chain and is falling short of the goal to reshore 30 GW by 2030.**

by backing the Solar Stewardship Initiative (SSI). The concept of resilience auctions, prioritising EU-made solar systems in public procurement, should be implemented and how to address Indian-made PV participation in the system should be discussed. Furthermore, instead of sanctioning the entire PV industry via tariffs, solar installations originating from resilient European industry should be supported. This approach would allow the expansion of solar deployment without disruption, while simultaneously fostering steady growth in European solar manufacturing.

In the short term, collaboration between the EU and India should prioritise ingot and wafer manufacturing, as Indian manufacturers have expressed interest in such partnerships. This focus is driven by the complexity of expanding capacities in upstream manufacturing segments. Moreover, with China dominating 97% of ingot and wafer production, it represents the most concentrated segment of the PV value chain, with the country also concentrating knowledge and skills in this critical area.

To promote diversification and cooperation with India, available funding should be directed towards enhancing strategic collaboration between the EU and India within the PV sector. Initiatives such as the Global Gateway can be leveraged and targeted to achieve this goal. They should give precedence to strategic investments and project proposals actively fostering collaboration and innovation in the solar PV sector. The EU should establish specific funding calls tailored to the development of projects aimed at diversifying PV supply chains in conjunction with India.

Creating resilient and sustainable supply chains is crucial to enable a just transition to clean energy. The solar sector needs to meet the growing expectations of both consumers and regulators for the sustainable sourcing of materials and components. The Solar Stewardship Initiative represents a specialised assurance program for the solar industry aimed at enhancing confidence in the manufacturing processes, locations, and actors involved in solar product production. As a result, enterprises and consumers can trust that their solar products comply with international environmental, social and governance standards. Non-price criteria, underpinned by the growing demand for more sustainable solar products and more supply chain transparency, can be a driver for the deployment of domestic manufacturing provided financial and regulatory support is there.

While there may not be a fully developed proposal at this time, it is imperative to explore collaboration opportunities in the identified areas, namely regarding the ingot/wafer segment, research and innovation, access to finance and supply chain transparency. Joint ventures and potential opportunities should be actioned with the mentioned companies and craft a compelling value proposition for cooperation initiatives. To foster this cooperation, a set of recommendations are outlined below.

Policy recommendations

The EU and the Indian government should:

- **Support the deployment of their respective domestic manufacturing capacities through the development and implementation of a strong and credible industry strategy for solar PV.** The Production Linked Incentive (PLI) scheme created by the Indian government is a good practice which the EU should consider as a template to encourage solar manufacturing in Europe. Financial support should extend beyond CAPEX to encompass OPEX with a revision of the TCTF for State Aid and the creation of

a Solar Manufacturing Bank dedicated to PV manufacturing. In India, the focus should be on the development of initiatives to boost domestic manufacturing technologies and equipment, promote solar manufacturing parks within broader non-fossil fuel energy manufacturing complexes, establish schemes akin to PLI to encourage domestic production of ancillary materials and promote MSME participation in solar manufacturing.

- **Support cooperation on the ingot/wafer segment through tools such as the EU Global Gateway Initiative.** Given China's dominance with 97% of production and concentrated expertise, EU-India cooperation in this segment is crucial as it represents weak link in supply chains. Funding should support strategic collaboration between the EU and India in the PV sector, utilising tools like the EU Global Gateway. Priority should be given to investments and projects that encourage collaboration to build resilient and sustainable supply chains. The EU should create funding opportunities specifically designed to diversify PV supply chains in partnership with India.

- **Recognise sustainability initiatives aimed at increasing supply chain transparency and ESG compliance such as the Solar Stewardship Initiative (SSI).** In the context of EU-India cooperation, the EU should also provide adequate support for capacity building in India and support for the formulation of EU-compatible Guidelines for ESG standards for Indian PV manufacturing and EPC installations. Supply chain transparency is vital for diversification and product sustainability.

- **Build strategic partnerships with third countries for critical raw materials mining and processing.** Critical raw materials have become a source of contention and potential geopolitical leverage. The EU and India face risks due to mineral supply concentration in a few countries, and international cooperation will be essential. To tackle this issue, the EU and India should consider establishing strategic partnerships via joint ventures. Furthermore, both countries should explore cooperation with South Africa, Australia or other countries, particularly in the raw materials and extraction domains. The Global Gateway should also be leveraged to facilitate investments.

- **Direct available funding to PV manufacturing and research cooperation between Europe and India.** Cooperation in research and development is crucial for building manufacturing capacities and advancing efficient technologies in both the EU and India. Leveraging the Horizon Europe program can significantly promote joint research efforts in the PV field, by including India as an associated partner. To support strategic objectives and promote a diversified PV supply chain, specific calls for cooperation with India should be established. These efforts should prioritise research and innovation priorities related to next-gen PV cells, circularity, and bringing innovations to the market.