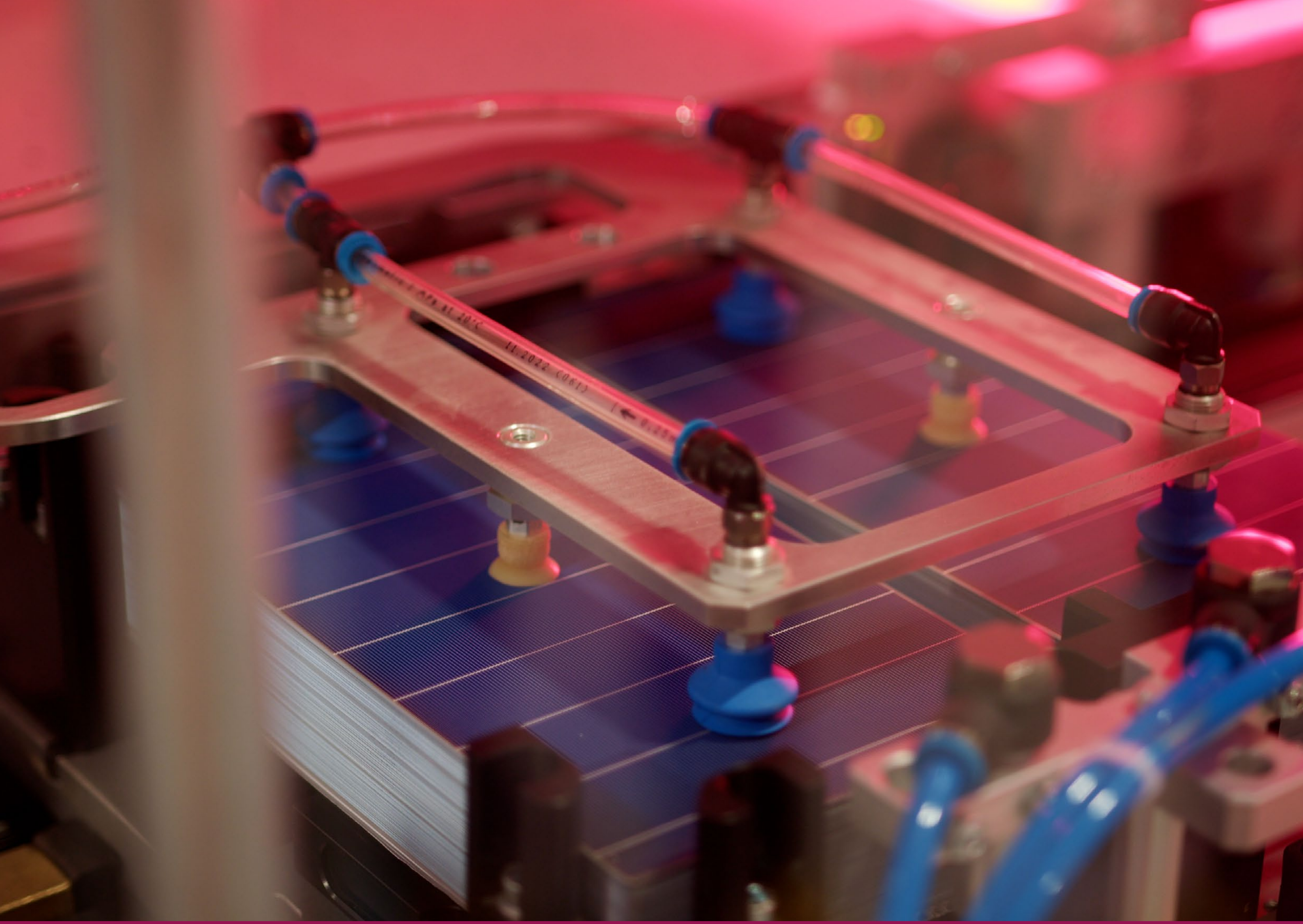

Reshoring Solar Module Manufacturing to Europe

A Cost Gap Analysis and Policy Impact Simulation

SolarPower Europe

Fraunhofer ISE

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Reshoring Solar Module Manufacturing to Europe:

A Cost Gap Analysis and Policy Impact Simulation

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Contents

AMER	Americas (North, Central, and South America)
APAC	Asia-Pacific region
BAs	Bank Acceptances
CAPEX	Capital Expenditures
C&I	Commercial & Industrial
CN	China
COGS	Calculation of direct Cost of Goods Sold
EU	European Union
Eurostat	European Statistic Office
FIT	Feed-in-Tariff
Fraunhofer ISE	Fraunhofer Institute for Solar Energy Systems
FTE	Full Time Equivalent
GWp/kWp	Gigawatt-peak/Kilowatt-peak
IRA	Inflation Reduction Act (US)
IRENA	International Renewable Energy Agency
LCOE	Levelized Cost of Electricity
LCRs	Local Content Requirements
MENA	Middle East and North Africa
MSP	Minimum Sustainable Price
NZIA	Net-Zero Industry Act
OECD	Organisation for Economic Co-operation and Development
OPEX	Operational Expenditures
PLI	Production Linked Incentive (India)
Poly-Si	Polycrystalline Silicon
PV	Solar Photovoltaics
R&I	Research and Investment
R&D	Research and Development
SEA	Southeast Asia
VAT	Value-added tax

Solar PV is the fastest-growing and most cost-effective electricity source worldwide.

Its supply chains, however, are heavily concentrated, exposing Europe to operational, economic, and geopolitical risks. The Solar Manufacturing Study, commissioned by SolarPower Europe and conducted by Fraunhofer ISE, quantifies the cost gap and lays out the policy levers needed for reshoring solar module module manufacturing in line with the EU Net- Zero Industry Act (NZIA) ambitions for 2030.

Commencing with an outlook on the global PV manufacturing landscape, the study calculates the production cost of PV modules and their components, based on an analysis performed by Fraunhofer ISE, NREL and RCT Solutions[1], to determine the existing cost gap in different key regions and potential reduction pathways for Europe.

Demand for solar in Europe is uncertain, manufacturing in Europe is weak.

EU solar demand has recently slowed down and, by 2030, ranges widely between 60–104 GWp/a. Most of that demand will likely be supplied by imports given that, today, China supplies 81–93% of the PV components along the value chain to Europe, and European annual manufacturing capacity is currently below 10 GWp/a across cells, wafers, and modules.

[1] Comparative Global PV Manufacturing Cost and Sustainable Pricing Assessment, 41st EU PVSEC, 2024.

The cost gap for NZIA-compliant solar modules is significant but can be reduced substantially with the right policy mix.

Producing a solar module in Europe with EU cells costs around 10.3 €ct/Wp more than producing the same module in China. The gap stems from higher costs in equipment (+40%), building and facility (+110%), labour (+280%), and material costs (+50%). As a result, such PV systems cost about 60.8 €ct/Wp compared to 50.0 €ct/Wp for a Chinese system for the utility segment, translating into a Levelized Cost of Electricity (LCOE) that is ~0.75 €ct/kWh or 14.5% higher for European-made modules. Importantly, and although only comparable as a proxy, the report finds that this falls within the 15% additional cost-per-auction cap outlined in the NZIA for non-price criteria in renewable auctions. Confirming compliance with the 15% threshold of course involves translating these results into actual auction-level cost outcomes.

The cost gap can, however, be further reduced to below 10% with the right mix of policies, combining CAPEX and OPEX schemes, both for solar manufacturers and project developers, with output-based support, and assuming production facilities of at least 5 GWp/a scale. The report highlights the effectiveness of output-based support schemes that are directly linked to the manufactured products and domestic value creation, as has been applied successfully in the United States and India. This report assumes output based support of 2 €ct/Wp for both cell and module production while the US IRA goes up to 11 $ct/Wp.

The Net-Zero Industry Act will drive diversification, but risks falling short of reshoring solar supply chains to the EU.

The analysis is performed for three solar PV system cases that are each compliant with the NZIA resilience criterion, but have different numbers of EU components: (1) a fully EU-based PV system from poly-Si to modules, including solar glass and inverters, (2) a solar system with EU-based cells, glass, modules and inverters and Chinese poly-Si, ingot & wafers, and (3) a solar system with South East Asian cells, glass, modules, inverter and Chinese poly-Si, ingot & wafers. The report finds that a fully EU-based system (1) is 12.8 €ct/Wp more expensive than a NZIA compliant system without any EU-made component (3).

Recreating a European solar ecosystem brings more net macro-economic benefits.

The report calculates that each GWp/a of EU PV manufacturing capacity creates up to 2700 new jobs and generates €12.6–66.4 Mn/a per GWp/a in tax and social revenues for case (3) to (1). The levels of support needed in each of these cases vary significantly, between €172.6 Mn/a per GWp/a (or €5.2 Bn/a for 30 GWp/a) for fully reshoring an EU-based PV value chain and €45.3 Mn/a per GWp/a (or €1.4 Bn/a for 30 GWp/a) for an NZIA-compliant supply chain without any EU-based component. The upfront cost is partly (28-39%) recovered through macroeconomic benefits which are highest in case (1) and lowest in case (3). In conclusion, a strong EU-based PV value chain requires more upfront investments but yields higher macro-economic benefits compared to that without any EU-based component.

The study concludes that the EU's 30 GWp/a solar module manufacturing target is both technically and economically achievable, provided the EU and Members States act swiftly and complete the policy and investment environment as follows:

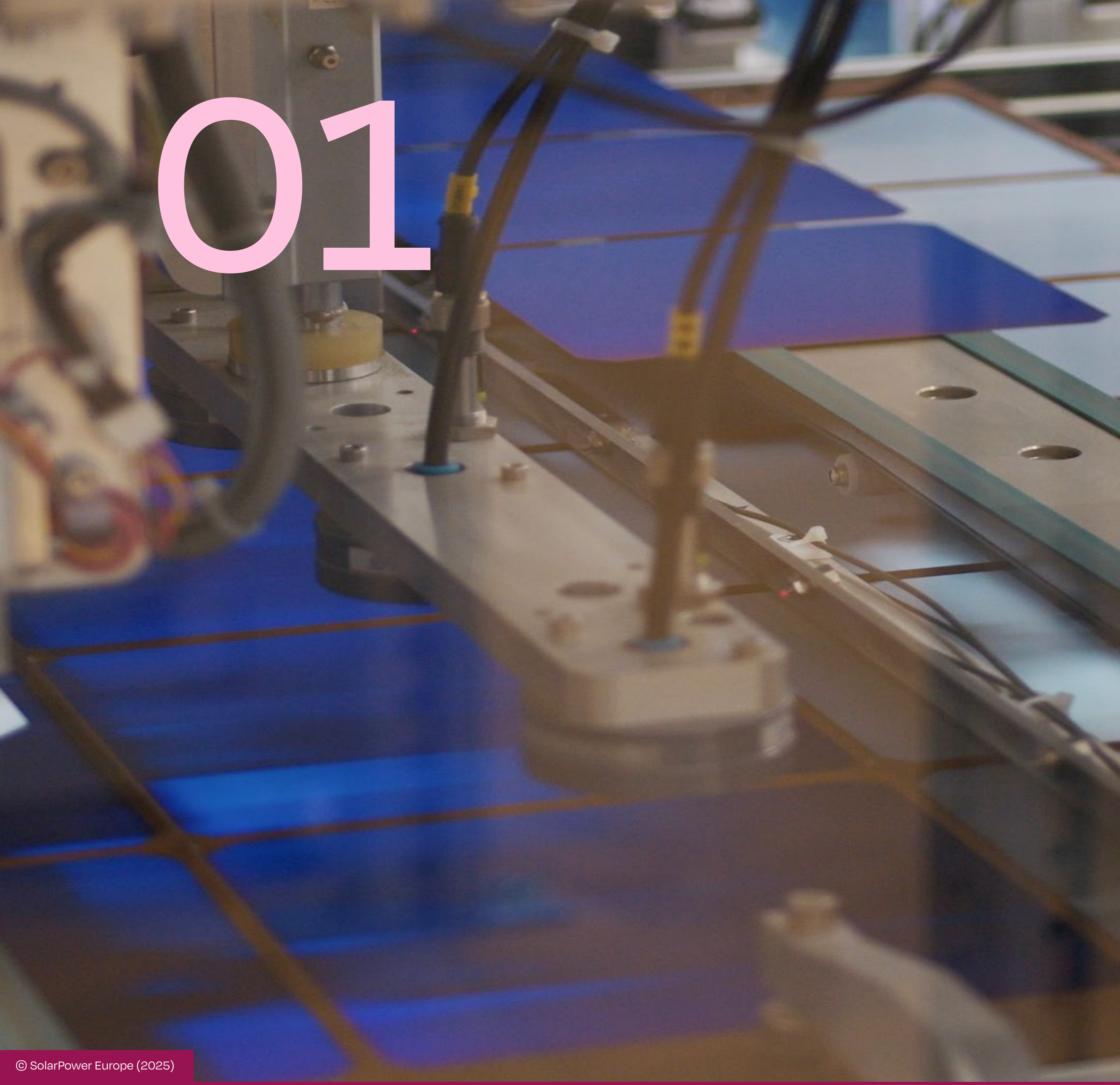
1. **Establish an EU-level output-based support scheme dedicated to solar manufacturing.** Such schemes would channel various sources of support including grants, loans and de-risking instruments for scaling up solar manufacturing in

Europe and– crucially – cover capital and operational expenditures, in the shape of production-based support.

2. **Effectively implement the NZIA policy schemes across EU Member States including Made-in-EU bonus points where possible.** Given the cost difference of 2.2 to 5.8 €ct/Wp between NZIA compliant EU-made and NZIA compliant non-EU-made modules, governments would be well advised to integrate "Made-in-EU" bonus points or an EU-preference approach in support schemes. This is especially important for rooftop schemes and public procurement in light of the upcoming revision of the EU Public Procurement directive, and in combination with the rooftop solar mandate which is estimated to drive the total PV rooftop market to 34-45 GWp/a for the period 2024-2029 for the whole of Europe.

Without these proposed interventions, the report warns that the European PV manufacturing sector will struggle to compete with dominant global players and risks losing its remaining industrial and technological capabilities in this field. Since scaling up manufacturing facilities typically takes two to three years, there is only a narrow window left to create the necessary conditions for investors to commit to manufacturing in the EU until 2030.

01



The Global PV manufacturing landscape in 2025 and projections for 2030

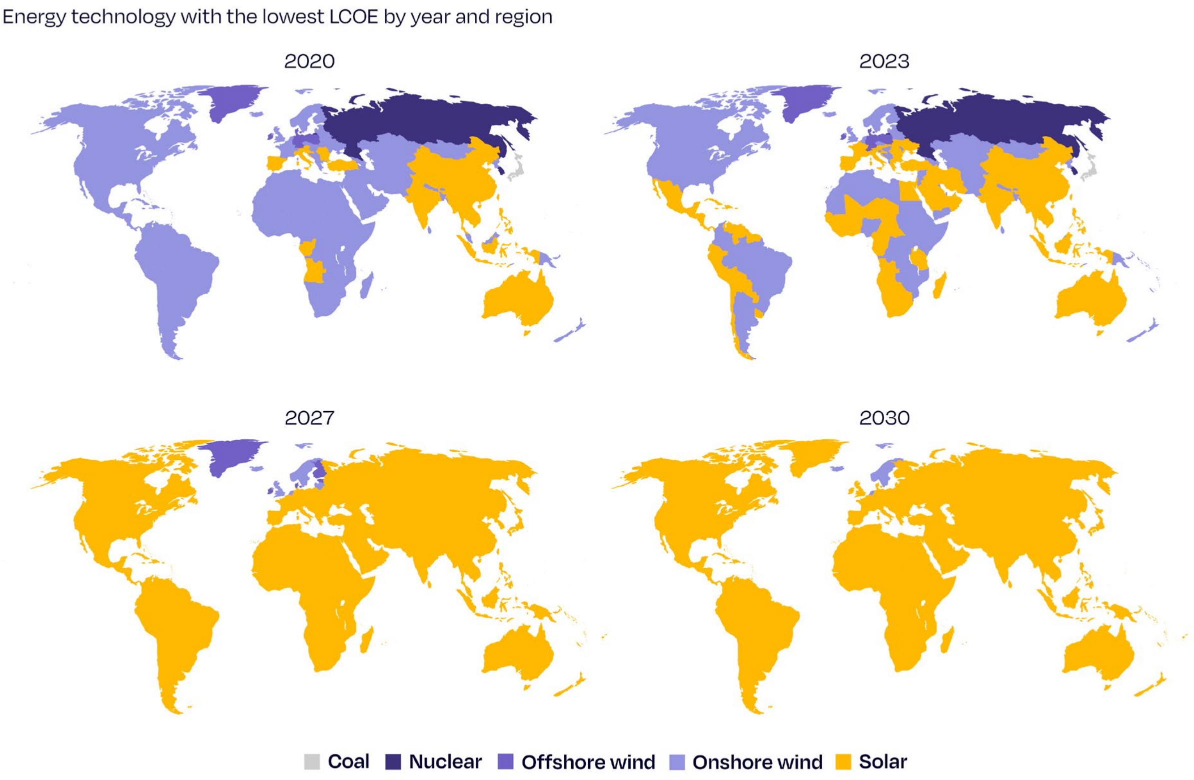
The global solar PV market development

In the last two decades, solar photovoltaics (PV) has evolved. Through technological advancements and industrial scaling, solar has grown from a niche technology to an important pillar for electricity production in many countries of the world. For the years to come until 2030, a significant transformation in energy technology is anticipated, with solar PV systems emerging as the most cost-effective source of electricity in most of the regions worldwide, as depicted in Figure 1 in an analysis by Nijsse et al.

By 2027, solar PV is projected to lead the market, offering the lowest levelized cost of electricity (LCOE) across all other electricity producing technologies. This trend underscores the rapid advancements in solar technology and its growing adoption, positioning solar PV as a leading solution in the transition towards sustainable energy systems.

Figure 1

Solar PV will be the cheapest source of electricity in most of the world before 2030



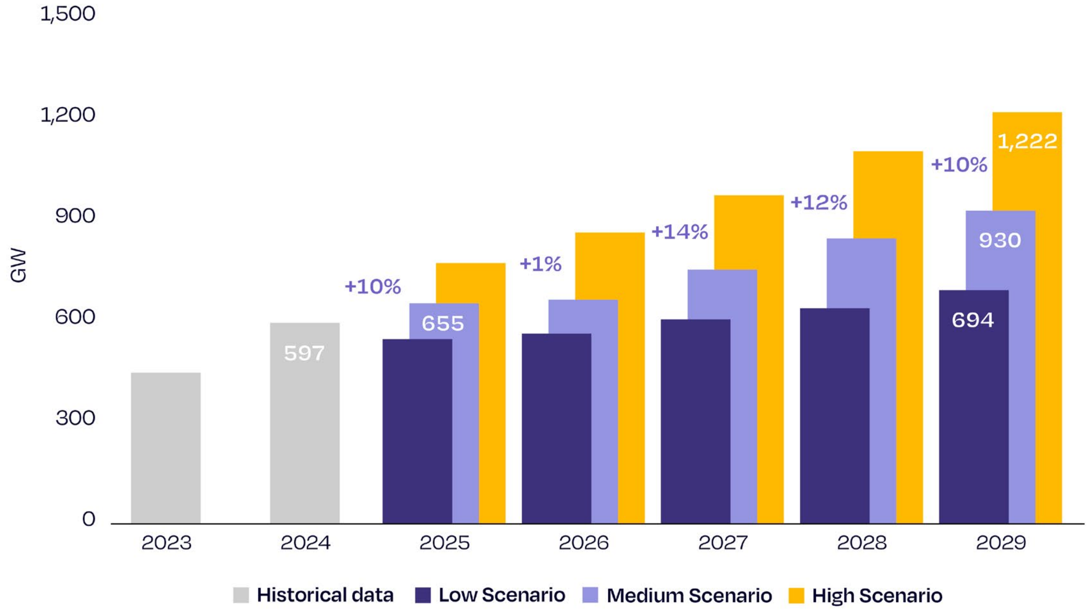
Source: Nijsse, F.J.M.M., Mercure, JF., Ameli, N. et al. (2023)

Despite the impressive cost reduction for solar PV, the forecast for the global PV module demand until 2030 indicates uncertainties in installation levels, with global annual demand projected to range between 694 and 1222 gigawatt-peak (GWp) per year (/a) as shown in Figure 2. A substantial portion of this demand, approximately 50%, is expected to be absorbed by China, highlighting the country's dominant position in the global PV market. Additionally, the distribution of global PV module demand by region will play a critical role in shaping the future landscape of the solar energy sector, as various markets adapt to evolving energy needs and technological advancements.

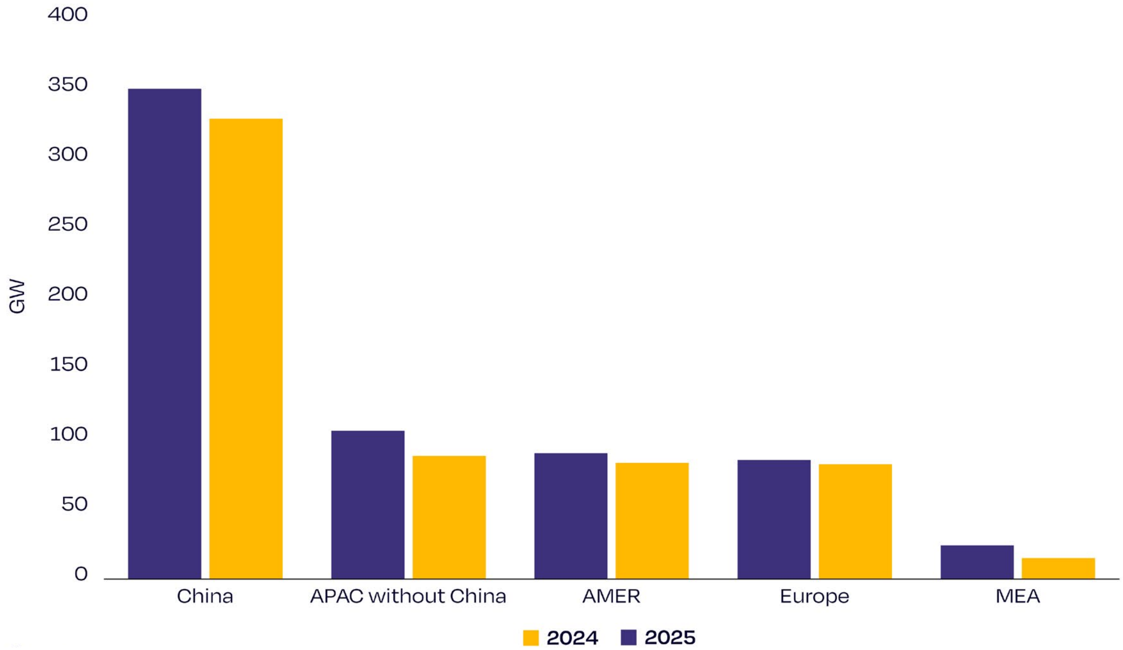
Figure 2

Global annual solar demand between 700 - 1200 GW per year by 2029, China absorbs half today

World annual solar PV market scenarios 2025-2029



Regional solar PV developments 2024-2025



Source: SolarPower Europe (2025) - Global Market Outlook for Solar Power 2025-2029

The expected slowdown in global market growth in comparison to the exponential growth in the past is explained by increasing key challenges in major solar PV markets like China and Europe, but also India, the Middle East and Southeast Asia regarding grid connection and the integration of solar PV into the energy system. Also, in some of these regions, policy stability and transparency as well as land acquisition are expected to hinder a further growing PV market.

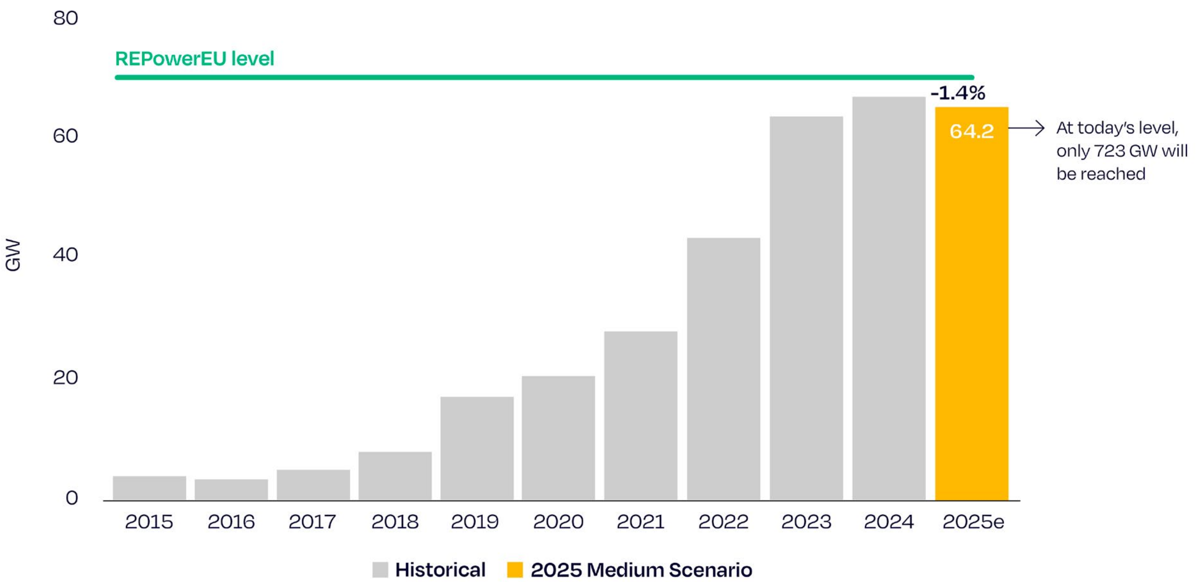
The European PV Market

The deployment of solar capacity in the European Union (EU) is expected to grow in the coming years; however, this growth will occur at lower levels than previously anticipated. According to SolarPower Europe, the EU PV module market is projected to decrease for the first time in 2025 with an annual capacity of 64.2 GWp and thus PV installations in Europe might not reach the REPowerEU target (see Figure 3). This underscores the continued need to support solar, as the sector has already contributed to Europe's energy resilience when it was most needed. Figure 4 shows the expected trend of an increasing share of utility scale systems for the new installation capacity in Europe.

Figure 3

69.6 GW needed annually to reach 750 GW 2030 REPowerEU target

Annual solar PV market 2015-2025 and average market size required to reach 2030 REPowerEU target



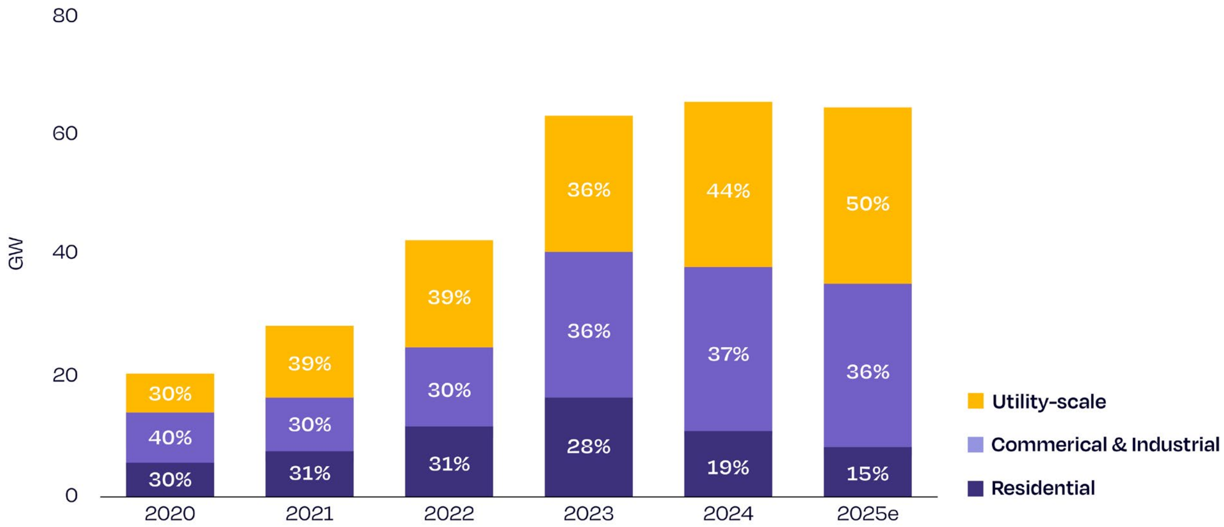
Source: SolarPower Europe (2025) - EU Market Outlook for Solar Power: 2025 Mid-Year Analysis[2]

[2] SolarPower Europe: EU Market Outlook for SolarPower: 2025 Mid-Year Analysis.

Figure 4

Growing ground-mounted solar to cover half of installed solar capacity in 2025

Annual solar PV market per segment 2020-2025



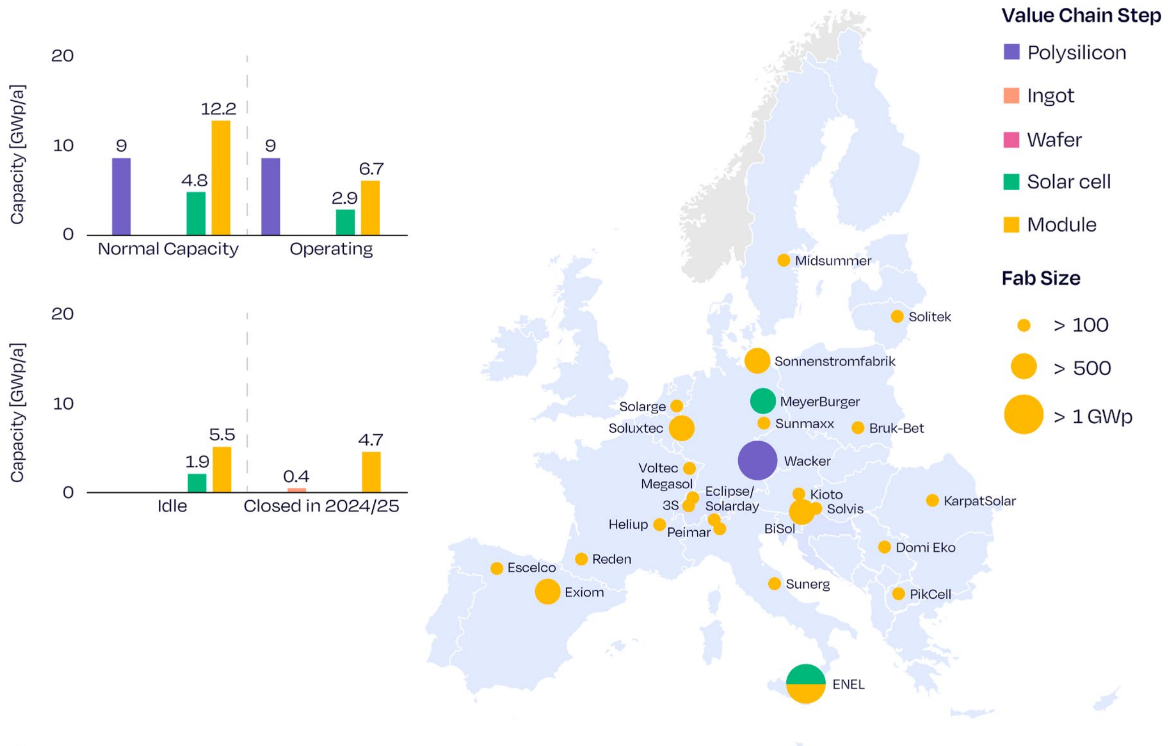
Source: SolarPower Europe (2025) - EU Market Outlook for Solar Power: 2025 Mid-Year Analysis

Figure 5 presents an overview of the current state of PV manufacturing within the EU. The data indicate that operational capacities are limited to polycrystalline silicon (Poly-Si), solar cells, and PV modules. Specifically, there is an idle capacity of 1.9 GWp for solar cells and 5.5 GWp for PV modules. In 2024, 4.7 GWp of module production capacity, along with the entirety of the ingot production capacity, was decommissioned. The right-hand side of Figure 5 visually represents these findings, highlighting regional disparities in manufacturing capabilities and the sector's reliance on specific technologies within the EU.

Figure 5

The EU has limited existing solar PV manufacturing capacity

Solar PV manufacturing value chain capacity across the EU 2025



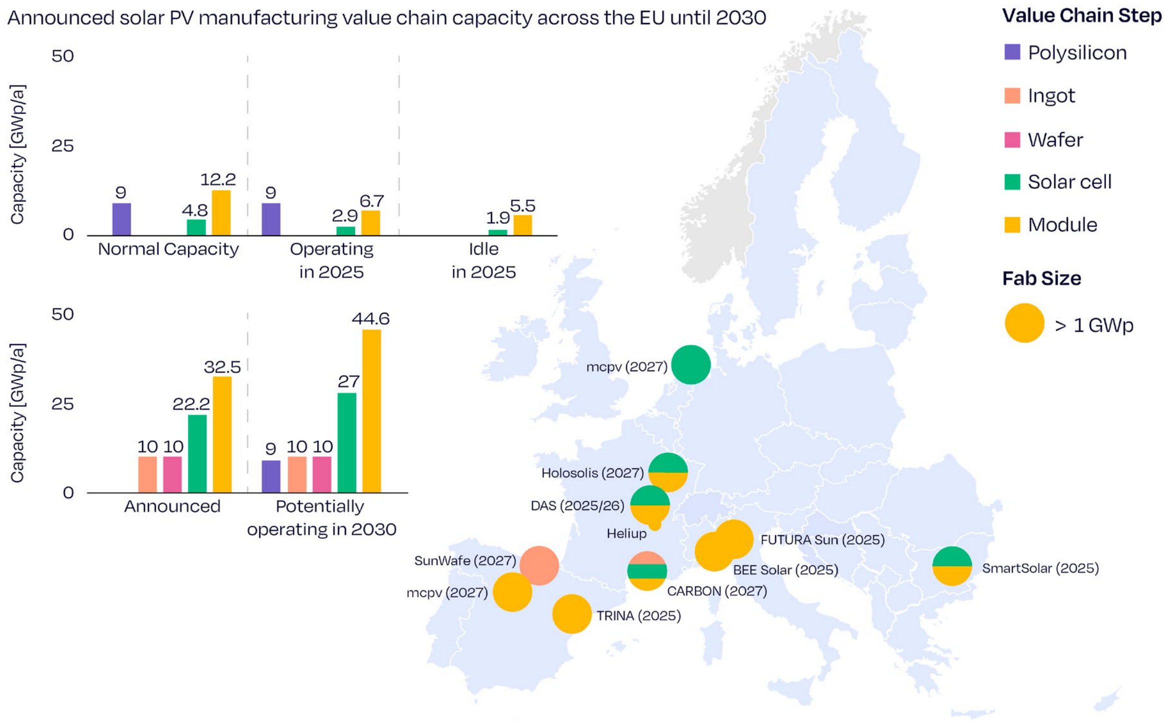
Source: Fraunhofer ISE

Figure 6 presents an overview of the announced manufacturing capacities for ingots, wafers, solar cells, and PV modules on the left-hand side, with respective capacities of 10 GWp, 10 GWp, 22.2 GWp, and 32.5 GWp respectively. Combining the current operational capacity in 2025 to the idle and announced capacities, an optimistic operational capacity of 9 GWp, 10 GWp, 10 GWp, 27 GWp and 44.6 GWp for Poly-Si, ingots, wafers, cells and modules respectively can be achieved in the year 2030.

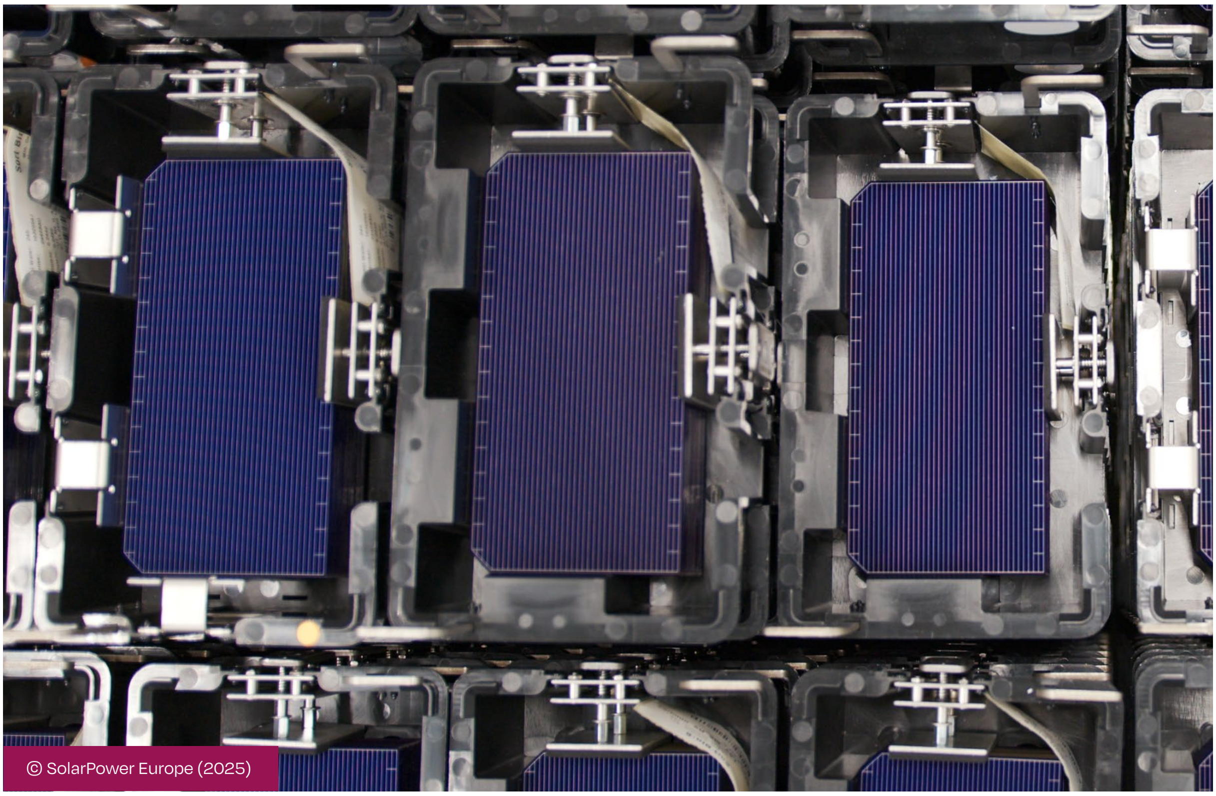
The right-hand side provides a visual representation of these announced manufacturing capacities, illustrating their geographical distribution and the associated manufacturing companies.
This mapping facilitates an understanding of the spatial dynamics within the photovoltaic manufacturing sector.

Figure 6

The EU could add substantial manufacturing capacity across the solar value chain by 2030



Source: Fraunhofer ISE based on public company announcements



Global PV Manufacturing Capacity vs. Demand

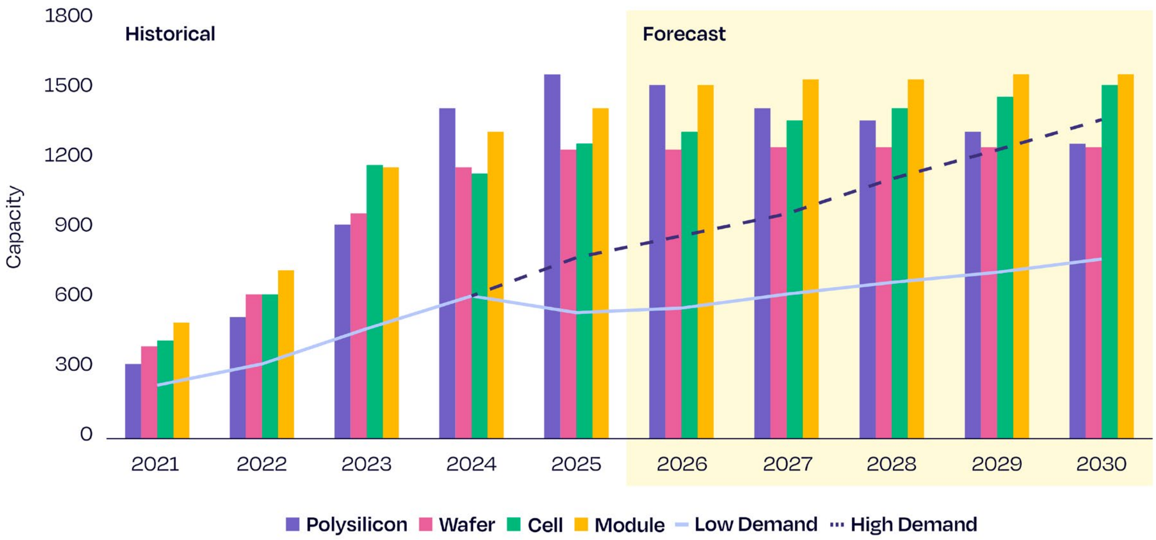
The global PV module production value chain is anticipated to maintain an overcapacity of a factor ranging from +20% to +100% higher depending on the projected low and high PV module demand scenarios, primarily driven by China's dominance across all stages of manufacturing (see Figure 7).

The current significant overcapacity has resulted in PV module sales prices falling below the manufacturing costs of Chinese producers, leading to substantial financial losses for PV manufacturers, including even the largest Tier 1 companies. This unfavorable market condition is expected to persist, with overcapacity likely remaining a challenge for the coming years (see detailed analysis in chapter 2).

Figure 7

Global solar manufacturing overcapacity will decrease, but is expected to remain high

Solar PV module global production capacity vs. demand forecast 2021-2030



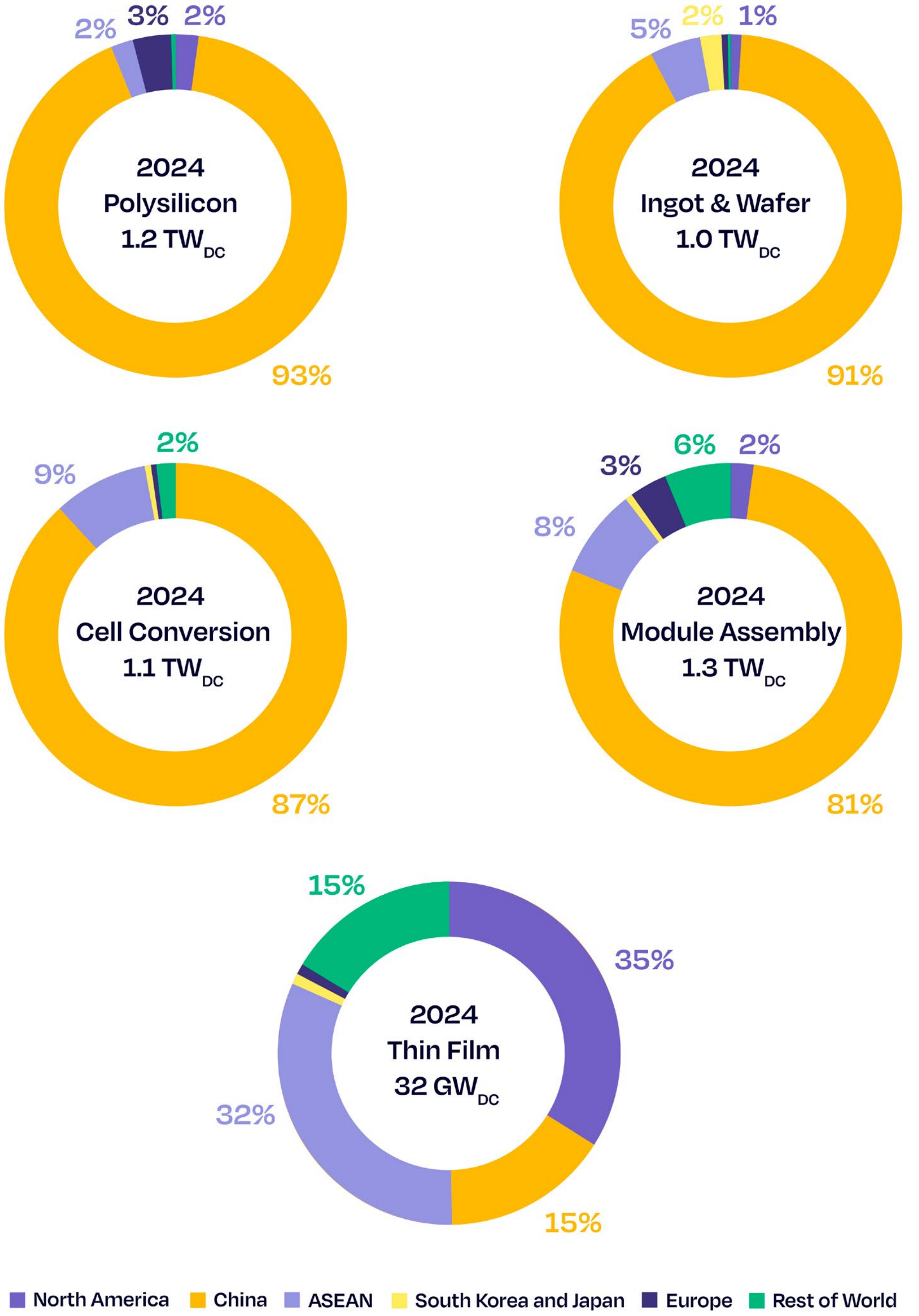
Source: InfoLink White Paper: On the Road to Net Zero

The pie charts on the right hand-side of Figure 8 shows that China supplies between 81% and 93% of the PV components along the value chain, which makes China the dominant country in the global PV manufacturing market. The left hand-side delineates the manufacturing locations in conjunction with the production capacities for each component, thereby highlighting the geographic distribution of PV component manufacturing from non-dominant countries.

Figure 8

Global solar manufacturing is dominated by China

Regional solar PV manufacturing capacities in 2024

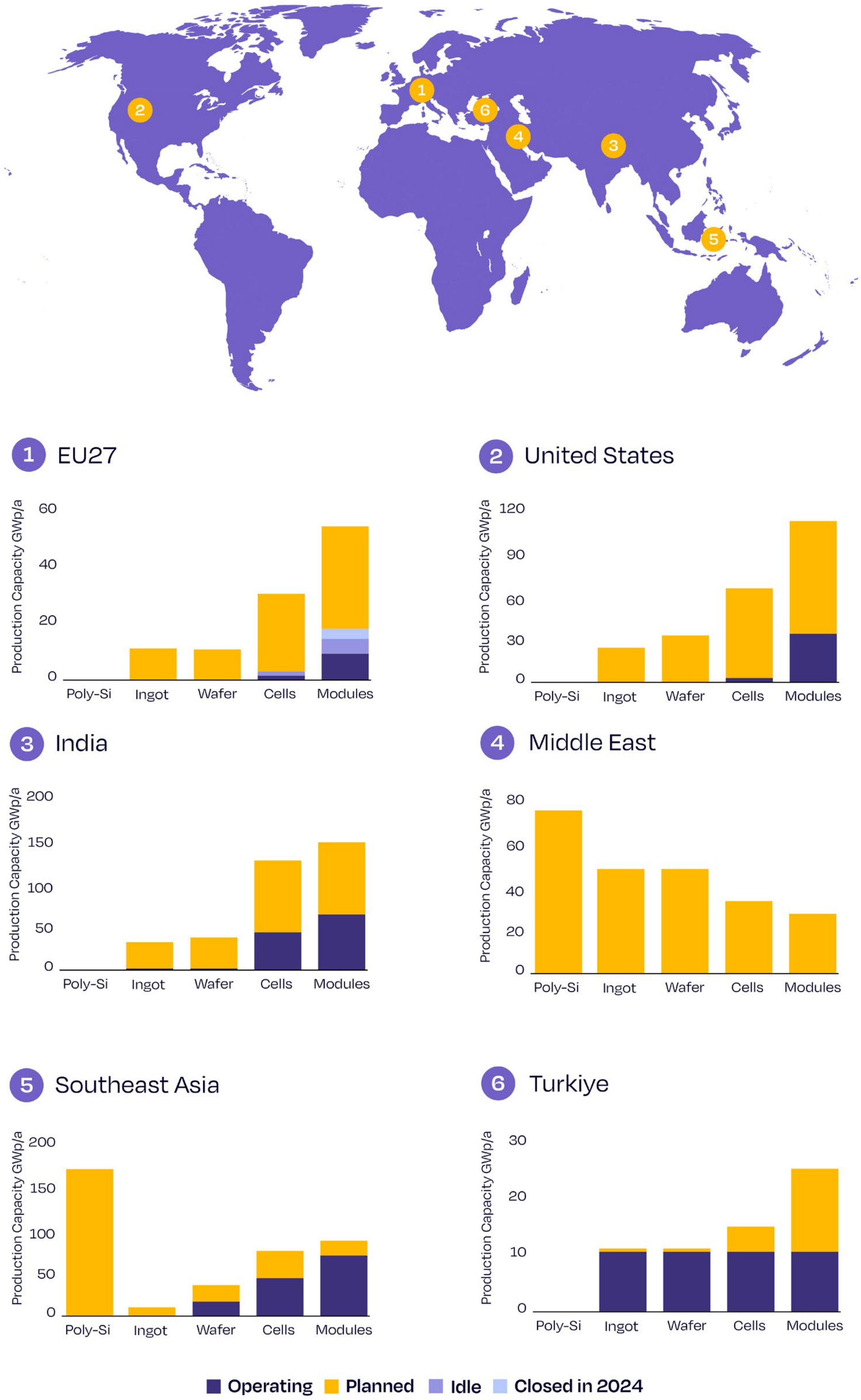


Source: Source: S. Nold, B. Goraya, R. Preu, J. Rentsch, J. Reichle, W. Jooß, P. Fath, M. Woodhouse, "Comparative Global PV Manufacturing Cost and Sustainable Pricing Assessment: China, Southeast Asia, India, USA, and Europe", 41st EU PVSEC, Vienna, September 27th, 2024

Figure 9

Policies and investments around the world are rapidly diversifying solar module

Global operating and announced solar manufacturing capacities 2025 outside China



Source: Fraunhofer ISE based on public company announcements

Figure 9 shows an overview of operating and announced PV capacities outside of China. The announced capacities are based on public capacity announcements from companies. Table 1 on this page sums the operating and announced PV production capacities which can serve as alternatives import options to the dominant supplying country for EU under the Net Zero Industry Act (NZIA). The US is included in Table 1, because it is unlikely that US modules will be exported to Europe due to the significantly higher PV module prices on the US market.

Table 1

Sum of operating and announced/planned PV production capacities and demand in 2030 in GW/a which can serve as alternative import options to the dominating country for EU under the NZIA.

Region	Poly-Si	Ingot	Wafer	Cell	Module	Demand in 2030	Comment
EU	**9**	**10**	**10**	**27**	**45**	**60-104**	**Capacity Build dependent on NZIA**
Türkiye	0	10	10	15	25	3-8	Manufacturing scheme existing (HIT-30)
Middle East	75	50	50	35	30	15-60	Low Electricity Prices & Financing
India	0	30	40	130	150	20-45	Manufacturing scheme existing (PLI)
SE Asia	170	5	40	80	90	5-40	Chinese Owned Manufacturing Hubs
US	31	25	33	68	112	43-60	Inflation Reduction Act (IRA)
Total (available)	285	130	183	355	452		

Source: Fraunhofer ISE based on public company announcements

The EU is projected to have a demand of 60 to 104 GWp/a[3] until 2030. Notably, the anticipated supply capacity from these non-dominant sources exceeds the EU's demand significantly. Furthermore, the planned resilience capacity for the EU, set at 40% of the projected demand, appears to be attainable, indicating a strategic opportunity for diversifying the supply chain within the region.

To summarize the chapter, PV technology is projected to become the most cost-effective source of electricity in numerous regions worldwide before 2030. However, growth in PV demand is encountering various challenges, with the global market anticipated to reach between 700 and 1200 GWp/a and the European market expected to achieve 60 to 104 GWp annually. Despite these growth prospects, overcapacity along the PV module production value chain is expected to persist, with a factor ranging from +20% to +100% higher depending on a high or low PV module demand development, primarily due to China's dominance across all stages of manufacturing. In contrast, potential alternative supply sources from non-dominant countries are forecasted to exceed EU demand significantly, and the planned resilience capacity for the EU, set at 40% of demand, appears to be achievable. A stable and robust local EU solar demand is essential for establishing PV manufacturing in Europe. However, the emergence of various alternative supply regions, like SE Asia, India, Middle East, and Türkiye will impact European manufacturing projects, particularly in the absence of "Made-in-Europe" policies.

[3] SolarPower Europe: EU Market Outlook for SolarPower: 2025 Mid-Year Analysis.

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02

PV Market Projection in Europe by Market Segment under NZIA

The total market for solar PV can be broadly separated into three segments, namely the utility market, the rooftop market and specialty products. Specialty products include more developed applications, like agrivoltaics, and developing concepts, such as vehicle integrated PV (VIPV) or Space-PV. The rooftop market may be further separated into residential, commercial and industrial (C&I) buildings where the larger systems show similarities to the utility segment.

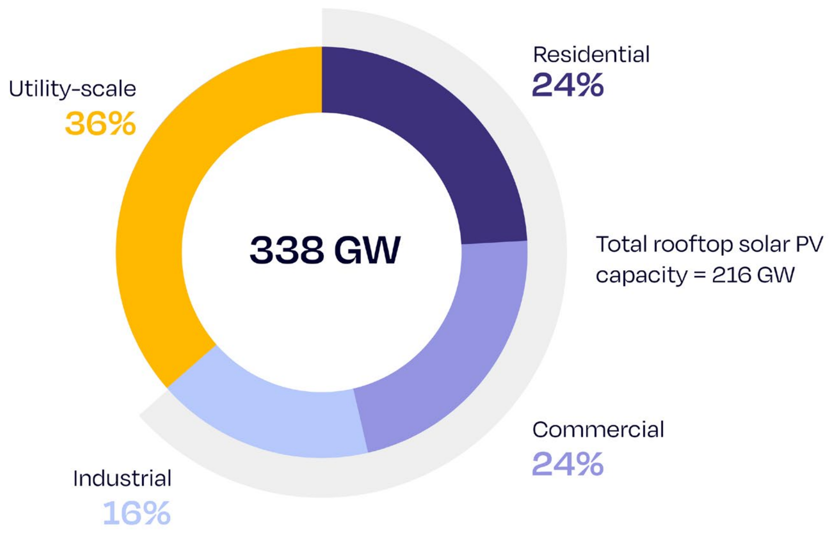
Historically, rooftop PV accounted for roughly two-thirds of EU solar PV installations, but demand in the household segment dropped in 2024 ending the strong absolute growth in 2022 and 2023 fueled by the energy crisis. The utility-scale segments share of the annual EU market rose to 42% of total installations in 2024, signaling a shift toward larger-scale deployment.

Cumulatively, in the European Union, the utility market has a share of 36% of the total installed capacity while total rooftop capacity accounts for 64% with residential rooftops at 24% and C&I at 40% (see Figure 10). This is, of course, different for each EU country. Spain and Germany, for example are very different. Spain has more than 80% share for the utility segment while in Germany the share of the utility segment is below 40%.

Figure 10

Two-thirds of the EU solar fleet is on rooftops

Segmentation of cumulative EU solar PV installations 2024



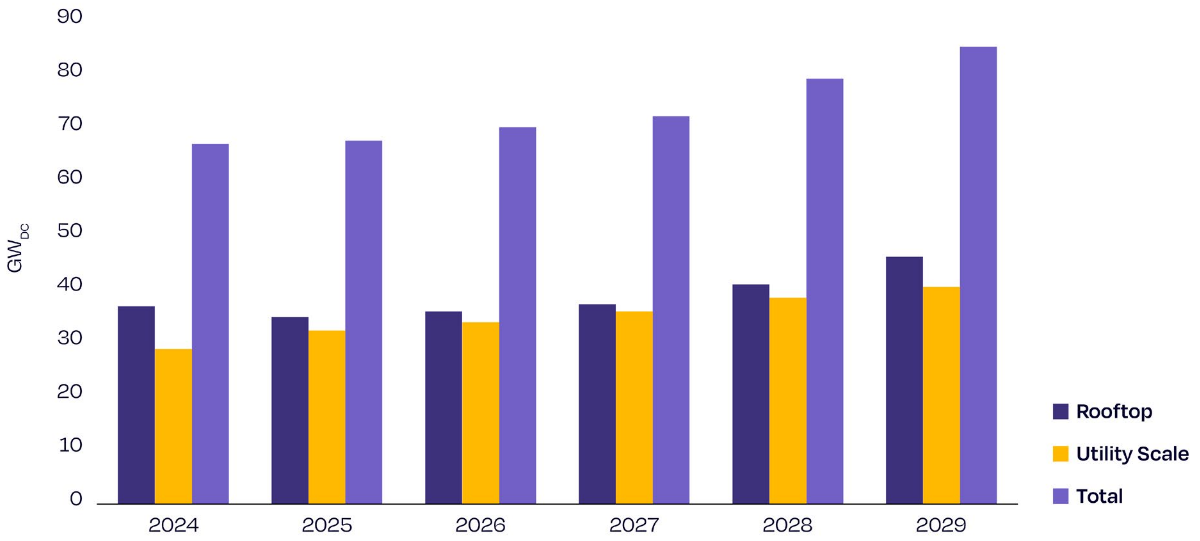
Source: SolarPower Europe, EU Market Outlook for SolarPower 2024-2028

Figure 11 shows the annual historical and forecast PV market segments in the EU for the rooftop and utility scale market for the period 2024 to 2029, based on data from SolarPower Europe. The rooftop segment shows a slight reduction in the period from 2024 to 2025 followed by a gradual increase to 2029. The utility segment shows a constant increase to 2029 and is expected to have a 46% share of the total European PV market in 2029.

Figure 11

EU rooftop and utility-scale solar PV market segments

Annual EU historical and forecast solar PV market segmentation 2024-2029



Source: SolarPower Europe (2025)

The NZIA makes sustainability / resilience non-price criteria a permanent part of public procurement, renewables auctions and other public support. This tilts incentives toward projects and suppliers that can demonstrate EU-based supply chains, social/cyber safeguards, timely delivery and higher sustainability — which helps EU manufacturing and utility-scale pipeline procurement most directly, helps some C&I installations (large public / corporate tenders) and only indirectly helps residential rooftop uptake unless Member States design explicit rooftop support that uses the NZIA criteria.

In plain language, Articles 25 to 28, which relate to market generation measures of the NZIA (Source: EU regulation 2024/1735) correspond to:

Article 25 — Public procurement (minimum requirements / non-price criteria): public buyers must include sustainability contribution and, where relevant, a resilience criterion such as supply-source diversification, social conditions, cyber-security or delivery guarantees in procurement for net-zero technologies. Application timing and scope have transitional rules for very large contracts/central bodies. (Source: EUR-Lex)

Article 26 — Auctions to deploy renewables: Member States' renewable auctions may, and for specific components must, apply the non-price sustainability/resilience criteria as prequalification or award criteria — i.e., auctions can reward/require resilient/sustainable supply chains. (Articles 26 implementing details are subject to Commission implementing acts.) (Source: EUR-Lex; Europäisches Parlament)

Article 27 — (Innovation/skills/sandboxes context): supports regulatory sandboxes, skills and innovation measures that reduce time-to-market for new net-zero technologies — useful for emerging PV technologies and balance-of-system innovation. (Source: EUR-Lex)

Article 28 — Other forms of public intervention: grants, incentives, loan support or state aids that deploy net-zero technologies must consider sustainability/resilience criteria too (so public rooftop subsidy schemes, industrial grants, etc., can include the same non-price rules). (Source: EUR-Lex)

Outlined below are plausible directional impacts to the respective PV market segments caused or amplified by applying Articles 25–28 of the NZIA.

Utility-scale (ground-mount / large PV)

remains the largest share of new capacity (roughly ~40–45% of annual additions in the 2025–30 window under central scenarios).

NZIA effect: Public procurement and auction rules mean large public tenders and auctioned projects can be structured to prefer bids with resilience guarantees and sustainability credentials — advantaging developers who source modules/inverters from outside the dominant source of supply or can credibly demonstrate diversified supply. That will support utility pipelines where public purchasing or subsidy-backed PPAs dominate. Given the price sensitivity of this segment, the additional cost of non-price criteria need to be addressed in the national implementations of the NZIA.

Commercial & Industrial (C&I) rooftops

remains large with ~30–40% of annual additions depending on the country (corporate procurement, industrial off-takers).

NZIA effect: Large corporate and public C&I tenders can be designed to use Article 25, 26 or 28 favouring integrators that provide resilience and sustainability features. This helps larger C&I projects more than small commercial rooftops. If Member States include rooftop subsidy programmes under Article 28 with resilience bonuses, C&I could gain a faster recovery. (Source: SolarPower Europe)

Residential rooftops

While forecasts show residential share falling to 10-20 % of annual additions in 2025–26, it is expected to recover towards 2030 driven by EU solar rooftop policies, especially on public buildings. (Source: EU Solar Standard - SolarPower Europe)

NZIA effect: indirect / small unless targeted. Article 25 primarily covers public procurement, , particularly relevant for rooftop solar on public buildings, and a less direct effect on private consumer buying. Article 28 can cover grants and subsidy schemes — so if Member States choose to ring-fence support for residential systems and add a sustainability/resilience bonus that favours EU-sourced modules or installers meeting social/cyber standards, the residential segment could benefit. However, without explicit national rooftop programmes using NZIA flexibilities, residential uptake is more sensitive to retail incentives, financing and grid rules than to NZIA alone. (Source: EUR-Lex; Europäisches Parlament)

PV Auction Market

The measures for grid connection of small-scale PV remain among the more straightforward auctions for renewable energy (Art. 26) mainly influence utility-scale projects, through weighted criteria, resilience/sustainability requirements, and periodic reassessment. Importantly, small projects (up to 10 MW under Art. 26(10)) may be exempt from volume calculations or treated separately. Article 26 stipulates that 30% of auctions should use NZIA criteria (sustainability, resilience, etc.) when evaluating bids.

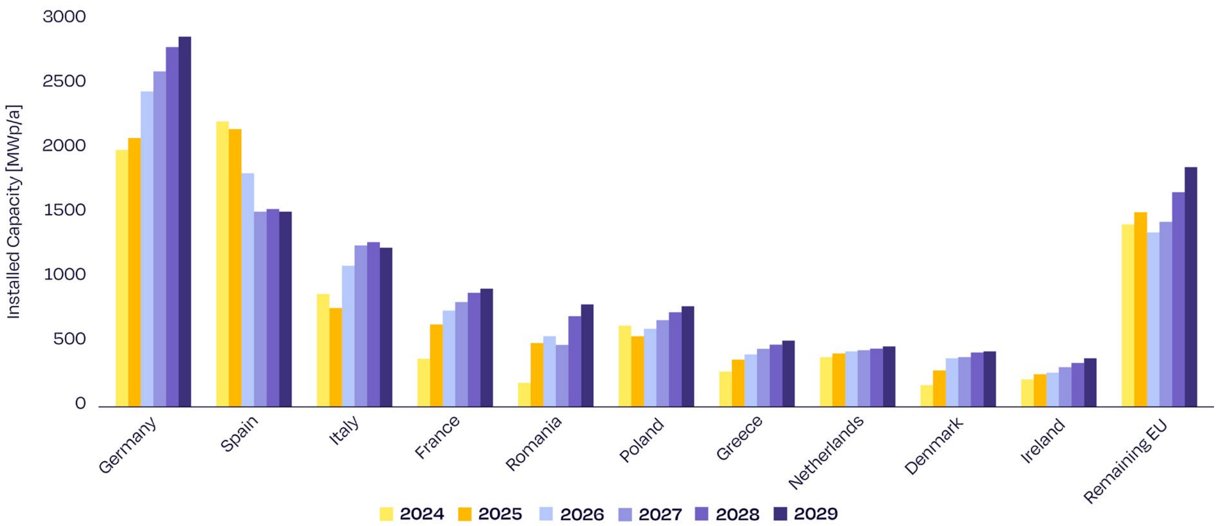
Assuming that the total utility scale market is tendered through auctions and considering the size of the utility scale market based on Figure 12 for the period 2024 to 2029, the market for NZIA auctions can therefore be estimated and is as shown in Figure 12 for the 10 largest European countries as well as a sum for the remaining European countries. Germany has the largest auction market of 2 to 3 GWp/a followed by Spain and Italy with 1 to 2 GWp/a until 2029.

Consolidating the individual countries, the PV auction market in Europe amounts to between 9 and 12 GWp/a (approximately 13% to 14% of the total European PV market) for the period 2024-2029.

Figure 12

In theory, NZIA utility-scale auctions could stimulate EU demand for 61 GW of resilient solar by 2029

Top 10 EU countries solar PV auction markets under NZIA scope (30% of total market), 2024-2029



Source: SolarPower Europe (2025)

Market for Building PV Rooftops

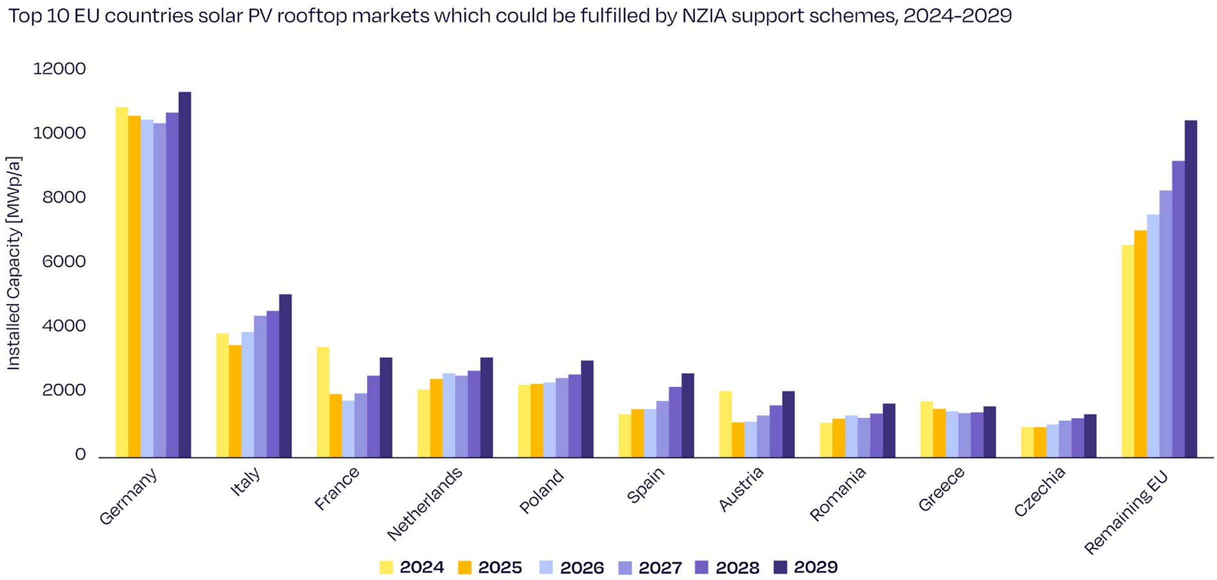
The building PV rooftops segment in the EU is on average larger than the utility PV segment (see Figure 11), but no implementation act or detailed rules have been published by the European Commission on the addressable NZIA segment within the building PV rooftop market. The rooftop segment is mainly addressed in Article 28 of the NZIA as "other forms of public intervention". The rooftop market can also fall under Public Procurement (Art. 25) and, to a lesser extent, auctions (Art. 26).

Assuming the entire European PV rooftop market to fall under the purview of Article 28, we can plot the estimated Article 28 market, as shown in Figure 13, for the 10 largest European countries as well as a sum for the remaining European countries.

Since no other information is available to this date, the total PV rooftop market is estimated to be between of 34-45 GWp/a (approximately 52% to 54% of the total PV market) for the period 2024-2029 for the whole of Europe.

Figure 13

In theory, NZIA support schemes could unlock 228 GW of EU demand for resilient rooftop solar



Source: SolarPower Europe (2025)

Market for Public Procurement

The market for public procurement is likely to be a market for rooftop modules (roofs of schools, administration buildings, hospitals). The European Commission[4] estimates that 3% of the total PV market can be assumed to fall under public procurement. Using this number and the size of the annual total PV market, one arrives at 2 GWp/a of public procurement in the EU for the period 2024 to 2029. Other studies [1] estimate that the PV potential on public buildings nationwide amounts to

[4] Personal communication by EU Commission.

between 2% and 4% of the total potential on building roofs which would equate to between 1.3 to 2.7 GWp/a in public procurement in EU27.

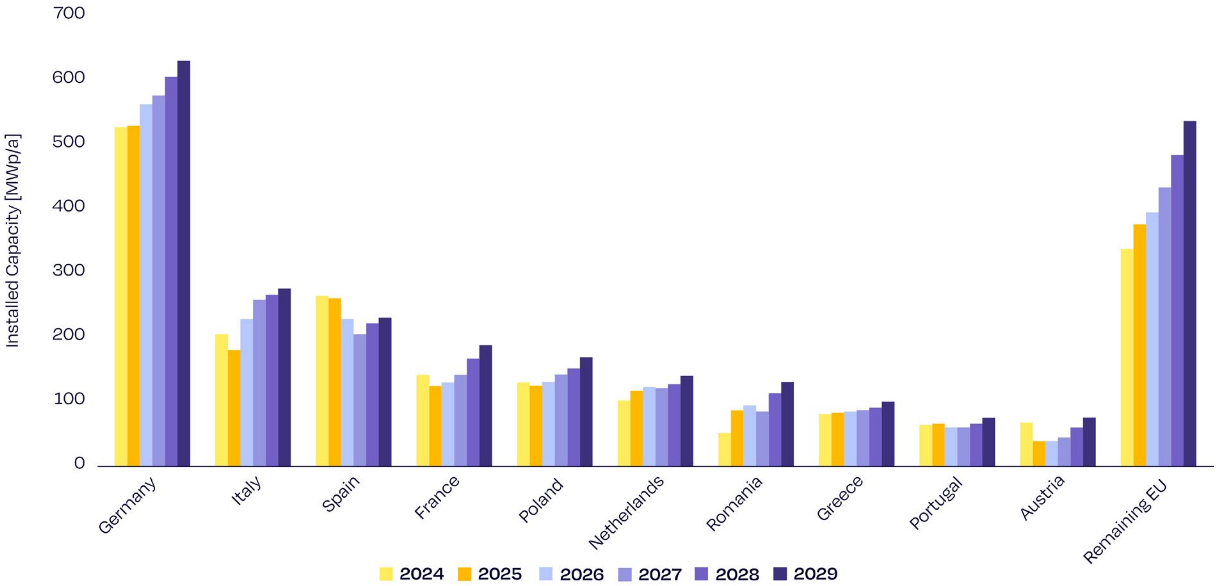
Assuming 3% of the entire European PV market to qualify for public procurement under Art. 25, we can plot the estimated Article 26 market, as shown in Figure 14, for the 10 largest European countries as well as a sum for the remaining European countries.

This is estimated to be 2 GW/a or 3% of the total PV market.

Figure 14

NZIA public procurement rules could unlock 13 GW of EU demand for resilient solar

Top 10 EU countries publically procured solar PV under NZIA scope, 2024-2029

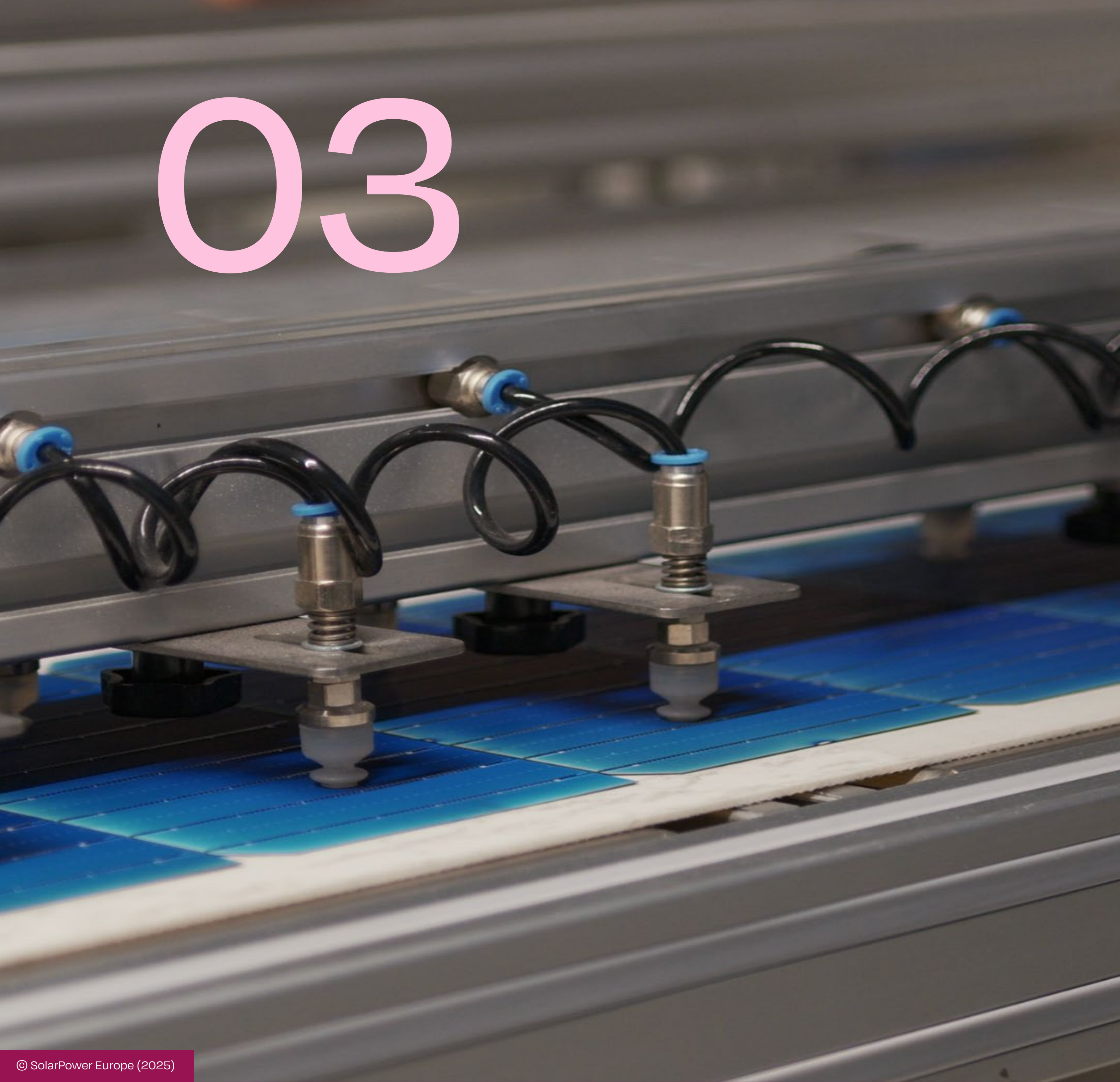


Source: SolarPower Europe (2025)

Total PV Market Projection under NZIA

In summary, consolidating the projected PV market segment shares for auctions, rooftops and public procurement from the estimations above, the total market potential for PV under the NZIA is estimated to be in the range of 46-60 GWp/a or about 70 % of the total PV market for the period 2024-2029.

Since important information on some market segments is still missing (i.e. an Implementation Act on Article 25) and national authorities may implement rules not covering the whole market (i.e. for rooftop PV) or extending the market (i.e. utility PV for more than 30% of the auctions). A final estimate on the total NZIA market is therefore not yet possible.



03

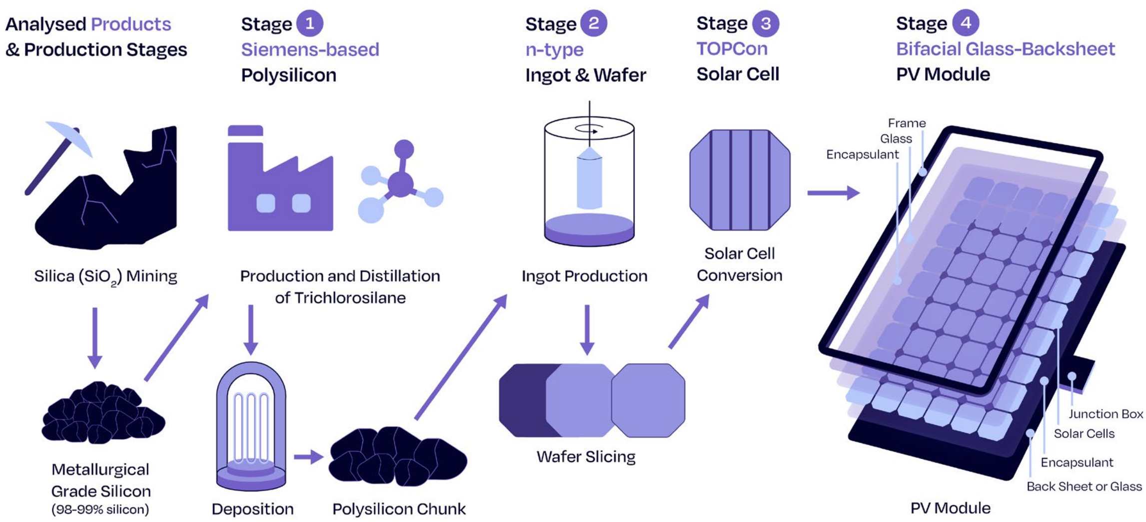
Comparing cost gap analysis for European PV Manufacturing

Production cost analysis for solar PV manufacturing in different global regions

The analysis of "fully-local" solar panel manufacturing in different parts of the world shows that there are big differences in costs, especially between production in Europe and in China. In 2024, the authors of Fraunhofer ISE together with PV cost analysis specialists from the US research institute NREL as well as from RCT Solutions GmbH conducted a "Comparative Global PV Manufacturing Cost and Sustainable Pricing Assessment: China, Southeast Asia, India, USA, and Europe". The study analysed the production costs for each PV production stage from Polysilicon to the PV Module as depicted in Figure 15.

Figure 15

Product and manufacturing stages along the solar PV value chain



Source: S. Nold, B. Goraya, R. Preu, J. Rentsch, J. Reichle, W. Jooß, P. Fath, M. Woodhouse, "Comparative Global PV Manufacturing Cost and Sustainable Pricing Assessment: China, Southeast Asia, India, USA, and Europe", 41st EU PVSEC, Vienna, September 27th, 2024

The methodology for the study is based on anonymised data input by NREL, RCT, and ISE for each manufacturing stage which is aggregated in a joint cost model. The joint cost model calculates the direct cost of goods sold (COGS) for a state-of-the-art greenfield production based on the PV technology depicted in Figure 15 and includes overhead costs, debt payments, and a minimum sustainable net-profit margin of 5% for the PV manufacturer at each stage. Thus, the Minimum Sustainable Price (MSP) herein is defined as the sum of the COGS and the overhead and profit for each production stage.

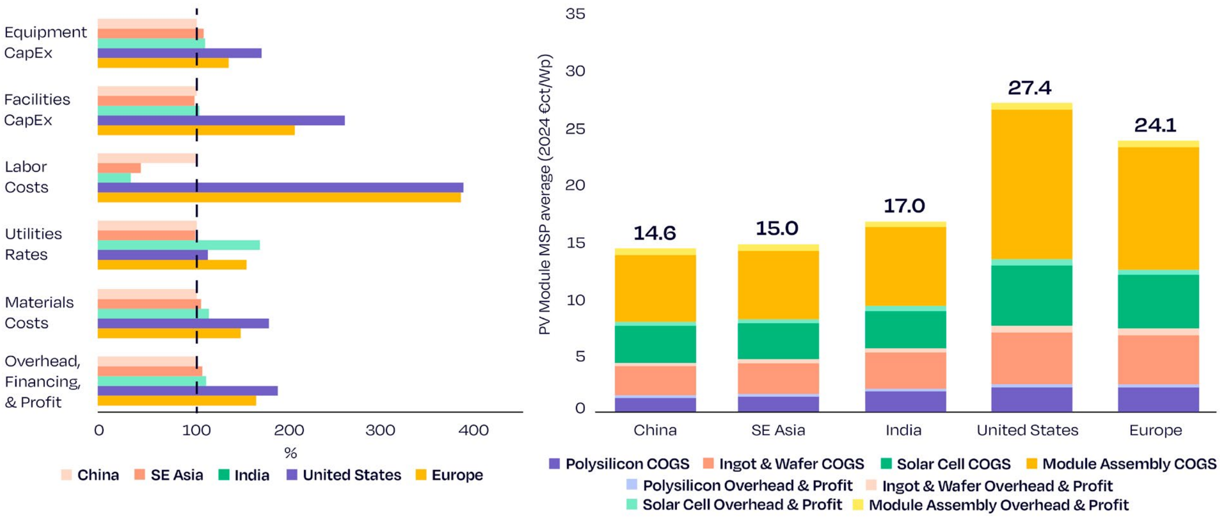
Based on the results of the authors cost analysis, the graph on the lefthand side of 6 presents a relative comparison of the key cost drivers for PV manufacturing among the analysed different global regions. The relative cost driver differences are weighted averages over all stages from polysilicon to the PV module. China is set as reference with 100% with the other global regions are compared with. The comparison of European key cost drivers (blue bar) compared to China (red bar) reveals significantly higher costs for manufacturing in Europe. The Equipment CAPEX for European factories is about 40% higher when using Western production equipment in contrast to Chinese equipment being used in Chinese factories. Building and Facility CAPEX costs are about +110% higher; Labor costs are about +280% higher due to wages and working hours; Utilities such as electricity and water are about 60% higher; Material costs are about 50% higher with a local bill of materials.

Even though overhead costs, financing, and profit are assumed to be the same percentages relative to the COGS, these add more to the MSP in €ct/Wp for Europe due to the higher COGS-base in Europe. It is important to note that each cost driver has a different weighting at each component manufacturing stage: PV module manufacturing is dominated by 80-90% of material costs, while polysilicon manufacturing is dominated by CAPEX-related costs and utility rates.

Figure 16

Solar module production in China is around 40% cheaper than in Europe, almost 50% than in United States

Cost difference in different regions of production for Photovoltaics (left) and resulting PV module production costs (right)



Source: S. Nold, B. Goraya, R. Preu, J. Rentsch, J. Reichle, W. Jooß, P. Fath, M. Woodhouse, "Comparative Global PV Manufacturing Cost and Sustainable Pricing Assessment: China, Southeast Asia, India, USA, and Europe", 41st EU PVSEC, Vienna, September 27th, 2024

Figure 17 presents the total PV module MSP results of the NREL/RCT/ISE cost analysis. The production cost analysis reveals that costs of PV manufacturing is significantly higher in Europe and the United States in comparison to the established manufacturing hubs China, Southeast Asia as well as to the emerging manufacturing region India.

The overall cost difference between Europe and China stem mainly from variations in material costs and CAPEX-related costs. Consequently, the minimum sustainable price (MSP) for a "fully-local" manufactured TOPCon PV module in Europe is estimated to be approximately 9.5 €ct/Wp higher than the MSP in China and 9.1 €ct/Wp higher than the MSP in Southeast Asia. India exhibits an about 2.0 €ct/Wp higher MSP than China.

Discussion on cost gap analysis

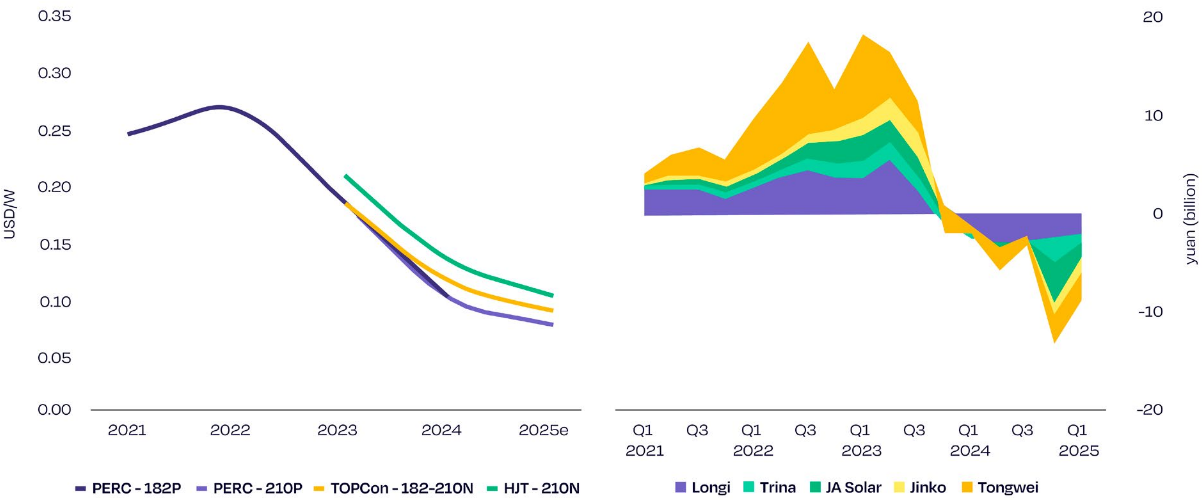
It is important to note, that the scale of production significantly influences the cost gaps in the PV sector. The presented analysis was performed for fully scaled PV production facilities with an annual production capacity of 10 GWp/a. A new entrant in PV production in Europe will first need to scale its production and build its supply chain. This it is expected that reshoring production to Europe will at first lead to higher costs as presented in this analysis. It is also important to note that the presented cost gap analysis does not include transport costs from the manufacturer country to Europe. Here a European manufacturer would have an advantage over suppliers from abroad, who need to additionally ship their PV modules to Europe adding transport-related costs of about 1.5 €ct/Wp to the final PV module price.

Global solar PV manufacturing overcapacity has led to PV module prices falling significantly below the before presented Minimum Sustainable Prices, resulting in substantial financial losses for PV manufacturers. From Q4 2023 onwards, PV module prices outside of China (Non-China) have been falling below 16 €ct/Wp. According to BNEF, as shown in Figure 17 in the right graph, the five leading PV manufacturers were all making losses since Q4 2023 onwards. In the first quarter of 2025 alone, the five leading Chinese PV manufacturers are projected to incur losses of approximately € 1.0 billion. This situation highlights the severe economic challenges facing the PV industry amidst the prevailing overcapacity conditions. In response, the China Photovoltaic Industry Association (CPIA) issued an industry self-regulation initiative, calling for fair competition among Chinese PV companies and the promotion of high-quality sector development. And in the summer of 2025, the Chinese government convened high-level PV industry meetings, urging manufacturers to address severe overcapacity and curb cut-throat, low-price competition. (Source: TaiyangNews)

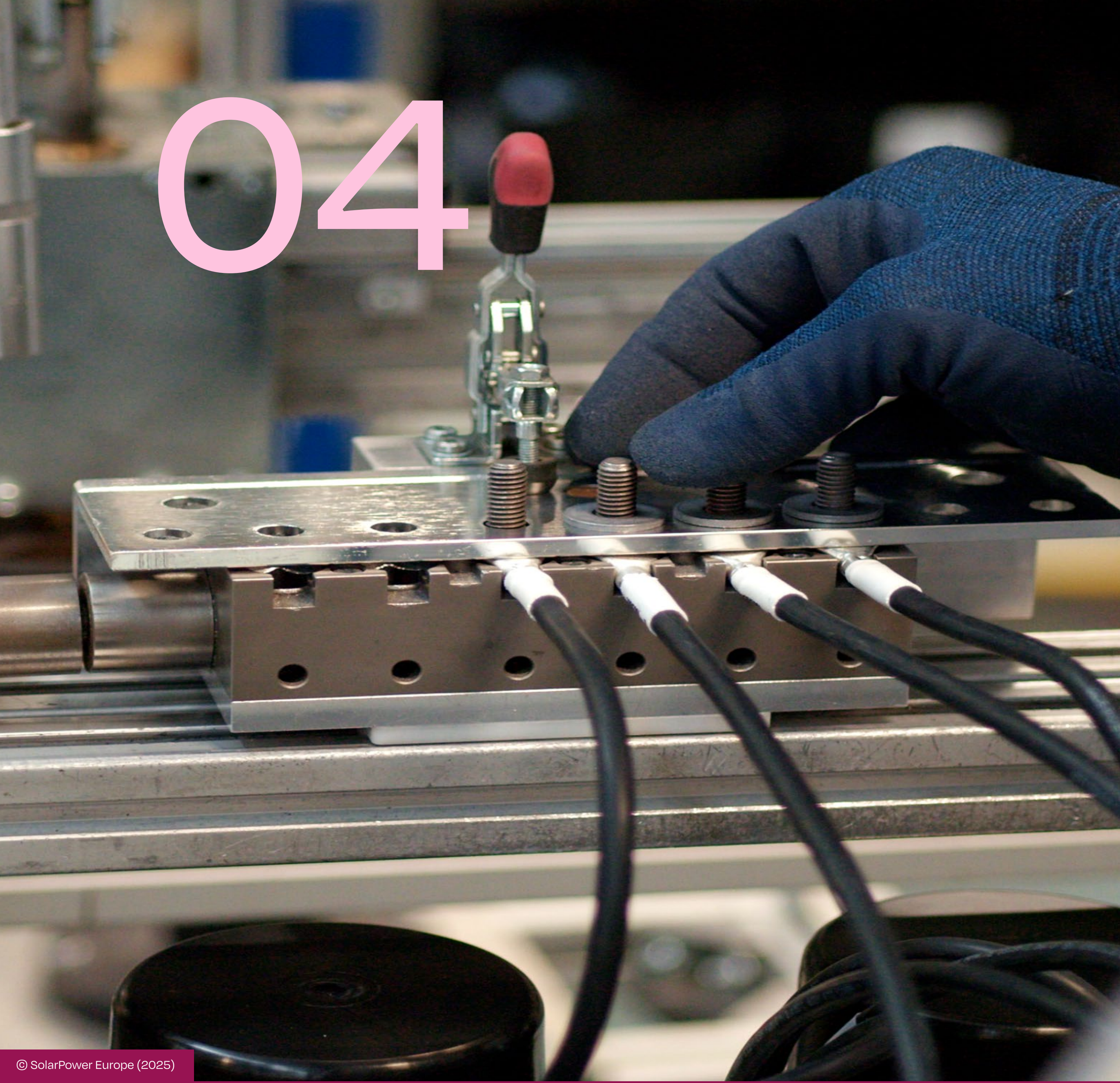
Figure 17

PV Manufacturing Cost Are Higher than PV Module Prices since Q4 2023

Global PV Overcapacity and Financial Losses



Source: InfoLink White Paper: https://www.infolink-group.com/market-report/whitepaper (left graph), https://www.energyconnects.com/news/renewables/2025/april/chinese-solar-losses-deepen-even-before-worst-of-us-tariffs/ (right graph)



What combination of regulatory and financing measures can help to fill the establisherd cost gap?

Overview of Finance Support Instruments for the PV industry in Europe

The EU and as well as national governments have stablished a variety of programs to support innovative and cleantech industries in Europe. The following table summarises a selection of existing policies schemes in the EU.

Table 2

Overview of Policy Schemes in the EU

Policy Scheme	Budget	Focus Area	PV Relevance
Horizon Europe	€95.5 billion (2021–2027); €73 million/a for PV	R&I, competitiveness, decarbonization	Supports PV innovation and cost reduction; relevant for PV pilot lines with high TRL
Innovation Fund	~€40 billion (2020–2030); €4.8B for industry/clean tech	Deployment & manufacturing of innovative clean tech	Supports industrial PV projects and pilot lines
InvestEU	€279 billion (within Green Deal)	Green transition, innovation, skills	Funded Exeger and Solaria; applicable to PV manufacturing and deployment
REPowerEU Plan	€210 billion by 2027	Energy independence, renewable rollout	Deployment-oriented; indirect support for PV pilot lines
Solar Energy Strategy	No direct budget	Strategic PV deployment, rooftop solar	Deployment-focused; limited support for manufacturing pilot lines
Clean Industrial Deal	€100 billion Industrial Decarbonisation bank - 1bn pilot project	Focus on industrial electrification, support made-in-EU clean tech, lower power bills	Unclear what amount is available for clean tech manufacturing; strong PV pilot line support.
European Solar Charter	No direct budget	Commitment to solar PV manufacturing	Directly targets PV manufacturing in EU; promotes pilot lines with member state support
European Innovation Council Fund (EIC)	€3.5 billion	Venture investment in breakthrough tech	Possible support for pilot lines (Pathfinder/Transition/Accelerator); limited PV track record
European Investment Bank (EIB)	€21B/year energy; €2B in PV in past decade	Energy, innovation, infrastructure	Offers venture/project/corporate debt; potential for PV pilot line financing as venture debt if up to 3,000 employees
European Investment Fund (EIF)	Not specified	SME financing, innovation, sustainability	Limited history with PV; supports strategic energy investments (e.g., REPowerEU alignment)

Source: Fraunhofer ISE based on public company announcements

For this study it has been decided to not identify and analyse each of the existing policy schemes in Europe for their effectiveness to support a reshoring of PV manufacturing in Europe. SolarPower Europe has published a State of Play report on the Support for European Solar Manufacturing at the end of 2024 which does a deep dive into the different EU and national support mechanisms. (Source: SolarPower Europe)

Structuring Finance Push Policy Instruments

The general approach for analysing the impact of potential policy instruments to reshore solar manufacturing to Europe involves firstly collecting potential finance-push and market-pull policy measures, including finance-push instruments (as e.g. rebates and subsidies, tax credits, feed-in tariffs, reduced VAT, loans and grants, production-linked incentives, OPEX support, etc.) and market-pull criteria (a dedicated market segment, resilience criteria, sustainability criteria).

For each finance-push and market-pull measure, the beneficial stakeholder can be identified (e.g. PV manufacturer or PV system owners/operator), who would benefit from the policy instrument. The impact of the policy measure can then be assessed regarding its impact on key cost elements, namely PV module or inverter prices, overall PV system prices, and the levelized cost of electricity (LCOE).

The approach further analyses cost gaps for every policy measure using the PV manufacturing cost model, PV system cost analyses, and LCOE or bidding-price analyses. It also considers potential market impacts, such as the effect of NZIA auctions on the utility market, implications for public procurement, and impacts on PV rooftop and private PV markets.

Table 3 structures potential Finance Push Policies for Photovoltaics and is the basis for the following cost gap analyses.

Table 3

Structuring of potential Finance Push Policies for Photovoltaics

Finance Push Policies for:	PV Manufacturer	Impact on costs/price?
CAPEX	EU Innovation Fund, EIB suppport, Member State Support	CAPEX support (Mn€/GWp)
OPEX	Electricity price reduction, Labour, Materials, ...	Cost reduction (in €ct/Wp)
Financing	Reduced financing interest rates (e.g. through EIB)	Reduced debt interest rate
Output-based	Production Support/Tax Credit (as e.g. 45X in IRA, PLI in India)	Refund per Wp (e.g. direct support or Tax credit)

Finance Push Policies for:	PV owner/operator/developer	Impact on costs/price?
CAPEX	Investment Tax Credit, VAT reduction, Investment refund	Refund per kWp
OPEX	n.a.	No relevant OPEX impact
Financing	Reduced financing interest rates (e.g. through EIB)	Reduced debt interest rate
Output-based	Production Tax Credit (USA) / Feed-in tariff bonus/adder	Refund/Award per kWh

Source: Fraunhofer ISE based on public company announcements

Overview of Global Governmental Support for Solar PV Manufacturing

The analysis in OECD TRADE POLICY PAPER NO. 289 provides firm-level evidence on government support to solar PV cells and modules and wind turbines across 2005-23, with a detailed focus on solar PV manufacturing. It finds that subsidies have been larger for solar PV manufacturing than for wind, and that China has long been the dominant recipient of support, with the Organisation for Economic Co-operation and Development (OECD) measures intensifying notably in 2023 in response to policy developments such as the Inflation Reduction Act (IRA) in the United States.

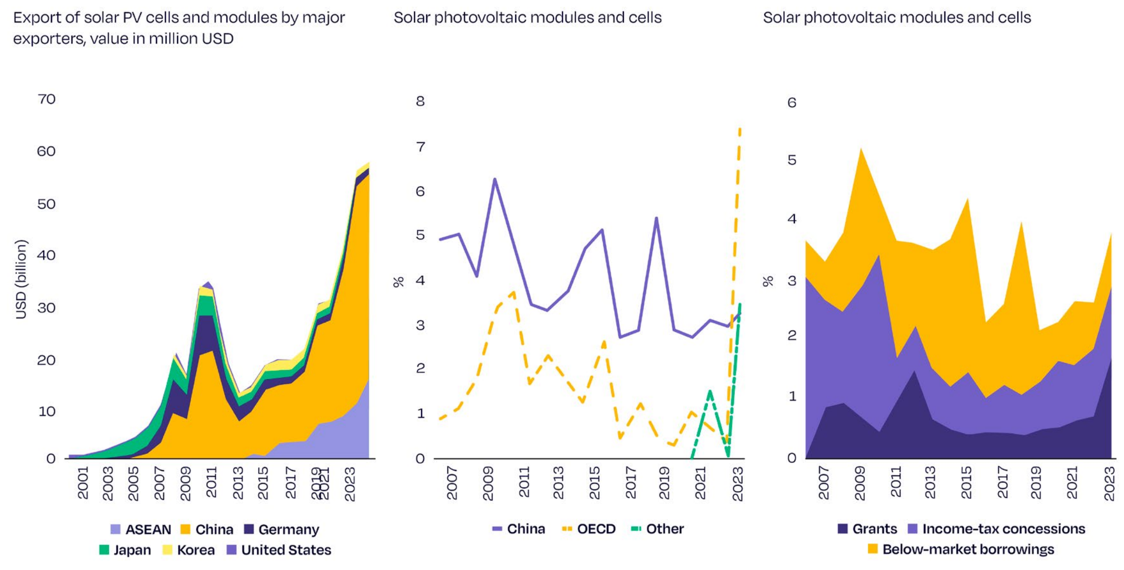
These patterns illuminate the trade-offs governments face between decarbonisation objectives, fair competition, and supply-chain resilience as manufacturing activity concentrates in China and, more recently, in Southeast Asia. The report emphasises how demand-pull policies and supply-side subsidies interact to shape capacity, prices, and trade, yielding both deployment benefits and structural market distortions. In the report, governmental subsidies are reflected as combined effect of

- government grants
- corporate income-tax concessions
- below-market borrowings

The report shows that grants and tax concessions have been significant, but below-market borrowings have often been the dominant channel for Chinese solar producers. Figure 18 shows graphs from the report. The left graphs shows that China and ASEAN countries are the main exporters of solar cells and modules with an export volume of close to 60 Bn USD in 2023 and a market share being close to 100%. The graph in the middle shows the historic governmental subsidy levels in China and OECD countries. Across the solar PV value chain, subsidies as a share of firm revenue are well above 3% with up to 5% of revenue for solar cells and modules and thus significantly larger than in other OECD countries, where the subsidy level has been below 1% between 2016 and 2022. Since 2023, the OECD level has significantly increased, mainly due to the Inflation Reduction Act (IRA) coming into force in the US.

Figure 18

Global Governmental Support for Solar PV manufacturing



Source: OECD TRADE POLICY PAPER NO.289

Impact assessment of Finance Push Policies on EU PV Production Costs

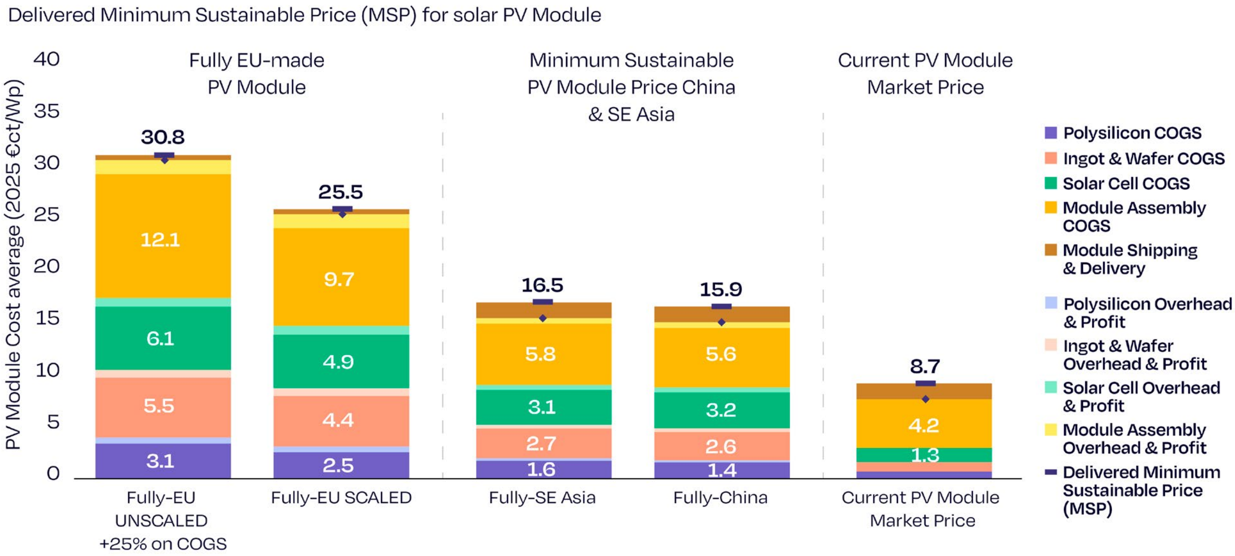
The global comparative cost gap analysis in chapter 3 shows that economically sustainable PV Module manufacturing in Europe including its upstream components (cell, ingot & wafer, polysilicon) incur significantly higher production costs as a sustainable manufacturing in China and Southeast Asia (SE Asia).

Figure 19 shows the results of the previous study, including costs for 'Module Shipping and Delivery' to Europe. Based on typical shipping costs and container loads, 1.5 €ct/Wp has been taken for transport from China or SE Asia to Europe, and 0.5 €ct/Wp has been taken for transport within Europe, which reduces the cost gap by 1.0 €ct/Wp compared to the previous results.

Figure 19 also includes additional cost bars on the left that are important to bear in mind. It is important to note, that all previously presented cost analysis results have been based on full-scaled PV production facilities with 10 GWp annual output. Production facilities with this size have up-to-now not been realized in Europe. An unscaled PV production facility (e.g. smaller than 3 GWp/a for solar cell manufacturing) will lead to higher manufacturing costs in each manufacturing stage due to an increase in factory CAPEX/GWp, a decrease in buying power when ordering smaller quantities as well as to higher overhead costs of the plant. For PV module manufacturing lower production capacities (even <1 GWp/a) can be competitive, as module manufacturing is significantly less CAPEX intensive and dominated by the cost of materials. We assume an increase of 25% in manufacturing costs as an optimistic average throughout all component manufacturing stages. All presented costs analysis do assume the costs of fully utilized facilities and do not include the initial ramp-up phase, which leads to a significant manufacturing cost increase as 25% for an unscaled production.

Figure 19

The current PV module market price is half the minimum sustainable price for Chinese & Southeast Asia modules and three times lower for European modules[5]



Source: Fraunhofer ISE

The center bars in Figure 19 show, that the minimum sustainable price (MSP) is higher than current market prices. Even large Tier-1 Asian PV manufacturers operating at a loss would require prices above current levels. Consequently, PV market prices are expected to rise, though the timing of this remains uncertain.

The right most bar of Figure 19 represents the 'Current PV Module Market Price in Europe' corresponding to fully Chinese made modules imported into the EU with the associated transport costs of 1.5€ct/Wp. This price acts as a reference price and is the price that existing local EU manufacturers or new entrants must compete with in the market. For manufacturers with only PV module production facilities in the EU, which depend on importing solar cells from Asia, as these are not available for purchase in Europe or elsewhere, even a currently potentially achievable PV module price of 14.5 €ct/Wp (not shown in the above figure) is not economically viable for European PV module manufacturers, which also (mostly) depend on purchasing solar glass from outside Europe, which implies significant transport costs for this heavy good and - when imported from China - anti-subsidy countervailing duties on imports of solar glass from China.

It is important to point out that these duties on solar glass import are due to expire, pending the completion of the latest expiry review investigation launched in July 2025. On PV modules from China and SE Asia, no solar glass import duties are implied, and these are currently sold at 8-10

[5] Disclaimer: All results presented in chapter 4 of this report have been calculated based on the joint NREL/RCT/ISE manufacturing cost model including current (2025) industry cost and productivity input parameters. Input parameters in other analyses may be different and Fraunhofer ISE will not take any liability for business decisions based on the results presented in this study.

€ct/Wp below manufacturing costs (compare Figure 17). For this study, we assume a reference price of 8.7 €ct/Wp for the 'Current PV Module Market Price' in 2025. The different PV module cost structures as presented in Figure 19 serve as a basis for the impact overview on financial policy measures in Figure 20.

Figure 20 gives an example on how potential finance push policies impact the PV module production costs and its component manufacturing – which is depicted in the graph on the left-hand side – and how these policies impact the PV system costs and LCOE – which is depicted in the graph on the right-hand side. It is important to note that Figure 20 shows only one example how PV module prices under NZIA could be lowered and how they could be financially supported at the EU or at the Member State level, but alternative paths and PV module component supply chain selections are possible as presented subsequently in Figure 22.

The two cost bars on the left of Figure 20 show the cost difference of an unscaled versus a scaled fully EU-made PV module component production from Polysilicon to PV module production, with both products consisting of 5 NZIA-compliant "main specific components". According to Article 7 of the Implementing Act on non-price criteria, for PV technologies "at least four main specific components used mustn't originate in that third country. The PV inverters and the PV cells or equivalent do not originate and the PV modules are not assembled in that third country." The bars demonstrate, that only scaled "Gigawatt" PV production facilities should be considered for PV module component production, as unscaled manufacturing most likely will lead to PV module manufacturing costs of 30 €ct/Wp and above which is not economically competitive on the PV market (especially for cell manufacturing and upstream components). For all the subsequent cost reduction steps to the right in the same graph, only scaled EU PV manufacturing has been assumed.

The production cost analysis calculates 25.5 €ct/Wp as the minimum sustainable price for a gigawatt-scale-manufactured, state-of-the-art, and fully EU-made PV module. This is not economically viable on the European market today, without any duties or market barriers for imported PV modules from Asia European PV module manufacturers will need to analyse their supply chain (SC) options and select which PV components they require to import as the current cost gap for a fully EU-made PV module in relation to imported PV modules is too high.

The section '**Supply Chain**' in Figure 20 presents two potential options (among others as discussed later in Figure 22) to use important components for PV Module manufacturing:

- **(SC1) CN Ingot/Wafer Production** describes shipping of polysilicon from Europe to China for the ingot & wafer production. Currently there is not even a single ingot & wafer manufacturing plant running in Europe. If a PV manufacturer chooses to use European-made polysilicon and sends it to an ingot/wafer manufacturing partner in China, it can reduce the PV module production cost by ~2.2 €ct/Wp to 23.2 €ct/Wp. We assume the Cost Of Goods Sold (COGS) for ingot & wafer production in China to be at the minimum sustainable price (MSP) of 2.6 €ct/Wp as shipping Poly-Si to China and the final wafer then sent back to Europe will, in our view, not give the opportunity to achieve the current below-cost for ingot & wafer production of 1.0 €ct/Wp. These can currently only be utilized in Europe if the China- or SE Asia-made wafer is bought by the European manufacturer as in option (SC2).

- **(SC2) CN wafer** stands for purchasing a wafer from a Chinese supplier, where polysilicon and the ingot & wafer production are both produced in China. According to the NZIA, the "main specific components" of a PV module which are mandatory not to be sourced from the "dominant source" are the solar cell and the PV module. (Source: EUR-Lex - C(2025)2900 - EN - EUR-Lex) This gives the option to source the full wafer from the cheapest location available, which is China, where the current wafer spot price level (in Aug. 2025) is at ~19 €ct/ piece for a G12 n-type wafer, which relates to ~1.8 €ct/Wp, considering a final PV module efficiency of 23.0%. Buying the silicon wafer from China would reduce the cost for the module by 4.3 €ct/Wp to option (SC1) to an MSP of 19.0 €ct/Wp for the PV module.

The two potential supply chain optimisation options 'SC1' and 'SC2' are exemplary for a PV cell and module manufacturer to reduce its final PV module price and enhance competitiveness on the European market against imported modules from Asia. But neither of these options support resilience for the European polysilicon and ingot & wafer manufacturing segment and are, of course, not applicable for those PV manufacturers in Europe who aim to produce these components locally. The examples are to demonstrate one of many potential models for reshoring EU PV manufacturing when starting at the PV module and cell manufacturing stage, before integrating the value chain further upstream.

The subsequent section to the right within Figure 20 is presenting the impact of potential finance push policies intended for '**NZIA PV Manufacturing Support**' for cell and module manufacturing. As introduced before in the previous sections of chapter 4, potential finance push policies for PV manufacturing can be categorised in:

(A) **CAPEX Support:** The European Union (EU) and its member states are able to provide PV manufacturers with direct support in the form of capital expenditure (CAPEX) grants. This support is facilitated through various mechanisms, including the EU Innovation Fund and national industry support schemes. In China, PV manufacturers have heavily been supported through governmental grants (see sub-chapter 4.3). The presented example (A) in Figure 20 shows the result of receiving a CAPEX grant which is reducing 50% of the total required investment for setting up a PV cell and module manufacturing facility. The cost analysis results show that this measure reduces the MSP of the final PV module by 0.88 €/Wp to 18.1 €ct/Wp, where ~75% of the cost reduction is related to cell manufacturing and ~25% to PV module manufacturing, which is significantly less CAPEX intensive.

The manufacturing costs of polysilicon, ingot and wafer production are higher in proportion to the total individual manufacturing costs when compared with cell and module manufacturing. Consequently, CAPEX Support for polysilicon manufacturing, ingot production and wafer manufacturing would have a higher relative impact on reduction of its manufacturing costs. In the example in Figure 20, the aggregate effect of capital expenditure (CAPEX) assistance for the two value chain segments, cell and module, on the total PV module is demonstrably insufficient to bridge the competitive gap with Asian PV manufacturers, who themselves benefit from CAPEX grants. Instead, it merely serves to marginally narrow the competitive gap for EU-based PV manufacturing.

(B) **OPEX Support:** The enhancement of the competitiveness of the European manufacturing industry through the provision of support for operational expenditures (OPEX) can be facilitated in a variety of ways as e.g. wage and employment subsidies, energy subsidies, employee training support, or R&D support as the EU is e.g. providing through its HORIZON Europe flagship funding program for research and innovation. While the latter is important for supporting the technological competitiveness for PV manufacturers in Europe, it can only indirectly support the reduction in manufacturing cost through successful innovation but does not have a direct effect for closing the cost gap to imported Asian PV modules. With PV manufacturing being energy intensive with increasing intensity for each upstream stage of the value chain, an OPEX support reducing the price for energy is attractive. In the example (B) in Figure 20, it has been assumed that the industrial electricity price for the manufacturer is reduced by 5.0 €ct/kWh for cell and module manufacturing. The cost analysis results show that this measure reduces the MSP of the final PV module by 0.59 €/Wp to 17.5 €ct/Wp. About 85% of the cost reduction is related to cell manufacturing and ~15% to PV module manufacturing, which is significantly less energy intensive.

The same measure for polysilicon or ingot & wafer manufacturing would have a higher impact on the component manufacturing costs and low energy costs are essential for these industry segments. However, for cell and module manufacturing, OPEX support in the form of electricity price reduction only provides a small impact for closing the cost gap, similar to a labour cost support scheme, due to the high automation degree of state-of-the-art high-volume PV manufacturing.

(C) **Output-based Support:** Output-based, also called production-linked support, is linked to the production output volume of the manufacturer. They are either granted via output-linked incentives or production tax credits or corporate tax concessions. In the global PV industry, the most effective support schemes are output-based support schemes.

- In China corporate income-tax concessions have been one key source of governmental support schemes (see chapter 4.3).

- In the USA the '45X Manufacturing Production Tax Credit'[6] scheme has stimulated over 100 GWp/a module manufacturing capacity and over 30 GWp/a in all of the further the upstream segments (compare Figure 9) by offering resalable manufacturing tax credits of 3 $/kg of polysilicon, 12 $/m² of wafer, 4 $ct/Wp of cell and 7 $ct/Wp module output manufactured in the USA. The scheme also includes further products like PV Module Backsheets, PV Inverters, Tracking Systems, Batteries, and Critical Minerals.

- In India the 'Production Linked Incentive (PLI) Scheme' provides incentives for several industries on incremental sales from domestically manufactured products and reducing reliance on imports. The PLI called 'The National Programme on High Efficiency Solar PV Modules'[7] is dedicated to the domestic production of PV components and has stimulated similar production capacity levels as in the USA.

In Figure 20 bar (C) the impact of an Output-based support scheme granting 1 €ct/Wp for each of cell and module manufacturing in the EU is shown. It can be seen that this incentive scheme is directly reducing the MSP of the PV module by the output-based amount being granted. Of course, granting 1 €ct/Wp for each manufacturing stage requires more governmental support budget than the previously introduced CAPEX- or OPEX-based support schemes. One key advantage of an output-based support scheme is, that it is directly linked to the manufactured products and

[6] https://www.energy.gov/sites/default/files/2022-10/Federal-Tax-Credits-for-Solar-Manufacturers.pdf

[7] Production Linked Incentive (PLI) Scheme: National Programme on High Efficiency Solar PV Modules | MINISTRY OF NEW AND RENEWABLE ENERGY | India

domestic value creation. The inclusion of 1 €ct/Wp for each manufacturing stage reduces the MSP of the PV module by 2 €ct/Wp to 15.5 €ct/Wp.

Financing Support

As described in chapter 4.3, an OECD analysis found below-market borrowings to be the dominant support mechanism in China over the last two decades. Receiving financing via below-market interest rates can be achieved through different governmental support activities as e.g. government guarantees for the manufacturing project or dedicated national funds supporting reduced interest rates for financing the project. Beside interest rate subsidy, tenure and grace period extensions are other potential financing support mechanisms. Most importantly, the general support for a project being eligible to receive debt financing is key to a manufacturing project to be executed at all. As Gigawatt-scale PV manufacturing projects require several hundred million Euros of investment capital, a political will and long-term support of the EU and the respective national governments seems essential for banks being optimistic on PV manufacturing as a viable business case in Europe. A specific financing support scheme has not been included in the analysis presented in Figure 20.

With the inclusion of the described 'Supply Chain' optimisations 'SC1' and 'SC2' as well as the introduced manufacturer finance support schemes, the PV module's MSP is reduced from 25.5 €ct/Wp for a fully EU-made PV module to 15.5 €ct/Wp for a NZIA-compliant PV module with a wafer purchased from China and solar cell and PV module manufacturing reshored to the EU.

The price level of around 15 €ct/Wp for a PV module is slightly below the calculated MSP for a PV module manufactured in China or SE Asia including transport to Europe (compare Figure 19). However, with a price level of 15 €ct/Wp, a PV manufacturer cannot be competitive against PV module imports below manufacturing costs from Asia. The 'Current PV Module Market Price' (in August 2025) ranges around 8.7 €ct/Wp, which includes high losses even for the large Tier 1 PV manufacturers in China (compare Figure 17) due to the industries manufacturing overcapacity (compare Figure 7).

The Chinese government is taking action for the PV industry to reduce overcapacity in specific PV segments[8] to mitigate this uneconomical market situation in China and for market prices to rise. Even so, MSP prices levels of 15 €ct/Wp, as calculated and shown in this study, do not seem in sight. The market analyst company Wood Mackenzie expects "that the PV industry may return to pre-Covid levels, with module prices ranging between $0.13/W and $0.14/W, or even higher"[9].

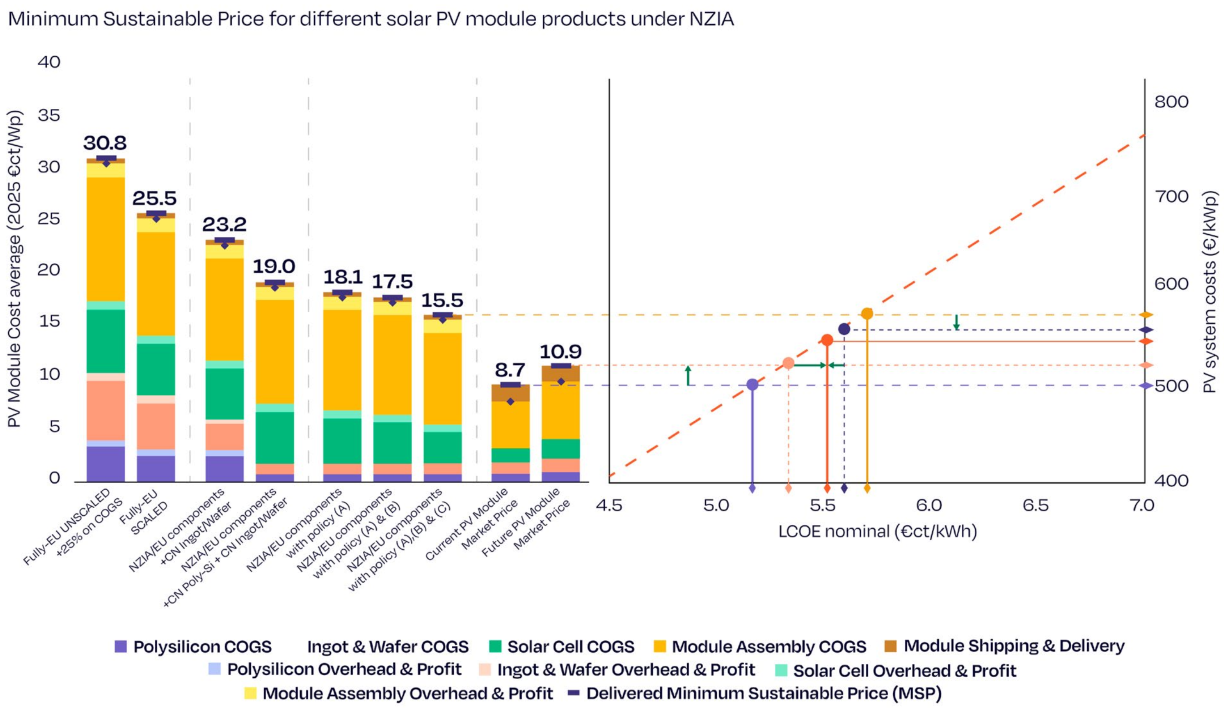
For this study, the 'Current PV Module Market Price' in Europe of 8.7 €ct/Wp is assumed to increase by 25% to 10.9 €ct/Wp for the 'Potential Future EU Market Price'. But even at such market price level, a cost gap of 4.7 €ct/Wp remains for an EU PV manufacturer to be able to compete against foreign imported PV modules.

[8] Is China's $7 billion plan to reduce polysilicon overcapacity feasible? – pv magazine International

[9] 'Solar module prices will soon go back to over $0.12/W' – pv magazine International

Figure 20

The right policies can reduce the price gap between imports and EU-made modules and cells to 4.7-6.8 cents per watt



Source: Fraunhofer ISE

LCOE assumptions: Multi-MWp Utility PV System, Irradiation 1,100 kWh/m2a, System lifetime 20a, WACC 5.0%, System Degradation rate 2.0%/a (1st Yr.), 0.5%/a (Yr.2-30), Bifaciality: 85%

An "EU premium", which is referred to as the willingness of the PV investor to pay a higher price for PV modules with European origin, domestic value and job creation has historically been very limited. Especially for large utility-scale or commercial installations, market dynamics require cost optimisation for each component of the PV system to remain profitable. Here PV modules are often referred to as commodity components where mainly price is relevant for the purchasing decision and where Chinese PV manufacturers were offering lower prices in times of overcapacity. At the same time, due to capacity increase in China over the last two decades, Chinese PV manufacturers are also supplying the most up-to-date PV technology, for a long-time including inventions based-on Western research development (as e.g. TOPCon cell technology) and based-on latest European production equipment.

Today, Chinese manufacturers are working with Chinese PV equipment, which has partly been successfully copied from European providers and are able to offer the latest PV technology with high quality at lowest costs. Thus, with respect to the current state of PV technology being manufactured and to the respective price for an EU-made PV module, paying an additional "EU Premium" most likely may only play a role for few private investors or in public procurement. Discussions of the authors with stakeholders in the PV industry indicate that an "EU Premium" based willingness to pay for European state-of-the-art PV technology to be in the range of 1 to maximum 2 €ct/Wp, which has not been proven to be sufficient for EU PV manufacturers to close the price gap. As can be seen from the left-hand side of Figure 20, the actual gap is currently 6.8 €ct/Wp, expected to drop to 4.7 €ct/Wp in the future with an increase in the PV module price.

The previously discussed finance policy push measures are solely dedicated to the PV manufacturers' side for lowering the PV module sales price and increase competitiveness for (partly) EU-made PV modules to be sold on the market. If the finance policy measures are not fully closing the price gap to imported PV modules, as the analysis above shows, respective measures must be established on the PV system side for the PV installer or rather the investor or owner of the PV system to buy EU-made PV modules.

On the PV system level, finance push policies have proven to be an effective instrument to drive PV installations, as e.g. Feed-in Tariff (FIT) schemes have successfully proven in many countries, by supplying a fixed electricity sales price over a predefined period for the investor. The profitability of a PV project with constant electricity sales prices can be analysed via its Levelized Cost of Electricity (LCOE), for which the net present value of a PV system is calculated by dividing the lifetime costs of a PV system by the electricity projected to being generated and sold. We explicitly use the calculation of nominal LCOE as the LCOE result is analogous to a FIT or PPA (Power Purchase Agreement) price that is constant each year across the economic life of project.[10]

The graph on the right-hand side of Figure 20 shows the effect of potential finance push policy instruments for closing the remaining cost gap for a NZIA-compliant PV manufacturer in the EU based on nominal LCOE analyses. The dashed line represents the sensitivity of the LCOE (on the x-axis), in relation to the PV system price (on the y-axis), which here is represented by a PV module price induced change.

The blue point on the right side shows the PV system cost and resulting LCOE for the EU-made "NZIA-compliant PV Module Price" (after inclusion of the above-described supply chain decisions and manufacturing support policies) and the red point is indicating the "Potential Future EU Market Price" for a PV Module. For the NZIA-compliant PV module being able to compete with an imported PV module based on its LCOE, either the CAPEX gap or the LCOE gap must be closed. This can be achieved either via (1) a direct CAPEX support reducing the initial CAPEX or through (2) NZIA-preferential financing support or via (3) an NZIA-based output-based support.

An OPEX support scheme for PV systems has not been considered, as the operational expenses for PV systems is so low, that an OPEX support scheme is not found to be an effective support scheme.

As defined in chapter 4.2 "Structuring Finance Push Policy Instruments", finance push policy instruments for PV system installers or owners can be structured as follows:

(1) **CAPEX Support:** On the PV system side, a CAPEX support is referred to a mechanism reducing the total required investment. As a governmental support scheme, CAPEX Support can be granted via different instruments, as e.g. the following:

- VAT (Value Added Tax) reduction or exemption provides a lower VAT rate on purchases for the PV System, which currently is already present in different European countries for the installation of PV Systems[11]. A VAT reduction immediately reduces the invoice price for households and other non-VAT-recovering buyers; VAT-registered businesses usually see little change in net cost (though cash flow improves).

- Investment Tax Credit (ITC) are more common in the USA. It is a credit against income/corporate tax equal to a percentage of eligible PV costs, claimed on the

[10] Assumptions and the levelized cost of energy for photovoltaics - Energy & Environmental Science (RSC Publishing)

[11] EU adopts directive allowing reduced VAT on several goods, including solar panels – pv magazine International

tax return (sometimes refundable or transferable). It directly lowers tax liability and improves project returns but depends on the investor's tax capacity and program rules.

- CAPEX award is a grant or cash subsidy or rebate that covers part of the PV system costs. It reduces upfront capital requirements regardless of the tax rate, but is typically subject to budgets, caps, and eligibility conditions.

Within an NZIA financial support scheme, a VAT rate reduction, a CAPEX award, or an ITC could be coupled to the NZIA resilience or sustainability, by applying higher CAPEX Support for PV systems including more components being acquired from the non-dominant source or even made in the EU.

(2) Financing Support: Financing PV systems is an important lever, as the main impact is the upfront CAPEX which needs to be financed, mostly through a combination of owner's equity and a bank loan. The combination of both is the weighted average cost of capital (WACC) and has a significant impact on the LCOE. Financing interest rates can be reduced through preferential loans with reduced interest rates, which are already existent on national levels (e.g. for residential owners) as well as on European level (e.g. through EIB project financing). Specific financing support programs could also be coupled with NZIA resilience and sustainability measures.

(3) Output-based Support: Output-based support pays PV owners per unit of electricity produced kWh, rather than subsidizing upfront costs, thereby linking incentives to actual electricity output. Depending on the PV market segment (residential, commercial, utility), different output-based support schemes exist, as e.g. Feed-in Tariffs, Feed-in Premiums, Contract for Difference. Output-based support schemes are able to include NZIA compliant awards, increasing the electricity sales price for the PV system owner.

Figure 21 presents an analysis on the support cost required for the three introduced finance support policy instruments for closing a cost gap of 1 €ct/Wp of PV module or system CAPEX. The analysis is presenting the total required support costs for a volume of 1 GWp installed PV capacity. The green bar represents the finance policy based on direct CAPEX support or NZIA-based award for a PV System. In this case the support cost is delivered upfront, thereby omitting financing costs. Closing 1 €ct/Wp with direct CAPEX support requires 10 Mn€/GWp of installed PV capacity.

The Output-based support under e.g. a Feed-in-Tariff (FIT) support framework herein is assumed to be contracted over a 20-year horizon. Consequently, as the costs of each kWh of system output includes the costs of financing, required finance support costs rise with an increase in the cost of capital (WACC). The analysis results show, that with a 5% WACC rate the required 'Nominal Lifetime Costs' to close the 1 €ct/Wp cost gap, increase to 15.3 Mn€/GWp and with an increase of the WACC to 8% further rise to 19.6 Mn€/GWp (see dark blue bars), being significantly higher than an upfront direct CAPEX Support of 10 Mn€/GWp.

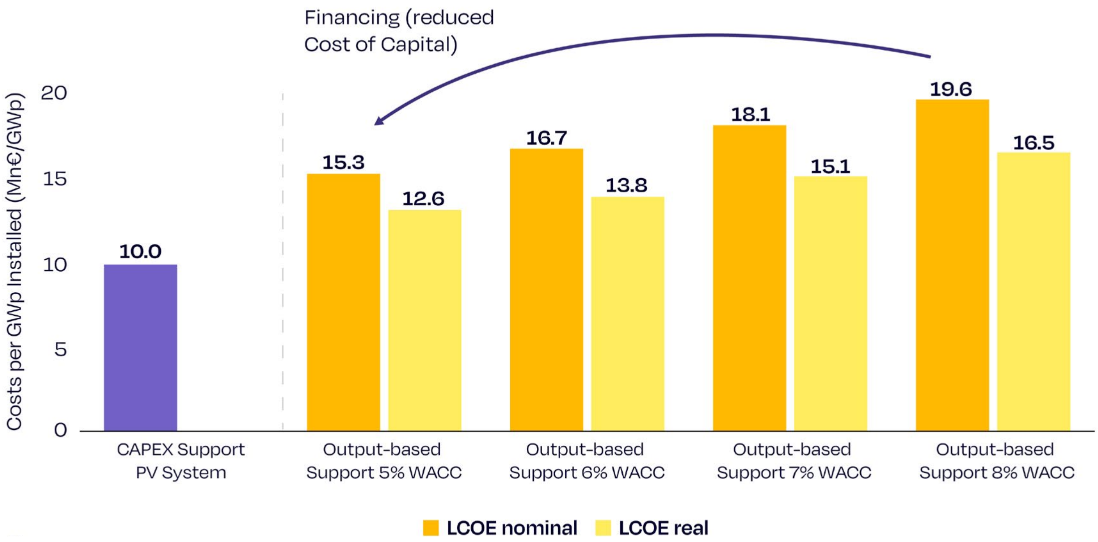
This seems on one hand to be much less attractive, as support costs are higher as for the upfront CAPEX support and part of the output-based support will go to the financing entities. But on the other hand, an output-based support scheme does not require to spend the full funding support amount upfront in the year of installation but spreads it evenly over the timeframe of the FIT-scheme (here over 20-years) which means that each year only 1/20 of the total support sum is spent. When additionally comparing the 'Real Lifetime Costs' of an output-based support scheme (light blue bars), which excludes inflation and shows the net present costs for the support scheme, the real costs for an output-based support scheme reduce to 12.6 Mn€/GWp for 5% WACC and to 16.5 Mn€/GWp for 8% WACC. Importantly, the difference between the nominal and the real lifetime costs is over a period of 20 years. The WACC has the largest impact and is the strongest lever which influences the LCOE and the lifetime costs. Thus, an 8% vs. 5% WACC rate has a very large increase in the total lifetime costs.

Figure 21 presents also shows clearly, that a WACC reduction provides significant support for PV owners and is a viable option for a NZIA financing support scheme.

Figure 21

Combining output-based support schemes with lower interest rates (WACC) significantly reduces solar manufacturing support costs over time

The effect of financial policy instruments based on the LCOE/GWp with different WACC



Source: Fraunhofer ISE

Cost gap assessment of potential reshoring paths for PV module component manufacturing to Europe under NZIA

This sub-chapter analyses potential reshoring paths for PV module component manufacturing to Europe. The objective is to evaluate the feasibility of reshoring the manufacturing of each primary PV module component under the NZIA, with respect to the maximum price gap of 15% as defined in NZIA Art. 26 for auctions. For reshoring manufacturing of the whole core PV module value chain, including polysilicon, ingot & wafer, solar cell, PV module, and solar glass, an investment in manufacturing either one of these NZIA 'main specific components' should be economically feasible under the NZIA finance support mechanisms.

Figure 22 presents five NZIA-compliant PV module supply chain alternatives. Four of these represent PV module types with at least one EU-made supply chain component, and one NZIA-compliant PV module type originates from Southeast Asia. As outlined in the NZIA, solar cell and PV module manufacturing are classified as 'main specific components' which are mandatory to be sourced from a non-dominant source. This means, that if either polysilicon, ingots or wafers are manufactured in the EU, cell and PV module manufacturing must not be sourced from the dominant source China. The analysis presented in Figure 22 follows that rule by sourcing these mandatory components from Southeast Asia if they do not originate from the EU. However, given the economic considerations, it is assumed that any other component is sourced from China.

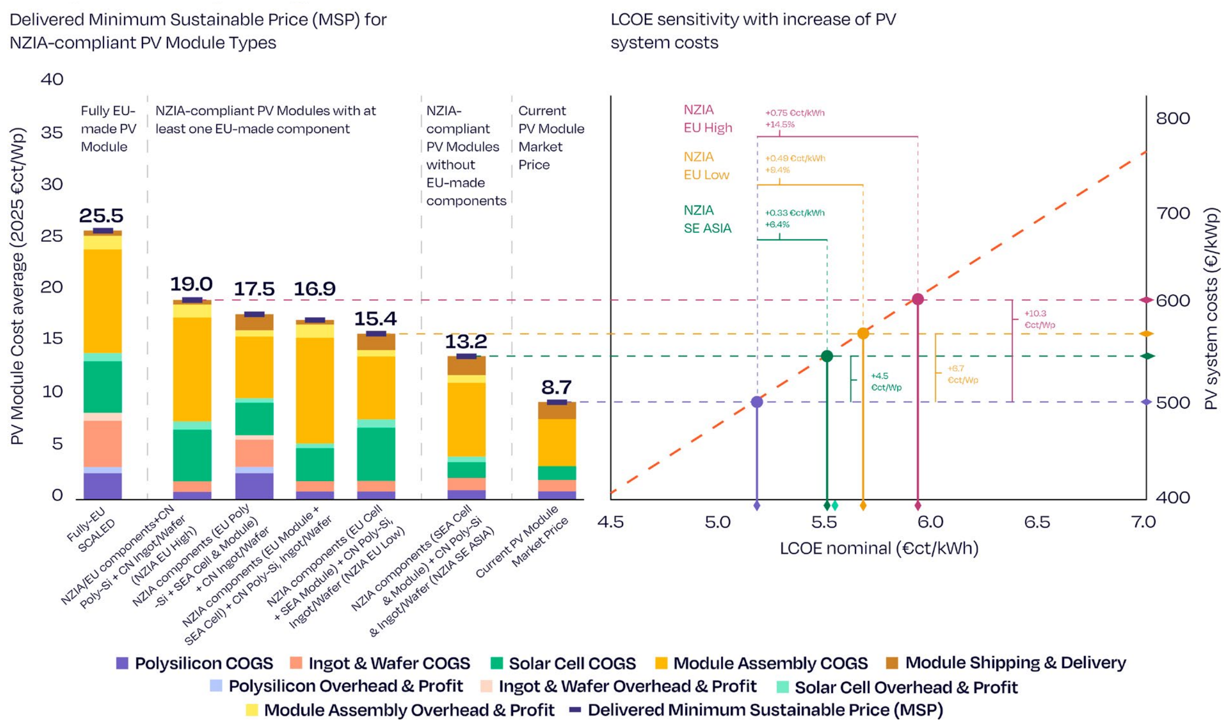
The description labels for each bar/module type indicate the number of NZIA-compliant components included as well as the components manufactured in the EU, then the ones manufactured in Southeast Asia (SEA), and finally the components sourced in China (CN). The number of components is counted as follows (in brackets) according to the NZIA list of main specific components: PV module (1), solar glass (1), cell (1), ingot & wafer (2), polysilicon (1). It is assumed, that solar glass is always supplied from the same region as the PV module. Thus, if the PV module is manufactured at a non-dominant source, then so is the solar glass, resulting in 3 NZIA components and up to 6 NZIA components if all components within the PV module are sourced from the non-dominant source. If the last step, the PV module is manufactured in Asia, we assume shipping costs of 1.5 €ct/Wp to Europe, if the PV module is manufactured in Europe, we assume 0.5 €ct/Wp as transport cost.

The bar on the very left within the left graph in Figure 22 represents the MSP of a 'Fully-EU SCALED' PV module with 6 NZIA main specific components. The following section to the right sorts 'NZIA-compliant PV modules with at least one EU-made component' from highest to the lowest MSP. The module type represented by the first bar on the left of this section consists of EU cell & module manufacturing with 3 NZIA components, including an EU-made solar glass and shows the highest MSP of 19.0 €ct/Wp. In the further LCOE cost gap analysis on the graph on the right-hand side, this module type is referred to as 'NZIA EU High'.

Not shown in Figure 22 but another possible combination represents the reshoring of an ingot & wafer production facility to Europe (total 2 NZIA components from EU). The solar cells and PV module (and solar glass) of this module type is assumed to be manufactured in Southeast Asia (adding 3 NZIA components), totalling in 5 NZIA component with only the polysilicon being purchased in China and an MSP of 18.4 €ct/Wp.

Figure 22

NZIA-compliant solar panels increase LCOE between 6.4% and 14.5%; more EU components equal higher LCOE



Source: Fraunhofer ISE

LCOE assumptions: Multi-MWp Utility PV System, Irradiation 1,100 kWh/m2a, System lifetime 20a, WACC 5.0%, System Degradation rate 2.0%/a (1st Yr.), 0.5%/a (Yr.2-30), Bifaciality: 85%

An MSP of 17.5 €ct/Wp is calculated for a PV module with EU-made polysilicon. With cell and module manufactured in SEA this module type comprises of 4 NZIA main specific components. Ingot & wafer are assumed to be manufactured in China, where we assume the MSP with COGS of 2.6 €ct/Wp of this step in China as a cost adder. We assume, that shipping polysilicon to China for ingot & wafer production and then sent to SEA will not give the opportunity to achieve the current cost for ingot & wafer production as part of the current below-cost wafer price (1.0 €ct/Wp).

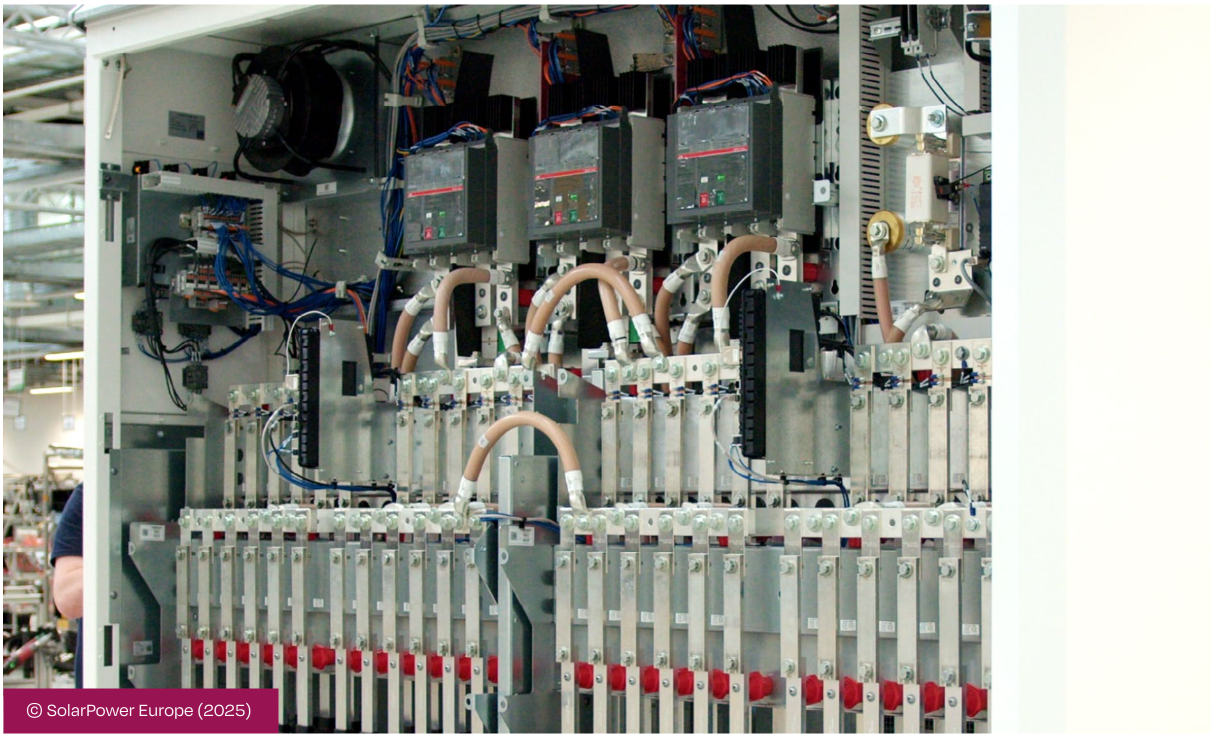
All other considered module type options further to the right in Figure 22 make use of the currently very low wafer price level, with polysilicon and ingot & wafer manufactured in China. Based on a Chinese wafer, but manufacturing the PV module plus solar glass in the EU and the solar cell in Southeast Asia reduces the delivered MSP of the PV module with a total of 3 NZIA main specific components to 16.9 €ct/Wp. The same amount of 3 main specific components but the lowest MSP of 15.4 €ct/Wp can be achieved with an EU-made solar cell which is shipped to SEA for PV module manufacturing. In the further analysis, this PV module type is referred to as 'NZIA EU Low'.

One key differentiator for PV module manufacturing outside of Europe is the lower purchasing price of the PV module materials, especially the expensive to transport solar glass, but also other PV module materials such as aluminium frame, encapsulant and backsheets.

We have analysed the costs of NZIA-compliant modules including different EU-made components, but the NZIA does not state that NZIA-compliant sourcing includes EU-made components. It only requires that a minimum of 4 out of 8 main specific components – with solar cell, PV module and inverter being mandatory – not originate from the dominating supply country. Thus, all components could be sourced in Southeast Asia, where most of the Chinese Tier 1 manufacturers already have established manufacturing hubs. These manufacturing hubs were established about one decade ago to circumvent minimum import price (MIP) measures present in the EU from 2013-2018.[12] Thus, a NZIA-compliant PV module consisting of 3 NZIA components and without any EU-made components can also be sourced from Asia, with cell and PV module manufactured in Southeast Asia and the upstream wafer in China. In Figure 22 this module type is referred to as 'NZIA-SE ASIA' PV module type and, with an MSP of 13.2 €ct/Wp, shows 2.2 €ct/Wp lower costs than a PV module with at least one EU-made PV Module component i.e. the cell in this case. Thus, in an auction or other price sensitive offer where NZIA-compliance is relevant, a PV module type consisting of at least one EU-made component may not be competitive against imported EU modules from Chinese Manufacturers delivering out of Southeast Asia.

The LCOE analysis on the graph on the right side of Figure 22 analyses the LCOE gap for a utility-scale PV system including either the module types 'NZIA EU High', NZIA EU Low', and NZIA-compliant without EU-made components shown as 'NZIA SE Asia' with a PV system including modules at the 'Current PV Module Market Price' of 8.7 €ct/Wp. The results show, that the module type 'NZIA EU High' with a price of 19.0 €ct/Wp and EU-made solar cells, PV module and solar glass does not imply an LCOE increase of more than the NZIA Art.26 threshold of 15%. With a 14.5% higher LCOE, a LCOE cost gap of 0.75 €ct/kWh would be required to be closed for a 'NZIA EU High' module type by an output-based finance push policy scheme. In a similar way, a 'NZIA EU Low' module type would require a cost gap support of 0.49 €ct/kWh and 9.4% above the current PV module market price. Thus, we can state the following key message:

If produced at scale, then the 15% added cost gap in NZIA is sufficient, even with one or more EU components.



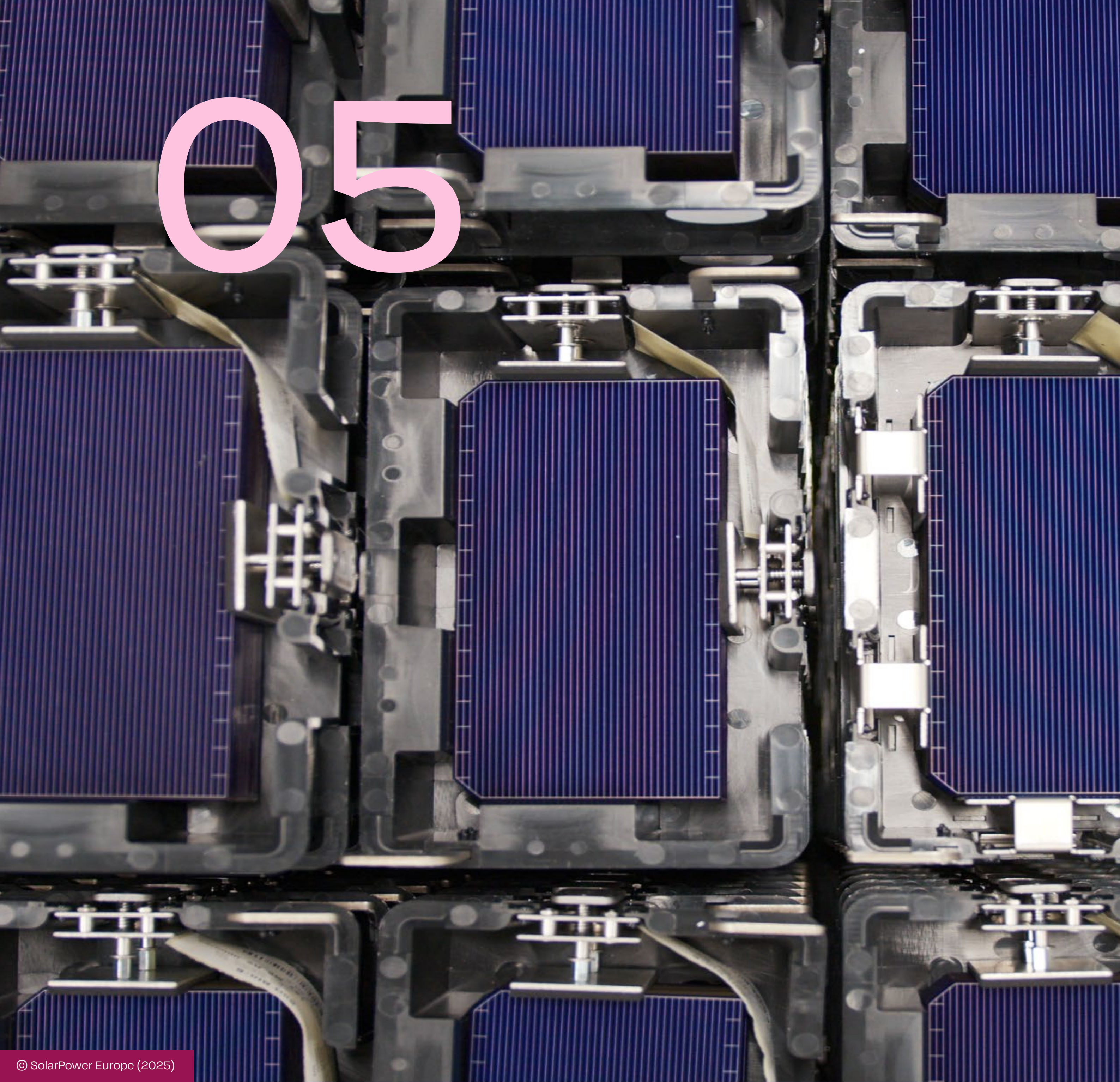
[12] EU officially ends MIP for Chinese solar imports – pv magazine International

But we also need to state, that neither of these module types consisting of EU-made components would be economically viable against an imported 'NZIA compliant PV module without EU 'PV module type' ('NZIA SE Asia'), which only requires 0.33 €ct/kWh or 6.4% for closing the LCOE cost gap. As all three compared module types include 3 main specific components, which would set them on an equal support level within NZIA auctions, public procurement or other NZIA based programs, if only resilience is chosen to be relevant. Thus, we also must state the following key message:

NZIA-compliant doesn't require any EU PV Module components. NZIA-compliant systems with only resilient components are substantially cheaper and outcompete all options with one or more EU components.

As a consequence, any support or subsidy under NZIA in Europe paid by the member states to improve resilience along the PV value chain would not help to reshore PV manufacturing to Europe, unless further criteria are established within the support schemes under NZIA.

We conclude, that with manufacturing PV components in the EU at scale, NZIA's 15% allowable cost premium is sufficient even for modules with one or more EU-made components. However, modules with EU components are not economically competitive versus NZIA-compliant without-EU-made modules, because NZIA does not require EU-made components and since resilient non-EU options are cheaper. Consequently, resilience-focused NZIA support paid by member states would not on its own reshore PV manufacturing to Europe. To address this, two non-price measures are proposed: a Made-in-EU bonus to favor domestic production and an effective sustainability criterion.



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05

Analysis of the macro-economic benefits of recreating a European solar ecosystem[13]

In order to determine the overall macro-economic benefits of re-establishing a European solar PV ecosystem, the key drivers of job creation per value chain step established, taxes - in terms of both corporate tax payments and a VAT on EU made products as well as social security transfers from personal income tax payments and social security contributions for the jobs created are the primary levers. The analysis is performed for three cases:

1. Fully-EU based PV value chain production from poly-Si to modules, also including solar glass and inverters,

2. 4 NZIA/EU components (cells, solar glass, modules and inverters) and poly-Si, ingot & wafers from China,

3. 4 NZIA/SEA components (cell, solar glass, modules and inverters) and poly-Si, ingot & wafers from China.

All three cases considered are NZIA compliant for measuring resilience since each scenario has at least 4 components - cells, solar glass, modules and inverters from either an European (case 1 and 2) or a non-dominant country/region (SEA; case 3) source.

Case 1 refers to the 'Fully-EU SCALED' PV module type in Figure 22, case 2 refers to "NZIA EU High' PV module type and case 3 refers to 'NZIA SE ASIA' PV module type in Figure 22.

Job creation is considered for both direct and indirect jobs whereas induced jobs and employment resulting from spending of wages by workers, are not considered.

Direct job creation is based on data from internal benchmark data from Gigafactory projects and the SolarPower Europe Jobs Report 2024 [3].

For indirect job creation, IRENA's Renewable Energy jobs report provides a range for indirect job creation multiplicators between 1.5 – 2. We use 1.5 as a multiplier in our analysis as a conservative assumption. Using the direct job data as shown in Table 4 , we calculate for case 1 that 1,065 indirect jobs are created for every GWp PV manufacturing. Thus, in total, 2,663 direct and indirect jobs are created per GWp of European PV manufacturing for case 1 as shown in Table 4. For case 2 and case 3, we calculate 845 and zero direct jobs and a total of 2113 and zero PV jobs per GWp of manufacturing respectively.[14]

[13] This analysis focuses exclusively on comparing the macro-economic benefits of closing the cost gap for local EU solar PV production under NZIA-compliant scenarios with financial policy support, based on the parameters described in this study. It does not include an assessment of potential changes in overall solar PV deployment rates, broader job creation across all steps of the PV value chain, or electricity price developments. These factors were outside the scope of the present analysis.

[14] It can be expected that with increased automation the number of jobs may decline in the future. The extent of this trend is difficult to predict.

Table 4

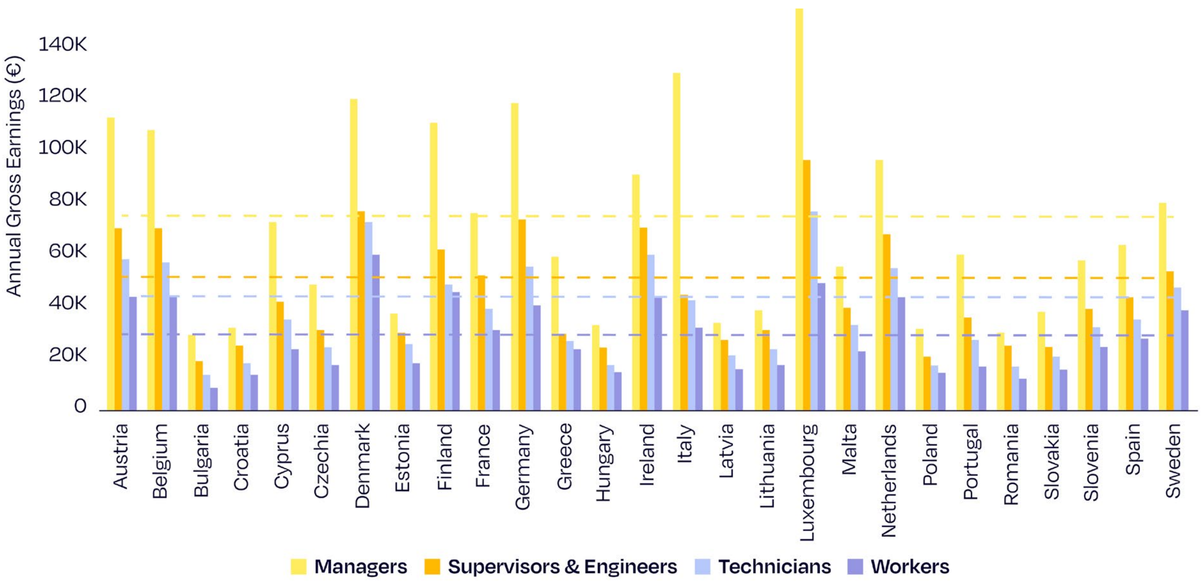
Direct and indirect jobs in full time equivalents (FTE) per GWp PV manufacturing capacity for the three scenarios.

	Case 1	Case 2	Case 3	
Direct Jobs in PV manufacturing	FTE/GWp/a	FTE/GWp/a	FTE/GWp/a	Source
Polysilicon	70	0	0	Benchmark data from Gigafactory projects
Ingot & Wafers	150	0	0	
Cells	200	200	0	
Modules	200	200	0	https://www.pv-tech.org/german-solar-glass-manufacturer-gmb-enters-insolvency/
Solar Glass	85	85	0	
Inverters	360	360	0	SPE Jobs report 2025
Direct Jobs for full PV cluster in EU	1,065	845	0	
Indirect PV Jobs in the EU (with job creation factor of 1.5)	1,598	1,268	0	
Total PV Jobs in the EU	2,663	2,113	0	

For each NZIA-induced worker in PV industry, an average wage as well as an average tax rate and social security transfers are assumed. The European statistical office (Eurostat) published that an average employee earned €39,058/a , as shown in Figure 23, and the average share of non-wage costs is 24.7% as shown in Figure 24: which equates to €9,647 per job per GWp produced PV modules in Europe.

Figure 23

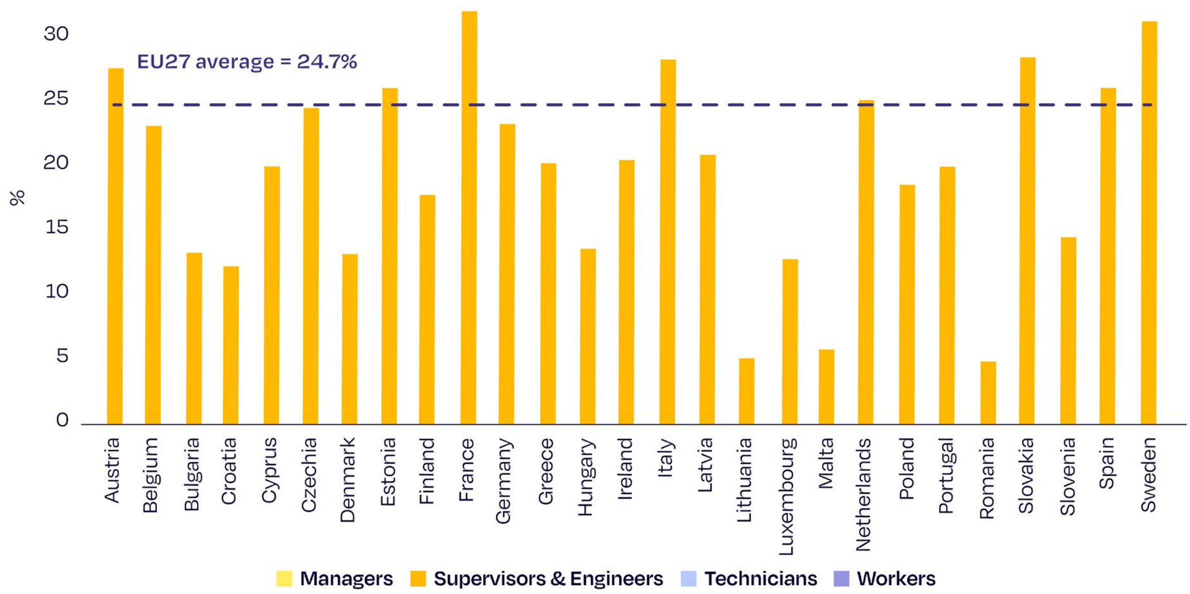
Annual gross earnings in Europe for managers, professionals, technicians and operators



Source: Eurostat; Mean annual earnings by sex, age and occupation - NACE Rev. 2, B-S excluding O (2022)

Figure 24

Share of social security and tax payments across the EU27 in 2024



Source: Eurostat Database

For setting up the NZIA goals of reshoring the fully-EU based PV module value chain (case 1: from Polysilicon to PV module production including solar glass and PV inverter production), we find the additional required costs of NZIA support to be at 17.3 €ct/Wp or €173 million/GWp, 10.8 €ct/Wp or €108 million/GWp for case 2, and 4.5 €ct/Wp or €45 million/GWp for case 3 as shown in Table 5. This is the amount a NZIA mechanism needs to provide to achieve resilience. The figures are calculated based on the difference in cost for production of the respective value chain step in the specified location according to the analysed scenario with the current low PV module price from China as a reference.

For the SEA based cell, glass module and inverter (case 3), the difference is based on a Chinese value chain production step for Poly-Si and Ingot & Wafer and with the MSP for the cell, glass, module and inverter production in SEA against the current low PV module price from CN (Reference CN). In case 1 and 2, the inverter is considered to be produced in the EU and and in SEA for case 3. These figures are expected to decrease due to market development.

Table 5

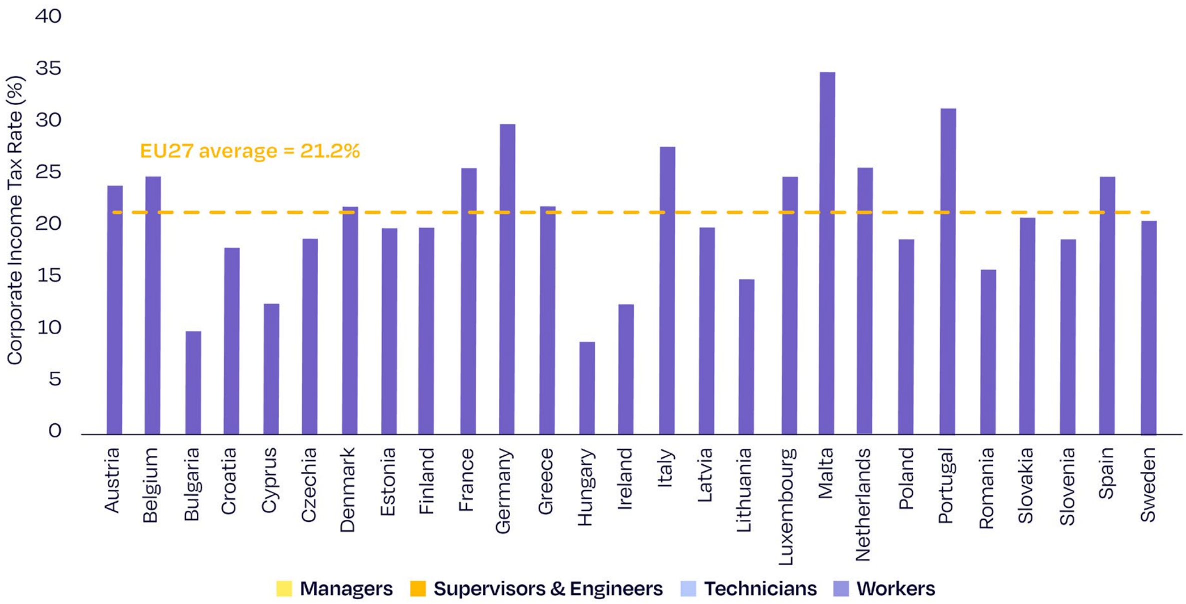
Minimum Sustainable Price in €ct/Wp of PV manufacturing for different PV products manufactured in different regions of the world.

Product (€ct/Wp)	Current low PV Module price from CN Reference CN	MSP of Fully-SEA made PV Module Reference SEA	Fully-EU SCALED Poly-Si to PV Modvule Production + Solar Glass + EU Inverter Case 1	EU product with local Cell, Glass, Module & Inverter Case 2	SEA Cell, Glass, Module & Inverter with CN Poly-Si, Ingot/Wafer Case 3	Difference between EU product to Current China-made PV Module and PV system (Reference) for Scenario 1 / 2 / 3
Polysilicon	0.7	1.9	3.0	0.7	0.7	2.3 / 0 / 0
Ingot & Wafer	1.0	3.1	5.2	1.0	1.0	4.2 / 0 / 0
Solar Cell	1.3	3.6	5.7	5.7	3.6	4.5 / 4.5 / 2.3
Glass	1.1	1.2	2.0	2.0	1.2	0.9 / 0.9 / 0.04
Module (ex glass)	3.1	5.2	9.0	9.0	5.2	5.9 / 5.9 / 2.2
Module Transport	1.5	1.5	0.5	0.5	1.5	-1.0 / -1.0 / 0
Total Module	**8.7**	**16.5**	**25.5**	**19.0**	**13.2**	**16.8 / 10.3 / 4.5**
Inverter	3.5	3.5	4.0	4.0	3.5	0.0
Tracker	11.8	11.8	11.8	11.8	11.8	0.0
Other BOS	26.0	26.0	26.0	26.0	26.0	0.0
Total System	**50.0**	**57.8**	**67.3**	**60.8**	**54.5**	**17.3 / 10.8 / 4.5**
Total NZIA subsidy (for Case 1 / 2 / 3)						**17.3 / 10.8 / 4.5**

Products sold in the European Union are typically subject to a Value Added Tax (VAT) and companies operating in the economic area are subject to corporate taxes. Corporate taxes range from 9% (Hungary) to 35% (Malta) while VAT is in between 17% (Luxembourg) and 27% (Hungary). The average corporate income tax in Europe (EU27) is at 21.2%, according to OECD and PwC as shown in Figure 25.

Figure 25

Overview of corporate income tax across the EU27 in 2023



Source: Source: OECD, OECD Statistics, https://stats.oecd.org/; PwC, PwC Worldwide Tax Summaries, https://taxsummaries.pwc.com

In this analysis and as summarised in Table 6 we assume a net income of 10% on the products in the three cases with an average corporate tax rate of 21.2% which leads to corporate tax payments on the net income of about €6.2, 4.8 and 3.6 million/a for case 1, 2 and 3 respectively. Considering a VAT[15] of 20% on the sales price increase of 17 €ct/Wp, 10.8 €ct/Wp and 4.5 €ct/Wp, against fully Chinese made PV (see Table 6), we get an annual VAT of about €34, €22 and €9 million for case 1, 2 & 3 respectively.

Combining the annual VAT generated with the corporate tax payments and the labour cost related tax payments of €25.6, €20.4 and €0 million (2663, 2113 and zero total jobs for case 1, 2 & 3 multiplied by the average social security and tax figure of €9,647 per job per GWp of produced PV modules), we get to total government revenue or NZIA based macro-economic returns of €66.4 and €46.8 and €12.6 million/a per GWp/a for case 1, 2 and 3 respectively against the needed NZIA support of €172.6, €107.8 and €45.3 million/a per GWp/a for the analysed cases.

[15] VAT revenue is calculated on the EU price premium. As VAT is also charged on imported modules sold in the EU, this figure represents a fiscal baseline rather than the total VAT revenue generated which would include imported PV modules.

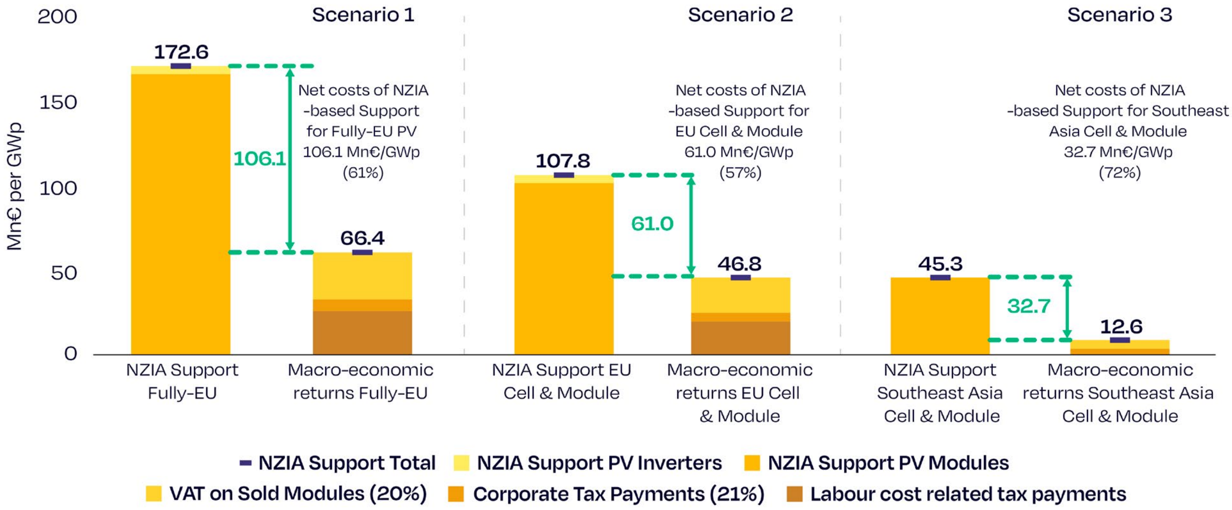
Table 6

Comparison of NZIA-based Macro-Economic Returns with the Total required NZIA Support resulting in the Total Net Costs of NZIA-based Support per GWp of deployed NZIA-compliant PV modules and inverters.

	Fully-EU SCALED Poly-Si to PV Module Production + Solar Glass + EU Inverter Case 1	EU product with local Cell, Glass, Module & Inverter Case 2	SEA Cell, Glass, Module & Inverter with CN Poly-Si, Ingot/Wafer Case 3	Comment / Unit
Share of non-wage costs	24.7%	24.7%	24.7%	EU average
Social Security & Tax	9,647 €	9,647 €	9,647 €	per job per year
Labour cost of related tax payments	€25,689,245	€20,379,976	€0	all jobs per GWp
Sales Price for modules	**0.255**	**0.190**	**0.132**	**€/Wp**
Sales Price for inverters	**0.040**	**0.040**	**0.035**	**€/Wp**
Sales Price for products	**0.295**	**0.230**	**0.167**	**€/Wp**
Net income	10.0%	10.0%	10.0%	Assumption
Corporate Tax Rate	21.2%	21.2%	21.2%	EU average
Corporate Tax Payments	2.1%	2.1%	2.1%	
Corporate Tax Payments (21.2%)	€6,246,898	€4,874,144	€3,548,716	per GWp
Sales Price increase for EU-/SEA made products	**0.173**	**0.108**	**0.050**	**€/Wp**
VAT on Sold Modules	20.0%	20.0%	20.0%	Assumption
VAT on Sold Modules	€34,513,002	€21,562,490	€9,058,453	per GWp
Total Government Revenue / NZIA based Macro-Economic Retuns	**66.4**	**46.8**	**12.6**	**Mn€ per GWp**
Total Government Revenue	€24,954	€22,162	€0	per job per GWp
NZIA Support PV Modules	167.6	102.8	45.3	Mn€/GWp
NZIA Support PV Inverters	5.0	5.0	0.0	Mn€/GWp
NZIA Support Total	172.6	107.8	45.3	Mn€/GWp
NZIA Support Total	€64,805	€51,035	€0	per job per GWp
Net Costs of NZIA Support	106.1	61.0	32.7	Mn€/GWp
Net Costs of NZIA Support	€39,851	€28,874	€0	per job per GWp

Figure 26

A stronger EU-based solar PV value chain requires more upfront investments but yields higher economic macro-economic benefits



Source: Fraunhofer ISE

For Case 1, we summarise that the upfront support of an NZIA-compliant implementation along the full PV module value chain plus inverter are in the range of €172.6 million/a per GWp/a (or €5.2 billion/a for 30 GWp/a). The macro-economic returns in form of taxes, social transfers, and VAT from setting up these value stages in Europe are estimated to be at €66.4 million/a per GWp/a Thus, the resulting net macro-economic cost of NZIA-based support for PV for case 1 is estimated to be at €106.1 million/a per GWp/a (or 61% of the upfront support of €172.6 million/a per GWp/a).

Similarly, for Case 2 and 3, the upfront support for implementing is €107.8 and €45.3 million/a per GWp/a (or €3.2 and €1.4 billion/a for 30 GWp/a respectively) with macro-economic returns of €46.8 and €12.6 million/a per GWp/a. This results in a net macro-economic cost of NZIA-based support for Case 2 and 3 of €61 and €32.7 million/a GWp/a (57% and 72% of the upfront support respectively).

Although, case 3 with a PV module and inverter product from SEA and China and without any EU-made components requires the least absolute net cost (€45.3 million/a per GWp/a) compared to the other two analysed cases, it should be noted that case 3 also results in no manufacturing related direct and indirect jobs created compared to 2663 and 2113 total jobs for case 1 and 2 respectively. Case 3 also generates the lowest amount of Total Government Revenue / NZIA based Macro-Economic Returns of €12.6 million/a per GWp/a which results in the highest relative net cost of 72% of the total upfront support required compared to 61% and 57% for case 1 and 2 respectively.

06

Are EU solar PV manufacturing goals for solar PV still relevant and realistic?

It is realistic, technically speaking, that an annual production capacity of 30 GW of PV manufacturing along the PV value chain can be built by 2030. Most of the technological know-how still exists within Europe, which, beside China, is the only region capable to set up state-of-the-art PV manufacturing facilities globally. If this European equipment builder and research know-how is lost, China will be the only country globally able to provide this which is an energy security risk for the fastest growing renewable energy technology worldwide, expected to be the dominant source of electricity by the mid-century. Therefore, in order to meet energy security and resilience needs in Europe for the long run, Europe must provide the framework conditions for making local PV manufacturing economically viable, the strategies for which are described and analysed in Chapter 3 and 4.

Additionally, as detailed in Chapter 5, the upfront cost to support the PV manufacturing industry in Europe is offset by between 28% to 39% by the respective macro-economic gains from labour taxes, VAT and corporate tax payments, depending on the manufacturing scenario considered.

Is the 30GWp PV capacity installation by 2030 still a relevant objective?

By 2030, establishing 30 GW of European photovoltaic (PV) manufacturing capacity would account for approximately 30–50% of the EU market and around 2–3% of the global PV market. To achieve this target, individual factories would need to operate at a minimum size of 3–5 GWp per year, meaning that six to ten such facilities would need to be built across Europe. Developing production on this scale would make it possible to foster a robust European supplier ecosystem, something that would be difficult to sustain at significantly lower capacity levels. At the same time, the remaining PV demand would continue to be met through imports from outside Europe, ensuring that a competitive international manufacturing landscape is maintained.

Is 2030 the appropriate and feasible target year for achieving the 30 GWp goal?

With a ramp-up time of two to three years, there is only a narrow window of about one to two years left to establish a stable and predictable investment environment that can trigger timely decisions from investors, emphasizing the urgency for EU Member States to adopt an effective NZIA policy framework at the national level. This compressed timeline makes it critical to design and implement national-level NZIA measures that can attract capital, accelerate deployment, and minimize policy uncertainty, which might otherwise discourage the necessary investments to meet the EU's PV manufacturing targets.

How would reaching this target affect the EU's competitive position in PV manufacturing and deployment?

Reaching this level of manufacturing capacity would make it possible to establish a European supplier ecosystem, something that would be difficult to achieve at significantly lower scales. At the same time, part of the capacity would still be met through imports from outside Europe, ensuring that global PV manufacturing remains competitive. Once a strong European supplier base is in place, market dynamics could increasingly drive pricing and competitiveness, reducing the sector's reliance on government regulation and fostering a more self-sustaining industry.

What will it cost to attain the 30GW manufacturing goal?

The answer is dependent on the cost gap and the analysed cases described in Chapter 3 and 4. The total NZIA support needed is found to be €172.6 (Case 1), €107.8 (Case 2) and €45.3 (Case 3) Mn/a per GWp/a. For the 30 GWp/a goal, this would equate to costs between €1.4 to €5.2 Bn/a. However, considering macro-economic gains from labour taxes, VAT and corporate tax payments which partly offset the total cost, the net macro-economic costs are found to be €106.1, €61 and €32.7 Mn/a per GWp/a for case 1, 2 and 3 respectively. This would imply that for the 30 GWp/a goal, net costs between €981 Mn to €3.2 Bn/a can be expected.

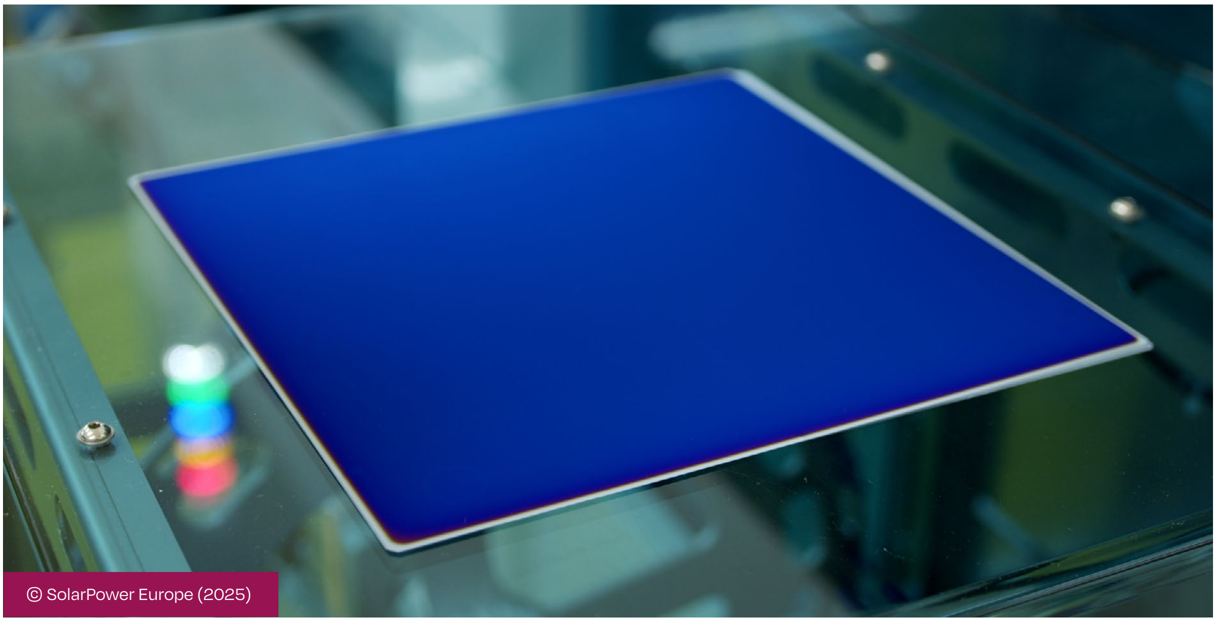
Is the EU better placed to compete in certain parts of the value chain than others?

Europe already possesses end-to-end technical expertise across the photovoltaic (PV) value chain, offering a clear strategic advantage over competitors such as the USA and India. Its research and development facilities are at the forefront of next-generation cell and module technologies, driving innovation while underpinning intellectual property creation and protection. In addition, Europe remains the only region outside of China capable of supplying industrial-scale equipment for nearly all major production steps in solar cell and PV module manufacturing. This includes cutting-edge processes for emerging technologies such as perovskite tandems, highlighting Europe's continued leadership in PV equipment manufacturing.

Which of the measures creates uncertainty in solar markets, risking the EU's solar deployment target?

As long as the proposed measures are implemented in a manner that provides reliable, long-term support—on the order of at least ten years—investors will be able to build viable business cases without added uncertainty from the policy framework itself. This timeframe is essential given that the ramp-up of multi-GWp integrated PV manufacturing facilities in Europe is expected to take two to three years, particularly for the earlier stages of the value chain, while equipment depreciation requires at least five years of operation. A ten-year support period therefore ensures sufficient stability for investment. Over time, the level of support could be gradually reduced as the European PV industry becomes more competitive, but this would require a clear and dependable set of rules regarding market segments, funding schemes, and capacity targets.

Furthermore, the measures are designed so that NZIA-compliant products are given priority in market access, which strengthens investor confidence. At the same time, the mechanism remains flexible: if capacity expansion in Europe progresses more slowly than anticipated, existing market actors outside Europe can fill the gap. This balance—providing priority for European production while maintaining openness to imports if needed—helps both to secure trust among investors and to ensure that capacity targets are reliably met.



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