Policy Brief
Issue n˚02/24 | February 2024

Smarter European Union industrial policy for solar panels

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Executive summary

THE EUROPEAN UNION plans a major increase in solar PV capacity from 263 GW today to almost 600 GW by 2030. If nothing changes, this expansion will be based almost exclusively on solar panels imported from China, which supplies over 95 percent of solar panels used in i0537 0.4eangloosl dipdo1p(ans a0.7086 545.5276 0.2.9692ia22)2 (2)5 (fl0)5 (6) flfifi in principle a non-binding solar panels and other identified strategic technologies, to be approached or achieved by 2030. However, for the solar sector specifically, there is no strong economic justification for an import-substitution approach. Such a strategy risks increasing the costs of solar panels, slowing deployment and creating industries that are over-reliant on subsidies.

EU SOLAR MANUFACTURING subsidies are not appropriate based on criteria of European production alone. Subsidies could, however, be justified on innovation grounds, by supporting new solar products that have a real chance to develop into sustainable industries that contribute to climate goals.

TO ADDRESS CONCERNS about short-term dependence, alternative tools should be employed: accelerated solar deployment, strategic stockpiling and gradually diversifying import sources. In the longer term, recycling of solar panels deserves greater attention and funding. In terms of strengthening economic resilience relative to China, Europe should implement an industrial policy that intervenes in sectors that are more likely to contribute to sustainable economic growth and alleviate decarbonisation bottlenecks.

Recommended citation
McWilliams, B., S. Tagliapietra and C. Trasi (2024) 'Smarter European Union industrial policy for solar panels', *Policy Brief* 02/2024, Bruegel

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Box 1: Forced labour in the solar supply chain

Allegations of forced labour have been made about polysilicon factories in Xinjiang, China. State-sponsored work programmes have been criticised for their coercive nature, often under the guise of poverty alleviation and anti-terrorism strategies. Evidence reported by the United Nations indicates that many Uyghur workers are subjected to conditions tantamount to forced labour and enslavement, unable to refuse work without the threat of re-education and internment (OHCHR, 2022). Further research highlighted that several major solar companies are implicated in the use of forced labour. Firms including Daqo, TBEA, Xinjiang GCL and East Hope, which account for more than a third of global solar-grade polysilicon supply, are implicated.

The issue extends beyond China, with evidence of forced labour also found in Malaysian factories[5], but the Chinese industry's dependence on supply from Xinjiang, combined with opaque reporting practices, complicates the avoidance of products produced using forced labour (Crawford and Murphy, 2023). This has led to a call for greater transparency and accountability within the industry.

The international response to these findings has varied. Following the anti-dumping and countervailing duty tariffs in place since 2012, 2015 and 2018, the United States blocked the import of solar panels and components from China with the Uyghur Forced Labor Prevention Act, in force since 2022 (The White House, 2021). The United Kingdom, under its Modern Slavery Act, requires companies with turnover above £36 million to report their efforts to prevent modern slavery in their supply chains.

In 2022, the European Commission (2022b) proposed an EU market ban on products made with forced labour. The regulations require companies to conduct due diligence to ensure that solar panels are produced ethically and sustainably.

Operating at the end of the value chain, module assemblers outside China typically import solar cells – the core component of the module. Module-assembly factories do not require high investment or substantial set-up time (ETIP PV, 2023). Production lines can be deployed in just one or two years. This means factories can be paused and then restarted quickly and easily. Many of the new factories planned in the EU will focus on module assembly because it is flexible and can adapt quickly to changes in the market or in policy. The EU has 10 GW capacity for assembling modules but this currently operates at only about 10 percent capacity[6]. The estimated capacities of European manufacturers at each stage of the value chain are shown in Figure 2. This contrasts with estimated deployment in 2023 of 60 GW.

5 Ivan Penn and Ana Swanson, 'Solar Company Says Audit Finds Forced Labor in Malaysian Factory,' *N T*, 15 August 2023, https://www.nytimes.com/2023/08/15/business/energy-environment/first-solar-forced-labor-malaysia.html.

6 Sandra Enkhardt, 'European solar manufacturers demand EU support,' *P M*, 12 September 2023, https://www.pv-magazine.com/2023/09/12/european-solar-manufacturers-demand-eu-support/.

Figure 2: Solar manufacturing expansion in Europe up to 2026

If the EU wishes to use import substitution to reduce dependency on China, it must have worldwide, which together with a 70 percent drop in polysilicon prices[8], led to drastically increased competition in the global solar PV market (Carvalho *et al*, 2017).

This surge in cheap Chinese solar panels became an existential threat to European manufacturers, leading to a significant decline in some segments of Europe's PV industry. Many European solar panel manufacturers struggled to compete with the low-priced imports, resulting in closures and a reduction in market share.

In 2011, Solarworld (a major German manufacturer) and Prosun (at the time, the representative ogranisation of European solar-panel manufacturers), petitioned the European Commission for anti-dumping and anti-subsidy investigations into Chinese solar panels. In 2012, the European Commission initiated a major investigation and determined that the appropriate value of a Chinese solar panel sold in Europe ought to be 88 percent higher than its then selling price[9]. The Commission proposed the 'price undertaking' agreement[10], under which Chinese companies were permitted to export solar products to the EU duty free up to an annual limit of 7 GW, provided the price stayed at or above €0.56 per watt. Exports exceeding this quota or priced below the minimum threshold were subject to anti-dumping duties, intended to increase the selling price of Chinese panels in Europe by an average of 47 percent starting in August 2013.

China responded with anti-dumping and anti-subsidy investigations into EU wine imports but the EU measures were nevertheless renewed in 2015 and 2017, with the duties reduced to 30 percent and the minimum import price adjusted to align with global market rates. Ultimately, in August 2018, the Commission removed the anti-dumping tariffs, considering it beneficial for the EU after evaluating the needs of producers against those of users and importers of solar panels[11]. This decision was influenced by the EU's goal of increasing the deployment of solar energy and by the reduction in the costs of solar components, which allowed import prices to align with world market prices. Furthermore, the European industry did not gain any advantage from the reduced market presence of Chinese imports that resulted from the imposed measures. Instead, the EU's solar market share declined further, primarily because of increases in imports from countries in South Asia[12].

And yet, every cloud has a silver lining. The competitive pressures, while forcing some Western firms out of the market, also spurred innovation among the remaining European companies, particularly those with a significant pre-existing base in innovation (Carvalho *et al*, 2017; Bloom *et al*, 2021). Most importantly, the overall decrease in solar equipment costs, largely attributed to Chinese manufacturing, significantly lowered the levelised cost of energy[13] for solar PV, making it a formidable competitor to coal and gas in electricity generation (Carvalho *et al*, 2017). In this context, the expansion of Chinese manufacturing had a positive impact on the solar sector at the global level (Andres, 2022; IEA, 2023a).

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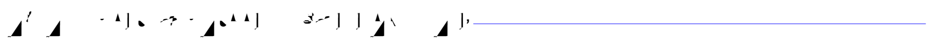
2.3 Europe's solar-panel dilemma: cost-efficiency vs geopolitical resilience

More than 90 percent of solar panels deployed in the EU are still imported from China, primarily because of their low price. In 2022, Chinese solar panels were estimated to be the cheapest in the world at $0.26/watt (Woodhouse *et al*, 2021). Solar panels produced in Germany were approximately 40 percent more expensive, at $0.38/watt. This disparity was largely driven by higher input costs, both in terms of energy (additional $0.05/watt) and labour (additional $0.04/watt).

Since then, a drop in polysilicon prices has further depressed the price of solar PV modules. In 2023, the price of Chinese solar panels dropped by over 40 percent, likely widening the price gap with the remaining European production. Bettoli *et al* (2022), prior to the surge in energy prices in Europe, estimated a $0.09/watt gap between European manufacturers and "*leading industry cost levels*". The difference was mainly driven by higher input costs in Europe (energy, labour and capital costs) and by lack of access to the critical raw materials needed for these technologies.

Since the price increases driven by supply-chain shortages between 2020 and 2022, module prices have crashed at record speed, reaching as low as $0.15/watt in September 2023 (Figure 3). Meanwhile, the EU has dramatically increased imports of Chinese solar panels to an average of 9.5 GW per month in the first nine months of 2023. This compares to total deployment in the EU in 2022 of around 36 GW.

Figure 3: EU imports of Chinese solar panels, volume (GW) and price ($/watt)



In August 2023, Norwegian Crystals filed for insolvency[15], while the following month Norsun announced a temporary wafer-production suspension because of an oversupply of low-priced

3.1 Scoring solar against economic intervention criteria

Industrial policy involves government efforts to change the structure of an economy, by encouraging resources to move into sectors deemed desirable for future development, in a way that would otherwise not be driven by market forces alone (Meckling, 2021). We consider there to be three reasons why the EU might want to support domestic manufacturing of clean technologies: 1) facilitating decarbonisation; 2) fostering green growth and creation of green jobs; 3) boosting geopolitical resilience (or strategic autonomy) in sectors considered to be important for the EU economy.

e EU does not need domestic solar PV manufacturing to accelerate its decarbonisation

In the case of solar panels, there is no strong economic case for EU support for the first two justifications, and at best a weak case for the third.

First, the EU does not need domestic solar PV manufacturing to accelerate its decarbonisation. The global solar PV market is vastly oversupplied, and the EU is currently importing twice the volume of solar panels it manages to deploy[20], creating a stockpile equivalent to well over one year's annual deployment. All indicators point to a further increase in this overcapacity, as Chinese companies expand aggressively, countries including the US and India ramp up their policy support to domestic manufacturing.

Overall, announced solar PV manufacturing expansion suggests that global capacity will double to over 1,000 GW by 2024-25 (Buckley and Dong, 2023), with China expected to maintain its 80 percent to 95 percent share of global supply chains (IEA, 2024). In 2023, global capacity ranged between 800 GW and 1,200 GW for different value-chain stages (IEA, 2023b). Meanwhile, the IEA has calculated that the world should achieve annual installations of 650 GW solar by 2030 to be on track for net-zero by 2050 (IEA, 2021). The speed of EU decarbonisation will continue to be defined by its capacity to speed-up deployment rather than by supply-side bottlenecks.

Second, the EU should not expect solar PV manufacturing to foster job creation and economic growth. In fact, the opposite might be true. Figure 4 shows that most solar-related jobs are in deployment rather than manufacturing. Solar PV manufacturing is not as job-intensive as deployment. To create jobs in this sector, the EU would thus better focus on accelerating the deployment of solar energy. Imposing trade restrictions on Chinese solar panels would lead to higher costs, slowing deployment of panels and, possibly, a net-negative job effect. That would occur if more jobs were lost from a slowing of deployment than new jobs were created in possible new manufacturing facilities. When it comes to economic growth, it is difficult to expect solar PV manufacturing to provide a major contribution, given that the EU has no comparative advantage in producing the existing generation of solar panels, and it is not clear where any unrealised advantage might lie.

20 See Rystad Energy press release of 20 July 2023, 'Europe hoarding Chinese solar panels as imports outpace installations; €7 billion sitting in warehouses', https://www.rystadenergy.com/news/europe-chinese-solar-panels-imports-installations-storage.

Figure 4: Full-time equivalent jobs per 1 GW solar PV manufacturing or installation capacity

[illegible] (202).

This leaves the third reason – resilience – as the only possible justification for supporting domestic manufacturing. The EU is fully dependent on China for solar panels and at least two conventional risks are associated with this. The first is the economic risk that China might in the future make use of its predominant position in global solar PV manufacturing to distort the market and artificially obtain additional economic rents. The second is the geopolitical risk that China might restrict solar-panel exports to certain goods like a solar panel is different. It would lead to a delay in the deployment of new solar panels, but would not affect the functioning of those already installed.

To measure the impact of such an event, one would have to estimate the resulting delay in European deployment of solar panels. This is understood as the time period between the end of Chinese supply and coming online of new supply. In Figure 5, manufacturing lead times for different stages of the value chain are estimated at between one and four years. These might be expedited in the extreme case of a sudden disruption, much like Europe was able to accelerate the deployment of liquified natural gas infrastructure following the Russian invasion of Ukraine.

4 Resilience priorities for solar policy

4.1 Stockpiling as a buffer solution

European companies already have a stockpile of an estimated 40 GW of solar panels[23], equivalent to almost one year of total EU deployment (section 3.1). The resilience benefit of a stockpile is that it provides breathing space for industry to respond in case of a sudden event that disrupts imports while continuing business-as-usual deployment.

Figure 5 shows the size of the current stockpile in terms of current monthly installations, and the estimated time it would take to build new factories for key components of the solar value chain. The figure shows that if all imports were ended tomorrow, the EU could develop its own manufacturing capacities, while running down its stockpile to continue current

If policymakers deem the risks of an immediate disruption to imports sufficiently high, the EU might explore more formal stockpiling arrangements to ensure supply-chain reliability. For example, it could require major importers to maintain a stockpile equivalent to three months (or more) of current import levels. Frequent turnover of the stockpile should ensure that only the latest technology of panel is maintained. As global supply is diversified, this requirement can gradually be replaced by a requirement to demonstrate import resilience in case of disruption to a main supplier.

Stockpiling is a tried-and-tested approach, in line with current IEA recommendations for

Reinforcing the EU's innovation ecosystem, the European Investment Bank (EIB) supports investments in clean energy, efficiency and renewables. In 2022, the EIB allocated €17.5 billion to transport and industrial sectors, with €3.3 billion targeting clean technology projects and €10.4 billion for energy projects, including €4.4 billion for renewable energy. Finally InvestEU, an EU initiative to stimulate private investment in innovation and the green transition[29], has a €26.1 billion EU budget guarantee to stimulate private investment in strategic areas, including sustainable infrastructure and innovation (Tagliapietra *et al*, 2023b).

European subsidies are less successful at growing new technologies from demonstration to commercial status (McWilliams and Zachmann, 2021). This is a problem as the cost of financing is higher for emerging technologies and often is not provided by the market. Public support for the commercial growth of technologies that offer a radical advantage over the current generation of solar panels is more likely to lead to the development of economically sustainable industries in Europe. Radically new technologies might enable a new start for a competitive, self-sustaining EU eco-system of cell manufacturing. Developing and bringing to scale next-generation panels could contribute to the goal of accelerating decarbonisation, within the EU, but, importantly, also beyond.

The deployment of much utility-scale solar PV across Europe is driven by government auctions or subsidies[30]. To stimulate innovation, governments might increase available subsidies if developers can demonstrate certain characteristics of the manufactured panels. To further promote innovation, governments could offer enhanced subsidies or higher bid limits for developers that show their solar panels excel in, for example, peak efficiency, low-light performance, recyclability and energy input requirements. Maximum bid prices or even sep-

Box 3: Recycling of end-of-life solar panels

The most widespread solar-panel recycling technology recovers only the aluminium frame, copper-containing junction box and sometimes the front glass panel. The central technical hurdle is the high-purity separation of encapsulated materials, which is vital for the economic viability of the recycling process (Granata *et al*, 2022).

The value of recovered materials varies, with silver, copper, silicon and tin being the most lucrative, particularly silver, which, despite its lower concentration, is valued 500 to 800 times more than tin and copper, making it a prime target for recycling. Silver content and processing volumes are key to the profitability of PV recycling: for panels with high silver concentration (0.2 percent), recycling is economically viable without fees at volumes above 18,000 tonnes per year; below this threshold, fees are necessary to cover up to 46 percent of costs (Granata *et al*, 2022). Panels with only 0.05 percent silver require fees for profitability, unless processed volumes exceed 43,000 tonnes annually. Optimal returns on investment are tied to both the timing of investment and silver-market prices, with the best outcomes predicted for early investments at higher silver prices and substantial processing volumes.

Emerging recycling technologies aim to refine the separation process and enhance the recovery of glass, silicon and metals. These technologies can be generally divided into physical, thermal and chemical methods (Pereira *et al*, 2023). Among these, the Advanced Photolife Process stands out, claiming over 80 percent material recovery through a combination of physical, thermal and chemical methods (Granata *et al*, 2022).

6 Conclusions

The approach under the NZIA of setting an indicative benchmark of about 40 percent for home production of diffent technologies raises significant concerns, which solar panels make plain. Supporting solar manufacturing purely for the sake of being European does not present clear advantages in terms of accelerated decarbonisation or increased economic growth. Nor is the political focus on increasing economic resilience in this sector a valid justification for committing substantial public resources. Instead, more efficient strategies should be employed.

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