CHINA STRATEGIC RISKS INSTITUTE

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Research Institute for **Democracy**, **Society**, and **Emerging Technology**

# A Brighter Future: Prospects for Europe-Taiwan cooperation in next-generation solar

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# Executive Summary

This report explores how Europe and Taiwan can work together to take advantage of the untapped potential of next-generation solar technologies. With China currently dominating the solar photovoltaic (PV) market, this collaboration offers a compelling alternative for a fairer, cleaner, and more resilient solar future.

### I. Next-generation solar's untapped potential

Solar PV technologies have made clean energy cheaper and more readily accessible than ever before. This has been made possible by China's innovations in low-cost mass production, due in large part to significant state support and some of the world's cheapest energy prices. However this success has not come without significant risks. China commands over 80% of the world's solar PV supply chain, exploiting economies of scale, state subsidies, and minimal environmental oversight. This monopoly exposes global energy security to significant risks, from the threat of supply chain disruptions to critical import dependencies and ethical dilemmas such as forced labour in the Xinjiang Uyghur Autonomous Region.

While China's dominance in today's silicon-based solar panels seems secure, next-generation solar technologies offer a chance to level the playing field. Perovskite solar cells (PSCs) and perovskite-tandem cells not only offer higher efficiency rates than silicon-only panels, but also offer up new and exciting innovations. PSCs are lighter weight and more flexible, raising the possibility of integrating solar technology into new areas such as building design, agriculture and wearable technologies. PSC production can also be greener than silicon-only panels, being less reliant on the energy intensive production of polysilicon. Less energy intensive production also means that manufacturing in Europe and other regions with high energy costs becomes more competitive. Taken together, this means that the next-generation solar market is likely to favour high quality, specialised and localised production, creating space for new entrants from outside of China. For Europe and Taiwan, this is a rare opportunity to drive green tech innovation, exploit new business opportunities and secure critical supply chains.

### II. Taiwan's strategic positioning in the PSC supply chain

Taiwan's strong foundation in semiconductor and electronics enabled its rise in solar cell production, reaching a 20% global market share by 2010. However, intense competition from China has pushed Taiwanese manufacturers to shift toward advanced technologies and specialized markets.

Today, Taiwan is investing heavily in next-generation solar technologies like tandem and PSCs, where it can compete on innovation rather than scale. Taiwanese firms have achieved breakthroughs in PSC efficiency and are exploring applications such as agrivoltaics, building-integrated photovoltaics (BIPV), and portable solar devices. These applications align with Taiwan's densely populated geography and growing demand for energy solutions tailored to specific environments.

This transition has been supported by government policies, which have imposed restrictions on imports of Chinese solar products and incentivized domestic production. With a vertically integrated supply chain, strong R&D capabilities, and targeted policies, Taiwan is well-positioned to lead the development and commercialization of PSC technologies.

## III. Prospects for Europe-Taiwan collaborations in next generation solar technologies

Europe's solar industry, while once world leading, has suffered from competition with China. Europe's solar industry is fragmented, focusing mainly on module assembly, with limited upstream production on upstream products like wafers and cells. Despite the EU's ambitious targets to boost domestic solar manufacturing to meet 40% of its annual deployment needs by 2030, Europe remains heavily reliant on imports from China for the foreseeable future.

Europe's role in next-generation solar technologies is more promising but still underdeveloped. Europe is host to a range of innovative projects in PSC technologies, and some of its companies lead the world in the commercialisation of perovskite-tandem solar cells. With the right policy support, PSCs could not only help Europe meet its climate and energy security goals, but could also provide major opportunities for European jobs and industry.

Together this raises new possibilities for Taiwan-Europe cooperation in next generation solar. Firstly, Taiwanese firms are increasingly looking to develop R&D collaborations with international partners to boost new innovations in PSC markets. Europe's strong science and technology research base could make it an attractive partner for such initiatives.

Secondly, Europe could become an important manufacturing site for Taiwanese companies looking to export to Europe. According to our interviews with leading Taiwanese solar producers, firms are optimistic about investing in Europe's production capacity. Some companies are considering expanding their future business in Europe based on their past experiences and existing networks in Czechia, Slovakia, and Lithuania. Alternatively, Taiwanese companies may seek to license patents to European solar producers. Partnering with European firms to manufacture in Europe can lower carbon emissions while helping Taiwanese firms navigate complex EU regulations on areas such as recyclability.

## IV. Fostering closer Europe-Taiwan collaboration

To fully exploit the potential of next-generation solar, further support is needed from the EU, Taiwan, and European governments. These efforts must focus on fostering collaboration and driving innovation.

This paper recommends that European governments should seek to further their R&D collaborations with Taiwan. This can be achieved through the renewal and expansion of R&D funding awards currently offered through some European representative offices in Taiwan. Exploring an Associate Member agreement with Taiwan under Horizon Europe could further unlock mutually beneficial research collaborations. Additionally, the EU should provide clear regulatory guidance and stakeholder consultations to help Taiwanese firms align with market standards, such as environmental and carbon footprint requirements. More broadly, EU initiatives must emphasise next-generation solar technologies as strategic priorities

separate to conventional silicon-only solar cells, where the potential for European innovation is much more limited. European governments should also work to simplify permitting processes and offer investment incentives to encourage Taiwanese solar companies to establish manufacturing operations in Europe.

This paper recommends that the Taiwanese government exploit its strategic advantages in next-generation solar by concentrating on high-value applications for PSCs, such as BIPV and agrivoltaics, while leveraging its integrated supply chain and R&D capabilities. Developing industrial parks and public demonstration sites will help scale PSC production and further accelerate innovation. To smooth efforts to enter the European market, Taiwan must also enhance supply chain traceability and ensure that its solar products meet stringent EU environmental and transparency standards. By collaborating closely with European companies to make and sell in Europe, Taiwan can gain a stronger foothold in the European market.

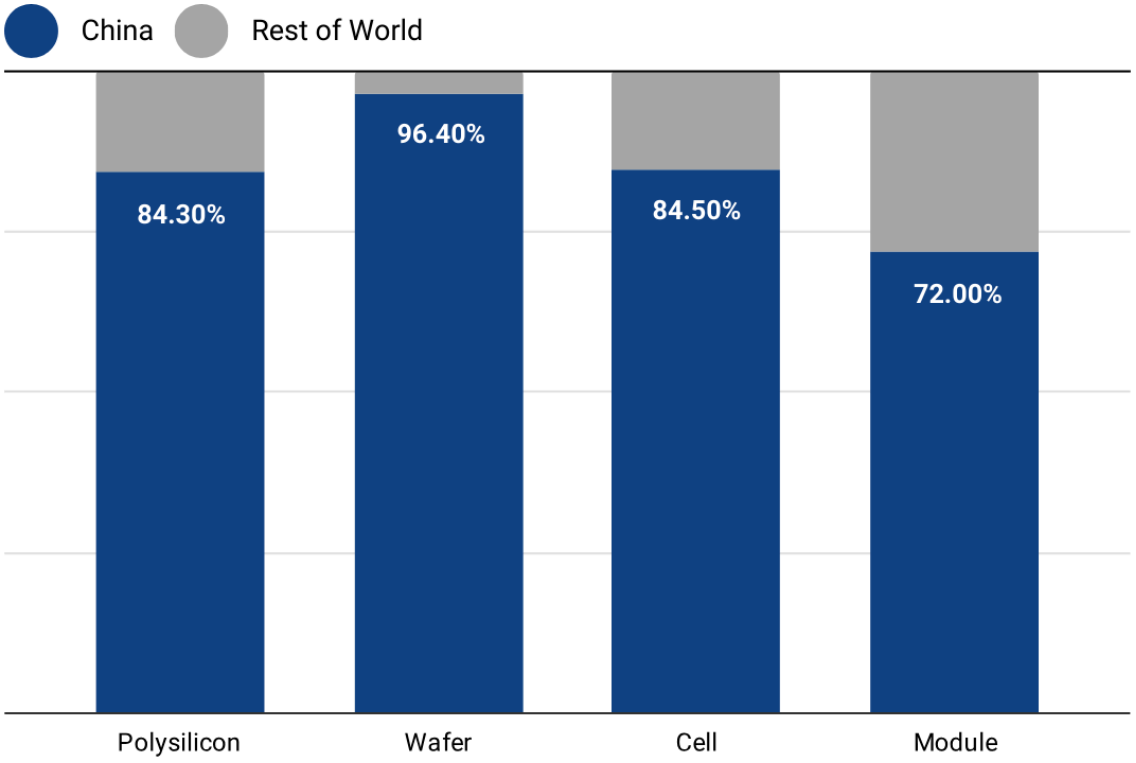
# Part one: How could next-generation solar transform the global solar PV supply chain?

## Risks posed by China's dominance of the global solar production

Today, China dominates the world's solar PV market. While once led by Europe, Taiwan, Japan and the US, the last decade has seen China's firms cement their position as the preeminent market leaders. China is the world's leading manufacturer at each stage of the solar PV supply chain, with 80% of total global production capacity, and stretching to over 99%[1] at the silicon wafers stage of production.[2]

### China's share of global solar PV production, by stage, 2022

CSRI Graphic. Data source: IEA (2022), Solar PV Global Supply Chains, IEA, Paris.




[1] Bernreuter, 'Why Wafers Are the Achilles' Heel of a Non-Chinese Supply Chain'.
[2] International Energy Agency, 'Special Report on Solar PV Global Supply Chains'.

While China's breakthroughs in solar PV have helped make solar technologies cheaper and more widely available than ever before, it has also entailed significant risks. The concentration of production in just one country leads to a higher risk of supply chain disruptions. This was an experience borne over the COVID-19 pandemic, where technical issues and lockdown restrictions at major polysilicon plants in China contributed to a near quadrupling of prices in 2020.[3]

As renewable energy becomes a larger part of the global energy mix, the geopolitical leverage that China gains from controlling a critical component of that supply chain will only increase. China has already shown a willingness to weaponise trade for strategic benefit: in 2023, the country implemented export controls on germanium and gallium products, two metals used in semiconductor manufacturing.[4] China's exports of the products plunged, catching many European firms off-guard and exposing a vulnerability in their critical raw material supply chain.[5]

The location of much of China's solar PV production within the Xinjiang Uyghur Autonomous Region (XUAR) adds a further layer of complexity, raising a host of ethical concerns for producers and consumers. State-sponsored forced labour is endemic in the XUAR and present in practically all industrial activity in the region. Approximately 35% of global polysilicon and 44% of China's total metallurgical grade silicon (MGS) output is produced in the XUAR.[6]

The dependence of global solar PV supply chains on China is particularly concerning given solar's role as one of the most strategically important clean-energy technologies of the future. Solar PV is increasingly seen as the key to achieving the green transition, lowering energy bills and securing energy independence. This ambition is seen in the EU's Solar Energy Strategy, which includes goals to triple solar capacity to almost 600 gigawatts by 2030. If successful, solar energy will then make up between 17% and 23% of the EU's electricity mix.[7][8] However the EU's ability to meet these targets on its own is very limited.[9] Over 95% of Europe's solar panels were supplied by China in 2022, according to Eurostat data.[10] Europe is not alone in this challenge. Taiwan is also looking to diversify its energy mix to bolster its energy security. As the cheapest form of clean energy production, solar PV will play an important part in these efforts. Yet so long as solar PV production is dependent on China, both Europe and Taiwan face a heightened risk of disruption from both supply chain disruptions and geopolitical factors.

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[3] Ibid.
[4] Lv and Patton, 'China Exported No Germanium, Gallium in August after Export Curbs'.
[5] Aarup et al., 'China's Threat on Mineral Exports Knocks EU off Balance'.
[6] Crawford and Murphy, 'Overexposed: Uyghur Region Exposure Assessment for Solar Industry Sourcing'.
[7] SolarPower Europe, 'New Report Reveals EU Solar Power Soars by Almost 50% in 2022'.
[8] European Commission, 'Non Paper on Complementary Economic Modelling Undertaken by DG ENER Analysing the Impacts of Overall Energy Efficiency Target of 13% to 19% in the Context of Discussions in the European Parliament on the Revision of the Energy Efficiency Directive'.
[9] See the methodology annexe in Yeh and Woods, 'Building A Green, Fair and Resilient Solar PV Supply Chain'.
[10] McWilliams, Tagliapietra, and Trasi, 'Smarter European Union Industrial Policy for Solar Panels'.

## The challenge of shifting China's dominance

Despite these risks, finding alternatives to China's solar PV production is challenging for a number of reasons. Firstly, China's producers are able to maintain much lower costs than the rest of the world. China's producers have access to significant state support in the form of financing, land permits and less stringent safety and environmental regulations than many other countries. This in turn has enabled China's producers to invest heavily in large-scale production, allowing them to benefit from economies of scale and vertical supply chain integration. Additionally, China's energy mix is among the cheapest in the world, in part due to the widespread use of coal-generated power in regions such as the XUAR. Polysilicon production in particular is very energy intensive, with energy costs contributing to approximately 40% of a factory's operating costs.[11] Together, this has allowed China's producers to reduce costs, undercut foreign competitors and deter new entrants from the market.

Secondly, as a mature technology, there is less room for new entrants to disrupt the market. Multicrystalline silicon solar cells have been commercially available since the 1980s, over which time significant advancements have been made in reducing costs and maximising performance. Multicrystalline silicon solar cells are approaching their inherent limit, which is believed to be at around 29%, with performances of around 20% in most commercial applications and 26% in laboratory conditions.[12] With most efficiency gains already realised, most solar products on the market today are relatively uniform and are not highly differentiated in nature. Producers are largely competing on price, which as has been demonstrated above, largely favours China's large-scale producers.

In recent years some diversification of the solar PV supply chain has taken place, driven largely by policy developments. The US Uyghur Forced Labor Production Act has caused many producers to move some production to Vietnam, Malaysia and other countries, while the US Inflation Reduction Act (IRA) has stimulated domestic production. While measures taken by European governments have not been as far reaching, there is evidence that European solar PV production is driven by consumers who are willing to pay a higher price to ensure higher ESG standards or more resilient supply chains. This has led to some solar producers looking to create bifurcated supply chains, with options for those that want to avoid links to China's supply chain. However, despite these efforts, China's large-scale production and price competitiveness across all stages of the solar PV supply chain means that it is likely to continue to dominate global markets for the foreseeable future.

## The promise of next-generation solar

Next generation PSCs and perovskite-tandem cells offer an alternative pathway that could see new players come to the fore in a more diverse and dynamic market. The vast majority of solar panels made today are polysilicon-based crystalline silicon cells, which account for

[11] Murtaugh et al., 'Secrecy and Abuse Claims Haunt China's Solar Factories in Xinjiang'.
[12] Andreani et al., 'Silicon Solar Cells'.

over 95% of global production.[13] Tandem solar technologies add a layer of thin-film material, (such as perovskite) to polysilicon-based cells. This increases the spectrum of light that the cell can absorb and convert into electricity, allowing for greater efficiency.

As an emerging technology, there is still much space for innovation in the perovskite-tandem solar market. September 2024 saw the world's first commercial sale of perovskite-tandem solar panels from OxfordPV, a UK-headquartered solar manufacturer, with a 24.5% module efficiency. While already significantly higher than traditional silicon technology, this is still some way off the theoretical efficiency of tandem solar cells, which is believed to be over 40%.[14] This opens the possibility of new centres of expertise, innovation and production outside of China's solar PV market. While China does have significant R&D initiatives in next-generation solar, its leadership is by no means guaranteed. Europe, Taiwan, Japan and the US all host R&D collaborations which have made major breakthroughs in recent years.

## Advantages of Perovskite Solar Cells (PSCs)

**FLEXIBILITY**

PSCs can be applied onto plastic and other materials.

**EFFICIENCY**

PSCs can achieve greater efficiency than polysilicon only panels.

**LIGHTWEIGHT**

PSCs can be used in portable and wearable technologies.

**LOW CARBON FOOTPRINT**

PSCs can be made without carbon-intensive polysilicon.

The greater efficiency and adaptability of PSCs and perovskite-tandem cells means that they can be applied in new contexts where previously solar solutions were not possible or not cost effective. The use of thin-film technologies, such as perovskite, means that PSCs are lighter and can be fabricated on flexible materials such as plastic. Innovative applications currently being explored include integration into windows, walls and other aspects of building design, or even as a supplementary power source for electric vehicles. PSCs could

[13] International Energy Agency, 'Special Report on Solar PV Global Supply Chains'.
[14] Andreani et al., 'Silicon Solar Cells'.

be integrated into wearable and portable devices, such as smartphones, and can be placed above crops in agricultural contexts, allowing for both food and energy production.[15] Higher efficiency rates and novel applications are particularly important for solar PV's growth in places such as Europe and Taiwan. Both Europe and Taiwan are densely populated, meaning that space is a major constraint for solar development. Taiwan and many parts of Europe also have low or inconsistent levels of sunshine, lowering the business case for traditional solar technologies. PSCs and perovskite-tandem cells could be a game changer for making solar energy cost effective in these contexts.

The sheer diversity of applications to which PSCs can be applied means that the next generation solar market could be much more fragmented than its predecessors. Next generation solar could favour a multiplicity of actors providing bespoke solutions to niche applications. This means that there will be less to be gained from mass production and the associated economies of scale that China's producers have used to their advantage. Producers will not be competing on price alone, and the need to work closely with end-users in the design of products could favour more geographically localised services. What is more, perovskite is a widely available material with a less energy intensive production process than polysilicon. As such, its production could take place in regions such as Europe where energy costs are higher.

Taken together, next generation solar technologies offer an exciting opportunity for a range of innovative producers. PSCs and perovskite-tandem cells raises the possibility of a solar industry that is more open to bespoke, localised and smaller scale production, and less prone to monopolisation by any one country.

## Properties of Solar PV technologies

Data Source: Jian Zhao (2024) and other publicly available information. Compiled by DSET.

| | Silicon-based Solar Cells | Thin-Film Solar Cells (e.g. CIS, CIGS) | Perovskite Solar Cells |
|---|---|---|---|
| **Main Material** | Silicon | Copper, Indium, Gallium, Selenium | Lead, Iodine |
| **Conversion Efficiency** | 15–22% | 10–15% | 25% or higher in lab settings |
| **Cost** | High | Moderate | Potentially low |
| **Manufacturing Process** | Energy-Intensive, High-Temperature | Deposition on substrates | Flexible manufacturing |
| **Physical Properties** | Rigid, Heavy | Lightweight, Flexible | Lightweight, Flexible, Semi-Transparent |

[15] Fraunhofer Institute for Solar Energy Systems ISE, 'Tandem Photovoltaics – From the Laboratory into the World'.

| | | | |
|---|---|---|---|
| **Stability** | High Stability (~25 years) | Moderate Stability | Short Stability (5-8 years) |
| **Applications** | Rooftop and Utility-Scale Installations | Rooftop; Portable Applications | Tandem Cells; BIPV; Low-Light Environments |
| **Market Share and Commercial Availability** | Fully Commercialized 97.5% | Commercialized but limited share | Under Development |

# Part two: How is Taiwan strategically posited in the PSC supply chain?

## Taiwan's solar PV development at a glance

Taiwan's solar industry began in the 1980s and was driven by the Industrial Technology Research Institute (ITRI). Early pioneers faced limited market demand, leading to small-scale applications like solar-powered calculators. The 1990s marked a turning point with Germany's ambitious renewable energy policies, creating stable solar panel demand. Taiwanese firms capitalized on this by leveraging their semiconductor expertise and becoming key suppliers in the global market.[16] By 2010, Taiwan held a remarkable 20% share of global solar cell production, establishing itself as a significant player.[17]

However, the rapid rise of China's solar industry, fueled by substantial subsidies and aggressive expansion, created intense competition. China's cost advantages and technological advances in monocrystalline silicon production reshaped the global market, leaving Taiwanese firms —focused on polycrystalline midstream manufacturing— struggling to compete. This led to industry mergers, with firms like Neo Solar Power, Gintech, and Solartech merging into United Renewable Energy (URE) to survive.[18] Most of Taiwan's largest solar companies are strategically focused on module production (see table below).

Facing China eclipsing market share in other countries, Taiwan's solar industry has pivoted to the domestic market, supported by government policies such as guaranteed feed-in tariffs, renewable energy targets, and restrictions on Chinese imports. Local firms now focus on high-efficiency products and niche applications, including perovskite-silicon tandem cells, BIPV, and agrivoltaic systems. Despite challenges including global price pressures and oversupply, Taiwan continues to adapt by emphasizing innovation and targeted applications to maintain its role in the evolving solar landscape.

[16] Huang, Pao-Szu. "A Study on the Rise-and-Fall and Development of the Solar Industry in Taiwan." Master's Thesis, National Sun Yat-sen University, 2021.
[17] ibid.
[18] Yang, Wen-Ju 'The largest merger in Taiwan's solar industry: United Renewable Energy Corporation is established.' Radio Taiwan International (RTI), October 16, 2017.

## Taiwan's Top Five solar PV companies

Data Source: Disfold (2024); UAnalyze (2024).

| Rank | Company Name | Specialty | Capital (Billion NTD) | Percentage of Sales Revenue | | |
|---|---|---|---|---|---|---|
| | | | | Cells | Modules | System |
| 1 | United Renewable Energy Co. Ltd (URE) | Leading manufacturer of solar modules | 16.28 | 25-30% | 55-60% | 6% |
| 2 | TSEC Corp | High-efficiency solar cells and modules | 5.39 | 0% | 100% | 0% |
| 3 | Motech Industries, Inc. | High-efficiency solar modules | 3.87 | 1.64% | 94.4% | 4% |
| 4 | Giga Solar Materials Corp | Conductive Pastes for Solar Cells | 3.51 | N/A (produces conductive pastes and wafers) | | |
| 5 | Tainergy Tech Co. Ltd | Solar Application System | 2.25 | 98.7% | 0.09% | 0% |

## Taiwan's investments in PSC innovation

Taiwan's journey on PSC began after Michael Grätzel and Nam-Gyu Park's breakthrough work achieved a 9.7% efficiency with PSC in 2012, quickly establishing PSCs as a promising and cost-effective alternative to second-generation solar technologies. In 2013, Taiwan's academic community extended these innovations. It began exploring technological improvements for applying perovskite in solar cells, marking the start of significant research efforts in this field (see figure below).

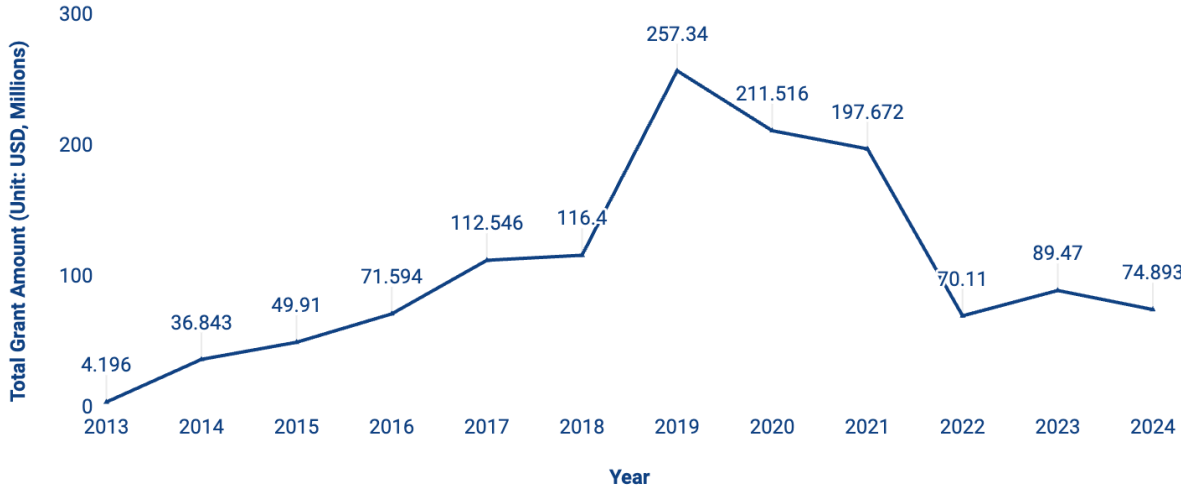
In 2015, PSC achieved breakthrough progress (20%) in conversion efficiency within the past five years, significantly surpassing the efficiency of other options such as organic solar cells (OPC) (11%) and dye-sensitized solar cells (DSSC) (13%). These advancements led to increasing investments peaking in 2019.[19] In 2020, the photovoltaic conversion efficiency of PSC soared from 3.8% to a certified 25.5% within just a decade.[20] After 2022, related research and development in Taiwan shifted from fundamental material science to application development, mainly focusing on tandem solar cells. For example, in 2023,

[19] You, Sheng-Min. 'Development Directions of Taiwan's Wafer-level packaging Industry.' Materialsnet, July 8, 2015.
[20] Li, Ming-Xian. 'Vapor Deposition of Hierarchical Perovskite for Solar Cell Module and Photodetector.' 2020.

Taiwan Perovskite Science and Technology (TPSC) collaborated with the Measurement Center of ITRI and they achieved an impressive photovoltaic conversion efficiency of 33.5% by applying perovskite to tandem cells, which represents a significant milestone for large-area, low-light power generation applications and testing.[21]

## Total Grant Awarded to Taiwan's PSC Research, 2013 - 2024

Data Source: Science & Technology Policy Research and Information Centre (2024). Compiled by DSET.




Some Taiwanese solar PV Companies, like TPSC and URE, strategically positioned themselves to capture significant value in the PSC value chain. Each of these firms leverages different approaches, applications, and strategies to optimise their market presence and potential.

Lai-Chu Chen, the CEO of TPSC, was formerly a senior executive in the panel industry. He envisions leveraging the opportunity and broad applications presented by PSC to enable Taiwan to achieve vertical integration across a new industry—from upstream materials, equipment, and manufacturing to downstream applications. To realise this vision, TPSC has recruited experts from the panel industries, actively integrating solar energy technology with the manufacturing expertise of the panel sector. This approach aims to develop equipment and processes capable of producing larger-scale PSC products. Furthermore, he has established an industry alliance named TPRIA to recruit companies across various sectors, forming a comprehensive solar energy supply chain in Taiwan.[22]

[21] Pan, Zi-Yin. 'Indoor weak light power generation efficiency reaches 33.5%—Taiwan's Gaiatech breaks through, setting a new record for large-area perovskite solar energy.' ETtoday, August 8, 2023.
[22] Lai-Chu, Chen. Interview with the President of the TPSC by DSET. Interview date: October 28, 2024.

## Advanced PSC developments in Taiwan: The case of TPSC and URE

Data Source: Lai-Chu, Chen (2024); URE Corporation (2024).

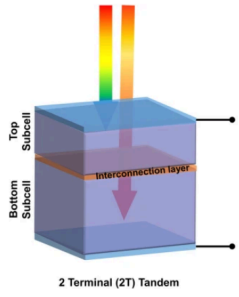
| Company | Type | Established | Primary Perovskite Product | Market Share |
|---|---|---|---|---|
| Taiwan Perovskite Science and Technology (TPSC) | Start-up | 2022 | Perovskite Solar Cells (A4 size, 297mm*210mm, Under development) | N/A |
| United Renewable Energy Co. Ltd (URE) | Mature | 2018 | Perovskite-Tandem Solar Cells (M10 size modules with cells scaled at 182mm*182mm) | 48% (2018) |

Perovskite materials, known for their tunable light absorption spectrum and transparency, are often paired with silicon solar cells to create tandem solar cells, designed to boost conversion efficiency. These tandem devices are typically categorized into two structures: two-terminal (2T) and four-terminal (4T) configurations. In the 2T structure, two subcells are stacked with an interconnection layer, forming an integrated device. Conversely, the 4T structure involves fabricating two separate cells individually and then physically combining them into a single device.[23]

## Different Types of Perovskite-Silicon Tandem Solar Cells

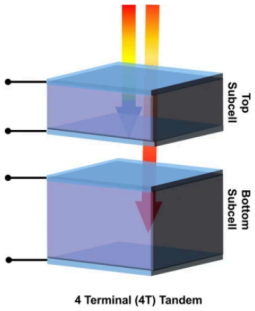
Data Source: Bati, A. S. R., Zhong, Y. L., Burn, P. L., et al. (2023)

### 2 Terminal (2T) Tandem




- Lower fabrication cost
- Higher conversion efficiency

### 4 Terminal (4T) Tandem




- Fabricate independently
- Replace easily

In general, the 2T architecture is considered more advantageous due to its lower fabrication costs and reduced optical losses compared to the 4T structure.[24] However, URE is currently focusing on the development of 4T tandem cells.[25] These consist of an upper perovskite cell

[23] Bati, A. S. R., Zhong, Y. L., Burn, P. L., et al. 'Next-Generation Applications for Integrated Perovskite Solar Cells.' Communications Materials 4, 2, 2023.
[24] H. R. Hsu, S. H. Wu, Y. L. Tung, S. Y. Tsai., 'The Applications of Perovskite in Tandem Solar Cells.' *Matrialsnet*, 381 (2018): 115.
[25] Sam, Hung. Interview with the Chairman of the United Renewable Energy Co., Ltd by DSET. Interview date: November 8, 2024.

sourced directly from external suppliers and a lower silicon cell utilising Topcon technology, a type of silicon-based solar cell.[26]

URE has chosen the 4T tandem structure as the main perovskite product for several strategic reasons. First, the fabrication process of 4T tandem cells does not interfere with the existing silicon solar cell production lines, preserving operational efficiency. Second, given the relatively short lifespan of PSC, the divided, physical stacking method significantly lowers replacement costs. Additionally, this approach seamlessly integrates with the well-established silicon solar market, eliminating the cost of establishing new markets and reducing the time to deployment. These factors make the 4T configuration optimal for mature solar module manufacturers like URE.

## Building market share through bespoke production

As Taiwan's PSC industry evolves, local manufacturers are adopting strategic approaches to carve out a competitive edge in global markets, particularly by focusing on tailored applications and niche market segments. Taiwanese PSC manufacturers are keenly aware that competing directly with Chinese companies in terms of mass production would be challenging due to the latter's existing scale and cost advantages. As mentioned, China has invested substantially in the research and development of perovskite technologies. It also has low-cost solar panel production, which gives it a significant advantage in terms of production volume and price. Instead, Taiwanese firms are focusing on differentiated, application-driven strategies that leverage their strengths in R&D and customisation. For example, By late 2024, TPSC had successfully produced A4-sized PSC panels and initiated plans to scale up to metre-sized panels within two years. This project highlights Taiwan's different approach from China's metre-scale PSC production strategy, and its ability to drive innovation and prioritize quality over production volume, distinguishing itself in the global PSC market.

### Case Study 1: Tackling the Silver Crisis with Graphene-Enhanced PSC Technology

TPSC is collaborating with GraphEnergyTech under the 2024 UK-Taiwan Collaborative R&D Programme to address the shortage of silver within the renewable energy sector. With rising demand and escalating costs of silver, a critical material in solar panels, the collaboration focuses on replacing silver electrodes within PSCs with graphene.[27] Graphene's superior properties improve photoelectric conversion efficiency, simplify manufacturing, and lower costs, offering a sustainable alternative for meeting growing demand for solar PV.

### Case Study 2: Building-Integrated Photovoltaics (BIPV)

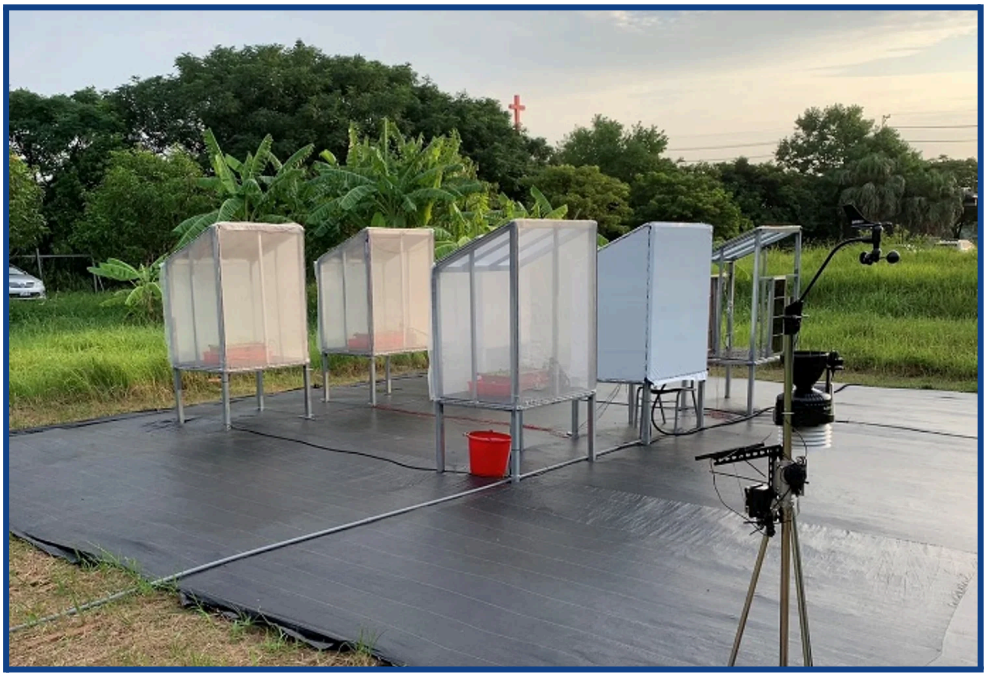
Building-integrated photovoltaics (BIPV) is a promising application of PSC technology, enabling buildings to generate their own energy. Companies like SHANG TIAN ALUMINUM

[26] Tunnel Oxide Passivated Contact (TOPCon) technology is developed by Taiwan's Industrial Technology Research Institute (ITRI), which can be regarded as an advanced version of the structure of the silicon solar cell, with a higher photoelectric conversion efficiency.
[27] Michaels, David. 'The Global Solar Power Boom Is Driving a Surge in Silver Demand.' *The Wall Street Journal*, June 22, 2024.

CO., LTD. are collaborating with TPSC to integrate PSCs into insulated glass, transforming conventional windows into energy-generating units.[28] This innovation positions Taiwan at the forefront of the growing market for smart buildings and sustainable architecture, where energy-efficient solutions are in high demand. The design and manufacture of these solar-integrated windows must be tailored to the specific requirements of different regions. For example, colder climates demand enhanced thermal insulation to retain heat, while hotter regions prioritize UV protection and cooling efficiency. By focusing on customized, high-value applications over mass-market solar panels, the manufacturers are leveraging their strengths in innovation and flexibility to meet the needs of global markets.

### Case Study 3: Agricultural Applications

PSC technology could transform agriculture in Taiwan through innovative agrivoltaic applications. TPSC and PROMATE have developed the TROPOX photovoltaic greenhouse, which optimizes land use by combining solar energy generation with agricultural production.[29] The system integrates PSC technology into a modular design, enabling flexible planning and deployment. This allows it to be tailored to specific crops, climates, and regional requirements. The system is particularly effective in low-light environments, ensuring consistent energy production while enhancing farming efficiency. This project exemplifies the integration of local needs with cutting-edge technology, showcasing Taiwan's ability to innovate in the agrivoltaic sector. By addressing energy and food production challenges simultaneously, the TROPOX system positions Taiwan as a leader in sustainable agricultural solutions.



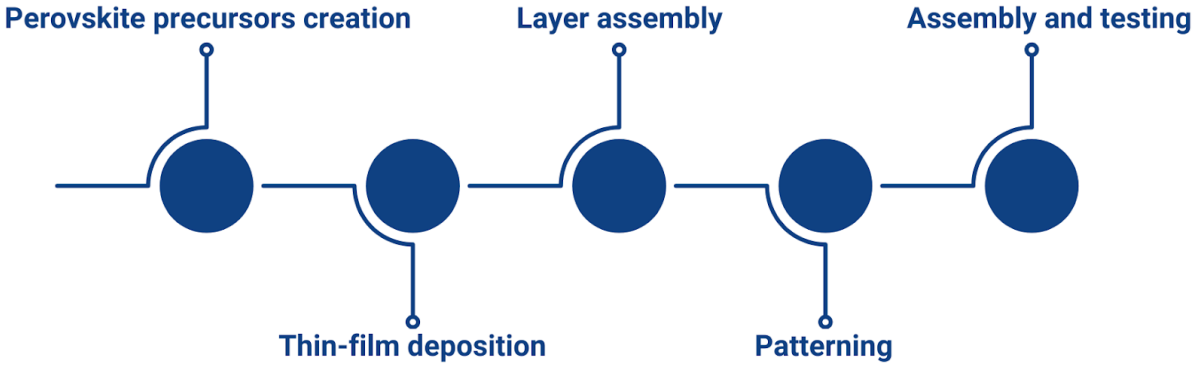
PSC greenhouses have been tested for agricultural cultivation in the northern region of Taiwan, and during the one-year trial, four different crops were selected. Photo Source: Allen Li (2024).

[28] Chi-Shiang, Liu. Interview with the Vice President of the SHANG TIAN ALUMINUM CO., LTD. by DSET. Interview date: October 30, 2024.
[29] Andy, Chen. Interview with the Chief Strategy Officer of the PROMATE Electronic Co.,Ltd by DSET. Interview date: November 1, 2024.

## Capitalising on Vertical Supply Chain Integration

Taiwan's advantage in the global PSC market lies not only in its technological capabilities but also in its robust, vertically integrated supply chain legacy from the panel industry. Panel manufacturing technology has many synergies with the PSC manufacturing process, and Taiwan retains a comprehensive supply chain for advanced panel technologies. In particular, the panel industry in Taiwan has mature large-scale glass manufacturing technology, as well as automated panel manufacturing and transport technology, all of which are necessary for the large-scale development of the PSC industry. This provides a strong foundation for the rapid development of PSC production.

### Stages of PSC Production




According to our interviewee, firstly, the primary substrate material for PSC is conductive glass, and the electrode material is transparent conductive oxide—both of which are already maturely used in existing panel manufacturing processes.[30] In the thin-film deposition stage, the perovskite layer is produced using wet-coating technology, similar to the photoresist and colour filter coating processes in the panel industry. This means that mass production equipment from the panel industry can be directly utilised. Next, in the layer assembly process, the electron/hole transport layers and electrodes used in PSC which are analogous to the metal layer manufacturing processes already established in the panel industry. Finally, PSCs are compatible with the later-stage processes of silicon solar cells, particularly in module integration and testing. This allows for integration with Taiwan's existing silicon solar module manufacturing processes and equipment.

However, it is important to note that while Taiwan maintains strong R&D and prototyping capabilities locally, the actual large-scale manufacturing processes often require facilities in mainland China, where production costs are lower. China's dominance in the global supply chain, particularly in the solar PV sector, highlights the challenges of this reliance.

By adopting a semi-customized production approach, Taiwanese companies can avoid direct price competition with Chinese manufacturers while capitalising on their own strengths in technology and application-driven solutions. This approach also aligns with Taiwan's

[30] Chien-Chih, Hsin. Interview with the Chief Marketing Officer of the TPSC by DSET. Interview date: October 30, 2024.

strategic focus on providing high-quality, specialised products rather than engaging in a race to the bottom on pricing.

Focusing on innovation, application-driven differentiation, and strategic market expansion, Taiwanese PSC manufacturers are well-positioned to navigate the complexities of the global solar industry. While challenges such as policy gaps and reliance on cross-strait supply chains persist, Taiwan's strengths in R&D, customisation, and niche market applications could enable it to secure a competitive edge in the next generation of solar technology.

# Part three: Collaboration between Taiwan and the EU in the emerging PSC industry

## Developments in the Europe's solar PV market

Europe's solar PV industry is highly fragmented, with no dominant players commanding the market. While some European firms operate at the upstream stages of the supply chain, such as polysilicon production and solar wafer manufacturing, the majority of activity is concentrated in module assembly. Polysilicon production is largely based in Germany, with Wacker Chemie AG as a notable example.[31] However, wafer and cell production remain limited, with Europe accounting for only a fraction of global capacity. The most developed segment of the value chain is module assembly, but even this stage faces significant competition from dominant international players, particularly China.

Europe's role in next-generation solar technologies, such as tandem and PSCs, is more promising but still underdeveloped. Oxford PV has emerged as a global leader, pioneering tandem perovskite-silicon panels and becoming the first company worldwide to commercialize such technologies. The company holds over 600 patents, many originating from research conducted at the University of Oxford. Despite these advancements, next-generation solar PV technologies in Europe remain largely in the research and development phase, with most projects yet to reach commercial viability or large-scale production.

The EU has taken some steps to support solar PV manufacturing, recognizing solar as a strategic net-zero technology in the 2024 Net Zero Industry Act (NZIA).[32] The Act aims to ensure that at least 40% of the EU's annual solar deployment needs are met by domestic manufacturing by 2030. To achieve this, the NZIA introduces measures to streamline administrative processes and reduce barriers for developers of net-zero manufacturing projects. It also seeks to stimulate demand for EU-manufactured renewables by incorporating sustainability and resilience criteria into procurement procedures and auctions. While these measures offer a framework for growth, the NZIA does not include direct financial support for capital investments or operational costs, a significant limitation compared to more ambitious schemes such as the US Inflation Reduction Act. This places EU solar PV manufacturers at a competitive disadvantage and underscores the need for additional mechanisms to bridge this gap.

[31] SolarPower Europe. 'EU Solar Manufacturing Map.' SolarPower Europe.
[32] European Commission. *Net-Zero Industry Act.* European Commission, March 16, 2023.

Member States have been able to provide some financial support due to temporarily relaxed state aid rules introduced in response to the energy crisis and Russia's invasion of Ukraine. The Temporary Crisis and Transition Framework (TCTF), announced in March 2023, allows governments to offer financial aid to renewable energy projects, including investments, tax benefits, loans, or guarantees, with maximum caps ranging from €150–350 million.[33] This framework has been complemented by the General Block Exemption Regulation (GBER), which permits Member States to provide investment aid without prior EU notification. Both frameworks have been extended, with the TCTF applying to net-zero projects until the end of 2025 and the GBER until the end of 2026.[3435]

However, reliance on state aid has exposed disparities between Member States. Financially stronger countries like Germany, France, and Italy have secured the majority of approved aid.[36] This creates unequal opportunities across the EU, distorting comparative advantages that financially weaker countries may have through lower labour or energy costs.

Specific support for next-generation solar technologies has come primarily through EU-funded research and development programs. Horizon Europe has supported projects such as the development of sustainable materials and manufacturing processes for perovskite-tandem modules, with a €5 million budget. Another project, PEARL, focuses on flexible PSCs with carbon electrodes and aims to achieve efficiencies exceeding 25% while lowering production costs. PEARL has a €4.5 million budget and involves a consortium of ten European partners.[37]

A more industrial-scale effort, the PEPPERONI project, is advancing tandem silicon-perovskite module manufacturing. Co-funded by the EU under Horizon Europe and the Swiss Secretariat for Education, Research and Innovation, this four-year project began in November 2022 and is coordinated by Helmholtz-Zentrum Berlin and Qcells.[38] It focuses on scaling up production capabilities for tandem solar PV cells, essential for achieving commercial competitiveness.

In addition to EU efforts, some Member States have launched their own initiatives. For instance, the FIT4Market project, supported by the Dutch government, seeks to commercialize two-terminal perovskite-silicon tandem solar cells.[39]

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[33] European Commission, 'Temporary Crisis and Transition Framework'; Cleary Gottlieb, 'Commission Adopts State Aid Temporary Crisis and Transition Framework'
[34] European Commission, *Commission Adjusts Phase-Out of Certain Crisis Tools of the State Aid Temporary Crisis and Transition Framework,* November 20, 2023.
[35] European Commission. *State Aid Regulations.*
[36] Makris, 'Temporary Crisis and Transition Framework'. *Kluwer Competition Law Blog,* April 4, 2023.
[37] European Commission, *Horizon Europe Project Details: FLEXIBLE PEROVSKITE SOLAR CELLS WITH CARBON ELECTRODES (101122283)*
[38]Pepperoni Project, *Pepperoni Project Website.*
[39] Topsector Energie. *Fit for Market.* Project number HER+21-02920432.; Kraemer, Ben. 'Consortium Led by TNO, Qcells Wants to Bring 2T Perovskite-Silicon Tandem Solar Tech to Market.' *PV Magazine*, March 14, 2023.

## Representative R&D programmes for next generation solar technologies funded by the EU and member states

| Project | Amount | Funder |
|---|---|---|
| Pilot line for European Production of PEROvskite-Silicon taNdem modules on Industrial scale (PEPPERONI) | €14.5m | Horizon Europe |
| Sustainable materials and manufacturing processes for the development of high efficiency, flexible, all-Perovskite Tandem photovoltaic modules with low CO2 footprint (SuPerTandem) | €4.9m | Horizon Europe |
| Flexible Perovskite Solar Cells With Carbon Electrodes (PEARL) | €4.5m | Horizon Europe |
| FIT-for-Market | €2.4m | The Netherlands Enterprise Agency |

The EU solar PV industry faces significant challenges. While research initiatives are yielding breakthroughs, the gap between R&D and large-scale commercialization remains broad. Current support mechanisms, though beneficial, are fragmented and fail to provide a unified EU-wide approach. Without stronger financial incentives and more equitable distribution of resources, Europe risks falling behind in the global race for solar dominance.

## How Taiwan can help Europe's ailing solar manufacturers

Taiwan not only possesses a comprehensive solar panel industry chain but has also been a long-term partner of the international market. Taiwanese solar manufacturers have years of experience collaborating with Europe which can serve as a foundation for Taiwan and Europe to jointly develop third-generation solar panels.[40][41] Such collaborations could see Taiwanese companies provide a much needed boost to investment, jobs and skills in Europe's ailing solar PV industry.

Taiwanese manufacturers hold several key advantages that make them well-suited for collaboration with Europe in the solar energy sector, particularly in the development and production of PSCs. Taiwan's solar industry benefits from a vertically integrated supply chain, allowing seamless coordination across manufacturing processes, from raw material procurement to final product assembly.[42] This integration ensures high-quality products with

[40] AUO. 'AUO to Showcase Its Integrating Position in the Solar Supply Chain at Italy's SolarExpo.'; Motech. 'Motech Announces Official Membership in the European Photovoltaic Industry Association (EPIA).' December 14, 2010.; AUO. 'AUO Starts EU Project to Provide First Made-in-Europe Solar Integrated Service Alliance.' August 15, 2012.
[41] Wagner Solar, '*AUO Closes Module Production in Brno, Czech Republic*.' April 1, 2019.
[42] Market Prospects. 'Situation and Trend of Taiwan's Solar Energy Industry.' March 28, 2022.

greater efficiency and cost-effectiveness, aligning with Europe's demand for innovative and reliable renewable energy solutions. Additionally, Taiwan's manufacturers are known for their expertise in precision engineering and automation, which translates into solar panels with enhanced durability and performance—a critical factor for meeting the diverse climatic conditions across Europe.[43]

## Taiwan Perovskite Research and Industry Association (TPRIA) Membership

Data compiled by DSET.


Following the EU's PEPPERONI project, the Taiwan Perovskite Research and Industry Association (TPRIA) was established in 2021, making it the second global organization dedicated to developing PSCs.[44][45] This underscores the importance Taiwanese manufacturers place in this industry. TPSC Chairman Chen Lai-Chu, who previously worked at AUO, brings extensive expertise in the panel industry. Chen expressed high expectations for Taiwan-Europe cooperation in the solar energy sector, including through investing in manufacturing facilities in Europe:

> *"Central European countries such as the Czech Republic and Slovakia are ideal partners for Taiwanese solar companies seeking to export entire manufacturing facilities. Their advantageous geographical location in Central Europe can reduce*

[43] ROC Embassies and Missions Abroad. *Taiwan Smart Factory Landscape*. June 2022.
[44] Pepperoni Project, Pepperoni Project Website.
[45] Taiwan Perovskite Research and Industry Association, 'About Us'

*carbon emissions during transportation and support compliance with the EU's Carbon Border Adjustment Mechanism [46](CBAM) by lowering overall carbon footprints."*[47]

Manufacturing PSCs in Europe is crucial to helping Taiwanese producers minimize the cost of CBAM certificates, which are tied to carbon prices under the EU ETS framework. This can offer Taiwanese companies a competitive edge as CBAM regulations tighten post-2026. Czechia's advanced industrial technologies (including semiconductors and photonics R&D) and its competitive cost structure position the country as an appealing destination for foreign investment in PSC development.[48] President Chen also noted the positive impact that Taiwanese investments in Europe's PSC sector could have:

*"Exporting entire facilities not only boosts perovskite solar panel production but also generates local job opportunities and fosters skilled talent, making it a mutually beneficial opportunity for both Taiwan and Europe."*[49]

Another example is Motech Industries, Inc., which became the first Taiwanese solar manufacturer to join the European Photovoltaic Industry Association (EPIA) in 2010.[50] This move marked the beginning of its commitment to collaboration with European companies in the solar industry. In 2023, Motech, in partnership with ITRI, developed high-transmittance solar modules and explored the potential of TOPCon technology.[51] This technology is suitable not only for offshore wind-solar hybrid systems but also for agrivoltaics. The company is currently in discussions with European tech farms about launching TOPCon-based agrivoltaic power plants in Europe in the future.[52]

Patent licensing is also a possible market strategy for Taiwanese manufacturers to enter the European market. Liu Chi-Shiang, Vice President of SHANG TIAN ALUMINUM CO., LTD., mentioned:

*"If we are able to secure a patent for this technology, we can license it directly to other countries for production. Since this process is patented, it means we don't necessarily need to set up factories ourselves; patent licensing can essentially be considered a form of export. This approach not only saves the costs associated with establishing factories overseas but also allows us to collaborate with other countries on the manufacturing process."*[53]

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[46] Infolink. 'Potential Impact of EU and US Carbon Regulations on Solar Exports and Countermeasures.' September 2, 2024.
[47] Lai-Chu, Chen. Interview with the President of the TPSC by DSET. Interview date: October 28, 2024.
[48] Czech-Taiwanese Business Chamber. 'Study on the Semiconductor Industry.' December 14, 2022.
[49] Lai-Chu, Chen. Interview with the President of the TPSC by DSET. Interview date: October 28, 2024.
[50] Motech. 'Motech Announces Official Membership in the European Photovoltaic Industry Association (EPIA).' December 14, 2010.
[51] Motech. 'Motech Launches Agrivoltaic Modules and Expands into the European Market.' October 18, 2023.
[52] Liberty Times Net. 'Motech successfully enters the aquavoltaics market with its TOPCon technology and plans to expand into agrivoltaic power plants in Europe next year.' October 18, 2023.
[53] Chi-Shiang, Liu. Interview with the Vice President of the SHANG TIAN ALUMINUM CO., LTD. by DSET. Interview date: October 30, 2024.

Finally, considering the need for extensive land space to accommodate the metre-size production lines and stages of the production process, leveraging existing science parks offers another potential model for Taiwan-Europe cooperation. Recently, Lithuania and ITRI partnered on a semiconductor capacity-building project aiming to establish a high-tech park in Lithuania.[54] If the park could include specialized zones for green energy technologies such as PSCs, it would significantly reduce the costs involved in cooperation and effectively accelerate the joint development of perovskite solar panels.

To materialize such cooperation, Taiwanese companies must adapt their designs and production standards to comply with the EU's stringent product regulations.[55] This includes utilizing environmentally friendly materials, ensuring recyclability, and minimizing hazardous substances in their products. Taiwan's prior experience in addressing "made-in-China" restrictions has equipped its industries with advanced traceability systems, ensuring transparency and compliance in global markets. Furthermore, aligning with the EU's carbon neutrality goals, Taiwanese firms can leverage their advanced technologies to create energy-efficient solar panels with lower embodied carbon. Close partnerships with local European companies will also help Taiwanese manufacturers better understand regulatory nuances and gain certification, facilitating smoother market entry. Through experience-sharing and collaboration, both sides can contribute to building a more sustainable future together.

[54] The Baltic Times. 'Teltonika, Lithuanian High-Tech Company Group, Signs Technology Cooperation Agreement with Taiwanese Partners.' January 18, 2023.
[55] SolarPower Europe. 'Statement: European Parliament Agrees on the EU Solar Standard.' March 12, 2024.

# Policy recommendations

## Recommendations for Taiwan: Accelerating domestic PSC development

Taiwan can utilise a range of policies to build its own competitive edge in next-generation solar technologies, with a number of lessons learned from other countries. Japan has established itself as a leader in PSC innovation by combining advanced R&D, domestic iodine production, and robust policy measures such as the Green Innovation Fund. Japan's success in PSC is driven by its focus on developing foundational technologies and creating alliances between government, academia, and industry. Initiatives such as public demonstration sites and industrial parks have helped the industry grow from small-scale development to an economically sustainable model, targeting strategic applications like BIPV and aiming to reduce electricity generation costs to 7 yen per kWh by 2030.

**(I) Establish public demonstration sites and projects.** Taiwan should build on successful initiatives like the Energy House in Taichung to showcase its solar technology capabilities and promote collaboration between government, academia, and industry. Government-led public demonstration sites can assist the PSC industry in technical verification and application testing. These platforms would not only validate advanced manufacturing techniques but also attract investment, expanding the industry's scale and fostering local R&D and production capabilities. Drawing from Japan's success, such sites could support the transition from small-scale development to mass production, enabling Taiwan to strengthen its position in the global PSC market.

**(II) Create perovskite industrial parks.** The Taiwanese government should establish industrial parks dedicated to PSC production. These parks would integrate all aspects of the supply chain, including raw materials, equipment, and advanced manufacturing processes, supporting the production of large-scale, metre-sized panels. Learning from China's planned perovskite industrial parks, Taiwan can create vertically integrated hubs that adapt quickly to foreign specifications. Producing high-value products like perovskite materials for BIPV within these parks would allow Taiwan to capitalize on the EU's zero-carbon building goals, gaining a critical first-mover advantage in international markets.

**(III) Enhance Compliance with EU Standards.** To strengthen its competitiveness in the European market, Taiwan must meet the EU's stringent standards for solar products. These include recyclability, energy labeling, and carbon footprint reduction. PSCs already have a significant carbon footprint advantage over silicon-based cells, making them well-suited for EU regulations. Implementing advanced supply chain traceability systems, such as third-party reporting and site labeling, can ensure transparency and compliance with EU import requirements, particularly those addressing forced labour and sustainability. Leveraging Taiwan's experience in navigating trade barriers, such as "Made-in-China" tariffs, will further enhance its ability to compete in the EU.

**(IV) Promote cross-border industrial cooperation.** Taiwan should strengthen its international collaborations by licensing PSC patents, exporting entire manufacturing facilities, or offering industrial park models to partner countries. For example, Czechia and Malaysia offer strategic advantages, including proximity to key markets and an abundant talent pool. By exporting comprehensive industrial park models, Taiwan can provide partner countries with entire supply chains, technology, and expertise, fostering mutually beneficial collaborations and expanding its global footprint in the solar industry.

**(V) Invest in talent development.** To maintain its competitive edge in the evolving solar technology sector, Taiwan must prioritize workforce development. Collaborations between industry, government, and academia can focus on building critical skills for PSC manufacturing processes, such as coating methods and electrode formation. Long-term investments in education and training will ensure a steady pipeline of skilled professionals, enabling Taiwan to remain at the forefront of PSC innovation.

**(VI) Support BIPV and agrivoltaic applications.** Taiwan should emphasize strategic applications of PSC technology, such as insulated glass windows for smart buildings and modular photovoltaic systems for agriculture. Initiatives like the TROPOX photovoltaic greenhouse demonstrate how PSCs can combine energy generation with agricultural needs, enhancing efficiency and adaptability. Expanding these niche applications will allow Taiwan to address local demands while creating innovative solutions for global markets.

By implementing these recommendations, Taiwan can leverage its strengths in PSC innovation, enhance its position in the global solar market, and align with international sustainability goals. These strategic measures will ensure that Taiwan remains a leader in next-generation solar technology.

## Recommendations for Europe: Recognising the potential of next-generation solar

Collaboration on the development of next-generation PSC solar technologies presents a major area of mutual interest between Europe and Taiwan. Greater adoption of PSCs can not only help Europe meet its Net Zero targets, but can also help Europe de-risk its dependence on China's solar PV supply chain while providing a boost to European jobs and industry.

Recommendations for European policymakers include specific steps for the EU and European governments to foster cooperation with Taiwanese partners, particularly in the field of joint research and development, as well as broader measures to further innovation within Europe's domestic solar industry.

**(I) Recognise the strategic case for developing next-generation solar.** The European Commission's recently published report *The future of European competitiveness* (also known as the 'Draghi Report') makes the case for the EU to focus support on technologies where it either has a lead or where there is a strategic case for developing domestic capacity.[56] While

[56] European Commission. 'EU Competitiveness: Looking Ahead.'

some analysts have sought to diminish the case for developing Europe's solar PV industries on the basis of China's dominant market position, this approach fails to separate out the strategic potential of next-generation solar technologies. While China's lead is well established in traditional silicon-based solar PV, this is not the case for PSCs and other emerging solar technologies, for which a number of European R&D initiatives have made important breakthroughs. The greater efficiency, diverse application and bespoke nature of these technologies mean that there is a strong strategic and economic case for the EU to seek to translate its R&D strengths into commercial and technological advantages in this sector. Measures proposed by the Draghi Report – including the creation of a European Advanced Research Projects Agency (ARPA) and streamlined funding for clean tech manufacturing through the Multiannual Financial Framework (MFF) – should include development of next-generation solar as a key part of such initiatives.

**(II) Further R&D collaborations between Europe and Taiwan.** A number of European countries have partnered with the Taiwanese government to provide joint funding schemes for R&D partnerships between European and Taiwanese companies. Austria, Sweden, Finland and the Netherlands support the GlobalStars Taiwan program through the Eureka network, which supports R&D collaborations in sectors such as semiconductors and digital technologies, while Taiwan and Germany previously supported a EUR 1.5 million annual fund for Joint Research on Battery Technology between 2017-2020.[57][58] European governments should renew and expand these schemes to include green energy technologies, such as next-generation solar. Schemes should aim to match the ambition of the UK-Taiwan collaborative research and development (CR&D) funding award, which offers up to GBP 5 million for innovative industrial research in sectors including green energy technologies.[59]

**(III) Explore an Associate Member agreement with Taiwan under Horizon Europe.** Taiwanese educational institutions are currently not eligible to receive funding under Horizon Europe, the EU's main research and innovation funding program. While Taiwanese companies can participate in Horizon Europe projects as Associated Partners, they need to raise their own funds through a co-funding mechanism with Taiwan's National Science and Technology Council.[60] However, upgrading Taiwan's status to become an Associate Member of Horizon Europe could enable Taiwanese entities to access funding in certain programmes. Non-EU countries with Associate Member status include Canada, Kosovo and the UK, with the EU currently exploring Associate Member status with countries including Japan and the Republic of Korea.[61]

**(IV) Support Taiwanese businesses adapting to the EU market.** In recent years the EU has brought in a raft of new regulations to ensure that imports into the single-market meet improved standards on areas including corporate due diligence, forced labour, carbon emissions and other environmental standards. The EU, through its Economic and Trade

[57] Eureka Network. 'Globalstars Call for Projects with Taiwan 2024.'
[58] National Science and Technology Council (NSTC). 'Taiwan-Germany Joint Research on Battery Technology– Making Taiwan a Green-Energy Homeland.' August 10, 2021.
[59] Innovate UK. 'Competition Overview: Innovation Funding.' *Innovation Funding Service.*
[60] Directorate-General for Research and Innovation. 'Horizon Europe Info Session 2023 in Taipei.' *European Commission.* February 28, 2023.
[61] Directorate-General for Research and Innovation. 'Updates on the Association of Third Countries to Horizon Europe.' *European Commission.* December 21, 2021.

Office in Taiwan, should offer regular stakeholder consultations with Taiwanese businesses to help them understand and adapt to new regulations.

**(V) Encourage Taiwanese firms to invest in European manufacturing.** Taiwan's solar PV industry is well placed to take advantage of innovations in next-generation solar products which could see high demand in European markets. The EU and European governments should also better resource their representative offices in Taiwan to support and encourage Taiwanese solar PV companies to consider investing in manufacturing capacity in Europe. Realising the Net Zero Industry Act's ambitions of cutting red-tape and expediting permitting will be critical to persuading Taiwanese firms to invest in European production. While individual EU Member States are able to offer investment aid under the General Block Exemption Regulation (GBER) and the Temporary Crisis and Transition Framework (TCTF), this results in a fragmented approach. A centralised EU Clean Tech Manufacturing fund would allocate resources most efficiently across the single market, allowing for expanded and more cost-competitive production.

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