International Energy Agency
Photovoltaic Power Systems Programme

PVPS

COUNTRY UPDATES

2025

PHOTOVOLTAIC POWER SYSTEMS TECHNOLOGY COLLABORATION PROGRAMME

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

Country Updates 2025

COVER PICTURE
MWp utility-scale project in Stourup, Denmark. The plant is owned by 3 local companies who also are the offtakes of the electricity produced. Owners engineer is Unison Energy Partners. Photo credit Solar Polaris.

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Figure 1: The Members of the Executive Committee and Task Managers at their meeting in Pamplona in October 2025.

INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organisation for Economic Cooperation and Development (OECD), which carries out a comprehensive programme of energy cooperation among its member countries. The European Union also participates in the IEA's work. Collaboration in research, development and demonstration (RD&D) of energy technologies has been an important part of the IEA's Programme.

The IEA RD&D activities are headed by the Committee on Research and Technology (CERT), supported by the IEA secretariat staff, with headquarters in Paris. In addition, five Working Parties on Industrial Decarbonization, Building and Transport, Fossil Energy and Carbon Management, Renewable Energy Technologies and Fusion Power, are charged with monitoring the various collaborative energy agreements, identifying new areas of cooperation and advising the CERT on policy matters.

The Renewable Energy Technologies Working Party (REWP) oversees the work of twelve renewable energy agreements and is supported by the Renewable Energy Division, Directorate of Energy Market and Security at the IEA Secretariat in Paris, France.

IEA PVPS

The IEA Photovoltaic Power Systems Programme (PVPS) is one of the Technology Collaboration Programmes (TCP) established within the IEA, and since its establishment in 1993, the PVPS participants have been conducting a variety of joint projects in the application of photovoltaic conversion of solar energy into electricity.

The overall programme is headed by an Executive Committee composed of representatives from each participating country and organisation, while the management of individual research projects (Tasks) is the responsibility of Task Managers.

By the beginning of 2025, twenty Tasks were established within the PVPS programme, of which nine are currently operational. The thirty-one PVPS members include twenty-eight countries: Australia, Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, India, Israel, Italy, Japan, Korea, Lithuania, Malaysia, Morocco, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Thailand, Türkiye, the United States of America, and the United Kingdom plus three sponsor members: the European Commission, Solar Power Europe and the Solar Energy Research Institute of Singapore.

MISSION AND OBJECTIVES

The mission of the IEA PVPS programme is:

Enhance the international collaborative efforts which facilitate the role of photovoltaic solar energy as a cornerstone in the transition to sustainable energy systems.

The IEA PVPS programme aims to realise its mission through the following objectives related to reliable PV power system applications, contributing to sustainability in the energy system and a growing contribution to CO_2 mitigation:

- PV technology development
- Competitive PV markets
- An environmentally and economically sustainable PV industry
- Policy recommendations and strategies
- Impartial and reliable information.

CURRENT TERM 2023-2028

In its 7th term from 2023 to 2028 IEA PVPS continues its commitment to advancing international cooperation in the field of photovoltaic technology. With many member countries contributing to its success over the past 29 years, PVPS outlines a strategic orientation aimed at supporting the overarching goals of IEA in terms of energy security, climate change mitigation, and economic competitiveness. The focus of this strategic plan is to empower photovoltaic technology to not only meet but surpass the targets outlined in the IEA's "Net Zero 2050 Scenario."

The significance of photovoltaic technology has been steadily rising, with its emergence as one of the most cost-effective means of electricity production. Its attributes including rapid deployability, ease of installation, and minimal maintenance costs have positioned it as a key player in the global transition towards clean energy systems. Moreover, PV's impact extends beyond the energy sector, infiltrating various domains such as buildings, transportation, agriculture, and industrial processes.

Under it's strategic framework, IEA PVPS participants are undertaking collaborative efforts encompassing research, development, demonstration, analysis, and information exchange related to photovoltaic power systems. Emphasizing both technical and non-technical aspects, the aim is to facilitate the large-scale and sustainable deployment and operation of PV.This includes integration into energy systems and infrastructure while embracing the emerging concept of circularity.

Looking beyond 2030, the strategic plan anticipates addressing forthcoming challenges such as physical, technical, and economic integration, alongside policy, regulatory, and social acceptance considerations. Collaboration with stakeholders from diverse energy sectors, networks, storage, and digitalisation arenas will be intensified to foster innovation and address evolving needs effectively.

AUSTRALIA

PHOTOVOLTAIC SECTOR STATUS 2025

Author: Renate Egan, APVI, UNSW, Australia

Figure 2: 30 kW ground mount install in regional Australia. Photo courtesy of Tindo Solar, Australia's leading solar manufacturer.

PV POLICY PROGRAMME

With over 40% of free-standing homes powered by solar, and an estimated 1.6 kW per capita installed PV, policy is now framed around dispatchable capacity. A major policy in the federal Cheaper Home Batteries Program was launched on 1 July 2025, providing a 30% rebate on battery installations and driving record-breaking uptake, with the installation of over 165 000 household batteries to year end, with an average size of over 20 kWhr. This followed an expansion, in 2023 of the Capacity Investment Scheme targeting 32 GW of new capacity nationally, made up of 23 GW of renewable capacity and 9 GW of clean dispatchable capacity by 2027.

Large scale solar investments (over 100 kWp) receive tradeable certificates for energy generated, while small -scale systems (less than 100 kWp) are supported through a Small -Scale Renewable Energy Scheme (SRES) based on an assessment of the amount of generation they are deemed to produce until the end of 2030. Small systems receive an up-front capital cost reduction through this process, with the level of support decreasing every year to 2030.

The Large-Scale Renewable Energy Target (LRET) of 33 000 GWh of renewable electricity annually saw the installation of close to 9 GW of solar installations. The larger challenge for utility scale solar now is curtailment due to excess solar. As a result, utility-scale solar in 2025 faced investment challenges as well as ongoing delays, while distributed rooftop systems and home batteries outperformed expectations. Recent policy adjustments reflect a shift to support for large- and small-scale storage.

2025 saw the release of funds under the Australian government commitment of $1 billion to an initiative aimed at building Australian solar PV manufacturing capability and supply chain resilience, informed by a 2024 analysis of the solar supply chain (APVI, Silicon to Solar).

National programmes in support of solar PV are also complemented by State based schemes, that seek to attract new investment in clean energy projects. Examples include Renewable Energy Zones (REZs) that aim to combine utility scale solar with wind, storage and high-voltage transmission to deliver energy to load centres. By co-ordinating investment, connection and location with respect to load, multiple generators and storage, the REZ can capitalise on economies of scale to deliver cheap, reliable and clean electricity.

RESEARCH, DEVELOPMENT & DEMONSTRATION

PV research, development and demonstration are supported at the National, as well as the State and Territory level. In 2025, research was supported by the Australian Renewable Energy Agency (ARENA), the Australian Research Council and Co-Operative Research Centres.

The Australian Centre for Advanced Photovoltaics (ACAP) was established in 2013 to coordinate solar PV research nationally. ACAP is a national centre, hosted at UNSW, with Professor Martin Green as

Founding Director. Funded by ARENA, ACAP has partners at leading research institutions around Australia including ANU, CSIRO, the Universities of Melbourne, Sydney and Queensland and Monash Uni. After ten successful years, ACAP funding was extended in 2023 supported by $45m AUD from ARENA and $10m AUD from partners.

ARENA also funded a host of new initiatives targeting commercialisation of research outcomes, making close to $60m AUD available over five years from 2023 and a further $80m AUD available in late 2025, under an Ultra Low-Cost Solar program, aiming to drive the levelized cost of electricity from large-scale solar down from the current $50/MWhr to below $20/MWhr. In addition, the federal government, under its education ministry, supported an initiative in research acceleration in the area of Recycling and Clean Energy (TRACE) with a program stream on solar technologies. The program has an ambitious goal to move rapidly to establish an innovation ecosystem to get research solutions to market faster.

Australia is active in all IEA PVPS tasks. Australia's participation in the IEA PVPS program is supported by the Department of Climate Change, Energy, Environment and Water (DCCEEW).

INDUSTRY AND MARKET DEVELOPMENT

Australia saw an estimated 4.9 GW of solar installed in total in 2025, with over 2.7 GW of rooftop solar and over 2.2 GW of utility scale solar. This number may increase once all new installations are reported for the year. If so, the market will remain stable at the historical 5-year average of 4.8 GW/year. Total installed solar capacity is now around 45 GW, 30 GW of which is rooftop solar. Solar costs stabilized in 2024-2025, with the average price per watt (installed system prices, with incentives) at $0.90.

"Australia's main grid achieved a record renewable share of more than 50 per cent as demand for power reached a record high and while electricity prices fell to their lowest value in two years."

Rooftop solar claimed an annual average fraction of total electricity demand of around 15%, while large-scale solar projects contributed over 7%, for an estimate of 22% of total electricity needs being met by solar over 2025. In Q4-2025, Australia's main grid reached a record renewable (wind and solar) share of more than 50 per cent as demand for power reached a record high and while electricity prices fell to their lowest value in two years (ABC News).

The Australian storage market remained strong in 2025, with the Clean Energy Regulator now tracking and reporting battery installations. A new federal government initiative to support household battery installs saw over 165 000 batteries installed in the 6 months to the end of the year, more than the sum total of ten years prior in voluntary reporting, resulting in 4.3 GWhr of storage capacity added.

The Australian market remains favorably viewed by overseas solar, battery and inverter manufacturers due to its high electricity prices, low feed-in tariffs, excellent solar resource, and large uptake of residential PV. There are also a large number of large-scale battery deployments planned, as excess solar in the middle of the day results in curtailment, and evening peaks challenge grid capacity.

2026 is expected to see stability in residential rooftop solar and continued growth in commercial and industrial installations. The economic fundamentals for residential and commercial PV are outstanding. Australia's high electricity prices and inexpensive PV systems means payback can commonly be achieved in 3-5 years; a situation that looks set to continue in 2026. Larger scale behind the meter PV and battery systems are increasingly attractive for the industrial and mining sectors.

Renewed investment in large scale solar and batteries is expected to start to yield projects and connections in 2026, with a pipeline of projects aimed at 23 GW of renewable capacity and 9 GW of clean dispatchable capacity to be delivered before 2027.

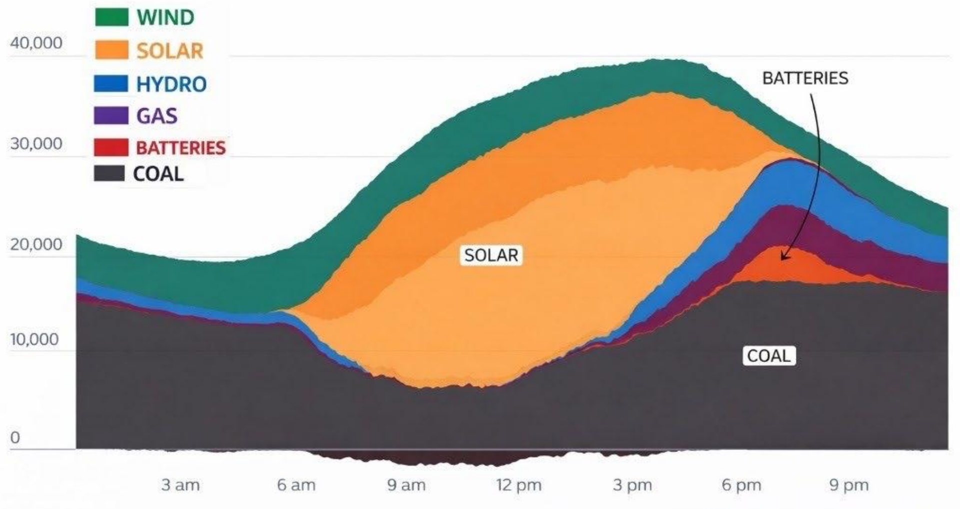

Figure 3: Solar plays a key role in managing surging demand in Australia, during a heatwave. The ABC News and energy commentator Tim Buckley of Climate Energy Finance, observe both increased grid and spot price stability due to solar and batteries, as demand rose.

AUSTRIA

PHOTOVOLTAIC SECTOR STATUS 2025

Author: Hubert Fechner, Austrian Photovoltaic Technology Platform, Austria

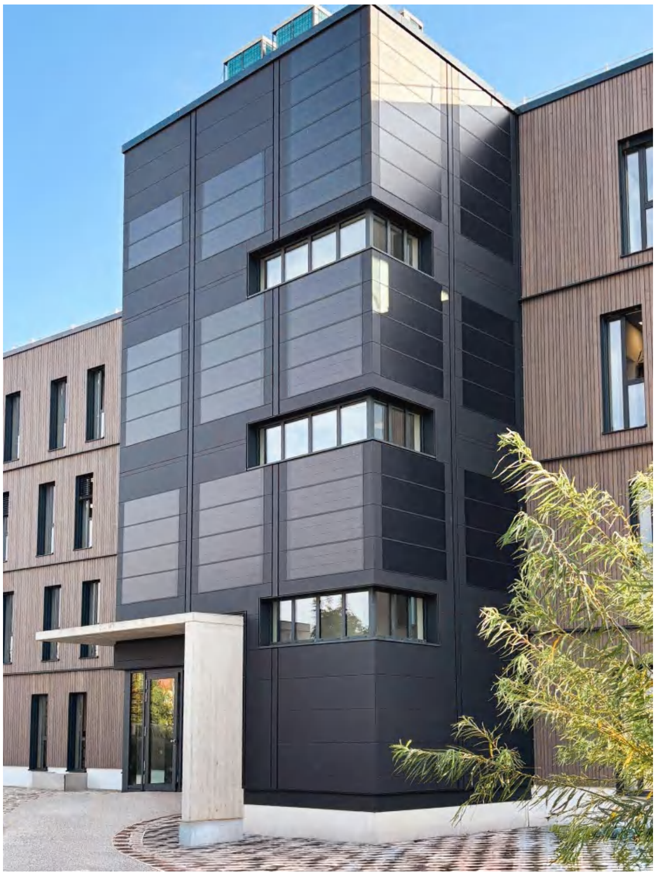

Figure 4: Planum Solar Facade, Domico.

PV POLICY PROGRAMME

After two years of annual installation rates well above 2.5 GW (DC), PV expansion in Austria slowed significantly in 2025. Around 1.8 GW (DC) have been connected to the grid in 2025.

The main reasons for the slowdown in PV installation are political changes, in particular, the new government's premature decision to end the VAT exemption for small PV systems leading to declining residential installations.

Despite the weaker development, large plant constructors remain active. At the end of the year, a total of around 11 GW (DC) was installed in Austria, which now contributes around 13% to the national electricity supply.

Nevertheless, photovoltaics is increasingly becoming a central component of the energy transition in Austria but faces challenges in terms of stable political framework conditions and targets. Overall, the share of renewable electricity production in Austria is quite high, with about 85 % in 2025 due to historically strong hydropower and through the expansion of wind power over the last 20 years; nevertheless this year showed a significant decline compared to 2024, primarily due to lower hydro and lower wind availability during the year.

In addition to nationwide subsidies, photovoltaic systems are also supported with subsidies in most of the federal states, however, always with a slightly different funding priority.

In energy legislation, the discussion about a new Electricity Act dominated: The Act was finally passed shortly before the end of the year and contains the following key points for photovoltaics:

- New PV systems above a certain capacity (e.g. above 3.68 kWp) must be technically designed in such a way that grid operators can remotely control them to a certain extent.
- Flexible grid access: The new law creates a legal framework for flexible grid connection. This means that PV systems can be connected even before the full grid capacity is available.
- Joint information platforms are required for grid operators to publish grid capacities, grid conditions and grid development plans.
- The new energy act creates the basis that PV electricity is traded or shared directly between producers and consumers via the public grid (energy communities, peer2peer, etc.)
- Electricity suppliers are required to offer contracts with dynamic energy prices and flexible grid tariffs are permitted.
- Joint operation of an Austrian national flexibility platform between electricity grid operators.

A widely discussed new grid-injection fee for electricity generation was finally reduced to system sizes beyond typical residential PV-systems.

RESEARCH, DEVELOPMENT & DEMONSTRATION

The Austrian Ministry for Innovation, Mobility and Infrastructure, in conjunction with the Austrian climate and energy fund, offers an ongoing broad program of research and innovation support in the field of renewable energy and energy efficiency. PV systems are an integral part of many subsidized projects [Austrian Energy research]; Public spending on research, development, and demonstration projects in the energy sector amounted to a record of 401 million EUR in 2024 of which about 9.4 million EUR went to Photovoltaic research. The topics of energy efficiency, transmission, storage, as well as hydrogen and fuel cells, were clearly in the foreground of the research, development, and demo projects. Due to budgetary consolidation measures, public funding for lighthouse projects in photovoltaic and storage systems has declined significantly in 2025.

The Austrian PV-Technology platform which was initially supported by the same ministry, acts as a legal body since 2012. It brings together about 35 Austrian-based industries and commercial entities, active in the production of PV relevant components and sub-components, as well as the relevant research community, in order to create more innovation in the Austrian PV sector. The transfer of the latest scientific results to the industry through innovation workshops, trainee programs, and conferences, joint national and international research projects, and other similar activities are part of the work program, in addition to the needed awareness raising, as well as aiming at further improving the framework conditions for manufacturing, research and innovation in Austria for the relevant decision-makers.

In the European research environment, Austria is coordinating the Clean Energy Transition Partnership (CETP), a co-funded Partnership in Horizon Europe.

Most Austrian producers in the photovoltaic sector are struggling to compete internationally. Research and innovation will increasingly play an important role.

The European Net Zero Industry Act is seen as a great opportunity that must be utilized nationally to strengthen the Austrian renewables sector together with European partners and ensure sovereignty in the energy supply.

Aspects of sustainability, recycling and the re-use of photovoltaic modules are becoming increasingly important and are the subject of intensive research. National and European Projects are dealing with recycling or extending the lifespan of PV Modules.

Special attention is paid to photovoltaic applications that generate particular added value, such as in agriculture, the transport sector or the building industry. For most of the Austrian Photovoltaic research priorities, close links to the tasks of the IEA PVPS are of great value.

Photovoltaics is increasingly becoming a central component of the energy transition in Austria.

INDUSTRY AND MARKET DEVELOPMENT

The year 2025 was characterized by discussions about the value of photovoltaic energy on the electricity market (negative energy market prices at times of high PV production) and thus about the tariffs granted for feeding into the public electricity grid. Discussions about grid compatibility were almost equally important, which can be attributed on the one hand to a lack of knowledge about real-time processes in the electricity distribution grids and on the other hand to the lack of incentives not to feed PV-electricity peaks into the grid.

Storage and the use of local flexibilities, vertical PV as well as dynamic grid access options are therefore at the beginning of widespread introduction and should gain momentum thanks to the new energy law. Further national laws and regulations in the electricity sector with an impact on the PV sector were discussed in 2025 but not finally endorsed.

At the Sölden Tiefenbach glacier skiing resort a remarkable alpine PV system with a target capacity of approximately 6 MW has been in the construction phase since the beginning of 2025. A special cross structure is designed to ensure that wind turbulence keeps the modules permanently free of snow, even at high alpine altitudes.

Larger open-space PV systems in MW and Multi-MW range are almost exclusively implemented in combination with agriculture due to better conditions for subsidies. The most common type is sheep breeding, but enormous benefits for agricultural production have been achieved, particularly in fruit cultivation (apples, peaches, berries...), when these areas are partially covered with photovoltaic elements. Most of these pilot plants are scientifically monitored and prepared for long-term studies.

The development of car park PV-roofing has gained enormous momentum in 2025, with various large-scale projects with a total of over 20 MW being implemented nationwide, not only making double use of already utilised space but also increasing convenience for motorists, mostly in conjunction with electric charging stations.

Building integration still needs to be expanded, with funding applications for building-integrated PV with around 15 MW submitted in 2025. Efforts to integrate PV as standard into Building Information Modelling (BIM) are being made as part of a major research project.

The Federal Association Photovoltaic Austria serves as the non-governmental interest group of the solar energy and storage industries in Austria. This association promotes solar PV at the national and international level and acts as an informant and intermediary between business sectors and the political and public sectors. Its focus lies in improving the general conditions for photovoltaic and storage systems in Austria and on securing suitable framework conditions for stable growth and investment security. Benefiting from its strong public relations experience, PV-Austria builds networks, disseminates key information about the PV industry to the broader public, and organizes conferences, workshops, and industry meetings.

Figure 5: HELIOPLANT® PV-System Tiefenbach Glacier Sölden, Tyrol Austria.

BELGIUM

PHOTOVOLTAIC SECTOR STATUS 2025

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Figure 6: Solar panels placed above a raspberry plantation of pcfruit, the experimental centre for fruit cultivation in Sint-Truiden © Foto: Noa Sneyers.

PV POLICY PROGRAMME

As Belgium is a federal state, the responsibilities for energy policy are divided among the three regions (Flanders, Wallonia, Brussels) and the federal Government, which is responsible for the renewable energy developments at the Belgian part of the North Sea.

In October 2025, the final national NECP was submitted. The regional ambitions are respectively 10/5.1/0.3 TWh of solar photovoltaic electricity generation by 2030 in Flanders, in Wallonia and in Brussels. Put together, this means a national generation target of 15.4 TWh/year (≈17 GW) by 2030 which falls short from the estimated 20-25 GW needed according to an EnergyVille study.

In 2025, there were no subsidies for new PV systems in Flanders, where competitiveness is driven by self-consumption, combined sales of surplus electricity to a utility, or by Power Purchase Agreements for larger plants. In Wallonia, there are not subsidies for new residential PV systems (<10 kW), for which competitiveness is driven by self-consumption combined sales of surplus electricity to a utility. For larger systems (>10 kW), green certificates can be obtained, even if the implementation of the new calculation method is suffering delays. The subsequent phase-out of net-metering in Flanders and then in Wallonia has also been accompanied with the increase of the combination of small-scale batteries and solar PV. Batteries connected to the distribution grid of the largest DSO in Belgium have risen from around 100 MW in 2021 to 740 MW at the end of 2024 (Elia). In Brussels, net-billing is in place for new residential PV systems (<5 kW) and green certificates are available for various sizes and typologies (BIPV-specific green certificate grant rate exists) of PV systems.

Since April 2025, consumers in all three regions are permitted to install plug-and-play solar panels. Although precise installation figures are not yet available, early indications suggest that this solution has rapidly gained popularity.

Across Belgium, solar integration obligations for buildings are increasingly linked to the EU recast Energy Performance of Buildings Directive. In Brussels and Wallonia, draft updates to regional building energy performance rules are considering how to include such solar requirements for new and existing buildings, with indicative deadlines for obligations falling within the 2027 to 2031 window depending on building type and size. The exact scope, exemptions and enforcement still need to be confirmed in 2026. In Flanders, alongside a reformulated ambition to accelerate the electrification of heating and transport, a specific obligation is already in place for large electricity users. Companies connected to a metering point withdrawing more than 1 GWh per year must meet a renewable energy obligation by 1 April 2026, following an extension from the initial 30th June 2025 deadline. The obligation can be met by commissioning PV, commissioning other renewables or related technologies, or by financial participation in renewable projects.

RESEARCH, DEVELOPMENT & DEMONSTRATION

In 2025, Belgian PV research continued to align closely with the electrification pathway reaffirmed by EnergyVille's updated PATHS2050 analyses. These scenarios underline that deep electrification is indispensable for meeting Belgium's climate objectives, with solar energy playing a structural role in the transition. Against this backdrop, Belgian RD&D remains strongly anchored in high-efficiency technologies - particularly perovskites and tandem architectures - while clearly shifting attention toward reliability, long-term validation, and industrial relevance.

Perovskites and tandems: durability becomes decisive – One of the most visible developments in 2025 was the shift from headline efficiency records to demonstrable operational stability. EnergyVille/imo-imomec and partners reported encouraging outdoor stability results for perovskite mini-modules, showing performance retention well beyond the short lifetimes that have historically limited confidence in the technology. By hosting both the tandemPV workshop and ISOS-16 in Genk, Belgium, it further confirmed its active role in shaping the international stability agenda. Discussions focused on degradation mechanisms, encapsulation strategies, measurement protocols, and improved data transparency - topics that are increasingly seen as prerequisites for bankability.

The annual installed solar PV capacity is estimated to be at least 925 MW.

At the same time, Belgian research groups continue to publish strongly on perovskite and tandem PV, with particular attention to interface engineering, degradation pathways, and scalable processing. Importantly, these scientific advances are no longer viewed in isolation. Through initiatives such as NOAK (Next-of-a-Kind) PV and broader reshoring ambitions, Belgian actors are explicitly linking advanced PV concepts to manufacturing strategies and international value-chain partnerships, signalling a growing alignment between research excellence and industrial positioning.

Flexible thin-film PV and new application domains – Beyond tandems, Belgium continues to invest in lightweight and flexible thin-film PV, including chalcogenide-based technologies. Work on ultra-thin glass substrates and mechanically robust device architectures highlights opportunities for high specific power applications, ranging from vehicle integration and building façades to aerospace use. Increasing attention is given to reliability under demanding operating conditions, including temperature cycling and space-relevant stress factors. These efforts expand Belgium's PV portfolio into high-value niches where performance-to-weight ratio and design flexibility are critical.

Agrivoltaics: from research concept to field practice – Agrivoltaics gained further momentum in 2025. EnergyVille/KU Leuven launched a practical web-based assessment tool within the Hyperfarm project to help stakeholders evaluate agrivoltaic configurations. The tool allows users to explore trade-offs between crop yield, shading effects, electricity production, and economic return, supporting informed project development. In parallel, field demonstrations - such as PV installations above fruit plantations in Sint-Truiden (PC Fruit) - illustrate that agrivoltaics is gradually moving beyond pilot status toward tangible deployment within Belgium's agricultural landscape.

Demonstration infrastructure: IN2PV at Thor Park – On the demonstration side, Belgium strengthened its validation capacity with the launch of the IN2PV test infrastructure at Thor Park in Genk. UHasselt, imec, and Soltech inaugurated a 55-are outdoor facility dedicated to free-standing and building-integrated PV systems. The site enables long-term monitoring of novel module technologies - including tandem concepts - in realistic applications such as canopies, façades, noise barriers, and agrivoltaic systems. In this way, IN2PV forms a concrete bridge between laboratory innovation and deployable, system-level integration.

PV within large-scale energy missions – Finally, Belgian PV expertise is increasingly embedded in broader energy-system missions. In 2025, EnergyVille partners initiated a comprehensive study on the sustainable energy supply for the Einstein Telescope, the potential third-generation gravitational wave observatory in the Euregio Meuse-Rhine region. The study evaluates electricity demand during construction and operation, grid integration challenges, storage needs, and hybrid renewable configurations. Solar PV is positioned as a key building block in designing a credible, large-scale renewable energy solution, illustrating how Belgian RD&D contributes not only to technology development but also to energy-system integration at the infrastructure scale.

INDUSTRY AND MARKET DEVELOPMENT

In 2025, the total electricity consumption in Belgium was 80.1 TWh. Solar PV represented 15% (10.1 TWh) of the electricity generation mix in 2025, a 25% increase compared to 2024 primarily attributable to favourable sunshine conditions in 2025 as well as to the continued annual solar PV capacity additions in 2024 and 2025.

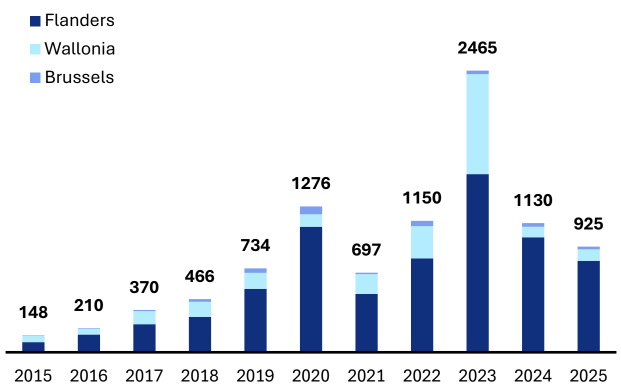

Figure 7: Annual solar PV market in Belgium (per region). Values for 2025 are still an estimation.

In 2025, the annual installed solar PV capacity is estimated to have been at least 925 MW, with respective contributions of Flanders, Wallonia and Brussels of 800 MW (estimation based on AC capacity), 100 MW and

25 MW. This brings the cumulative installed capacity close to 13 GW and Watt per capita penetration to 1 080. These figures should be treated as provisional, since full year data are not yet available for all regions. In recent years, reported annual totals have typically been revised upwards by 15 to 20 percent once final data are published, which could ultimately place the 2025 market closer to 1.1 GW.

There are just a few, niche-market, solar module producers in Belgium. BelgaSolar (called EvoCells until recently) added a new 50 MWp production line in 2024. Another example is Soltech, which targets the special use market of solar PV integrated in facades, glass, street furniture and stepping stones for instance. Their factory at a former coal mine site in Genk was officially opened in 2023 and shows a (solar PV) picture of a coal mine worker on their own façade. Belgium hosts a couple manufacturing projects, although these initiatives are not yet operational and remain at varying stages of maturity

CANADA

PHOTOVOLTAIC SECTOR STATUS 2025

Authors: Christopher Baldus-Jeursen, Natural Resources Canada, Canada
Yves Poissant, Natural Resources Canada, Canada

Figure 8: Inaugurated in January 2024, the 4.8 MW community-owned PV array in Mahone Bay, Nova Scotia, is part of the province's Community Solar Program which facilitates shared ownership of PV projects. The array was partly funded by the Government of Canada and the project was developed by AREA, a 100% municipally owned company formed in 2014 (photo credit: Goldbeck Solar).

PV POLICY PROGRAMME

The development of the photovoltaic (PV) sector in Canada fits within the broader context of efforts to decarbonize electricity production. There are no specific capacity installation targets for PV set by the federal, provincial, or territorial governments. As of December 31, 2024, Canada's PV sector reached approximately 7.35 GW_{DC} of installed capacity, representing a 4% increase (or around 299 MW_{DC}) over the previous year. These data and other information on PV policy, prices, and industry trends are reported in Canada's annual National Survey Report (NSR) provided to the International Energy Agency Photovoltaic Power Systems Program.

At the national level, PV is eligible for several federal support programmes including the CAD 4.56 billion Smart Renewables and Electrification Pathways Programme, the CAD 500 million Low Carbon Economy Fund, the CAD 520 million Clean Energy for Rural and Remote Communities programme, and the CAD 100 million Smart Grid programme. There are also tax incentives for Canadian industry including, more recently, **Canada's Clean Technology Manufacturing (CTM) Investment Tax Credit** which refunds 30% of the capital costs for new machinery and equipment used to manufacture low carbon technologies or to extract minerals and other resources used in their fabrication. The CTM credit is available to eligible property that was acquired between January 1, 2024, and December 31, 2034.

Provinces and territories also implement their own local support policies such as capital subsidies, self-consumption, net metering, and Property Assessed Clean Energy programmes whereby PV costs are repaid through property taxes.

RESEARCH, DEVELOPMENT & DEMONSTRATION

Fundamental materials research into PV cell or module technology is conducted primarily through university and industry research groups, while research, deployment, and optimization of PV systems tend to be the purview of industry, local utilities, and governmental institutions. At the Federal level, PV systems research and deployment occurs mainly through the Renewable Energy Integration (REI) programme of CanmetENERGY in Varennes. To this end, the REI program conducts PV research on the performance, durability, and costs of PV systems and components as well as their integration into buildings and electricity grids. CanmetENERGY also studies PV system applications in remote Arctic communities in Nunavut, Yukon, Northwest Territories, and the northern Quebec region of Nunavik. Renewable energy deployment in these communities reduces diesel fuel dependence while increasing grid flexibility and energy storage options.

Aside from the installation of ground-mounted and rooftop PV systems, there is also interest in agrivoltaics among Canadian PV installers, project developers, and farmers. More work is needed to promote research, develop case studies for different crops and PV configurations, establish regulatory frameworks, and define and implement policy support mechanisms. Agrivoltaics Canada, a farmer-led not-for-profit advocacy group, was recently incorporated to help realize these goals. Agrivoltaics Canada works in partnership with the PV industry, as well as with provincial and federal government agencies and academic institutions including the University of Western Ontario and the Ontario Agricultural College at the University of Guelph.

Canada's Clean Technology Manufacturing Investment Tax Credit refunds 30% of the capital costs for new machinery and equipment used to manufacture low carbon technologies or to extract minerals and other resources used in their fabrication. This option is available to eligible property that was acquired between January 1, 2024, and December 31, 2034.

INDUSTRY AND MARKET DEVELOPMENT

Total PV electricity production as a percentage of total electricity consumption in Canada is around 1.4%. In terms of DC capacity, approximately 73% of Canada's cumulative PV capacity consists of ground-mounted centralized systems providing bulk power on the supply side of electricity meters without self-consumption. The remaining 27% is distributed PV capacity on the demand side of the electricity meter and often embedded on a customer's premises. The economic value of the Canadian PV industry in 2024 was approximately CAD 863 million.

The combined number of full-time manufacturing, installation, distribution, and research employment in this sector was estimated to be approximately 6 502 jobs. This estimate, outlined in Canada's latest NSR, is highly conservative since it does not include PV system design and engineering, sales and marketing, project development and management, or legal/financial services and administration. Examples of several large PV manufacturers in the Canadian market include Canadian Solar, Heliene, and Silfab. Other participants in the production chain include Canadian Premium Sand, a major patterned glass supplier in North America. There is also a variety of array racking and component manufacturers and distributors. Turnkey prices in CAD per Watt (CAD/W), as reported in the NSR, are divided into rooftop (building-added PV) and ground-mounted systems. For rooftop PV systems from 5 to 10 kW, prices were around 2.30 to 3.90 CAD/W. Larger rooftop arrays from 10 to 100 kW had prices that were around 2.00 to 3.20 CAD/W. Commercial roof-mounted PV from 100 to 250 kW varied between 1.90 to 2.40 CAD/W. Small centralized arrays between 1 and 20 MW were from 1.65 to 1.90 CAD/W. For systems larger than 20 MW, prices were generally less than 1.31 CAD/W. Overall, the price estimates for 2024 were similar to 2023 as a decline in module price was offset by an increase in balance-of-system cost.

CHINA

PHOTOVOLTAIC SECTOR STATUS 2025

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Figure 9: 22.8MW Xiamen Xiang'an International Airport, jointly developed by LONGi and CENTER INT.

PV POLICY PROGRAMME

In 2025, China employed multi-dimensional measures aimed at removing obstacles hindering the healthy development of the industry and creating a more standardized and stable market environment for demand-side installations, thereby providing an all-round stimulus to the growth of photovoltaic installations.

1. On January 1, 2025, the ***Energy Law of the People's Republic of China*** officially came into force. As a foundational and overarching legislation in the energy sector, it explicitly enshrines in law, for the first time, state support for the priority development and utilization of renewable energy. It establishes key mechanisms including minimum renewable energy consumption targets, power consumption guarantee obligations, and measures to promote green energy consumption.

2. In January, NEA released ***"Management Measures for the Development and Construction of Distributed PV Power Generation"***. Various grid-integration models were subjected to refined categorization and clear regulatory definitions, moving away from unregulated development.

3. In February, NEA released ***"Notice on Deepening Market-oriented Reform of New Energy Feed-in Tariffs to Promote High-Quality Development of New Energy"***, establishing that 100% of the electricity generated from new energy projects shall in principle be enrolled in the power market through a sustainable pricing settlement mechanism

4. In September, NDRC released a notice titled *"**Improving the Pricing Mechanism to Promote Local Consumption of New Energy Power Generation**"*, specifying that in accordance with the principle of "beneficiary pays", local consumption project shall fairly bear costs such as transmission and distribution fees and system operation fees for the stable supply services provided by the power system

5. In November, NDRC's ***"Guiding Opinions on Promoting the Integration and Regulation of New Energy"*** proposed an annual target of integrating over 200 GW of new energy capacity, with the majority of newly added electricity consumption to be primarily met by new energy

sources. It also supports the participation of energy storage systems and virtual power plants in the electricity market.

In 2025, the core logic of China's PV supply-side policy was to "eliminate export subsidies and expand green connotations," steering the industry from "scale expansion" toward "quality and efficiency improvement."

1. Full Removal of Export VAT Rebates for PV Products(Although announced in early 2026, this policy reflects the strategic direction set in 2025): On January 8, 2026, the Ministry of Finance and the State Taxation Administration jointly issued an announcement abolishing VAT export rebates for major PV products—such as wafers, cells, and modules—effective April 1, 2026. This marks a major pivot in China's PV support policy, shifting the basis of global competition toward technological innovation and product quality. It sends a strong signal to drive high-quality development on the supply side.

2. Policy Push for "PV+" and Green Manufacturing: In October 2025, the National Energy Administration released the *Guiding Opinions on Promoting Integrated and Converged Development of New Energy*. The policy explicitly encourages "supporting green manufacturing of the new energy industry chain with new energy" (i.e., using green electricity to produce PV products) and promotes the convergence of new energy with emerging sectors such as high-end equipment manufacturing. This reflects a deep shift in policy orientation —from merely expanding manufacturing scale to fostering green supply chains and enhancing low-carbon competitiveness across the entire industrial chain.

RESEARCH, DEVELOPMENT & DEMONSTRATION

In 2025, China's PV industry achieved significant progress in R&D and demonstration, contributing importantly to global PV technology innovation and cost reduction. Key highlights are as follows:

1. Breakthroughs in frontier technologies: Chinese research institutions set 9 new world records in cell conversion efficiency certified by NREL during the year of 2025. The lab efficiency of silicon-perovskite tandem cells reached 35%; average mass production efficiencies of TOPCon and HJT cells hit 25.7% and 25.9%, respectively.

2. Rapid evolution of industrialization technologies: The market share of rectangular and micro-rectangular silicon wafers surged to nearly 70%, driving continuous module power improvement. Cost-reduction technologies such as BC cells and silver-free/low-silver metallization are accelerating toward mass production, with 0BB (busbar-free) technology already scaled up.

3. Expansion of diversified application demonstrations: China actively promoted integrated PV application demonstrations across various scenarios.

3.1 Ecological restoration: In line with national plans, "PV for desert control" entered the preparatory phase for large-scale implementation, targeting a cumulative 253 GW of new installed capacity by 2030.

3.2 Zero-carbon industrial parks: Construction of the first national-level zero-carbon parks was initiated. According to the construction notice issued by the NDRC and other departments, these parks are required to source no less than 50% of their electricity directly from green power, exploring local consumption models for high-penetration new energy.

3.3 System integration: The development pathway for virtual power plants (VPPs) as a solution for integrating distributed resources was clarified. According to the *Guiding Opinions on Accelerating the Development of Virtual Power Plants* (NDRC Energy [2025] No. 357), it is planned to achieve over 50 GW of regulation capacity by 2030.

4. Policy guidance for high-quality development: At the policy level, measures such as the removal of export VAT rebates are steering enterprises to shift their competitive focus from price to technological innovation, objectively increasing corporate investment incentives in advanced R&D and cost-reduction technologies.

These developments demonstrate that China's PV industry, through sustained R&D investment and extensive exploration of application scenarios, is committed to advancing global PV technology and driving the transition of the energy mix.

INDUSTRY AND MARKET DEVELOPMENT

In 2025, China's total electricity consumption reached 10.4 trillion kWh, with a year-on-year increase of 5.0%.

For PV installation in power mix, by 2025, PV cumulative installation comprised 31% of the total installation, while it was 27% in 2024. The share of PV continuously increased.

Table 1: China PV Additional Installation (GW_{ac})

	2024	2025	YoY
Utility-scale sector	159	164	3%
C&I sector	89	N/A[1]	N/A
Residential sector	30	N/A[2]	N/A
Distributed sector	118	153	29%
Total	278	317	14%

Source: NEA (National Energy Administration)

In 2025 alone, China PV added 317 GWac, with a year-on-year increase of 14%, hitting another record high, and amongst which:

- Utility-scale sector installations were 164 GWac, accounting for 52% of the total incremental installation, with a year-on-year increase of 3%.
- The C&I sector installed 107 GWac, accounting for 34%, with a year-on-year increase of 21%.
- The residential sector installed 46 GWac, accounting for 14%, with a year-on-year increase of 55%, due to the regulation and policy change.

With the increased PV penetration ratio, more synergies with other industries are required for a more sustainable development of the Chinese PV industry. By the end of 2025, the national installed capacity of new energy storage that was completed and put into operation reached 136 GW / 351 GWh[3], a more than 40-fold increase compared to the end of the 13th Five-Year Plan period, achieving leapfrog development. The average energy storage duration is 2.58 hours, which represents an increase of 0.30 hours compared with the end of 2024.

From supply side, according to CPIA (China Photovoltaic Industry Association), in 2025, the total polysilicon output reached 1.3 million

1 C&I data not yet broken down for 2025
2 Residential data not yet broken down for 2025
3 As of end of 2025, source: NEA

tons, Wafer output reached 680 GW, Cell 660 GW, and module 620 GW, presenting a declined utilization rate.

Table 2: Chinese PV Industry Production Output

	2024	2025	YoY
Polysilicon (kt)	1823	1340	-26%
Silicon Wafers (GW)	776	680	-12%
Cells (GW)	695	660	-5%
Modules (GW)	628	620	-1%

Source: CPIA (China Photovoltaic Industry Association) Preliminary estimates (as of Jan 2026).

Looking ahead to 2026, China's PV market is expected to enter a phase of high-quality growth, with a focus on grid integration, storage synergy, and international cooperation under the framework of the Belt and Green Initiative.

DENMARK

PHOTOVOLTAIC SECTOR STATUS 2025

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Figure 10: 57 MWp utility-scale project in Stourup. The plant is owned by 3 local companies who also are the offtakes of the electricity produced. Owners engineer is Unison Energy Partners. Photo credit Solar Polaris.

PV POLICY PROGRAMME

The political target of 70% reduction of the carbon oxide emissions in 2030 is followed by a goal of 100% in 2045. This was announced by the new government established after the national election November 2022. The latest forecast from the Danish Energy Agency expects PV to reach 7.5 GW by 2025 and more than 12 GW by 2030 and 18 GW by 2035. These figures are periodically revised. By the end of 2025 the installed capacity was approximately 6.5 GWp

The main potential for deployment of PV in Denmark has traditionally been identified as building applied or integrated systems. However, the number of ground-based centralized PV systems in the range of 50 MW to >200 MW has been growing. Mostly, the projects are based on commercial PPAs or providing power to the actual market price (Nordpool).

Net-metering for privately owned and institutional PV systems was established in 1998, and is still existing, however with consequent limitations and restrictions.

In 2025, the BAPV solar industry continued the decline from 2024 in the activities. This can, among other things, be explained by rising interest rates and low electricity prices. Another element is that the government has reduced the tax for private households from 12 EUR¢/kWh to 0.11 EUR¢/kWh by January 1st 2026.

Furthermore, rising costs for grid connection and long municipality and utility approval time negatively impacted the market. This contributed to the fact that the competition between the actors intensified for the realized projects.

Despite the more difficult conditions, the accumulated installed capacity reached over 6.5 GWp in 2025 due to increased installed capacity for utility-scale projects.

To promote the green transition, the parliament has started negotiations with the purpose of reducing bureaucracy for municipalities and other public institutions if they want to install PV systems. It is also possible to continue the depreciation basis for industrial and commercial facilities to 108% in 2026. Customers can lease or obtain other forms of third-party financing. Obtaining tax deductions for the assembly work is possible for private installations. For solar installations on residential properties over two floors, it will be possible to apply for support for the project.

The government is expected to designate areas for large utility scale projects to promote the approval process. These areas will especially be areas with low-lying soil, where the CO2 emission is high due to drainage channels and drains.

Because of the reasons mentioned above, the government has now indicated that the ambitions and targets for the green transition will be revised, and some kind of public guarantee will be considered. Until now, nothing has been decided.

Figure 11: SolarLab 98.9 kWp BIPV plant at TEKNIQ Headquarters in Glostrup showcases a full-façade upgrade that combines refined architectural expression with high-performing, integrated photovoltaics.

RESEARCH, DEVELOPMENT & DEMONSTRATION

The National Energy Research and Development Programmes have a website at https://energiforskning.dk/en, where general information about the programs can be found, as well as a link to the specific R&D support scheme. Information about ongoing and former R&D projects can also be found there.

Innovation Fund Denmark supports early-stage R&D (TRL 1-3). EUDP, GLDK, MUDP, and GUDP support development and demonstration (TRL 4-8). EIFO and the EU Innovation Fund support marked introduction (TRL 9).

The Energy Technology Development and Demonstration Programme (EUDP), under The Danish Energy Agency, funds work by enterprises and universities on demonstration of new green energy technologies. The program can support PV and every year different PV related projects are supported. The R&D program, as well as the ongoing and ended PV-related projects, can be found on the EUDP webpage.

The strategic innovation topics in the EUDP program are:

1. More green electricity – and for multiple purposes
2. Energy efficiency
3. Passenger transport and light goods transport
4. Heavy transport and large scale P2X
5. Heat and heat storage
6. Green process energy
7. Flexible electricity use, grid expansion and digitalization
8. CO_2 capture, utilization and storage

ELFORSK - Danish Energy Association

ELFORSK supports projects that ensure a more efficient use of electricity at the end-users. The projects are located in a wide range within the value chain from applied research through development forward to deployment.

Innovation Fund Denmark, under the Ministry of Education and Research creates a framework for entrepreneurs, researchers and businesses so they can develop innovative and viable solutions to society's challenges

INDUSTRY AND MARKET DEVELOPMENT

The total installed PV capacity in 2025 was 1.1 GWp, compared to 712 MWp in 2024. An amount of 309.7 MWp was actually post-registered to the installed capacity in 2024 but actually installed in 2025. The increase in installed capacity was due to an increase in utility-scale projects. The overall market for BAPV slightly decreased compared to 2024, with some reduction in the commercial and industrial sector.

The total installed PV capacity in 2025 was 1.1 GWp, compared to 712 MWp in 2024

The electricity consumption in 2025 was 40.45 TWh, a 5 % increase compared with 2024. Almost 85% of the electricity was covered by renewable energy, including biogas and sustainable biomass, whereas solar covered 11%. On a national level, the average CO_2 emissions of a kWh used was 64 g per used kWh.

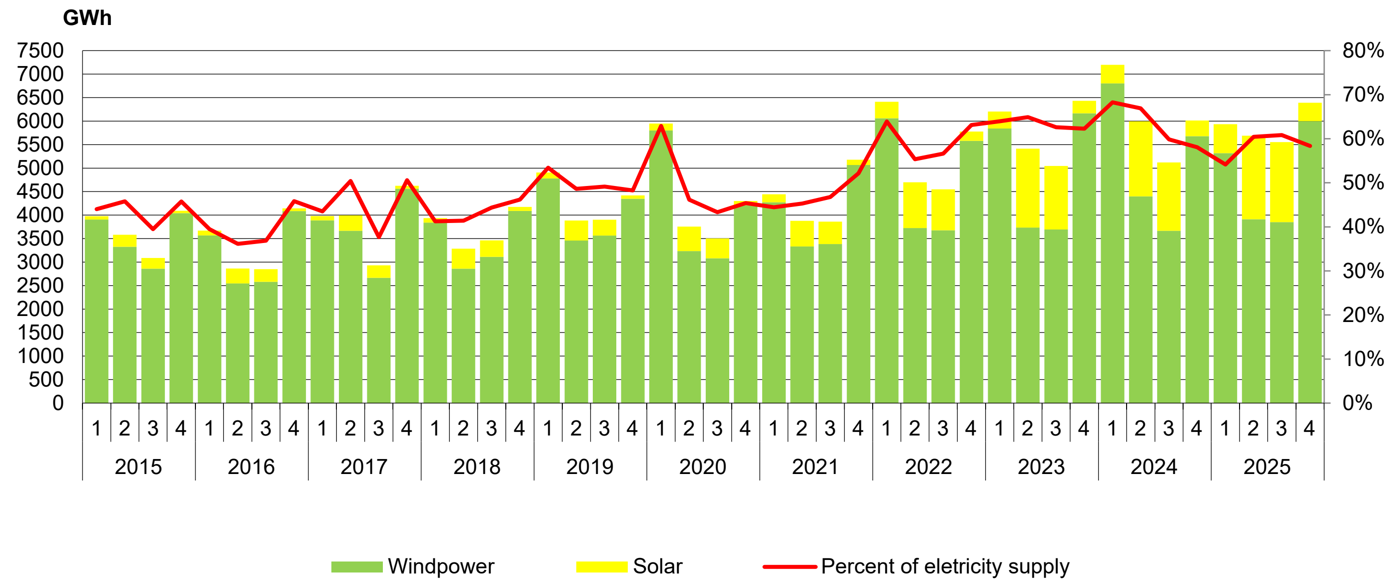

Figure 12: Electricity production from solar and wind.

The yearly average electric price was 0.61 DKK/kWh, peaking at 58.18 EUR¢/kWh on January 20th, 2025, between 5 PM and 6 PM. On the 21st of June, between 2 – 3 PM, prices were negative with 2.55 EUR¢/kWh. Due to the low prices in peak production for solar, the business case is under pressure. The foreseen electrification of fossil fuels is progressing more slowly than expected, and there is a lack of flexibility in the system for real major time shifting of consumption.

The Danish PV Association established late 2008 with approximately 60 members has provided the emerging PV industry with a single voice and is introducing ethical guidelines for its members. A few PV companies producing tailor-made modules such as windows-integrated PV cells can be found. A Li-Ion and a vanadium redox flow battery (VFB) manufacturer are now engaged in the PV market and offering storage solutions. A few companies develop and produce power electronics for PV, mainly for stand-alone systems for the remote-professional market sector such as telecoms, navigational aids, vaccine refrigeration and telemetry. Many companies are acting as PV system developers or integrators designing, developing and implementing PV systems for the home market and increasingly at the international level. Danish investors have entered the international PV scene on a rising scale acting as international PV developers/owners of large-scale PV farms. Some of the members have activities inside and outside Denmark.

New grid compliance requirements from the Danish TSO now challenge many PV companies and suppliers of PV inverters since the requirements are different from those seen in other countries. This is disturbing the market and causing delays in the implementation of all sizes of projects. Grid constraints are seen on both DSO and TSO level causing delays for the connection of both production and consumers to the grid.

Battery storage is becoming a very important part of both new and existing PV systems. A combination of price reductions for batteries and very low electricity prices in some hours has improved the business case for these systems. Larger MW-scale systems and smaller storage systems collected in clusters are seen delivering ancillary services to the TSO through aggregators.

EUROPEAN UNION

PHOTOVOLTAIC SECTOR STATUS 2025

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Figure 13: Qcells pilot line in Thalheim, Germany, from project PEPPERONI, which Horizon Europe supported with 13 million EUR to deliver a pilot line for the production of perovskite-silicon tandem cells and modules on industrial scale.

PV POLICY PROGRAMME

The Commission has continued promoting the deployment of solar energy. To follow up to the EU Solar Energy Strategy and the Action Plan for Affordable Energy, the Commission adopted in July 2025 a **Recommendation and guidance for Member States to promote the development of innovative technologies and forms of renewable energy deployment**, such as Agrisolar, Floating solar or Building-Integrated solar.

To facilitate the implementation of the solar mandate, which was introduced in the **Energy Performance of Buildings Directive**, a **guidance was published in June 2025.**

With the **European Grids Package**, published in December 2025, the Commission aims to build a modern, integrated, EU-wide grid network that can accommodate the growth of renewables and complete the internal energy market, ensuring a more affordable and secure EU energy system. As part of this package, the Commission has also put forward legislative proposals to streamline and shorten permitting procedures for small-scale solar PV installations and energy storage.

To strengthen manufacturing of PV and other net-zero technologies, the **Net-Zero Industry Act (NZIA)** is a key policy. It aims to a secure and sustainable supply of net-zero technologies through scaling up their manufacturing capacity in Europe. And sets as benchmark the manufacturing of at least 40% of the Union's annual deployment. In 2025, the Commission put forward a number of secondary legislation to further support the implementation of the NZIA, including the following: A Delegated act on primarily used components under the Net-Zero Industry Act; an Implementing Act on non-price criteria in renewable energy auctions; an Implementing Act on main specific components relevant for the NZIA 'Access to markets' chapter and a Communication on shares of Union supply; an Implementing Act for guidelines on strategic projects.

RESEARCH, DEVELOPMENT & DEMONSTRATION

2025 saw the launch of the **European Partnership of Innovation in Photovoltaics (EUPI-PV)** under **Horizon Europe**. This co-programmed partnership builds on the organisation of the **European Technology and Innovation Platform on PV** (ETIP-PV) and the different associations that structure the PV R&I landscape (SolarPower Europe, EERA-PV JP, ESMC, EUREC, PVthin), to better align European support for PV innovation with the priorities of the sector and increase the involvement of the PV industry in the research and innovation process.

The EUPI-PV aims to accelerate solar PV research and innovation by coordinating efforts across industry, universities and research centres, supporting the resilience and competitiveness of the European PV value chain, and fostering leadership in PV innovation. Key objectives include improved R&I collaboration, development of breakthrough PV technologies, and scaling up next-generation solutions to meet European energy transition and policy targets.

The first EUPI-PV topics were included into the **Horizon Europe 2025 Work Programme (Cluster 5: Climate, Energy, and Mobility)**. Their focus was on:

1. Advanced Manufacturing and Technology Development:
   - **Optimised/Alternative Silicon Growth Technologies:** Focused on silicon growth from liquid or gaseous phases to improve efficiency and reduce costs in PV applications. The total indicative budget for the topic was EUR 18.00 million.
   - **Perovskite PV Commercialization:** Towards commercialization of Perovskite PV and development of dedicated manufacturing equipment. The total indicative budget for the topic was EUR 24.00 million.
2. System Integration and Flexibility
   - **Novel Inverter Technologies:** Developing smart inverters with high power density, using wide-bandgap materials (GaN, SiC) to supply synthetic inertia and grid services. The total indicative budget for the topic was EUR 18.00 million.

INDUSTRY AND MARKET DEVELOPMENT

In terms of **deployment,** preliminary data show an annual installed capacity of around 65 GW_{DC}, which is slightly lower than the capacity installed in 2024. This slowdown is linked to several factors, including the declining impact of the energy crisis that had previously accelerated the deployment of rooftop PV, and the phase-out of net metering support schemes in several EU markets. The total cumulative installed capacity surpassed the 400 GW_{DC}, exceeding the 2025 EU Solar Energy Strategy target of 320 GW_{AC}, which is equivalent to approximately 380 GW_{DC}. Even with this lower growth rate the EU Solar Energy Strategy's target of achieving a nominal capacity of over 720 GW_{DC} (600GW_{AC}) by 2030 should be met.

In terms of **manufacturing,** due to persistent low prices for PV modules, European PV manufacturers face challenging times. The EU manufacturing capacity in the solar PV value chain amounts to approximately 12 GW_{DC} of PV modules, around 2 GW_{DC} of PV cells, 25 GW_{DC} of polysilicon, and less than 1 GW_{DC} of PV ingots and wafers. Inverter manufacturing is still quite strong in the EU (over 121 GW_{AC}) but there is similar worrying pressures and trends as for the rest of the supply chain.

A key reason for the relatively low EU PV manufacturing capacity are the higher manufacturing costs for producing a PV module. The study "Reshoring Solar Module Manufacturing to Europe", 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.

A key priority for the European Union is to scale up innovative solutions. To do so, it employs the **Innovation Fund**, the EU fund for climate policy, with a focus on energy and industry. The Innovation Fund aims to bring to the market solutions to decarbonise European industry and support its transition to climate neutrality while fostering its competitiveness. From its 2024 call for NetZero Technologies (IF24 Call), 3 projects resulted in support of PV technologies; 2 projects in support of **PV manufacturing** and the third one in support of **Floating PV deployment**, all launched in 2025.

- **FENICE**: FuturaSun advancEd italiaN manufacturIng Centre. The project aims to establish a new photovoltaic (PV) module production factory in Italy, specialising in n-Type and xBC (Back Contact) technologies developed in-house. The factory will produce up to 7.6 GWp of high-efficiency PV modules during its first ten years of operation. The project receives EUR 21 380 500 in EU contribution.

- **MOD4PV**: Gigawatt scale assembly plant of disruptive technology PV modules. MOD4PV aims to set new solar photovoltaic (PV) module production standards with an innovative PV module assembly plant in Extremadura, Spain. Targeting an annual production capacity of over 1.5 GWp, the project will rely on advanced heterojunction technology (HJT), which features higher efficiencies and energy yields than conventional PV technologies. The project receives EUR 87 774 046 in EU contribution.

- **Floating Sky: FUSIO demonstrator**: The project introduces a breakthrough Floating PhotoVoltaic (FPV) solution called FUSIO®, which aims to reduce the current costs of FPV solutions. Following its demonstration with a 100-kilowatt (kW) pilot, Floating Sky will launch its first large-scale FPV production facility of 12.2MWp in Belgium. The project receives EUR 3 200 000 in EU contribution.

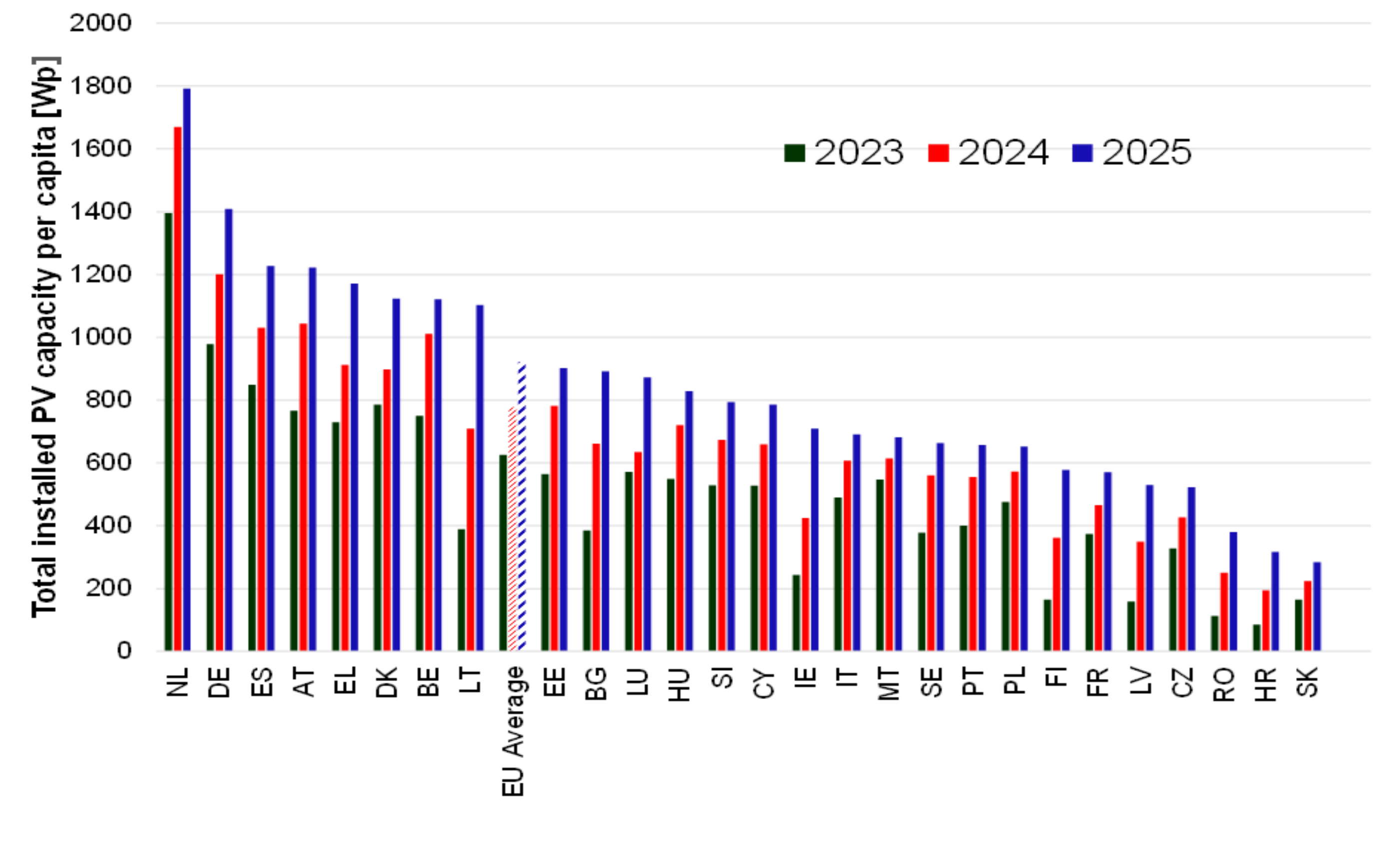

Figure 14: PV capacity per capita in the EU for 2023 to 2025 (Jäger-Waldau, 2026, Snapshot of Photovoltaics, [Manuscript in preparation]).

FINLAND

PHOTOVOLTAIC SECTOR STATUS 2025

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Figure 15: Snow load testing of thin glass PV modules. Photo: Shuo Wang, Turku University of Applied Sciences.

PV POLICY PROGRAMME

Finland has the objective to become a carbon-neutral society by 2035 and proceed to carbon negativity (the Climate Act 2022). The Programme of Prime Minister Petteri Orpo's Government (20 June 2023) highlights Finland's goal to become a leader in clean energy and a positive climate handprin. On 4 December 2025, the Government submitted the national Energy and Climate Strategy compiling the Government's energy and climate policies to the Parliament as a report. The main focus of the strategy is on achieving the EU's climate and energy targets for 2030 and the objectives of the Climate Act.

Approximately 70% of all greenhouse gas emissions in Finland come from energy production and consumption, including transport. One of the main solutions to achieve carbon neutrality is direct and indirect electrification of energy use with carbon-neutral electricity. In 2025, carbon-neutral electricity already accounted for 96% of Finland's electricity production. Finland aims to become a key player in the hydrogen economy in Europe. In addition, Finland aims to lead the way in the capture and utilisation of biogenic carbon dioxide (technological carbon sinks). The increase of wind power and PV production highlights the importance of introducing various flexible solutions such as energy storage and system integration.

There are no specific national strategy nor objectives for PV electricity generation in Finland. Earlier PV has mainly been considered an energy technology that can be used to enhance the energy efficiency of buildings by producing electricity for self-consumption. However, interest in grid-connected PV systems has increased during the last few years.

To support PV installations, the Ministry of Economic Affairs and Employment and Business Finland can grant investment subsidies to renewable energy projects. Energy aid may be granted to projects that promote new technology and its commercial utilisation. The support is only intended for companies, communities, and public organizations, and it is provisioned based on applications. The need for and level of aid are assessed on a case-by-case basis. Agricultural companies are eligible to apply for an investment subsidy of up to 40% for PV installations from the Economic Development Centres. Individuals are eligible for a tax credit for the labour component of the PV system installation. In 2025, the sum was up to 35% of the total labour cost, including taxes.

RESEARCH, DEVELOPMENT & DEMONSTRATION

In Finland, there are no specific budget lines, allocations, or programmes for solar energy RD&D, but PV is funded as part of open energy programmes.

The research and development work at universities and research institutes is mainly funded by the Research Council of Finland and Business Finland, which also finance company-driven development and demonstration projects, as well as the European Union funding programmes.

Research and development topics related to PV range from material science to PV systems and grid integration, and from nature assessment to solar economy. Research and development activities are spread out over a wide array of universities and research institutes: Aalto University, Lappeenranta-Lahti University of Technology, Tampere University and Turku University, Metropolia, Satakunta and Turku Universities of Applied Science, as well as VTT Technical Research Centre of Finland, Natural Resources Institute Finland (Luke), and the Finnish Environment Institute.

INDUSTRY AND MARKET DEVELOPMENT

For a long time, the Finnish PV market was dominated by small off-grid systems. There are more than half a million holiday homes in Finland, a significant proportion of which are powered by an off-grid PV system capable of providing energy for lighting, refrigeration, and consumer electronics. By the end of 2024, the installed off-grid PV capacity was estimated to be approximately 23 MW.

Presently, the market of grid-connected systems heavily outnumbers the market of off-grid systems. Since 2010, the number of grid-connected PV systems has gradually increased.

In the beginning of 2025, the installed grid-connected PV capacity was estimated to be approximately 1250 MW. In 2025, PV represented 1.2% of the total electricity production in Finland.

The grid-connected PV systems are still mainly roof-mounted installations on public and commercial premises and in private dwellings. The first multi-megawatt ground-mounted PV plant in Finland, then with a total capacity of 5 MW, started its operation in 2018 in Nurmo, owned by Atria. The largest PV plant in Finland started its operation in 2025 in Utajärvi. This PV plant of 106.8 MW is owned by Utajärven Solarpark Oy (Skarta Energy). In recent years several companies have announced their plans for multi-megawatt scale PV plants, even up to a scale of hundreds of MW. According to Renewables Finland, in June 2025, there were approximately 26 200 MW of published solar power projects under planning in Finland.

Integrating battery energy storage systems in PV plants is often considered beneficial for balancing variable PV production. In addition, there is an interest to combine PV production with wind power production, thus balancing the variation of electricity production, using a common infrastructure, and improving the cost effectiveness of the projects.

FRANCE

PHOTOVOLTAIC SECTOR STATUS 2025

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Figure 16: Parc solaire de Cahuzac-sur-Adour inauguré en novembre 2025 – Photo credit : Q Energy.

PV POLICY PROGRAMME

The French National PV policy is built around a series of support mechanisms including Call-for-Tenders for the larger installations and Feed-in Tariffs for the smaller ones. As module prices dropped and new capacity increased, the mechanisms for reducing tariffs as a factor of increased capacity were adjusted, resulting in increasing target volumes but decreasing tariff values. All of these measures are aimed at supporting the photovoltaic sector in achieving the objectives assigned to it in the 10-year Energy Programme Decree (PPE), the main French strategic document that sets the development trajectories for the various renewable energy sectors.

In February 2026, the new PPE Decree was published, with a delay of more than two years. For the solar sector, the new action plan sets targets of 48 GW_{AC} of installed capacity by 2030 and between 55 GW_{AC} and 80 GW_{AC} by 2035. This trajectory corresponds to an average annual increase in capacity of approximately 3.5 GWAC (4.3 GW_{DC}), a significantly slower growth rate than that observed in recent years (6.0 GW_{DC} in 2024 and 7.4 GW_{DC} in 2025). In terms of electricity production, the new PPE sets a target of approximately 59 TWh by 2030 and approximately 67 to 98 TWh by 2035. According to these objectives, the photovoltaic sector is foreseen to become the first renewable energy for electricity generation in France ahead of onshore or offshore wind power and hydro power. This national plan will need to be adapted by each of the French regions, which will have to set their own capacity and power targets for 2030 and 2035. The regions will then be able to make use of the previously defined renewable energy acceleration zones. These zones define, for each renewable energy sector, areas identified as suitable for future projects. In these areas, simplified procedures will be implemented to reduce administrative lead times.

Concerning the residential installations or solar plants on buildings, barns, and parking canopies, with a capacity from 100 kWp to a maximum of 500 kWp, the support mechanisms changed in 2025. The revision of the S21 scheme in March 2025 reviewed eligibility criteria, reduced subsidies, and partially shifted the scheme towards a competitive allocation system. The former Feed-in Tariff support was turned into a simplified Call-for-Tenders system. The first one was held in September 2025, but with a significantly lower capacity was allocated as compared to the initially intended one (see table 1). The reform also introduced stricter requirements for projects, including a financial guarantee of €10 000 for each complete connection application for installations over 100 kWp.

Changes have also impacted the residential installations up to 9 kWp, where the option to sell the whole electricity production to the grid is not allowed anymore. Now, only the injection of surplus electricity into the grid is possible, but with a very low Feed-in Tariff per kWh (see table 2). However, since October 2025, private persons can benefit, under specific conditions, from a reduced VAT rate of 5.5% on the purchase of panels for residential installations. The main condition concerns the carbon footprint of the modules, which must be less than 530 $kgCO_2$ eq/kWp.

*Table 3: Competitive tenders called in 2025 * Call-for-Tender is not limited to photovoltaics systems; other RES technologies are eligible as well. ** Only PV projects have been awarded for this call.*

	Call	Deliberation	Called capacity (MW_{AC})	Awarded capacity (MW_{AC})	Average tender price
PPE2 2021-2026 **Ground based systems**	7th 8th	Feb. 2025 July 2025	925 925	887.5 971	79.09 EUR/MWh 79.48 EUR/MWh
PPE2 2021-2026: **Building mounted systems, green- houses and parking canopies**	9th 10th 11th	Jan. 2025 May 2025 Sept. 2025	400 400 300	220.3 191.2 300.9	98.20 EUR/MWh 97.53 EUR/MWh 96.48 EUR/MWh
PPE2 2021-2026: **Technology neutral***	4th	Nov. 2025	500	507.7**	74.13 EUR/MWh
ZNI 2023 -2028: **Systems in overseas departments and territories**	3rd 4th	March 2025 Nov. 2025	99 99	14.4 32.6	112.52 EUR/MWh 92.04 EUR/MWh
Simplified tender for building mounted systems and parking canopies (100 kW - 500 kW)	1st	Oct. 2025	192	43.5	88.73 EUR/MWh

Table 4: Feed in tariffs for 4th quarter 2025.

Power of PV installation (kW)	Feed in tariff no self- consumption (Ta,b,c)	Feed in tariff for partial self-consumption (Pa,b)
0 - 9 kW	0 EUR/kWh	0.04 EUR/kWh
9 - 36 kW	0.1049 EUR/kWh	0.0617 EUR/kWh
36 - 100 kW	0.0912 EUR/kWh	0.0617 EUR/kWh

RESEARCH, DEVELOPMENT & DEMONSTRATION

Research and development (R&D) in the photovoltaic sector in France is based on a structured framework that integrates public and private research, technological innovation, and industrial development. Every stage of the value chain is covered, from basic materials research through to production.

Among the public sector players the two major organisations are: the French Alternative Energies and Atomic Energy Commission (CEA) and the National Centre for Scientific Research (CNRS). In the field of PV, they are active in semiconductor physics, materials chemistry, and energy engineering. These two organisations also lead (or co-lead) several networks of R&D stakeholders, some of which focus on photovoltaic energy, such as CEA-Liten or the Lyon Institute of Nanotechnologies (INL). Furthermore, the CEA and the CNRS are founding members of the National Alliance for the Coordination of Energy Research (ANCRE), which plays a strategic role in defining major scientific orientations and research priorities, coordinating stakeholders, and structuring research programs. French public funding for research and development in the field of photovoltaics amounted to 78 million euros in 2023 (latest available data) out of a total of 183 million euros for all renewable energies.

The Photovoltaic Institute of Île-de-France (IPVF) and the National Institute for Solar Energy (INES) are two other major institutions involved in photovoltaic research in France. The former focuses on upstream research and advanced photovoltaic technologies, while the latter is more oriented towards applied research and demonstration projects. However, both organizations collaborate with companies to validate the technological advances resulting from their research in the marketplace. In collaboration with the manufacturer Voltec Solar, the IPVF is notably participating in the STaFF (Industrial Sovereignty Tandem of French Manufacturing) project, which aims at accelerating the industrialization of perovskite/silicon tandem photovoltaic modules. INES is working on low-carbon modules and improving the efficiency of perovskite/silicon tandem cells (up to 30.8% by January 2025) and heterojunction silicon cells. Recently, new research areas have been added, such as accelerated degradation testing to better understand cell aging, and the recycling of end-of-life panels, including module delamination and the recovery of materials such as silver, copper, and silicon.

The principal state agencies that are financing research are:

- the National Research Agency (ANR), which finances projects through topic-specific or generic calls and also through tax credits for internal company research.
- The French Agency for Ecological Transition (ADEME) runs its own calls for R&D on renewable energies and supports PhD students. It is the French relay for the IEA PVPS and M-ERA.net pan-European network.

INDUSTRY AND MARKET DEVELOPMENT

While annual volumes of new connections previously rarely exceeded one gigawatt, the growth of the French solar photovoltaic sector took on a new dimension in 2022. The connected capacities reached 2.8 GW_{DC} in 2022, 4.0 GW_{DC} in 2023, 6.0 GW_{DC} in 2024, and preliminary figures for 2025 indicate an addition of 7.4 GW_{DC}—a record for the country. Thanks to that, France's total photovoltaic capacity peaked at 37.6 GW_{DC} by the end of 2025, with nearly 1 135 million installations. Solar technology has thus become the leading national renewable electricity sector in terms of installed capacity, ahead of hydropower (26 GW). In addition to installed capacity, the list of projects that have obtained all necessary permits and are awaiting grid connection reached 45 GW_{DC} by the end of 2025 (36.9 GW_{AC}, a stable level compared to 2024).

However, despite these very high figures, the growth of activity in the photovoltaic market in 2025 was slowed by a change in the regulatory framework that took effect in March of the same year. The several-months time lag between sales and grid connections explains why growth in new capacity was largely unaffected, except in the residential segment. In 2025, large-scale roof-mounted systems and solar parking canopies ranging from 100 to 500 kWp constituted the leading segment, accounting for 44% of the additional capacity installed and 3.3 GW_{DC} (+50% compared to 2024). With 2.5 GW_{DC} (+23% compared to 2024), large ground-mounted plants and roof-mounted installations also remain a pillar of the development of the French solar sector, accounting for 33% of the capacity added in 2025. In contrast, the growth in newly connected capacity for residential systems (up to 9 kWp) slowed significantly, to 0.9 GW_{DC} (-25%). 4.6 GW_{DC} of capacity was called in 2025, with 3.8 GW_{DC} awarded under the Contracts for Difference (CfD) organised by the French Energy Regulator, CRE, (compared to 2.9 GWDC put out to tender / 2.7 GW_{DC} awarded in 2024). Given a 2 to 3-year delay between the announcement of the winning bids and their connection to the grid, an additional 4 GW_{DC} of capacity can be expected to be connected in 2026 and 2027 for large-scale installations.

Furthermore, the growth of self-consumption remains very strong in France. According to the most important French DSO, Enedis, the number of domestic self-consumption installations increased by 39% in 2025 to reach 484 734 plants, representing an installed capacity of 6.5 GW_{DC}. The fact that the total sale of electricity is no longer possible for residential installations since March 2025 has further strengthened self-consumption trend. Collective self-consumption is also continuing to grow. Since collective self-consumption was legally introduced in 2016, the regulatory framework for this type of projects has become increasingly flexible, notably with the raise of the project cap to 5 MW (10 MW for projects led by local communities). By the end of 2025, collective self-consumption represented 1 625 operational projects with a total capacity of 0.3 GW_{DC}.

Regarding employment and economic activity, the latest available data are for 2024. Direct full-time equivalent jobs are estimated at 37 000, a figure showing a sharp increase compared to 2023 (27 560, +34%). In terms of revenue, the sector's activity in France is estimated at 14.65 billion euros in 2024, also showing a strong growth (+29%). However, these figures are expected to decline in 2025: several companies (particularly installers in the residential segment) have announced job cuts to adapt to the market slowdown.

France's total photovoltaic capacity peaked at 37.6 GW_{DC} by the end of 2025, with nearly 1 135 million installations.

GERMANY

PHOTOVOLTAIC SECTOR STATUS 2025

Authors: Klaus Prume, Projektträger Jülich (PtJ), Forschungszentrum Jülich GmbH, Germany
Christoph Hünnekes, Projektträger Jülich (PtJ), Forschungszentrum Jülich GmbH, Germany

Figure 17: Photovoltaic system at open-cast mine in North Rhine-Westphalia (© RWE).

PV POLICY PROGRAMME

Germany's energy transition is reshaping the country's energy supply to make it secure, clean, and affordable. The Federal Government is moving away especially from fossil fuels and accelerating the shift toward renewable energy and greater energy efficiency. Germany has already made major progress; e.g. renewable energies account for approximately 59.0% of total net electricity generation in Germany in 2025.

A key goal is to make the transition a driver of innovation, modernisation, and digitalisation across electricity and heat, as well as in transport, agriculture, and industry—while maintaining international competitiveness.

In Germany, the switch to renewable energies is being driven forward, with photovoltaics (PV) playing a central role. New legislation encourages tenant participation through landlord-to-tenant solar electricity models. Since December 2025, product standard DIN VDE V 0126-95 (VDE V 0126-95:2025-12) has applied to the connection of balcony power plants. For the first time, it regulates the safety requirements for grid-connected balcony power plants.

The simplified commissioning of balcony solar power plants has led to 433 000 new installations in 2025. Currently around 1.24 Mio. of them are already in operation (Bundesnetzagentur). This high number shows that PV has reached the centre of society and enjoys a high level of social acceptance.

Finally, the transition depends heavily on expanding and modernising electricity grids. Because renewable generation is increasingly decentralised—and wind power is often produced in the north but needed in the south—Germany is working to strengthen transmission and distribution networks. Smart grids and smart meters are seen as essential tools to balance supply and demand and improve efficiency through digital management of the energy system.

By 2045, the German electricity supply should be almost climate-neutral, i.e. nearly completely powered by renewable energies and green hydrogen. The German government has therefore decided to increase the share of renewable energies in Germany's (gross) electricity consumption to over 80% in 2030. To this end, the Renewable Energy Sources Act (EEG) provides for 215 gigawatts of installed photovoltaic (PV) capacity in 2030. This requires an annual increase of 19.5 GW in the coming five years. With a slight decline in new capacity compared to the previous year, the current status indicates that the increase in 2025 will be 16.9 GW. Just under half of the added capacity was accounted for by rooftop solar systems, with the rest coming from ground-mounted photovoltaic systems. In the previous year, rooftop solar systems accounted for twice as much capacity as ground-mounted solar systems. The total installed solar capacity reached 117.5 GW as shown in Figure 19.

So, Germany is still on the way to achieving its solar goals. This is also reflected in the consistently high participation in the Federal Network Agency's tendering rounds for ground-mounted PV systems. The total tender volume in 2025 was 8.8 GW for ground-mounted, rooftop, and innovation systems together. The development of surcharge values over recent years is shown in Figure 18.

This strong expansion is sensible and necessary, as photovoltaics is one of the cheapest sources of energy and therefore one of the most important sources of electricity generation in the future.

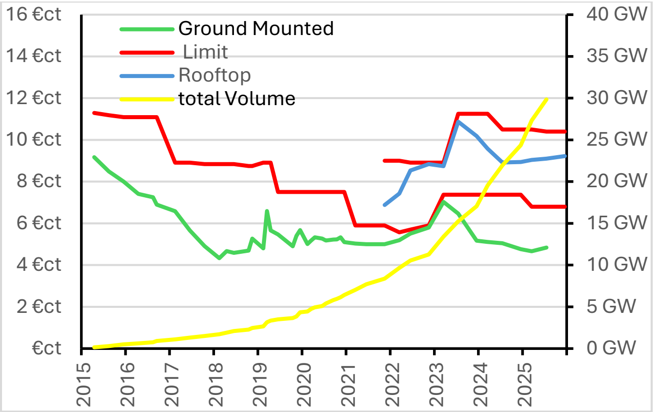

Figure 18: PV Tenders – Ground mounted and Rooftop PtJ created graph based on data from the Bundesnetzagentur.

RESEARCH, DEVELOPMENT & DEMONSTRATION

For many years, industry-related applied energy research is supported by specific funding programs (see here).

The funding announcement for the most recent 8th Energy Research Program for applied energy research entitled 'Research contracts for the energy transition' has been in force since April 2024. It sets out the objectives and priorities for research funding in the coming years. For the first time, the BMWE is pursuing a mission-oriented research and innovation policy. The focus is on cross-sector and cross-thematic project funding that is targeted at specific and ambitious goals. In this way, research results should contribute to accelerating the transformation of the energy system and be put into practice quickly.

The five missions of the BMWE's energy research program are

- Mission Energy System 2045: Research for a resilient and efficient energy system
- Mission heat transition 2045: Research for a climate-neutral heating and cooling supply
- Mission electricity transition 2045: Research for the conversion of the electricity supply to renewable energies
- Hydrogen mission 2030: research for a sustainable hydrogen economy
- Mission Transfer: rapid transfer of research results into practice

PV is an important part of the Mission electricity transition. The main focal points for photovoltaics research in 2025 were again topics relating to technology developments for highly efficient solar cells and modules, silicon-perovskite tandem solar cells, and issues of reliability and sustainable operation of photovoltaic systems. A secondary topic deals with the integration of PV systems in both, the built environment and the energy system.

The Federal Energy Research Report provides an overview of the strategic direction, progress and successes of energy research in Germany. This report contains information and figures on current research and development projects being funded in the energy sector, particularly in the field of photovoltaics.

Electricity generation using photovoltaics has overtaken lignite as a source.

INDUSTRY AND MARKET DEVELOPMENT

In 2025, Germany's photovoltaic industry experienced a strong expansion in installations while domestic manufacturing remained under significant pressure. Although solar capacity additions continued at a high pace and photovoltaic power generation increased markedly, the industrial side of the sector faced considerable challenges. This situation is somewhat paradoxical: record levels of solar expansion coinciding with weak or largely absent large-scale manufacturing within the country. Overall, 2025 can be characterised as a year of continued robust PV growth and rising solar electricity output in Germany. For the first time, electricity generation from photovoltaics ranks second as a source of electricity generation, overtaking lignite as a source. The share of renewable energies based on gross electricity generation is 57.3 per cent. Photovoltaic systems contributed 89.5 billion kWh to this total. However, this year has also seen a significant slowdown in the private rooftop system segment and ongoing structural challenges for the domestic PV manufacturing industry.

The number of people employed in the German photovoltaic industry has risen significantly in 2025, with estimates suggesting over 100 000 jobs. This growth is primarily driven by the massive expansion of installed capacity.

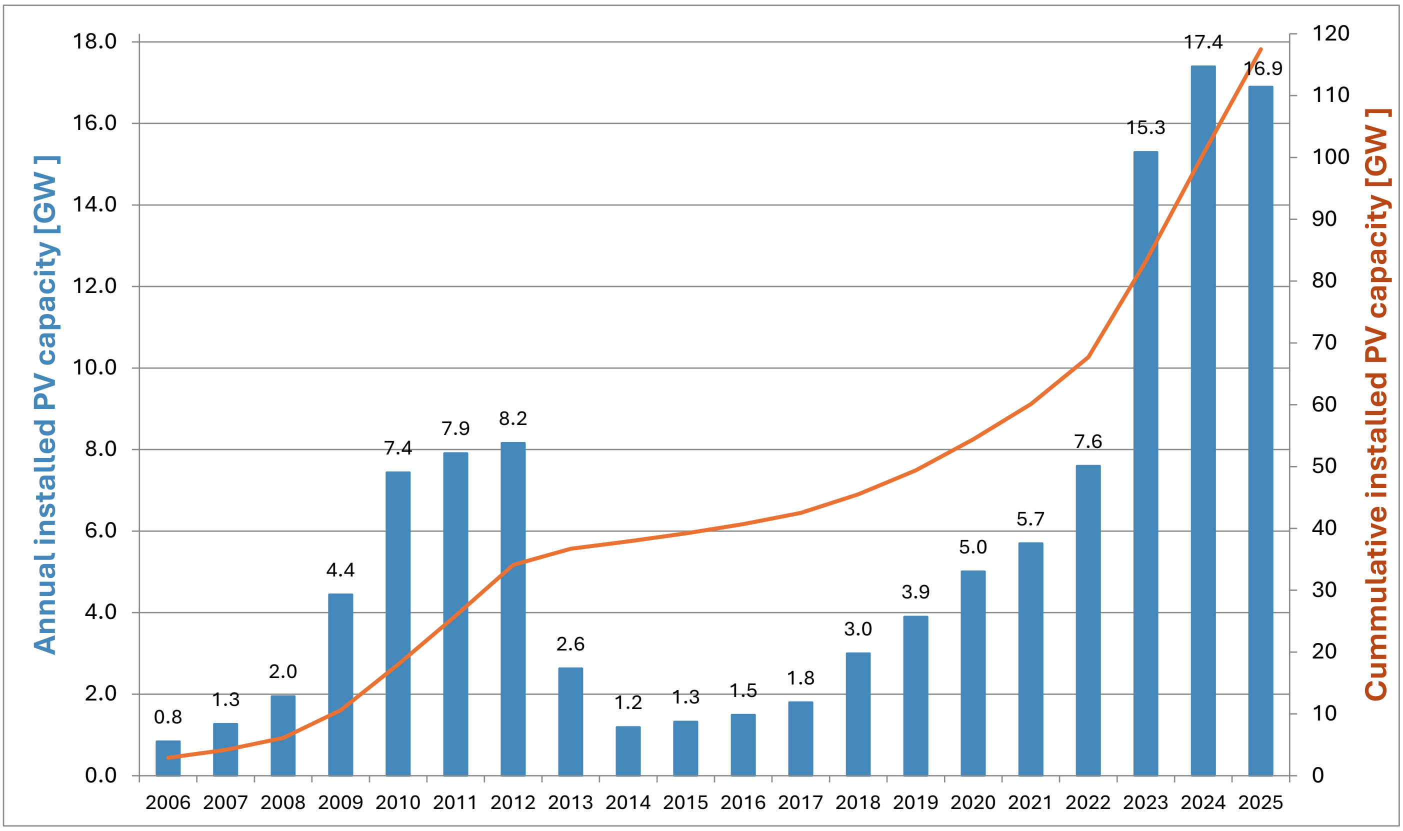

Figure 19: Development of annual PV installations and cumulated installed capacity (for 2025 best estimate as of January 2026) [based on data from the Federal Network Agency - Bundesnetzagentur].

ISRAEL

PHOTOVOLTAIC SECTOR STATUS 2025

Authors: Eliraz Shifman Berman, Head of Renewable Energy Policy, Ministry of Energy and Infrastructure, Israel

Figure 20: Agrivoltaic installation in Israel demonstrating dual-use of land for solar energy generation and agricultural cultivation.

PV POLICY PROGRAMME

Israel continues to advance its photovoltaic (PV) sector as a central pillar of its energy transition strategy. The government has set a national target of achieving 30% renewable electricity generation by 2030, with solar PV expected to contribute the vast majority of this capacity due to favourable climatic conditions and given Israel's specific geographical and environmental conditions, which limit the deployment of other renewable energy technologies.

Policy efforts in recent years have focused on accelerating deployment while addressing system integration challenges. A key development is the transition towards a market-based model, gradually replacing administratively set tariffs with competitive market mechanisms. In parallel, planning regulations have been adapted to enable a broader range of PV applications, with a particular emphasis on agrivoltaics. At the distribution level, recent regulations require the installation of solar systems on new buildings, marking a significant step in expanding distributed generation, while dedicated incentive schemes continue to support the expansion of PV systems in the low-voltage segment, especially in residential, commercial, and public buildings.

In addition, Israel is emerging as a global frontrunner in the deployment and integration of energy storage. Recent regulatory and planning reforms have significantly accelerated the deployment of energy storage, including dedicated planning frameworks, updated tariffs for hybrid systems, and large-scale procurement processes. Storage has become a central component of PV policy and market design, with requirements for co-located storage in utility-scale projects and increasing adoption in distributed systems. This leadership is reflected in both the scale of planned and operational storage capacity and the integration of storage into market mechanisms, enabling enhanced grid flexibility, improved peak management, and higher penetration of solar energy.

Public perception of solar energy remains positive, and PV is widely regarded as a key solution for enhancing energy security, reducing emissions, and supporting system reliability and the transition to a more sustainable energy system.

Despite strong progress, several challenges remain, including land constraints, grid congestion, permitting complexity, and the need for advanced grid flexibility solutions. Future policy is therefore expected to focus on unlocking distributed potential, improving regulatory frameworks for flexibility, and enabling higher levels of digitalisation and system optimisation.

Figure 21: Solar canopy over a school sports facility in Israel, reflecting national efforts to promote PV deployment in public buildings and maximise dual-use of urban space.

RESEARCH, DEVELOPMENT & DEMONSTRATION

Research, development, and demonstration (RD&D) activities in Israel's PV sector are driven by a dynamic innovation ecosystem that combines academic excellence, a strong start-up culture, and targeted government support. Efforts are primarily focused on system-level challenges associated with high penetration of solar energy, including grid integration, energy storage, and digitalisation. In recent years, increasing attention has been given to hybrid PV and storage systems, advanced forecasting and optimisation tools, and the development of smart grid solutions that enable greater flexibility and resilience. In parallel, there is growing interest in innovative applications such as agrivoltaics and building-integrated PV, which aim to maximise land use efficiency and expand deployment in densely populated areas. Demonstration projects play a key role in testing these technologies under real-world conditions, particularly in scenarios of high PV penetration and constrained grid capacity. Overall, Israel's RD&D landscape reflects a shift from purely technology-driven innovation towards integrated, system-oriented solutions that support the reliable and efficient expansion of solar energy.

INDUSTRY AND MARKET DEVELOPMENT

In recent years, Israel's PV sector has experienced steady and significant growth, both in installed capacity and in its role within the national electricity system. By the end of 2025, renewable energy accounted for approximately 16% of total electricity consumption, with solar PV representing the vast majority of this generation. While official data for 2025 has not yet been fully published, it is estimated that around 1 GW of new renewable capacity was added during the year, bringing total installed renewable capacity to approximately 8 GW, most of which is solar. This trend reflects Israel's strong solar resource, supportive regulatory framework, and the limited availability of alternative renewable energy sources.

The market is characterised by a combination of utility-scale projects and a rapidly expanding distributed generation segment, including residential, commercial, and public rooftop installations. In addition, solar canopies are increasingly being deployed in urban environments, including parking areas and sports facilities, contributing both to renewable energy generation and improved land use efficiency. In recent years, there has been a clear shift towards integrating energy storage as a standard component of new PV installations, particularly in large-scale projects, in order to address grid constraints and enable higher penetration of solar energy. A major regulatory shift includes the transition to a market-based model, allowing generators to sell electricity directly to suppliers, including virtual suppliers, without regulated tariffs. At the same time, the sector is increasingly moving towards more advanced market structures, including the development of private power purchase agreements and the gradual transition to market-based mechanisms in higher voltage levels.

Despite the absence of a significant domestic manufacturing base for PV components, Israel benefits from a strong ecosystem of project developers, engineering companies, and innovative start-ups, particularly in the fields of digitalisation, smart grid technologies, and energy management. Current market trends include the expansion of dual-use applications with a focus on agrivoltaics, increased deployment in urban environments supported by targeted incentives, and the growing role of digital tools in system optimisation and grid management.

Looking ahead, Israel is currently in the process of defining its renewable energy targets for 2035, alongside the development of a comprehensive national strategic plan expected to be published in the coming weeks. The emerging strategy places strong emphasis on the systematic utilisation of dual-use applications, with agrivoltaics expected to become a central component of the renewable energy mix. At the same time, significant attention is given to the continued development of large-scale ground-mounted PV installations, alongside accelerated expansion of the electricity grid to accommodate increasing shares of renewable generation. These efforts are supported by a coordinated government approach aimed at ensuring effective planning, integration, and synchronisation across infrastructure, regulation, and market development.

Figure 22: Urban rooftop PV installation in central Israel, highlighting the integration of solar energy into densely built environments.

ITALY

PHOTOVOLTAIC SECTOR STATUS 2025

Authors: Giosuè Maugeri, RSE SpA, Italy
Alessandra Scognamiglio, ENEA, Italy

Figure 23: Agrivoltaic system in South Tyrol, Italy. Photo credit: Symbiosyst project, Create a Symbiosis where PV and agriculture can have a mutually beneficial relationship, is an Horizon Europe Innovation Action under grant agreement Nº 101096352.

PV POLICY PROGRAMME

The Integrated National Plan for Energy and Climate (PNIEC), bolstered by various initiatives under the National Recovery and Resilience Plan (PNRR), serves as the definitive framework for advancing energy decarbonization in Italy. In 2024 the PNIEC was revised to strengthen the targets for 2030, aligning with the objectives of the Fit for 55 package and the REPowerEU strategy. The updated framework increases the share of Recovery and Resilience Facility funds allocated to climate-related objectives from the original 37% to approximately 39-40%. The primary objective for 2030 is to achieve a 39% share of renewable energy sources (RES) in gross final energy consumption. , Achieving this objective will require a significant expansion of photovoltaic (PV) capacity, reaching 79.2 GW of installed capacity and generating 97.6 TWh of electricity annually. While the trajectory of PV installations appears to be progressing in accordance with the required advancements in photovoltaic deployment, challenges persist in securing the necessary permits for installation, despite the costs being competitive enough to enable market parity for PV plant installations. In 2025 in Italy has been added 6.4 GW of PV capacity, reaching 43.5 GW of cumulative capacity (+22% compared to 2024).

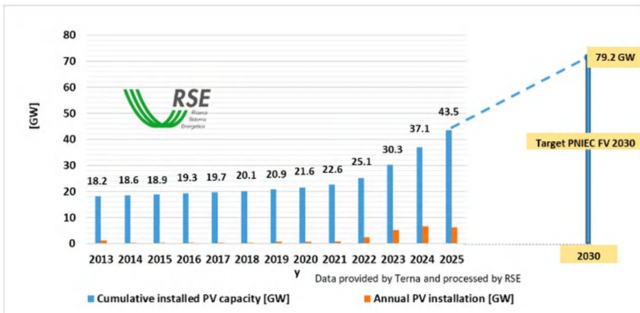

Figure 24: *Annual and cumulative PV capacity in Italy over the last 13 years and projected targets to 2030. Source: Data by Terna and PNIEC 2023 processed by RSE for RdS.*

Below are some of the main measures to support PV installations:

a) Economic support

- The tax relief mechanism for the installation of residential systems reimbursing 50% of the photovoltaic installation costs up to a maximum cost of €96 000 per residential unit. A feed-in tariff mechanism, provided by Ministerial Decree, is in place for supporting less renewable energy technologies, such as biomass, biogas, geothermal energy and offshore wind

- A premium tariff for shared and self-consumed energy in the Renewable Energy Communities (CER), thanks to the decree that increased the single plant power limit to 1 MW and enlarged perimeter to primary electric station
- Access to the 40% non-repayable grant, previously limited to CER project located in Municipalities with a population up to 5 000 inhabitants, has been extended to include CER with production plants located in Municipalities with a population up to 50 000 inhabitants.
- The extension of the PNRR investment promoting advanced Agri PV (with certain requirements in terms of height from ground and monitoring systems) developed by agricultural companies (or temporary associations between investor and agricultural companies), composed of an incentive tariff granted for 20 years and capital contributions up to 40% of the investment costs (competitive auctions have been called)
- PNRR investment to support industrial decarbonisation and strategic clean-energy supply chains (PV, wind, batteries, heat pumps, electrolysers and carbon capture technologies).
- A feed-in tariff mechanism, provided by Ministerial Decree, has been enacted for supporting "mature" RES (PV plants, on shore wind and so on), with two auctions having been called in 2025, one which dedicated to NZIA projects.

b) Structural reforms for an easier market penetration.

- Environmental permitting procedures for renewable energy plants were further simplified in late 2025 through amendments to the TU FER (2024), aiming to streamline and accelerate authorization processes
- Fast-track authorization procedures have been introduced for renewable energy projects in designated "suitable areas", including abandoned industrial sites, degraded lands, and former quarries and mines. Regional criteria for identifying these areas were revised in 2025 and are currently being implemented.
- Agrivoltaics has been defined at legislative level, requiring the continuation of agricultural activities on site and, where necessary, the use of elevated modules and digital or precision farming tools.

RESEARCH, DEVELOPMENT & DEMONSTRATION

To achieve the ambitious goals of the National Integrated Energy and Climate Plan (PNIEC) and the National Recovery and Resilience Plan (PNRR), research and innovation activities are focused on next-generation photovoltaic technologies and integrated solutions that support the national energy transition. Research and innovation in the renewable energy sector play a dual strategic role: they support the integration of renewable electricity into the National energy system while strengthening a competitive domestic value chain and delivering economic and environmental benefits.

Within this framework, research activities focus on advanced materials and device architectures aimed at improving the performance of photovoltaic technologies, including crystalline silicon, heterojunction, CIGS, and perovskite-based solar cells. Particular attention is devoted to high-efficiency tandem concepts, such as perovskite/silicon monolithic two-terminal devices. Research also explores wide-bandgap perovskite films for single-junction, tandem, and triple-junction configurations, as well as the integration of silicon with III–V compounds and nitride-based thin films. Parallel activities focus on optimizing the energy production and reliability of photovoltaic (PV) systems. This includes the integration of AI-based tools into Operation and Maintenance (O&M) strategies, enabling the remote detection of underperformance and faults and supporting the transition toward advanced digital O&M approaches. Particular attention is also given to bifacial tracking systems, in the optimization of tracking algorithms and measures to maximize the annual energy yield. Land-use optimization and multifunctional integration remain central pillars of the research programme. Beyond agrivoltaic and floating PV solutions already under development, activities include the design and fabrication of organic and dye-sensitized solar cells (DSSC) engineered to selectively transmit specific portions of the solar spectrum required for plant growth. Furthermore, new agrivoltaic concepts are being explored, including innovative "algovoltaic" configurations that combine conventional ground-mounted PV systems with photobioreactors for microalgae cultivation. Resilience under climate change is also an integral component of the research agenda. As extreme weather events become more frequent and intense, dedicated studies investigate the vulnerability of PV systems to these events, identifying innovative mitigation measures to enhance system robustness and long-term performance stability. In this context, the Research Fund for the Italian Electrical System (RdS), financed by the Ministry of the Environment and Energy Security (MASE) and supported by the PNRR, provides substantial funding for research, development, and demonstration activities related to innovative photovoltaic technologies, involving several research institutes and PV operators.

Among them, ENEA focuses on high-efficiency solar cells based on perovskite/c-Si tandem structures, module ecodesign, the digitalization of PV systems, and the conceptualization and promotion of "Sustainable Agrivoltaics," also through the realization of demonstrators. Furthermore, RSE SpA, is carrying out research activities on: (1) multi-junction PV cells; (2) III–V compounds and nitride-based thin films deposition on silicon for tandem applications; (3) advanced PV plant O&M strategies aimed at optimizing production through anomaly detection and fault recognition techniques, including the sharing of a dedicated public fault-data repository; and (4) Life Cycle Assessment (LCA) of the most promising innovative PV technologies.

Other major research organizations include CNR, which is active in the evaluation of innovative low-cost thin-film processes on silicon cells, and EURAC Research, which works on improving PV plant performance and reliability as well as on Building Integrated Photovoltaics (BIPV). Additional contributions are provided by several university laboratories, including the CHOSE Centre of the University of Rome Tor Vergata, the University of Milano-Bicocca, and the University of Turin, as well as by PV industry operators covering the entire value chain, from cells and modules to inverters and tracking systems.

It is also important to mention ReteIFV – the Italian Network for Research, Development and Innovation in Photovoltaics – which promotes coordination and knowledge sharing among research institutions, universities, and manufacturers of PV components and systems, supporting collaborative initiatives and shared research infrastructures at the national level.

Italy is progressively strengthening its role within the European photovoltaic value chain by combining advanced research, industrial innovation, and resilient system integration strategies.

INDUSTRY AND MARKET DEVELOPMENT

The Italian PV industry includes companies operating in the major segments such as BIPV, BAPV and electric mobility (VIPV), with a strong focus on innovative and high-efficiency module technologies. National manufacturing experienced significant growth in recent years, driven by major investments and new production facilities. A key development is the expansion of Enel Green Power's 3SUN factory in Catania, which is planned to reach a total capacity of 3 GW per year at full operation.

FuturaSun, within the framework of the FENICE project funded by Innovation Fund, plans to establish a new PV module manufacturing plant in Veneto with an initial production capacity of approximately 2 GW per year, designed for future expansion. The manufacturing plant will be focused on advanced n-Type and xBC technologies. In parallel, FuturaSun acquired Solertix, a spin-off from the CHOSE -Centre at the University of Rome Tor Vergata-, specializing in perovskite–silicon tandem technologies. Other investments include DAX Solar's 600 MW facility in Lazio, producing high-efficiency PERC and TOPCon modules, and the near completion of Midsummer Italia's 50 MW CIGS thin-film factory in Bari, introducing lightweight, flexible modules for industrial roofs and mobility applications.

In the field of mounting structures for PV modules, several Italian companies specialize in the development of single-axis trackers for utility-scale applications, including Convert Italia (a Valmont Industries company), Comal, AcriGroup, REM Tec, RCM Italia, and Soltigua. Among them, Convert Italia, Comal, and REM Tec also supply tracker systems for agrivoltaic installations.

Ecoprogetti, a leading company in the design and assembly of production machinery and quality control systems for PV modules, launched – already in 2024 - a fully automated solar panel recycling line capable of recovering up to 100% of key materials without the use of chemical treatments, providing a scalable and economically viable solution to the growing challenge of PV waste management.

These developments highlight a dynamic and evolving Italian PV supply chain, positioning Italy to play an increasingly relevant role in the European PV value chain. However, smaller manufacturers have experienced declining production due price competition from Asian suppliers, highlighting the need for sustained investment in innovation, quality, and advanced services to remain competitive.

Within this evolving PV ecosystem, agrivoltaics (APV) is emerging as one of the most promising market segments. Agrivoltaics in Italy has evolved from small research installations to a rapidly expanding sector supported by national guidelines and incentive schemes under the National Recovery and Resilience Plan (PNRR). The technology is considered a strategic solution for PV deployment, as it helps address land-use and landscape constraints while maintaining agricultural activity. Its importance is expected to increase further following Law 15 January 2026 n.4 (conversion of Law Decree n.175/2025), which establishes that only agrivoltaic installations are permitted in agricultural areas.

National studies estimate a technical potential between 50 and 70 GW of agrivoltaic capacity (according to reports published by RSE 2022; ENEA 2023). Operational installations remain limited but are steadily increasing, with several pilot and pre-commercial systems typically ranging from 0.5 to 5 MW, showing electricity yields comparable to conventional ground-mounted PV systems (around 1 300–1 600 MWh/MW/year, depending on location).
The first two national PNRR agrivoltaic calls (2024–2025) admitted 747 projects for approximately 2.0 GW, nearly double the initial target of 1.04 GW. The scheme supports "experimental" agrivoltaic projects, as defined by Ministerial Decree n.436/2023, emphasizing the innovative role of APV in strengthening the resilience and sustainability of the agricultural sector.

Beyond the PNRR scheme, the agrivoltaic pipeline is significantly larger. Studies indicate more than 50 GW of projects currently awaiting authorisation, confirming the strong interest in agrivoltaics as a dual-use solution combining renewable electricity generation with agricultural production.

Figure 25: Agrivoltaic systems in Italy – Photo credit: Le Greenhouse (left), AIAS (centre), REM Tec (right).

JAPAN

PHOTOVOLTAIC SECTOR STATUS 2025

Authors: Atsuyuki SUZUKI, New Energy and Industrial Technology Development Organization (NEDO)
Izumi KAIZUKA, RTS Corporation

Figure 26: PV system at the Yumeshima Transportation Terminal 1, EXPO2025 OSAKA,KANSAI (Sekisui Chemical Co., Ltd.; film-type perovskite solar cells), (Osaka City, Osaka Prefecture, Japan). © New Energy and Industrial Technology Development Organization (NEDO Green Innovation Fund website).

PV POLICY PROGRAMME

In 2025, three fundamental policy frameworks defining the future direction of PV deployment in Japan were established. The Government of Japan formulated the "GX2040 Vision", outlining national goals to ensure stable energy supply, economic growth, and decarbonization toward 2040. The Ministry of Economy, Trade and Industry (METI) formulated the Seventh Strategic Energy Plan, positioning PV as the largest power source in Japan's electricity mix by 2040. Under this plan, total electricity generation in 2040 is projected at approximately 1 100 – 1 200 TWh, with renewables accounting for 40 – 50 %, nuclear 20 %, and thermal 30 – 40 %. Renewables are thus expected to surpass thermal power to become the dominant electricity source. Within renewab https://www.env.go.jp/content/000338677.pdfles, PV is projected to account for approximately 23 – 29 % of total electricity generation.

In terms of both installed capacity and electricity generation, PV is expected to become Japan's leading power source among all generation technologies (thermal is not disaggregated by fuel type).

In terms of both installed capacity and electricity generation, PV is expected to become Japan's leading power source among all generation technologies (thermal is not disaggregated by fuel type). Estimated PV installed capacity in FY 2040 is projected to reach 263–371 GWDC. In parallel, the Ministry of the Environment (MOE) formulated a new "Plan for Global Warming Countermeasures," promoting energy transition toward decarbonized power sources.

Against this policy backdrop, METI implemented a wide range of measures to improve the business environment for full-scale PV deployment. These measures include support for initial investment in rooftop PV systems, the introduction of an approval scheme for Long-term Stable Qualified PV Power Producers, promotion of the FIP scheme, enhanced evaluation of renewable energy value, strengthened support for perovskite solar cells (PSC), and support for grid-scale storage battery systems. MOE has promoted locally-led deployment through the designation of Decarbonization Leading Areas, implemented proactive installation in public facilities, supported the expansion of self-consumption by private companies and the utilization of the PPA model, and has also initiated efforts toward the deployment of next-generation solar cells. The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) amended the Building Energy Efficiency Act to mandate compliance with energy conservation standards for all new residential and non-residential buildings, while expanding renewable deployment across public infrastructure sectors, including railways, roads, ports, and airports. The Ministry of Agriculture, Forestry and Fisheries (MAFF) revised the basic policy under the Act on Promoting Generation of Electricity from Renewable Energy Sources Harmonized with Sound Development of Agriculture, Forestry and Fisheries, clarifying the concept of “desirable agrivoltaic systems” and accelerating their deployment. Local governments advanced the designation of renewable energy promotional areas and expanded PV deployment on public facilities and public land through PPAs. Tokyo Metropolitan Government and Kawasaki City introduced mandatory PV installation for newly built houses.

In December 2025, the government convened the first Ministerial Council concerning Large-scale PV Projects to strengthen regulatory measures, enhance coordination with local communities, and prioritize support for projects in harmony with local communities. At the meeting, the government adopted the “Package of Measures for Large-Scale PV Projects (MW-scale PV power plant),” which consists of three pillars: strengthening legal regulations for inappropriate projects that raise environmental or safety concerns, reinforcing coordination with local initiatives, and prioritizing support for community-based projects. These measures will be reflected in support schemes from FY 2026 onward.

RESEARCH, DEVELOPMENT & DEMONSTRATION

As for research, development and demonstration activities concerning PV, technology development for commercialization administered by METI has been conducted by the New Energy and Industrial Technology Development Organization (NEDO) and fundamental R&D administered by Ministry of Education, Culture, Sports, Science and Technology (MEXT) has been promoted mainly by the project of the Japan Science and Technology Agency (JST) and the project to subsidize the Grants-in-Aid for Scientific Research.

In March 2025, NEDO formulated a new technology development roadmap, “NEDO PV Challenges 2025,” which presents strategic directions for enabling large-volume introduction of PV systems. Based on this strategy, NEDO launched and is implementing the “Technology Development Project for the Expansion of PV Introduction” (FY 2025 – FY 2029) as a new program starting in FY 2025. In September 2025, a total of 24 projects were selected under this program, including 20 R&D themes and 4 trends survey themes. The project includes the development of tandem solar cell technologies, installation and O&M technologies for PV systems tailored to specific installation sites, as well as recycling technologies for PSCs.

NEDO is also implementing the Next-Generation Solar Cell Development Project under the Green Innovation Fund (GIF) project (FY 2021 – FY 2030). This project focuses on the development and demonstration of fundamental and commercialization technologies for film-type PSCs. In 2025, three additional companies were selected under the demonstration project. The three selected companies, in collaboration with installation contractors and other partners, conducts five-year programs on mass production technology development and field demonstrations toward the commercialization of both film-type and building-integrated glass-type PSCs.

In cooperation with METI, MOE launched a new deployment support program aimed at creating social implementation models for film-type PSCs, under which four proposals submitted by local governments were selected.

In addition to NEDO programs, numerous PSC demonstration projects were implemented in 2025. Companies such as Sekisui Chemical, EneCoat Technologies, Aisin, Toshiba, Ricoh, Panasonic, and YKK AP initiated demonstration installations at various facilities in collaboration with local governments and private-sector users.

Regarding demonstration of PV system utilization technologies, METI, NEDO, and MOE conduct demonstration projects related to power system control incorporating PV and storage battery systems. In 2025, METI and MOE jointly continued demonstration projects for Net Zero Energy Buildings (ZEB). MOE conducts technology development and demonstration projects toward the realization of carbon neutrality. In 2025, it implemented projects including R&D on grid-scale electricity storage systems to facilitate renewable energy integration, demonstration projects to improve PV performance in snowy regions, and the development and demonstration of tandem PSC technologies. In Leading Decarbonization Areas designated by MOE, local governments conducted PV-related demonstrations as part of decarbonization initiatives. In the private sector, demonstration tests were launched for agrivoltaic systems and PPA business models combining PV and storage batteries.

INDUSTRY AND MARKET DEVELOPMENT

Japan’s cumulative PV installed capacity is estimated to have exceeded 100 GW as of 2025. Meanwhile, annual installations in 2025 are estimated at approx. 5.7 GW, at a level comparable to 2024 (preliminary estimate by RTS Corporation). Compared to the peak annual installation level of 10.8 GW in 2015 under the FIT program, annual installations have nearly halved, and market stagnation continues.

Until around 2022, most PV installations were driven by the FIT program. However, declining FIT purchase prices, reductions in PV system costs, growing demand for renewable energy procurement among consumers, and rising electricity prices have accelerated PV deployment through PPAs. As a result, the self-consumption market, centered on installations on buildings and facilities owned by electricity consumers, has begun to emerge.

PV deployment through PPAs continued to expand steadily. In on-site PPAs, initiatives to effectively utilize surplus electricity gained momentum. In addition to conventional wholesale market sales and retail supply, diverse schemes were observed, including intra-group and local electricity interchange, and the combination of on-site and off-site PPAs. Cases in which the environmental value of surplus electricity is allocated to PPA off-takers also increased. In the future, the utilization of storage batteries is expected to become a key factor in meeting consumer demand for higher self-consumption rates. In off-site PPAs, including physical and virtual PPAs, matching between power producers and electricity consumers has been a challenge. In 2025, however, the use of matching services expanded. This trend was further supported by the expansion of relative transactions for environmental value from existing FIP-certified PV systems, including those transitioned from the FIT, to cover all eligible facilities. PPA adoption has also spread in the public sector, contributing to the expansion of local decarbonization initiatives.

Agrivoltaic initiatives continued to expand in 2025. Agriculture-led PV deployment and business development of agrivoltaics progressed, involving organizations such as agricultural cooperatives, agricultural machinery manufacturers, and agricultural and livestock universities. New technologies, such as adjustable-tilt mounting structures, tracking systems, and vertical installations using bifacial modules, were adopted, marking the beginning of diversification in installation configurations.

In the residential market, toward MLIT's target of equipping 60 % of newly constructed detached houses with PV systems by 2030, PV is beginning to become a standard feature, and installation volumes have shifted to an upward trend. This shift has been driven by mandatory compliance with energy conservation standards and promotion of Zero Energy Houses (ZEH). The introduction of compact, anti-glare, and BIPV products tailored to Japan's housing conditions has also contributed to market growth.

In the non-residential building segment, preferential measures under the FIT introduced in 2023, persistently high electricity prices, and promotion of green electricity under the Energy Conservation Act have led to the gradual spread of PV installations in private-sector buildings, particularly relatively large commercial facilities, factories, and logistics warehouses located in suburban areas. PV deployment has also been proactively advanced in public buildings and infrastructure owned by national and local governments, including airports, roads, and railway

KOREA

PHOTOVOLTAIC SECTOR STATUS 2025

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Figure 27: Centre for Advanced Solar PV Technology (CAST) at the Korea Institute of Energy Research (KIER). Courtesy of KIER.

PV POLICY PROGRAMME

Following the early presidential election in June 2025 after the impeachment of the former president, a new government was established in Korea, redefining national energy policy. The new administration has positioned climate crisis response and energy security as central priorities. As part of institutional restructuring, the Ministry of Climate, Energy and Environment (MCEE) was established to integrate climate and energy policy functions and strengthen coordination for carbon neutrality and energy transition. The 2035 Nationally Determined Contribution (NDC) was also finalized, setting a greenhouse gas reduction target of 53–61% compared to 2018 levels.

In terms of energy transition, large-scale renewable energy expansion and the gradual phase-out of coal-fired power generation have been prioritized. The plan targets 100 GW of renewable energy capacity by 2030, focusing on solar PV and wind power. Solar PV deployment is expected to accelerate through regulatory reforms, including relaxed setback requirements and the expansion of agrivoltaics. Reducing generation costs remains a key objective, with long-term targets of approximately KRW 100/kWh for solar PV and below KRW 250/kWh for offshore wind.

Power system transformation is another key component of the policy framework. An AI-based "Energy Expressway" has been proposed to strengthen transmission networks and improve renewable integration. Korea also aims to transition toward a distributed power system based on local production and consumption, supported by region-based electricity pricing.

- Establishment of the Ministry of Climate, Energy and Environment (MCEE). MCEE was launched on 1 October 2025 through the consolidation of energy-related functions from the Ministry of Environment (ME) and the Ministry of Trade, Industry and Energy (MOTIE), marking the most significant restructuring of Korea's climate and energy governance in over three decades. It serves as the central authority for carbon neutrality, energy transition, and climate crisis response, covering electricity, renewable energy, parts of the nuclear sector, and hydrogen. Its 2026 budget is approximately KRW 19.17 trillion (+9.9% YoY), and it also manages the Climate Response Fund.

• "Energy Expressway". As a key national infrastructure project, the government has proposed the development of an "Energy Expressway" to support large-scale renewable energy expansion. The plan includes approximately 20 GW of offshore wind transmission capacity along the west coast by 2030 and a U-shaped offshore transmission network across the Korean Peninsula by 2040. It also involves the introduction of AI-based intelligent grid systems to better integrate distributed renewable energy. Grid flexibility will be enhanced through the deployment of 2.3 GW of energy storage systems (ESS) by 2029 and the promotion of virtual power plants (VPPs).

• "Sunlight and Wind Pension". Community-based renewable energy models are being promoted through the "Sunlight and Wind Pension" scheme, which distributes revenues from solar and offshore wind to local residents. Building on the model in *Shinan* County, similar programs are being expanded nationwide. From 2026, more than 500 "Sunlight Income Villages" will be developed annually across approximately 38 000 rural administrative units.

• Promotion of RE100 industrial Complexes. Renewable electricity–based industrial complexes are being promoted to support corporate RE100 commitments. A task force was launched in July 2025, followed by a Special Act proposal in October. Financial support for rooftop solar has been expanded, increasing the subsidy ceiling from 100 kW to 200 kW in 2025.

• Expansion of Zero Energy Building (ZEB) Requirements. ZEB mandates are being progressively expanded. Since 2025, ZEB Grade 4 applies to buildings larger than 1 000 m^2 and designated categories. From December 2025, private buildings over 1 000 m^2 must meet ZEB Grade 5–equivalent standards, including renewable energy systems, driving BIPV demand.

• Mandatory Installation of Renewable Energy Systems in Public Parking Lots. Public parking lots (≥1 000 m^2) must install renewable energy systems of at least 100 kW under revised regulations effective November 2025. The policy aims to expand urban renewable deployment and improve land-use efficiency, supported by MCEE guidance.

• Agrivoltaics Special Act. A special act on agrivoltaics is being prepared for 2026 to enable solar deployment on farmland while maintaining agricultural production. The framework extends temporary land use from 8 to up to 23 years, with eligibility limited to actual cultivators and cooperatives.

• Special Act on National Resource Security. The Resource Security Council, launched in December 2025, serves as the central body for resource security policy. It covers a wide range of strategic resources including renewable energy and will establish a 10-year master plan every five years, with the first scheduled for 2026.

The government plans to deploy 100 GW of renewable energy capacity by 2030, focusing primarily on solar PV and wind power. Solar PV deployment is expected to accelerate through regulatory reforms.

RESEARCH, DEVELOPMENT & DEMONSTRATION

The 5th Energy Technology Development Plan (2025–2034) was established as a mid- to long-term strategy for energy technology R&D to achieve carbon neutrality and strengthen energy security. Following the roadmap announcement in December 2024, the plan was finalized in 2025 after inter-ministerial consultations. It aims to accelerate the energy transition and enhance global competitiveness through renewable expansion, power system innovation, and clean energy technologies. Key areas include advanced solar and wind technologies, green hydrogen via water electrolysis, next-generation grids and energy storage systems (ESS), small modular reactors (SMRs), and distributed digital-based energy systems.

The solar PV roadmap focuses on strengthening competitiveness in next-generation photovoltaic technologies. Early commercialization of tandem solar cells is a key priority to secure ultra-high-efficiency PV and enhance global competitiveness. The roadmap also promotes expanded applications—including BIPV, floating PV, and agrivoltaics—supporting the transition to distributed energy systems. It further emphasizes digital-based O&M technologies to improve efficiency and reliability, along with lifecycle carbon reduction through recycling and circular economy approaches.

Following the new administration, the "Ultra-Innovative Economy" concept and the "15 Ultra-Innovative Leading Projects" were introduced to strengthen industrial competitiveness and future growth engines. Announced between September and November 2025, the projects are grouped into advanced materials and components, climate and energy sectors, and K-Boom-Up industries. They include power semiconductors, LNG containment systems, superconductors, graphene, specialty steel, solar and next-generation grids, offshore wind and HVDC, hydrogen and SMRs, as well as smart agriculture, fisheries, satellite applications, and K-industries (e.g., bio, content, beauty, and food). The initiative is supported by policy packages covering R&D, workforce development, finance, overseas expansion, and regulatory reform.

Within this framework, solar PV aims to strengthen industrial competitiveness through next-generation technologies. R&D is being intensified to achieve global leadership in tandem solar cell commercialization within five years, targeting approximately 35% cell efficiency and 28% module efficiency. The initiative also promotes value chain collaboration—materials, equipment, cells, and modules—to enhance technological self-reliance and industrial capacity.

• Opening of the BIPV Demonstration Center (so-called *"Building-type Solar Power Verification Test Facility"*). On April 21, 2025, the BIPV Demonstration Center was inaugurated in Eumseong, providing integrated testing, certification, and performance evaluation for BIPV systems. Established under the BIPV Infrastructure Development Project (2022, MOTIE), it involves an investment of approximately KRW 13.98 billion. Built on a 13 573 m^2 site (1 530 m^2 floor area), the facility includes integrated evaluation, fire, and structural testing units. It is equipped with 14 testing systems covering electrical, structural, and fire performance. Led by KETEP and KCL, with participation from Chungbuk Technopark, KTL, and universities, the center provides one-stop evaluation services, reducing development costs and supporting the BIPV ecosystem and ZEB deployment.

Figure 28: BIPV demonstration Centre in Eumseong, inaugurated in April 2025. Courtesy of Jin Hoo Kim of The Korea Electric Times.

• Newly launched solar PV R&D projects. In 2025, several solar PV R&D projects were initiated in line with the roadmap. These include ultraviolet down-conversion encapsulant films for tandem and HJT modules; testing methods and standardization for perovskite/silicon tandem modules; and environmentally friendly recycling technologies. Additional projects focus on high-power zero-busbar (0BB) modules to reduce silver use, degradation mitigation technologies for stable outdoor operation, lifecycle management technologies, balcony plug-in modules, and PV recycling and resource recovery. Further initiatives include mobile recycling systems, global demonstration projects, and greenhouse gas reduction assessment platforms that integrate PV deployment potential analysis with power system modeling.

• R&D activities at the Centre for Advanced Solar PV Technology (CAST). CAST serves as an open R&D platform integrating industry, academia, and research institutes. Following the successful validation of high-efficiency solar cell and module technologies using domestically developed equipment, it now focuses on next-generation PV technologies and their commercialization in line with the national roadmap. CAST conducts research on tandem solar cells and projects on low-carbon, recyclable module materials and processes in collaboration with KETI, KITECH, Chungbuk Technopark, Wonkwang S&T, and Shinsung E&G, among others. In partnership with organizations such as Hanwha Solutions, KTL, KOES, Hojeonable, and KENTECH, it is advancing initiatives including 0BB modules, tandem module testing and evaluation systems, electrode materials for high-efficiency solar cells, and the investigation of degradation mechanisms.

CAST (KIER) also leads international joint research through a Korea–Switzerland program in collaboration with CSEM (Swiss Center for Electronics and Microtechnology), involving industrial partners Fluxim and TNETech under the "*MetroPero*" project. In addition, by utilizing its silicon solar cell manufacturing processes, CAST verifies the performance of domestically developed deposition equipment, thereby supporting exports through its role as a demonstration platform.

Figure 29: CAST-KIER. Courtesy of KIER.

Solar PV aims to strengthen industrial competitiveness through next-generation PV technologies, supported by integrated policy packages.

INDUSTRY AND MARKET DEVELOPMENT

As of 2024, cumulative installed solar capacity in Korea reached 32.0 GW[4], of which 27.4 GW (approximately 86%) was accounted for by power generation businesses. Residential installations represented 2.5 GW (8%), industrial and commercial applications 1.7 GW (5%), and other uses 0.3 GW (1%). By system size, approximately 14 GW (43.6%) corresponds to systems of 100 kW or less, about 12 GW (38.1%) to systems between 100 kW and 1 MW, and around 5.8 GW (18.2%) to systems larger than 1 MW. These figures are based on Renewable Energy Deployment Statistics published by the Korea Energy Agency (KEA) and reclassified by application category. While power generation businesses dominate, small- and mid-scale systems still account for a significant share of total capacity, with systems larger than 20 MW representing only about 1.9 GW (approximately 6%).

Given current policy directions, evolving market structures, the 100 GW renewable energy target by 2030, and the Korea Green Transformation (K-GX), solar PV deployment is moving beyond simple capacity expansion toward rapid growth accompanied by structural transformation. Solar PV is increasingly positioned as a core component of the national energy transition. The 100 GW target represents a substantial increase from current capacity and requires a significant rise in annual installations. To support this, comprehensive measures—including electricity market reform, grid expansion, regulatory easing, and demand-side policies—are being implemented, signaling a shift from gradual growth to policy-driven acceleration. K-GX reinforces this transition by linking renewable expansion with industrial decarbonization, electrification, and grid modernization, positioning solar PV as key infrastructure for industrial competitiveness. The transition to a contract-based market is expected to improve investment stability and enable more planned expansion, supporting both large-scale and distributed systems. In parallel, grid enhancements will alleviate curtailment and congestion, while siting policies and community-based models diversify deployment and strengthen social acceptance.

[4] Based on KEPCO's *Monthly Electricity Statistics*, total installed capacity is estimated to have increased to 36.298 GW in 2025.

Looking ahead, more detailed deployment pathways and targets will be presented in the forthcoming 12th Basic Plan for Long-term Electricity Supply and Demand (2026–2040). Overall, the solar PV market in Korea is expected to evolve into a dual-structure system, in which both large-scale and distributed installations expand under a contract-based market and grid-centered framework, with development strongly guided by policy planning.

• Electricity Market and Tariff Reforms. The Renewable Portfolio Standard (RPS) will be phased out by the end of 2026 and replaced by a contract-based procurement system based on competitive auctions and long-term contracts. Auction volumes will be set by energy source to support planned capacity expansion. The REC spot market will be gradually phased out, with a transition period for existing projects until around 2029. Facilities commissioned from 2027 onward will no longer be eligible for RECs and will instead participate in contract markets or power purchase agreements (PPAs). The current SMP + REC structure is expected to transition to a contract-for-difference (CfD) mechanism. Additional measures, including dedicated auction tracks for small-scale projects, virtual power plants (VPPs), and Renewable Energy Service Companies (ReSCOs), will broaden market participation.

• NDC 2035 and the Korea Green Transformation (K-GX). The 2035 NDC, targeting a 53–61% reduction in greenhouse gas emissions from 2018 levels, was finalized in November 2025. As a follow-up, K-GX was introduced as an implementation strategy, with detailed plans to be developed by the first half of 2026. Industry consultations began in late November 2025, and MCEE defined K-GX as a whole-of-economy transition strategy focused on renewable expansion, grid modernization, industrial decarbonization, and electrification. A public–private task force was launched in January 2026, followed by inter-ministerial coordination in March to develop sectoral pathways and supporting R&D, financial, and regulatory frameworks.

• Initiation of the 12th Basic Plan for Long-term Electricity Supply and Demand (BPLE 12). On 27 November 2025, MCEE initiated preparation of BPLE 12 (2026–2040). The plan will reflect recent developments, including the new administration's policy agenda, the 2035 NDC, and rising electricity demand driven by AI industries and electrification. It aims to improve demand forecasting and establish a carbon-free–oriented power mix, while outlining key directions such as renewable expansion and coal phase-out. Supporting measures include grid expansion, enhanced system flexibility, demand decentralization, and electricity market reform.

LITHUANIA

PHOTOVOLTAIC SECTOR STATUS 2025

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Figure 30: 2 100 MWp solar PV plant in Moletai region, Lithuania, 2025.

PV POLICY PROGRAMME

The foundation for renewable energy development in Lithuania was the National Energy Independence Strategy adopted by the Parliament (Seimas) in 2019. The strategy established the following targets: a) to eliminate dependence on Russian electricity imports by 2023; b) to generate 45% of electricity from renewable sources by 2030; and c) to produce 80% energy from renewable sources—including electricity, heating, and transport—by 2050.

The rapid development of renewable energy at the country called for a more ambitious plan and new version of National Energy Independence Strategy was adopted at 2024, bringing forward the 100% renewable electricity target even to the year 2030. It means that all electricity will be produced locally and represents a dramatic transformation compared to 2015, when approximately 80% of Lithuania's electricity was imported, almost entirely from Russia.

A major milestone in Lithuania's energy transition was reached in 2025, when Lithuania, together with Latvia and Estonia, withdrew from the BRELL (Belarus–Russia–Estonia–Latvia–Lithuania) electricity ring. The Baltic grids were synchronized with the Continental European network, ensuring full technical and political independence from the Russian system.

Solar PV has played a key role in this transformation. From virtually zero capacity in 2010 and only 90 MW in 2020, rapid development over the past five years increased installed capacity to 3 040 MW in 2025. This corresponds 1 053 kW per capita, placing Lithuania among the EU leaders in photovoltaic deployment.

In 2025, solar power plants generated 1.79 TWh of electricity, accounting for 14.2% of total national electricity consumption. Together with wind farms—producing 4.29 TWh from 2.47 GW of installed capacity—renewable sources covered 68.1% of Lithuania's domestic electricity demand.

The main driver for this rapid development has been a consistent and forward-looking state policy implemented by the Ministry of Energy. Between 2015 and 2022, the most effective instrument for PV expansion was the introduction and expansion of a net-metering scheme supporting the growth of "prosumers."

Introduced in Lithuania net-metering scheme has high flexibility. There were no capacity limits for households or companies. Consumers were allowed to purchase a share of a solar park located anywhere in the country and use the generated electricity at their place(s) of consumption. A user-friendly IT platform enabled efficient accounting, while providing option to settle grid service charges by part of the electricity generated.

This attractive support scheme led to the emergence of 170 000 prosumers by 2025, representing approximately 9% of all electricity consumers. Prosumers accounted for around 70% of total solar electricity production in 2025. The net-metering system also enabled efficient use of solar electricity for heating through heat pumps, significantly increasing the popularity of green heat and hot water production in both single-family and multifamily buildings.

Recently modifications to the support were introduced for commercial companies which are now required to transit to a net-billing system, while net-metering system still can be applied to households and non-profit entities. In the near future all new solar producers are expected to operate under net-billing arrangements.

Another important driver of PV development has been a well-designed public investment support scheme, typically covering up to 30% of installation costs. This support has been available to households and small and medium-sized enterprises, but not to utility-scale solar parks. Large-scale projects generally do not require subsidies due to the significant decline in PV module costs in recent years.

The main source of financial support has been the Climate Change Programme, funded through revenues received by Lithuania under the EU Emissions Trading System (EU ETS).

By 2025, the main obstacle to further PV expansion became grid connection capacity. The rapid growth of both solar and wind installations exceeds the absorption capacity of distribution and transmission grids. As a result, energy storage systems (BESS) have become a key driver for further growth of the renewable energy generation.

In 2025, technical permits were issued for the development of BESS facilities with a combined capacity of nearly 2 GW. This is expected to significantly improve grid flexibility in the near future. The Kruonis Pumped Storage Power Plant with 900 MW operating in Lithuania make a significant contribution to balancing the fluctuations of solar and wind power. To increase generation flexibility, it is currently being reconstructed to a capacity of 1 050 MW. This will significantly expand the grid's capability to integrate electricity generated by renewable energy sources.

Additional mitigation is provided by allowing solar and wind installations to share the same grid connection point. This newly introduced option was based on studies showing that in Lithuania's climatic conditions, solar PV generation peaks during summer and daytime hours, while wind generation is stronger in winter and at night. Such hybrid power plants make it possible to connect capacities that exceed the nominal technical limits of the grid, effectively increasing grid utilization and partially resolving competition between solar and wind projects.

The geopolitical situation in Europe, particularly the war in Ukraine, has significantly increased the importance of cybersecurity in the energy sector. Many inverters used in solar installations are manufactured outside the EU, primarily in China. PV operators in Lithuania are actively implementing government recommendations and seeking technical solutions to reduce dependence on external control systems.

RESEARCH, DEVELOPMENT & DEMONSTRATION

Two decades ago, Lithuania took steps to accelerate solar energy development by establishing local manufacturing of PV cells and modules. Several modern factories with a combined capacity of approximately 200 MW were deployed. However, like in other EU countries, these manufacturers faced strong competitive pressure from Chinese imports and were forced to adapt or change their business models.

Subsequently, several R&D institutions and companies formed a Photovoltaic technology cluster focused on innovative solutions, particularly building-integrated photovoltaics (BIPV). Currently, three manufacturers produce customized PV products, including solar roofing replacements, PV tiles, metal-roof-integrated modules with matte surfaces, colored modules, and PV elements integrated into roadside barriers.

Collaboration between researchers, developers, and manufacturers in Lithuania is strong, and exports of these specialized products are increasing annually.

A major new area of expansion is the integration of PV systems with heat pumps. Public institutions responsible for the refurbishment and energy modernization of Soviet-era multifamily buildings have recognized the potential of this combination. Several Horizon 2020 projects enabled the establishment of demonstration sites where rooftop PV systems power heat pumps. These projects clearly demonstrated the economic and environmental benefits of such systems for apartment owners, and the initiative is now expanding rapidly across the country.

The next stage of the development involves integration not only BESS but also thermal energy storage. Advanced heat storage systems using phase-change materials in combination with heat pumps have begun to be deployed, initially in households. R&D institutions are also contributing to the further enhancement of energy management systems, which are becoming increasingly important as PV systems, heat pumps, electrical storage, and thermal storage are integrated. Some Lithuanian companies have already achieved promising results in this area.

Priority for BESS research in Lithuania has focus on sodium-based storage solutions, as they are safer and perform better under outdoor conditions in the cold climate.

INDUSTRY AND MARKET DEVELOPMENT

PV installations have experienced extremely rapid growth in recent years. From 26 MW in 2022, installed capacity increased to 3 040 MW in 2025.

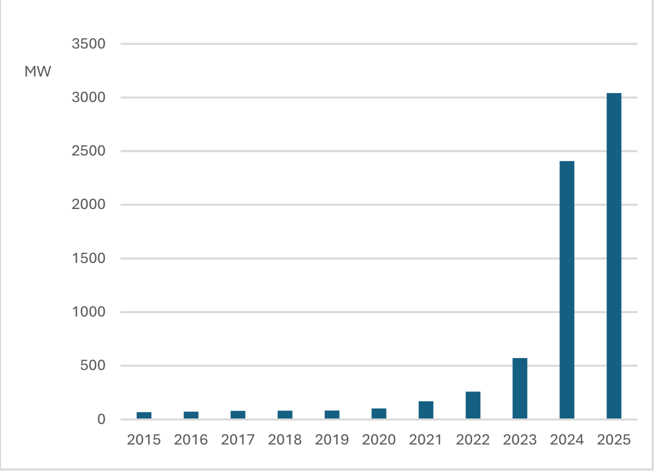

Figure 31: Cumulative solar PV capacity in Lithuania, MWp.

The largest solar park in Lithuania, with a capacity of 100 MW, was commissioned in 2025, and several similar projects are scheduled to begin operation in the coming year.

Growth is expected to continue, as technical permits have already been issued for an additional 4 GW of solar capacity. However, grid connection availability remains the primary constraint.

The state-owned transmission system operator, Litgrid, has prepared a comprehensive grid development programme supported by both its own financial resources and EU funding. The Lithuanian Solar Energy and Storage Association works closely with the Ministry of Energy and grid operators to propose balanced technical and regulatory solutions.

With continued grid reinforcement and storage deployment, PV developers expect a return to accelerated growth in the coming years.

MALAYSIA

PHOTOVOLTAIC SECTOR STATUS 2025

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Figure 32: SEDA Malaysia new office building featuring rooftop and parking canopy solar PV installations to support on-site renewable energy generation.

PV POLICY PROGRAMME

Malaysia's energy policy supports economic growth while advancing the national energy transition and sustainability goals. The National Energy Policy 2022–2040, the Malaysia Renewable Energy Roadmap (MyRER), and National Energy Transition Roadmap (NETR) provide the main frameworks guiding this transition. Under NETR, Malaysia aims to achieve 70% renewable energy installed capacity and carbon neutrality by 2050, with solar photovoltaic (PV) serving as a key driver. By the end of 2025, Malaysia has successfully achieved interim capacity target of 31% installed capacity dominated by hydro and PV.

The government promotes PV deployment through several schemes including Feed-in Tariff (FiT), Net Energy Metering (NEM), Large Scale Solar (LSS), and Self-Consumption (SELCO). The Energy Commission oversees the LSS and SELCO programmes, while the Sustainable Energy Development Authority (SEDA) Malaysia manages the FiT and NEM initiatives. Nonetheless, these initiatives are not executed in Sarawak due to its separate electricity supply ordinance. In Sabah, the energy sector is regulated by the Energy Commission of Sabah (ECoS).

The FiT programme established in 2011 allows the electricity generated from renewable energy (RE) sources to be sold to the grid at premium prices. Since 2016, solar PV has been phased out from the FiT programme, with support continuing only for biomass, biogas, and small hydro. In 2025, improvements were made to FiT 2.0, including revisions to the tenure and tariff structure. The Renewable Energy Power Purchase Agreement (REPPA) tenure was standardized to 21 years for biomass, biogas, and small hydro projects. Previously, the REPPA tenure was 21 years for solar PV and small hydro, but only 16 years for biomass and biogas. Additionally, FiT 2.0 implements a two-phase tariff structure, with SEDA determining the rate for the first ten years and qualifying producers bidding for the remaining 11 years.

The NEM programme, introduced in 2016, allows PV owners to offset their electricity consumption. The programme concluded in June 2025, with more than 2 600 MW of quota awarded. It will be replaced by the Solar Accelerated Transition Action Programme (Solar ATAP) starting January 2026. Solar ATAP provides greater flexibility than NEM, as it eliminates quota restrictions, provides a continuous program without a predetermined end date, and higher capacity limits for three phase domestic users (single phase ≤ 5 kW_{ac}; three phase ≤ 15 kW_{ac}) For non-domestic users, installations can reach 100% maximum demand capped at 1 000 kW. Domestic users offset their electricity consumption based on the regulated retail tariff, while non-domestic users under Solar Atap are credited at based on System Marginal Price (SMP).

In 2025, Sarawak launched its own policy framework, Sarawak Energy Transition Policy (SET-P) outlining the state's strategy to achieve their energy transition target. Among the programmes introduced is a subsidy scheme under the NEM programme. The NEM subsidy will apply for successful NEM Installation from 2026 under the Domestic Tariff category for landed residential properties.

Following LSS PETRA 5 in 2024, the Ministry of Energy Transition and Water Transformation (PETRA) announced a supplementary round of bidding (LSS PETRA 5+) in early 2025, offering 2 GW of capacity. The programme allocates 1 500 MW for ground-mounted solar projects and 500 MW for floating solar projects, with projects targeted to be operational between 2027 and 2028. Out of the total quota, 1 975 MW was successfully awarded.

SELCO (Solar for Self-Consumption) applies when electricity generated from solar PV is used for on-site consumption only, with no export to the grid. The SELCO guidelines were revised in 2025, introducing more relaxed rules to encourage wider adoption of on-site solar, particularly among commercial and industrial users. Key changes include the removal of the 85% capacity limit for non-domestic users, allowing systems to meet up to 100% of electricity demand, and the expansion of installations to include ground-mounted and floating solar. The mandatory BESS requirement for systems above 72 kWp has been deferred until 31 December 2025, while a standby charge applies only to systems above 1 MWp (about RM12/kWp per month). The programme has also been extended to agricultural users.

On the other hand, several initiatives facilitate the virtual purchase of solar energy by consumers, including the Corporate Green Power Programme (CGPP), Corporate Renewable Energy Supply Scheme (CRESS), and Community Renewable Energy Aggregation Mechanism (CREAM). CRESS was introduced in 2024 to boost renewable energy adoption, including solar, by allowing direct electricity supply from RE developers to corporate consumers through the grid. Initially, CRESS mainly targeted new electricity demand, such as companies expanding capacity or establishing new facilities. Following a revision effective 1 March 2025, the scheme was expanded to all existing medium- and high-voltage TNB customers, allowing companies to procure renewable electricity without increasing their electricity demand. The update also streamlined the application and contracting process, making the scheme more accessible to both developers and corporate buyers. A System Access Charge (SAC) is imposed for grid usage, was revised to 25 cent/kWh for firm energy with battery storage and 45 cent/kWh for non-firm energy.

The CREAM mechanism enables residential rooftops to be aggregated for solar PV generation, allowing homeowners to lease their rooftop space to third-party developers. Based on the concept of open grid access, developers can connect multiple rooftops to form distributed solar systems that supply renewable electricity to neighbouring consumers within a 5 km radius. Participating energy firms administer rooftop leasing agreements with homeowners. CREAM projects are subject to a Community Access Charge (CAC) of 15 cent/kWh for the use of the distribution network; this charge was later reduced by 40% to 9 cent/kWh, significantly improving project economics and enhancing the programme's attractiveness. Under this mechanism, the first flagship project in City of Elmina, developed by Sime Darby Property, aim to lease 6 000 residential rooftops within a 5 km radius for PV installations to generate electricity for nearby commercial and industrial users.

To further support RE adoption, the government waived the 1.6% Renewable Energy Fund (KWTBB) charge on electricity tariffs for the Green Electricity Tariff (GET), CRESS and CREAM programmes. The exemption aims to encourage greater participation from corporate and industrial consumers while supporting the government's goal of accelerating renewable energy development and integration into the national electricity supply.

Financial assistance, investments, incentives, and rebates are provided to promote the adoption of renewable energy and accelerate the energy transition. The Green Technology Financing Scheme (GTFS) 4.0 continues with a total allocation of RM1 billion until December 2025, supporting six sectors, including energy. Additionally, the National Energy Transition Facility (NETF) supports energy transition projects by functioning as a blended finance platform that attracts public, private, and international funding. Malaysia Debt Ventures Berhad, as one of the implementing agencies for NETF, has approved approximately RM122.65 million in financing for several projects, including those in the energy sector, along with about RM40.09 million in targeted incentives for six technology-based companies.

LSS Update: The LSS program has achieved 2 237 MW cumulative capacity installed capacity by the end of 2025. In 2025, a total of 60 MW of LSS capacity was commissioned, comprising two floating solar plants, DTU 1 and DTU 2, located in Pasir Mas, Kelantan.

FiT Update: As of 2025, the cumulative FiT capacity (biogas, biomass, WTE, small hydro and PV) for Peninsular Malaysia and the Federal Territory of Labuan is 1 225.29 MW_{ac}, of which 618.84 MW_{ac} is operational. Solar PV projects are fully operational and represent the largest segment of active projects, with a total capacity of 345.41 MW.

NEM Update: Since its implementation in 2016, the NEM program has provided a cumulative quota of 3 000 MW_{ac} through a series of implementations. NEM 3.0 operates across three distinct categories: NEM Rakyat, NEM GoMEn, and NOVA (Net Offsets Virtual Aggregation), with corresponding quotas of 700, 100, and 1 700 MW_{ac}. By the conclusion of 2025, 87.71 % of NEM quotas have been subscribed with a cumulative capacity of 2747.92 MW.

Figure 33: Aerial view of SEDA Malaysia building with rooftop and car park solar PV installations.

RESEARCH, DEVELOPMENT & DEMONSTRATION

As of 2025, Malaysia achieved a total cumulative capacity of 5776.72 MW from solar PV installations under the LSS, FiT, and NEM schemes.

As of 2025, Malaysia achieved a total of cumulative capacity of 5 777.73 MW from solar PV installation under the LSS, FiT and NEM schemes. The breakdown of the installation is shown in the following table:

Table 5: Breakdown of PV installations in Malaysia by support program and system type.

MECHANISM	2025 (MW)
LSS	2684.4
FiT	345.41
NEM	2747.92
TOTAL	**5777.73**

INDUSTRY AND MARKET DEVELOPMENT

The PV industry in Malaysia has undergone significant transformation due to global trade policies, particularly U.S. tariffs and China's export tax adjustments, as well as domestic electricity tariff restructuring. The United States has imposed high anti-dumping and countervailing duties on solar products imported from several Southeast Asian countries, including Malaysia, increasing the cost of Malaysian exports to the U.S. market. This has contributed to weaker export demand and placed financial pressure on manufacturers operating in Malaysia. In response to these trade restrictions and broader market challenges, several PV manufacturers in Malaysia, including First Solar, Jinko Solar, Risen Energy, JA Solar, and LONGi, have scaled back operations or ceased manufacturing activities.

Despite these challenges, solar PV prices in Malaysia have remained low, largely due to oversupply from China and continued production from domestic manufacturers. Intense competition has led to a sustained price war, enabling Malaysia to procure PV systems at relatively low cost. As a result, solar PV installations have increased, supported by government incentives and rising electricity tariffs, which have improved the economic attractiveness of solar adoption.

China's reduction of VAT export rebates for PV products (wafers, cells, and modules) from 13% to 9% in December 2024 has increased export costs and placed upward pressure on global module prices, including in Malaysia. However, due to persistent oversupply and intense price competition, the impact was muted throughout 2025, with prices remaining low until gradual increases emerged toward the end of the year. Higher solar module prices are expected in 2026 following the full removal of VAT export rebates.

In parallel, Malaysia's electricity tariffs, typically reviewed every three years, have recently been revised upward, reflecting higher generation costs driven by rising fuel prices and increased investment in grid infrastructure. The tariff adjustment announced in the third quarter of 2025 does not affect approximately 85% of domestic users but poses challenges for industrial consumers. In response, the government has introduced measures to improve energy efficiency and mitigate cost impacts, including the Energy Efficiency Incentive, Time-of-Use (TOU) scheme, targeted subsidies, and the Automatic Fuel Adjustment (AFA), which replaces the Imbalance Cost Pass-Through (ICPT) mechanism. The TOU scheme promotes more efficient electricity consumption by charging higher rates during peak periods and lower rates during off-peak hours. Overall, rising electricity tariffs are expected to further support RE adoption, particularly solar, while encouraging more efficient energy use.

Meanwhile, grid flexibility and stability are essential for managing the variability of RE sources. Energy storage systems play a critical role by storing excess electricity generated during periods of high solar production and releasing it when demand increases, thereby improving overall grid stability. Energy Comission recently announced successful bidders for grid-connected Battery Energy Storage System (BESS) projects under the MyBEST programme, with a total capacity of 400 MW / 1 600 MWh, expected to be commissioned in 2027. Sabah has taken a major step by launching Malaysia's first large-scale BESS project in Lahad Datu, with a total capacity of 100 MW / 400 MWh. At the regional level, initiatives such as the ASEAN Power Grid (APG), supported by the Asian Development Bank (ADB) and the World Bank, aim to strengthen electricity connectivity between Southeast Asian countries. Improved regional grid interconnection can increase electricity system flexibility and facilitate higher renewable energy penetration across the region.

MOROCCO

PHOTOVOLTAIC SECTOR STATUS 2025

Authors: Soukaina BOUDOUDOUH, IRESEN, Morocco
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Contributors : Amine ARAQI HOUSSAINI, RENPOWER, Morocco

Figure 34: Largest PV plant in Morocco, Khouribga. Ref : https://www.infomediaire.net/ocp-green-energy-premiere-phase-programme-solaire-202-mwc/.

PV POLICY PROGRAMME

Morocco has set a strategic national objective to achieve 52% of installed electricity capacity from renewable energy sources by 2030, as part of its long-term energy transition strategy.

To accompany this vision, Decree No. 2.25.100 established the regulatory framework governing the construction and operation of electricity self-generation installations under law No. 82-21. It introduces a differentiated approach based on the size and grid connection level of the installations, defining specific procedures ranging from a simple declaration regime for small off-grid systems to connection approval and formal authorization requirements for medium- and high-voltage grid-connected projects. This framework provides greater regulatory clarity for investors and supports the development of decentralized renewable energy and self-consumption in Morocco.

For self-consumption applications and in coherence with the provisions of Article 5 of Law No. 13-09 on renewable energy, as amended and supplemented by Law No; 40-19, and Article 23 of Law No. 82-21 on electricity self-generation, the National Electricity Regulatory Authority (ANRE) approved the hosting capacity of the electricity system for 2025 at a solar hosting capacity of 2 798 MW in the 2025 communication and the solar hosting capacity projected for 2026 was 2 900 MW. However, in the new 2026 communication the declared capacity is 2 709 MW.

For what is the renewable capacity progress that has been made throughout the year, by mid-2025 Morocco had already reached 45.5% renewable installed capacity, indicating strong progress and making clear that the 52% target could be achieved as early as 2028. This capacity currently comprises conventional hydropower (44.6%), wind (23.8%), solar (16.9%) and pumped storage (14.8%). This progress is supported by the next generation solar projects, notably Noor Midelt II and Noor Midelt III, each with a capacity of 400 MW. These plants are designed as hybrid projects combining solar generation with battery energy storage systems (BESS). Each facility will be co-located with a 602 MWh battery storage system, significantly enhancing grid flexibility and enabling higher penetration of variable renewable energy. These developments reflect Morocco's evolving energy policy increasingly focused on PV combined with storage in line with national goals of long-term energy security and cost efficiency.

According to the National Electricity Regulatory Authority (ANRE), the country deployed approximately 204 MWp of new utility-scale solar capacity throughout the year. In addition, more than 1GW of capacity was added across the commercial and industrial (C&I), solar pumping and residential segments, based on import data from Moroccan customs. However, the distributed segments remain difficult to track accurately due to limited official reporting and reliance on import statistics. The cumulative installed capacity stands at approximately 1 285 MWp of utility-scale solar PV and 534 MWe of concentrated solar power (CSP), according to data from the National Office of Electricity and

Drinking Water (ONEE). And beyond the utility-scale, the C&I, solar pumping and residential segments are estimated to account for more than 3 GWp of additional installed capacity. These figures are largely derived from equipment import data especially from China.


Figure 35: Floating park 13 MW in Oued Rmel, Tangier (Ref: h24)

In parallel, Morocco is diversifying its solar portfolio through innovative technologies including the development of a 13 MW floating photovoltaic plant. This project reflects a forward-looking policy approach that optimizes land use, reduces water evaporation from reservoirs and contributes to distributed generation strategies. The integration of floating PV further demonstrates Morocco's commitment to technological diversification and resources efficiency within its broader decarbonization roadmap.

For what is industrial-scale deployment, OCP Green Energy is adopting remarkable accelerating actions by commissioning the first phase of its solar program with 202 MWp, reported as the largest PV plant currently in operation in Morocco—within OCP Group's broader ambition to supply its industrial operations with ~5 GW of clean energy by 2027.

Looking at the 2030 vision, we identify the 2025-2030 Electric Equipment Plan which clearly translates Morocco's long-term energy transition objectives into concrete investment priorities. With a total planned additional capacity of 12 445 MW, of which nearly 80% will be renewable, the plan confirms that decarbonization remains the structural backbone of national power sector policy. Solar alone represents the largest share of new additions (35.8%), reflecting a strategic pivot toward PV driven capacity growth, increasingly combined with storage solutions. Wind power continues its expansion (31.8%), consolidating Morocco's position as a regional leader in wind deployment.
At the same time, the inclusion of 1 500 MW of battery energy storage systems (BESS) signals a major policy evolution: the focus is no longer solely on adding renewable capacity, but on ensuring system flexibility, dispatchability, and grid resilience. The 20.6% allocation to gas turbines further illustrates a pragmatic transition strategy, providing fast-reacting backup capacity to secure while enabling higher penetration of variable renewables.

Overall, the plan demonstrates a balanced and forward-looking policy framework dependency, and positions Morocco on the path to exceed its 2030 renewable target ahead of schedule.

As for rooftop applications, the SR500 (Solar Rooftop 500) project has been recently introduced to accelerate the deployment of distributed solar photovoltaic systems. The initiative aims to install up to 500 MW of rooftop solar capacity, primarily across commercial, industrial and public sector buildings. By promoting decentralized generation, SR500 will increase solar penetration in the energy mix, reduce pressure on the grid and contribute to a more resilient and sustainable electricity system.

RESEARCH, DEVELOPMENT & DEMONSTRATION

Morocco continues to strengthen its position in PV R&D and demonstration in line with the national objectives with current R&D priorities spanning PV grid integration and advanced control, technology adaptation to harsh climates (high-performance and bifacial module performance, soiling/thermal mitigation, optimized cleaning/cooling), storage and hybridization (PV+BESS, hydrogen-based and hybrid solutions), and diversified PV applications (Floating PV, Agri-PV, and Power-to-X).

Complementing OCP's large-scale renewable deployments, GEP researchers are advancing (i) Digital Twin O&M tools to support performance monitoring, predictive maintenance, and operational optimization for the 105 MW flagship plant, and (ii) a new decision-support platform for large industrial sites that co-optimizes process operations, material-flow dynamics, storage, and renewable assets across multiple time horizons to quantify flexibility value (buffering, sizing, smart scheduling), maximize renewable utilization, and reduce curtailment and emissions. In addition, R&D efforts increasingly focus on modeling and evaluating PV (and hybrid renewable) potential for emerging green hydrogen projects, leveraging geo-spatial and techno-economic screening approaches illustrated by Morocco's Green H2 Atlas initiative that maps and analyzes green hydrogen, potential hybrid solar inclusion, and wind potential to support project development and bankability. (greenh2atlas.ma)

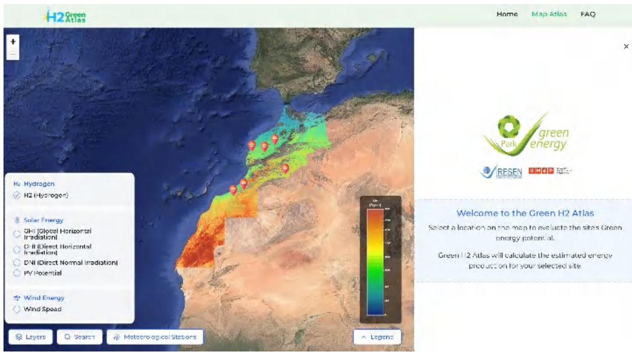

Figure 36: R&D platform for Green Hydrogen mapping

Always within the research framework, and in response to the lack of tracking tools for on-grid and off-grid PV installations, IRESEN is currently developing a PV detection tool which leverages geospatial analysis and GIS (Geographic Information System) technologies. The tool is being designed not only to identify PV installations but also to classify them by building type and integrated them into a comprehensive geospatial map layer, aggregating all relevant information through trained detection models.

INDUSTRY AND MARKET DEVELOPMENT

In the context of PV industry development, Solaris Tangier, the strategic local producer of half-cell panels, based in the Tangier Free Zone, has a production capacity of 700 MW and is primarily export-oriented. The company focuses on international markets because the current regulatory framework in Morocco does not strongly encourage local production. Imported solar panels from China face relatively low duties of only 2.5%, making it difficult for locally manufactured products to compete and stand out in the domestic market. As a result, export markets — particularly in the Americas— represent a strategic outlet for

Solaris Tanger. This contrasts with other countries, such as Tunisia, that actively support domestic manufacturing by imposing import duties of around 30% on foreign panels, creating a more favourable environment for local products.

At the market development level, large-scale utility projects remain the dominant driver of capacity additions. Recent large-scale solar power plant installations illustrate the growing dynamism of private-led development. These projects reflect remarkable progress in technical expertise and the successful implementation of high-capacity installations, demonstrating increasing investor confidence and the continued maturation of the market. In this context, the structure of the distributed market provides additional insight into sector dynamics, according to a solar market assessment study conducted in 2024, solar pumping represents around 60% of the distributed market, C&I account for approximately 30% and residential systems make up about 10%.

Utility-scale projects are not included in this breakdown as their annual contribution varies significantly depending on tender schedules and project commissioning timelines. In addition, the main driver of Morocco's solar market was falling technology costs and improving project bankability. Looking ahead, several key drivers are expected to further accelerate deployment such as ongoing regulatory maturation with new laws and decrees being approved, and rising electricity tariffs. Drivers are expected to further accelerate deployment such as ongoing regulatory maturation with new laws and decrees being approved, and rising electricity tariffs.

THE NETHERLANDS

PHOTOVOLTAIC SECTOR STATUS 2025

Author: Otto Bernsen, RVO, the Netherlands

Figure 37: Solar integrated on Roof, image bank RVO.

PV POLICY PROGRAMME

The gradual phasing out the net metering scheme began in 2025 and will finish in 2027. At the same time, subsidy schemes for electrical vehicles and heat pumps were cancelled and in general the market has not been favorable. New elections and a change of government in 2026 may alter these general policies. In the meantime, the solar sector has moved to integrated solar-battery products, dynamic energy contracts and to revisiting solar integrated products like solar car ports, BIPV and floating PV, even combining these systems in so called energy hubs.

The major driver for these developments has been increasing grid congestion, which has persuaded companies to look for alternatives and higher levels of self-consumption with renewable energy sources and storage. Waiting lists for new grid connections have grown and new plans for solar parks are advised to look into options with battery storage, cable pooling, peak shaving and congestion management.

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In 2025, the available budget for the SDE++ category for larger systems (> 15 Kwp) reached 8 billion euros but stricter conditions were put in place to encourage more nature inclusive solar parks, for example with vertical solar panels.

The Netherlands remain committed to achieving net zero carbon emissions by 2050 but, according to the national environment assessment agency PBL, the chances of reaching the mid-term goals of 55% emission reduction in 2030 are extremely small.

Increasingly the focus is shifting towards system integration of renewable sources like solar and wind, as these infrastructural and societal barriers are hit. However, the lead times for grid reinforcement are long and therefore a renewed interest in decentralized systems has reemerged. A national program on energy hubs started with a modest budget for R&D. RVO estimates that over one thousand locations will be suited suited with another 3 GWp of capacity by 2030.

Cybersecurity of the energy infrastructure remains another priority and together with higher levels of resilience is shared with other ministries and exceeds the climate policies.

RESEARCH, DEVELOPMENT & DEMONSTRATION

In 2025 the mission-oriented R&D program topics remained largely the same:

- Renewable Energy Production
- Energy Saving
- Flexibility of the Energy System
- Circular Economy
- Natural gas free Neighborhoods and Buildings

In 2025 the first independent quality label for new solar parks was published by the TNO led consortium Eco-Certified. It not only guarantees sustainable and autonomous energy production but also delivers measurable benefits for soil quality, biodiversity, and the landscape.

Higher technology readiness levels (TRL) are managed in separate programs for fundamental research by the national organizations NWO and STW. The research activities themselves are dispersed over several universities and research institutes like AMOLF, DIFFER, TNO (the national institute for applied research) and several universities.

Figure 38: Picture Eco certified solar park, courtesy TNO.

INDUSTRY AND MARKET DEVELOPMENT

The accelerated growth of the solar PV market flattened out in 2023 and the market for solar panels stabilized in 2024 on a somewhat lower level. For 2025 however mixed messages surfaced using different sources. The CBS reported 647 MWp installed in the first half of the year.

Usually a similar result for the second half of the year can be assumed but there was a large degree of uncertainty and the figure below is a rough first estimate based also upon preliminary data from the SDE plus scheme by RVO.

Both the solar roof top market and ground mounted systems have reached levels where the proverbial “low hanging fruit” has been plucked. Over 50% of house owners have now installed solar panels in the Netherlands while the rental home market falls behind with an estimated 20%. On business parks and utility construction there is still much space but congestion and split incentives obstruct a faster roll out. All markets are therefore changing towards more integrated products and higher degrees of self-consumption within the home, company or so-called energy hubs.

Homeowners are increasingly combining solar panels with home battery storage which will have to be integrated with energy management systems (EMS), and the same goes for EV’s. Heat pumps are another enabler of solar PV and its market share is on the rise but still an early adopter market.

Energy communities are on the rise but are struggling in the current market setting. In the Netherlands an update of the energy law is planned for the beginning of 2026.

Solar parks can already use battery storage and cable pooling to relieve the national grid. The national grid operator Tennet has reduced transport tariffs to a maximum of 65% for larger solar parks with battery storage and expects an increase with these measures up to 5 GW of battery capacity for flexibility.

The niche market of BIPV remains predominantly a business-to-business market notwithstanding government initiatives that target renovation of the existing building stock and of social housing in particular.

VIPV is taking off in the market segment for trucks and semi-trailers and setting international examples.

The result is a drop in the growth of the installed capacity in the Netherlands and unforeseen effects on the solar hours produced by increasing curtailment measures.

The market may perform a little better in the second half of the year and possibly reach 1.6 GWp of newly installed capacity which is significantly lower than in years before. The total amount of installed capacity over the years will probably exceed the 30 GWp.

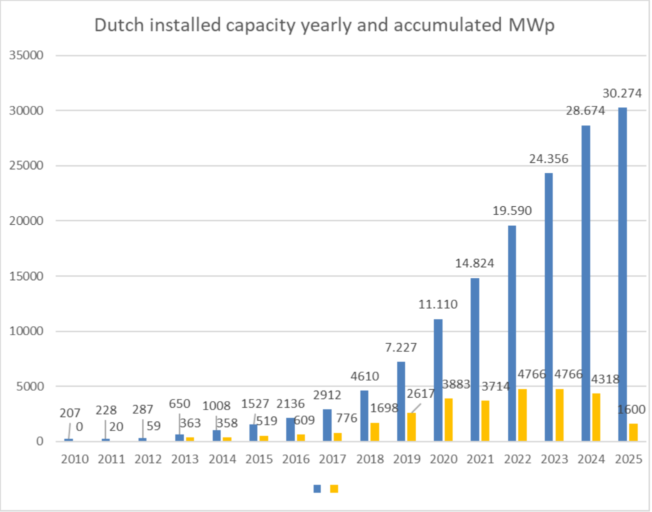

Figure 39: Dutch installed capacity yearly and accumulated.

NORWAY

PHOTOVOLTAIC SECTOR STATUS 2025

Authors: Birgit Hernes, The Research Council of Norway, Norway
Jarand Hole, The Norwegian Water Resources and Energy Directorate, Norway

Figure 40: FPV by Ocean Sun AS.

PV POLICY PROGRAMME

Norway's programmes in the energy sector are generally aiming for promoting renewable energy and increasing energy efficiency. Support for implementation of PV is integrated into these programmes.

Owners of small-scale PV installations are eligible for registering as prosumers. Prosumers are exempt from grid fees that are otherwise charged from electricity suppliers. Surplus electricity can be transferred to the grid at net electricity retail rates (i.e., excluding grid costs, taxes, and fees). If such installations exceed a limit of 100 kW electric power feed-in to the grid, excluding own consumption, grid connection fees will apply.

The public agency Enova SF subsidizes 25% of the installation costs for grid connected residential PV systems at a rate up to 2 500 NOK per kW. This programme also includes leisure homes with grid connection.

The government agency Innovation Norway supports investments in PV systems in the agricultural sector. It is required that the PV system is used for the commercial operation of the actual farm.

Since 1 October 2023, Norwegian grid customers can take part in a virtual self-consumption scheme, virtually deducting excess renewable electricity produced by another grid customer from their own electricity use. The criteria being that the grid customers "sharing" electricity are on the same legal property and that the installed capacity of the generation does not exceed 1 MWAC. This scheme was essentially targeted at grid customers in apartment buildings, to remove the discrimination between people living in apartments and people living in houses, when it comes to the right to produce their own electricity.

As of 19 February 2026, there are 390 instances of the virtual self-consumption scheme in use, with 434 metering points contributing and 2 157 receiving/virtually deducting electricity as self-consumed.

On 1 July 2025, the Norwegian government passed an extension, targeting commercial and industrial buildings, to encourage more decentralised PV electricity in industrial areas. The capacity limit for this extension is increased from 1 MWAC to 5 MWAC and the geographical constraint is changed from grid customers on the same property to grid customers in a single commercial area.

Since 1 October 2023, Norwegian grid customers can take part in a virtual self-consumption scheme.

Solar power for a global market is one of the 6 priority areas in Energi21 - The Norwegian national strategy for Research, Development and Commercialization of New climate friendly energy Technology. The PV-industry is from 2023 also made a priority area in the Norwegian governments strategy for green industry (Grønt industriløft).

RESEARCH, DEVELOPMENT & DEMONSTRATION

The Research Council of Norway (RCN) is the main agency for public funding of research in Norway. Within the energy field it funds industry-oriented research, basic research, and socio-economic research. The PV related part of the portfolio consists of R&D projects on the silicon chain from feedstock to solar cells research, on novel solar cell concepts, novel applications, and on applied and fundamental materials research.

Leading national research groups and industrial partners in PV technology participate in the Norwegian PV Research Centre (www.fmesolar.no), which is funded by RCN and Norwegian industry partners. The centre is hosted by the Institute for Energy Technology (IFE). FME SOLAR will be in operation from 2024 until 2032, with a total budget exceeding 300m NOK.

FME SOLAR performs R&D targeting the main challenges associated with the extremely rapid growth in the use of PV worldwide. The research topics include digitalization to support accelerated deployment and integration of PV power plants, the role, performance, reliability and impact of PV power plants operating under Nordic conditions, integration of PV systems, sustainable production and recycling of PV materials, as well as new applications and disruptive technologies. Education is a key activity in FME SOLAR, and the centre aims at educating 20 PhD candidates and post-docs, as well as 100 MSc candidates

There are six main R&D groups in the university and research institute sector of Norway, which all participate in the Research Centre:

- Institute for Energy Technology (IFE): Focus on polysilicon production; design, production, and characterization of silicon solar cells; and the effects of material quality on solar cell performance.
- University of Oslo (UiO): The Centre for Materials Science and Nanotechnology (SMN) is coordinating the activities within materials science, micro- and nanotechnology.
- Norwegian University of Science and Technology (NTNU) Trondheim: Materials science, micro- and nanotechnology relevant for solar cells.
- SINTEF Trondheim and Oslo: Focus on silicon feedstock, refining, crystallisation, sawing and material characterisation.
- Norwegian University of Life Sciences (NMBU): Fundamental studies of materials for PV applications and assessment of PV performance in high-latitude environments.
- Agder University (UiA): Research on silicon feedstock. Renewable Energy demonstration facility with PV-systems, solar heat collectors, heat pump, heat storage and electrolyser for research on hybrid systems.

There are also new initiatives, both in new and existing enterprises, for developing new services or solutions for the PV market. Examples are Ocean Sun that works with Floating PV (FPV) and companies that work with BIPV products, roofing products for bifacial modules, or module designs adapted to Northern European conditions, etc.

Norway's electricity supply is dominated by hydropower (88%) and wind (10%). The Norwegian PV market is small on an international scale. At the end of 2025, the grid connected capacity was 876 MW with an estimated generation of 661 GWh, less than 0.5 percent of total electricity generation. The steep increase in installation volume was caused by exceptionally high electricity prices.

INDUSTRY AND MARKET DEVELOPMENT

The Norwegian PV industry is now dominated by downstream activities from companies developing small and medium sized PV-equipment to be deployed in Norway and companies that specialize in planning, building and operate large utility scale PV-plants internationally.

Examples of companies that earlier have been producing PV grade silicon and wafers are REC Solar Norway, Norsun and Norwegian Crystals. The products supplied by these companies had a low carbon footprint compared to the industry average. The operations of these companies were severely impacted by the challenges with competition and prices in Europe and production is now shut down.

Scatec is a large renewable power producer. A major part of its operations is development and operation of PV power plants. The present portfolio of PV power plants has a capacity of approximately 2 GW, located in Africa, Asia, South America, and Europe. Also, companies like Equinor and Statkraft are active in these markets.

Figure 41: Scatec PV-plant.

The PV market has decreased since the record year of 2023, declining both in 2024 and 2025. Especially, installations in the residential sector have plummeted. In 2022, residential installations made up 53% of the market volume, which was down to 11% in 2025.

PORTUGAL

PHOTOVOLTAIC SECTOR STATUS 2025

Authors: Sara Freitas, APREN – Portuguese Renewable Energy Association, Portugal
Ricardo Aguiar, DGEG – Directorate-General for Energy and Geology, Portugal

Figure 42: Solar PV power plant "Douro", in Vila Chã da Beira, Portugal, owned by Sonnedix, has a capacity of 150 MW and started operation in 2025.

PV POLICY PROGRAMME

Photovoltaic development in Portugal during 2025 continued to be framed by the revised National Energy and Climate Plan 2030 (NECP), which confirmed solar PV as the principal contributor to incremental renewable electricity capacity. The target of 20.8 GW AC of installed solar capacity by 2030 implies a sustained acceleration of deployment over the second half of the decade.

By the end of 2025, total renewable installed capacity reached approximately 21.9 GW, of which solar PV represented 6.8 GW. Solar capacity increased by more than 1 GW during the year, maintaining its position as the fastest-growing renewable technology in the country. Since 2016, installed PV capacity has expanded from less than 1 GW to nearly 7 GW, illustrating the structural transformation of the electricity mix.

Electricity generation from renewable sources reached around 45 TWh in 2025, corresponding to approximately 75% of gross electricity production (see Fig. 1). Solar PV alone generated about 8.7 TWh, an increase of more than 20% compared to 2024. Solar PV now accounts for roughly one sixth of total electricity generation and close to one fifth of renewable generation.

As PV penetration increases, policy focus is progressively shifting from capacity expansion to system integration. Grid reinforcement measures foreseen in the national transmission and distribution development plans are advancing, although connection capacity remains regionally constrained, particularly in high-resource areas.

Limited curtailment episodes were recorded during 2025, amounting to approximately 14 hours at transmission level. While modest in quantitative terms, these events illustrate the gradual emergence of flexibility constraints during periods of high renewable output.

The large-scale system disturbance of 28 April 2025 did not originate in photovoltaic generation but contributed to renewed reflection on operational resilience in a system increasingly dominated by inverter-based resources. Discussions during the year addressed enhanced monitoring of distributed generation, advanced inverter functionalities and coordination between transmission and distribution operators.

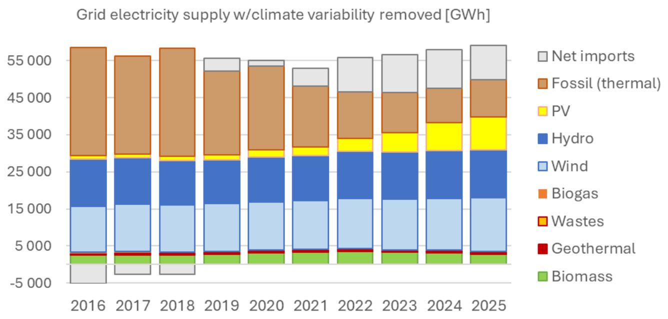

Figure 43: Centralized electricity production by technology in the last decade, removing the high variability of wind and hydro resources.

Extreme weather events also underlined the importance of installation quality and structural compliance. During early 2026, storm Kristin brought extreme winds. This caused localised damage to some installations, reinforcing the relevance of wind-load standards, inspection regimes and installer certification.

In parallel, cybersecurity considerations gained increasing prominence as PV plants —particularly large-scale and hybrid facilities— rely extensively on digital monitoring and remote-control systems. Strengthening communication protocols and digital resilience is progressively becoming embedded in system planning.

As solar deployment accelerates, social acceptance and public perception are becoming increasingly relevant factors in project implementation. In some regions, large-scale photovoltaic developments have been subject to public scrutiny regarding land use, biodiversity protection and landscape integration. While environmental assessment procedures are well established within the Portuguese regulatory framework, public debate has at times been influenced by incomplete or inaccurate information circulating through digital platforms.

In response to these challenges, the renewable sector has strengthened its engagement with scientific institutions and civil society. A relevant example is the BioImpacte+ initiative, promoted by APREN in partnership with the environmental consultant BioInsight, which aims to assess and communicate the real biodiversity impacts of renewable energy projects based on empirical evidence. By combining field research, environmental monitoring and stakeholder dialogue, such initiatives contribute to improving transparency, countering misinformation and reinforcing evidence-based policy discussion.

Ensuring that local communities perceive tangible environmental and socio-economic benefits from photovoltaic projects will be decisive for maintaining deployment momentum towards the 2030 targets.

RESEARCH, DEVELOPMENT & DEMONSTRATION

Photovoltaic research and innovation activities in Portugal continue to evolve from component-level investigation towards system integration, hybridisation and applied demonstration projects aligned with high renewable penetration scenarios. Public support is largely channelled through European programmes, notably Horizon Europe, complemented by national Recovery and Resilience Plan (PRR) funding.

A representative-applied initiative is the FruitPV project, financed under the Portuguese Recovery and Resilience Plan. The project explores agrivoltaic configurations adapted to fruit orchards, assessing agricultural productivity alongside photovoltaic performance. Led by the Centro Operativo e Tecnológico Hortofrutícola Nacional (COTHN), in partnership with the National Institute for Agricultural and Veterinary Research (INIAV), Akuo and other stakeholders, FruitPV is testing structural designs and light-management strategies to optimise dual land use. Private R&D also exists, e.g. the Portuguese LuxOEnergy company, in partnership with SBFC Hightech, is running pilot projects of shading orchards with their flexible bifacial panels. Agrivoltaics more broadly is emerging as a growing research and demonstration field, particularly in southern Portugal. Pilot projects increasingly incorporate digital monitoring systems to assess microclimatic effects, crop yield impacts and energy output optimisation.

Portuguese universities and research centres remain active across the PV value chain. Institutions such as Instituto Superior Técnico (University of Lisbon) and the University of Porto conduct research on power electronics, inverter control strategies and grid integration under high shares of inverter-based generation. Participation in Horizon Europe consortia further supports work on hybrid PV-plus-storage optimisation, digital twins for predictive maintenance, flexibility services and cybersecurity for decentralised energy systems.

The increasing operational complexity of the electricity system has strengthened research interest in dynamic modelling and stability analysis. Collaboration between academia and system operators is expanding in order to simulate high-renewable dispatch conditions and evaluate resilience under stress scenarios.

Workforce capacity is emerging as a structural pillar of the energy transition. Sustained annual additions of solar capacity require expansion of qualified personnel in installation, electrical engineering, structural compliance, SCADA operation and hybrid plant management.

Universities, polytechnic institutes and vocational training centres are progressively updating curricula to include renewable integration, smart grids and digital energy systems. Industry associations are reinforcing certification frameworks and technical training programmes to safeguard installation quality and long-term asset reliability.

For the 2026–2030 period, alignment between research institutions, training bodies and industry will be essential to ensure that technological innovation translates into scalable and resilient deployment.

Ensuring that local communities perceive tangible environmental and socio-economic benefits from photovoltaic projects will be decisive

INDUSTRY AND MARKET DEVELOPMENT

Photovoltaic deployment remained strong in 2025. Total renewable installed capacity reached approximately 22 GW, with solar accounting for 6.8 GW. Solar continues to lead annual renewable capacity additions.

Solar generation reached approximately 8.7 TWh in 2025, confirming its position as the third-largest renewable source after hydro and wind. Regional distribution remains concentrated in the south, with the Alentejo accounting for more than one third of national solar output, followed by the Centro and Norte regions.

Distributed generation continued to expand steadily. Installed decentralised PV capacity surpassed 3 GW, with self-consumption units representing the majority share. Production from decentralised systems exceeded 3.7 TWh, reflecting the increasing participation of commercial and industrial consumers alongside residential installations.

Wholesale market dynamics during 2025 were characterised by continued intraday price volatility, particularly during hours of high solar production. Long-term Power Purchase Agreements remain the principal risk mitigation instrument for utility-scale projects, while hybridisation with battery storage is increasingly incorporated into plant design to mitigate price cannibalisation and enhance dispatchability.

Portugal's photovoltaic industry remains predominantly service-oriented, with strong capabilities in project development, engineering, construction, operation and asset management. Although upstream manufacturing is limited, expertise in system integration, agrivoltaics, floating PV and digital optimisation tools is strengthening.

In the wake of less ambitious goals for renewable hydrogen by 2030, the NECP target of 20.8 GW solar capacity is probably going to be downsized in the near future. Even so, PV additions must rise to above 1.5 GW per year, which appears challenging given the current slow licensing pace and increasing social opposition. Also, grid reinforcement and digitalisation will be decisive in unlocking additional connection capacity. Battery storage deployment is expected to scale progressively to support flexibility and mitigate revenue volatility under high solar penetration scenarios. Market design evolution, including long-term contracting frameworks and flexibility remuneration mechanisms, will influence investment stability. As solar share increases, revenue structures are likely to diversify, combining merchant exposure, corporate PPAs and hybrid asset strategies.

If enabling conditions evolve coherently, solar PV is expected to become the dominant source of electricity generation in Portugal before the end of the decade, playing a central role in decarbonisation and energy security objectives.

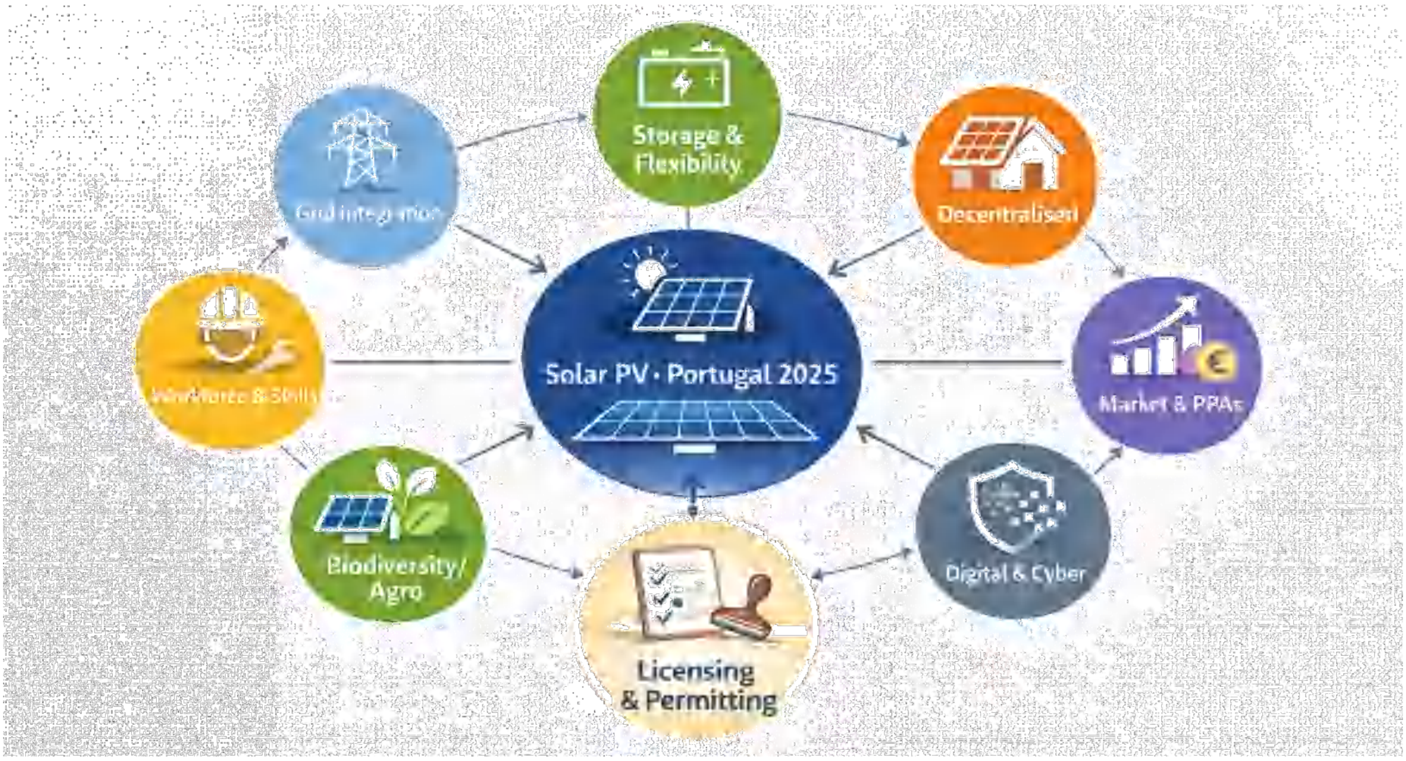

Figure 44: Environment of multiple types of initiatives related to the deployment of solar PV in Portugal.

SOLAR ENERGY RESEARCH INSTITUTE OF SINGAPORE

PHOTOVOLTAIC SECTOR STATUS 2025

Authors: Dr Thomas REINDL, SERIS, Singapore
Prof Armin ABERLE, SERIS, Singapore

Figure 45: Singapore strives to strike a balance between green and solar: this site is a test system from SERIS exploring impact of climate on energy yield.

NATIONAL CONTEXT

Singapore is a signatory to the Paris Agreement and has committed to achieving net-zero emissions by 2050. The nation's "Energy Story" outlines four supply switches - natural gas, solar PV, regional power grids and low-carbon alternatives - to transform and decarbonise the energy sector. These measures align with Singapore's broader sustainability agenda, including the SG Green Plan 2030. The nation's installed PV capacity (DC) is now at more than 1.7 gigawatt-peak and is growing steadily.

The Solar Energy Research Institute of Singapore (SERIS) supports the country's energy transition by developing and commercialising solar technologies tailored to urban, tropical environments, and by fostering industry development and wider solar adoption. A major constraint for PV deployment in the City-state is land scarcity. SERIS addresses this by researching solutions that enable multiple uses of limited space, such as building-integrated PV (BIPV), floating solar, agrivoltaics (dual use of PV and crop production), and solar canopies over existing infrastructures like car parks and flood canals.

Figure 46: Supporting NUS and Singapore to net-zero buildings: 600kWp system with high efficiency modules.

"SERIS has been a key driving force in Singapore's energy transition journey. Their efforts to facilitate innovative deployments such as vertical and floating solar, and to support the Singapore Government in deployment planning and technical assessments have been crucial in helping us achieve ambitious solar deployment targets."

Mr LOW Xin Wei, Assistant Chief Executive from the Energy Market Authority (EMA)

RESEARCH, DEVELOPMENT & DEMONSTRATION

SERIS, with its 110 research staff is active from cells to systems. Some of the highlights in 2025 were:

- The solar cell flagship project continued to advance rapidly. Our single-junction perovskite cells (1 cm^2) reached an efficiency of 26.6%, while our 2-junction perovskite-Si tandem devices improved to 33.3% (1 cm^2). The efficiencies of 16-cm^2 and 244-cm^2 2-junction perovskite-Si tandems improved to 28.2% and 24.1%, up from 25% and 20% a year earlier. These figures are among the highest reported by public research institutions for these device classes. We also converted the large tandem cells into glass-glass single-cell mini-modules, raising module efficiency to more than 21%. Together, these results strengthen our pathway to the project target of 30% efficient mini-modules with an active area of at least 150 cm^2 by March 2027. Our team also made a perovskite-organic 2-junction tandem cell (1 cm2) with 26.4% certified efficiency, which is a new world record.
- As part of the BIPV flagship project, an entire BIM (building information modelling) workflow was created for adding BIPV products to the overall BIM framework. This includes 3D modelling, PV layouts, energy yield projections and life cycle cost assessments.
- SERIS published on its findings on the global status and potential of both inland reservoirs (including water savings from reduced evaporation) and off-shore sea spaces. The paper shows that utilising merely 10% of the techno-economic areas could power the entire world today, and even a future 100% renewable energy scenario.
- NUS and SERIS implemented a 600 kWp system on one of the campus buildings to achieve net-zero energy usage by retrofitted building. In addition the project will allow the study of LCOE of high efficient modules. This system is the last addition to the 10 MW solar PV systems already deployed on campus.

INDUSTRY COLLABORATIONS

Working with and for industry is one of the key objectives of SERIS. In 2025 these projects can be specially mentioned:

- The REC@NUS Corporate Laboratory project made strong progress with establishing a new R&D pilot line at SERIS for ultra-large (up to 440 cm2, G12 wafer size) 30% perovskite-silicon tandem solar cells using an ultra-fast perovskite deposition process. This pilot line will be ready for R&D in Q1 2026. Using existing labs at SERIS, the Corporate Lab team achieved tandem cell efficiencies of about 25% for 244-cm2 devices, confirming the robustness and potential of our technology.
- SERIS signed a MoU with company Geoharbour to jointly develop novel deployment solutions for their ~20% efficient single-junction perovskite solar foils, which open fundamentally new opportunities for integration into the urban fabric (e.g. large-scale over-arching solar canopies).
- SERIS spin-off PV Doctor Pte Ltd, a PV asset performance management and smart O&M company, had a flying start and managed to sign up more than 1 GWp of 'Assets under Management' (AUM) across 1 300+ sites in 21 countries within its first year, demonstrating strong global reach and establishing itself as one of the fastest-growing digital asset-intelligence platforms in the solar industry.

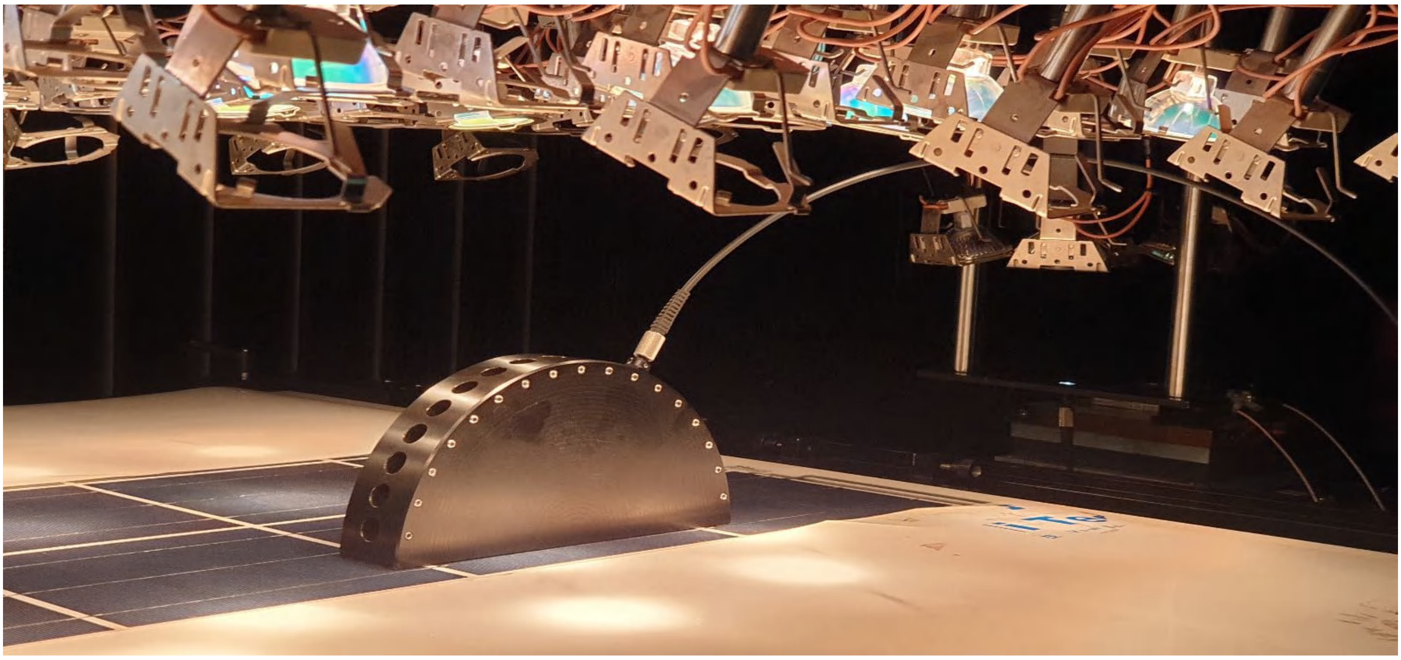

Figure 47: High accurate innovative test methods for modules are deployed in the 17025 certified indoor test facilities of SERIS.

SOLAR POWER EUROPE

PHOTOVOLTAIC SECTOR STATUS 2025

Author: Christophe Lits, SolarPower Europe, Belgium

Figure 48: Solar installers at work in Langenenslingen-Wilfingen in 2024 © EnBW Uli Deck

PV POLICY PROGRAMME

The European Union has passed several directives and regulations to shape the deployment of solar PV. The main framework is set in the European Climate Law, which requires a reduction of EU's greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. Additionally, the Renewable Energy Directive set a binding target for renewables to make up at least 42.5% of total energy consumption by 2030, with an indicative 45% ambition. According to the EU Commission estimates, the 42.5% binding RES target corresponds to an indicative benchmark of 69% of renewable electricity generation by the same year.

During the 2022 energy crisis, the EU Commission also published the REPowerEU plan to phase out Russian fossil fuels and accelerate the green transition. As part of it, the EU Solar Energy Strategy aims to reach 400 GW_{DC} of cumulative solar PV capacity by 2025 and 750 GW_{DC} by 2030 – the former target has been narrowly surpassed at the end of last year.

More specifically for rooftop solar, the Energy Performance of Buildings Directive introduced the EU Solar Standard, making solar installations progressively mandatory on new public and commercial buildings by 2026, renovated non-residential buildings by 2027, new residential buildings by 2029 and existing public buildings by 2030.

Nevertheless, over the recent years, the deployment of solar has not been limited by the demand, but by energy system framework constraints. EU grids are unable to assimilate the electricity coming during peak-production time of renewables, especially solar, leading to curtailment and a growing amount of hours with negative electricity prices, hampering the business case of solar PV.

To remedy this, the EU Commission introduced several legislative packages aiming at improving the flexibility of the EU electricity system. Among the key files, the Electricity Market Design reform requires transmission system operators (TSOs) to develop a common flexibility-needs assessment methodology. By December 2026, Member States must publish national objectives for non-fossil flexibility, covering both energy storage and demand response.

At the same time, the Grids Package removes major barriers for deploying flexible assets by streamlining permitting for storage, reforming grid connection rules through first ready first served queue management, and enabling flexible connection agreements. These measures create more predictable and efficient access to the grid for battery storage and demand response while embedding flexibility into both system planning and day-to-day operations.

Aside from supporting deployment, grid integration and flexibility, the Net-Zero Industry Act (NZIA) was passed in 2024 to strengthen Europe's clean-tech manufacturing, including solar PV. The NZIA aims to build a more resilient value chain and reduce dependence on imports for strategic clean-tech technologies, including solar components and batteries. Member States are required to introduce resilience, environmental and other non-price criteria in auctions, public procurement, and other forms of public support, starting from 2026. The legislation aims for the EU to produce at least 40% of its demand in clean-tech technologies by 2030.

RESEARCH, DEVELOPMENT & DEMONSTRATION

Solar PV is set to become the main source of electricity in Europe, supported by rapid cost declines, large deployment targets and the electrification of transport, heating and industry. Current EU work on research and development therefore focuses on ensuring that solar can be integrated securely and efficiently into the energy system, supported by digitalisation, storage, flexible grids and updated market rules. These efforts align with broader goals such as energy security, competitiveness and reduced dependence on fossil fuel imports.

European R&D also prioritises next-generation PV technologies. Key focus areas include perovskites, tandem cells, advanced silicon concepts and improved manufacturing processes. Work is ongoing to enhance stability, scalability, lifetime, and the removal of critical materials, along with the development of new inverter technologies capable of grid-forming operation, higher voltages and improved digital monitoring. These efforts support the EU ambition to strengthen its industrial base and remain competitive in a fast evolving global PV market.

Innovation is expanding PV use into new applications. Significant work is underway on building integrated PV, vehicle integrated PV, Agri-PV and floating PV, each requiring specific design, durability, and permitting solutions. Research is developing digital twins for Agri-PV, optimised floater structures for offshore systems and high-voltage architectures for industrial electrification. These activities aim to unlock new deployment areas, reduce system constraints and ensure that PV can serve diverse sectors across Europe.

Sustainability and circularity form another major priority. Europe is investing heavily in repairability and reuse, material recovery, recycling processes, and unified environmental and social life-cycle assessment methods. Improving module lifetimes, reducing the carbon footprint, expanding reuse, and ensuring reliable long-term performance are key tasks. Additional work targets better risk mitigation, predictive maintenance and improved diagnostics for residential systems. These initiatives aim to ensure that solar expansion in the EU is environmentally responsible, resource efficient and supported by EU citizens.

Flexibility is the key to further success for European solar. Without rapid deployment of battery storage, demand response, grid digitalisation and expansion, solar's value will continue to be constrained just at a time that EU businesses and citizens are craving for affordable electricity.

INDUSTRY AND MARKET DEVELOPMENT

After a decade of high expansion, the EU solar market declined slightly in 2025, installing 65.1 GW, compared to 65.6 GW in 2024, marking a 0.7% decrease. The slowdown reflects the fading impact of the energy crisis that had previously accelerated rooftop deployment. Before the recent conflict escalation in the Middle East, gas and electricity prices had remained at high levels, but the sense of urgency for households and businesses to invest in solar had diminished compared to the previous years. At present, current geopolitical developments are difficult to read, but could lead to another wave of strong interest in self-sufficiency and energy independence.

Rooftop support schemes in several key markets have been phased out, contributing to a visible decline in the distributed segment. On the utility-scale side, auctions, corporate PPAs and earlier merchant projects continue to support activity, but grid congestion, rising negative-price occurrence and policy uncertainty weigh on solar bankability.

Nevertheless, solar PV's contribution to the EU power system is growing quickly and represented 13.2% of the electricity generation in 2025, more than doubling its 2021 share of 5.7%. In June 2025, solar PV even became the first source of electricity in the EU, generating 22% of total power output during that month, according to SolarPower Europe's EU Solar Market Outlook 2025-2030.

The structure of the EU solar market shifted noticeably in 2025 as rooftop activity slowed down while utility-scale installations took the lead. The residential (0-10 kW) and C&I (11-999 kW) segments, which have traditionally been the driving force of EU installations, jointly represented only 47% of new installations in 2025. Residential solar observed the steepest decline, reflecting the phase-out of support schemes in several mature markets and the limited expansion of rooftop solar beyond early-adopter households. On the contrary, utility-scale solar became the main engine of EU installations, exceeding 50% of annual capacity for the first time. Despite increasingly tougher project economics, it remained the most resilient solar segment, supported by public auctions and PPA commitments made during the strong 2022-2024 period that are now reaching completion.

Looking further, EU solar installations are expected to continue declining in 2026 and 2027 before slightly recovering toward the end of the decade. In SolarPower Europe's most updated Medium Scenario, the EU market is expected to experience two years of further single-digit contraction, followed by a slow rebound that brings annual additions back to growth territory, though at low one-digit levels, reaching around 67 GW by 2030, recovering above 2025 installation volumes only by that year.

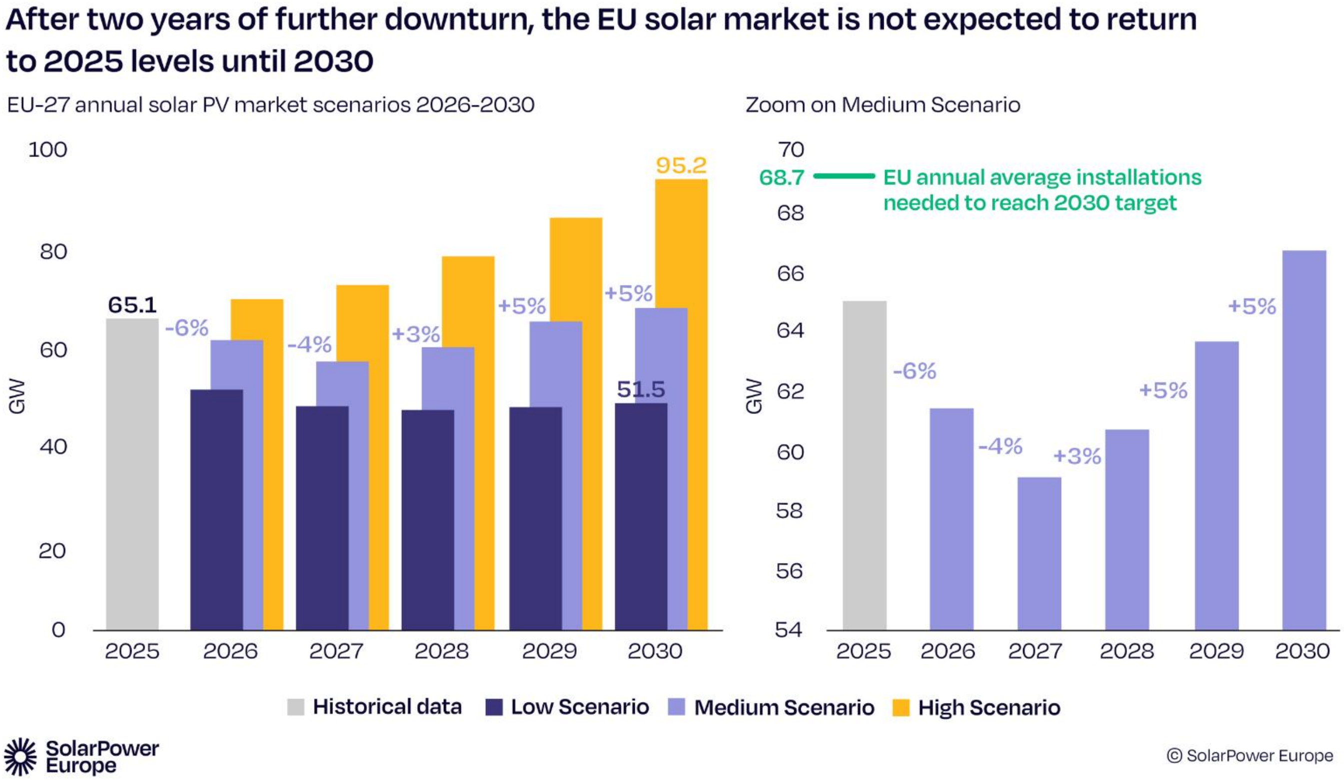

Figure 49: EU-27 annual solar PV market scenarios 2026-2030.

From a cumulative point of view, the EU solar capacity reached 407 GW at the end of 2025, slightly surpassing the EU interim solar target. Nevertheless, with the annual market size not expected to grow in the coming years, the cumulative capacity in 2030 is poised to reach 718 GW, missing the 750 GW target by about 30 GW, as per our Medium Scenario.

Flexibility is the key to further success for European solar. Without rapid deployment of battery storage, demand response, grid digitalisation and expansion, solar's value will continue to be constrained just at a time that EU businesses and citizens are craving for affordable electricity. Negative prices and curtailment are eroding business cases, and investor confidence is weakening at a moment when Europe needs more clean energy investment for its energy security and competitiveness, and urgently needs to detach itself from volatile fossil fuel imports. For this reason, the EU needs a decisive push on flexibility with a dedicated EU Flexibility Strategy that unlocks the enormous potential of battery storage and demand-side flexibility.

SOUTH AFRICA

PHOTOVOLTAIC SECTOR STATUS 2025

Author: Dr Karen Surridge, Manager Renewable Energy, South African National Energy Development Institute (SANEDI)

Figure 50: Photo taken by Dr Karen Surridge, SANEDI.

PV POLICY PROGRAMME

South Africa's photovoltaic (PV) deployment is guided by national electricity planning and renewable energy procurement policies. Central policy instruments include the Integrated Resource Plan (IRP 2025), which outlines the country's long-term electricity capacity expansion pathway, and the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). The IRP establishes targets for renewable energy capacity in the national generation mix, while the REIPPPP provides the procurement mechanism through which privately developed renewable energy projects are competitively selected and contracted. Together, these frameworks support the diversification of South Africa's historically coal-dominated electricity sector and aim to improve energy security while reducing greenhouse gas emissions.

The REIPPPP, launched in 2011, is South Africa's flagship renewable energy procurement programme and has been internationally recognised as one of the most successful renewable procurement programmes in emerging economies. Through a series of competitive bidding rounds ("Bid Windows"), independent power producers develop utility-scale solar PV and other renewable energy projects, which sell electricity to the national grid under long-term power purchase agreements (PPAs). The programme has enabled substantial private sector investment and contributed significantly to the deployment of utility-scale solar PV capacity in South Africa.

In addition to utility-scale deployment, recent regulatory reforms have facilitated the growth of distributed generation and rooftop PV systems. These include the removal of licensing requirements for embedded generation projects below certain capacity thresholds and fiscal incentives such as temporary tax rebates for residential rooftop solar installations. The government has also introduced initiatives aimed at strengthening grid infrastructure and enabling greater integration of renewable energy into the national power system.

Public perception of solar PV in South Africa has become increasingly positive, largely driven by persistent electricity supply shortages and recurring load-shedding events. As a result, households, commercial entities, and industrial consumers have increasingly adopted rooftop PV systems to improve energy security and reduce reliance on the national grid. This rapid growth in distributed generation has been complemented by ongoing investments in utility-scale solar PV projects under the REIPPPP. Consequently, in recent years South Africa has emerged as one of the largest solar PV markets on the African continent.

The future outlook for solar PV in South Africa remains strong, supported by continued policy commitment to renewable energy expansion, evolving regulatory frameworks for distributed generation and increasing private sector participation in the electricity market. Planned updates to the IRP are expected to further expand the role of solar PV in the national energy mix, while complementary investments in transmission infrastructure and energy storage will be essential to support higher levels of renewable penetration. Overall, solar PV is expected to play a central role in South Africa's transition toward a more resilient, diversified, and lower-carbon electricity system.

RESEARCH, DEVELOPMENT & DEMONSTRATION

South Africa's renewable energy R,D&D agenda is aligned with national energy transition goals and guided by strategic frameworks such as the Science, Technology and Innovation (STI) energy programmes. These initiatives aim to support the development, localisation and deployment of solar and other renewable technologies while reducing dependence on fossil fuels. In addition, the national R,D&D agenda is closely linked to broader energy system transformation goals outlined in the IRP, recognising the role of innovation in enabling transition to a diversified and low-carbon electricity system.

Several national programmes support renewable energy innovation, typically coordinated by the Department of Science, Technology and Innovation (DSTI), the South African National Energy Development Institute (SANEDI), Universities and Science Councils. Key initiatives include the Renewable Sustainable Energy (RSE) Hub and Spokes programme promoting collaboration between universities and research institutions to advance renewable energy technologies and commercialisation of publicly funded intellectual property. Applied research initiatives also address system-level challenges associated with increasing renewable penetration. Projects supported by SANEDI and academic partners are investigating advanced grid planning tools, hosting capacity limits and operational strategies for integrating distributed energy resources such as rooftop PV, electric vehicles and battery storage into municipal distribution networks. In parallel, research collaborations between universities and SANEDI are exploring renewable energy integration with emerging technologies such as green hydrogen production, including the use of solar-generated electricity to power electrolyser systems.

Recent research efforts have focused on improving technical performance and economic competitiveness of solar technologies and enabling large-scale integration of renewable energy into the national electricity system. Key highlights include modelling studies on renewable energy system planning and grid integration, experimental studies on PV module performance under local climatic conditions, and analysis of solar PV and battery storage value chains to identify opportunities for industrial development and localisation within South Africa's renewable energy sector.

South Africa's renewable energy R,D&D strategy prioritises several key areas, including:

- Grid integration and system flexibility
- Localisation and industrial development of solar PV and energy storage value chains
- Hybrid energy systems viz. sector coupling between electricity, transport, and industrial applications
- Distributed energy systems, such as microgrids and municipal-scale energy management solutions.
- Advanced modelling and energy system planning, to support long-term decarbonisation pathways and infrastructure development.

Persistent electricity instability has accelerated solar PV adoption in South Africa, driving rapid growth in both utility-scale and rooftop solar installations. As a result, South Africa is the largest solar photovoltaic (PV) market in Africa, with more than 10 GW of installed capacity and rapidly expanding deployment across both utility-scale and distributed generation sectors.

INDUSTRY AND MARKET DEVELOPMENT

South Africa has the largest solar photovoltaic (PV) market in Africa, with rapid expansion over the past decade driven by supportive policy frameworks, declining technology costs and persistent electricity supply constraints. Utility-scale PV deployment has been largely enabled through the REIPPPP, which has attracted significant international and domestic investment in solar projects. In parallel, a growing ecosystem of local installers, engineering firms, and service providers has emerged to support the increasing demand for distributed and rooftop PV systems.

Solar PV is playing an increasingly important role in South Africa's electricity system as the country seeks to diversify its historically coal-dominated generation mix. Utility-scale solar plants contribute to grid-connected renewable generation, while distributed PV systems support energy resilience for households and businesses. National energy planning frameworks anticipate a continued increase in solar PV capacity as part of the country's long-term energy transition. The PV market is characterised by strong growth across both utility-scale and distributed generation segments. Large-scale projects continue to be procured through national programmes and private power purchase agreements, while the commercial and industrial sector has become a key driver of market expansion. Residential rooftop PV adoption has also increased significantly in response to electricity supply instability and rising energy costs.

Photovoltaic–thermal (PVT) technologies that simultaneously generate electricity and heat from a single solar collector, present significant potential for deployment in South Africa due to the country's high solar resource, strong demand for both electricity and thermal energy and growing interest in integrated energy solutions. Compared with many international markets, South Africa has seen relatively strong uptake and interest in PVT, particularly in applications where electricity generation can be combined with water heating or low-temperature process heat. The technology is particularly relevant for residential, commercial and industrial sectors where energy costs and supply constraints have encouraged the adoption of distributed renewable systems. PVT systems can improve overall solar energy utilisation by increasing total energy yield per unit of collector area, this is advantageous in urban environments with limited rooftop space. In addition, the ability to provide both electrical and thermal energy aligns well with national energy efficiency and decarbonisation objectives.

Figure 51: Photo taken by David Volkwyn, Greenline Africa Windtown Langebaan PV-T installation + HP + Tanks. System operating since mid-December 2021; picture taken at 2:30 PM on 25/01/2022, 20 PVT system is generating 69°C and 2000L tank is heated up to 60°C using 20 PVTs.

The outlook for South Africa's PV sector remains positive, supported by continued renewable energy procurement, private sector investment, and growing demand for reliable electricity supply. Future market expansion will depend on improvements in grid infrastructure, regulatory clarity, and the integration of storage technologies to accommodate increasing levels of solar generation.

SPAIN

PHOTOVOLTAIC SECTOR STATUS 2025

Authors: Eugenia Zugasti, National Renewable Energy Centre of Spain (CENER), Spain
Jaione Bengoechea, National Renewable Energy Centre of Spain (CENER), Spain

Figure 52:Aerial electroluminescence inspections. CELSOS powered by CENER.

PV POLICY PROGRAMME

Spain's Strategic Energy and Climate Framework outlines its pathway to achieving climate neutrality. The framework consists of four core initiatives, several of which received updates in 2025:

Integrated National Energy and Climate Plan 2023-2030 (INECP). One of the most significant aspects of the updated 2024 plan is the pivotal role of photovoltaic technology in Spain's energy transition. The strategy targets 76 GW of installed solar photovoltaic capacity including 19 GW of self-consumption capacity by 2030—double the original goal of 39 GW—alongside robust growth in energy storage, reaching 22.5 GW;

Long-Term Decarbonisation Strategy 2050. This strategy is currently under review to align with the new targets and requirements outlined in the INECP. The Spanish Government launched a public consultation at the end of 2024, which concluded in January 2025, yet unpublished;

Law 7/2021, of 20 May, on Climate Change and Energy Transition;

Just Transition Strategy & National Strategy against Energy Poverty. A prior public consultation on the Just Transition Strategy 2026-2030 was launched on 1 December 2025 with the primary goal to capitalize on economic and employment opportunities from the shift to a low-emission economy, while mitigating the impact on workers and vulnerable regions.

Other relevant initiatives that also form part of the Energy Transition Strategy include the following and have been update in 2025:

The Self-consumption Roadmap: the Government introduced a Royal Decree to modernize the regulatory framework for self-consumption. The updated National Integrated Energy and Climate Plan (2023–2030) raises the ambition for Spain's energy transition, projecting 19 GW of self-consumption capacity by 2030.

The Ministry for the Ecological Transition and the Demographic Challenge (MITECO) unveiled the **2025-2029 Mineral Raw Materials Action Plan**, emphasizing recycling, sustainability, and strategic autonomy. The draft, released for public consultation in March 2025, marks the first action plan under the Roadmap for Sustainable Management of Raw Materials for the 2025–2029 period.

Planning of the Electricity Transmission Network 2021-2026: In July 2025, a second round of modifications to the Electricity Transmission Network 2021–2026 Development Plan was approved, further enhancing the resilience of Spain's electricity grid. This update represents the second amendment to the plan, following the initial revision in 2024. The new amendment introduced 65 targeted actions designed to strengthen the grid's infrastructure.

Following the major blackout on 28 April 2025, Spain introduced new decrees and regulations addressing photovoltaic energy and electricity market reforms.

The Spanish Government enacted Royal Decree Law 7/2025 of 24 June 2025, introducing urgent measures to enhance the resilience and flexibility of Spain's electricity system and modernize the regulatory framework in response to energy sector challenges. However, this decree was later repealed by Parliament. In response, the Government issued Royal Decree 997/2025, of 5 November, introducing urgent measures to reinforce the electricity system. This decree includes provisions to streamline the approval process for hybrid storage systems linked to existing or planned generation facilities. The update and implementation of the new Operating Procedure (OP) 7.4, approved on 12 June 2025, will bring stability to the system by allowing renewable plants, such as wind and photovoltaic plants, to actively contribute to voltage control, which is crucial for the stability of the electricity system.

Finally, Royal Decree 917/2025, of 15 October, amending Royal Decree 413/2014, of 6 June, regulating the production of electricity from renewable energy sources, cogeneration and waste. The new measures ensure regulated profitability for power plants operating in markets with zero or negative prices, while also enhancing supply security by improving the System Operator's oversight and control. Additionally, the decree promotes the integration of energy storage and strengthens the sustainability of waste treatment.

While renewables were cleared of responsibility for the April 2025 blackout, the implementation of OP 7.4 will enable wind and photovoltaic plants to proactively secure the system through active voltage management.

RESEARCH, DEVELOPMENT & DEMONSTRATION

Spain's Ministry of Science, Innovation, and Universities oversees national policy on scientific research, technological development, and innovation, including the energy sector. This policy framework is guided by two key documents: The Spanish Science, Technology, and Innovation Strategy 2021–2027 (EECTI) and the State Plan for Scientific and Technical Research and Innovation 2024–2027 (PEICTI), launched in 2024 as the second phase of the previous plan (2021–2023), aimed at implementing the EECTI and achieving its goals. The Strategy focuses on addressing the challenges of Spain's strategic sectors, prioritizing areas critical for knowledge transfer and R&D&I in the business sector, such as: Health; Culture, creativity, and inclusive society; Security for society; Digital world; industry space, and defense; Climate, energy, and mobility; Food, bioeconomy, natural resources, and environment. For 2025, the budget allocated for grants and aids exceeds 4 billion euros. The Annual Action Programme details the funding distribution for each initiative under the PEICTI, with 1.4 billion euros specifically designated for projects related to energy.

In 2025 the PERTE ERHA (Strategic Project for the Recovery and Economic Transformation of Renewable Energy, Renewable Hydrogen, and Energy Storage) allocated a budget related to the energy transition of around 6.7 billion. Some of the main initiatives are summarized in the following paragraphs:

MITECO has allocated 35.6 million in NextGenEU funds to support the creation of 27 new energy communities across the country. This initiative was later expanded to support the creation of 106 new energy communities across Spain with an additional 10.7 million in grants.

First RENOINN call for innovative renewable energy projects with storage was launched and after a competitive evaluation process, 199 pioneering projects were selected and awarded 148.5 million. Spanning sectors from agriculture to urban infrastructure, they will add nearly 300 MW of renewable capacity and over 350 MWh of storage, fostering innovative renewable energy integration nationwide.

The Ecological Transition Ministry allocated 148 million to 199 pioneering projects featuring agrivoltaic systems with storage, renewables in infrastructure, and heat pumps. Nearly 300 million were Granted through the RENOVAL program to strengthen the domestic renewable energy supply chain. These funds support projects dedicated to manufacturing renewable technology equipment and storage components within Spain. These grants aim to bolster Spain's industrial and technological development in the green energy sector. Moreover, recent funding cycles have secured significant advancements across the sector.

Under the Public-Private Collaboration call, awards were granted to two material recycling initiatives and a project focused on organic PV modules for greenhouses. Simultaneously, the Knowledge Generation call funded several projects spanning the solar value chain—from nanostructures and materials to data-driven hybridization. Furthermore, Spanish partners successfully secured Horizon Europe (HEurope) funding for projects targeting Energy Communities, Solar Urban e-Mobility, and Resource Efficiency.

INDUSTRY AND MARKET DEVELOPMENT

Over the past few decades, Spain's photovoltaic industry has expanded significantly, establishing a strong presence across nearly the entire value chain. While the country lacks domestic production of silicon feedstock, ingots, wafers, and cells, it excels in manufacturing power electronics, structures, and solar trackers. The ecosystem is supported by a robust network of companies specializing in project development, including engineering, procurement, distribution, and construction, as well as in PV operations, such as operation and maintenance (O&M) and asset management. In the module sector, both, established firms and new entrants, are active in production with some agents focused on Building Integrated Photovoltaics (BIPV) or Agrivoltaics (APV), and complemented by specialized providers of module manufacturing equipment.

As of 2025, Spain's installed photovoltaic (PV) capacity reached 11 426 MW, comprising 10 059 MW from utility-scale projects, 1 301 MW from distributed PV, and 66 MW from off-grid installations *(note: figures are preliminary and subject to revision as the year progresses)*. This represents a sound increase in utility deployment compared to 2024, when 7 815 MW were deployed plus a stable pace for distributed where1 387 MW of distributed PV were added. Nevertheless, it needs to be highlighted that this rate falls short to reach the objective of 19 GW for 2030.

Cumulatively, Spain now boasts 59 962 MW of installed PV capacity, including 48 831 MW from utility-scale, 10 946 MW from distributed systems, and 185 MW from off-grid projects, in comparison to 48 667 MW last year. As a final remark, photovoltaic projects including battery storage have become the new standard for the utility scale sector, with 4 hours of storage being the most popular configuration.

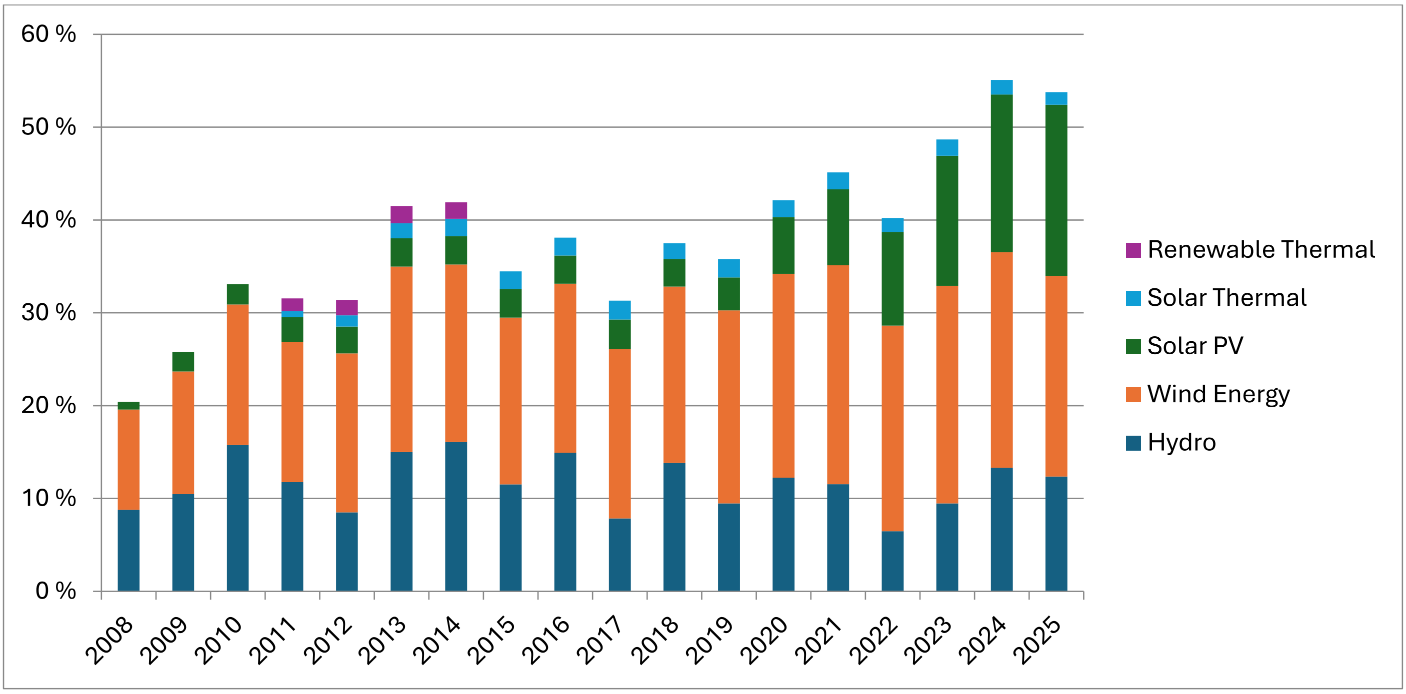

Figure 53: Percentage of demand coverage from renewable energies in Spain since 2008

From a generation perspective, 2025 was a record-breaking year as renewables accounted for almost 54% of Spain's national mix, with solar PV alone covering more than 18% of total energy demand. Economically, the year saw an average electricity price of €65.5/MWh, and notably, again, no new auctions for PV generation were conducted.

SWEDEN

PHOTOVOLTAIC SECTOR STATUS 2025

Author: Jonas Pettersson, Swedish Energy Agency, Sweden

Figure 54: Agrivoltaic system with bifacial photovoltaic modules installed at Kärrbo Prästgård, Västerås, Sweden (Source: SOLVE).

PV POLICY PROGRAMME

Swedish energy policy aims to combine security of supply, competitiveness and ecological sustainability. It is based on the legislation established within the EU.

The Swedish power system is divided into four bidding areas (SE1–SE4) by the Swedish National Transmission System Operator, Svenska Kraftnät. The aim with this division is to address electricity supply-demand imbalance:

The bidding areas are intended to pinpoint bottlenecks and regions in Sweden where grid expansion is necessary and where increased electricity generation can alleviate consumption demands, thus reducing the need for long-distance electricity transmission.

Sweden and Norway have a common technology-neutral market-based support system for renewable electricity production called "the electricity certificate system". The scheme has been an important driving force for the deployment of renewable energy. The 2030 goal within the scheme of 46.4 TWh new renewable electricity generation was reached already in 2021. The scheme has been closed for new applications since the end of 2021.

A tax deduction for individuals installing PV, batteries or charging points for electric vehicles has been in place since 2021. Through this incentive, a 15% deduction (reduced from 20% on July 1st, 2025) for labour and material costs associated with PV installations can be applied. The tax deduction has a cap of 50 000 SEK per person and year. For batteries, purposed for storing own electricity production, as well as for charging equipment for electrical vehicles, the deduction is 50%.

In 2015 a tax credit scheme for small-scale renewable electricity generation injected to the grid was introduced. The scheme entitled the owner of a PV system, having a main fuse ≤ 100 A, to a feed-in premium in form of a tax credit of 0.6 SEK per kWh of electricity fed into the grid. You couldn't, however, receive credit for more kWh than the amount of electricity you consumed from the grid in a year. There was a cap on the tax credit of 30 000 kWh/18 000 SEK per year. As of January 1st, 2026, the tax credit has expired.

A PV electricity producer that owns one or more PV systems whose total installed power amounts to less than 500 kWp does not have to pay any energy tax for the electricity consumed on the same premises as where the PV systems are installed.

Currently, there is no well-defined implementation of energy communities in Sweden, nor a clear definition that fosters widespread adoption in society. However, amendments to the Swedish Electricity Act, effective 1 January 2023, have clarified and expanded the right to operate internal electricity networks without a grid concession. Property owners and groups of neighbours can now share electricity within a defined area —provided the network is not open to the public and remains internal to a single property or delimited site.

RESEARCH, DEVELOPMENT & DEMONSTRATION

Research, development, and demonstration is supported through several national research funding agencies, universities, and private institutions in Sweden. Among the national research funding agencies, the Swedish Energy Agency (SEA) is specifically responsible for the national research related to energy and is the largest funding source for research and innovation projects within PV. In 2024 the Swedish Energy Agency distributed approximatively 42m SEK to PV-related research.

Starting in 2022, the main program of SEA for the funding of projects related to the electricity system is Future Power Systems (Framtidens Elsystem). This is a broad research and innovation program covering topics ranging from electricity production and the electricity grid to research related to electricity use. The current program period is from 2022 to 2029, and the budget is 1 327m SEK. International projects are funded within the EU-collaboration CETPartnership.

Figure 55: A squirrel climbing on an off-grid PV panel (Source: Johan Lindahl).

The Swedish Energy Agency also funds the centre of excellence, Solar Electricity Research Centre, Sweden (SOLVE). This is a strategic partnership between research institutions and stakeholders within the private and public sectors. The activities in SOLVE are funded in equal parts by the academic partners, the public/private sector partners and the Swedish Energy Agency. The total budget of SOLVE is more than 100m SEK over five years (2022 – 2026).

Some other organisations funding PV research are The Swedish Research Council (Vetenskapsrådet), The Swedish Governmental Agency for Innovation Systems (Vinnova), and The Swedish Foundation for Strategic Research (SSF).

Swedish solar cell related research is diverse and consists of fundamental research into new types of solar cells and photovoltaic materials as well as research on system performance, sustainability, and the integration of PV with storage and the power system. An overview of then active research groups was included in the National Survey Report-of PV Power Applications in Sweden 2021.

INDUSTRY AND MARKET DEVELOPMENT

There are no official national targets for PV in Sweden, but the industry has set a goal of reaching an annually generated solar electricity production of 30 TWh by 2030 and 45 TWh by 2045.

In 2024, Sweden installed 848 MW of new PV capacity, bringing total installed capacity to around 4.8 GW (see National Survey Report of PV Power Applications in Sweden 2024). Thus, the market contracted by almost half compared to the previous year. It is worth to note that 2023 was an exceptionally strong year with installations driven largely by high electricity prices. Despite the decline, 2024 still stands as the second-best year on record for Swedish PV deployment.

The PV development in Sweden is primarily distributed, constituting about 92% of the cumulative installations. Electricity from PV in 2024 amounted to 4.1 TWh corresponding to 2.4% of the total net electricity generation.

Battery energy system storage (BESS) has become an increasingly important component of the Swedish PV market. The Swedish solar association has estimated that the cumulative installation of batteries was approximately 1.0 GW at the end of 2024. The combination of PV and batteries is driven by the tax reduction for green technology, opportunities to increase self-consumption, and the possibility of participating in grid service markets.

In 2025, a 100 MWp PV park was commissioned in Hultsfred, in the south of Sweden, making this the country´s largest solar park by far.

Utility-scale solar is still evolving in Sweden and the main business model is corporate PPAs. Sweden is seeing the emergence of a new generation of large solar parks, with projects well above 20 MW and several exceeding 100 MW now under development. Permitting delays and grid connection bottlenecks do however remain challenges for ground-mounted PV parks, especially in areas with high connection demand or limited capacity. In 2025, a 100 MWp PV park was commissioned in Hultsfred, in the south of Sweden, making this the country´s largest solar park by far.

Also in 2025, the association of large-scale solar developers (the Network for Solar Parks) merged with the Swedish Wind Energy Association to form Green Power Sweden.

The Swedish PV industry mainly consists of small to medium size installers and retailers of PV modules or systems. The downstream industry of installers and retailers in Sweden has grown for several years. Thera are two active, though relatively small, module manufacturing companies, Midsummer and Swemodule, and in recent years new initiatives in polysilicon and silicon module production have emerged. There are also companies manufacturing production machines or balance of systems components as well as some R&D companies.

SWITZERLAND

PHOTOVOLTAIC SECTOR STATUS 2025

Author: Stefan Oberholzer, Swiss Federal Office of Energy

Figure 56: *«Madrisa Solar», Switzerland's first alpine large-scale photovoltaic plant located at around 2 000 m above Klosters, began feeding electricity into the grid in 2025 as part of the national «Solarexpress» (EKZ / Repower, 2025). Currently, about 15% of the installation is connected. Once fully built, the project will comprise approximately 20 000 bifacial modules of 580 Wp each, corresponding to an installed DC capacity of around 11 MWp. By 2027, the plant is expected to produce around 17 GWh annually, over 40% of it in winter, thus contributing to Swiss winter electricity supply. The total investment amounts to approximately 70 million Swiss francs (Photo: Madrisa Solar AG).*

PV POLICY PROGRAMME

During 2025, the staged implementation of the new Federal Electricity Supply Act shaped national PV policy. The first part of the ordinances entered into force on 1 January 2025, introducing a more flexible regulatory framework that expands possibilities for self-consumption. This includes the use of low-voltage grid infrastructure at the grid connection point and the option to form virtual metering arrangements based on the smart metering systems operated by distribution grid operators. The objective is to reduce administrative complexity, broaden access to self-consumption and create more uniform and predictable conditions for PV deployment.

Stakeholders noted that the transition toward the new regulatory framework brought temporary uncertainties, particularly regarding remuneration rules, metering concepts and evolving administrative procedures. As the new legal instruments began to take effect, grid operators and project developers had to adapt internal processes and customer interfaces, resulting in a period of adjustment throughout 2025.

According to the Federal Act on a Secure Electricity Supply from Renewable Energy Sources, interim targets for the expansion of renewable electricity production must be defined every five years to ensure progress toward the legally binding expansion targets (35 TWh by 2035 and 45 TWh by 2050, excluding hydropower). With the amendment of the relevant ordinance on 1 January 2026, these interim targets were defined for the first time. By 2030, renewable electricity production is to reach 23 TWh, of which 18.7 TWh are expected from solar photovoltaics and 2.3 TWh from wind power. These targets are demanding, as doubling today's PV production of just over 8 TWh must be achieved within four years.

Several policy elements scheduled to take effect on 1 January 2026 already influenced planning practices in 2025. These include the introduction of the *Winterstrombonus* (winter electricity bonus) under the revised Energy Promotion Ordinance (EnFV), which supports PV systems with high winter output. It replaces the previous *Solarexpress* and provides targeted support for systems above 100 kW that achieve high specific winter yields. While the earlier scheme applied a fixed threshold of 500 kWh/kW and allowed investment contributions of up to 60%, the new *Winterstrombonus* is a variable, performance-based incentive calculated on the specific winter yield above the 500 kWh/kW reference value. As it modifies existing investment contribution and market premium mechanisms rather than introducing a separate subsidy level, overall support is less generous and more differentiated than under the *Solarexpress*.

The Local Electricity Communities (LEG) framework will also enter into force in 2026. It will enable local trading of PV electricity within the same grid level and municipality, applying reduced tariffs for locally consumed electricity and thereby supporting more decentralised cooperation models.

A further regulatory innovation concerns the introduction of dynamic grid usage tariffs from 2026 onward. Network charges will vary over time, being lower during periods of high electricity availability and higher during grid congestion. This is intended to create incentives for consumption patterns that better align with system conditions. An overview of the tariff models is available at: https://smartgridready.ch/news/neu-alle-dynamischen-tarife-im-ueberblick.

Overall, 2025 marks a year of regulatory transition and market adjustment. The combination of the new Electricity Act, the forthcoming 2026 instruments and ongoing discussions on future electricity cooperation with the EU provides the strategic framework for PV deployment in the coming years.

RESEARCH, DEVELOPMENT & DEMONSTRATION

According to Swiss energy research statistics, CHF 40.94 million in public funds were allocated to photovoltaics research in 2024. This amount represents 10.6% of total public expenditure on energy research in Switzerland and 43.9% of all public funding directed toward renewable energy sources. Data for 2025 have not yet been released.

The chart below provides an overview, as of 27 February 2025, of the number of projects and the associated financial commitments, disaggregated by subject area (source: https://pv.energyresearch.ch). A total of 97 research and demonstration projects are currently underway. Compared to 2024 (last year's report), the share of public funding allocated to solar cell research has decreased slightly, from 57.9 percent in 2024 to 46.4 percent in 2025.

According to official statistics for 2024, 39 per cent of photovoltaic projects—measured by the volume of public funding—received support through European cooperation. Funding provided via the Swiss Federal Office of Energy's PV programme accounts for a little over 9 per cent, but will decline in future due to the discontinuation of the pilot and demonstration funding line (see below). In 2025, some 20 per cent of the SFOE's available funds for PV research were allocated directly to IEA PVPS Task projects, complemented by numerous SFOE-funded and other national and European projects that contribute to the various research topics within IEA PVPS.

The government's proposed measures (Relief Package 27) to achieve a balanced federal budget in the coming years — currently under discussion in Parliament — include broad austerity steps that also affect federal support for research. Energy research funding is among the areas concerned, with the funding line for pilot and demonstration projects at the Swiss Federal Office of Energy being discontinued. These developments are expected to have a corresponding impact on national photovoltaic research.

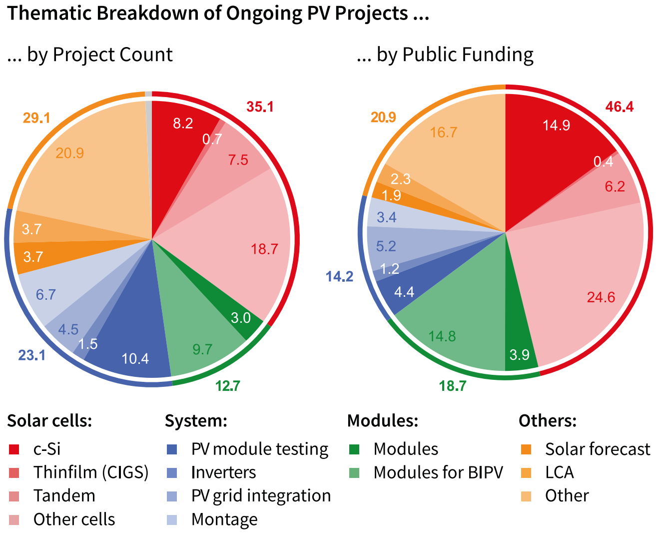

Figure 57: Thematic breakdown of ongoing PV research projects in Switzerland by project count and funding (as of 27 February 2026).

INDUSTRY AND MARKET DEVELOPMENT

According to Swissolar, the national solar association, the industry has entered a phase of consolidation after several years of rapid expansion. Following another record year in 2024 with 1.8 GW of newly installed capacity, a slight decline to around 1.5 GW of newly installed capacity is expected for 2025 (Swiss Solar Monitor).

Despite this slowdown, expansion remains at a high level and must continue in order to achieve the ambitious targets for 2030. By the end of 2025, solar energy is projected to cover around 14 per cent of final electricity consumption. With an annual production of more than 8 TWh, it has become systemically relevant, and its contribution continues to increase. Current assessments underline the scale of the required expansion: according to Swissolar, annual additions on the order of around 2 GW and increasingly more towards the end of the decade will be necessary to reach the 18.7 TWh PV production target for 2030. Sustained high installation rates are essential to remain on track for the 2030 and 2035 milestones.

The market structure continues to be shaped overwhelmingly by rooftop PV systems. Small and medium-sized installations account for the largest share of cumulative capacity, and larger commercial rooftop systems also represent a significant proportion of the market. Other application types such as façade systems, infrastructure-integrated PV, alpine installations or Agri-PV currently contribute only marginally to total installed capacity.

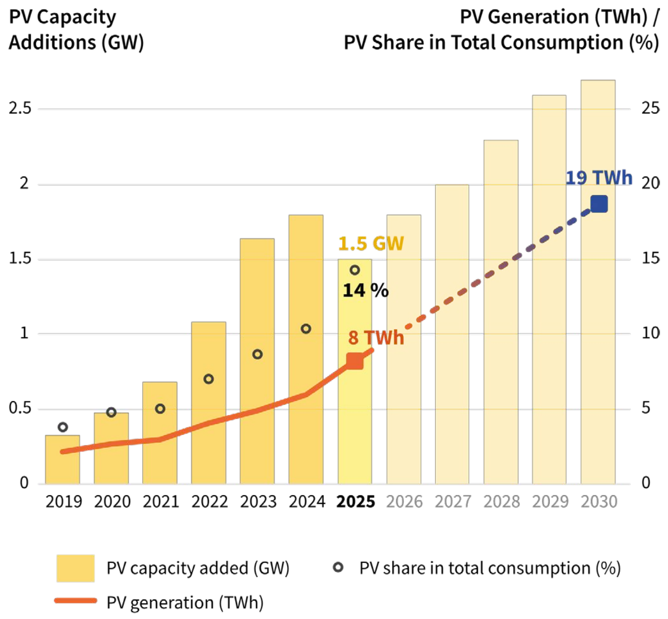

Figure 58: Photovoltaics capacity additions and generation in Switzerland. With 8 TWh and a 14% share in total consumption by the end of 2025, PV is systemically relevant to Switzerland's energy supply. (Data source: SFOE/Swissolar). With a new ordinance valid from 2026, an interim target of 18.7 TWh has been defined for PV expansion by 2030.

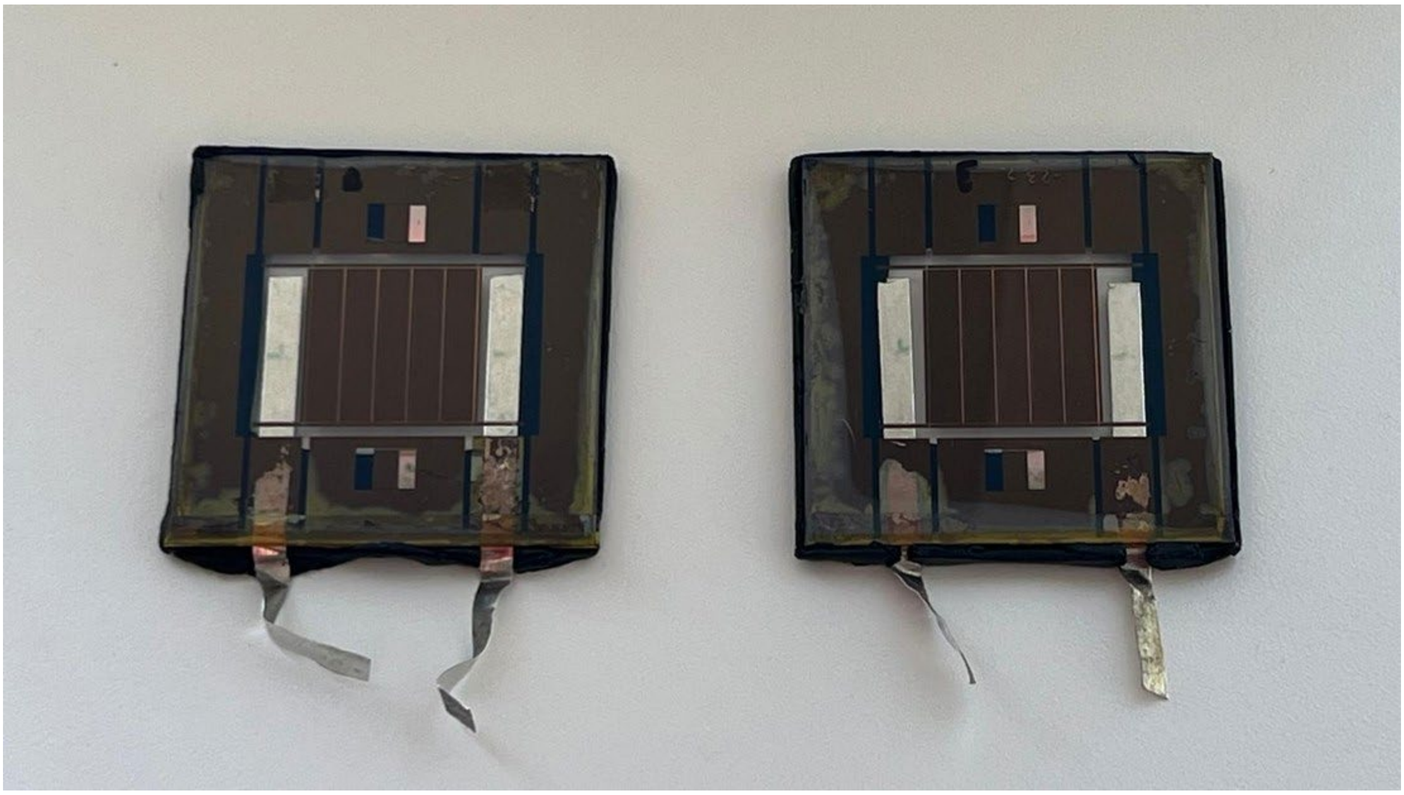

*Figure 59: **R&D-highlight 2025: Perovskite solar cells Research at EPFL Neuchâtel:** High-throughput, standardised testing platforms are becoming increasingly important for accelerating progress in perovskite materials, a field characterised by a vast compositional space and extreme sensitivity to small variations in formulation or processing. At EPFL/CSEM in Neuchâtel, automated tools are being deployed to achieve reproducible ink formulations and parallelised, controlled ageing of thin-film samples. These systems make it possible to evaluate large numbers of perovskite samples under precisely defined thermal and lighting conditions—up to 110 °C and 2.2 suns—while continuously monitoring their optical response, thereby removing key bottlenecks such as variability, limited throughput, and inconsistent stability data. By enabling systematic investigations and comparable, high-quality measurements across many different material combinations, this type of automation provides the solid foundation needed to unlock the full potential of next-generation perovskite technologies. Just very recently, these approaches have led to internationally verified and recognised stability records for perovskite solar cells of various sizes and configurations, including stability records for small and larger devices at elevated temperatures, under continuous illumination and under various ageing conditions (More info and photo source: https://www.epfl.ch/labs/pvlab/).*

THAILAND

PHOTOVOLTAIC SECTOR STATUS 2025

Author: Department of Alternative Energy Development and Efficiency, Ministry of Energy of Thailand

Figure 60: 24 MW EGAT's Hydro-Floating Solar Hybrid located in Khon Kaen province, Thailand.

PV POLICY PROGRAMME

Thailand continues to promote solar PV as a key pillar of its energy transition, aligned with decarbonization goals and energy security objectives to become net zero GHG emission by 2050. The overarching framework is guided by the National Energy Plan (NEP) along with the Power Development Plan (PDP) and the Alternative Energy Development Plan (AEDP), which targets a significant increase in renewable energy capacity, with solar PV playing a central role.

According to the draft AEDP 2024, which set the target of 37% share of renewable energy in total final energy consumption by 2037, the target of solar power installation capacity was set to achieve 38 974 MWp and floating solar target hybrid with hydro power plant was at 2 789 MWp.

As of 2024, Thailand's cumulative installed PV capacity reached 9 942 MWp, which was consisted of 6 334 MWp solar ground-mounted, 3 310 MWp solar rooftop, 281 MWp floating solar, and 17 MW off-grid solar systems. In cases where electricity can be sold back to the grid under utility PPA, the figure includes all projects that are commercially supplying electricity to the grid, projects with PPA signed, and projects notified of power purchase acceptance.

As of 2024, Thailand's cumulative installed PV capacity reached 9 943 MWp

Key policy instruments included Feed-in Tariff Scheme - for solar ground-mounted, solar ground-mounted with BESS, and residential sector -, the Utility Green Tariff (UGT) program, a solar rooftop tax deduction program development for residential sector, regulatory simplification and processes streamlining, and exploration of emerging trends including utility third party access, and integration of BESS in all levels.

RESEARCH, DEVELOPMENT & DEMONSTRATION

Thailand continued to strengthen applied research and pilot deployment to support higher PV penetration and innovative technologies. For example, the National Science and Technology Development Agency (NSTDA) in collaboration with Kaneka Corporation, Japan, demonstrated the experiment of the "Building-Integrated Photovoltaic (BIPV) to evaluate energy performance, thermal impacts, and economic feasibility under tropical conditions, with the aim of developing localized design standards.

Figure 61: BIPV Demonstration at NSTDA.

Moreover, NSTDA also developed the **SolarSure platform**, a data management and quality screening system for solar PV modules which serves as a tool to enable the safe and appropriate reuse of previously used solar panels that still maintain high performance

Many organizations were also interesting in implementing demonstration projects in integrating solar PV with agricultural area (Agrivoltaic) to explore the possibility of advancing Thailand agricultural-intensive perspective with solar PV, to develop scalable models for dual land use, and to improve social acceptance of solar deployment

INDUSTRY AND MARKET DEVELOPMENT

Thailand's PV industry and market continued its expansion in 2024, driven by policy support, raising awareness of self-consumption and energy saving, increasing manufacturing capacity and export demand.

In 2024, there were 15 PV cell and module manufacturers in Thailand, (up from 10 in 2023), with machine production capacity of up to 10 GW/year. Moreover, 7 inverter manufacturers and 3 Li-ion battery manufacturers were presented in Thailand.

As of 2024, export activity still remained a key driver with slightly drop from the previous year, with PV panel exports valued at approximately $2.1 billion and PV cell exports at $0.9 billion.

In 2024, the price of PV modules in Thailand ranged between $0.11 – $0.37 USD/Wp (slightly decreased from last year), while installation costs for PV systems in the residential, commercial, and industrial sectors were also slightly decreased as follows:

Residential:	$0.58 – 0.92 USD/Wp
Commercial:	$0.55 – 0.73 USD/Wp
Industrial	$0.52 – 0.58 USD/Wp

TÜRKİYE

PHOTOVOLTAIC SECTOR STATUS 2025

Authors: Ömer Faruk TUNÇBİLEK, Turkish Energy, Nuclear and Mineral Research Agency, Clean Energy Research Institute, Türkiye
İbrahim ATEŞ, Turkish Energy, Nuclear and Mineral Research Agency, Clean Energy Research Institute, Türkiye

Figure 62: Ayaş AgriPV Facility, Ankara: An exemplary application achieving dual land-use productivity through the integrated use of solar panels and agricultural areas.

PV POLICY PROGRAMME

Türkiye's 2025 PV policy framework has been shaped in alignment with the long-term energy transition targets set out in the National Energy Plan. The target of reaching a total installed capacity of 120 GW based on solar and wind energy by 2035 has continued to serve as the primary reference point for policy design. The policy approach has centered on maintaining the rate of capacity growth, ensuring the safe grid integration of increasing renewable generation, expanding generation models integrated with storage, and deepening the domestic manufacturing value chain. This approach points to a policy architecture that simultaneously pursues not only capacity growth but also system flexibility and industrial policy objectives.

By the end of 2025, Türkiye's total installed electricity capacity reached 122.5 GW, while solar energy installed capacity surpassed 25 GW. The majority of solar energy capacity has been commissioned under the unlicensed generation model, particularly through commercial and industrial (C&I) self-consumption investments. This demonstrates that the investment dynamics of PV market in Türkiye are predominantly shaped by a growth model focused on distributed generation and consumption.

The Renewable Energy Resource Areas (YEKA) model continued to be used for solar energy capacity allocation in 2025. Under YEKA SPP-2025, a competitive tender process was conducted for a total of 650 MW of capacity across eight separate competition zones, with a floor price of 3.25 Euro-cent/kWh and an initial ceiling price of 5.50 Euro-cent/kWh. The contract model reflects a hybrid risk-sharing approach that balances investor returns with long-term financing security by combining an initial five-year market-exposed period with a subsequent twenty-year purchase guarantee.

Throughout 2025, regulatory adjustments to the electricity market design concentrated particularly on self-consumption, storage, and system flexibility. Amendments to the Regulation on Unlicensed Electricity Generation restructured application, technical assessment, and grid connection priority procedures; made the central preparation of technical evaluation reports mandatory; and clarified the criteria to be applied in cases of capacity constraints. Provisions related to capacity increase applications, plant transfers, and the treatment of surplus generation were updated to make the unlicensed generation framework more predictable and to strengthen technical compatibility with the grid.

In 2025, the regulatory infrastructure for floating solar power plants was established, and the application, technical evaluation, and permitting processes for facilities to be built on water surfaces were defined. This regulation is considered an important policy step in terms of reducing land use restrictions and opening up new areas of application. Floating PV applications have the potential to increase resource diversity by enabling the use of existing reservoirs and dam areas for energy production. Finally, the first YEKA Floating PV tender is planned for the Demirköprü hydroelectric power plant reservoir area in Manisa province, with a capacity of 35 MW.

Amendments to the Regulation on Electricity Market Storage Activities enabled the installation of storage facilities within unlicensed renewable generation plants. Settlement and payment principles for electricity supplied to the grid from storage systems were defined, and the participation framework of storage facilities in ancillary services and balancing markets was clarified. These measures have strengthened the role of storage-integrated solar systems in enhancing system flexibility and renewable integration. In addition, lowering the annual consumption threshold for the last-resort supply tariff for residential consumers from 5 000 kWh to 4 000 kWh aims to expose high-consumption households earlier to market price signals and encourage demand-side participation.[1]

Increasing solar energy capacity is turning electricity grid management into a critical issue and introducing storage-based power plants using different technologies as an alternative. According to data from the Energy Market Regulatory Authority (EMRA), some of the projects that received preliminary licenses under the 33 GW storage-integrated generation capacity allocation announced in 2022 have progressed to the licensing stage, and by the end of 2025 the first storage-integrated solar power plant had been commissioned. This development indicates a growing investment trend toward the co-planning of generation facilities with storage. The regulatory framework continues to be implemented in a manner that supports applications contributing to the system integration of renewable energy generation.

RESEARCH, DEVELOPMENT & DEMONSTRATION

Research and development activities in the field of PV in Türkiye throughout 2025 continued to focus on high-efficiency cell technologies, improvement of production processes, cost efficiency, and technical studies on grid integration. The activities were carried out by universities, public research institutions, and industrial companies, and efforts were made to ensure coordination between research and industrial application areas.

During 2025, the Turkish Energy, Nuclear and Mineral Research Agency (TENMAK) continued its research and support activities for solar energy technologies. In this context, a project call titled “Solar Energy System Technologies” was published under the Technology and Product Development Projects Support Program, aiming to support the domestic production of photovoltaic system components, high-efficiency cell technologies, and innovative applications. In addition, technical studies have been initiated on the integration of solar power plants with storage systems. Furthermore, TENMAK organized a “Workshop on Circularity and Recycling in the Turkish Photovoltaic Sector.” Within the scope of the workshop, industry representatives, public institutions, and technical experts came together to comprehensively address the assessment of photovoltaic technologies from a circular economy perspective, end-of-life management, the technical and economic dimensions of recycling processes, and the regulatory and policy needs in this area.

TENMAK Clean Energy Research Institute (TEMEN) launched a solar panel and battery recycling project in 2025. Technical studies have been carried out to ensure that the recycling process is environmentally friendly and cost-effective, as well as to identify the work needed to scale up from R&D-level investments to pilot and industrial scale. Considering the rapidly increasing number of solar power plant installations in Türkiye as of 2015 and the technologies of the period, forecasting studies have been initiated for power plants with recycling potential over the next decade.

The Center for Solar Energy Research and Applications (ODTÜ-GÜNAM) has assumed a role contributing to the strengthening of knowledge transfer between both the fundamental scientific dimensions of PV technologies and industrial application domains through nationally supported projects and international collaboration activities. An invention developed by the Center's researchers was awarded a gold medal at the ISIF'25 International Invention Fair held in September 2025. This activity is noteworthy in terms of the development of innovations related to module manufacturing processes and their presentation on international platforms. Furthermore, the Center received support for three projects under the "Cluster 5" calls within the European Union's Horizon Europe programme; these projects cover R&D-focused areas such as high-efficiency cell technologies and system integration. This development contributes to the integration of Turkey's research capacity with European research networks. Within the scope of demonstration activities, AgriPV pilot projects were carried out by the Center in Ankara-Ayaş, Kayseri-Erciyes, and Bursa-Mustafakemalpaşa, where the integration of single-axis tracker systems with agricultural production was tested. These studies are of strategic importance in terms of increasing the diversity of PV applications and optimizing land-use efficiency.

Forecasting systems for grid integration were another key focus of R&D efforts in 2025. Efforts were made to develop a solar energy production forecasting system in line with the requirements of Türkiye Elektrik İletim A.Ş. (TEİAŞ), the electricity grid operator in Türkiye. The project aimed to develop a forecasting infrastructure at the national and power plant basis and to monitor accuracy levels through performance indicators. This type of project contributes to managing the effects of increasing PV capacity on system operation.

Increasing solar energy capacity is turning electricity grid management into a critical issue and introducing storage-based power plants using different technologies as an alternative.

INDUSTRY AND MARKET DEVELOPMENT

By 2025, Türkiye's photovoltaic market, which has surpassed 25 GW of installed capacity, has continued its trend of capacity growth. According to data from TEİAŞ, 4 694 MW of new solar energy capacity was commissioned in 2025. Of the new installations, 4 175 MW came from unlicensed production facilities and 521 MW from licensed power plants. At the end of the year, unlicensed solar installed capacity reached approximately 22 500 MW, while licensed solar installed capacity reached 2 540 MW. This distribution shows that growth has largely progressed through self-consumption and distributed generation models.

In 2025, the strategic orientation of Türkiye’s PV industry focused on increasing domestic solar cell manufacturing capacity, commercializing advanced cell technologies, and establishing an integrated PV value chain within the framework of the HIT-30 High Technology Investment Programme. The HIT-30 PV Workshop, held at ODTÜ-GÜNAM, strengthened public–industry–academia collaboration on domestic cell capacity targets, the industrial scalability of high-efficiency technologies such as TOPCon, and the reduction of dependency on critical materials.

In terms of industrial capacity, Türkiye ranks among the countries in the European region possessing gigawatt-scale module manufacturing infrastructure. Although the current production structure is predominantly concentrated at the module assembly level, the announcement of new investment plans in 2025 aimed at expanding both cell and module manufacturing capacity signals a strengthening of the integrated production model (cell and module). These developments demonstrate the continuation of scaling-up trends within the industrial structure, aimed at deepening the domestic supply chain and supporting technological modernization.

The policy framework for domestic production has become clearer in 2025. Raising the import surveillance reference values applied to product groups such as photovoltaic cells and wafers to USD 170/kg demonstrates the strengthening of trade policy instruments aimed at protecting domestic production. Under the YEKA GES-2025 regulations, a minimum local content requirement of 75% for solar modules and at least 51% for DC cables, carrier structures, and inverter equipment has been defined. This regulation establishes a direct link between capacity allocation and domestic production obligations. Furthermore, investment incentive applications now require that solar panels be manufactured from domestically produced cells and that panel carrier construction systems be domestically produced. This approach demonstrates that incentive mechanisms are structured to cover not only final assembly but also the cell production stage. Furthermore, the updating of import surveillance practices for PV cell and wafer products has been evaluated within the scope of trade policy instruments supporting domestic cell production investments. The joint consideration of domestic content ratios, investment incentives, and surveillance practices reveals a policy framework aimed at creating a more integrated structure in the production chain.

With the definition of the administrative and technical framework for PV installation on water surfaces, floating PV projects have begun to be included in capacity allocation mechanisms. Considering potential benefits such as reduced land use constraints, evaluation of existing reservoir and dam areas, and reduced evaporation losses, floating PV applications are considered a complementary area for the expansion of PV capacity in Türkiye.

On the cost side, price increases observed in the global PV supply chain became particularly pronounced in the TOPCon module and n-type wafer segments. Reference prices for TOPCon modules increased to approximately USD 0.115/Wp, while n-type wafer prices rose by more than 10%.[1] The increase in silver prices affected cell manufacturing costs. These developments have also influenced investment costs in Türkiye, which remains sensitive to global equipment and raw material prices, demonstrating the continued integration of the domestic market with the international PV value chain.

Overall, 2025 has been a period of continued progress in Türkiye's PV sector, both in terms of installed capacity growth and the development of domestic manufacturing capacity. The simultaneous advancement of capacity expansion, industrial investments, and new application areas indicates that the market is undergoing a multidimensional development process.

UNITED KINGDOM

PHOTOVOLTAIC SECTOR STATUS 2025

Author: Amal Mansor, Department for Energy Security & Net Zero, UK

Figure 63: The Stourton Park & Ride, which opened in 2021, is the first solar carpark in the UK, with 1.2MW solar, 500kW/950kWh battery system and 26 EV charging units.

PV POLICY PROGRAMME

The Clean Energy Superpower Mission sets out the UK's ambition to become a global leader in clean energy by delivering Clean Power by 2030 and accelerating progress toward Net Zero. The mission focuses on four major outcomes: enhancing energy security, protecting billpayers, creating economic growth and green jobs, and reducing greenhouse gas emissions.

Figure 64: Illustrative solar deployment (GW) scenarios 2024-2035, Great Britain.

Central to this effort is the Clean Power 2030 Action Plan, which includes commitments for clean energy to produce at least as much power as Great Britain (GB) consumes, deliver at least 95% clean generation, and reduce the carbon intensity of electricity generation to below 50 gCO_2e/kWh by 2030. It also calls for the rapid acceleration of solar deployment, from over 21.6 GW at present, to 45-47 GW by 2030.

The UK's Solar Roadmap, published in 2025, sets out a national plan to accelerate solar deployment to support its clean energy strategy, highlighting solar as one of the cheapest power sources. The Roadmap outlines 72 actions to remove barriers to solar deployment, including through the £15 billion Warm Homes Plan which will help households take up measures such as solar panels and batteries. The upcoming Future Homes Standard will also ensure solar panels are installed on most new build homes.

For the commercial and public sectors, the removal of the 1 MW planning cap simplifies rooftop deployment, while new permitted development rights will allow solar canopies in car parks. In addition, the threshold for requiring complex grid assessments has been raised from 1 MW to 5 MW in England and Wales, exempting all rooftop solar projects, lowering costs and speeding up connections.

The Clean Power Action Plan calls for the rapid acceleration of solar deployment, from over 21.6 GW at present, to 45-47 GW by 2030.

The main mechanism for supporting large scale solar PV deployment in the UK is through the Contracts for Difference (CfD) scheme, which was launched in 2014. In the most recent allocation round, a total of 4.9 GW of solar capacity was awarded, with 1.9 GW expected to come online by 2028 and the remaining 3 GW by 2029. The Roadmap commits to targeting CfD reforms to ensure the scheme can accommodate the volume of new solar needed for Clean Power 2030 while keeping consumer costs low, and is reviewing how innovative technologies such as floating solar are treated within the scheme. UK Companies can also access Government-backed finance through several organisations including the British Business Bank (BBB), the National Wealth Fund (NWF) and UK Export Finance (UKEF).

The Roadmap further outlines actions to address barriers relating to planning, grid connections, supply chain and skills, while enabling innovation and alternative deployments options such as advanced solar cell technologies, plug-in solar, floating solar and space based solar power. For example, the Government has commissioned a plug-in solar safety study to explore how they can be deployed safely in the UK

RESEARCH, DEVELOPMENT & DEMONSTRATION

Solar technology is one of the research areas funded by the UK Engineering and Physical Sciences Research Council (EPSRC), with an estimated £37.6 million in grant funding awarded. The scope includes:

- Fundamental materials research into new and novel materials for solar PV
- Thin-films, flexible PV and the utilisation of new materials for increased efficiency, better stability and lower costs
- Solar fuels, solar thermal and floating solar
- Systems integration

The £1 billion Net Zero Innovation Portfolio (NZIP) provided funding from 2021-25 for low carbon technologies and systems, including projects relevant to solar deployment and integration. Some highlights include:

- Open Climate Fix, funded through the AI for Decarbonisation Innovation Programme, has integrated satellite imagery, weather data and real-time solar PV generation data to create an open-source foundational model for forecasting near-term, hyper-local solar PV generation. This is now fully operational in Great Britain's National Energy System Operator's (NESO's) control room, saving 300 000 tonnes of CO_2 and £30 million per year in balancing costs, with potential to reach £150 million by 2035.
- Sunsave Group Ltd, funded through the Green Home Finance Accelarator, piloted a novel 'Solar as a Service' model for residential rooftop solar. The Sunsave Plus solar subscription, trialled with 110 customers, provided a solar PV and battery system installation at no upfront cost, with households paying a fixed monthly subscription fee.
- The £5.5 million Space Based Solar Power Programme was launched to explore the feasibility and commercial potential of SBSP. Funding was awarded to eight leading universities and technology firms across four themes: wireless power transmission, concentrated solar photovoltaics, systems energy engineering, and space mission architecture.

INDUSTRY AND MARKET DEVELOPMENT

Solar PV Cumulative Installed Capacity

Renewables generated an average of 63% of GB's electricity during 2025. Solar continues to grow rapidly as part of the electricity mix, accounting for roughly 6.5% of generation, an increase from 5% in 2024. Solar reached a new maximum generation record of 14 GW on 8 July 2025. By the end of December 2025, the UK had 21.6 GW of installed solar capacity across 1 918 000 installations —an increase of 13.6% (2.6 GW) since December 2024. This includes the 373 MW Cleve Hill solar farm, which is now the UK's largest operational solar farm.

Over the course of 2025, a total of 262 000 installations came online, the highest annual total to date. The 2.6 GW new capacity added in 2025 was the highest annual figure since 2015, when 4.3 GW was added and just behind 2014 when 2.7 GW was added.

Most solar PV installations in the UK are domestic but they only account for 29% of the total capacity. At least 40% (8.6 GW) came from ground-mounted or standalone solar installations, including 21 on CfD, 19 of which came online during 2025.

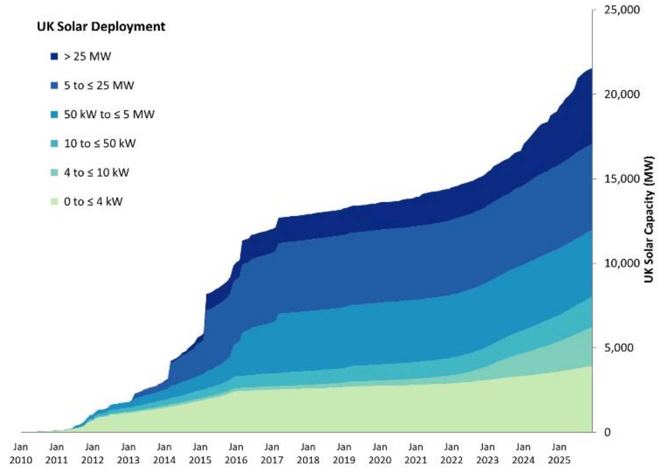

Figure 65: UK solar deployment (MW) scenarios 2010-2025.

After a sharp drop in April 2020 due to Covid-19 restrictions, the number of installations recovered in late 2020 and gradually exceeded pre-pandemic levels. Between 2016 and 2021, the median monthly installations was around 3 000 per month. The median over the past 12 months was over 22 000 installations per month.

Cost Trend

Table 6: Inflation adjusted installation cost per kW for small-scale solar (0-50 kW). The inflation index used is the "All items CPI" as published by the UK Official National Statistics in May 2025.

	0-4 kW: median (£/kW)	4-10 kW: median (£/kW)	10-50 kW: median (£/kW)
2021/22	1 532	1 355	898
2022/23	1 806	1 669	988
2023/24	1 719	1 670	1044
2024/25	1 392	1 320	932

Small-scale installation costs have fluctuated, peaking in 2022/23 when median prices exceeded £2 000/kW. This was driven by a number of factors, including supply chain pressures, higher shipping costs, and increased demand pushed by high electricity prices. Prices then fell through 2024/25 to their lowest levels in years. Over the past year, median £/kW decreased for all installation sizes: by 19% for 0–4 kW, 21% for 4–10 kW, and 11% for 10–50 kW compared to 2023/24. Larger installations continue to show lower £/kW, and advances in technology alongside increased supply have driven prices down despite rising demand.

For grid scale solar, the UK's CfD scheme provides the best indicator of cost trend. In this scheme, developers compete in an auction for long-term contracts that guarantee a fixed price for the electricity they will generate with the strike price representing the minimum revenue needed for economic viability.

Table 7: Cleared strike prices across CfD auctions.

Allocation Rounds (AR)	(AR1) 2015	(AR4) 2022	(AR5) 2023	(AR6) 2024	(AR7) 2026
Strike Price ($£_{2024}$/MWh)	69.67	64.09	65.49	69.77	65.23

Solar projects were originally allowed to compete in the first auction but were excluded in subsequent rounds. Solar was then allowed to bid again for the allocation round 4 (2022) where 3.1 GW capacity was secured. Across the years, the price of solar projects has remained the lowest of all renewable technologies. In 2024-adjusted prices, strike prices were £64.09/MWh in 2022, £65.49/MWh in 2023, and £69.77/MWh in 2024. The most recent auction saw solar strike price fall again to £65.23/MWh, representing a 10% decrease from 2024. However, this round offers 20-year contract, unlike the 15-year contracts used in all previous rounds, therefore the lower price possibly reflects longer revenue support rather than a real cost reduction.

Figure 66: Secretary of State for Energy Security and Net Zero Ed Miliband visits Tiln Farm Solar Park. Picture by Lauren Hurley / DESNZ.

PARTICIPATION MATRIX

Please note:

- The information presented in the Participation Matrix reflects the participation status as of February 2026.
- The numbers in the table refer to IEA PVPS Tasks.
- The ‘TM’ squares indicate that an Expert from the lsited entity is a Task Manager.
- ExCo is the abbreviation for the Executive Committee delegate.

Country	Entities	ExCo	1	12	13	15	16	17	18	19	20	AG
Australia	Australian PV Institute (APVI)	ExCo	1									
	Ekistica								18			
	Global Sustainable Energy Solutions (GSES)								18			
	IT Power Australia							17				
	RINA Consulting				13							
	Sustainable Energy for All	ExCo										
	University of Adelaide										20	
	University of Melbourne					15						
	University of New South Wales (UNSW)	ExCo	1	12	13		16	17				
	University of South Australia (UniSA)						16					
Austria	Austrian Institute of Technology GmbH (AIT)				13	15				19		
	Austrian PV Technology Platform (TPPV)	ExCo	1									
	Austrian Research Institute for Chemistry and Technology (OFI)			12	13	15						
	Federal Ministry of Innovation, Mobility and Infrastructure	ExCo										
	Fronius International									19		
	Polymer Competence Center Leoben GmbH (PCCL)			12	13							
	University of Applied Sciences Technikum Vienna					15						
	University of Applied Sciences Upper Austria (FH-OÖ)						16					
	Vienna University of Technology (TU Wien)					15						
Belgium	Becquerel Institute		1			15						
	Energyville - IMEC				13			17				
	Energyville - KU Leuven	ExCo	1							19		
	Energyville – UHasselt	ExCo			13	15						
	Energyville – VITO			12								
	Lucisun				13	15						
	PV Cycle Association			12								
	Royal Meteorological Institute of Belgium (RMIB)						16					
Canada	Canadian Renewable Energy Association (CanREA)	ExCo	1									
	Concordia University					15						
	McGill University			12								
	National Research Council Canada					15						
	Natural Resources Canada - CanmetENERGY	ExCo	1		13	15	16					
	University of Waterloo					15						
	Yukon University Research Centre								18			
China	China Electric Power Research Institute									19		
	China Epower Solutions Corp. Ltd.								18			
	Energy Internet Research Institute, Tshinghua University							17				
	GoodWe					15						
	Institute of Electrical Engineering, Chinese Academy of Sciences (CAS)	ExCo		12	13				18	19	20	
	LONGI Green Energy Technology Co., Ltd.		1			15						
	Public Meteorological Service Center (CMA)						16					
	PV Committee of China Green Supply Chain Alliance (ECOPV)	ExCo	1	12								
	Siemens Energy Co., Ltd.									19		
	Sungrow Renewables Development Co., Ltd.									19	20	
	Trinasolar Co. Ltd.					15						
	Xi’an LONGi Hydrogen Energy Technology Co.										20	

Country	Entities	ExCo	1	12	13	15	16	17	18	19	20	AG
	Zhejiang Jinko Solar Co. Ltd.			12								
Denmark	Danish Institute of Fire and Security Technology (DBI)					15						
	Danish Meteorlogical Institute (DMI)						16					
	EMD International									19		
	FKSol ApS	ExCo										
	Kenergy	ExCo	1									
	SiCon				13							
	Solar City Denmark					15						
	Technical University of Denmark (DTU)				13	15	16					
European Union	European Commission Directorate-General for Research & Innovation	ExCo										
	Joint Research Centre - European Commission		1				16			19		AG
Finland	Aalto University School of Science					15						
	Fortum Renewables Oy				13							
	Innovation Funding Agency Business Finland	ExCo										
	Lappeenranta-Lahti University of Technology LUT		1									
	Turku University of Applied Sciences				13					19		
	University of Turku									19		
	VTT Technical Research Centre of Finland	ExCo										
France	ADEME (The French Agency for Ecological Transition)	ExCo						17				
	Becquerel Institute France		TM									
	Department of Solar Technologies (CEA-LITEN)			12								
	Ecole Polytechnique à Palaiseau						16					
	Electricité de France (EDF R&D)						16					
	EnerBIM					15						
	European Space Agency						16					
	French Alternative Energies and Atomic Energy Commission							17				
	HESPUL									19		
	Institut National de l'Energie Solaire (INES)|Laboratoire des systèmes Solaires (L2S)				13							
	Laboratoire PIMENT|University of Reunion						16					
	Lorraine University									19		
	Mines ParisTech			12			16					
	Planair France SAS	Chair	1					17				
	Réseau de Transport d'Électricité (RTE)						16					
	SAP Labs France							17				
	Scientific and Technical Centre for Building (CSTB)					15						
	SOREN (PV Cycle France)			12								
	TotalEnergies			TM	13		16					AG
	Université de Technologie de Compiègne							TM				
	UPEC									19		
Germany	Africa GreenTec								18			
	Asantys								18			
	CSP Services						16					
	Ecolog Institute								18			
	Energynautics GmbH									19		
	Forschungszentrum Jülich GmbH							17				

Country	Entities	ExCo	1	12	13	15	16	17	18	19	20	AG
	Projektträger Jülich (PTJ)	ExCo	1									
	Fraunhofer Center for Silicon Photovoltaics CSP				TM							
	Fraunhofer IEE									19		AG
	Fraunhofer Institute for Solar Energy Systems (ISE)			12	13		16		18			
	German Aerospace Center (DLR)						16					
	Institute for Solar Energy Research GmbH (ISFH)				13							
	OFRES								TM			
	Reiner Lemoine Institute								18			
	Rolls Royce Solutions								18			
	Technische Hochschule Ulm (THU)									TM		
	TÜV Rheinland Solar GmbH				13							
	Univers GmbH				13							
India	Himachal Pradesh University				13							
	National Institute of Solar Energy (NISE)	ExCo					16					
	School of Planning and Architecture New Delhi					15						
Israel	Ministry of Energy & Infrastructure	ExCo	1									
Italy	Becquerel Institute Italia (BII)				13							
	European Academy Bozen/Bolzano (EURAC)				13	15	16					
	Gestore dei Servizi Energetici (GSE S.p.A.)		1		13	15						
	GreenHorse Legal Advisory		1									
	i-em						16					
	National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA)	ExCo	1	12			16			19		TM
	Politecnico Milano					15						
	Ricerca Sistema Energetico (RSE S.p.A.)	ExCo	1	12	TM		16					
	Sapienza University of Rome				13							
	Tor Vergata University of Rome											AG
	University of Catania				13							
	University of Naples Federico II					15						
	University of Rome II - Tor Vergata						16					
Japan	Lixil					15						
	National Institute of Advanced Industrial Science and Technology (AIST)				13	15						
	New Energy and Industrial Technology Development Organization (NEDO)	ExCo		12						19		
	Photovoltaic Power Generation Technology Research Association (PVTEC)					15						
	RTS Corporation		TM									AG
	Tokyo University of Science									19		
	University of Miyazaki			12				TM				
Korea	KENTECH		T1									
	Kongju National University					15						
	Korean Energy Agency (KEA)	ExCo										
	Korean Institute for Energy Research (KIER)	ExCo										
Lithuania	Protech	ExCo	1			15						
Malaysia	Sarawak Energy Berhad								18			
	Sustainable Energy Development Authority (SEDA)	ExCo	1									

Country	Entities	ExCo	1	12	13	15	16	17	18	19	20	AG
	Tenaga Nasional Berhad									19		
Morocco	Green Energy Park	ExCo			13					19		
	IRESEN	ExCo	1						18			
Norway	Institute for Energy Technology (IFE)				13	15	16			19		
	Norwegian Meteorological Institute						16					
	Norwegian University of Science and Technology (NTNU)				13	15						
	Norwegian Water Resources and Energy Directorate (NVE)	ExCo	1									
	Research Council of Norway	ExCo										
	RISE Fire Research AS					15						
Portugal	Directorate-General for Energy and Geology (DGEG)	ExCo	1							TM		
	Finerge									19		
	Portuguese Renewable Energy Association (APREN)	ExCo								19		
	University of Lisbon						16	17				
Sponsor members	Solar Energy Research Institute of Singapore (SERIS)	ExCo			13	15						
	Solar Power Europe	ExCo	1									AG
South Africa	South African National Energy Development Institute (SANEDI)	ExCo	1									
Spain	Becquerel Institute Spain					TM						
	Centre for Research on Energy, Environment and Technology (CIEMAT)			12		15	16					
	Mactech						16					
	National Hydrogen Centre (CNH2)										20	
	National Renewable Energy Centre of Spain (CENER)	ExCo			13		16					
	Public University of Navarra (UPNA)						16					
	Polytechnic University of Madrid							17				
	Tecnalia					15		17				
	Trama Tecno Ambiental								18			
	Union Española Fotovoltaica (UNEF)		1									
	University of Alcala								18			
	University of Almeria						16					
	University of Castilla La Mancha									19		
	University of Jaen						16					
	University of La Laguna									19		
	University of Las Palmas de Gran Canaria						16					
	University of Malaga						16					
	University of Murcia			12								
	University of Sevilla						16					
Sweden	Becquerel Sweden AB		1									
	Chalmers University of Technology			12								
	CheckWatt AB				13							
	Dalarna University			12						19		
	IVL Swedish Environmental Research Institute			12								
	Mälardalen University (MDU)				13							AG
	Research Institutes of Sweden (RI.SE)			12	13							
	Swedish Energy Agency	ExCo										
	Swedish Meteorological and Hydrological Institute (SMHI)						16					
	University Uppsala						16					

Country	Entities	ExCo	1	12	13	15	16	17	18	19	20	AG
Switzerland	Bern University of Applied Sciences				13							
	CSEM PV-Center|EPFL Photovoltaics Laboratory				13							
	Dr. Schüpbach & Muntwyler GmbH							17				
	Eastern Switzerland University of Applied Sciences (OST); Institute SPF						16					
	HES-SO Geneva (HEPIA)					15						
	Megasol					15						
	Meteotest						TM			19		
	NET - Ltd	ExCo										
	Planair SA		1									
	Swiss Center for Electronics and Microtechnology (CSEM)							17				
	Swiss Federal Office of Energy	ExCo										
	Treeze Ltd.			12								
	University of Applied Sciences and Arts of Southern Switzerland (SUPSI)				13	TM						
	Viridén + Partner					15						
	Zurich University of Applied Sciences (ZHAW)			12								
Thailand	Department of Alternative Energy Development and Efficiency	ExCo	1									
	King Mongkut University of Technology Thonbury, CES Solar Cells Testing Center (CSSC)				13							
The Netherlands	bear-ID					15						
	Delft University of Technology			12					18		20	
	Eindhoven University of Technology									19		
	Netherlands Enterprise Agency RVO	ExCo	1						18	19	TM	
	Netherlands Organisation for Applied Scientific Research (TNO)			12		15		17				
	SmartGreenScans			12								
	University of Twente									19		
	Utrecht University				13		16					
	ZUYD					15						
Turkiye	Middle East Technical University								18			
	Turkish Energy Nuclear and Mineral Research Agency (TENMAK)	ExCo	1									
United Kingdom	Department for Energy Security and Net Zero (DESNZ)	ExCo										
	Northumbria University			12								
	Oxford Brookes University			12								
	Peak Designs Ltd						16					
	UK Power Networks									19		
USA	Case Western Reserve University (SDLE)				TM							
	Clean Power Research (CPR)						16					
	David Renne Renewables						16					
	Electric Power Research Institute (EPRI)			12								
	First Solar			12								
	National Aeronautics and Space Administration (NASA)						16					
	National Laboratory of the Rockies (NLR)			TM	13		TM		18			TM
	Sandia National Laboratory (SNL)				13							
	Solar Consulting Services						16					
	State University of New York (SUNY Albany)						16			19		
	Univers Inc.				13							

Country	Entities	ExCo	1	12	13	15	16	17	18	19	20	AG
	University of Central Florida				13							
	University of Oregon						16					
	University of Washington			12								
	US Department of Energy	ExCo	1									